FES 08-44

FINAL

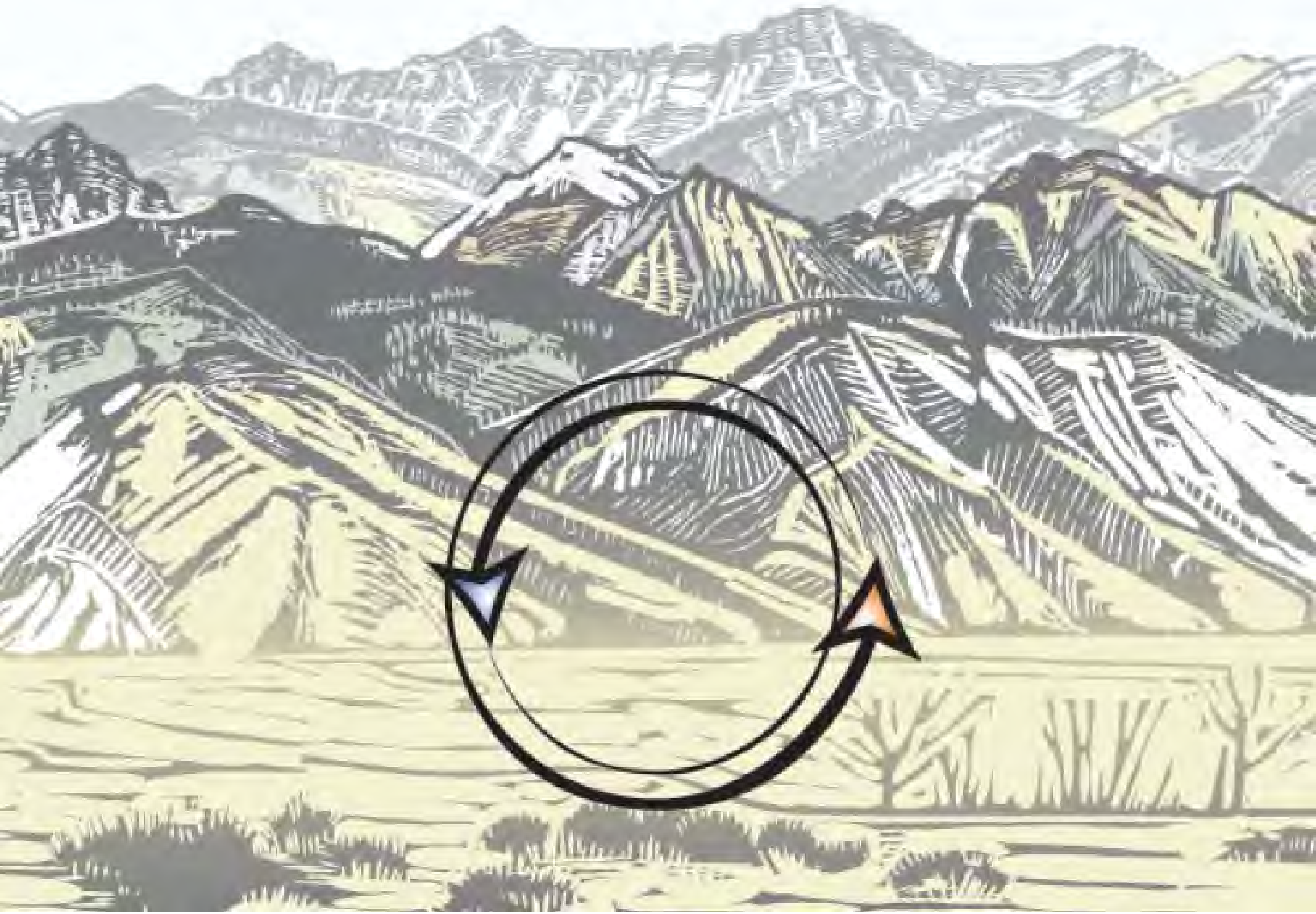
Programmatic Environmental Impact Statement for

Geothermal Leasing

in the Western United States

Volume I: Programmatic Analysis

October 2008



FES 08-44

FINAL

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR

GEOTHERMAL LEASING IN THE WESTERN UNITED STATES

VOLUME I: PROGRAMMATIC ANALYSIS

OCTOBER 2008

US DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

US DEPARTMENT OF AGRICULTURE

UNITED STATES FOREST SERVICE

United States Department of the Interior
BUREAU OF LAND MANAGEMENT
Washington, DC 20240
http://www.blm.gov

TAKE PRIDE IN AMERICA

OCT 0 3 2008

Dear Reader:

In August 2005, the U.S. Congress enacted the Energy Policy Act of 2005, Public Law 109-58, which recognizes the increasing demand for renewable energy and the need to facilitate leasing decisions for geothermal resources on public lands. Section 225 of this Act, titled "Coordination of Geothermal Leasing and Permitting on Federal Lands," requires that the Secretary of the Interior and Secretary of Agriculture establish a program for reducing by 90 percent the backlog of geothermal lease applications that were pending as of January 1, 2005. The Act also mandated that action be taken by August 8, 2010.

Enclosed is the Final Programmatic Environmental Impact Statement (FPEIS) for Geothermal Leasing for lands administered by the Bureau of Land Management (BLM) (termed "public lands") and the U.S. Forest Service (FS) (termed "National Forest System lands") that have geothermal potential in the 12 western states of Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. The BLM and FS jointly prepared the FPEIS in collaboration with the public; tribes; federal, state, and local agencies; universities and research institutions; stakeholder organizations; and industry.

The FPEIS evaluates various alternatives for allocating lands as being closed or available for leasing and analyzes stipulations to protect sensitive resources. The document describes the proposed amendments for 122 BLM-administered land use plans, also termed resource management plans (RMP), to adopt the allocations, stipulations, procedures, and Best Management Practices analyzed in the FPEIS. In addition, the FPEIS provides site-specific analysis for 19 pending geothermal lease applications for lands within 7 geographical areas that were filed prior to January 1, 2005.

The FPEIS and proposed RMP amendments have been developed in accordance with the National Environmental Policy Act of 1969 (NEPA), the Council on Environmental Quality's regulations for implementing NEPA (40 Code of Federal Regulations [CFR] 1500–1508), the Energy Policy Act of 2005, and applicable BLM and FS authorities. The three volumes of the FPEIS contain the programmatic analysis of geothermal leasing on BLM- and FS-administered lands, the proposed RMP amendments, site-specific analysis for the 19 pending lease applications, copies of the written comments received during the public review period of the Draft PEIS, and responses to these comments.

Because developing this and other alternative energy resources is of strategic importance in enhancing the Nation's domestic energy supplies, the Assistant Secretary, Land and Minerals Management, in the Department of the Interior is the responsible official for these proposed

BLM RMP amendments. The FLPMA and its implementing regulations provide land use planning authority to the Secretary of the Interior, as delegated to this Assistant Secretary. The Assistant Secretary, Land and Minerals Management will be approving these proposed RMP amendments. Therefore, there will be no administrative review (protest) of the proposed amendments under the BLM or Departmental regulations (43 CFR 1610.5-2). The Assistant Secretary, Land and Minerals Management, is the responsible official for the decision (Record of Decision) to be made with respect to the BLM RMP amendments.

As required by NEPA, the Environmental Protection Agency will publish a Notice in the *Federal Register* announcing the availability of the FPEIS for public review. The BLM is also providing a 60-day period for state governors to review the FPEIS and proposed RMP amendments for consistency with state plans. The BLM will wait until the end of this Governor's Consistency review period before signing and issuing the Record of Decision and approving the plan amendments.

The Record of Decision and approved plan amendments will be mailed or made available electronically to all who participated in the planning process. They also will be available to all parties via the Geothermal PEIS website (www.blm.gov/Geothermal_EIS) or by mail upon request.

Sincerely,

Dennis R Rosin

For: James L. Caswell
Director

Final Programmatic Environmental Impact Statement (PEIS) for Geothermal Leasing in the Western United States

Lead Agencies: US Department of the Interior (DOI), Bureau of Land Management (BLM)
US Department of Agriculture, Forest Service (FS)

Location: Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming

Contacts: Jack G. Peterson, BLM National Project Manager; (208) 373-4048, jack_g_peterson@blm.gov

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Project website: www.blm.gov/geothermal_eis

Abstract:
In accordance with the Energy Policy Act of 2005, the project's goal are: (1) to make geothermal leasing decisions on pending lease applications submitted prior to January 1, 2005; and (2) to facilitate geothermal leasing decisions on other existing and future lease applications and nominations on the federal mineral estate in the western United States. Approximately 143 million acres of public lands administered by the BLM and 104 million acres of National Forest System (NFS) lands contain geothermal resources suitable for commercial electrical generation and direct uses, such as heating. Lands that are part of the National Park System and National Wildlife Refuge System are closed to geothermal leasing. The BLM and FS are proposing to allocate approximately 118 million acres of public lands and 79 million acres of NFS lands as open to geothermal leasing subject to existing laws, regulations, formal orders, stipulations attached to the lease form, and terms and conditions of the standard lease form. To protect special resource values, the BLM and FS have developed a comprehensive list of stipulations, conditions of approval, and best management practices. Under the proposed action, the BLM would amend 122 land use plans to adopt the allocations and the appropriate stipulations, and the FS would use the PEIS to facilitate subsequent consent decisions for any leasing on NFS lands. An alternative to the proposed action would limit the lands available for geothermal leasing to those that are in close proximity to existing transmission lines or those under development. The no action alternative would allow the processing of pending geothermal lease applications; however, they would be evaluated on a case-by-case basis and would require additional environmental review. Based on the analysis contained in the PEIS and public comments on the Draft PEIS, the BLM has selected Alternative B as the Preferred Alternative. The PEIS also provides site-specific analysis for 19 pending lease applications submitted prior to January 1, 2005, that are located in seven geographical clusters throughout Alaska, California, Nevada, Oregon, and Washington.

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Volume I: PROGRAMMATIC ANALYSIS

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LIST OF ACRONYMS

ACEC - Area of Critical Environmental Concern

ADR - Alternative Dispute Resolution

ANCSA - Alaska Native Claims Settlement Act

ANILCA - Alaska National Interest Lands Conservation Act

APD - Application for Permit to Drill

AUM - Animal Unit Month

BLM - United States Department of the Interior, Bureau of Land Management

BMPs - Best Management Practices

C - Celsius

CA - Conservation Agreement

CERCLA - Comprehensive Environmental Response, Compensation and Liability Act

CEQ - Council on Environmental Quality

CFR - Code of Federal Regulations

COAs - Conditions of Approval

CS - Conservation Strategy

CSU - Controlled Surface Use

CX (or CE) - Categorical Exclusion

DM - Departmental Manual

DNA - Documentation of Land Use Plan Conformance and National Environmental Policy Act (NEPA) Adequacy

DOI - Department of the Interior

DR - Decision Record (for an EA)

EA - Environmental Assessment

EFH - Essential Fish Habitat

EIS - Environmental Impact Statement

EPAct of 2005 - Energy Policy Act of 2005 (Public Law 109-58, August 8, 2005)

ESA - Endangered Species Act

F - Fahrenheit

FACA - Federal Advisory Committee Act

FLPMA - Federal Land Policy and Management Act of 1976 (43 United States Code 1701 et seq.)

FONSI - Finding of No Significant Impact

FS - United States Department of Agriculture, Forest Service

FWS - Fish and Wildlife Service

GIS - Geographic Information System

IBLA - Interior Board of Land Appeals

ITAs - Indian Trust Assets

IMP - Interim Management Policy

KGRAs - Known Geothermal Resource Areas

LAC - Limits of Acceptable Change

LUP - Land Use Plan

MFP - Management Framework Plan

MOU - Memorandum of Understanding

NEPA - National Environmental Policy Act of 1969

NFMA - National Forest Management Act of 1976

NFS - National Forest System

NGD - No Ground Disturbance

NHPA - National Historic Preservation Act

NLCS- BLM's National Landscape Conservation System

NMFS - National Marine Fisheries Service

NOA - Notice of Availability

NOAA - National Oceanographic and Atmospheric Administration

NOI - Notice of Intent

NPS - National Park Service

NRCS – National Resources Conservation Service

NREL - US DOE National Renewable Energy Laboratory National Renewable Energy Laboratory

NRHP - National Register of Historic Places

NSO - No Surface Occupancy

OSHA - Occupational Safety and Health Administration

OHV - Off-Highway Vehicle

PAC - Provincial Advisory Council

PEIS - Programmatic Environmental Impact Statement

PFYC – Potential Fossil Yield Classification

PM10 - Particulate Matter Less than 10 Micrometers in Diameter

PM2.5 - Particulate Matter Less than 2.5 Micrometers in Diameter

POD - Plan of Operation and Development

Ppm - Parts per Million

RAC - Resource Advisory Council

RFD - Reasonably Foreseeable Development

RMP - Resource Management Plan

RNA - Research and Natural Area

ROD - Record of Decision (for an EIS)

ROS - Recreation Opportunity Spectrum

ROW- Right of Way

SMS - Scenery Management System

T&E - Threatened and Endangered

TL - Timing Limitation

TMDL -Total Maximum Daily Load

US - United States

USC - United States Code

USDA - United States Department of Agriculture

US DOE - United States Department of Energy

US DOI - United States Department of the Interior

US EPA - United States Environmental Protection Agency

USGS - United States Geological Survey

USFWS - United States Department of Interior, Fish and Wildlife Service

VRM - Visual Resource Management

WGA - Western Governors Association

WSR - Wild and Scenic River

WSA - Wilderness Study Area

Executive Summary

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EXECUTIVE SUMMARY

ES.1 INTRODUCTION

Recent government policies and advances in technology have increased the demand for accessing geothermal resources on federal lands in the western United States (US). About 530 million acres in the 12 western states of Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming have geothermal potential for electrical generation or direct heat applications (such as heating buildings, spas, and greenhouses). Of this area, approximately 143 million acres are lands administered by the US Department of the Interior (DOI), Bureau of Land Management (BLM) and 104 million acres are within the National Forest System (NFS) administered by the US Department of Agriculture (USDA) Forest Service (FS). This represents about 47 percent of all western lands that have geothermal potential. Tribal lands and federal lands within units of the National Wildlife Refuge System and National Park System are closed to geothermal leasing, and adjacent public and NFS lands require special analysis prior to issuance of geothermal leases.

The BLM has the delegated authority to issue geothermal leases on federal mineral estate, such as that underlying lands administered by the FS. A geothermal lease is for the earth's heat resource where there is federal mineral estate. The BLM currently (at the end of fiscal year 2007) administers approximately 480 geothermal leases that covered over 700,000 acres. Of those, 57 are producing geothermal energy, 54 are for electrical generation and three for direct use (BLM 2008b). Leasing geothermal resources by the BLM vests with the lessee a non-exclusive right to future exploration and an exclusive right to produce and use the geothermal resources within the lease area subject to existing laws, regulations, formal orders, and the terms, conditions, and stipulations in or attached to the lease form or included as conditions of approval in permits. Lease issuance alone does not authorize any ground-disturbing activities to explore for or develop geothermal resources without site specific approval for the intended operation. Such approval could include additional environmental reviews and permits.

ES.2 PROPOSED ACTION

The Energy Policy Act (EPAct) of 2005 (Public Law 109-58, August 8, 2005) recognizes the increasing demand for geothermal resources and the need to facilitate leasing decisions. In accordance with the EPAct, the BLM and the FS are proposing to make geothermal leasing decisions on pending lease applications submitted prior to January 1, 2005 and to facilitate geothermal leasing decisions on other existing and future lease applications and nominations.

To achieve this, the BLM and FS are proposing to do the following:

1. Identify public and NFS lands with geothermal potential as being legally open or closed to leasing.
2. Issue or deny geothermal lease applications pending as of January 1, 2005.

Under the proposal, the BLM would also do the following:

3. Identify public lands that are administratively closed or open to leasing, and under what conditions.
4. Develop a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing and development on public and NFS lands.
5. Amend BLM land use plans to adopt the resource allocations, stipulations, best management practices, and procedures.

All lands that are currently closed by statute to geothermal leasing would remain closed and would not be affected by the proposal. Examples of these lands include but are not limited to National Park System lands, wilderness areas, wilderness study areas, National Recreation Areas, Indian trust or restricted lands, and the Island Park Geothermal Area in Wyoming and Montana.

ES.3 PURPOSE OF AND NEED FOR ACTION

The purpose of the proposed action is threefold:

1. To complete processing active pending geothermal lease applications and nominations by deciding whether, and under what stipulations, to issue geothermal leases on NFS and BLM administered lands.
2. To amend BLM land use plans to allocate BLM-administered lands with geothermal resource potential as closed, open, or open with major or moderate constraints to geothermal leasing. This includes establishing a projected new level of potential geothermal development with existing planning level decisions, termed reasonably foreseeable development (RFD) scenario, and identifying appropriate stipulations, best management practices, and

procedures to protect other resource values and uses while providing sufficient pre-leasing analysis to enable the BLM to make future competitive geothermal leasing availability decisions.

3. To provide suitability information to the FS to facilitate its subsequent consent decision to the BLM for leasing on NFS lands. Provide environmental analysis to assist future NFS land use decisions by providing possible land use allocations and stipulations for geothermal leasing.

There are three needs for the federal action:

1. To issue decisions on pending lease applications in accordance with the EPAct of 2005. Specifically, Section 225 requires that the Secretary of Interior and Secretary of Agriculture establish a program for reducing by 90 percent the backlog of geothermal lease applications that were pending as of January 1, 2005. The EPAct of 2005 mandates that action be taken by August 8, 2010.
2. To address other provisions of the EPAct of 2005 (Sections 211 and 222[d][1]); respond to other policy directives calling for clean and renewable energy (see Section 1.8 Renewable Energy Policies); and to meet the increasing energy demands of the nation while reducing reliance on foreign energy imports, reducing greenhouse gas emissions, and improving national security.
3. To facilitate geothermal resource leasing in an environmentally responsible manner to help meet the increasing interest in geothermal energy development on public and NFS lands in the western US (EPAct Section 211).

ES.4 PLANNING AREA AND DOCUMENT SCOPE

This programmatic environmental impact statement (PEIS) analyzes the potential environmental, social, and economic effects of these actions in accordance with the National Environmental Policy Act of 1969 (NEPA), the Council on Environmental Quality's (CEQ) regulations for implementing NEPA (40 Code of Federal Regulations [CFR] 1500–1508), and applicable BLM and FS authorities.

The project area is defined as the 12 western states, including Alaska. The planning area is defined as the 530 million acres within the 12 western states that have the potential for geothermal resources. The planning area includes BLM- and FS-administered surface lands with minerals under federal ownership that have geothermal potential and the subsurface federal geothermal mineral estate on other lands. Surface lands administered by other federal agencies, such as the National Park Service and US DOI, Fish and Wildlife Service (USFWS), and state agencies are not assessed in this document unless their administrative boundaries overlap with public or NFS lands. If these lands have subsurface federal geothermal mineral estate, the BLM would apply the management direction provided in this PEIS, with the surface management agency's consent, for lease nominations or applications. Lands that are not administered by the BLM or FS, or that are closed to geothermal leasing by statute are not part of the analysis, including National Park System lands.

ES.5 ALTERNATIVES

Three alternatives are evaluated in detail in the PEIS: the no action alternative and two action alternatives. A comparison of the different allocations between the action alternatives is presented in Table ES-1.

Table ES-1
Comparison of Geothermal Resource Allocations between the Action Alternatives

	Alternative B: Proposed Action (acres)	Alternative C: Leasing Near Transmission Lines (acres)
Public Lands in Planning Area	143,154,205	143,154,205
NFS Lands in Planning Area	103,582,163	103,582,163
Public Lands Open to Indirect Use[1]	118,007,636	61,202,746
Public Lands Open to Leasing for Direct Uses	118,007,636	118,007,636
NFS Lands Open to Leasing for Indirect Use[1]	79,217,147	37,870,654
NFS Lands Open to Leasing for Direct Uses	79,217,147	79,217,147
Public Lands Closed to Indirect Use[1]	25,146,569	81,951,459
Public Lands Closed to Leasing for Direct Uses	25,146,569	25,146,569
NFS Lands Closed to Leasing for Indirect Use[1]	24,365,016	65,711,509
NFS Lands Closed to Leasing for Direct Uses	24,365,016	24,365,016

[1] Indirect use includes commercial electrical generation.

Alternative A: No Action

Alternative A is the No Action Alternative. Under this alternative, no BLM land use plans would be amended, and the existing plan decisions, stipulations, and allocations would not change as a direct result of the PEIS process. Therefore, any plans that do not address geothermal leasing would not be amended and the public and NFS lands would not be allocated as open or closed to geothermal leasing.

Processing of pending geothermal lease applications would continue; however, they would be evaluated on a case-by-case basis using analysis in the existing land use plans. Likewise, future lands nominated for leasing would be evaluated using analysis in existing land use plans. This could require additional NEPA documentation and possibly amendments to the plans. Many plans currently do not adequately address geothermal leasing, do not have allocation decisions for geothermal leasing, and do not have appropriate RFDs on geothermal leasing.

Taking no action would not facilitate the leasing process and does not meet the stated purpose and need; however, this alternative is analyzed in detail to provide a baseline from which to evaluate the other alternatives in accordance with CEQ guidance.

Alternative B: Proposed Action (Preferred Alternative)

Approximately 117 million acres of BLM administered public land would be allocated as open and 75 million acres of NSF land would be legally open to geothermal leasing for direct and indirect use subject to existing laws, regulations, formal orders, stipulations attached to the lease form, and the terms and conditions of the standard lease form. The authorized officer retains the discretion to issue leases with stipulations that impose moderate to major constraints on use of surface of any leases in order to mitigate the impacts to other land uses or resources objectives as defined in the guiding resource management plan. The 118 million acres of public land and 79 million acres of NFS land that would be open to geothermal leasing under the Proposed Action represent about 80 percent of public lands and NFS lands within the planning area. The remaining 25 million acres of BLM administered public land and 24 million acres of NFS lands in the planning area would be closed to geothermal leasing. The closed areas encompass non-discretionary and discretionary (BLM only) determinations, including the statutorily closed Island Park Geothermal Area. Island Park encompasses over 470,000 acres of NFS and public lands around the west and southwest boundary of Yellowstone National Park for the explicit purpose of protecting the geothermal features of the Park. The BLM would amend 122 land use plans to adopt the allocations, RFDs, and specific stipulations, best management practices, and procedures. Based on the analysis contained in the PEIS and public comments on the Draft PEIS, the BLM has selected Alternative B as the Preferred Alternative.

Alternative C: Leasing Lands near Transmission Lines

Under Alternative C, the BLM and FS would only consider leasing lands for commercial electrical generation if they are within a 20-mile corridor (10-mile from centerline) from existing transmission lines and lines currently under development at 60kV to 500kV. All lands within this corridor would be designated as closed or open with moderate to major constraints to leasing using the criteria outlined for the Proposed Action. Island Park Geothermal Area would also be closed (as with Alternative B); however, the area would be expanded to include no leasing within 15 miles of the boundary of Yellowstone National Park boundary. Given the limited transmission line grid and demand for localized power sources for remote communities, the lands available for geothermal leasing in Alaska would be the same as for Alternative B - Proposed Action. Leases for direct use would be considered for the entire planning area and would not be constrained by the location of transmission lines. Therefore, direct use leasing would be the same as the Proposed Action.

Under Alternative C, approximately 61 million acres of public land and 38 million acres of NFS lands would be open for geothermal leasing for commercial electrical generation. These lands would be subject to moderate to major constraints as detailed in the Proposed Action. This alternative would increase the amount of land that would be unavailable for geothermal leasing with in the planning area; specifically, about 81 million acres of public land and 66 million acres of NFS lands would be closed. Other lands outside the corridor would not be closed to leasing, but would require evaluation on a case-by-case basis as described under the No Action Alternative.

ES.6 REASONABLY FORESEEABLE DEVELOPMENT SCENARIO

An RFD for commercial electrical generation and direct use was developed to serve as a basis for analyzing environmental impacts resulting from future leasing and development of federal geothermal resources within the western US over the next 20 years. It is estimated that within the planning area there are 5,540 megawatts (MW) of geothermal potential considered viable for commercial electrical generation by 2015, with a further 6,660 to 6,670 MW being forecast by 2025. This capacity is expected to be realized through approximately 110 additional power plants by 2015, and a further 132 more power plants by 2025. Using these values, it is estimated that the average viable capacity at any particular site is 50 MW by 2025. Most of the development would likely occur in northern Nevada, California, and Idaho, with the least amount in Wyoming and Montana.

It is estimated that by 2015, direct use applications could be developed in the amount of 1,600 thermal MW, and by 2025, this number is estimated to be 4,200 thermal MW. This development could occur anywhere within the planning area.

ES.7 IMPACT ANALYSIS

Designating lands for geothermal leasing potential and amending land use plans, in and of itself, does not cause any direct impacts as defined by CEQ regulations, which states that such effects "are caused by the action and occur at the same time and place" (40 CFR 1508.8[a]). It is reasonable, however, to foresee that on-the-ground impacts would occur if the BLM issues geothermal leases but that the impacts would not occur until some point in the future. Therefore, the analysis in the PEIS addresses both direct and indirect impacts based on the foreseeable on-the-ground actions, including exploration, drilling, and utilization. These impacts cannot be analyzed site-specifically, but they are analyzed for the planning area based on the RFD scenario. Additional site-specific analysis would be conducted during the permitting review process for subsequent exploration, drilling, and utilization applications.

A typical geothermal electrical generation plant has a surface disturbance of between 53 to 367 acres for all associated activities, such as exploration, drilling, and construction, depending on site conditions and the type of geothermal plant. Reclamation is done on areas that are no longer needed for these activities, so the actual area of disturbance for an operating power plant is generally much less. Geothermal resources also provide a wide range of direct use applications, which can require land disturbances of less than one acre to more than 50 acres. Geothermal development has similar short-term impacts as other land disturbing activities but has fewer long-term impacts compared to other energy generation activities. If geothermal leases were developed, the following general adverse impacts would be expected:

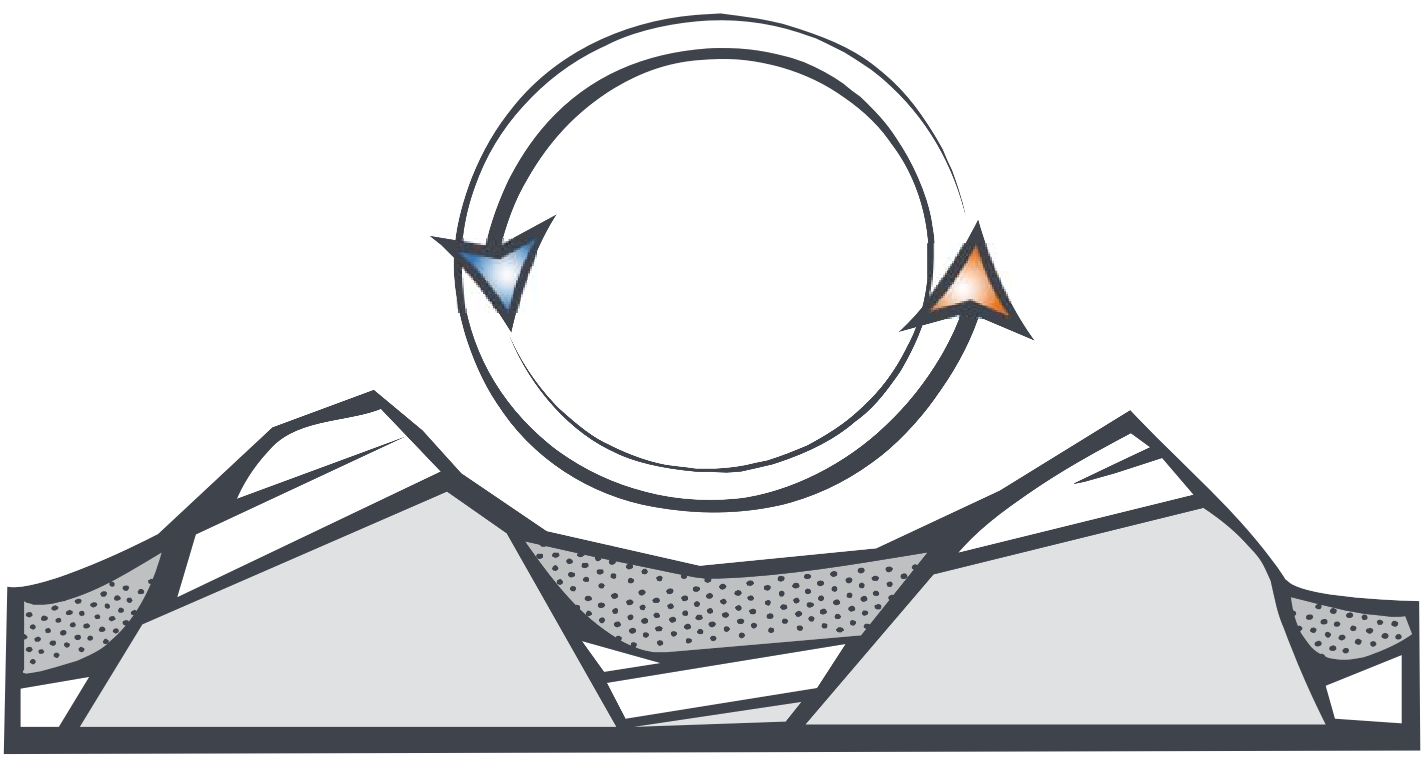
- Long-term loss of vegetation, habitat, and soil.
- Short-term and intermittent noise impacts from construction and maintenance activities. Operations would have minimal noise impacts in most areas on federal lands; however, areas with minimal noise sources (i.e., remote areas) would experience a greater change in the noise characteristics.
- Loss of some recreational opportunities from energy infrastructure, although new roads could provide access for additional recreational opportunities.
- Long-term visual impact from power plants and infrastructure.
- Short-term impact to ground water during drilling.
- Loss of other land uses, such as livestock grazing, on lands occupied by geothermal facilities.
- Short-term increase in air emissions from drilling and construction activities. Compared to nonrenewable energy sources, electrical

generation with geothermal resources has minimal emissions. Therefore, on a megawatt basis, geothermal production would have a beneficial long-term impact in reducing emissions and greenhouse gases.

The cumulative impacts associated with geothermal development, such as erosion, habitat loss and fragmentation, propagation of invasive species, and viewshed degradation, would occur but would be relatively minor. At the maximum projected build out in 2025, up to 89,500 acres could be disturbed from exploration, drilling, and utilization and operational activities. This represents less than 0.01 percent of the 17 million areas of public land that have other commercial uses. Geothermal developments also tend to have relatively small operational footprints compared to other uses (such as wind farms and oil and gas fields) and are generally compatible with other uses, such as livestock grazing.

The subsequent impacts from geothermal leasing are relational to the areas that are available for leasing. Alternative C would limit the areas open to geothermal leasing to 99 million acres while Alternative B proposes about 197 million acres as open to leasing. The No Action Alternative does not formally identify geothermal resources as open or closed for leasing; instead it relies on existing plans for determining any allocations on a case-by-case basis, if such allocations have been decided in the plan. If such determinations are not made, additional NEPA and a possible land use plan amendment would be required. Therefore, Alternative C would result in less future development and ground-disturbing activities compared to Alternative B. However, Alternative C would forego opportunities to use geothermal resources as a renewable energy source and to offset some of the impacts from conventional energy sources.

Under both Alternatives B and C, a comprehensive list of stipulations, best management practices, and procedures would be adopted through the land use amendment process and subsequent permitting to avoid, minimize and mitigate impacts associated with geothermal leasing, exploration, drilling, utilization, and reclamation and abandonment.



Chapter 1

Purpose of and Need for Action

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CHAPTER 1
PURPOSE OF AND NEED FOR ACTION

1.1 INTRODUCTION

The goal of this project is to make geothermal leasing decisions on pending lease applications submitted prior to January 1, 2005 and to facilitate geothermal leasing decisions on other existing and future lease applications and nominations. Geothermal resources are abundant in the western United States (US) and have high potential for providing reliable base demand electrical generation and "direct use" heating applications. Recent Federal and state policies and advances in engineering and technology have increased the demand for accessing geothermal resources. Federal lands in the continental US contain about 46 percent of the nation's geothermal resources, and about 70 percent of Federal lands have potential for geothermal development, defined as heat flow above 140° Fahrenheit (F) (60° Celsius [C]) (Energy Information Administration 2007). Obtaining leases and development permits on Federal lands has been identified as a significant barrier for geothermal developers (Farhar 2000; Western Governors' Association 2006; Geothermal Energy Association 2007a). A notable constraint to leasing on Federal lands is that many land use plans and their associated environmental analyses do not adequately address geothermal resources, thereby requiring a land use plan amendment before geothermal resources can be leased. This constraint has resulted in a number of backlogged lease applications that require processing.

Public Lands: Lands administered by the BLM.

National Forest System Lands: Lands administered by the FS.

National Park System Lands: Lands administered by the National Park Service are closed to geothermal leasing.

In accordance with the Energy Policy Act (EPAct) of 2005 (Public Law 109-58, August 8, 2005), the US Department of the Interior (DOI), Bureau of Land Management (BLM) and the US Department of Agriculture (USDA), Forest Service (FS) propose to facilitate geothermal leasing on lands administered by the BLM (termed "public lands") and the FS (National Forest System [NFS] lands) that have geothermal potential in the 12 western states, including Alaska. Tribal lands and Federal lands within units of the National Wildlife Refuge System and National Park System are closed to geothermal leasing. Public and NFS lands in proximity to a National Park System unit with a "significant thermal feature" require special analysis prior to issuance of geothermal leases.

Under the proposal, the BLM and FS would do the following:

(1) Identify public and NFS lands with geothermal potential as being legally open or closed to leasing.

(2) Issue or deny geothermal lease applications pending as of January 1, 2005.

Under the proposal, the BLM would also do the following:

(3) Identify public lands that are administratively closed or open, and under what conditions.

(4) Develop a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing and development on public and NFS lands.

(5) Amend BLM land use plans to adopt the resource allocations, stipulations, best management practices, and procedures.

Approving the leasing and development of geothermal resources on public and NFS lands is a Federal action and requires analysis under the National Environmental Policy Act of 1969 (NEPA). This programmatic environmental impact statement (PEIS) evaluates the potential environmental, social, and economic effects of these actions in accordance with the NEPA, the Council on Environmental Quality's regulations for implementing NEPA (40 Code of Federal Regulations [CFR] 1500–1508), and applicable BLM and FS authorities. This PEIS presents broad impacts associated with the proposed action and alternatives to the proposed action. Programmatic evaluations are generally done for planning-level actions over large geographic areas (40 CFR 1502.4), which is appropriate for the proposed action. However, issuing decisions on the pending geothermal backlogged lease applications requires more lease-specific analysis, which is provided in Volume II of the PEIS.

This chapter describes the purpose of the proposed action and the need that is driving this process. This chapter also provides background on geothermal resources and how they are utilized, and a description of the process by which Federal geothermal resources are leased.

1.2 PURPOSE OF THE ACTION

The purpose of the proposed action is threefold:

1. To complete processing active pending geothermal lease applications and nominations by deciding whether, and under what stipulations, to issue geothermal leases on NFS and public lands.

2. To amend BLM land use plans to allocate BLM-administered lands with geothermal resource potential as closed, open, or open with major or moderate constraints to geothermal leasing. This includes establishing a projected new level of potential geothermal development with existing planning level decisions (termed

reasonably foreseeable development scenario), and identifying appropriate stipulations, best management practices, and procedures to protect other resource values and uses while providing sufficient pre-leasing analysis to enable the BLM to make future competitive geothermal leasing availability decisions.

3. To provide suitable information to the FS to facilitate its subsequent consent decision to the BLM for leasing on NFS lands. Provide environmental analysis to assist future National Forest land use decisions by providing possible land use allocations and stipulations for geothermal leasing.

1.3 NEED FOR THE ACTION

There are three needs for the Federal action:

1. To issue decisions on pending lease applications in accordance with the EPAct of 2005. Specifically, Section 225 requires that the Secretary of Interior and Secretary of Agriculture establish a program for reducing by 90 percent the backlog of geothermal lease applications that were pending as of January 1, 2005. The EPAct of 2005 mandates that action be taken by August 8, 2010.
2. To address other provisions of the EPAct of 2005 (Sections 211 and 222[d][1]); respond to other policy directives calling for clean and renewable energy (see Section 1.8 Renewable Energy Policies); and to meet the increasing energy demands of the nation while reducing reliance on foreign energy imports, reducing greenhouse gas emissions, and improving national security.
3. To facilitate geothermal resource leasing in an environmentally responsible manner to help meet the increasing interest in geothermal energy development on public and NFS lands in the western US (EPAct Section 211).

1.4 BACKGROUND FOR GEOTHERMAL RESOURCES

The term *geothermal* comes from the Greek *geo* meaning “earth” and *thermal* meaning “heat.” As such, geothermal energy is energy derived from the natural heat of the earth. Geothermal resources are typically underground reservoirs of hot water or steam created by heat from the earth, but geothermal resources also include subsurface areas of dry hot rock. In cases where the reservoir is dry hot rock, the energy is captured through the injection of cool water from the surface, which is then heated by the hot rock and extracted as fluid or steam. Geothermal steam and hot water can naturally reach the earth’s surface in the form of hot springs, geysers, mud pots, or steam vents. Geothermal reservoirs of hot water are also found at various depths beneath the Earth's surface. In the US, most geothermal reservoirs are located in the western states, Alaska, and Hawaii (NREL 2007). Geothermal resources can be accessed by wells and used to provide heat directly. This is called the *direct use* of geothermal energy. The heat energy can also be used to commercially generate electricity; a process called *indirect use*. As shown on Figure 1-1, there are a wide range of uses for geothermal resources.

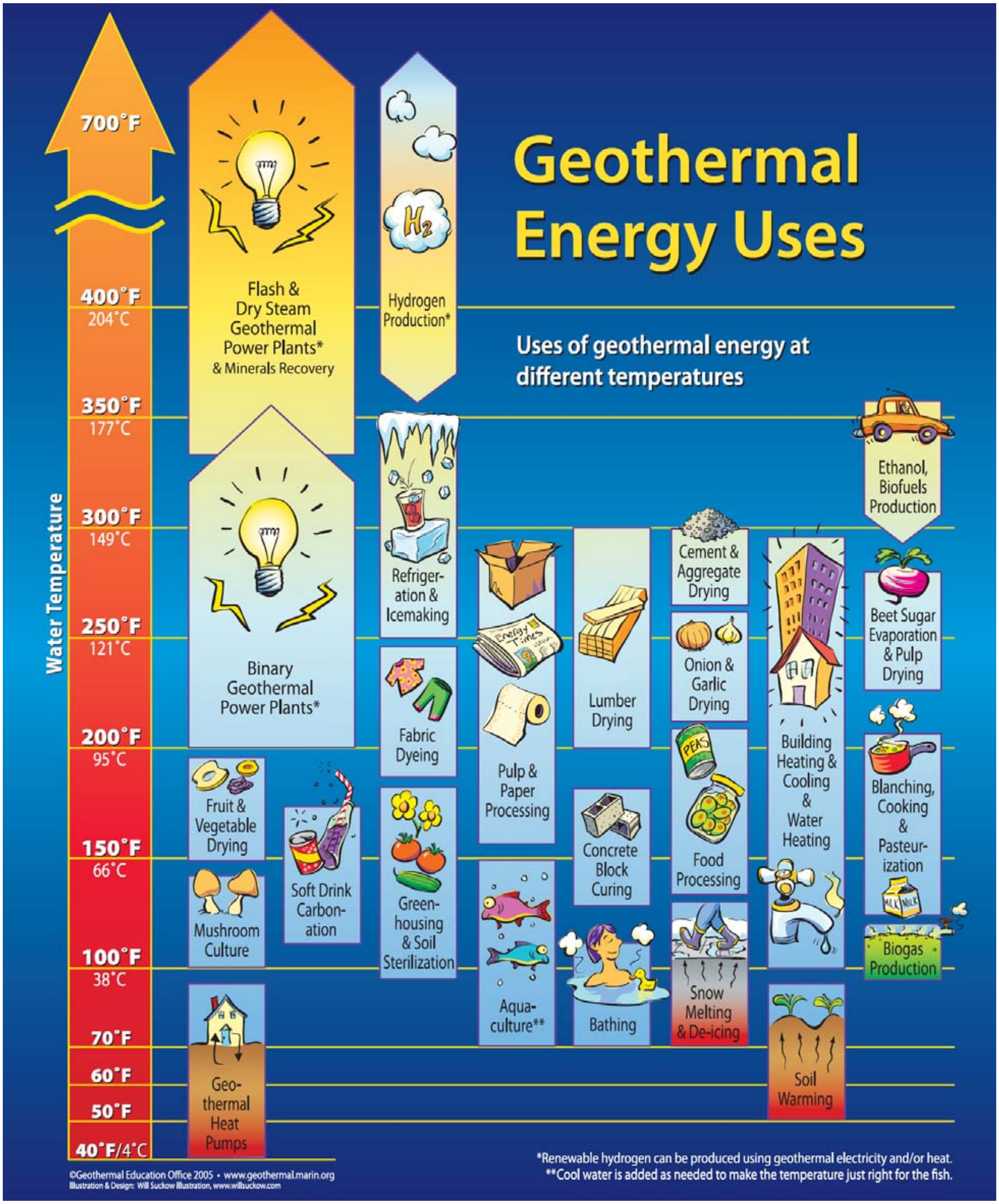
1.4.1 Direct Use

Humans have been using geothermal resources in the form of hot springs for thousands of years. Today, geothermal reservoirs of low- to moderate-temperature water – 68°F to 302°F (20°C to 150°C) – provide numerous opportunities for direct use. Direct use means utilization of geothermal resources for commercial, residential, agricultural, public facilities, or other energy needs other than the commercial production of electricity (43 CFR 3200.1). Direct use includes using heat energy from naturally occurring hot water or using other technology to capture the heat from the earth (e.g., heat pumps). Modern hot water direct-use systems access geothermal reservoirs by drilling into them from the surface to develop a steady stream of hot water. The water is brought up through the well, and a mechanical system consisting of piping, a heat exchanger, and controls delivers the heat directly for its intended use. A disposal system then either injects the cooled water underground or disposes of it on the surface.

Geothermal energy is used as heat in the US, either directly or through the use of ground-source heat pumps, for a variety of applications, such as:

- Heating pools, spas, greenhouses, aquaculture facilities, and buildings;
- Melting snow on sidewalks and driveways; and
- Drying agricultural products.

Direct use applications in the US have been growing at about six percent per year (Lund 2003). These low-temperature resources are fairly abundant throughout the West. A recent survey of 10 western states identified more than 9,000 thermal wells and springs, more than 900 low- to moderate-temperature geothermal resource areas, and hundreds of direct-use sites (Western Governors' Association 2006).



C://EMPSi/GeothermalPEIS/Figures

Geothermal energy has many uses, including heating, agriculture, and commercial electrical generation.

SOURCE: Geothermal Education Office 2005

Uses of Geothermal Energy

Figure 1-1

1.4.2 Commercial Electrical Generation

Commercial electrical generation from geothermal resources is also called *indirect use*. Electrical generation uses geothermally heated fluid to turn a turbine connected to a generator. As discussed below, the fluid may be the naturally occurring steam or water in the geothermal reservoir or another fluid which has the geothermal heat transferred through a heat exchange system.

What's a Watt?

A watt is the International System of Units standard unit of power and is the equivalent of one joule per second.

Kilowatt = 1,000 watts

Megawatt = 1,000 kilowatts

Gigawatt = 1,000 megawatts

Fast Facts:

- ✓ One megawatt serves about 1,000 homes in the US.
- ✓ The western US generates about 2,400 megawatts from geothermal resources annually.

Geothermal energy produces about 2,400 megawatts annually in the western US, supplying less than one percent of the US electrical demand (Energy Information Administration 2007). It is estimated that the 12 Western states have 5,500 MW of geothermal potential considered viable for commercial development by 2015, with a further 6,600 MW being forecast by 2025 (Section 2.6 discusses the reasonably foreseeable development scenario for electrical development).

Geothermal power plants can be small (300 kilowatts), medium (10 to 50 megawatts) and large (50 megawatts and higher) (Nemzer *et al.* 2007). Generation capacity is guided by the number of turbines within a plant. In general, commercial electrical generation requires hot geothermal reservoirs with a water temperature above 200°F (93°C); however, new technologies have proven that lower-temperature water (e.g., 165°F [74°C]) can also be used for electrical generation.

Three types of geothermal power plant systems are commonly used to generate electricity depending on temperature, depth, and quality of the water and steam in the area (US Department of Energy [DOE] 2007a):

(1) flash steam;

(2) binary-cycle; and

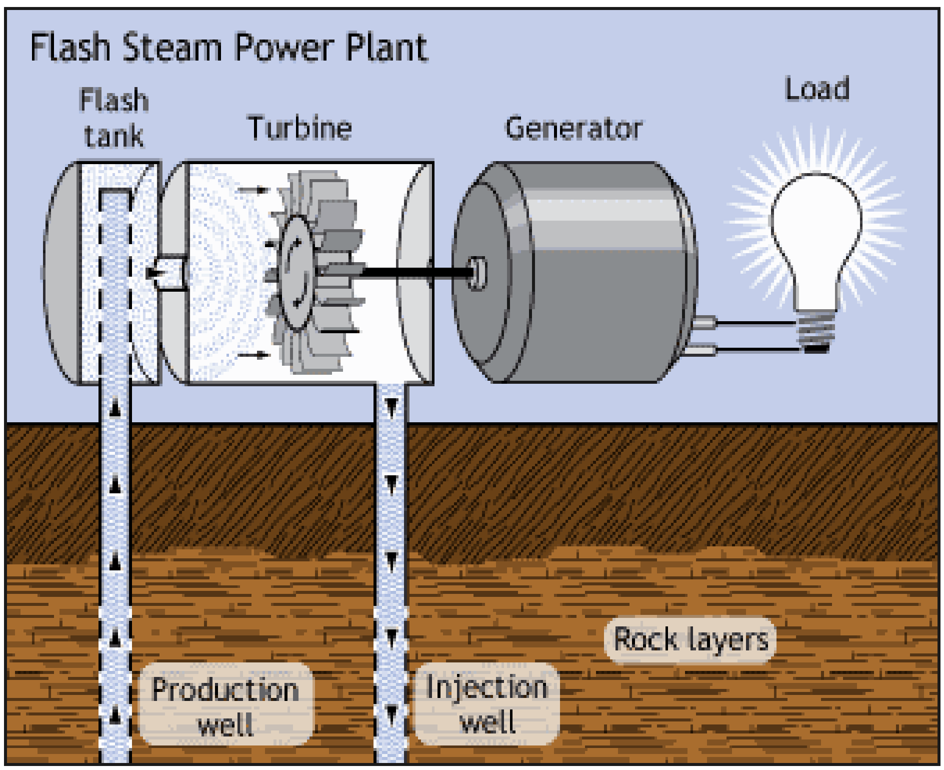
(3) dry steam power plants.

These plants can also be hybridized by including elements of the different technologies at a single location. All three methods reinject the remaining geothermal fluid back into the ground to replenish the reservoir and recycle the hot water.

Flash Steam Power Plants

Flash steam power plants use hot water above 360°F (182°C) from geothermal reservoirs. The high pressure underground keeps the water in the liquid state, although it is well above water's boiling point at standard atmospheric pressure. As the water is pumped from the reservoir to the power plant, the drop in pressure causes the water to convert, or "flash," into steam to power the turbine (Figure 1-2, Flash Steam Power Plant). Any water not converted into steam is injected back into the reservoir for reuse. Flash steam plants, like dry steam plants, emit small amounts of gases and steam. Flash steam plants are the most common type of geothermal power generation plants currently in operation (US DOE 2007a).

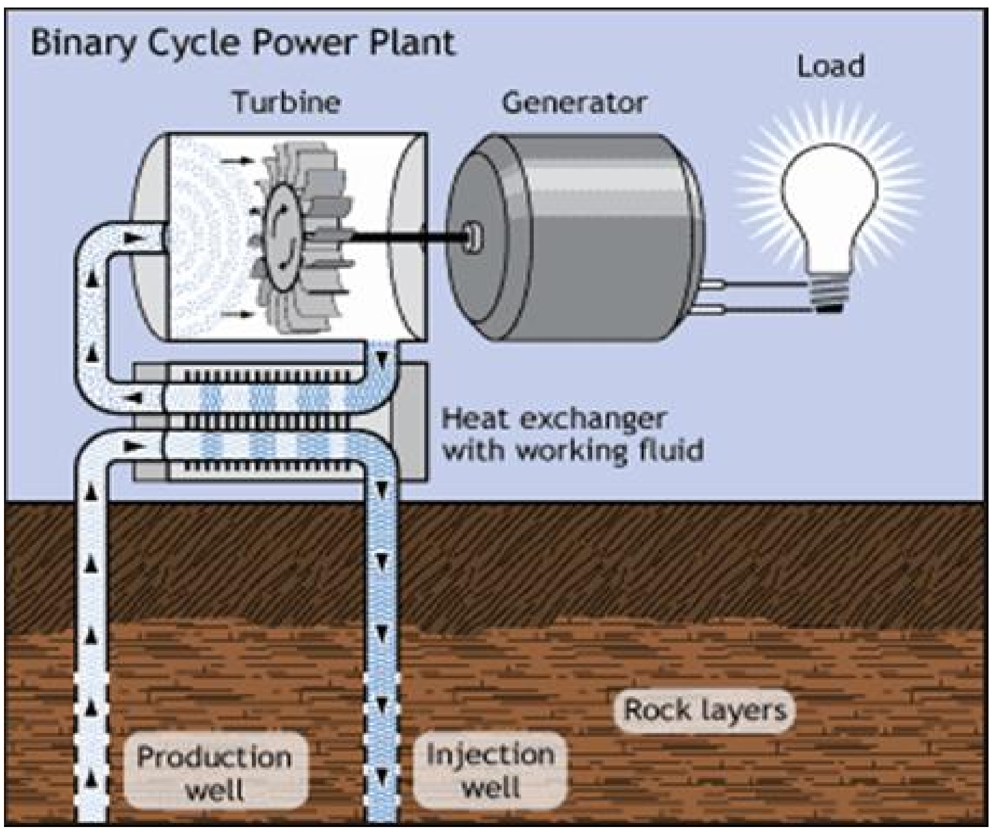
Figure 1-2
Flash Steam Power Plant



Binary Cycle Power Plants

Binary-cycle power plants typically use cooler fluids than flash steam plants (165 to 360°F [74 to 182°C]). The hot fluid from geothermal reservoirs is passed through a heat exchanger, which transfers heat to a separate pipe containing fluids with a much lower boiling point. These fluids, usually iso-butane or iso-pentane, are vaporized to power the turbine (Figure 1-3, Binary-cycle Power Plant). The advantage of binary-cycle power plants is their lower cost and increased efficiency. These plants also do not emit any excess gas and, because they use fluids with a lower boiling point than water, are able to use lower-temperature geothermal reservoirs, which are much more common. Most geothermal power plants planned for construction in the US are binary-cycle (US DOE 2007a).

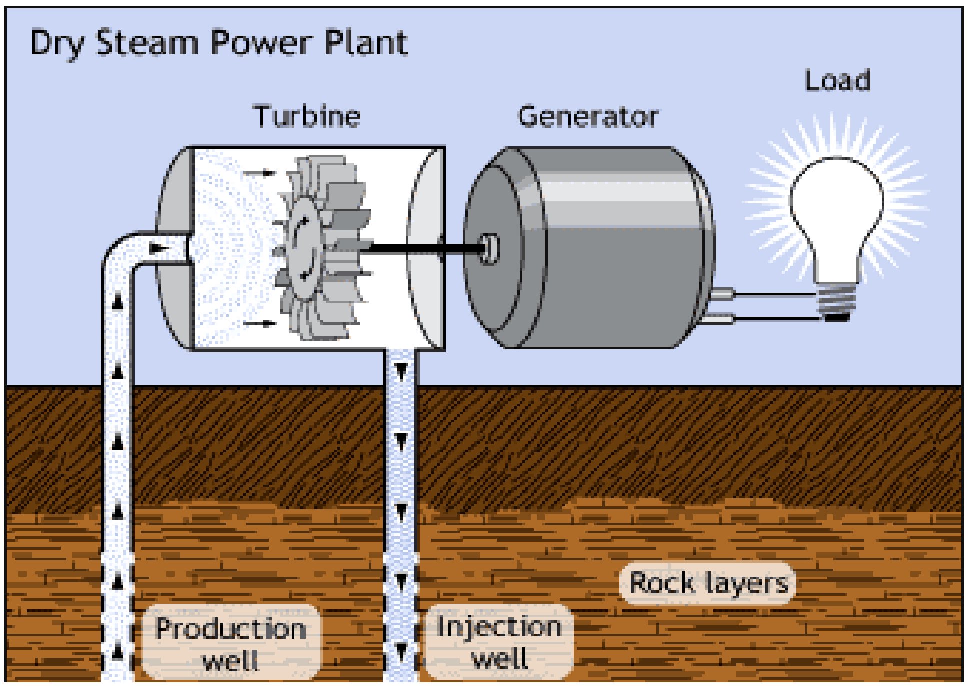
Figure 1-3
Binary Cycle Power Plant



Dry Steam Power Plants

Dry steam power plants use very hot (>455°F [235°C]) geothermal reservoirs that exist primarily in the form of steam. The steam is routed to the surface via a well and used to turn a turbine. The turbine drives a generator that produces electricity (Figure 1-4, Dry Steam Power Plant). While this is the rarest form of power plants, it was both the first type of geothermal reservoir used to produce electricity (at Lardarello, Italy, in 1904) and is the reservoir type being used at the world's largest geothermal production site, The Geysers in Northern California. Dry steam power plants emit only excess steam and very minor amounts of gases (US DOE 2007a). Geothermal sources with dry steam generation capability are very rare.

Figure 1-4
Dry Steam Power Plant



Emerging Technologies

Geothermal Energy from Oil and Gas Production

Oil and gas wells are typically thousands of feet deep and often produce very hot fluid. Along with the oil and gas, wells produce water that must be separated from the oil and gas and usually reinjected deep below domestic aquifers. The Rocky Mountain Oilfield Testing Center, located in the Teapot Dome Oilfield near Casper, Wyoming, is demonstrating the use of warm reservoir fluids from oil and gas production to produce electricity that can be used to power the oil and gas pumps (Rocky Mountain Oilfield Testing Center 2007). This technique is referred to as co-produced geothermal fluids or produced water cut (NREL 2006). Because the electricity is used on site, there is no need to purchase additional electricity which eliminates the need for power lines to be run to oil and gas facilities. This technology could be applied at many oil and gas facilities throughout the West.

Enhanced Geothermal Systems

Enhanced geothermal systems are engineered reservoirs created to produce energy from geothermal resources deficient in water and/or permeability (US DOE 2007b; US DOE 2006). With enhanced geothermal systems, a developing reservoir is targeted within a volume of rock that is hot and tectonically stressed. Through a combination of hydraulic, thermal, and chemical processes, the reservoir can be stimulated, causing fractures to open, extend, and interconnect. This creates a fluid-conductive fracture network and an interconnected reservoir system. The process can extend the margins of existing geothermal systems or can create entirely new ones wherever optimal thermal and tectonic conditions exist (University of Utah Energy and Geoscience Institute) 2007). Enhanced geothermal systems technology is relatively new in the geothermal field and has been found to have great potential for providing electrical power; one study found the potential for 100 gigawatts of power (US DOE 2006). Until recently, lack of research and development funding, government policies, and lack of incentives had not favored the growth of enhanced geothermal systems, with most development occurring outside of the United States (US DOE 2006). It is anticipated that there may be applications for research and development drilling on public and NFS lands in the future. Until it becomes a technically and economically proven technology, it is unlikely that it will be applied at a large scale in the western US within the next 20 years.

1.5 LEASING AND DEVELOPMENT PROCESS OF GEOTHERMAL RESOURCES ON FEDERAL LANDS

1.5.1 Geothermal Leasing Laws and Regulations

A geothermal lease is for the heat resource of the earth where there is Federal mineral estate. Unless specifically owned in fee, the Federal government does not own the hot water commonly associated with the heat; this falls under state water laws. Geothermal developers must obtain the appropriate water rights and state permits, in addition to the Federal lease for the resource.

The BLM has the delegated authority to issue geothermal leases on Federal lands. The BLM currently administers about 480 geothermal leases that covered over 700,000 acres at the end of fiscal year 2007. Of those 57 are producing geothermal energy, 54 producing resource for electrical generation and 3 for direct use (BLM 2008b). It is the policy of the Federal government, consistent with Section 2 of the Mining and Mineral Policy Act of 1970 and Sections 102(a)(7), (8), and (12) of the Federal Land Policy and Management Act of 1976 (FLPMA) (43 US Code [USC] 1701 *et seq.*), to encourage the development of mineral resources, including geothermal resources, on Federal lands. The Geothermal Steam Act of 1970 (30 USC Section 1001, *et seq.*), which was amended and supplemented by the EPAct of 2005, provides statutory guidance for geothermal leasing by the BLM. New Federal geothermal development regulations (43 CFR Parts 3000, 3200, and 3280 – Geothermal Resource Leasing and Geothermal Resources Unit Agreements) were made effective June 1, 2007 (72 Fed Reg. 24358, May 2, 2007), as a result of a directive provided in the EPAct of 2005. These statutes and regulations delineate lands that are available and unavailable for leasing.

1.5.2 Available and Unavailable Lands for Geothermal Leasing

In accordance with the Geothermal Steam Act of 1970, as amended (30 USC Section 1001) and the Geothermal Resources Leasing Rule (43 CFR 3201.10), the BLM may issue leases on the following "available" lands:

- Lands administered by the DOI, including public and acquired lands not withdrawn from such use;
- Lands administered by the USDA with its concurrence;
- Lands conveyed by the US where the geothermal resources were reserved to the US; and
- Lands subject to Section 24 of the Federal Power Act, as amended (16 USC 818), with the concurrence of the Secretary of Energy.

Conversely, the BLM is prohibited from issuing leases on the following statutorily closed Federal lands as defined in the Geothermal Resources Leasing Rule (43 CFR 3201.11). Other lands administered directly by the BLM and FS may also be closed through other authorities, which are discussed in Chapter 2.

- Lands where the Secretary of Interior (Secretary) has determined that issuing the lease would cause unnecessary or undue degradation of public lands and resources;
- Lands contained within a unit of the National Park System, or that are otherwise administered by the National Park Service;
- Lands where the Secretary determines after notice and comment that geothermal operations, including exploration, development, or utilization of lands, are reasonably likely to result in a significant adverse effect on a significant thermal feature within a unit of the National Park System;
- Lands within a National Recreation Area;
- Fish hatcheries or wildlife management areas administered by the Secretary;
- Indian trust or restricted lands within or outside the boundaries of Indian reservations;

- The Island Park Geothermal Area (in Idaho and Montana); and
- Lands where Section 43 of the Mineral Leasing Act (30 USC 226-3) prohibits geothermal leasing, including:
    - Wilderness areas or Wilderness Study Areas administered by the BLM or other surface-management agencies;
    - Lands designated by Congress as Wilderness Study Areas, except where the statute designating the study area specifically allows leasing to continue; and
    - Lands within areas allocated for wilderness or further planning in Executive Communication 1504, Ninety-sixth Congress (House Document 96-119), unless such lands are allocated to uses other than wilderness by a land and resource management plan or are released to uses other than wilderness by an act of Congress.

1.5.3 Leasing Process, Rights, and Limitations

The BLM grants access to geothermal resources through a formalized leasing process based on the end use. For direct uses, an applicant can apply noncompetitively for a lease. For indirect use, such as commercial electrical generation, the BLM awards leases through a competitive bidding process. Historically, certain lands were designated as known geothermal resource areas (KGRAs). All lands designated within KGRAs were leased through a competitive bidding process. Until the passage of the EPAct of 2005, lands outside of KGRAs could be leased noncompetitively. Section 222 of the EPAct of 2005 modified the Geothermal Steam Act of 1970 to allow only competitive lease sales for all Federal geothermal resources and their associated lands. The geothermal leasing regulations provide for four types of lands available for noncompetitive leasing: (1) Parcels of land that did not receive bids in a competitive sale; (2) Lands available exclusively for direct use; (3) Lands subject to mining claim and a current plan of operation; and (4) Lands for which a lease application was pending on August 8, 2005, if the applicant so chooses. Lease areas are nominated by the public for a lease sale.

When the BLM receives a nomination, it is adjudicated, and configured into lease parcels by the respective BLM state office. Lease parcels are then forwarded to the appropriate field office or FS regional office where the appropriate environmental analysis and review is conducted. This process is discussed in detail below.

The four stages of geothermal resource development within a lease are exploration, drilling operations, utilization, and reclamation and abandonment. Each stage requires a permit from the BLM. Leasing geothermal resources by the BLM vests with the lessee a non-exclusive right to future exploration and an exclusive right to produce and use the geothermal resources within the lease area, subject to existing laws, regulations, formal orders, and the terms, conditions and stipulations in or attached to the lease form or included as conditions of approval to permits. Lease issuance alone does not authorize any ground-disturbing activities to explore for or develop geothermal resources without site specific approval for the intended operation. Such approval could include additional environmental reviews and permits. Also at each stage, the BLM, in consultation with the FS on NFS lands, can issue site-specific conditions-of-approval to protect resource values. The specific activities associated with each phase are detailed in Chapter 2.

A lease is issued for a primary term of 10 years and may be extended for two five-year periods. Each of these extensions is available provided the lessee meets the work commitment requirements or lessee made payment in lieu of minimum work requirements of each year. At any time a lease may receive a 5-year drilling extension. Once commercial production is established, the lease may receive a production extension of up to 35 years and a renewal period of up to 55 years. The lease must continue to produce to remain in effect. BLM may grant a suspension of operations and production on a lease when justified by the operator (see 43 CFR 3207).

Geothermal exploration and production on Federal land conducted through leases is subject to terms and stipulations to comply with all applicable Federal and state laws pertaining to various considerations for tribal interests, sanitation, water quality, wildlife, safety, cultural resources, and reclamation.

1.5.4 Environmental Review Requirements for Lease Sales

All geothermal decisions must be provided for and in conformance with the applicable land use plan. Prior to geothermal lease sales, individual BLM field offices must prepare Documentation of Plan Conformance and NEPA Adequacy (also termed DNAs) for parcels within their respective jurisdictions to determine: (1) whether the issuance of a particular lease is in conformance with the applicable land use plan; and (2) whether the BLM can properly rely upon existing NEPA documents that analyze the potential impacts of geothermal leasing (i.e., an environmental impact statement that accompanies a land use plan). Additionally, the BLM must also document completion of required government to government consultation with tribes and environmental reviews required to comply with other laws, including but not limited to the Endangered Species Act and National Historic Preservation Act.

While a DNA can provide NEPA compliance, it is not an "environmental document" per se, and cannot supply missing analysis; if the DNA evaluation shows a need for further analysis, a new or supplemental NEPA document would need to be prepared. Upon completion of the DNA, the BLM field office can make one of the following recommendations to the BLM State Office: (1) the parcel(s) be offered for sale; (2) the parcel(s) be offered for sale with slightly modified legal descriptions or additional lease sale notices and stipulations.

Stipulations could include areas identified for no surface occupancy (NSO), areas subject to controlled surface use (CSU), or areas subject to timing limitations; (3) that certain parcels not be offered for lease until additional NEPA and/or planning documentation is prepared; or (4) deny the lease due to lack of conformance with the existing land use plan. This PEIS seeks to amend appropriate land use plans to facilitate the leasing process.

On NFS lands, where the BLM leases the mineral estate, the FS forwards consent determinations to BLM as to which parcels should be offered for lease. The BLM cannot lease lands over the objection of the FS. The FS makes its consent decision after conducting a leasing analysis, including NEPA. This analysis determines if an area is administratively open to leasing and if so, what if any special stipulations are required. The proposed action identifies the lands open to leasing and those that are closed by statute, regulation, or order. The FS will conduct a separate process to determine if these lands are administratively open or closed. This subsequent leasing determination will be used to amend FS land use plans, as appropriate.

All National Park System lands are closed to geothermal leasing. If a lease parcel is near a National Park, the BLM and FS, in coordination with the National Park Service, must also determine if any subsequent development would likely impact a "significant thermal feature" within a unit of the National Park System. National Parks with such significant thermal features include, but are not limited to, the following areas: Mount Rainier National Park, Crater Lake National Park, Yellowstone National Park, John D. Rockefeller, Jr. Memorial Parkway, Bering Land Bridge National Preserve, Gates of the Arctic National Park and Preserve, Katmai National Park, Aniakchak National Monument and Preserve, Wrangell-St. Elias National Park and Preserve, Lake Clark National Park and Preserve, Lassen Volcanic National Park, Lake Mead National Recreation Area, Hot Springs National Park*, Big Bend National Park (including that portion of the Rio Grande National Wild Scenic River within the boundaries of Big Bend National Park)*, Hawai'i Volcanoes National Park*, and Haleakala National Park* (10 USC Section 1026[a]).

If the Secretary of the Interior determines that exploration, development, or utilization of the lease parcel is "reasonably likely to result in a significant adverse effect on a significant thermal feature within a unit of the National Park System," then the lease would not be issued. If it is determined that use of the lease would be "reasonably likely to adversely affect" any significant thermal feature, then stipulations are included on leases and permits to protect the thermal features (10 USC Section 1026[c][d])."

1.6 AREAS WITH GEOTHERMAL POTENTIAL

In order to assess where geothermal development could occur, the BLM and FS, in partnership with the US DOE and US Geological Survey (USGS), conducted a detailed evaluation of the literature and state of the science to create a geothermal potential map of the planning area. The Notice of Intent (NOI) to prepare this PEIS (72 Fed Reg. 32679, June 13, 2007) noted that the PEIS would evaluate leasing on lands with moderate to high geothermal potential. Based on input from the public, industry, and other Federal, state, and local agencies, it was determined that the scope of the analysis needed to ensure that the geothermal potential area captures all opportunities for direct use, in addition to commercial electrical generation. It was also noted that the terms moderate and high potential were historically tied to use; however, as discussed earlier, there is a dynamic range of direct and indirect uses, and rapidly changing technology is lowering temperatures for electrical generation. Therefore, for the PEIS the geothermal potential area focuses on areas where there may be underground reservoirs of hot water or steam created by heat from the earth, or that have subsurface areas of dry hot rock. These areas are where the BLM and FS would likely receive geothermal lease nominations and applications in the near future.

1.6.1 Mapping Methods

Primary data sources for assessing geothermal potential included scientific literature; government, academic, and industry sources; and other stakeholders who identified areas of interest during the public scoping process. The BLM and FS initially reviewed geothermal potential maps from various sources and identified the assessments most commonly accepted by government agencies involved in geothermal research and development and the geothermal industry. Some of the states have conducted extensive research into geothermal potential; this information was collected and incorporated. The status of geothermal resources by state is provided in Appendix A (State of the States).

The most recent and widely accepted maps were produced in 2005 by the Idaho National Engineering and Environmental Laboratory. The laboratory produced geothermal resource maps of 13 western states for the US DOE. The maps were developed by: 1) digitizing the geothermal maps of each state that were published by the National Oceanographic and Atmospheric Administration (NOAA) and the USGS in the 1980 to 1983 timeframe, also known as the Circular 790 maps; and 2) incorporating data from other sources, some of which were state-specific. In 2007, at the request of the BLM and FS, the Idaho National Engineering and Environmental Laboratory merged the state-specific maps into a single resource potential map for the 12-state PEIS project area. The laboratory also reevaluated the maps and made adjustments as appropriate where new data had become available.

This new map was then overlain with the following data sources that were considered indicators of geothermal potential, and then the potential area was expanded as necessary to include any such missing areas.

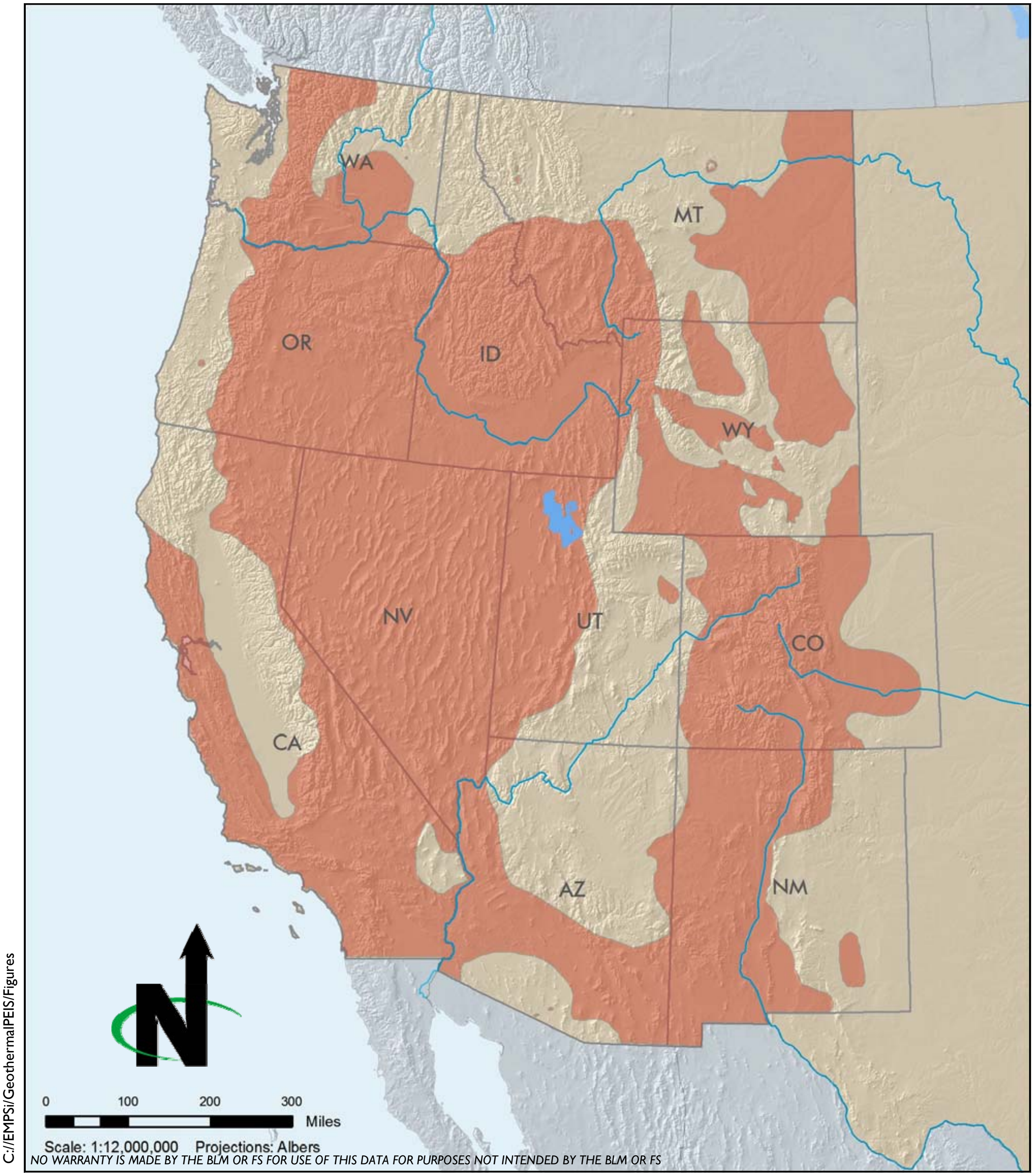
- Locations of operating geothermal facilities;
- Locations of issued leases and pending lease applications on BLM and FS lands;
- Maps provided by state agencies showing areas that they have identified as having geothermal potential, along with any other data on geology, water chemistry, and hydrogeology; and
- Areas identified during PEIS scoping comments from individuals, state agencies, and industry.

After inclusion of the above data sources, the BLM, FS, and US DOE identified further areas to be included that were known to have geothermal potential but had not appeared in any of the information sources listed above. The results were reviewed by subject experts within the BLM, FS, US DOE, USGS, and academia.

1.6.2 Western US Geothermal Potential Areas

In total, about 530 million acres in the 12 western states, including Alaska, are identified as having geothermal potential for indirect or direct applications (Figures 1-5, Areas of Geothermal Potential in the 11 Western States, and 1-6, Areas of Geothermal Potential in Alaska). The hottest resources and where commercial electrical generation would most likely occur, are generally within central and northern Nevada, western Utah, southern and central Idaho, southern and northeastern California, southeast Oregon, and along the Cascade mountain range. The reasonably foreseeable development scenario in Chapter 2 provides more specific details on the locations of where commercial electrical generation could likely occur.

Within the geothermal potential area, about 47 percent of the surface estate is administered by the BLM or FS. Approximately 143 million acres are on public lands within 103 BLM field offices and covered by over 130 BLM land use plans. There are approximately 104 million acres with geothermal potential on NFS lands within 68 National Forest units administered by 254 ranger districts. The acreage by BLM and FS administration by state is summarized in Table 1-1, BLM Public and NFS Lands Included in the Geothermal Potential Area. A detailed listing of the specific BLM Field Offices and National Forests, and their associated acres, is provided in Chapter 2.



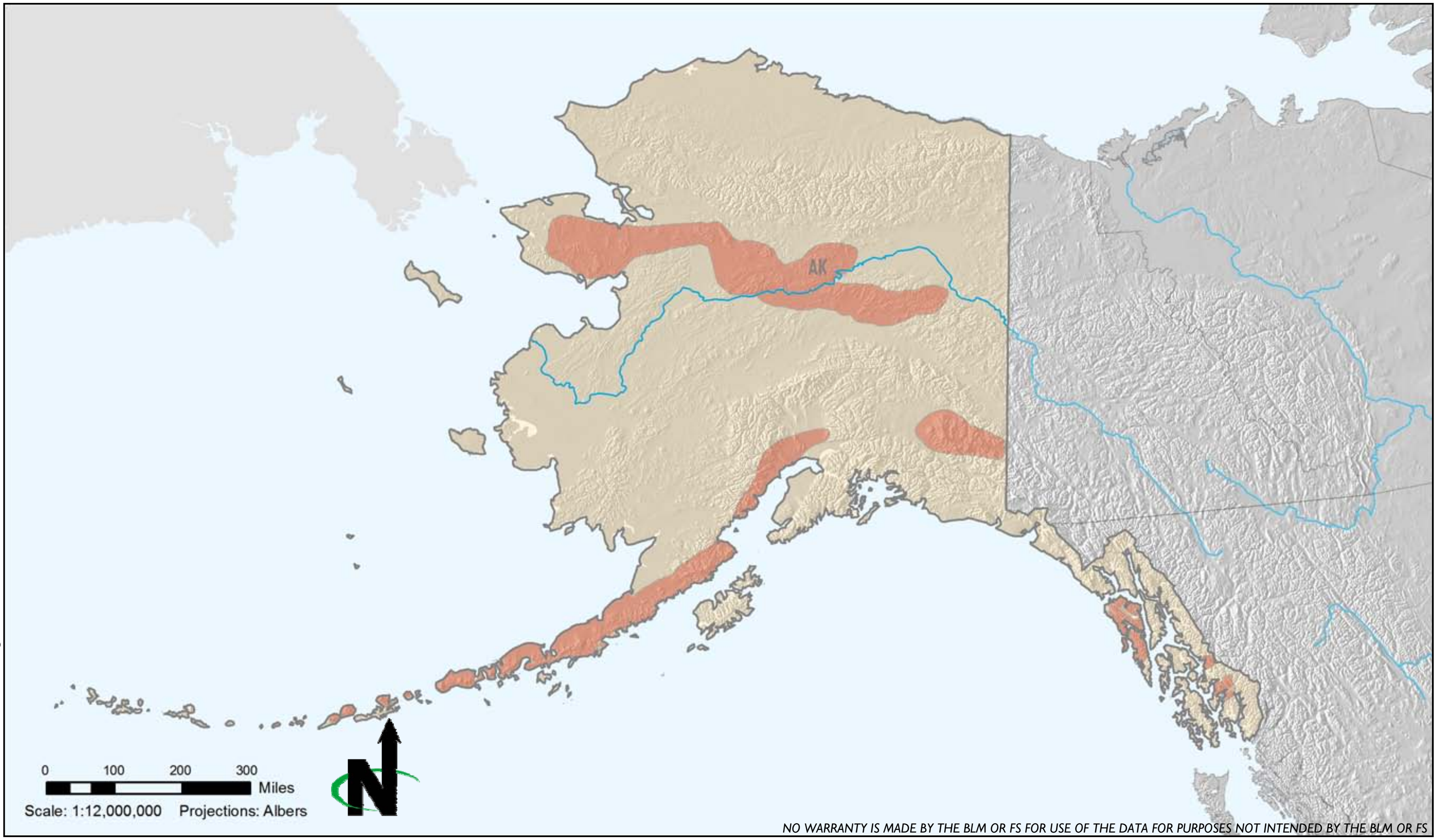
Over 480 million acres in the 11 western states have geothermal potential.

LEGEND:

Geothermal potential area

Areas of Geothermal Potential in the 11 Western States

Figure 1-5



About 50 million acres in Alaska have the potential for geothermal resources.

LEGEND:

Potential geothermal area

Areas of Geothermal Potential in Alaska

Figure 1-6

Table 1-1
BLM Public and NFS Lands Included in the Geothermal Potential Area

State	BLM Public Lands (Acres)	NFS Lands (Acres)[1]
Alaska	5,860,536	2,732,322
Arizona	8,842,090	2,166,912
California	13,969,825	13,467,992
Colorado	6,288,740	15,878,198
Idaho	12,716,814	17,767,599
Montana	3,438,730	8,370,307
Nevada	45,991,073	6,221,008
New Mexico	9,507,142	8,314,108
Oregon	14,025,425	14,746,444
Utah	10,766,598	3,056,933
Washington	--[3]	6,430,898
Wyoming	11,747,232	4,429,442
Total	143,154,205	103,582,163

Source: BLM 2008a

[1] Calculations are based on FS ranger district acreage. Acreage is assigned to the state in which the ranger district's address is located, as many ranger districts cross state lines.

[2] Does not include Native or state selected lands.

[3] Acreage calculations for Oregon and Washington are combined because states share one single BLM state-level office.

1.7 BUREAU OF LAND MANAGEMENT AND FOREST SERVICE LAND PLANNING PROCESS

The BLM administers approximately 258 million acres of public lands and 700 million acres of subsurface mineral estate in the US. This administrative responsibility must balance stewardship, conservation, and competing resource use, including the development of energy resources in an environmentally sound manner. Management of these public lands must be conducted in accordance with the requirements of the FLPMA and many other public laws. The FLPMA requires the BLM to develop land use plans, also called resource management plans (RMPs), to guide the management of the public lands it administers. An RMP typically covers public lands within a particular BLM field office. In order for geothermal leasing to occur on public lands, geothermal resource development must be allocated as an allowable use in the appropriate land use plan. If the plan does not include an allocation of some lands as open to geothermal leasing, or if the level of use (reasonably foreseeable development) for geothermal resources is absent or outdated, the land use plans for where such leasing would occur must be amended.

This PEIS is being developed to support the amendment of BLM land use plans covering those areas where leasing may eventually be proposed. An amendment is initiated when a proposal changes the scope of resource uses or a change in the terms, conditions and decisions of an approved plan (43 CFR 1610.5-5). The Record of Decision (ROD) for this PEIS could amend 123 BLM land use plans as discussed in Chapter 2. Amendments would include allocating BLM-administered lands with geothermal resource potential as closed, open, or open with major or moderate constraints to geothermal leasing. This includes establishing a projected new level of potential geothermal development with existing planning level decisions (termed reasonably foreseeable development scenario), and identifying appropriate stipulations, best management practices, and procedures to protect other resource values and uses while providing sufficient pre-leasing analysis to enable the BLM to make future competitive geothermal leasing availability decisions.

The FS administers about 192 million acres of lands in the US. The FS administrative responsibility must address stewardship of the National Forest System (NFS) to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations. Management of NFS lands must be conducted in accordance with the requirements of the National Forest Management Act of 1976 (16 USC 1600) and many other public laws. The FS administers its lands under land management plans, or forest plans, which are generally prepared for each National Forest. Forest plans provide the overall guidance (goals, objectives, standards, and management area direction) to achieve the desired future condition for the area being analyzed, and they contain specific management area prescriptions for each National Forest.

The FS uses the information in the Forest Plans in conducting leasing analysis for proposed geothermal leases. Under this analysis the FS determines if an area is administratively open for leasing and if it should be leased. If available for leasing, the analysis also evaluates if additional stipulations would be required to meet the goals and objectives of the Forest plan. This project will identify areas that are legally open to leasing; however, the FS will conduct a subsequent process to determine if these lands are administratively open. This subsequent leasing determination could be used to amend FS land use plans as appropriate. If the FS elects to amend a plan, the FS would follow its own procedures for any necessary NEPA compliance, which could include tiering to the PEIS. For pending lease applications on NFS lands included in this project (see Volume II), the FS would use this PEIS process to conduct leasing analyses and make final leasing consent decisions.

1.8 Renewable Energy Policies

1.8.1 Energy Policy Act of 2005

The EPAct of 2005 encourages the leasing and development of geothermal resources on Federal lands. Specifically, Section 225 requires that the Secretary of Interior and Secretary of Agriculture establish a program for reducing by 90 percent the backlog of geothermal lease applications that were pending as of January 1, 2005. The EPAct of 2005 mandates that action be taken by August 8, 2010. As of January 1, 2005, there were 194 applications for geothermal leases pending on BLM and FS lands (Clarke 2006).

Section 211 of the EPAct of 2005 provides a ten-year goal for the Secretary of the Interior to seek approval of non-hydropower renewable energy projects located on the public lands with a generation capacity of at least 10,000 megawatts of electricity, including electricity from geothermal resources. Section 223 gives the Secretary of the Interior authority to identify areas that could be leased exclusively for direct use of geothermal resources.

Section 222(d)(1) of the EPAct of 2005 states that, "It shall be a priority for the Secretary [and the FS] to ensure timely completion of administrative actions, including amendments to applicable forest plans and RMPs, necessary to process applications for geothermal leasing pending on the date of enactment of this subsection." This section also contains the requirement that, "All future forest plans and RMPs for areas with high geothermal resource potential shall consider geothermal leasing and development."

Section 225 requires a memorandum of understanding between the BLM and the FS (completed April 14, 2006) that will, among other tasks:

- Establish a five-year program for geothermal leasing for National Forest System lands and a process for updating that program every five years; and
- Establish a program for reducing the backlog of geothermal lease applications pending as of January 1, 2005, by 90 percent (by August 8, 2010).

The memorandum of understanding was completed on April 14, 2006 and is provided in Appendix B (*Memorandum of Understanding: Implementation of Section 225 of the Energy Policy Act of 2005 Regarding Geothermal Leasing and Permitting*).

1.8.2 Executive Order 13212

On May 18, 2001, the President signed Executive Order 13212, Actions to Expedite Energy-Related Projects, which states that, "the increased production and transmission of energy in a safe and environmentally sound manner is essential." Executive departments and agencies are directed to "take appropriate actions, to the extent consistent with applicable law, to expedite projects that will increase the production, transmission, or conservation of energy." Executive Order 13212 further states that: "For energy-related projects, agencies shall expedite their review of permits or take other actions as necessary to accelerate the completion of such projects, while maintaining safety, public health, and environmental protections. The agencies shall take such actions to the extent permitted by law and regulation and where appropriate." This PEIS addresses the leasing of geothermal resource for energy production. The BLM completed a PEIS for wind energy development on western lands in 2005, and an interagency team is preparing a PEIS for establishing corridors for energy transmission (including electrical lines and pipelines) (BLM 2005a; US DOE and BLM 2007).

1.8.3 Climate Change Policy

In 2002, the Federal government released the Global Climate Change Initiative and Policy Book that outlines a comprehensive plan to address climate change. The plan includes a goal to reduce the greenhouse gas intensity of the US economy by 18 percent over the ten-year period from 2002 to 2012 and to provide initiatives to reduce greenhouse gas emissions, including encouraging renewable energy resources development (US White House 2002). A study comparing greenhouse gas emissions from electrical generation using fossil fuels and geothermal fluids found that geothermal produces an order of magnitude less in carbon dioxide, hydrogen sulfide, methane, and ammonia. Table 1-2, Comparison of Geothermal and Fossil Fuel Carbon Dioxide Emissions for Electrical Generation, highlights the difference in emissions of carbon dioxide from these different energy sources. Direct use of geothermal resources, such as using geothermal to heat buildings, has the potential to displace 18 million barrels of oil per year (Western Governors' Association 2006). Increased geothermal energy utilization could help the US reduce greenhouse gas emissions and meet policy goals (Bloomfield *et al.* 2003).

Table 1-2
Comparison of Geothermal and Fossil Fuel Carbon Dioxide Emissions for Electrical Generation

	Geothermal	Coal	Petroleum	Natural Gas
Emissions (pounds carbon dioxide per kilowatt-hour)	0.20	2.095	1.969	1.321

Source: Bloomfield *et al.* 2003

On the state level, many states have passed renewable portfolio standards, which require electric utility providers to obtain a minimum percentage of their energy from renewable generation sources (including geothermal, wind, solar, hydroelectric, and other renewables such as biomass and tidal). Geothermal development has the potential to make significant contributions to meeting renewable portfolio standards, especially given that it provides reliable and consistent base power, unlike solar or wind. A summary of states that have legislative renewable portfolio standards is provided in Table 1-3, State Renewable Portfolio Standards (as of April 2008).

In 2005, the Western Governors' Association established the Clean and Diversified Energy Initiative, which included forming the Geothermal Task Force. The Task Force issued a detailed report on geothermal potential and constraints and a strategy for improving geothermal development. A key recommendation of the report was a call for initiatives to facilitate the timely leasing and permitting of geothermal resources (Western Governors' Association 2006).

What is a renewable portfolio standard?

The renewable portfolio standard is a legal requirement that obligates each retail seller of electricity to include in its resource portfolio (the resources procured by the retail seller to supply its retail customers) a certain amount of electricity from renewable energy resources, such as wind, solar and geothermal energy. The retailer can satisfy this obligation by either:

(1) Owning a renewable energy facility and producing its own power; or

(2) Purchasing renewable electricity from someone else's facility.

Renewable portfolio standard policies are implemented at the state level and vary considerably in their requirements with respect to their time frame, resource eligibility, treatment of existing plants, arrangements for enforcement and penalties, and whether they allow trading of renewable energy credits.

Using a renewable portfolio standard has recently become one of the most popular ways to encourage greater use of renewable energy. A renewable portfolio standard is an efficient method of meeting policy targets for greater use of renewable energy, and can be implemented in both regulated and restructured markets.

Source: US Department of Energy 2007

Table 1-3
Western States Renewable Portfolio Standards (as of April 2008)

State	Amount[1]	Year[2]	Organization Administering Renewable Portfolio Standards
Arizona	15%	2025	Arizona Corporation Commission
California	20%	2010	California Energy Commission
Colorado	20%	2020	Colorado Public Utilities Commission
Montana	15%	2015	Montana Public Service Commission
New Mexico	20%	2020	New Mexico Public Regulation Commission
Nevada	20%	2015	Public Utilities Commission of Nevada
Oregon	25%	2025	Oregon Energy Office
Washington	15%	2020	Washington Secretary of State

[1] Percentages refer to a portion of electricity sales and megawatts to absolute capacity requirements.
[2] Most of these standards phase in over years, and the date refers to when the full requirement takes effect.
Source: US DOE 2007c

1.9 Scope of Analysis

As previously stated, Section 225 of the EPAct of 2005 requires that the US DOI and USDA Forest Service reduce the backlog of geothermal lease applications pending as of January 1, 2005, by 90 percent (by August 8, 2010). Section 222(d) dictates that it be a priority for the BLM and the FS to ensure timely completion of actions such as amendments to FS plans and RMPs necessary to process lease applications pending on August 8, 2005, and that all future forest plans and RMPs in areas of geothermal resource potential consider geothermal leasing and development. To respond to these directives and the stated need for action, the PEIS incorporates two different scopes for analysis. The first scope covers the programmatic analysis to allocate lands as available for leasing and development of geothermal resources and apply stipulations. The second scope covers the site-specific analysis of the backlogged lease application areas.

1.9.1 Programmatic Scope

> ***Project Area:*** The 12 western states, including Alaska.
>
> ***Planning Area:*** Lands with geothermal potential in the 12 western states.

For the programmatic analysis, the "project area" is defined as the western US (Alaska, Arizona, California, Colorado, Idaho, Nevada, New Mexico, Montana, Oregon, Utah, Washington, and Wyoming). The "planning area" for which planning level decisions would be made, is the defined area of geothermal potential (see Section 1.6.2 Western US Potential Areas). The planning area includes BLM- and FS-administered surface lands with minerals under Federal ownership that have geothermal potential and the subsurface Federal geothermal mineral estate on other lands. Surface lands administered by other Federal agencies, such as the National Park Service and US DOI, Fish and Wildlife Service (USFWS), and state agencies are not assessed in this document unless their administrative boundaries overlap with public or NFS lands. If these lands have subsurface Federal geothermal mineral estate, the BLM would apply the management direction provided in this PEIS, with the surface management agency's consent, for lease nominations or applications.

Lands that are not administered by the BLM or FS, or that are closed to geothermal leasing by statue, are not part of the analysis. These include lands contained within a unit of the National Park System, or that are otherwise administered by the National Park Service; fish hatcheries or wildlife management areas administered by the Secretary; State fish and wildlife refuges and state parks; and Indian trust or restricted lands within or outside the boundaries of Indian reservations (43 CFR 3201.11).

This PEIS is a programmatic document that analyzes the broad impacts associated with allocation of geothermal resources for leasing along with the adoption of stipulations and best management practices. As such, it meets the intent of the implementing regulations for the NEPA, which state, "Agencies shall prepare statements on broad actions so that they are relevant to policy and are timed to coincide with meaningful points in the agency planning and decisionmaking" (40 CFR 1502.4). The PEIS does not evaluate site-specific issues associated with geothermal exploration, drilling, utilization, or reclamation and abandonment. A variety of location-specific factors (e.g., soil type, watershed, habitat, vegetation, viewshed, public sentiment, the presence of threatened and endangered species, and the presence of cultural resources) varies considerably from site to site, especially over the 12-state project area. The PEIS analyzes a reasonably foreseeable development scenario to assess the likely impacts from development following leasing in the planning area. The PEIS will provide the necessary information to support the amendment of land use plans covering those lands where leasing may eventually be proposed (see Section 1.7 – BLM and FS Land Planning Process). The PEIS also provides analysis to allow the FS to more efficiently provide subsequent consent decisions for leasing actions on NFS lands.

Site-specific impacts for subsequent geothermal exploration, drilling, utilization, or reclamation and abandonment would be assessed during the permitting process and in separate NEPA documents prepared by local BLM and FS offices. Such analysis could tier to this document in accordance with NEPA implementation regulations (40 CFR 1502.20).

1.9.2 Scope of Environmental Analysis of Pending Lease Applications

In addition to the programmatic analysis, this PEIS also provides site-specific analysis to inform leasing decisions to be made on 19 pending lease applications located in seven geographical clusters on public and NFS lands. This supplemental analysis is provided in Volume II and is delineated by individual chapters for each geographical cluster. The project and planning areas are specific to the analysis region and are defined in their respective chapters. The analysis focuses on relevant issues and resource concerns in those planning area.

If resources are not expected to be impacted, they are not included in the analysis. The leasing analysis tiers to the programmatic analysis, as appropriate.

1.9.3 Scope of Geographic Information System Data and Graphics

Data from geographic information systems (GIS) have been used in developing acreage calculations and for generating many of the figures. Calculations in the PEIS are rounded and dependent upon the quality and availability of data. Data was collected from a variety of sources including the BLM and FS, and other planning efforts. Given the scale of the programmatic analysis, the compatibility constraints between datasets, and lack of data for some resources, all calculations are approximate and serve for comparison and analytic purposes only. Likewise, the figures are provided for illustrative purposes and subject to the limitations discussed above. Detailed information is available from local BLM and FS offices. Since the publication of the Draft PEIS, additional GIS data were received, including updated land administrative boundaries and the digitizing of the Island Park Geothermal Area. The acres in the Final PEIS have been recalculated and revised accordingly.

1.10 Planning Criteria

In accordance with BLM planning regulations (43 CFR 1610.4-2), planning criteria were developed to help guide data collection, alternative formulation, and impact analysis. Criteria are generally based on laws, regulations, and agency guidance and serve as side-boards to keep the planning process focused.

1. The PEIS will be completed in compliance with the Federal Land Policy and Management Act, the Endangered Species Act, the Clean Water Act, the Clean Air Act, the National Environmental Policy Act and all other applicable laws, Executive Orders and management policies of the BLM.
2. The PEIS will provide the analytical basis for decisions to amend the appropriate individual land use plans as necessary to respond to the potential for increased levels of leasing and development of geothermal resources on BLM-administered lands. Lands open, closed, and open with restrictive stipulations to geothermal leasing will be identified in the affected plans.
3. The PEIS will be limited to addressing leasing and development of geothermal resources, and will not address management of other resources, although the BLM will consider and analyze the impacts on other managed resource values of this increased use. Management of other resources in the planning areas affected will continue to be governed by the applicable RMPs.
4. The RMPs, as amended, will recognize valid existing rights.

5. BLM will coordinate with local, State, Tribal and Federal agencies in the PEIS to strive for consistency with their existing plans and policies, to the extent practicable.
6. BLM will coordinate with Tribal governments and will provide strategies for the protection of recognized traditional uses in the PEIS process.
7. BLM will take into account appropriate protection and management of cultural and historic resources in the PEIS process, and will engage in all required consultation.
8. BLM will recognize in the PEIS the specific niche occupied by public lands in the life of the communities that surround them and in the nation as a whole.
9. BLM will make every effort to encourage public participation throughout the process.
10. BLM has the authority to address lands with wilderness characteristics and describe protective management prescriptions in RMPs. In keeping with the public involvement process that is part of all land use planning efforts, the BLM will consider public input regarding lands to be managed to maintain wilderness characteristics.
11. Environmental protection and energy production are both desirable and necessary objectives of sound land management practices and are not to be considered mutually exclusive priorities.
12. The PEIS will consider and analyze climate change impacts in its land use plans and associated NEPA documents, including the anticipated climate change benefits of geothermal energy.
13. The PEIS will comply with the Geothermal Steam Act, as amended, and the legislative directives set forth in the Energy Policy Act of 2005.
14. Geospatial data will be automated within a GIS to facilitate discussions of the affected environment, formulation of alternatives, analysis of environmental consequences, and display of results.

1.11 Decisions to Be Made

As discussed above, the PEIS contains two distinct scopes, one for the programmatic analysis and one for the pending lease applications. Separate decisions will be made for each scope.

1.11.1 Decisions on the Programmatic Analysis

No sooner than 30 days after the US Environmental Protection Agency (EPA) publishes the Notice of Availability of the Final EIS, the BLM and FS will issue a Record of Decision on the findings of the programmatic analysis. The Record of Decision will include:

- An explanation of the decision, including a discussion of the factors that influenced the decision;
- A summary of the alternatives considered;
- Identification of the environmentally preferable alternative;
- A list of BLM RMPs that would be amended by the action; and
- Documentation of stipulations, best management practices, and procedures that would be adopted for leasing actions or imposed at the development stage.

BLM Decisions Resulting from this PEIS

The signing of the Record of Decision would amend all affected BLM land use plans as discussed in Section 1.7 – BLM and FS Land Planning Process. Amendments would include allocating BLM-administered lands with geothermal resource potential as closed, open, or open with major or moderate constraints to geothermal leasing. This includes establishing a projected new level of potential geothermal development with existing planning level decisions (termed reasonably foreseeable development scenario), and identifying appropriate stipulations, best management practices, and procedures to protect other resource values and uses while providing sufficient pre-leasing analysis to enable the BLM to make future competitive geothermal leasing availability decisions.

Once the plans are amended, the BLM can make decisions whether or not to issue geothermal leases in conformance with the amended land use plan on the basis of this PEIS. Following this amendment process, it is the intent of the BLM that, upon receipt of future nominations or applications for direct use, affected BLM offices would be able to conduct a DNA evaluation to make lease sale decisions without further plan amendments or NEPA analysis, unless special circumstances require additional environmental evaluation. The BLM and FS would conduct other environmental reviews to comply with other laws, including but not limited to the Endangered Species Act and National Historic Preservation Act, prior to issuing leases (see Section 2.2.2 Lease Stipulations, Best Management Practices, and Procedures).

FS Decisions Resulting from this PEIS

For the FS, this PEIS would identify those lands that are legally open or closed to consideration for geothermal leasing on affected NFS lands, along with any terms and conditions. The FS would be able to tier from the PEIS to facilitate future leasing analysis and any allocation or stipulation decisions. For any leasing on NFS lands beyond the specific pending lease applications discussed in Volume II, the FS would still need to provide consent. Prior to providing consent to the BLM the FS generally must identify specific lands that are administratively available for leasing of geothermal resources and under what conditions. In order to make the administrative availability decision the FS generally must prepare an additional NEPA document (leasing analysis). The FS is not proposing to amend any land use plans as part of the proposed action.

Implementation of the proposed action would minimize the delays that currently occur for geothermal leasing, ensure consistency in the leasing process, provide a programmatic basis for future lease-specific consent decisions to leasing on NFS lands, reduce costs, and provide opportunities to tier future site-specific NEPA analyses from the Final PEIS.

BLM Decisions to be Made Following Subsequent NEPA Analysis

Although the BLM expects to be able to rely upon this analysis, combined with DNA evaluations to document NEPA adequacy, to make lease issuance decisions in the near term, the issuance of a lease does not give the lessee the right to proceed with exploration or development (i.e., any surface disturbing activities beyond casual use) in the absence of further site-specific permits with associated environmental analysis. This document does predict a general level of anticipated future geothermal development in BLM areas that have geothermal potential, but it is not intended to provide full analysis of all phases of development. There are several stages of decision making necessary to approve geothermal resource development, each with its own environmental compliance requirements, and this document covers only the land use planning and lease issuance stages.

Forest Service Decisions to be Made Following Subsequent NEPA Analysis

This programmatic analysis does not identify lands for which the FS would or would not consent to the issuance of geothermal leases, with the exception of the pending lease application areas discussed in Volume II. It also does not amend NFS land use plans as may be necessary when the FS decides to consent to the issuance of a geothermal lease for a particular area of land. This PEIS does provide enough analysis to predict likely areas where major and minor stipulations or protective constraints on surface use would be needed, which would facilitate the subsequent NEPA process that would be necessary to provide future leasing consent decisions. Approval of permits allowing any surface disturbing activity generally would be issued following additional site-specific analysis completed after issuance of a geothermal lease.

1.11.2 Decisions on Pending Lease Applications

The BLM and FS will issue separate decisions for each of the seven areas associated with the pending lease applications. This will require execution of Records of Decision separate from the programmatic action. The decision maker for the pending application areas will be the field office manager or forest supervisor, so it is likely that multiple Records of Decision could be signed (e.g., one decision for each of the seven geographical clusters with leasing applications). The decisions may be issued all at once or may be independently released as issues are addressed and other compliance actions are completed (e.g., tribal consultation).

These decision documents are each supported by a narrower and more specific scope of analysis than that which can be provided at the programmatic level for the broader areas of geothermal potential. This analysis is intended to be sufficient to allow BLM and FS managers to determine areas legally and administratively open or closed, and any necessary stipulations or other terms and conditions to protect other resource values that should be attached to leases in the event that the decisions do allow leases to be issued for the pending applications.

The analysis for these seven pending application areas will provide FS leasing analysis, and provide the basis for FS consent decisions related to each individual application covered in this PEIS. The BLM will be able to decide whether or not to issue leases for each of the pending applications, on both NFS and BLM lands, following this PEIS and the associated Record(s) of Decision.

1.11.3 Future Stages of Decision Making and NEPA Analysis for Pending Lease Application Areas

As stated above, the issuance of a lease on pending applications (on either FS or BLM administered lands) does not give the lessee the right to proceed with exploration or development in the absence of further site-specific permits with associated environmental analysis. This document does predict a general level of anticipated future geothermal development in areas that have geothermal potential, but it is not intended to provide full analysis of all phases of development. There are several stages of decision making necessary to approve geothermal resource development, each with its own environmental compliance requirements, and this document covers only the land use planning and lease issuance stages.

1.12 PUBLIC INVOLVEMENT

1.12.1 Scoping Process and Public Review of the Draft PEIS

The NEPA requires an early and open process for determining issues that should be addressed and analyzed in the PEIS to help decision makers implement the proposed action or an alternative. To formally solicit public input, the public scoping period began with the publication of the NOI in the *Federal Register* on June 13, 2007, and continued through August 13, 2007. A project website was launched prior to the beginning of the scoping period and was maintained and expanded throughout scoping. Soon after the scoping period began, project newsletters were mailed to the project mailing list of approximately 1,600 individuals. Public scoping meetings, hosted by the BLM and FS, were held throughout July 2007 in ten cities across the western US, including Alaska. These meetings provided opportunities for the public, local government, tribes, utilities, and other interest groups to learn about the PEIS, to provide input into the development of the PEIS, and to voice their concerns related to potential environmental impacts that should be addressed in the PEIS. Approximately 174 individuals attended the scoping meetings.

The comments received and evaluated during the scoping period were considered in formulating the alternatives and conducting initial impact evaluations. One hundred and one (101) verbal comments were cataloged. Also, 79 written comment submittals were received as comment cards and letters (received by US Mail), email, and facsimile. Public comments received during the scoping period were related to the NEPA process, purpose and need, alternatives, impact analysis, and project coordination. Some comments addressed issues pertinent to geothermal development but were outside the scope of the PEIS. Table 1-4, Summary of the PEIS Public Scoping Comments, summarizes the general themes from the public comments.

Issue identification was used in the PEIS process to develop alternatives and to focus the analysis. A planning issue is a concern regarding management of resources or uses on the public lands that can be addressed in a variety of ways. Based on the analysis of public scoping comments, three planning issues were identified: (1) How will the values and unique resources within special management areas be protected? (2) What actions or restrictions will be needed to avoid or minimize impacts natural resources and to wildlife and their habitat, including sagebrush-obligate species and old growth forest species? (3) How will geothermal leasing and any subsequent development protect and conserve cultural resources?

On June 20, 2008 the Notice of Availability of the Draft PEIS was published in the *Federal Register*. The NOA initiated the 90-day public comment period. The BLM and FS conducted 13 public meetings during July 2008 in the 12 western states to solicit comments. Over 70 organizations, government agencies, industry representatives, and individuals provided unique letters during the comment period. Most of the written submissions contained multiple comments on different topics, and over 500 unique comments were made. In addition, two form letters were submitted. Chapter 6 provides a detailed review of the public comments on the Draft PEIS.

1.12.2 Consultation and Coordination with Tribes

The BLM and FS are consulting with federally recognized Native American Indian Tribes in accordance with Section 106 of the National Historic Preservation Act and Executive Order 13175, Consultation and Coordination with Indian Tribal Governments. Letters were mailed in September 2007 to each tribal executive official of over 400 tribes and pueblos in the western US and Alaska from the Deputy Director of the BLM and Deputy Chief of the Forest Service (see Chapter 6 for the distribution list). The letters documented the PEIS process and detailed the pending lease applications that are being assessed in the PEIS, and invited them to participate in the consultation process. Seven tribes provided a response letter. One letter noted that no lease applications were in their area of interest, four letters requested consultation if any lease applications would fall in their areas of interest, and two letters requested consultation and to help participate in the PEIS process. The consultation process will be ongoing throughout the project.

Table 1-4
Summary of the PEIS Public Scoping Comments

Comments Related to the NEPA Process	
	The BLM and FS should ensure the PEIS conforms to all requirements of NEPA.
	The PEIS should adequately address the cumulative impacts of proposed and future geothermal projects, as well as the need for associated infrastructure.
	The PEIS should be used as tiering document for subsequent, area-specific and site-specific development.
Comments on the Purpose and Need	
	The PEIS should address how the project will satisfy the requirements of policy and regulations such as the Energy Policy Act of 2005.
	The PEIS should clarify the geographic scope of the project, including the process used to designate potential lease areas and areas that will be excluded from leasing analysis.
	The PEIS should clearly define the extent to which the PEIS will cover tribal lands.
	How will the PEIS address individual backlogged leases?
	How will the PEIS define and address future technologies?
	Some comments identified specific areas as potential lease areas or areas that should be excluded.
Comments on Alternatives	
	Alternatives should include the exclusion of sensitive areas, such as special designated lands, including Areas of Critical Environmental Concern, wilderness, and wild and scenic rivers.
	Lands surrounding Yellowstone National Park should be excluded.
	Leasing should only be allowed near existing infrastructure and transmission lines.
Comments on Impact Analysis	
	The PEIS should analyze all potential impacts related to geothermal exploration and development. The most common concerns were effects to wildlife, wildlife habitat, groundwater, and aesthetics.
Comments on Coordination and Consultation	
	Appropriate Federal and state agencies should be included in and consulted throughout the geothermal PEIS process.
	Tribal governments should be involved throughout the process.
	How will the PEIS identify areas of high potential without divulging valuable proprietary information of potential developers who have already identified resources within the areas?
	The scoping period should be extended and additional scoping meeting locations should be added to allow full scoping opportunities.
Comments Outside the Scope of the PEIS	
	The PEIS should be a joint NEPA/California Environmental Quality Act document and should identify the California Environmental Quality Act lead agency.
	The PEIS should assess impacts from development on tribal lands.
	The PEIS should include provisions that detail the necessary enforcement to ensure that reclamation is effectively completed after exploration activities. Agencies should also be obligated to research and disclose the environmental and legal track record of potential geothermal leaseholders.

1.13 Relationship to Bureau of Land Management and Forest Service Policies, Plans, and Programs

The leasing of geothermal resources is subject to a number of Federal, state, and local laws, regulations, and plans. The following section summarizes the most pertinent Federal and state policies, plans, and laws that affect this PEIS.

1.13.1 Federal Land Policy and Management Act of 1976

The FLPMA mandates that multiple use and sustained yield principles govern the management of public lands. The concept of multiple use directs the BLM to manage public lands to best meet the present and future needs of the American people. The FLPMA (Section 103) defines multiple use as "a combination of balanced and diverse resource uses that takes into account the long-term needs of future generations for renewable and nonrenewable resources," and sustained yield as "the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the public lands consistent with multiple use."

As a result of this PEIS, the BLM will amend land use plans to adopt allocations, stipulations, and best management practices to allow for geothermal leasing.

1.13.2 National Forest Management Act of 1976

The National Forest Management Act (NFMA) is the primary statute governing the administration of national forests. The Act expanded and otherwise amended the Forest and Rangeland Renewable Resources Planning Act of 1974, which called for the management of renewable resources on national forest lands. The National Forest Management Act requires the Secretary of Agriculture to assess forest lands, develop a management program based on multiple-use, sustained-yield principles, and implement a resource management plan for each unit of the National Forest System. In doing so, the Secretary must: use an interdisciplinary approach; coordinate with state and local resource management efforts; provide for public participation; and provide for multiple-use and sustained-yield of products and services. The Secretary must revise the management plans whenever significant changes occur in a unit. Each National Forest will use information in the PEIS to determine if its specific resource plan needs to be amended to incorporate geothermal leasing.

1.13.3 National Environmental Policy Act

The NEPA supports a national policy that requires Federal agencies to review the effects of their actions on the quality of the human environment. The review process ensures that the environmental impacts of any Federal or federally funded action is available to public officials and citizens before decisions are made and before actions are taken.

1.13.4 Clean Air Act

The Clean Air Act was passed to regulate air pollution and improve air quality. It regulates air emissions from area, stationary, and mobile sources. This law also authorizes the US EPA to establish National Ambient Air Quality Standards to protect public health and the environment.

1.13.5 Clean Water Act

The Clean Water Act established the basic structure for regulating discharges of pollutants into waters of the US. Also included are requirements to set water quality standards for all contaminants in surface waters. The Clean Water Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit was obtained under its provision.

1.13.6 Mining and Mineral Policy Act of 1970

Section 2 of the Mining and Mineral Policy Act of 1970 encourages the development of mineral resources, including geothermal resources, on Federal lands.

1.13.7 Geothermal Steam Act of 1970

The Geothermal Steam Act of 1970, as amended, governs the leasing of geothermal steam and related resources on Federal lands. This Act authorizes the Secretary of the Interior to issue leases for development of geothermal resources and also prohibits leasing on a variety of public lands, such as those administered by USFWS.

1.13.8 Energy Policy Act of 2005

The EPAct of 2005 was intended to establish a comprehensive, long-range domestic energy policy. It provides incentives for traditional energy production as well as newer, more-efficient energy technologies and conservation. It contains several provisions related to geothermal energy to make it more competitive with traditional methods of energy production.

1.13.9 Endangered Species Act

The Endangered Species Act provides for the Federal protection of threatened plants, insects, fish, and wildlife. The USFWS and the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries) administer the Endangered Species Act on behalf of the US. The major components of the Endangered Species Act include:

- Provisions for the listing of threatened and endangered species;
- The requirement for consultation with USFWS and NOAA Fisheries on Federal projects, under certain circumstances;
- Prohibitions against the taking of listed species; and
- Provisions for permits to allow the incidental taking of listed species.

1.13.10 The Migratory Bird Treaty Act of 1918, as Amended

The Migratory Bird Treaty Act makes it unlawful to pursue, hunt, kill, capture, possess, buy, sell, purchase, or barter any migratory bird, including the feathers or other parts, nests, eggs, or migratory bird products. Executive Order 13186, signed January 10, 2001, sets forth the responsibilities of Federal agencies to further implement the provisions of the Migratory Bird Treaty Act by integrating bird conservation principles and practices into agency activities by ensuring that Federal actions evaluate the effects of actions and agency plans on migratory birds.

1.13.11 The Wild Free-Roaming Horse and Burro Act of 1971, as Amended by the Public Rangelands Improvement Act of 1978

This Act provides for the management, protection, and control of wild horses and burros on public lands and authorizes the adoption of wild horses and burros by private individuals.

1.13.12 The Fish and Wildlife Conservation Act of 1980

The Fish and Wildlife Conservation Act of 1980 encourages Federal agencies to conserve and promote the conservation of nongame fish and wildlife species and their habitats.

1.13.13 The Taylor Grazing Act of 1934

The Taylor Grazing Act of 1934 introduced Federal protection and management of public lands by regulating grazing on public lands.

1.13.14 The Public Rangelands Improvement Act of 1978

The Public Rangelands Improvement Act of 1978 requires the BLM to manage, maintain, and improve the condition of the public rangelands so that they become as productive as feasible.

1.13.15 National Historic Preservation Act of 1966, as Amended

The National Historic Preservation Act of 1966 provides for the establishment of the National Register of Historic Places (NRHP) to include historic properties such as districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology, and culture. Section 106 of the Act requires Federal agencies with jurisdiction over a proposed Federal project to take into account the effect of the undertaking on cultural resources listed or eligible for listing on the NRHP, and afford the State Historic Preservation Offices and the Advisory Council on Historic Preservation an opportunity to comment regarding the undertaking. The NRHP eligibility criteria have been defined by the Secretary of the Interior's Standards for Evaluation (36 CFR 60).

1.13.16 Alaska National Interest Lands Conservation Act

The Alaska National Interest Lands Conservation Act (ANILCA) was passed in 1980 designating 104 million acres for conservation by establishing or expanding national parks, wildlife refuges, wild and scenic rivers, wilderness areas, forest monuments, conservation areas, recreation areas, and wilderness study areas to preserve them for future generations. Section 810(a) of the ANILCA requires that an evaluation of subsistence uses and needs be completed for any Federal determination to "withdraw, reserve, lease, or otherwise permit the use, occupancy, or disposition of public lands."

1.13.17 Alaska Native Claims Settlement Act

The Alaska Native Claims Settlement Act (ANCSA) was passed by Congress in 1971 to settle aboriginal land claims in Alaska. Under the settlement the Natives received title to a total of over 44 million acres, to be divided among some 220 Native Villages and 12 Regional Corporations established by the act.

1.14 OTHER PLANS AND PROGRAMS

The following plans and programs also apply to geothermal leasing.

1.14.1 State Renewable Portfolio Standard Program

Renewable portfolio standards are state laws requiring electric utility providers to obtain a minimum percentage of their energy from renewable generation sources. These renewable resources include geothermal, wind, solar, hydroelectric, and other renewables such as biomass and tidal. Eight of the twelve states considered in this PEIS have renewable portfolio standard policies in place (Table 1-3, State Renewable Portfolio Standards). Alaska, Idaho, Utah, and Wyoming do not have renewable portfolio standards in place.

1.14.2 State Greenhouse Gas Reductions Laws

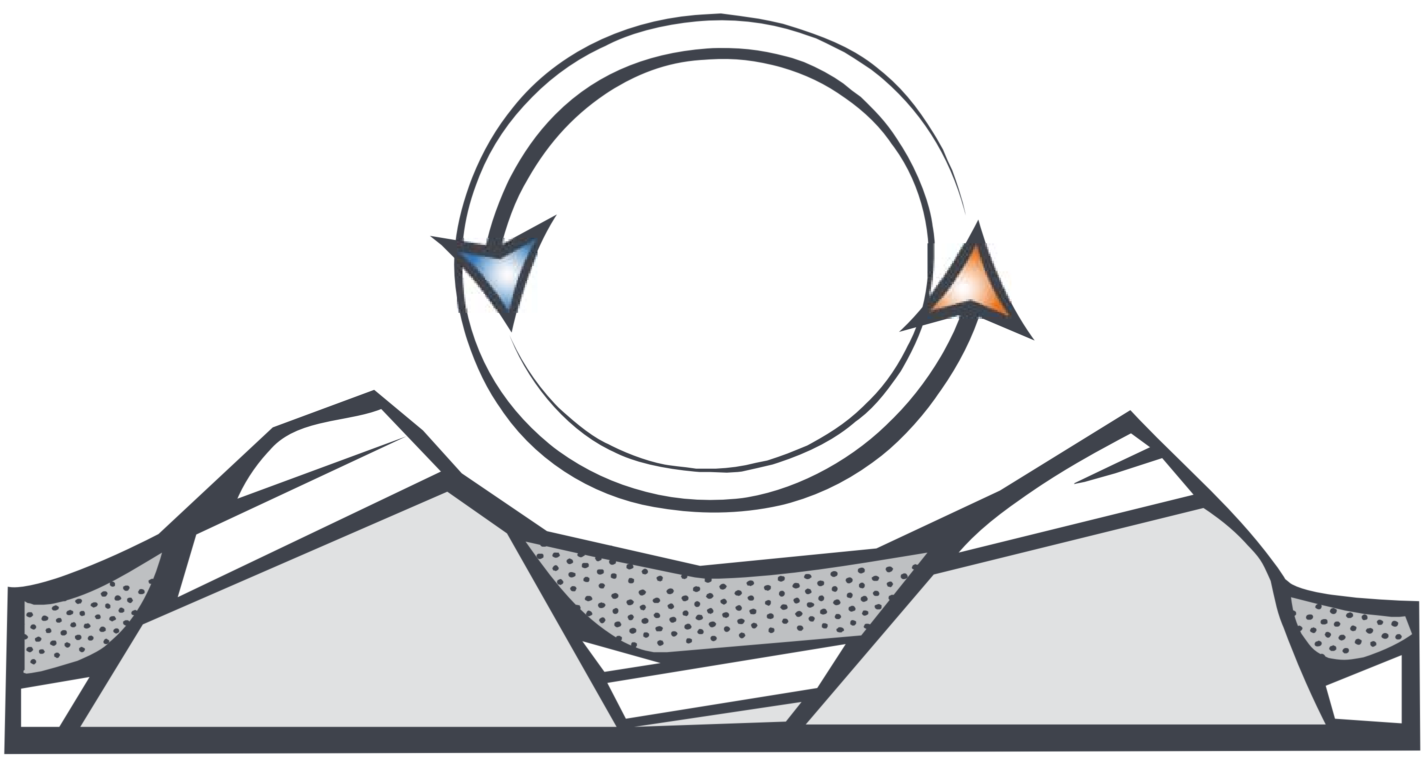
Greenhouse gas reduction laws have been passed in several states in response to the potential threat of climate change. The laws set greenhouse gas reduction goals at future milestones and work in conjunction with state renewable portfolio standards. Greenhouse gas reduction laws work indirectly as an incentive in renewable energy development.

1.14.3 West-wide Energy Corridor Programmatic Environmental Impact Statement

The US DOE, BLM, FS, and US Department of Defense are preparing a PEIS to evaluate issues associated with the designation of energy corridors on Federal lands in 11 western states (US DOE and BLM 2007). Based on the information and analyses developed in this PEIS, each agency would amend its respective land use plans by designating a series of energy corridors. The proposed transmission corridors could provide transmission services to potential geothermal power plants located on public lands addressed for leasing in this PEIS.

1.15 READERS GUIDE TO THE PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

The Programmatic EIS is divided into three volumes. Volume I provides the programmatic environmental impact statement, Volume II provides the supplemental environmental analysis for the pending geothermal lease applications, and Volume III includes the appendices.



Chapter 2

Proposed Action and Alternatives

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CHAPTER 2
PROPOSED ACTION AND ALTERNATIVES

2.1 INTRODUCTION

This chapter provides the details of the proposed action, alternatives to the proposed action, a discussion of alternatives considered but eliminated from detailed analysis, and an overview of the reasonably foreseeable development (RFD) scenario for geothermal resources in the western US.

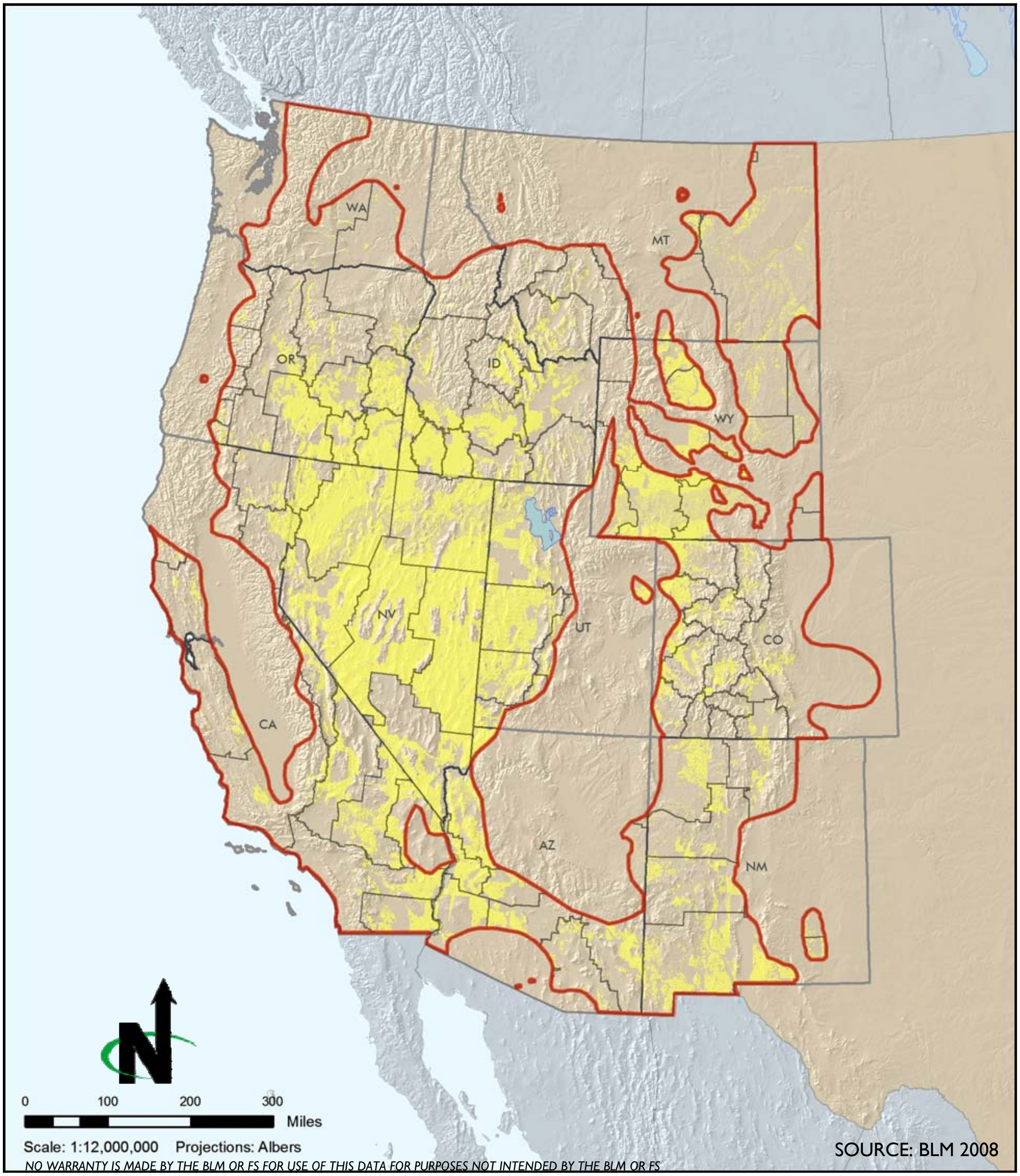
2.2 PROPOSED ACTION

The BLM and FS are proposing to facilitate geothermal leasing on BLM administered public lands and NFS lands that have geothermal potential in the twelve western states, including Alaska. This would be accomplished by the following four specific actions:

- Identify public and NFS lands with geothermal potential as being open or closed to leasing;
- Provide a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing and development;
- Amend BLM Resource Management Plans (RMPs) to adopt the RFDs, resource allocations and list of stipulations, best management practices, and procedures; and
- Make decisions to issue or deny geothermal lease applications on BLM and NFS lands pending as of January 1, 2005.

2.2.1 Identify Lands for Leasing

Under this proposed action, all lands in the 12 western states with geothermal potential and administered by the BLM and FS would be identified as being open to geothermal leasing with possible moderate to major constraints or closed to leasing. In the Record of Decision the BLM would amend the appropriate RMPs for these allocations. Figures 2-1 and 2-2 show the BLM Field Office boundaries within the geothermal potential area and Figures 2-3 and 2-4 show National Forests.



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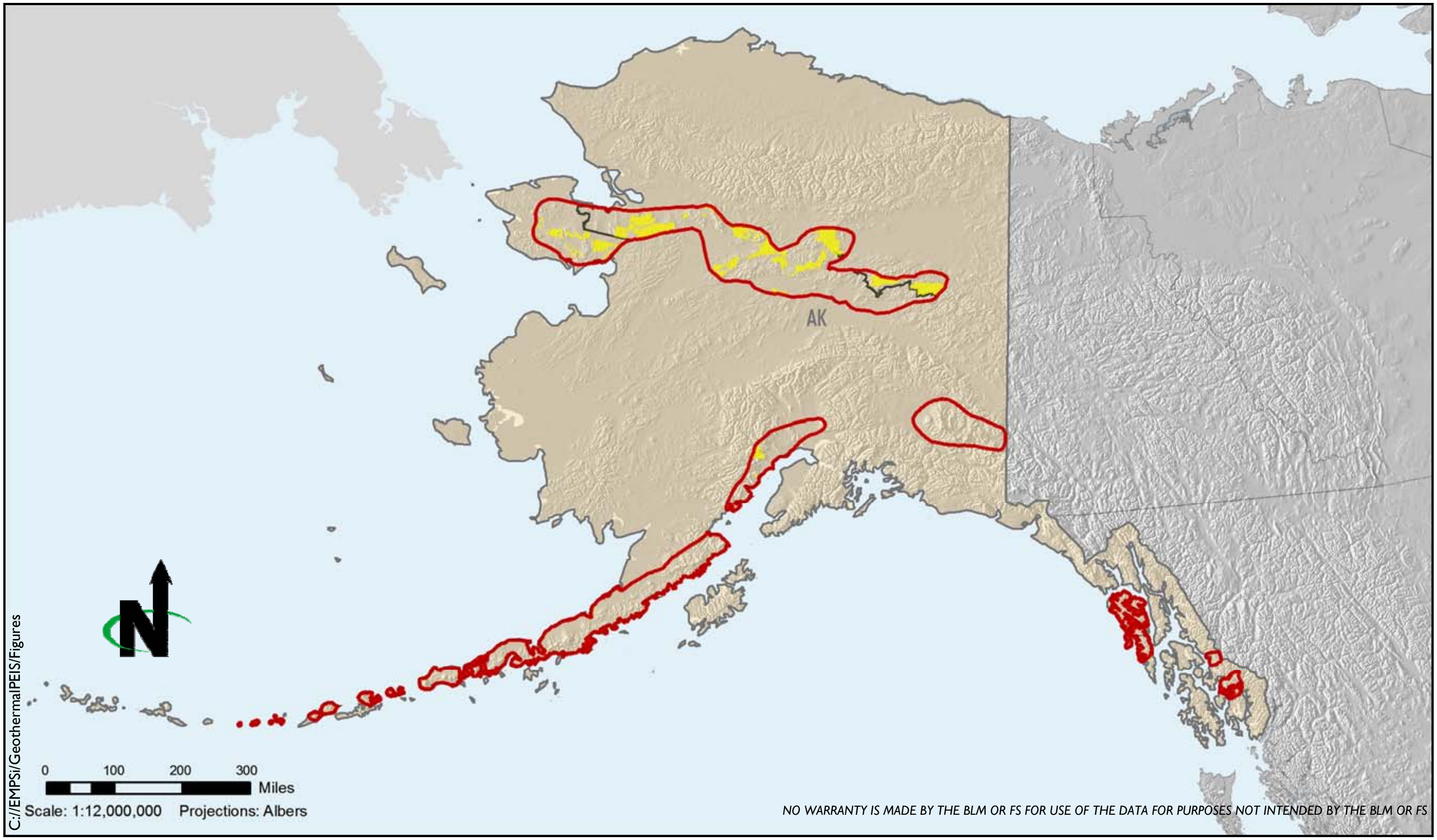
About 137 million acres of public land are within the geothermal potential area in the 11 western states and are administered by 97 field offices.

LEGEND:

- Potential Geothermal Area
- BLM Field Office Boundary
- BLM Public Land

BLM Field Office Boundaries within the Planning Area of the 11 Western States

Figure 2-1



Almost six million acres of public land in Alaska have geothermal potential.

LEGEND:

Potential Geothermal Area

BLM Field Office Boundary

BLM Public Land

BLM Administrative Boundaries in the Planning Area of Alaska

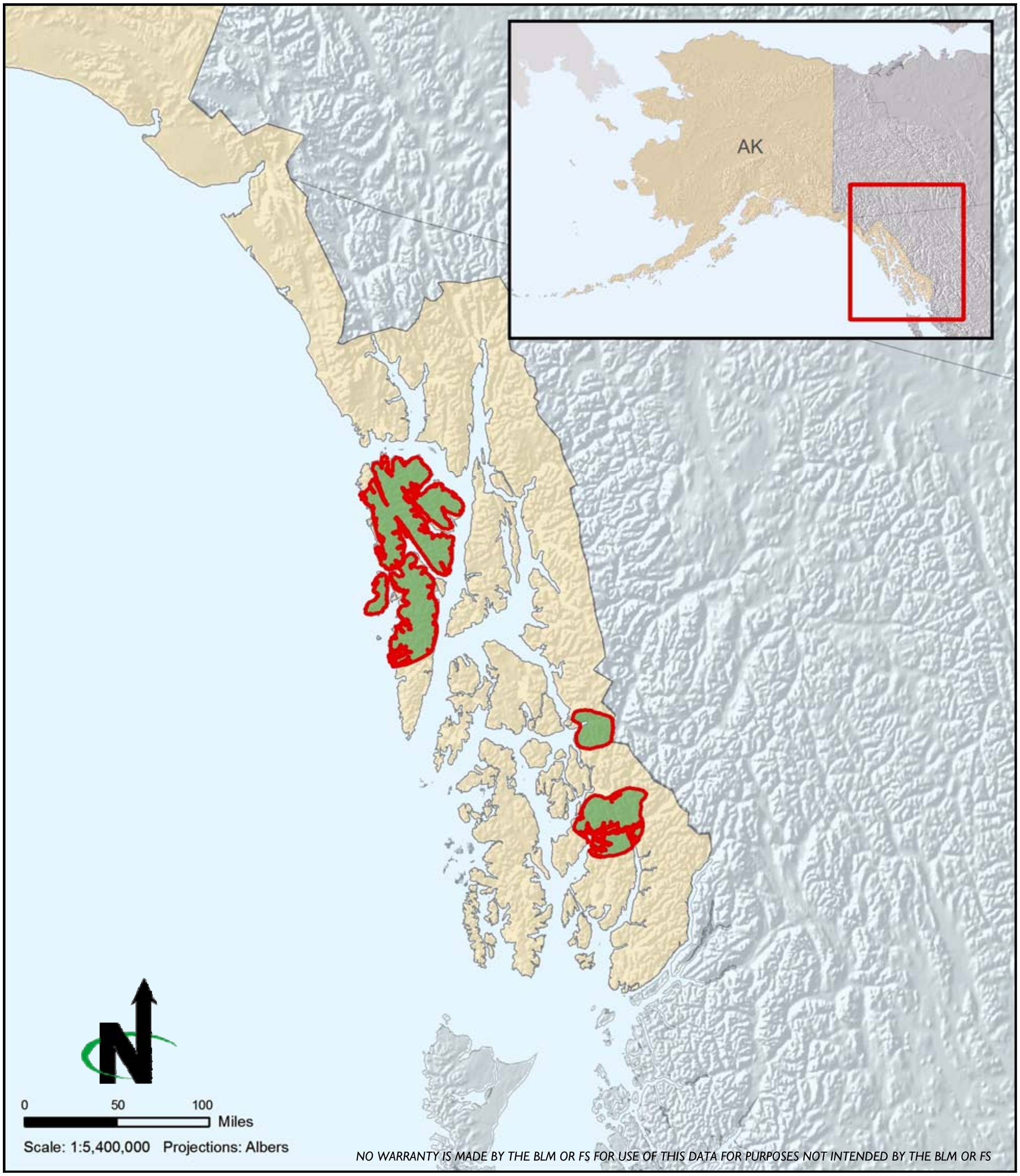
Figure 2-2

Over 101 million acres of NFS lands are within the geothermal potential area in the 11 western states.

LEGEND:
Geothermal potential area
NFS lands

National Forest System Lands and Districts in the Planning Area of the 11 Western States

Figure 2-3



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Almost three million acres of NFS lands within the Tongass National Forest on the Alaskan panhandle have geothermal potential.

LEGEND:

Geothermal potential area

NFS lands

National Forest System Lands in the Planning Area of Alaska

Figure 2-4

The BLM and FS have determined that certain lands within the planning area are excluded from geothermal leasing on the basis of existing laws, regulations (see 43 CFR 3201.11), and Executive Orders. These non-discretionary closures include the following lands administered by the BLM and FS:

- National Monuments.
- National Conservation Areas (NCA) and similar designations with the exception of King Range NCA and Steese NCA.
- Wilderness Areas and National Wilderness Areas.
- Wilderness Study Areas.
- Lands within areas allocated for wilderness or further planning in Executive Communication 1504, Ninety-Sixth Congress (House Document 96-119), unless such lands are allocated to uses other than wilderness by a land and resource management plan or are released to uses other than wilderness by an act of Congress.
- National Recreation Areas.
- Designated Wild Rivers under the Wild and Scenic River Act.
- The Island Park Geothermal Area (includes NFS lands in Idaho and Montana).
- Withdrawn lands under Section 17(d)(1) of the Alaska Native Claims Settlement Act.[1]

As discussed in Chapter 1, there are other lands administered by other Federal agencies that are closed to leasing, including lands managed as part of the National Wildlife Refuge System (16 USC 668 [dd]) and lands within units of the National Park System. Prior to making a leasing decision on lands in proximity to a National Park System unit, the BLM or FS must determine if there would be any impacts to thermal or hydrological features within the unit, in accordance with the Geothermal Steam Act Amendments (30 USC Section 1026).

In addition to non-discretionary closures, the BLM and FS have the administrative authority to issue discretionary closures to protect special resource values. BLM and FS have had a great deal more experience managing lands for development of oil and gas resources, and many more management plans address these resources. Development of oil and gas resources result in many of the same kinds of impacts as development of geothermal resources

[1] Section 17(d)(1) of the Alaska Native Claims Settlement Act (ANCSA) of 1971 authorized the Secretary of the Interior to withdraw and reserve lands for study and classification. These withdrawals closed the lands to disposal and appropriation under public land laws, including mining and mineral leasing laws. The withdrawals remain in effect on about 50 million acres of public land in Alaska. The BLM makes recommendations for revocation of the withdrawals through the planning process, and the Secretary makes the final determination. This PEIS recognizes that most land administered by the BLM in Alaska is withdrawn from geothermal leasing; however, these lands are included for analysis because the Secretary could revoke lands from withdrawal in the future. This PEIS does not make any recommendations on what lands are recommended for revocation from withdrawal; such determinations will be made in the appropriate BLM land use plans.

(e.g., surface disturbance resulting from the footprints of facilities, wells, pads and pipelines, as described in Section 2.5, Reasonably Foreseeable Development Scenario); therefore, BLM and FS have determined that it is appropriate to take an approach to development of geothermal resources similar to that taken to development of oil and gas resources. Areas that require protection from the effects of development of fluid resources are more likely to require protection from the similar effects of development of geothermal resources. Because of this, the BLM has determined that, for ACEC's the management approach to development of oil and gas resources may appropriately serve as a surrogate for development of geothermal resources, absent more explicit geothermal-specific treatment. The following areas are proposed BLM discretionary closures for geothermal leasing; the Forest Service is not proposing to amend any land use plans to make such administrative decisions as part of the Proposed Action (see Section 1.11.1 Decisions on the Programmatic Analysis).

- The California Desert Conservation Area[2].
- Areas of Critical Environmental Concern where the BLM determines that geothermal leasing and development would be incompatible with the purposes for which the ACEC was designated, or those whose management plans expressly preclude new leasing or development for oil and gas or geothermal resources. A list of ACECs that are currently open and closed to fluid mineral leasing is provided in Appendix C. No new closures are proposed.
- Other lands within BLM's National Landscape Conservation System (NLCS), such as National Historic and Scenic Trails.
- National Landmarks and Research Natural Areas.
- Military reservations encompassing public lands are open for development except in instances where geothermal development conflicts directly with the terms of the reservation or the mission as identified by the military.
- Areas previously closed to fluid minerals development in approved land use plans.

Under the Proposed Action approximately 118 million acres of BLM public land would be allocated as open to geothermal leasing subject to existing laws, regulations, formal orders, stipulations attached to the lease form, and the terms and conditions of the standard lease form. While these lands are allocated as open, compliance with laws and regulations could nevertheless prohibit some lands from leasing. For example, if the BLM or FS determines that subsequent exploration, development, or utilization of nominated lands would likely result in a significant adverse effect on a significant thermal feature within a unit of the

[2] Geothermal leasing and development is allowed in designated portions of the California Desert Conservation Area in accordance with the California Desert Conservation Area Plan, 1980, as amended (BLM 1999).

National Park System, the lease would not be issued pursuant to the Geothermal Steam Act Amendments of 1988 (30 USC Section 1026[c]).

The authorized officer retains the discretion to issue stipulations that impose moderate to major constraints on use of surface of any leases in order to mitigate the impacts to other land uses or resources objectives as defined in the guiding resource management plan. In addition, 79 million acres of NFS lands have been identified as not being closed by statute, regulation, or orders, and as such, would be considered for evaluation for leasing.

In total, this represents about 80 percent of public lands and NFS lands within the planning area. Conversely, the non-discretionary and discretionary closures would restrict approximately 25 million acres of BLM public land. About 24 million acres of NFS lands would be closed (by law, regulations, or other authority) to geothermal leasing within the planning area. This represents about 20 percent of all public and NFS lands in the planning area. All of these lands are outside of Alaska except for about 1.8 million acres along the Alaskan panhandle within the Tongass National Forest in the Fairbanks District of the BLM. Tables 2-1 and 2-2 list the approximate acreage of closed areas within each BLM Office and National Forest and Figures 2-5 and 2-6 illustrate the closed and open lands in the 11 western states and in Alaska.

Table 2-1
BLM Public Lands with Geothermal Potential and Proposed Closed Areas to Leasing

State	District or Field Office	Acres within Planning Area	Proposed Acres Closed	State	District or Field Office	Acres within Planning Area	Proposed Acres Closed
AK	Anchorage (District)	992,786	--[1]	CA	El Centro	1,236,466	853,632
AK	Fairbanks (District)	4,867,749	1,444,835[1]	CA	Folsom	274	82
AZ	Arizona Strip	626,291	328,799	CA	Hollister	273,622	29,240
AZ	Hassayampa	701,670	88,515	CA	Needles	1,498,782	1,203,713
AZ	Kingman	2,219,911	373,299	CA	Palm Springs-South Coast	1,555,386	1,017,252
AZ	Lake Havasu	1,352,613	178,621	CA	Redding	51,209	2,954
AZ	Lower Sonoran	860,793	344,285	CA	Ridgecrest	1,831,176	1,296,514
AZ	Safford	1,270,987	90,893	CA	Surprise	1,430,221	397,653
AZ	Tucson	520,812	172,746	CA	Ukiah	264,147	40,333
AZ	Yuma	1,289,013	186,006	CO	Columbine	63,001	2,795
CA	Alturas	502,188	89,093	CO	Del Norte	38,185	9,160
CA	Arcata	83,436	56,341	CO	Dolores	427,661	143,103
CA	Bakersfield	560,591	330,725	CO	Glenwood Springs	567,172	27,717
CA	Barstow	2,892,852	1,488,168	CO	Grand Junction	420,016	66,622
CA	Bishop	747,823	284,029	CO	Gunnison	614,233	164,408
CA	Eagle Lake	1,041,655	407,959	CO	Kremmling	367,370	13,807

Table 2-1
BLM Public Lands with Geothermal Potential and Proposed Closed Areas to Leasing

State	District or Field Office	Acres within Planning Area	Proposed Acres Closed	State	District or Field Office	Acres within Planning Area	Proposed Acres Closed
CO	La Jara	241,147	20,985	NV	Ely	11,418,529	1,241,356
CO	Little Snake	962,205	4,457	NV	Las Vegas	3,426,674	709,582
CO	Pagosa Springs	5,777	699	NV	Winnemucca	8,232,520	546,952
CO	Royal Gorge	661,011	73,627	OR/WA	Andrews	1,604,455	1,006,091
CO	Saguache	235,756	52,516	OR/WA	Ashland	120,365	52,750
CO	Uncompahgre	800,861	130,462	OR/WA	Baker	435,461	44,309
CO	White River	884,343	22,415	OR/WA	Border	99,042	8,439
ID	Bruneau	1,604,986	316,553	OR/WA	Butte Falls	89,148	14
ID	Burley	849,597	70,471	OR/WA	Cascades	138,070	19,008
ID	Challis	908,313	139,652	OR/WA	Central Oregon	899,351	228,336
ID	Cottonwood	90,128	13,963	OR/WA	Deschutes	752,690	66,748
ID	Four Rivers	1,340,695	562,196	OR/WA	Jordan	2,589,122	971,352
ID	Jarbidge	1,565,165	131,547	OR/WA	Klamath Falls	223,594	8,634
ID	Owyhee	1,497,330	303,451	OR/WA	Lakeview	3,202,746	528,942
ID	Pocatello	554,115	44,554	OR/WA	Malheur	2,023,254	309,650
ID	Salmon	520,764	60,464	OR/WA	Three Rivers	1,664,151	48,965
ID	Shoshone	1,904,389	428,425	OR/WA	Upper Willamette	31,923	0
ID	Upper Snake	1,881,331	237,801	OR/WA	Wenatchee	152,054	5,976
MT	Billings	149,410	6,768	UT	Cedar City	2,102,417	23,739
MT	Butte	272,708	35,014	UT	Fillmore	4,310,287	455,524
MT	Dillon	910,199	165,583	UT	Kanab	145,417	15,519
MT	Lewistown	183,749	133	UT	Richfield	400,725	49,649
MT	Malta	4,076	0	UT	Salt Lake	3,066,003	390,815
MT	Miles City	1,863,245	84,618	UT	St. George	468,886	63,378
MT	Missoula	55,344	2,564	UT	Vernal	272,862	0
NM	Carlsbad	186,375	0	WY	Buffalo	571,425	12,301
NM	Farmington	1,421,241	113,860	WY	Casper	517,576	9,160
NM	Las Cruces	5,000,939	523,188	WY	Cody	722,834	39,317
NM	Rio Puerco	978,622	362,255	WY	Kemmerer	693,806	83,508
NM	Roswell	119,750	0	WY	Lander	1,201,201	32,423
NM	Soccoro	1,267,174	299,915	WY	Newcastle	132,922	0
NM	Taos	533,041	144,066	WY	Pinedale	704,239	39,119
NV	Battle Mountain	10,419,122	933,196	WY	Rawlins	2,308,513	72,173
NV	Carson City	4,988,877	677,456	WY	Rock Springs	3,356,775	338,172
NV	Elko	7,505,351	536,717	WY	Worland	1,537,942	91,803
					TOTAL	**143,154,205**	**25,146,569**

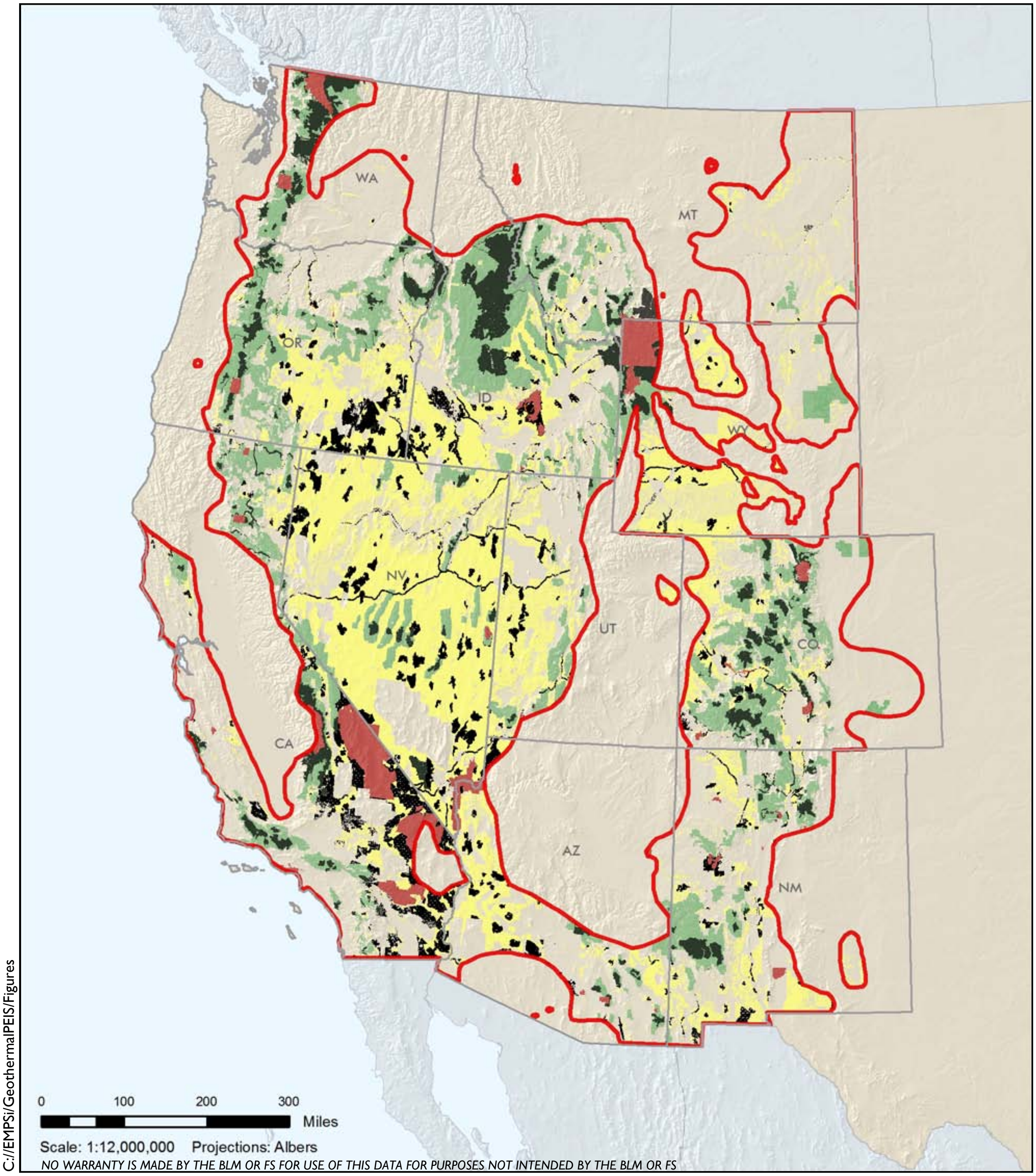
[1] Most of the land administered by the BLM within the planning area of Alaska are withdrawn from mineral leasing under Section 17(d)(1) of the Alaska Native Claims Settlement Act of 1971. The closed acres in this table represent the acreage that would remain closed to geothermal leasing if the Secretary of the Interior revoked the withdrawal from all public lands in the planning area.

Table 2-2
National Forest System Lands with Geothermal Potential and Areas Legally Closed to Geothermal Leasing

National Forest	Acres within Planning Area	Proposed Acres Closed	National Forest	Acres within Planning Area	Proposed Acres Closed
Angeles National Forest	700,526	96,078	Manti-Lasal National Forest	122,731	0
Apache-Sitgreaves National Forests	536,388	4,290	Medicine Bow-Routt National Forest	2,914,429	251,084
Arapaho and Roosevelt National Forests	2,144,801	372,359	Mendocino National Forest	591,785	36,294
Ashley National Forest	103,212	102,345	Modoc National Forest	2,021,948	219,334
Beaverhead-Deerlodge National Forest	3,567,861	432,617	Mt Baker-Snoqualmie National Forest	1,982,319	867,833
Bitterroot National Forest	1,663,506	882,053	Mt. Hood National Forest	1,099,844	391,579
Boise National Forest	2,598,828	64,944	Nez Perce National Forest	2,251,928	1,080,050
Bridger-Teton National Forest	1,952,301	827,311	Ochoco National Forest	1,154,882	42,730
Caribou-Targhee National Forest	3,070,701	662,433	Okanogan-Wenatchee National Forests	2,760,232	1,603,964
Carson National Forest	1,486,469	234,997	Payette National Forest	2,441,522	810,267
Cibola National Forest	1,746,158	103,812	Pike-San Isabel National Forest	2,768,326	425,753
Clearwater National Forest	816,236	386,237	Plumas National Forest	885,039	54,615
Cleveland National Forest	561,166	75,577	Rio Grande National Forest	1,946,489	427,455
Coronado National Forest	1,235,266	346,707	Rogue River-Siskiyou National Forests	476,358	87,619
Custer National Forest	645,473	29,538	Salmon-Challis National Forest	4,330,550	1,237,515
Deschutes National Forest	1,868,469	311,583	San Bernardino National Forest	808,076	142,148
Dixie National Forest	1,005,239	72,117	San Juan National Forest	2,094,174	575,868
Eldorado National Forest	19	0	Santa Fe National Forest	1,590,231	382,810
Fishlake National Forest	982,768	2,022	Sawtooth National Forest	2,189,973	800,234
Fremont-Winema National Forests	2,809,657	127,477	Sequoia National Forest	997,457	475,698
Gallatin National Forest	1,844,331	873,419	Shasta Trinity National Forest	532,564	48,650

Table 2-2
National Forest System Lands with Geothermal Potential and Areas Legally Closed to Geothermal Leasing

National Forest	Acres within Planning Area	Proposed Acres Closed	National Forest	Acres within Planning Area	Proposed Acres Closed
Gifford Pinchot National Forest	1,420,495	300,565	Shoshone National Forest	417,267	231,025
Gila National Forest	3,387,242	851,641	Sierra National Forest	278,345	259,661
Grand Mesa, Uncompahgre and Gunnison National Forests	3,126,701	641,501	Tahoe National Forest	240,795	1,256
Helena National Forest	737,819	7,327	Tongass National Forest	2,732,322	284,967
Humboldt-Toiyabe National Forest	6,487,894	1,249,964	Tonto National Forest	465,533	127,666
Inyo National Forest	1,945,283	653,371	Uinta National Forest	278,551	41,092
Klamath National Forest	358,944	34,226	Umatilla National Forest	1,460,291	304,807
Lassen National Forest	1,353,926	194,251	Umpqua National Forest	492,171	108,973
Lewis and Clark National Forest	31,732	0	Wallowa-Whitman National Forest	2,382,077	886,641
Lincoln National Forest	33,825	0	Wasatch-Cache National Forest	611,876	111,912
Lolo National Forest	347,638	42,112	White River National Forest	2,488,788	748,248
Los Padres National Forest	1,927,933	802,714	Willamette National Forest	1,730,532	422,731
Malheur National Forest	1,543,957	89,150	**TOTAL**	**103,582,163**	**24,365,016**



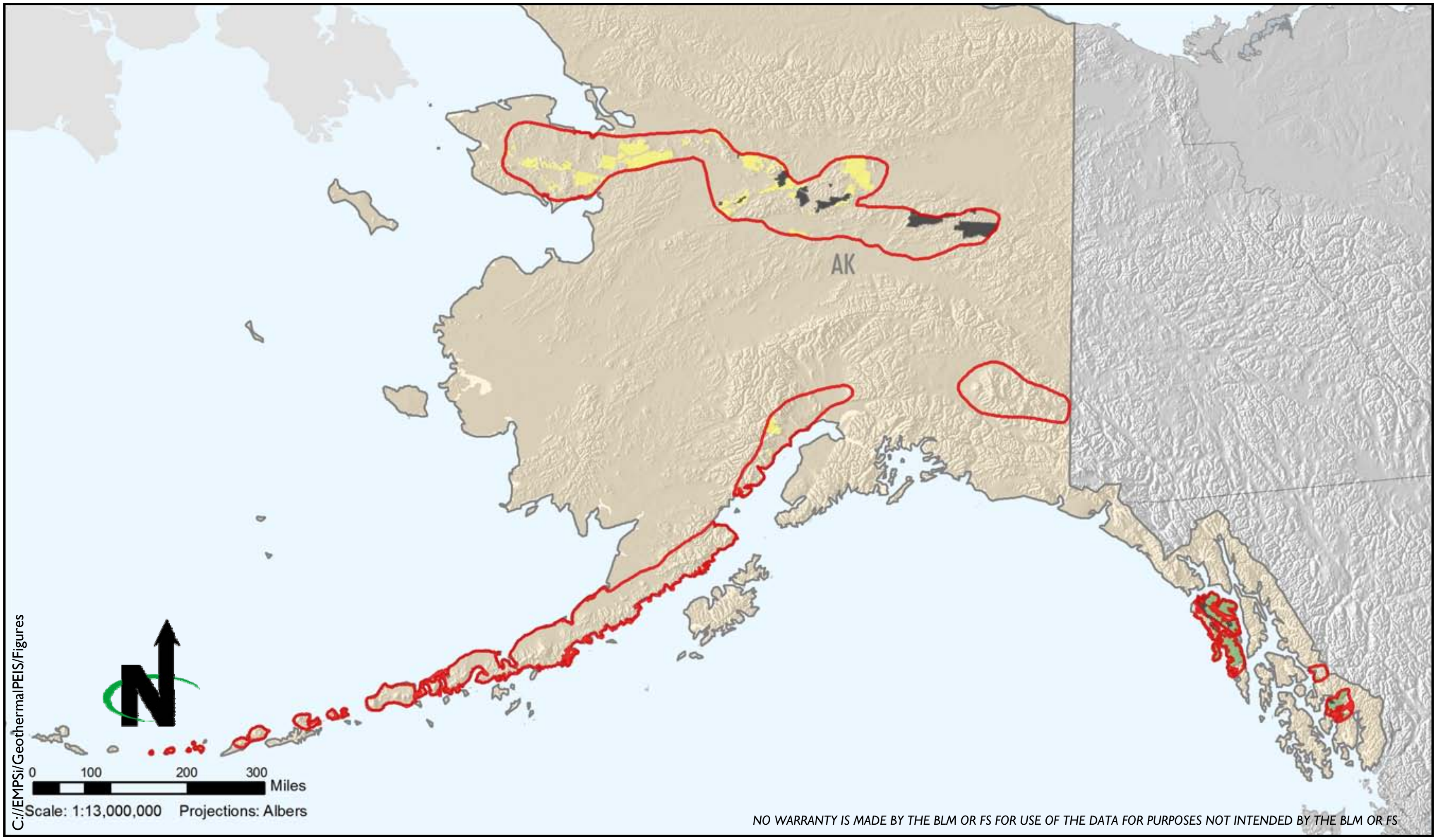
Under the Proposed Action, about 118 million acres of BLM public land and 79 million acres of NFS land would be allocated as open to geothermal leasing. National Park lands are closed.

LEGEND:

- Potential geothermal area
- National Park System Lands Closed to Leasing
- Public Lands Open to Leasing
- NFS Lands Open to Leasing
- Public and NFS Lands Closed to Leasing

BLM Public and NFS Lands Open and Closed in the 11 Western States

Figure 2-5



Under the Proposed Action, about 285,000 acres along the Alaskan panhandle within the Tongass National Forest and about 1.5 million acres in the Fairbanks District of the BLM would be closed to geothermal leasing. All National Park lands are closed.

LEGEND:

- Geothermal potential area
- Public Lands Open to Leasing
- NFS Lands Open to Leasing
- Public and NFS Lands Closed to Leasing

BLM Public and NFS Lands Open and Closed in Alaska

Figure 2-6

2.2.2 Lease Stipulations, Best Management Practices, and Procedures

Lease Stipulations

This section provides the list of constraints that would be applied as appropriate by the authorized officer to any new leases for lands that are available for geothermal leasing. Lease stipulations are major or moderate constraints applied to a new geothermal lease. A lease stipulation is a condition of lease issuance that provides a level of protection for other resource values or land uses by restricting lease operations during certain times or at certain locations or by mitigating unacceptable impacts, to an extent greater than standard lease terms or conditions. A stipulation is an enforceable term of the lease contract, supersedes any inconsistent provisions of the standard lease form, and is attached to and made a part of the lease. Lease stipulations further implement the BLM's regulatory authority to protect resources or resource values.

Local land use plans take different approaches to protect resources depending on the circumstances on those planning areas. Because this is a programmatic document, the geothermal stipulations herein have been developed to address a wide variety of landscapes, climates, and ecosystems, without disrupting the management approach of local land use plans. These stipulations were selected for inclusion based on a comprehensive review of land use plans, program guidance, geothermal development activities, published data on geothermal development impacts, industry standards, and best professional judgment. In addition, other reports on fluid mineral leasing and development (e.g., oil and gas) were consulted because of the similarity of most of the activities and impacts, such as from exploration, drilling, and site development. Where the agency determines that particular stipulations may be inappropriate for a planning area, the procedures for waivers, exception, and modifications would be followed.

Lease Exceptions, Waivers, and Modifications

To ensure leasing decisions remain appropriate in light of continually changing circumstances and new information, the BLM develops and applies lease stipulation exception, waiver, and modification criteria. An exception, waiver, or modification may not be approved unless, (1) the authorized officer determines that the factors leading to the stipulation's inclusion in the lease have changed sufficiently to make the protection provided by the stipulation no longer justified; or (2) the proposed operations would not cause unacceptable impacts. (43 CFR 3101.1-4)

- An **exception** is a one-time exemption for a particular site within the leasehold; exceptions are determined on a case-by-case basis; the stipulation continues to apply to all other sites within the leasehold. An exception is a limited type of waiver.
- A **waiver** is a permanent exemption from a lease stipulation. The stipulation no longer applies anywhere within the leasehold.

- A **modification** is a change to the provisions of a lease stipulation, either temporarily or for the term of the lease. Depending on the specific modification, the stipulation may or may not apply to all sites within the leasehold to which the restrictive criteria are applied.

An exception, waiver, or modification may be approved if the record shows that circumstances or relative resource values have changed or that the lessee can demonstrate that operations can be conducted without causing unacceptable impacts and that less restrictive requirements would meet resource management objectives.

The authorized officer may require the operator to submit a written request for an exception, waiver, or modification and information demonstrating that (1) the factors leading to the inclusion of the stipulation in the lease have changed sufficiently to make the protection provided by the lease stipulation no longer justified or (2) that the proposed operation would not cause unacceptable impacts. Requests from the operator should contain, at a minimum, a plan including related on-site or off-site mitigation efforts, to adequately protect affected resources; data collection and monitoring efforts; and timeframes for initiation and completion of construction, drilling, and completion operations. The operator's request may be included in a permit application (e.g., application for permit to drill), Notice of Staking, Sundry Notice, or letter. The BLM may also initiate the process.

During the review process, coordination with other state or Federal agencies would be undertaken, as appropriate, and documented. For example, it may be appropriate to coordinate the review of wildlife exceptions, waivers, and modifications with the local office of the State wildlife agency. Staff review and recommendations would be documented along with any necessary mitigation and provided to the authorized officer for approval or disapproval. The applicant would then be provided with a written notification of the decision.

Public notification (30-day public review) is generally not required for exceptions because an exception is seldom a substantial modification or waiver of a lease term or stipulation (43 CFR 3101.1-4), particularly if the exception criteria is outlined in the lease or the land use plan. Nor is public review required for waivers or modifications that the authorized officer determines are not substantial and do not substantially waive or modify the terms of the lease. "Substantial" in this case would include the exception, waiver, or modification having a "substantial" effect on the environment that was not previously considered. However, the applicable land use plan may contain additional notification requirements. The public notice, if required, should include identification of the modified lease terms and a description of the affected lands or a map.

When Public Notice is appropriate, the following procedures may apply:

- Approval of an exception, waiver, or modification with the permit approval: A notice describing the modified lease terms, when required, may be posted for 30 days in the BLM office; posted on the BLM website; posted in a local paper as a legal notice or incorporated into a newspaper article; or the notice may be included as part of the NEPA document's public review, if the NEPA document is offered for review.
- Approval after the permit has been approved: Public notice, if required, may take the form of a 30-day posting on the BLM website, a legal notice or article in the newspaper, or a notice and associated public review conducted as part of the public review of a NEPA document.
- Approval after drilling has commenced: Unless specified in the land use plan, it is unlikely public notification would be necessary.

The BLM must analyze and document how the exception, waiver, or modification is in conformance with the land use plan and identify the plan decision (including goals, objectives, or desired outcomes) supported by the proposed exception, waiver, or modification. If existing NEPA analysis does not support the exception, waiver, or modification, the BLM must conduct the appropriate environmental review and NEPA analysis. If the proposed exception, waiver or modification is not in conformance with the land use plan or that document does not disclose the conditions under which such proposed change would be allowed, BLM must either amend the plan or deny the exception, waiver, or modification.

It may be necessary to add, delete, or modify lease stipulations in the land use plan as a result of pre-lease issuance parcel reviews, statewide lease stipulation consistency reviews, plan amendments, changed circumstances on the ground, or changed resource protection priorities. This is accomplished and documented either through the plan maintenance process (for minor changes consistent with an approved land use plan) or the plan amendment process (for changes resulting in modification of terms, conditions, or decisions in an approved land use plan).

Applicability of Stipulations

Stipulations provided in this PEIS would serve as the minimal level of protection and would be adopted into local land use plans upon signing of the ROD. For example, if an administrative unit has eligible wild and scenic rivers, the wild river stipulation would apply. If an existing land use plan offers more protective measures or has resource specific commitments (e.g., memorandum of understanding for cultural resources), those more protective measures would apply instead. Existing land use plans would also be used to help identify locations of applicability, buffer sizes, and timing conditions for the stipulations.

No Surface Occupancy Lease Stipulations

No Surface Occupancy (NSO) stipulations are considered a major constraint as they do not allow for surface development. For example, a lessee of a NSO area must develop any surface infrastructure outside the NSO area and would need to use advanced technology, such as directional drilling, to access the geothermal resource under the NSO area. These NSO stipulations are applied to the standard lease form as condition of the lease. An NSO is appropriate when the standard terms and conditions, other less restrictive lease stipulations (see below), and best management practices for permit approval (Appendix D) are determined to be insufficient to achieve the resource protection objectives.

- Designated or proposed critical habitat for listed species under the Endangered Species Act of 1973 (as amended) if it would adversely modify the habitat. For listed or proposed species without designated habitat, NSO would be implemented to the extent necessary to avoid jeopardy.
- Within the boundary of properties designated or eligible for the National Register of Historic Places, including National Landmarks and National Register Districts and Sites; and additional lands outside the designated boundaries to the extent necessary to protect values where the setting and integrity is critical to their designation or eligibility.
- Areas with important cultural and archaeological resources, such as traditional cultural properties and Native American sacred sites, as identified through consultation.
- Water bodies, riparian areas, wetlands, playas, and 100-year floodplains.
- Developed recreational facilities, special-use permit recreation sites (e.g., ski resorts and camps), and areas with significant recreational use with which geothermal development is deemed incompatible; excluding direct use applications.
- Designated National Scenic and Recreational Rivers under the Wild and Scenic River Act.
- Segments of rivers determined to be potentially eligible for Wild and Scenic Rivers (WSR) status by virtue of a WSR inventory, including a corridor of 0.25 miles from the high water mark on either side of the bank[3].

[3] A number of land use plans are currently undergoing revision, and as part of that process WSR inventories have been undertaken. Where a river or river segment has been found to be "eligible" for inclusion in the WSR system as part of one of these inventories, the BLM has the obligation to protect the lands along the eligible segment until a "suitability" determination has been made as part of the land use planning process. If the river or river segment is found to be "non-suitable," the lands along the river then would be available for other uses. If a river or river segment is determined to be suitable for inclusion in the WSR system, the BLM will forward that recommendation to Congress for action and will continue to protect the lands along the river.

- Designated important viewsheds, including (1) public lands designated as VRM Class I and (2) NFS lands with a Scenery Management System integrity level of Very High.
- Slopes in excess of 40 percent and/or soils with high erosion potential.
- Areas that are defined as having special resource values for subsistence needs in Alaska.

Additional NSO stipulations could be applied in conformance with the local land use plan to address site-specific resource concerns.

Timing Limitations and Controlled Surface Use Lease Stipulations

Where standard lease terms and permit-level decisions are deemed insufficient to protect sensitive resources but where an NSO is deemed overly restrictive, the BLM and FS would apply seasonal or time limited (TL) stipulations or controlled surface use (CSU) stipulations to leases. In general, timing limitations are used to protect resources that are sensitive to disturbance during certain periods. Such stipulations are generally applicable to specific areas, seasons, and resources. They are commonly applied to wildlife activities and habitat, such as winter range for deer, elk, and moose; nesting habitat for raptors and migratory birds; and breeding areas. Buffer zones are also used to further mitigate impacts from any human activities. The size of buffers can also be specific to species and location, and can change based on findings of science or movement of species. Therefore, timing limitations would be applied by the authorizing officer as appropriate for the specific lease areas and in compliance with the unit's resource management plan. The BLM and FS would consult with the appropriate agencies (e.g., state wildlife agencies) in establishing the periods and extent of area for timing limitations.

A CSU allows the BLM and FS to require any future activity or development be modified or relocated from the proposed location if necessary to achieve resource protection. The project applicant will be required to submit a plan to meet the resource management objectives through special design, construction, operation, mitigation, or reclamation measures, and/or relocation. Unless the plan is approved, no surface occupancy would be allowed on the lease. The following CSUs would be applied by the authorizing officer as appropriate for the specific area and site conditions.

- ***Protection of riparian and wetland habitat.*** This stipulation would be applied within 500 feet of riparian or wetland vegetation to protect the values and functions of these areas. Measures required will be based on the nature, extent, and value of the area potentially affected.
- ***Protection of visual resources.*** This stipulation would be applied to BLM VRM Class II areas (VRM Class III management objectives

would be met through conditions of approval applied during the permit approval process, and may be referenced in a lease notice); NFS lands with a Scenery Management System integrity level of High; and other sensitive viewsheds, such as within the visual setting of National Scenic and Historic Trails or near residential areas.

- ***Protection of recreational areas.*** This stipulation would be applied to minimize the potential for adverse impacts to recreational values, both motorized and non-motorized, and the natural settings associated with the recreational activity.
- ***Compatibility with urban interface.*** This stipulation would be applied to minimize the potential for adverse impacts to residential areas, schools, or other adjacent urban land uses.
- ***Protection of erosive soils and soils on slopes greater then 30 percent.*** This stipulation would be applied to minimize the potential for adverse impacts to erosive soils as defined as severe or very severe erosion classes based on Natural Resources Conservation Service (NRCS) mapping.
- ***Protection of important habitat and migration corridors***. This stipulation would be applied to protect the continuity of migration corridors and important habitat.

Other Lease Stipulations

Protection of Geothermal Features

Under the following situations, the BLM or FS would apply stipulations to protect the integrity of geothermal resource features, such as springs and geysers. If it is determined that geothermal operations are reasonably likely to result in a significant adverse effect to such a feature, then BLM would decline to issue the lease.

- The BLM or FS would include stipulations to protect any significant thermal features of a National Park System unit that could be adversely affected by geothermal development. These stipulations will be added, if necessary, when the lease or permit is issued, extended, renewed or modified (43 CFR 3201.10[b]).
- Any leases that contain thermal features (e.g., springs or surface expressions) would have a stipulation requiring monitoring of the thermal features during any exploration, development, and production of the lease to ensure that there are no impacts to water quality or quantity.

Endangered Species Act Stipulation

In accordance with BLM Instruction Memorandum No. 2002-174, the BLM will apply the following stipulation on any leases where threatened, endangered, or other special status species or critical habitat is known or strongly suspected. Additionally, the BLM will provide a separate notification through a lease notice to prospective lessees identifying the particular special status species that are present on the lease parcel offered.

> "The lease area may now or hereafter contain plants, animals, or their habitats determined to be threatened, endangered, or other special status species. BLM may recommend modifications to exploration and development proposals to further its conservation and management objective to avoid BLM-approved activity that will contribute to a need to list such a species or their habitat. BLM may require modifications to or disapprove proposed activity that is likely to result in jeopardy to the continued existence of a proposed or listed threatened or endangered species or result in the destruction or adverse modification of a designated or proposed critical habitat. BLM will not approve any ground-disturbing activity that may affect any such species or critical habitat until it completes its obligations under applicable requirements of the Endangered Species Act as amended, 16 USC 1531 et seq., including completion of any required procedure for conference or consultation."

Sensitive Species Stipulation

For agency designated sensitive species (e.g., sage grouse), a lease stipulation (NSO, CSU, or TL) would be imposed for those portions of high value/key/crucial species habitat where other existing measures are inadequate to meet agency management objectives.

Cultural Resources Stipulation

In accordance with BLM Instruction Memorandum No. 2005-003, the BLM will apply the following stipulation to protect cultural resources:

> "This lease may be found to contain historic properties and/or resources protected under the National Historic Preservation Act (NHPA), American Indian Religious Freedom Act, Native American Graves Protection and Repatriation Act, E.O. 13007, or other statutes and executive orders. The BLM will not approve any ground disturbing activities that may affect any such properties or resources until it completes its obligations under applicable requirements of the NHPA and other authorities. The BLM may require modification to exploration or development proposals to protect such properties, or disapprove any activity that is likely to result in adverse effects that cannot be successfully avoided, minimized or mitigated."

Roadless Area Stipulation

The FS manages about 51,477,000 acres of land in the planning area that is designated as inventoried roadless areas. A non-discretionary restriction would be placed on any leases within NFS inventoried roadless areas. Specifically, no new road construction or reconstruction would be allowed in designated roadless areas. If future legislation or regulation change the roadless area designation, the restriction would be revised along with any appropriate environmental review.

Best Management Practices

In addition to lease stipulations, during any subsequent exploration, drilling, utilization, or reclamation and abandonment of geothermal resources, the BLM and FS would require project-specific mitigation measures (Appendix D) to permits. The agency's first priority is to mitigate impacts on-site. When the agency determines that impacts cannot be mitigated to an acceptable level on-site, it may be necessary to deny the permit, ask the applicant to modify the proposal, or mitigate remaining impacts off-site. Best Management Practices are state-of-the-art mitigation measures and may be incorporated into the permit application by the lessee or may be included in the approved use authorization by the BLM as conditions of approval. Conditions of approval are not lease stipulations, but they are site-specific and enforceable requirements to minimize, mitigate, or prevent impacts to resource values from an intended operation. Conditions of approval can limit or amend the specific actions proposed by the operator.

Monitoring

Mitigation measures, including lease stipulations and conditions of approval as well as the general operation of geothermal developments, would be monitored by the lessee or the appropriate Federal agency to ensure their continued effectiveness through all phases of development. Using adaptive management strategies, where mitigation measures are determined to be ineffective at meeting the desired resource conditions, the BLM and FS would take steps to determine the cause and require the operator to take corrective action. This information would also be used to inform future geothermal leasing and development.

Procedures Prior to Leasing

To ensure compliance with regulations and Federal laws, the following procedures would be implemented prior to any lands being included in a competitive lease sale. Stipulations listed above would also be used to help achieve resource protection in accordance with laws and regulations.

- The FS will be consulted and provide a consent determination (including terms and conditions or stipulations) to the BLM prior to any parcels on NFS lands being offered for lease sale. As a condition of consent to the issuance of any lease, the Forest Service would be consulted on the development of a surface use plan.
- The authorized officer of the BLM or FS would consult with the appropriate Native American Tribal governments and Alaska Natives to identify tribal interests and traditional cultural resources

or properties that may be affected by the Federal land leases and potential for geothermal energy development. Tribal interests include economic rights such as Indian trust assets and resource uses and access guaranteed by treaty rights. Traditional cultural resources or properties include areas of cultural importance to contemporary communities, such as sacred sites or resource gathering areas. There may be issues related to the presence of cultural properties, access rights, disruption to traditional cultural practices, cultural use of hot springs and water sources and impacts to visual resources important to tribes. Areas proposed for leasing may include lands where there are tribal interests and traditional cultural resources that are not currently identified. Consultations on leases should include a full disclosure of the lease as a commitment of the land that may eventually involve future development that could preclude other tribal uses. Consideration and research should be directed to determine if there are other ethnic and social groups that may have traditional uses or ties to the lands proposed for leases.

- The authorized officer of the BLM or FS would consult with the appropriate Native American Tribes, Alaska Natives, and State Historic Preservation Officers regarding historic and cultural resources per Section 106 of the National Historical Preservation Act. The presence of archaeological sites and historic properties would be determined on the basis of a records search and literature review of recorded sites and properties in the proposed lease area and a buffer around the lease area, if appropriate. The BLM or FS would assess the adequacy of the cultural resource identification and evaluation effort for the leasing stage. Additional historical, cultural or ethnographic research, consultation and/or inventories may be required to identify resources, determine effects, mitigate adverse effects and complete the Section 106 process. This PEIS addresses the Section 106 process at a programmatic level and serves as a basis for the phased consultation process. All existing memorandums of understanding and agreements regarding the identification and protection of cultural resources would remain valid.
- The authorized officer of the BLM or FS would determine if any listed or proposed threatened or endangered species or critical habitat is present on nominated lease parcels. If so, the authorized officer would comply with Section 7 of the Endangered Species Act, which may include consultation or conferencing with the US Fish and Wildlife Service and/or NOAA Fisheries. Additional consultation would occur during the site-specific project permitting process.

- The authorized officer of the BLM or FS would review the lands for any other sensitive resources (e.g., paleontological, BLM sensitive status species, and FS species of local concern) and provide for the necessary stipulations to protect these resources and ensure compliance with the land use plan. Assessment of the resource would include consulting with agency experts, coordinating with other appropriate agencies, and site surveys if warranted.
- During the processing of any lease nomination or application in Alaska, the authorized officer of the BLM or FS would conduct and document a site-specific analysis of the effects of the lease on subsistence uses and needs in accordance with Section 810(a) of the ANILCA.
- Prior to making a leasing decision on lands in proximity to a National Park System unit, the BLM or FS would coordinate with the National Park Service to determine if there would be any impacts to thermal or hydrological features within the unit. In accordance with the Geothermal Steam Act Amendments (30 USC Section 1026), if it is determined based on scientific evidence that exploration, development, or utilization of the lands subject to the lease application or nomination is reasonably likely to result in a significant adverse effect on a significant thermal feature within the National Park System, the lease would not be issued. In the event that development is reasonably likely to adversely affect a significant thermal feature, the BLM would apply the appropriate stipulations to protect the park units (see Protection of Geothermal Features stipulations above).
- Prior to making leasing decisions, the BLM will assess the adequacy of existing NEPA documentation (i.e., through completion of a DNA) to determine if there is new information or new circumstances that warrant further analysis. For example, additional NEPA analysis may be required in light of new information, or a potential change in management approach regarding resources identified for special management (e.g., travel management planning or areas under consideration by BLM for management for wilderness characteristics).
- The level of environmental analysis to be required under NEPA for subsequent individual exploration, development, and production permits will be determined at the Field Office and FS unit level. In certain instances, it may be determined that a tiered environmental assessment (EA) is appropriate in lieu of an EIS. To the extent that land use plans or this PEIS anticipates issues and concerns associated with individual projects, including potential cumulative impacts, the BLM and FS will tier from land use plans and/or the

PEIS analysis and decisions; thereby limiting the required scope and effort of additional project-specific NEPA analysis.

- The authorized officer of the BLM or FS would collaborate with appropriate state agencies, especially in the case of geothermal energy, as the states manage and typically have regulatory authority for water quality, water rights, and wildlife.
- Applicants for geothermal development and production on public or NFS lands shall develop a project-specific operations plan that incorporates the applicable mitigation and best management practices provided in Appendix D and, as appropriate, the requirements of other existing and relevant BLM and FS mitigation guidance. Additional mitigation measures will be incorporated into the operations plan and into the conditions of approval or project stipulations. The operations plan will include site plans, location of facilities, wells, pipelines, transmission lines, roads, and other infrastructure.

2.2.3 Amend BLM Land Use Plans

The BLM is proposing to amend specific BLM land use plans for lands with potential developable geothermal resources to incorporate the allocations, stipulations, and procedures detailed above. The plans proposed for amendments are identified in Table 2-3.

Table 2-3
Land Use Plans Proposed for Amendment under the PEIS

State	District or Field Office†	Land Use Plan(s)
AK	Anchorage	Ring of Fire RMP
	Central Yukon	Central Yukon RMP
	East Interior	Kobuk-Seward RMP
AZ	Arizona Strip	Arizona Strip RMP
	Kingman	Kingman RMP
	Lake Havasu	Lake Havasu RMP
	Yuma	Lower Gila South RMP* Yuma RMP*
	Safford	Safford RMP
	Tucson	Safford RMP Phoenix RMP*
	Hassayampa	Lower Gila North MFP*; Phoenix RMP*
	Lower Sonoran	Phoenix RMP* Lower Gila South RMP*

Table 2-3
Land Use Plans Proposed for Amendment under the PEIS

State	District or Field Office†	Land Use Plan(s)
CA	Barstow	West Mojave RMP
	El Centro	E. San Diego County RMP
	Palm Springs-S. Coast	South Coast RMP*
	Alturas	Alturas RMP Cedar Creek/Tule Mountain Integrated RMP*
	Arcata	Arcata RMP Headwaters RMP
	Bakersfield	Caliente RMP* Hollister RMP
	Bishop	Bishop RMP
	Eagle Lake	Eagle Lake RMP
	Hollister	S. Diablo Mountain Range and Central Coast RMP
	Redding	Redding RMP
	Surprise	Surprise RMP
CO	Columbine	San Juan/San Miguel RMP*/Glenwood Springs RMP*
	Delores	San Juan/San Miguel RMP*
	Glenwood Springs	Glenwood Springs RMP*
	Grand Junction	Grand Junction RMP*
	Gunnison	Gunnison RMP
	Kremmling	Kremmling RMP*
	Little Snake	Little Snake RMP*
	Pagosa Springs	San Juan/San Miguel RMP*
	Royal Gorge	Northeast RMP Royal Gorge RMP
	Uncompahgre	Uncompahgre Basin RMP* San Juan/San Miguel RMP*
	White River	White River RMP
ID	Bruneau	Bruneau MFP
	Four Rivers	Cascade RMP* Kuna MFP* Jarbidge RMP*
	Owyhee	Owyhee RMP
	Cottonwood	Chief Joseph MFP*
	Challis	Challis RMP
	Pocatello	Malad MFP* Pocatello RMP*
	Salmon	Lemhi RMP
	Upper Snake	Big Desert MFP* Big Lost MFP* Little Lost-Birch MFP* Medicine Lodge RMP*
	Burley	Cassia RMP Twin Falls MFP Monument RMP

Table 2-3
Land Use Plans Proposed for Amendment under the PEIS

State	District or Field Office†	Land Use Plan(s)
ID (cont.)	Jarbidge	Jarbidge RMP*
	Shoshone	Bennett Hills/ Timmerman Hills MFP Magic MFP Monument RMP Sun Valley MFP
MT	Billings	Billings Resource Area RMP*
	Butte	North Headwaters RMP*
	Dillon	Dillon RMP
	Lewistown	Judith Valley Phillips RMP*
	Malta	West HiLine RMP*
	Miles City	Big Dry RMP* Powder River Resource Area RMP*
	Missoula	Garnet Resource Area RMP
NV	Battle Mtn	Shoshone-Eureka RMP Tonopah RMP
	Carson City	Carson City Consolidated RMP
	Elko	Elko RMP Wells RMP
	Las Vegas	Las Vegas RMP
	Winnemucca	Paradise-Denio MFP* Sonoma-Gerlach MFP*
NM	Rio Puerco	Rio Puerco RMP*
	Soccoro	Socorro RMP*
	Farmington	Farmington RMP
	Taos	Taos RMP*
	Las Cruces	MacGregor Range RMP Mimbres RMP* White Sands RMP
	Carlsbad	Carlsbad RMP
	Roswell	Roswell RMP
OR	Burns†	Three Rivers RMP
	Eugene†	Eugene District RMP*
	Medford†	Medford RMP*
	Prineville†	Two Rivers RMP* Brothers/LaPine RMP* John Day RMP* John Day River MP* Lower Deschutes RMP
	Roseburg†	Roseburg RMP*
	Salem†	Salem RMP*

Table 2-3
Land Use Plans Proposed for Amendment under the PEIS

State	District or Field Office†	Land Use Plan(s)
UT	Cedar City	Cedar Beaver Garfield Antimony RMP Pinyon MFP
	Fillmore	House Range Resource Area RMP Warm Springs Resource Area RMP
	Kanab	Paria MFP* Vermilion MFP* Zion MFP*
	Richfield	Mountain Valley MFP* Henry Mountain MFP* Parker Mountain MFP*
	Salt Lake	Box Elder RMP Iso-tract MFP Park City MFP Pony Express RMP Randolph MFP
	St. George	St. George (formerly Dixie) RMP
	Vernal	Book Cliffs MFP* Diamond Mountain RMP*
WA	Spokane†	Spokane RMP
WY	Buffalo	Buffalo RMP
	Casper	Platte River RMP*
	Cody	Big Horn Basin RMP Cody RMP*
	Kemmerer	Kemmerer RMP*
	Lander	Lander RMP*
	Newcastle	Newcastle RMP
	Pinedale	Pinedale RMP* Snake River RMP
	Rawlins	Great Divide RMP* Green River RMP*
	Rock Springs	Green River RMP*
	Worland	Grass Creek RMP* Waskakie RMP*

MP = Management Plan; MFP = Management Framework Plan; RMP = Resource Management Plan
* = Plans are under revision but the record of decision has not been signed and is not expected until after the record of decision for this PEIS. These field offices could elect to amend their existing RMP/MFP with the decisions in this PEIS until their RMP record of decision is signed.
† = Oregon and Washington Districts manage RMPs in their respective states.

Proposed amendments include (1) adoption of the proposed resource allocations of lands being open or closed to geothermal leasing (see Section 2.2.1) at the level of use indicated in the RFD (see Section 2.5); and (2) adoption of moderate and major constraints on use (stipulations and best management practices) and procedures appropriate for resource values present, for leasing as outlined in Section 2.2.2.

The rationale for amending these plans includes the following:

- The land use plan does not address geothermal leasing.
- The land use plan does not allocate areas as being open or closed to geothermal leasing.
- The land use plan does not assess the reasonably foreseeable development scenario for geothermal development, or the analysis requires updating.
- The land use plan does not have adequate or appropriate stipulations or best management practices to apply to geothermal leases to protect sensitive resources.

Some plans within the 12-state project area were excluded from amendment under this PEIS for a variety of reasons, including the following: (1) the plan falls outside of the area with geothermal potential, (2) the plan was previously amended or revised to adequately address geothermal leasing and development, (3) the plan currently is being amended or revised in a separate NEPA review and that amendment or revision will address geothermal leasing and development, or (4) some other reason(s) exist(s) to exclude the plan from amendment under this PEIS (e.g., a plan revision is scheduled in the foreseeable future and there is likely little interest in geothermal leasing for the area in the near term). As land use plans are revised, the BLM would incorporate the proposed geothermal stipulations, procedures, BMPs, and analysis contained in this PEIS, as appropriate.

2.2.4 Pending Lease Applications

The Energy Policy Act of 2005 requires that the Secretary of the Interior and the Secretary of Agriculture enter into a Memorandum of Understanding (see Appendix B) regarding coordination of leasing and permitting for geothermal development of public lands and National Forest System lands under their respective jurisdictions and further:

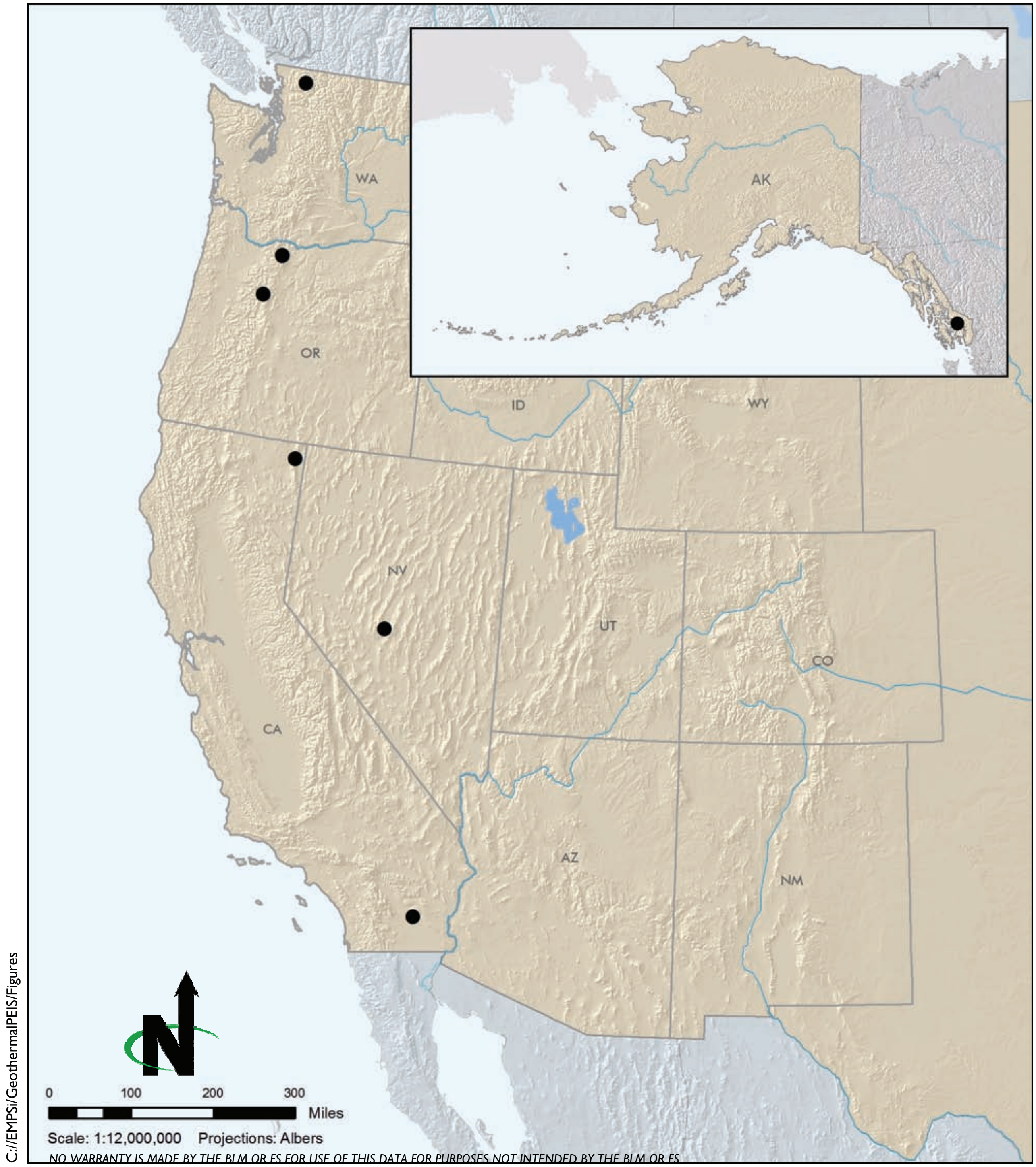
> "that the Memorandum of Understanding shall establish a program reducing the backlog of geothermal lease application pending on January 1, 2005, by 90 percent within the 5-year period beginning on the date of enactment of this Act, including, as necessary, by issuing leases, rejecting lease applications for failure to comply with the provisions of the regulations under which they were filed, or determining that an original applicant (or the applicant's assigns, heirs, or estate) is no longer interested in pursuing the lease application."

As of January 1, 2005, there were 194 pending lease applications; 130 on BLM public lands and 64 on NFS lands (Clarke 2006). Since January 1, 2005 the BLM and FS have processed or resolved many of the lease applications. Based on a detailed review of the status of pending leases, the BLM and FS have identified a total of 19 lease applications that require site-specific analysis in this PEIS to inform decisions to be made on whether to issue the lease or deny the application. Chapter 10 provides more details on the status of pending leases. These 19 leases are grouped together in seven geographic clusters (Table 2-4 and Figure 2-7). Two of the leases are on public lands administered by the BLM, 16 are on NFS lands, and one is on both public and NFS lands.

Under the proposed action, the FS would provide consent determinations for lease applications on NFS lands, and the BLM would issue the leases to the geothermal lease applicants. Separate decisions could be issued for each of the 19 leases, and lease boundaries could be adjusted in the decision to avoid unacceptable impacts to sensitive resources. The analysis of the lease areas is provided in Volume II.

Table 2-4
Pending Lease Applications (Prior to January 1, 2005)

Group	State	BLM or FS Office	Serial Number	Acres
1	AK	Tongass NF	AKAA 084543	2560
1	AK	Tongass NF	AKAA 084544	2560
1	AK	Tongass NF	AKAA 084545	2560
2	CA	El Centro FO	CACA 046142	2161
2	CA	El Centro FO	CACA 043965	1160
3	CA	Modoc NF	CACA 042989	480
3	CA	Modoc NF	CACA 043744	2560
3	CA	Modoc NF	CACA 043745	2560
4	NV	Battle Mtn FO and Humboldt-Toiyabe NF	NVN 074289	605
5	OR	Mount Hood NF	OROR 017049	1538
5	OR	Mount Hood NF	OROR 017051	2480
5	OR	Mount Hood NF	OROR 017052	2480
5	OR	Mount Hood NF	OROR 017053	1376
5	OR	Mount Hood NF	OROR 017327	1294
6	OR	Willamette NF	OROR 054587	1115
7	WA	Mt Baker NF	WAOR 056025	2403
7	WA	Mt Baker NF	WAOR 056027	2560
7	WA	Mt Baker NF	WAOR 056028	2544
7	WA	Mt Baker NF	WAOR 056029	1941



There are 19 pending noncompetitive lease application sites in seven different geographic areas evaluated in the PEIS. These are addressed in Volume II.

LEGEND:

● Pending lease application site

Evaluated Pending Lease Site Areas in the in the 11 Western States and Alaska

Figure 2-7

2.3 ALTERNATIVES

Three alternatives are evaluated in detail in the PEIS, the no action alternative and two action alternatives. Each is discussed below. A comparison of the action alternatives is presented in Table 2-5.

Table 2-5
Comparison of Geothermal Resource Allocations between the Action Alternatives

	Alternative B: Proposed Action (acres)	Alternative C: Leasing Near Transmission Lines (acres)
Public Lands in Planning Area	143,154,205	143,154,205
NFS Lands in Planning Area	103,582,163	103,582,163
Public Lands Open to Indirect Use[1]	118,007,636	61,202,746
Public Lands Open to Leasing for Direct Uses	118,007,636	118,007,636
NFS Lands Open to Leasing for Indirect Use[1]	79,217,147	37,870,654
NFS Lands Open to Leasing for Direct Uses	79,217,147	79,217,147
Public Lands Closed to Indirect Use[1]	25,146,569	81,951,459
Public Lands Closed to Leasing for Direct Uses	25,146,569	25,146,569
NFS Lands Closed to Leasing for Indirect Use[1]	24,365,016	65,711,509
NFS Lands Closed to Leasing for Direct Uses	24,365,016	24,365,016

[1] Indirect use includes commercial electrical generation.

2.3.1 Alternative A: No Action

Alternative A is the no action alternative. Under this alternative, no BLM land use plans would be amended and the existing plan decisions, stipulations, and allocations would not change as a direct result of the PEIS process. Therefore, any plans that do not address geothermal leasing would not be amended and the public lands would not be allocated as open or closed to geothermal leasing.

Processing of pending geothermal lease applications would continue; however, they would be evaluated on a case-by-case basis using analysis in the existing land use plans. Likewise, impacts on lands nominated in the future for leasing would be evaluated using analysis in existing land use plans. This could require additional NEPA documentation and possibly amendments to the plans. Many plans currently do not address geothermal leasing, do not have allocation decisions for geothermal leasing, and/or do not have appropriate RFDs on geothermal leasing. Taking no action would not facilitate the leasing process and does not meet the stated purpose and need; however, it is analyzed in detail to provide a baseline from which to evaluate the other alternatives in accordance with CEQ guidance.

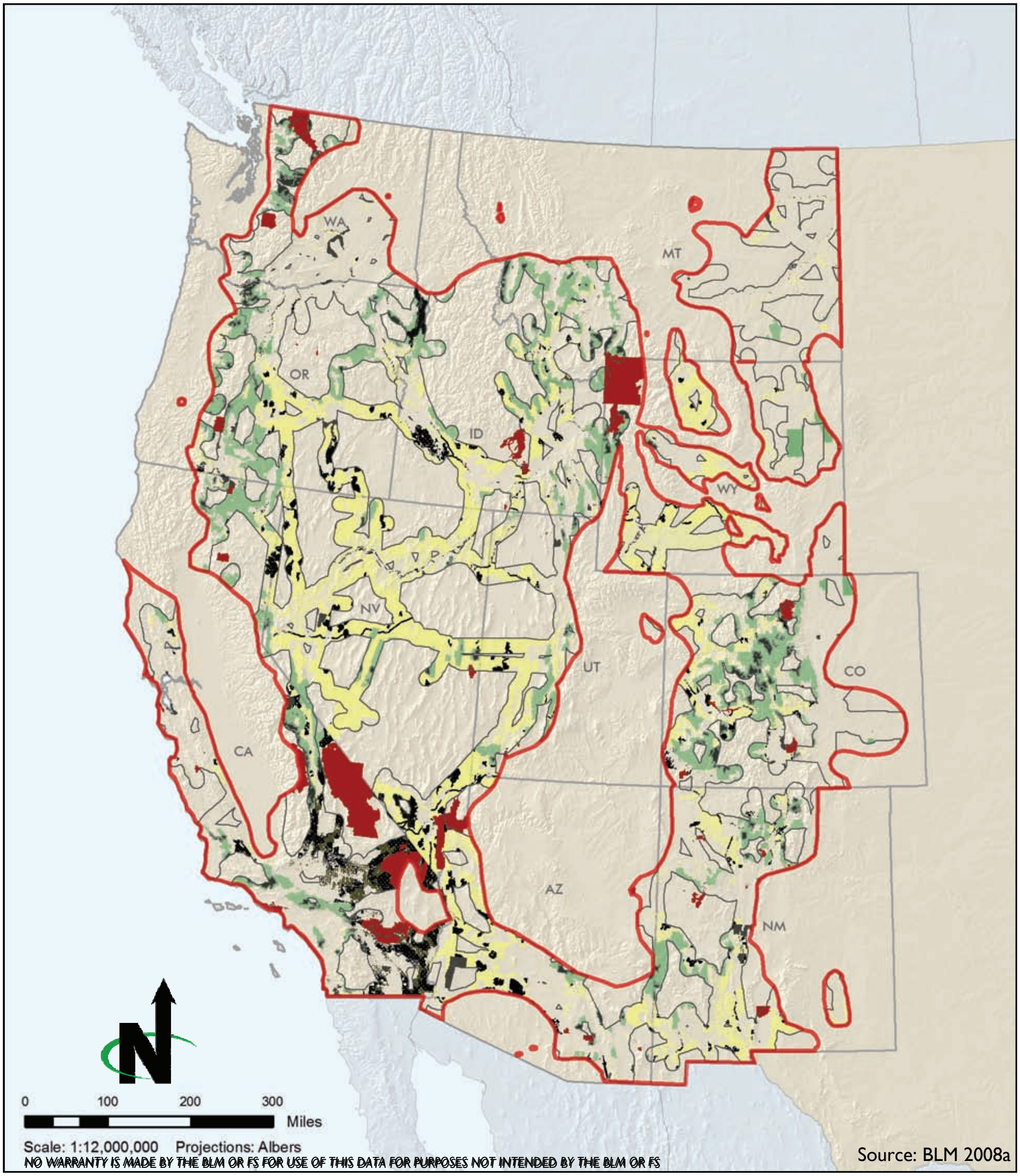
2.3.2 Alternative B: Proposed Action (Preferred Alternative)

As discussed above (Section 2.2 – Proposed Action) approximately 118 million acres of public land would be allocated as open and 79 million acres of NSF land would be legally open to geothermal leasing for direct and indirect use subject to existing laws, regulations, formal orders, stipulations attached to the lease form, and the terms and conditions of the standard lease form. The authorized officer retains the discretion to issue leases with stipulations that impose moderate to major constraints on use of surface of any leases in order to mitigate the impacts to other land uses or resource objectives as defined in the guiding resource management plan. This represents about 80 percent of public lands and NFS lands within the planning area. The remaining 25 million acres of public land and 24 million acres of NFS lands in the planning area would be closed to geothermal leasing. The closed areas encompass non-discretionary and discretionary (BLM only) determinations, including the statutorily closed Island Park Geothermal Area. This area encompasses over 470,000 acres of NFS and public lands around the west and southwest boundaries of Yellowstone National Park for the explicit purpose of protecting the geothermal features of the Park. The BLM would amend 122 land use plans to adopt the allocations, RFDs, and specific stipulations, best management practices, and procedures. Based on the analysis contained in the PEIS and public comments on the Draft PEIS, the BLM has selected Alternative B as the Preferred Alternative.

2.3.3 Alternative C: Leasing Lands near Transmission Lines

Under Alternative C, the BLM and FS would only consider leasing lands for commercial electrical generation if they are within a 20-mile corridor (10-mile from centerline) from existing transmission lines and lines currently under development at 60kV to 500kV (Figure 2-8). All lands within this corridor would be designated as closed or open with moderate to major constraints to leasing using the criteria outlined for the Proposed Action. Island Park Geothermal Area would also be closed (as with Alternative B); however, the restricted area would be expanded to include no leasing within 15 miles from the boundary of Yellowstone National Park. Given the limited transmission line grid and demand for localized power sources for remote communities, the lands available for geothermal leasing in Alaska would be the same as for Alternative B - Proposed Action. Leases for direct use would be considered for the entire planning area and would not be constrained by the location of transmission lines. Therefore, direct use leasing would be the same as the proposed action.

Under this alternative, approximately 61 million acres of public land and 38 million acres of NFS lands would be open for geothermal leasing for commercial



C://EMPSi/GeothermalPEIS/Figures

Under Alternative C, only BLM public and NFS lands near transmission lines would be available for leasing for commercial electrical generation. Direct use and Alaska would be the same as the Proposed Action.

LEGEND:

- Potential geothermal area
- National Park System Lands Closed to Leasing
- Public Lands Open to Leasing
- NFS Lands Open to Leasing
- Public and NFS Lands Closed to Leasing

Alternative C: BLM Public and NFS Lands Near Transmission Lines

Figure 2-8

electrical generation. These lands would be subject to moderate to major constraints as detailed in the Proposed Action. This alternative would increase the amount of land that would be unavailable for geothermal leasing with in the planning area; specifically, about 81 million acres of public land and 66 million acres of NFS lands would be closed. Other lands outside the corridor would not be closed to leasing, but would have to be evaluated on a case-by-case basis as described under the No Action Alternative. This alternative was developed in response to written and verbal recommendations during public scoping.

2.4 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED STUDY

2.4.1 No Leasing or Development of Geothermal Resources on Public or NFS Lands

The No Lease Alternative would not allow leasing of any geothermal resources. Under this alternative, all pending and future geothermal lease applications and nominations would not be approved so as to preclude any and all environmental consequences. This alternative was considered but eliminated from detailed analysis because it violates the multiple-use provisions of FLPMA and is inconsistent with the President's National Energy Policy, the Energy Policy Act of 2005, and Executive Order 13212. Consequently, the No Lease Alternative was not carried forward for detailed analysis.

2.5 REASONABLY FORESEEABLE DEVELOPMENT SCENARIO

The following reasonably foreseeable development (RFD) scenario serves as a basis for analyzing environmental impacts resulting from future leasing and development of Federal geothermal resources within the western US over the next 20 years. A variety of factors (e.g., economic, social, and political) are beyond the control of the BLM and FS and will influence the demand for geothermal resources. Therefore, the RFD scenario is a best professional estimate of what may occur if public and NFS lands are leased. It is not intended to be a "maximum-development" scenario; however, it is biased towards the higher end of expected development and shows where the potential development might occur. If future development eventually exceeds RFD predictions, then the BLM and FS will assess the impacts to the resources under the context of the analysis provided in the PEIS or specific land use plans and determine if additional analysis is warranted.

The RFD was based on a review of recent government and industry reports providing assessments of geothermal potential across the western US (Western Governors' Association 2006; DOE and BLM 2003; NREL 2006; BLM 2007a; Geothermal Energy Association 2007a) and the typical impacts associated with geothermal development (GeothermEx 2007). Few quantitative evaluations have been conducted at this scale, and those that exist are considered largely speculative due to the wide array of variables around future geothermal development. These variables include the speculative estimation of unexplored geothermal resources, the development of geothermal technologies that may allow for extraction of resources currently unusable, the unknown nature of future energy markets, and the unknown future of regulatory and political climates. While some reports cite substantial barriers to geothermal development, current movements in energy markets as well as political and regulatory climates look favorable for an expansion of geothermal energy development to move forward.

The BLM and FS have updated the RFD in this PEIS in response to public and agency comments and upon further reflection regarding recent developments that support the potential for some commercial electrical generation in Montana and Wyoming.

2.5.1 RFDs for Electrical Generation (Indirect Use)

Nearly 50 percent of the nation's geothermal energy production occurs on Federal land, largely in California and Nevada. The BLM manages 57 producing geothermal leases that provide geothermal energy to 54 power plants, with a capacity of 1,275 megawatts and produced about 4,609 gigawatt hours of electricity during fiscal year 2007.

Projected Power Plant Development

It is estimated that the 12 states in the project area have 5,540 MW of geothermal potential considered viable for commercial development by 2015, with a further 6,660 to 6,670 MW being forecast by 2025. This capacity is expected to be realized through approximately 111 additional power plants by 2015, and a further 133 power plants by 2025. Using these values, it is estimated that the average viable capacity at any particular site is 50 MW by 2025 (Western Governors' Association 2006). This projection is in addition to existing and plan capacity for the given locations.

Location of Development

Development would be distributed across the area shown by the geothermal potential map, developed as part of this PEIS (see Figures 1-5 and 1-6). The greatest development is expected to occur in California and Nevada, and the least in Arizona, Colorado, Wyoming, and Montana. A state-by-state breakdown of the potential is provided in Table 2-6, listing the states in order of decreasing capacity and decreasing expected intensity of development.

State-by-state potentials are further broken down into specific areas in Table 2-7, along with the likely development capacities for those areas. The table also includes the BLM Field Offices and National Forests associated with the high potential areas. These potential development sites are based on current best available information. Heat flow maps and existing hot spring location maps do not show a consistent area of high potential in Montana and Wyoming; therefore, no location-specific development expectations have been included in

Table 2-6
Estimated Future Geothermal Electrical Generation Development by State

State	Estimated Commercial Development by 2015 (MW)	Estimated Commercial Development by 2025 (MW)
California	2375	4703
Nevada	1473	2880
Idaho	855	1670
Oregon	380	1250
Utah	230	620
Washington	50	600
New Mexico	80	170
Alaska	20	150
Arizona	20	50
Colorado	20	50
Montana*	20	50
Wyoming*	20	50

Source: Western Governors' Association 2006; BLM and DOE 2003.
* Commercial development was not anticipated for Montana or Wyoming by the Western Governor's Task Force; however, based on input during the review of the Draft PEIS and recent developments in the two states, there is evidence that there is commercial generation potential.

Table 2-7
Commercially Viable Geothermal Capacity for Electrical Generation by High Potential Area and Associated BLM Field Offices and National Forests

State	Area of Potential	Projected MW at 2015	Projected MW at 2025	Associated BLM FO	Associated National Forest
CA	Border	0	30	El Centro	none
CA	Brawley	200	463	El Centro	none
CA	Calistoga	10	20	Ukiah	none
CA	Clear Lake Volcanic Field area	20	50	Ukiah	none
CA	Coso area	75	150	Ridgecrest	none
CA	Dunes	0	10	El Centro	none
CA	East Mesa	50	100	El Centro	none
CA	Glamis	0	10	El Centro	none
CA	Heber	20	50	El Centro	none
CA	Honey Lake & Wendell & Amidy	10	10	Eagle Lake	none
CA	Kelly HS	0	10	Alturas	none
CA	Mono - Long Valley	120	240	Bishop	Inyo
CA	Medicine Lake / Glass Mountain	480	480	Alturas	Modoc

Table 2-7
Commercially Viable Geothermal Capacity for Electrical Generation by High Potential Area and Associated BLM Field Offices and National Forests

State	Area of Potential	Projected MW at 2015	Projected MW at 2025	Associated BLM FO	Associated National Forest
CA	Morgan Springs-Growler Springs (includes parts of Lassen not in the National Park)	0	50	Redding	Lassen
CA	Mount Signal	25	25	El Centro	none
CA	Niland	75	150	El Centro	none
CA	Randsburg area	10	40	Ridgecrest	none
CA	Salton Sea area	860	2000	El Centro	none
CA	Superstition Mountain	25	25	El Centro	none
CA	Surprise Valley/Lake City	25	50	Surprise	none
CA	The Geysers	150	300	Ukiah	Mendocino
CA	Westmorland	50	100	El Centro	none
CA	Truckhaven	25	50	El Centro	none
CA	Mount Shasta - Military Pass Road area	120	240	Redding	Shasta
CA	East Brawley	25	50	El Centro	none
NV	Aurora	120	240	Carson City	Toiyabe
NV	Baltazor Hot Springs	15	30	Winnemucca	none
NV	Beowawe Hot Springs	50	100	Elko	none
NV	Blue Mountains	30	90	Winnemucca	none
NV	Brady Hot Springs	10	20	Winnemucca	none
NV	Buffalo Valley, Big Smoky Valley, Smith Creek Valley, and Monitor Valley	100	200	Battle Mountain	none
NV	Colado	30	60	Winnemucca	none
NV	Crescent Valley	50	100	Battle Mountain	none
NV	Desert Peak area	20	50	Winnemucca	none
NV	Dixie Valley	70	70	Carson City	none
NV	Sulfur Hot Springs (Double - Black Rock)	0	50	Elko	Humboldt
NV	Emigrant	50	100	Elko	none
NV	Fallon / Carson Lake	50	150	Carson City	none
NV	Fish Lake Valley	50	75	Battle Mountain	none
NV	Fly Range (Granite Ranch)	10	20	Winnemucca	none
NV	Great Boiling Springs (Gerlach)	30	60	Winnemucca	none
NV	Hawthorne	20	40	Carson City	none
NV	Hazen (Black Butte)	10	20	Carson City	none
NV	Hot Sulphur Springs (Tuscarora)	20	40	Elko	none

Table 2-7
Commercially Viable Geothermal Capacity for Electrical Generation by High Potential Area and Associated BLM Field Offices and National Forests

State	Area of Potential	Projected MW at 2015	Projected MW at 2025	Associated BLM FO	Associated National Forest
NV	Hyder Hot Springs	10	20	Winnemucca	none
NV	Kyle Hot Springs	15	30	Winnemucca	none
NV	Kyle Hot Springs (Granite Mtn.)	15	30	Winnemucca	none
NV	Leach Hot Springs	18	36	Winnemucca	none
NV	Lee & Allan Hot Springs	30	60	Carson City	none
NV	McGee Mountain	10	20	Winnemucca/ Surprise	none
NV	New York Canyon	35	70	Winnemucca	none
NV	North Valley / Black Warrior Peak	37	49	Winnemucca	none
NV	Pinto Hot Springs	29	58	Winnemucca	none
NV	Pirouette Mountain	23	46	Carson City	none
NV	Pumpernickel Valley	30	60	Winnemucca	none
NV	Pyramid Lake Indian Reserve	25	50	Carson City	none
NV	Rye Patch (Humboldt House District)	15	30	Winnemucca	none
NV	Salt Wells	50	50	Carson City	none
NV	San Emidio Desert area (Empire)	13	20	Winnemucca	none
NV	Shoshone-Reese River	18	36	Battle Mountain	none
NV	Silver Peak	50	100	Battle Mountain	none
NV	Soda Lake area	20	35	Carson City	none
NV	South Hot Springs	10	20	Carson City	Toiyabe
NV	Steamboat Springs	50	100	Elko	Toiyabe
NV	Stillwater area	30	60	Elko	Humboldt
NV	Trinity Mountains	50	75	Carson City	none
NV	Wabuska	10	20	Carson City	none
NV	Wilson Hot Springs	10	20	Carson City	Toiyabe
NV	Other non-geographically named locations.	150	300	Battle Mountain, Carson City, Elko, Winnemucca	Toiyabe
ID	Crane Creek - Cove Creek area	25	50	Four Rivers	none
ID	Raft River	150	200	Burley	none
ID	Big Creek Hot Springs	10	20	Salmon	Salmon-Challis
ID	Rexburg	20	100	Upper Snake	none
ID	Willow Springs	100	200	Upper Snake	none
ID	China Cap	100	200	Pocatello	none

Table 2-7
Commercially Viable Geothermal Capacity for Electrical Generation by High Potential Area and Associated BLM Field Offices and National Forests

State	Area of Potential	Projected MW at 2015	Projected MW at 2025	Associated BLM FO	Associated National Forest
ID	Other potential locations	450	900	Four Rivers, Burley, Jarbidge, Shoshone	
OR	Newberry Caldera	240	480	Prineville	Deschutes
OR	Crump's Hot Springs	20	40	Lakeview	none
OR	Three Creeks Butte	20	40	Prineville	Deschutes
OR	Trout Creek area	10	20	Prineville	Deschutes
OR	Neal Hot Springs	25	50	Vale	none
OR	Lakeview ~ Hot Lake area	20	20	Lakeview	none
OR	Summer Lake	20	50	Lakeview	Fremont
OR	Three Sisters, Mt Rose (east), Mt Hood	25	500	Prineville	Ochoco, Deschutes, Mt Hood
OR	Other potential locations	0	50	Burns, Vale, Prineville	none
UT	Cove Fort-Sulphurdale	50	200	Fillmore	Fishlake
UT	Roosevelt Hot Springs	100	250	Cedar City	none
UT	Thermo Hot Springs	50	100	Cedar City	none
UT	New Castle	10	20	Cedar City	none
UT	Other (Monroe, Mineral Mountain, etc.)	20	50	Richfield	Fishlake
WA	Mt Baker	50	100	Wenatchee	Mt. Baker-Snoqualmie
WA	Other Cascade volcanoes (Mt Adam area, Wind River area)		500	Wenatchee	Gifford Pinchot, Mt. Baker-Snoqualmie, Okanogan-Wenatchee
NM	Lower Rio Grande Rift (Including Tortugas Mtn. & Rincon)	50	100	Las Cruces	Gila (Lower Rio Grande Rift)
NM	Lightning Dock	20	40	Las Cruces	none
NM	Radium Springs, McGregor, San Diego, Lower Frisco	10	30	Las Cruces	none
AK	Hot Springs Bay Valley, Bell Island Hot Springs, Circle Hot Springs, Unalaska	20	150	Anchorage and Eastern Interior	Tongass (Bell Is. only)

Table 2-7
Commercially Viable Geothermal Capacity for Electrical Generation by High Potential Area and Associated BLM Field Offices and National Forests

State	Area of Potential	Projected MW at 2015	Projected MW at 2025	Associated BLM FO	Associated National Forest
AZ	Clifton, Gillard	20	50	Safford	Apache/ Sitgraves National Forest
CO	Waunita, Routt, Cottonwood, Mt Princeton, Poncha and Pagosa Hot Springs. Wagon Wheel Gap, Orvis, Ouray.	20	50		Routt (Routt), Uncompahgre (Orvis, Ouray), Rio Grande (Wagon Wheel Gap), San Juan (Poncha), Gunnison (Pagosa, Waunita), Arapaho/Gunnison (Cottonwood, Mt. Princeton)

Source: Western Governors' Association 2006; BLM and DOE 2003.

Table 2-7 for these two states. Additional locations unknown or unexpected at this time may occur. Development at any site will require additional NEPA evaluation to address site-specific resource values and analyze potential impacts.

Typical Phases in Geothermal Development

This RFD for geothermal resource use involves four sequential phases: (1) exploration, (2) drilling, (3) utilization, and (4) reclamation and abandonment. The success or failure of each phase affects the implementation of subsequent phases, and, therefore, subsequent environmental impacts. Development of geothermal resources is unique to the industry, but many activities are similar in scope to other fluid minerals (e.g., oil and gas), such as surveying, drilling, site-development (well pads and roads), and reclamation and abandonment. The general assumptions outlined in the following four phases serve to establish RFD scenarios for analyzing future environmental impacts that may result from development following BLM issuance of leases for geothermal resources within the identified area of geothermal potential. It should be noted that the RFD scenario permits a general evaluation of the types of impacts that may occur but cannot accurately predict the magnitude and extent of these impacts. This is due in part to the uncertainty about the timing, location, distribution of the geothermal resources, and the likely types of development.

Table 2-8 provides the estimated acreages of land disturbance for each phase in geothermal development for a typical power plant. The actual area of disturbance varies greatly depending upon site conditions and the type and size of power plant being constructed; therefore, a range is provided. Acreages are not provided for the Reclamation and Abandonment phase since this phase involves the return of previously disturbed lands to their existing conditions. The total potential amount of area disturbed under the utilization phase includes development activities. Much of the land would be reclaimed after the initial exploration, drilling, and construction; therefore, the actual amount of land occupied during operation, would be less. A typical development generally requires several leases or the use of private or other adjacent lands. The details of each phase of development are described below.

Table 2-8
Typical Disturbances by Phase of Geothermal Resource Development

Development Phase	Disturbance Estimate per Plant
Exploration	**2 – 7 acres**
Geologic mapping	negligible
Geophysical surveys	30 square feet[1]
Gravity and magnetic surveys	negligible
Seismic surveys	negligible
Resistivity surveys	negligible
Shallow temperature measurements	negligible
Road/access construction	1- 6 acres
Temperature gradient wells	1 acre[2]
Drilling Operations and Utilization	**51 – 350 acres**
Drilling and well field development	5 – 50 acres[3]
Road improvement/construction	4 – 32 acres[4]
Powerplant construction	15 – 25 acres[5]
Installing wellfield equipment including pipelines	5 – 20[6]
Installing transmission lines	24 – 240[7]
Well workovers, repairs and maintenance	Negligible[8]
TOTAL	**53 – 367 acres**

[1] Calculated assuming 10 soil gas samples, at a disturbance of less than three square feet each.
[2] Calculated assuming area of disturbance of 0.05 to 0.25 acre per well and six wells. Estimate is a representative average disturbance of all well sites. Some wells may require a small footprint (e.g., 30x30 feet), while others may require larger rigs and pads (e.g., 150x150 feet).
[3] Size of the well pad varies greatly based on the site-specific conditions. Based on a literature review, well pads range from 0.7 acres up to 5 acres (GeothermEx 2007; FS 2005). Generally a 30MW to 50 MW power plant requires about five to 10 well pads to support 10 to 25 production wells and five to 10 injection wells. Multiple wells may be located on a single well pad.
[4] One-half mile to nine miles; assumes about ¼ mile of road per well. Estimates 30-foot wide surface disturbance for a 18-20 foot road surface, including cut and fill slopes and ditches.
[5] 30 MW plant disturbs approximately 15 acres; 50 MW plant disturbs approximately 25 acres.
[6] Pipelines between well pad to plant assumed to be ¼ or less; for a total of 1½ to seven miles of pipeline in length, with a 25-foot-wide corridor
[7] Five to 50 miles long, 40-foot-wide corridor.
[8] Disturbance would be limited to previously disturbed areas around the well(s).

Phase One: Geothermal Resource Exploration

Before geothermal resources are developed, a geothermal resource developer explores for evidence of geothermal resources on leased or unleased land. Exploration includes ground disturbance but does not include the direct testing of geothermal resources or the production or utilization of geothermal resources. Exploration operations include, but are not limited to, geophysical operations, drilling temperature gradient wells, drilling holes used for explosive charges for seismic exploration, core drilling or any other drilling method, provided the well does not reach the geothermal resource. It also includes related construction of roads and trails, and cross-country transit by vehicles over public land. Exploration involves first surveying and then drilling temperature gradient wells. It generally takes between one and five years to complete exploration.

Surveying includes conducting or analyzing satellite imagery and aerial photography, volcanological studies, geologic and structural mapping, geochemical surveys, and geophysical surveys of leasable areas that could support geothermal resource development. The surveys consist of collecting electrical, magnetic, chemical, seismic, and rock data. For example, water samples from hot springs could be used to determine the subsurface characteristics of a particular area. Once the data is compiled, geologists and engineers examine the data and make inferences about where the higher temperature gradients may occur. High temperature gradients can indicate the location of potential underground geothermal reservoirs capable of supporting commercial uses.

Surveys may require creating access using four-wheel drive vehicles, or by helicopters or on foot to areas with no roads or very poor roads. Cutting of vegetation may be required in some areas to facilitate access. In some cases, gas collectors may be installed to measure soil gases. These collectors have partially buried sensors and may disturb small areas of less than three square feet (BLM 2007b).

While not widely used for geothermal surveys, seismic surveys have the greatest survey impact on the local environment. These surveys typically involve setting up an array of geophones and creating a pulse or series of pulses of seismic energy. The pulse is created either by detonating a small charge below the ground surface (requires drilling a narrow "shot hole") or by a vibroseis truck that is driven through the survey area. Data is transmitted from the geophones to a central location. The geophones may be installed on the ground's surface, in small excavations made specifically for burying the geophones, and/or in existing wells. These surveys are typically undertaken over the course of a few days. In areas where there is a lot of natural seismic activity, longer term installation of geophones may be undertaken to record naturally occurring earthquakes. Such cases do not involve a vibroseis truck (BLM 2007b).

Resistivity surveys include various methodologies from laying out long cables (up to 1,000 feet or more) on the land surface, or setting up equipment repeatedly in small areas (a few tens of square feet at the most for each measuring site). Minor, temporary disturbances are associated with each site for the burial of sensors (BLM 2007b).

The second step of the exploration phase is to drill temperature gradient wells on leased or unleased land. This process confirms a more precise location of high temperature gradients. Temperature gradient wells can be drilled using a truck-mounted rig and range from 200 feet to over 4,000 feet deep. The number of gradient wells also varies, depending on the geometry of the system being investigated and the anticipated size of power development. Geologists examine either rock fragments or long cores of rock that are brought up from deep within the well. Water samples are taken from any groundwater encountered during drilling. Also, temperatures are measured at depth. Both well temperatures and the results of rock sample analyses are used to determine if additional exploration is necessary to identify the presence and characteristics of an underground geothermal reservoir. After collecting the desired materials and data, the wells are completed with sealed, water-filled tubing from surface to bottom, often with cement around the tubing (BLM 2007b).

Source: Geothermal Education Office

Truck Mounted Rotary Rigs are commonly used to drill temperature gradient wells.

Most temperature gradient wells are drilled with a small rotary rig (often truck-mounted) similar to that used for drilling water wells, or a diamond-coring rig, similar to that used for geologic sampling in mineral exploration and civic works projects. Neither rig of this size requires construction of a well pad or earth moving equipment unless the site is sharply graded. Support equipment is needed, including water trucks, tanks for mixing and holding drilling fluids, personnel and supply transport vehicles, and sometimes a backhoe for earth-moving activities is needed to prepare the drilling site. A temperature gradient drilling operation can be run by about three on-site personnel and others traveling to the site periodically with materials and supplies (BLM 2007b).

Temperature-gradient well drilling requires road access. Whenever possible, a driller would access the temperature gradient well site using existing roads. When existing roads are not available, new access roads may need to be constructed for the truck-mounted rig to reach the site; this could require one to six acres of disturbance.

Preparing the site for drilling could include leveling the surface and clearing away vegetation. Several temperature gradient wells are usually drilled to determine both the areal extent of the temperature anomaly and where the highest temperature gradient occurs. Each drill site could disturb approximately 0.10 acres, and the drill rig could be approximately 60 feet tall. During exploration, a driller is not permitted to produce any fluids out of, or inject any fluids into, the well; therefore, the site may also host a sump or tanker truck. Additionally, a diesel generator may also be used at the site to power equipment. The well site itself involves excavation of a small cellar (typically less than three feet square and less than three feet deep) to allow the conductor casing to be set beneath the rig. Drilling may last for several weeks.

Temperature gradient wells are not intended to directly contact the geothermal reservoir, and therefore produce no geothermal fluids. In areas of known artesian pressures, any drilling expected to penetrate the groundwater table would include blow-out prevention equipment. In cases where a temperature gradient well does penetrate a geothermal zone, any release of geothermal fluids at the surface is likely to be minimal due to the small well diameters and the use of blow-out prevention equipment (BLM 2007b).

Drilling fluids may include drilling mud (bentonite clay, activated montmorillonite clay and crystalline silica-quartz), drilling mud additives (caustic soda, sodium bicarbonate, and anionic polyacrylamide liquid polymer), cement (Portland cement and calcium chloride), fuel (diesel), lubricants (usually petroleum-based) and coolants. The specific fluids and additives depends on a variety of factors, including the geologic formations being penetrated and the depth of the well. Releases of drilling muds are not permitted; a sump and tanker truck are required to capture all fluids. The risk of spills of other fluids is similar to that of any other project involving the use of vehicles and motorized equipment (BLM 2007b).

All surface disturbances would be reclaimed to the satisfaction of BLM and FS. If a temperature gradient well was unsuccessful, it would be abandoned, and the drill site would be reclaimed. Abandonment includes plugging, capping, and covering the wells. Reclamation includes removing all surface equipment and structures, regrading the site to predisturbance contours, and replanting native or appropriate vegetation to facilitate natural restoration.

Phase Two: Drilling Operations

Once exploration has confirmed a viable prospect for commercial development and necessary leases have been secured, the drilling of exploration wells to test the reservoir can proceed. Drilling Operations include flow testing, producing geothermal fluids for chemical evaluation or injecting fluids into a geothermal reservoir. This would also involve the construction of sumps or pits to hold excess geothermal fluids. It could involve development of minor infrastructure to conduct such operations.


Source: Geothermal Education Office
Drilling is an intensive process that requires the use of large production drill rigs

Drilling is an intense activity that requires large equipment (e.g., drill rig) and can take place 24 hours a day. A drilling operation generally has from 10 to 15 people on-site at all times, with more people coming and going periodically with equipment and supplies. Getting the rig and ancillary equipment to the site may require 15 to 20 trips by full-sized tractor-trailers; with a similar amount for de-mobilizing the rig. There would be 10 to 40 daily trips for commuting and hauling in equipment (BLM 2007b).

If a reservoir is discovered, characteristics of the well and the reservoir are determined by flow testing the well. If the well and reservoir were sufficient for development, a wellhead, with valves and control equipment, would be installed on top of the well casing. Excess geothermal fluids are stored in temporary pits or sumps, generally lined with plastic (small sumps) or clay (large sumps). The water is left to evaporate and any sludge is removed and properly disposed.

Phase Three: Utilization

Utilization and production is the next phase after a viable reservoir is determined and includes the infrastructure needed for commercial operations, including access roads, construction of facility structures, building electrical generation facilities, drilling and developing well fields, and installing pipelines, meters, substations, and transmission lines. The utilization phase could last from 10 to 50 years and involves the operation and maintenance of the geothermal field(s) and generation of electricity.

The type of development utilization that occurs is based on the size and temperature of the geothermal reservoir. Geothermal resources can be classified as low temperature (less than 90°C, or 194°F), moderate temperature (90°C to 150°C, or 194 to 302°F), and high temperature (greater than 150°C, or 302°F). Only the highest temperature resources are generally used for generating electrical power; however, with emerging technologies and in colder climates such as Alaska, even the lower temperature resources are proving usable for electrical generation.

High temperature reservoirs are suitable for the commercial production of electricity. Three types of power plants that harness geothermal resources are dry steam plants, flash steam plants, and binary-cycle plants. Occasionally a hybrid between flashed steam and binary system is also used. Dry steam power plants use the steam from the geothermal reservoir as it comes from the wells and route it directly through turbine/generator units to produce electricity. Flash steam power plants use water at temperatures greater than 182°C (360°F). Water is pumped under high pressure to the generation equipment at the surface, the pressure is suddenly reduced, allowing some of the hot water to convert, or "flash," into steam, and the steam is used to power the turbine/generator units to produce electricity. Binary-cycle power plants use water from the geothermal reservoir to heat another "working fluid." The working fluid is vaporized and used to turn the turbine/generator units. The geothermal water and the working fluid never come in contact with each other. Binary-cycle power plants can operate with lower water temperature 74°C to 182° C (165°F to 360°F) and produce few air emissions. See Chapter 1 for a more detailed discussion.

Development of the lease would involve the following construction and operations:

- Access roads—New access roads to accommodate the larger equipment associated with the development phase could be constructed. In general, a plant can require 1/2 –mile to nine miles of roads in order to access the site, well pads, and power plant. Depending on the type and use-intensity of the road, the areas of surface disturbance is about 30-feet wide for a 18-20 foot wide road surface, including cut and fill slopes and ditches.
- Drill site development— Multiple wells may be drilled per lease. Production-size wells can be over two miles (10,560 feet) deep. The number of wells is dependent upon the geothermal reservoir characteristics and the planned power generation capacity. For example, a 50MW (net) power plant could require up to 25 production wells and 10 injection wells. It is common that multiple wells would be installed on a well pad. The size of the well pad is dependent upon site conditions and on the number of wells for the pad, but they are typically about one to five acres, including minor cut and fill. In order to drill these deep holes, a large drilling rig or derrick would be erected. Various temporary support facilities may be located on-site, including generators, mud tanks, cement tanks, trailers for the drillers and mud loggers, housing trailers, and storage sheds. As appropriate, facilities can be painted to blend in with the surrounding environment. Drilling operations can occur 24 hour a day.
- Wellfield equipment—A geothermal power plant is typically supported by pipeline systems in the plant's vicinity. The pipeline systems include a gathering system for produced geothermal fluids, and an injection system for the reinjection of geothermal fluids after heat extraction takes place at the plant. Pipelines are usually 24 to 36 inches in diameter, but can be


Source: Geothermal Education Office
A well head and pipeline are part of the overall well field that connects the resource to the power plant

Source: Geothermal Education Office

Pipelines connect the wells to the power plant.

as small as 8 inches depending on the type of pipeline. Pipelines transporting hot fluids or steam to the plant are covered with insulation, whereas injection pipelines are generally not. When feasible, they would parallel the access roads and existing roads to the destination of the geothermal resource's steam or water. Pipelines are typically constructed on supports above ground, resulting in little if any impact to the surrounding area once construction is complete and the corridor has been revegetated. The pipelines typically have a few feet of clearance underneath them, allowing small animals to easily cross their path. The pipelines are typically painted to blend in with the surrounding environment. In general, plants have about 1½ to seven miles of pipes with a corridor width of about 25 feet.

Power plants include a variety of infrastructure, including cooling towers.

- Power plant—A 50 MW plant would utilize a site area of up to 20 to 25 acres to accommodate all the needed equipment, including the power plant itself, space for pipelines geothermal fluids and reinjection, a switch yard, space for moving and storing equipment, and buildings needed for various purposes (power plant control, fire control, maintenance shop, etc.). The power plant itself would occupy an estimated 25 percent of this area for a water-cooled plant, or about 50 percent for an air-cooled plant. Where topography permits, the power plant could be situated so as to be less visible from nearby roads, trails, scenic vistas or scenic highways. The site of the plant requires reasonable air circulation to allow for efficient operation of the plant's condensers. A smaller, 20 MW plant would typically require approximately five to ten acres for the entire complex.

Transmission lines are critical for getting the power from the resource to the consumer.

- Electric transmission lines—Transmission lines may range in length from 5 miles to 50 miles with a corridor width of approximately 40 feet. Wooden poles most likely support them, and about 5 acres could be disturbed per mile of transmission line.

- Reclamation—When a production well is successful, a wellhead with valves and control equipment is installed on top of the well casing. If a production well is unsuccessful, the production well would be plugged and capped, and the site would be reclaimed.

The number of personnel required during construction varies significantly, but at any one point there may be a few hundred laborers and professionals on-site with attendant vehicle traffic. The number of people required for routine operation of a power plant is typically three per shift; however, additional personnel (as many as 12 total, depending on plant size) may be on site during the day for maintenance and management (BLM 2007b)

Activities associated with operation and maintenance and energy production would involve managing waste generated by daily activities, managing geothermal water, landscaping, and the maneuvering of construction and maintenance equipment and vehicles associated with these activities.

Phase Four: Reclamation and Abandonment

This phase involves abandoning the well after production ceases and reclaiming all disturbed areas in conformance with BLM and FS standards. Abandonment includes plugging, capping, and reclaiming the well site. Reclamation includes removing the power plant and all surface equipment and structures, regrading the site and access roads to predisturbance contours, and replanting native or appropriate vegetation to facilitate natural restoration.

Areas of Disturbance from Power Plant Development

The phase of development resulting in the greatest area of disturbance is the geothermal resource development stage, which includes the expansion of well pads and access roads, drilling of the production and reinjection wells, construction of the power plants, pipelines, and electrical transmission lines. Projected ranges for areas of disturbance from each of these components on both a per-plant basis (Table 2-8) and cumulatively across the entire planning area for both 2015 and 2025 are shown in Table 2-9.

Table 2-9
Cumulative Range of Acre Disturbances for the RFD

Component	Total Acreage Range per 50MW Plant[1]	Projected 2015 Acreage Range Across Planning Area[2]	Projected 2025 Acreage Range Across Planning Area[2]
Access roads	4 – 32	444 – 3,552	976 – 7,808
Well pads	5 – 50	555 – 5,550	1,220 – 12,200
Pipelines	5 – 20	555 – 2,220	1,220 – 4,880
Power plants	15 – 25	1,665 – 2,775	3,660 – 6,100
Electrical transmission lines	24 – 240	2,664 – 26,640	5,856 – 58,560
TOTAL	**53 – 367**	**5,883 – 40,737**	**12,932 – 89,548**

[1] See assumptions in Table 2-8.
[2] Calculated assuming 111 power plants at 50 MW each by 2015, and a further 133 power plants of 50 MW each by 2025.

Geothermal Fluid Production and Associated Waste

Geothermal fluid production and associated waste production is likely to occur for short periods as wells are tested to determine reservoir characteristics. If geothermal fluids are discovered in commercial quantities, development of the geothermal field is likely. The rate of fluid production from a geothermal reservoir is unknown until the development testing phase is completed. During the initial stages of testing, one well is likely to be tested at a time. If testing is successful and the well and reservoir are sufficient for development, wellheads, valves, and control equipment would be installed on top of the well casing.

Using data from other areas of geothermal development, it appears that production of geothermal fluids can be expected to vary widely from one to six million gallons per well, per day. Assuming five million gallons per day, per well as an average production figure, a lease with two producing wells would produce 10 million gallons of fluid per day.

Most geothermal fluids produced are re-injected back into the geothermal reservoir, via reinjection wells. In flash steam facilities about 15-20 percent of the fluid can be lost due to flashing to steam and evaporation through cooling towers and ponds. Binary power plants utilize a closed loop system, therefore, well production and reinjected operate with no fluid loss. Fluids can also be lost due to pipeline failures or surface discharge for monitoring/testing the geothermal reservoir.

The routinely used chemicals for a binary geothermal plant include the hydrocarbon working fluid (such as iso-butane or n-pentane) and the lubricating oil used in the downhole pumps. If a well's pressure falls below the "bubble point," if it possible that downhole scaling might occur. This requires either a mechanical clean-out with a drilling rig or a coiled-tubing unit, or an "acid job," during which acid (typically hydrochloric acid or less commonly hydrogen fluoride) is injected into the wellbore to dissolve the scale. If scaling is persistent, the operator may choose to adopt routine injections of a scale-inhibitor chemical, such as polymaleic anhydride or polyacrylic acid, used in dosages of one to 10 parts per million (US BLM 207b).

2.5.2 RFDs for Direct Use

Geothermal waters are being used directly for a wide variety of applications across the western US. These uses include:

- Agricultural uses, such as controlling environmental conditions for growing crops, flowers, or trees;
- Aquacultural uses, such as controlling environmental conditions for raising fish or other animals;

- District heating and cooling systems for college campuses, residential neighborhoods, municipal buildings, national park buildings, and other types of buildings;
- Public safety uses, such as eliminating ice and snow on public sidewalks;
- Public health uses through food processing, such as dehydration, washing, and processing; and
- Recreational uses, such as hot tubs, steam baths, and mud baths.

Direct use applications are distributed across the project area, with the greatest number being in California, Idaho, Oregon and Colorado. Table 2-10 lists the six major categories of direct use applications, and the prevalence of each within the 12 states covered by this PEIS. The size of these applications range from less than 0.1 to 30 thermal megawatts, with most being between one and six thermal megawatts.

Table 2-10
Distribution of Direct Use Applications within Project Area

Direct Use Application	AK	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY
Greenhouses	4	0	4	1	13	4	4	0	4	5	0	1
Aquaculture	0	4	17	4	5	1	0	5	2	1	0	1
Spas/pools	10	6	57	18	36	19	12	13	18	11	6	16
Space heating	7	1	18	15	9	10	1	6	22	2	0	1
District heating	0	0	3	1	5	0	2	4	2	0	0	0
Industrial	0	0	1	0	0	1	0	0	1	0	0	0

Source: Oregon Institute of Technology 2008

Projected Applications Development

Quantitative estimates of the thermal energy of likely-to-be-developed direct use applications over the 2015 to 2025 timeframe are not available for the western US in the way that they are for indirect uses; however, for the US as a whole, the DOE National Renewable Energy Laboratory has developed estimates of thermal megawatts that are developable. It is estimated that by 2015, direct use applications could be developed in the amount of 1,600 thermal megawatts, and by 2025, this number is estimated to be 4,200 thermal megawatts (NREL 2006).

The cost in exploration of geothermal resources for direct use is a limiting factor in many direct use proposals. Drilling exploration wells is cost-intensive and there is no guarantee of finding a sufficient resource on first attempt. Unlike most geothermal electric power projects that are funded by corporations who can handle both the risk and substantial costs of exploration activities, most direct use projects are implemented by smaller companies or individual entrepreneurs or communities that have less financing and smaller projected profits.

Advances in exploratory technology and methodology as well as new grant programs to help project proponents get exploration underway could result in an acceleration of development of direct use applications across the western US.

Location of Development

Direct uses do not require the same high-temperature waters that are required for electricity generation; therefore, the geographic areas considered to have potential for direct use applications are much broader than the areas considered having potential for indirect use. The potential areas of development of direct use applications are indicated by the bounds of the geothermal potential map, developed as part of this PEIS (see Figures 1-5 and 1-6).

Direct use resources are more likely to be developed when they are in proximity to existing communities. In the 12 state project area, it is estimated that there are 293 "collocated" cities and communities with a combined population of 7.4 million that could potentially utilize geothermal heat through direct uses. The collocated communities counted here are defined as being within five miles of a known geothermal resource having a temperature of at least 122°F (50°C) (Oregon Institute of Technology 2008).

Typical Phases in Development

Phase One: Exploration

Existing direct use applications are largely collocated with, and draw directly from, existing surface geothermal manifestations such as hot springs, eliminating the need for most exploration activities. Exploration activities in the past have often been limited to water temperature and chemistry analysis.

Looking to the future, it is likely that most direct use applications will not be able to draw from existing surface manifestations as they have in the past. Surface manifestations such as naturally occurring hot springs have become increasingly sought after with increases in population in the western US, increased recreational use, and more stringent regulations preserving such resources for their recreational, cultural or scenic value. In such cases where surface manifestations are not nearby or are not being utilized directly, exploration activities similar to those described above for indirect use would also apply for direct use.

Phase Two: Drilling

In applications where a surface manifestation is used directly, the resource development phase involves installing piping into that manifestation to withdraw the hot water. For applications requiring the drilling of a well, drilling activities would be the same as described above under Phase Two for indirect use.

Phase Three: Utilization

The utilization phase typically lasts for several decades or longer. Activities associated with the production phase are generally limited to maintenance and repair activities of all components of the collection, distribution and injection/use/disposal system.

As described above for indirect use, the drilling of production wells may be necessary. Drilling activities would be similar to that discussed above in the drilling phase. Some applications may inject the post-use geothermal fluids back into the ground, in which case an injection well would be drilled and connected via piping to the application. In other applications where the spent geothermal fluids are discharged to a surface water body or used for some other purpose, then discharge piping, collection systems or distribution systems may need to be constructed. For such systems where the waters are not reinjected into the geothermal reservoir but are rather discharged or otherwise used, treatment systems may need to be installed to reduce levels of any naturally occurring but toxic chemicals present within the geothermal waters, such as mercury, arsenic and boron to meet applicable health or environmental standards.

Operation and maintenance of existing facilities and production of geothermal energy also takes place during the production phase. Activities associated with operation and maintenance and energy production would involve managing waste generated by daily activities, managing geothermal water, landscaping, and the maneuvering of construction and maintenance equipment and vehicles associated with these activities.

Phase Four: Reclamation and Abandonment

As described above for indirect use, this phase involves abandoning the well after production ceases and reclaiming all disturbed areas in conformance with BLM and FS standards. Abandonment includes plugging, capping, and reclaiming the wells. Reclamation includes removing all surface equipment and structures, regrading the site to predisturbance contours, and replanting native vegetation.

Areas of Disturbance from Direct Use Applications

Surface disturbances for direct use are generally much less than for indirect use since direct uses are more likely to be located near existing communities with less of a need for new access roads. Also, since direct use applications utilize the geothermal energy on-site, there is no need for the construction of electrical equipment and transmission lines, except for bringing in electricity from the existing grid to the facility being constructed. Surface disturbances can still be expected for well pad development, site access, and construction of the facility utilizing the resource, although in some cases the facility may already exist and may simply be shifting its heat source to geothermal.

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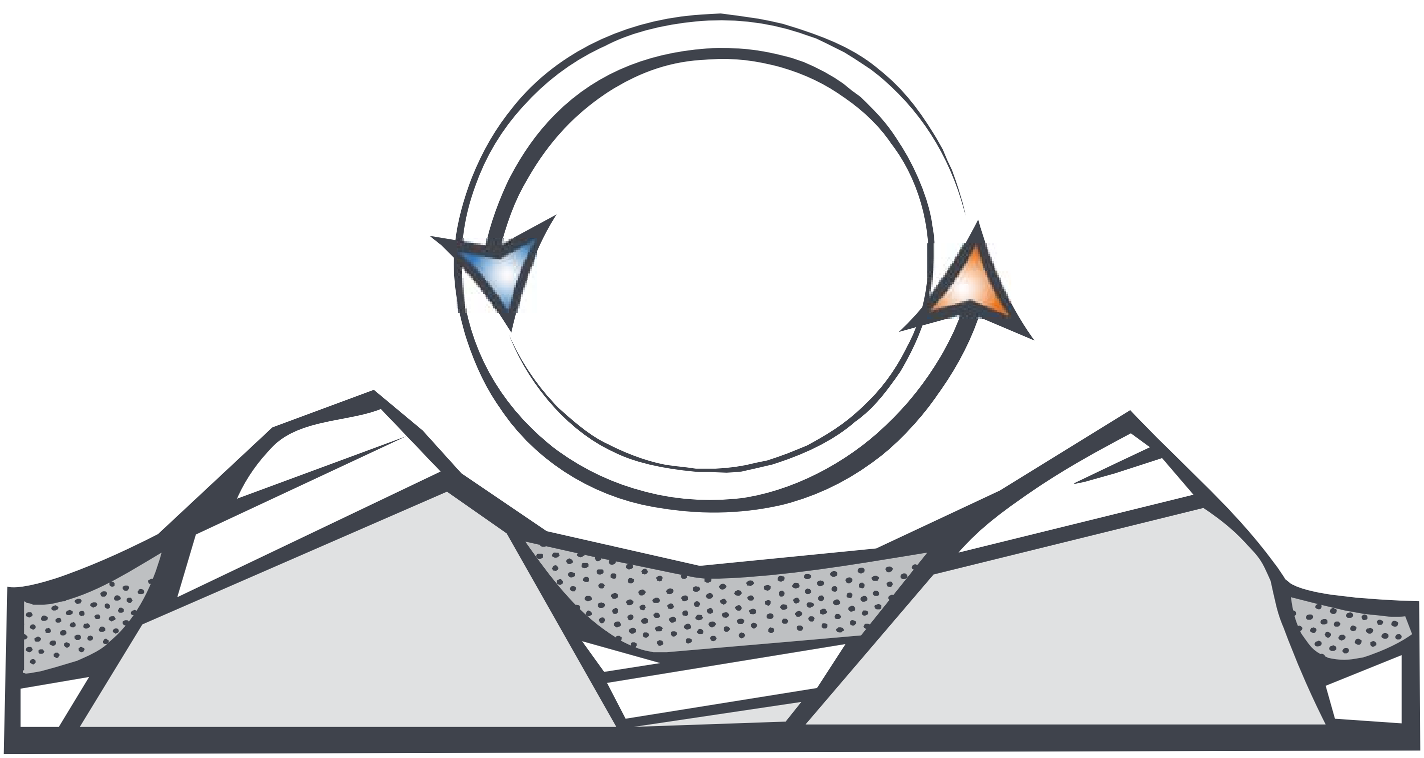


Chapter 3
Affected Environment

CHAPTER 3
AFFECTED ENVIRONMENT

3.1 INTRODUCTION

This chapter provides a description of the biological, physical, and socioeconomic characteristics, including human uses, that could be affected by any future actions (including but not limited to any decisions to lease and/or develop geothermal resources) that may be taken consistent with implementing one of the alternatives considered in this PEIS, as described in Chapter 2. Information from broad-scale assessments were used to help set the context for the planning area. The information and direction for BLM resources has been further broken down into fine-scale assessments and information where possible. Specific aspects of each resource discussed in this section (e.g., water supply, air emissions, weeds, OHV use) were raised during the public and agency scoping process. The level of information presented in this chapter is commensurate with and sufficient to assess potential effects of any future actions (including but not limited to leasing and/or develop geothermal resources) that may be taken consistent with the alternatives in Chapter 4.

The planning area for the Geothermal PEIS is the area of geothermal potential in the western US states. The planning area includes BLM- and FS-administered surface lands with minerals under federal ownership that have geothermal potential and the subsurface federal geothermal mineral estate on other lands (see Section 1.9.1).

This section contains a description of the biological and physical resources of the planning area and follows the order of topics addressed as follows:

- Land Use, Recreation, and Special Designations;
- Geologic Resources and Seismic Setting;
- Energy and Minerals;
- Paleontological Resources;

- Soil Resources;
- Water Resources;
- Air Quality and Climate;
- Vegetation;
- Fish and Wildlife;
- Threatened and Endangered Species and Special Status Species;
- Wild Horse and Burros;
- Livestock Grazing;
- Cultural Resources;
- Tribal Interests and Traditional Cultural Resources;
- Natural Scenic and Historic Trails;
- Visual Resources;
- Socioeconomics and Environmental Justice;
- Health and Safety; and
- Noise
- Health and Safety

Table 3-1 lists identified critical resources and where they are addressed in this EIS.

Table 3-1
Critical Resources Identified Through Scoping

Resource	Corresponding PEIS Section
Air Quality	Air Quality and Climate
Areas of Critical Environmental Concern	Land Use, Recreation, and Special Designations
Cultural Resources	Cultural Resources and Tribal Interests and Traditional Cultural Resources
Hazardous Materials	Health and Safety
Invasive and Nonnative Species	Vegetation
Migratory Birds	Fish and Wildlife
Native American Religious Concerns	Tribal Interests and Traditional Cultural Resources
Threatened and Endangered Species	Threatened and Endangered Species and Special Status Species
Water Quality (Surface/Ground)	Water Resources
Wetlands/Riparian Zones	Vegetation
Wild and Scenic Rivers	Land Use, Recreation, and Special Designations
Wilderness	Land Use, Recreation, and Special Designations

3.2 LAND USE, SPECIAL DESIGNATIONS, AND RECREATION

3.2.1 Land Use

The western US is comprised of federally managed lands intermixed with private parcels. In some areas, federally managed lands dominate the landscape with small parcels of private lands (e.g., Nevada). However, in other instances, large tracts of private lands are interspersed with smaller tracts of federally managed lands (e.g., California). Federal lands are managed by federal agencies that have specific legislation guiding how their lands are to be used. The BLM and FS are two of the largest land management agencies mandated by national policies to administer their lands under the concept of multiple uses, while protecting long-term land health. Other federal land managers include the US Department of Defense, USNPS, USFWS, and US Bureau of Reclamation. Table 3-2, Acreage and Percentage of Federally Managed Lands in the Project Area as of Fiscal Year 2006, identifies the acreage of federal land within the project area (12 western states).

Table 3-2
Acreage and Percentage of Federally Managed Lands in the Project Area as of FY2006

State	Total State Acreage	Federal Land Acreage	Percent Land Federally Managed
Alaska	368,993,000	250,640,000	67.93
Arizona	72,777,000	51,084,000	70.19
California	100,977,000	52,879,000	52.37
Colorado	66,624,000	27,604,000	41.43
Idaho	53,339,000	36,413,000	68.27
Montana	94,234,000	37,940,000	40.26
Nevada	70,828,000	62,530,000	88.28
New Mexico	77,925,000	35,077,000	45.01
Oregon	62,126,000	34,840,000	56.08
Utah	54,318,000	39,018,000	71.83
Washington	43,064,000	16,825,000	39.07
Wyoming	62,593,000	31,633,000	50.54
Total	**1,127,798,000**	**676,483,000**	**59.98**

Source: BLM 2008c; FS 2008a

Federal Lands in the Planning Area

Within the planning area, or geothermal potential area, the BLM manages about 143 million acres and the FS manages about 104 million acres. These agencies are responsible for managing natural resources and resource uses, such as timber, minerals, livestock grazing, recreation, wildlife, and wilderness.

Table 3-3, Acreage of Public and NFS Lands in the Planning Area, identifies the amount of land managed by the BLM and FS in the planning area.

Table 3-3
Acreage of Public and NFS Lands in the Planning Area

State	BLM-Surface Acres	NFS- National Forest Acres	NFS- National Grasslands Acres[1]	Total Acreage
Alaska	5,860,536	2,732,322	-	8,592,858
Arizona	8,842,090	2,166,912	-	11,009,002
California	13,969,825	13,467,992	-	27,437,817
Colorado	6,288,740	15,092,198	786,000	22,166,938
Idaho	12,716,814	17,691,599	76,000	30,484,413
Montana	3,438,730	8,370,307	-	11,809,037
Nevada	45,991,073	6,221,008	-	52,212,081
New Mexico	9,507,142	8,314,108	-	17,821,250
Oregon	14,025,425	14,579,444	167,000	28,771,869
Utah	10,766,598	3,056,933	-	13,823,531
Washington[2]	--	6,430,898	-	6,430,898
Wyoming	11,747,232	2,863,442	1,566,000	16,176,674
Total	**143,154,205**	**100,987,163**	**2,595,000**	**246,736,368**

[2] Acreage calculations for Oregon and Washington are combined because states share one single BLM state-level office.
Source: BLM 2008c; FS2008a; [1]Olson 1997

United States Department of Agriculture, Forest Service

The National Forest Management Act of 1976 amended the Forest and Rangeland Renewable Resources Planning Act of 1974, which called for the management of renewable resources on NFS lands. The National Forest Management Act requires the Secretary of Agriculture to assess NFS lands, develop a management program based on multiple-use, sustained-yield principles, and implement a resource management plan for each unit of the NFS. The primary statues which authorize the disposal of renewable resources on NFS lands include the Organic Administration Act, Multiple-Use Sustained-Yield Act and the Bankhead-Jones Farm Tenant Act.

The FS is the federal agency responsible for the administration of the 191 million acres of land that comprise the NFS (Olson 1997). These lands consist of national forests and grasslands. The largest component of the NFS is the national forests. There are 155 national forests that contain more than 187 million acres. This amounts to almost 98 percent of the total acreage in the NFS.

The second largest component of the NFS is the national grasslands (Olson 1997). The FS currently administers 20 national grasslands consisting of

3,842,278 acres. National grasslands are located in 13 states. However, nine national grasslands consisting of 3,161,771 acres are in the Great Plains states of Colorado, North Dakota, South Dakota, and Wyoming. National grasslands in these four states alone contain more than 82 percent of the total national grassland acreage.

Bureau of Land Management

The BLM manages public lands under the authority of the Federal Land Policy and Management Act of 1976, Public Law 94-579, (43 USC 1714) (FLPMA). FLPMA provides direction for land use planning, administration, range management, rights-of-way, designated management areas (including specific locations and general designation of wilderness areas), and effects on existing rights (BLM 2008i).

The BLM is responsible for carrying out a variety of programs for the management and conservation of resources on 258 million surface acres, as well as 700 million acres of subsurface mineral estate (BLM 2008f). These surface acres comprise about 13 percent of the total US land surface and more than 40 percent of all land managed by the federal government.

Most of the public lands located in the western US, including Alaska, are characterized predominantly by extensive grassland, forest, high mountains, arctic tundra, and desert landscapes (BLM 2008j). The BLM manages multiple resources and uses, including energy and minerals; timber; forage; recreation; wild horse and burro herds; fish and wildlife habitat; wilderness areas; and archaeological, paleontological, and historical sites. In addition to its minerals management responsibilities, the BLM administers mineral leasing and oversees mineral operations on federal mineral estate underlying other state, private, or federally administered land, and manages most mineral operations on Indian lands.

The BLM administers approximately 57 million acres of commercial forests and woodlands through the Management of Lands and Resources and the Oregon and California Grant Lands appropriations (BLM 2008j). Under its multiple-use management mandate, the BLM administers more than 18,000 livestock grazing permits and leases and nearly 13 million authorized livestock AUMs on 160 million acres of public rangeland. The BLM also manages herd management areas and facilities for 57,000 wild horses and burros.

The BLM has an active program of soil and watershed management on 175 million acres in the lower 48 states and 86 million acres in Alaska (BLM 2008j). The 258 million acres of public lands include over 117,000 miles of fisheries habitat. Practices such as revegetation, protective fencing, and water development are designed to conserve and enhance public land, including soil and watershed resources.

Land Use Authorizations

Land use authorizations include various authorizations and agreements to use BLM-administered land, such as right-of-way (ROW) grants, road use agreements, and associated temporary use permits. Land use authorizations are issued for a variety of purposes, both short and long term. Short-term uses include agricultural leases, military training areas, and other uses involving minimal land improvements or disturbances. Long-term uses include rights-of-way grants for power lines, highways, roads, pipelines, fiber optics, communication sites, electric power generation sites, and irrigation.

Rights-of-way and Utility Corridors

As a general rule, a ROW is needed whenever a project is built on public lands (BLM 2008e). A ROW grant is an authorization to use a specific piece of public land for a certain project, such as roads, pipelines, transmission lines, and telephone lines. The grant authorizes rights and privileges for a specific use of the land for a specific period of time. Generally, a BLM or FS ROW is granted for a term commensurate with the life of the project. Typically, BLM grants are issued with 30-year terms, and most can be renewed. A more complete explanation of the BLM ROW program is found in Title 43 CFR 2800 and 2880. The BLM has also initiated efforts to streamline the application processing procedures (Instruction Memorandum No. 96-27 and Instruction Memorandum No. 97-18). A FS grant remains in effect unless terminated by mutual agreement or one agency giving the other 90 days prior written notice (FS 2003a). A more complete description to the FS ROW program is found in FS Manual 5460.

The EPAct of 2005 includes various initiatives directed at securing the nation's energy future, which include authorizing the US DOE in collaboration with federal land management agencies to designate corridors for energy transmission on federal lands within the 11 contiguous western states. The PEIS for Designation of Energy Corridors on Federal Land in the 11 Western States (US DOE and BLM 2007) considers 11 contiguous western states for the possible construction, operation, maintenance, and decommissioning and dismantling of energy infrastructure such as oil and gas pipelines and electric transmission lines; the states considered are Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. Geothermal resource development would use energy corridors to distribute electricity (US DOE and BLM 2007).

Land Use Permits and Leases

A lease is an authorization to possess and use public land for a fixed period of time. A lease is issued when there is going to be substantial construction, development, and improvement and there is an investment of large amounts of capital that will be amortized over time. Permits are authorized when uses of public lands will be short term and involve little or no land improvement, construction, or investment. Permits and leases are subject to process and monitoring fees and a fair market rental value.

Withdrawals

A land withdrawal is a real estate management tool to implement resource management planning prescriptions or to transfer administrative jurisdiction from one federal agency to another (BLM 2008c). A withdrawal creates a title encumbrance on the land, thereby restricting an agency's ability to manage its lands under multiple use management principles. The restrictions generally segregate the lands from some or all the public land laws and some or all of the mining and mineral leasing laws for a specific period of time, generally 20 years for post-FLPMA withdrawals. Withdrawn land can be closed to mining, mineral leasing, or mineral material disposal.

There are four major categories of formal withdrawals: administrative; Presidential Proclamations; Congressional; and Federal Power Act or Federal Energy Regulatory Commission Withdrawals (BLM 2008d). Withdrawals accomplish one or more of the following: transfer total or partial jurisdiction of federal land between federal agencies; close (segregate) federal land to operation of all or some of the public land laws and/or mineral laws; and dedicate federal land to a specific public purpose.

Split Mineral Estate

Public and NFS land ownership can involve split mineral estate situations, which involve separate surface ownership than subsurface ownership. For example, a parcel may contain private surface ownership and federal subsurface ownership, or it may contain federal surface ownership and private subsurface ownership. Through various acts, the federal government has retained mineral values, while encouraging settlement. As late as the 1980s, BLM policy concerning mineral estate was to reserve all oil and gas rights, as well as any other mineral values. Those lands on which the US reserved minerals and where they contain valuable mineral resources are generally kept in federal ownership. Many of the private surface owners have requested that the subsurface minerals be sold or transferred to their ownership.

3.2.2 Special Designations

The following section describes special management designations on public and NFS lands in the project and planning areas. These special areas have been designated to protect unique characteristics and contain resources that have been identified as scientifically, educationally, or recreationally important. Special management is administered with the intent to improve the manageability of the areas, allowing the BLM and FS to preserve, protect, and evaluate these significant components of national heritage. Special area designations on public and NFS lands can be established by Congress, Presidential Proclamation, or administratively. The BLM and FS have the authority to adopt special management designations through RMP or Forest Plan amendments or revisions.

Areas Designated by Congress or Presidential Proclamation

Congressional designations (Table 3-4) include Wilderness, National Conservation Areas, National Scenic Areas, National Recreation Areas, rivers in the National Wild and Scenic Rivers System, National Trails (discussed in detail under Section 3-16, National Scenic and Historic Trails) and Other Congressionally Designated Areas. The Steens Act Mineral Withdrawal Area is a Congressional designation specific to southeastern Oregon. National Monuments are designated by Presidential Proclamation or less commonly by Congressional designation. In instances where designations occur by an Act of Congress or Presidential Proclamation, the law or order designating each area provides specific objectives and guidelines for that area's management. Neither the BLM nor the FS has jurisdiction over lands other than public or NFS lands, respectively, within nationally designated areas.

Wilderness Areas

These areas are part of the National Wilderness Preservation System to ensure preservation and protection of their natural conditions. Nationwide, the FS manages more Wilderness areas (418) than any other agency, followed by the BLM (189). In the project area, there are a total of 408 Wilderness areas; California contains the most Wilderness areas (137), followed by Arizona (90), Nevada (68), and Alaska (48). In the planning area, there are 362 Wilderness areas. Activities and uses that do not support management objectives of these areas are prohibited. As such, subject to valid existing rights, Wilderness areas are withdrawn from all forms of mineral entry, location, and patent under the mining laws, and from disposition under all laws pertaining to mineral leasing.

National Conservation Areas

National Conservation Areas are designated mainly for the purpose of protecting natural or cultural resources. They may also be established to protect a variety of ecological, scenic, scientific, riparian, and recreation values. While most are managed for resource protection and recreation, activities such as grazing, logging, mining, and other commercial enterprises are often permitted. There is no single congressional act that guides the management of these areas. Instead, the particular Act that authorizes designation of each National Conservation Area identifies the unique values to be protected and any other specific management guidelines to be followed. In the project area, the BLM manages 17 National Conservation Areas, and the FS manages none. In the planning area, the BLM manages 15 National Conservation Areas, and the FS manages none.

Table 3-4
Congressional, Presidential, and Administrative Special Designation Areas on Public and NFS Lands in the Project and Planning Areas

Agency	Acreage									
	Congressional Designations							Administrative Designations		
	Wilderness Areas	National Conservation Areas	National Scenic Area	National Recreation Area	Wild and Scenic Rivers	Other Congressionally Designated Areas (FS)[1]	National Monuments	Wilderness Study Areas	Areas of Critical Environmental Concern (BLM)[2]	National Forest Inventoried Roadless Areas (FS)[3]
BLM (Project Area)	7,663,272	15,291,405	-	-	631,605	-	4,770,225	13,641,594	12,450,547	-
BLM (Planning Area)	6,441,930	2,223,694	-	-	333,254	-	1,288,035	10,050,923	8,243,565	-
FS (Project Area)	32,352,798	-	199,705	2,258,250	604,110	2,021,534	310,784	3,227,819	-	52,934,355
FS (Planning Area)	19,057,887	-	180,299	1,709,808	310,140	1,177,521	192,228	788,597	-	31,457,013
Total (Project Area)	**40,016,070**	**15,291,405**	**199,705**	**2,258,250**	**1,235,715**	**2,021,534**	**5,081,008**	**16,869,413**	**12,450,547**	**52,934,355**
Total (Planning Area)	**25,499,817**	**2,223,694**	**180,299**	**1,709,808**	**643,394**	**1,177,521**	**1,480,264**	**10,839,520**	**8,243,565**	**31,457,013**

1 Other Congressionally-Designated Areas are a FS-specific designation
2 Areas of Critical Environmental Concern are a BLM-specific designation
3 National Forest Inventoried Roadless Areas are a FS-specific designation
Source: BLM 2008c, FS 2008a

National Scenic Areas

These areas are designated to protect the scenic, cultural, historic, recreational, and natural resources in specific areas, while allowing compatible uses. The management policies for a specific National Scenic Area are set forth in the legislation designating it. In the project area the FS manages five National Scenic Areas. In the planning area, the FS manages three National Scenic Areas. No National Scenic Areas in the project or planning area are managed by the BLM.

National Recreation Areas

This designation was established primarily to protect important recreation, scenic, scientific, and natural values for the enjoyment of current and future generations. The activities center on water- and land-based activities associated with the natural environment. The uses and activities allowed within National Recreation Areas depend on the law designating the area and can vary widely. The FS manages 32 National Recreation Areas in the project area and nine in the planning area. No National Recreation Areas within the project or planning area are managed by the BLM.

Rivers in the National Wild and Scenic Rivers System

To effectively manage these special river segments, Congress established the National Wild and Scenic Rivers System. Rivers, or segments of rivers, must be free flowing and possess at least one outstandingly remarkable value, such as scenic, recreational, geologic, fish, wildlife, historic, cultural, or other features. The Bureau has many rivers not congressionally designated under the Act, but found to be eligible under the act. The outstandingly remarkable values of eligible rivers must be protected until superseded by Congress. Within the National Wild and Scenic Rivers System, three classifications define the general character of designated rivers: wild, scenic, or recreational. Classifications reflect levels of development and natural conditions along a stretch of river. These classifications are used to help develop management goals for the river.

There are approximately 1,235,715 acres of rivers in the National Wild and Scenic Rivers System in the project area and approximately 643,384 acres in the planning area. Nationwide, the northwestern states of Alaska, Washington, Oregon, Montana, and Idaho contribute well over half of the rivers to the National Wild and Scenic Rivers System, with Oregon leading the US with 48 designated rivers (National Wild and Scenic River System 2007). Four federal agencies cooperatively manage the congressionally designated rivers where rivers flow through federal lands. On federal lands, the National Park Service manages the most segments (29 percent), followed by FS (27 percent), BLM (22 percent), and USFWS (19 percent). The remaining river segments (less than 3 percent) are administered by a state.

National Monuments

These areas are designated to protect unique resources identified within the monument boundaries. National Monuments are managed by the BLM, FS, USFWS and NPS. Federal lands in National Monuments are generally closed to mineral development subject to valid existing rights. One exception is the Canyons of the Ancients National Monument in southwestern Colorado, which permits new leasing for oil and gas where a lessee makes a discovery on an existing lease and efficient recovery of the oil and gas resources requires drilling, or where necessary to protect oil and gas resources on federal lands against drainage.

Administrative Designations

At their discretion, both the BLM and FS may apply administrative designations (Table 3-4) in areas requiring special management. Administrative designations are not legislative. Special areas that are designated administratively by the BLM include Areas of Critical Environmental Concern (ACECs), Research Natural Areas, National Natural Landmarks, Backcountry Byways, and Watchable Wildlife Areas. Special areas designated by the FS include WSAs, Research Natural Areas, and Inventoried Roadless Areas. In addition, for the purposes of analysis in this PEIS, Wilderness Study Areas (WSAs) are also evaluated under administrative designation, however only Congress can provide additional direction for these areas.

Uses are permitted in the administratively designated areas to the extent that the uses are in harmony with the purpose for which the area was designated. All of the areas identified under this section would be closed to geothermal leasing or would be open with major constraints.

Wilderness Study Areas

The BLM and FS manage approximately 13,641,594 and 310,784 acres of WSAs in the project area, respectively. In the planning area, the BLM and FS manage approximately 10,050,923 and 788,597 acres of WSAs, respectively. The agencies are responsible for managing WSAs in such a manner to prevent impairment of their suitability for congressional designation as wilderness. The WSA designation remains until Congress makes a final decision on whether to designate the WSA as Wilderness, adding it to the National Wilderness Preservation System, or to release the lands from wilderness review. There are no time limitations on Congress, so it is uncertain when final decisions will be made on any WSA designation.

Areas of Environmental Concern

The FLPMA states that the BLM will give priority to the designation and protection of ACECs in the development and revision of land use plans. The ACEC designation is an administrative designation unique to the BLM; no other agency uses this form of designation. The ACEC designation indicates to the public that the BLM recognizes that an area has significant values and has established special management measures to protect those values. In addition, an ACEC designation also serves as a reminder that significant values(s) or resource(s) exist that must be accommodated when future management actions and land use proposals are considered near or within an ACEC. These ACECs differ from other special management designations, such as WSAs, in that designation by itself does not automatically prohibit or restrict other uses in the area. The one exception is that a mining plan of operation is required for any proposed mining activity within a designated ACEC. In the project area, the BLM manages 794 ACECs encompassing approximately 12,450,547 acres. In the planning area, the BLM manages 616 ACECs comprising approximately 8,243,565 acres. Appendix C identifies which ACECs are open or closed to fluid mineral leasing and what stipulations are required in areas open to leasing.

Inventoried Roadless Area

This FS-specific administrative designation represents some of the nation's most highly valued expanses of open space. Under this designation, approximately 58.5 million acres are conserved nationwide, or 31 percent of NFS lands, totaling about 2 percent of the total US land base. Nationwide, approximately 25 percent of the total acres of inventoried roadless areas are in Alaska. Another 72 percent of the nationwide total is in the remaining 11 states of the project area. The remaining 3 percent is outside the project area. In the project area, there are approximately 52,934,355 acres of inventoried roadless areas; and in the planning area, there are approximately 31,457,013 acres of inventoried roadless areas.

3.2.3 Recreation

Recreation opportunities on public and NFS lands range from dispersed uses, such as hiking and wildlife viewing, to developed recreation, including campgrounds and interpretive sites. Recreation is an important component of the multiple use management practices carried forth by both the BLM and FS. Recent surveys by these agencies demonstrate that recreational use on public and NFS lands is increasing annually. Steady population growth continues to increase the recreational demand on undeveloped public and NFS lands as visitors and nearby residents seek a diversity of recreational opportunities.

The Recreation Opportunity Spectrum is both a classification system and a prescriptive tool for recreation planning, management, and research (Clark and Stankey 1979). It is used by both the BLM and FS to illustrate the recreational setting by describing a combination of the physical, biological, social, and managerial conditions that give value to a place. The Recreation Opportunity Spectrum embodies six land classes: primitive; semiprimitive, nonmotorized; semiprimitive, motorized; roaded, natural; rural; and urban. Each setting prompts experiences that range from a sense of isolation and closeness to nature (at the primitive end of the spectrum) to social experiences in highly structured environments (at the urban end of the spectrum). The immense landscape of the project area contains a variety of recreation settings and opportunities allowing visitor to select the experiences most closely matching their reason for using public and NFS lands.

United States Department of Agriculture, Forest Service

Many people use NFS lands, waters, and recreation sites for physical exercise, nature exploration, and as an important means of relaxation (FS 2008a). The FS reports visitation estimates using standard definitions of national forest visits and national forest site visits. A national forest visit is defined as the entry of one person upon a national forest to participate in recreation activities for an unspecified period of time. A site visit is defined as the entry of one person upon a national forest site or area to participate in recreation activities for an unspecified period of time. In effect, a national forest visit is composed of one or more national forest site visits (FS 2008a).

According to the National Forest Visitor Use Monitoring Program, annual visitation to NFS lands nationwide is approximately 204.8 million national forest visits. Visitors averaged about 1.2 site visits for each national forest visit, or 245.9 million site visits. Included in the site visit total are 8.8 million site visits to designated Wilderness (FS 2008a).

Providing outdoor recreational opportunities is a primary goal identified in the FS Strategic Plan for Fiscal Years 2004 to 2008 (FS 2004a). More specifically, the FS recreational objectives are to:

- maximize opportunities for visitors to know and experience nature while engaging in outdoor recreation;
- develop and manage sites consistent with the available natural resources to provide a safe, healthful, esthetic, nonurban atmosphere; and
- provide a maximum contrast with urbanization at NFS sites (FS 2006a).

Many people visit NFS lands to camp, picnic, boat, or visit some other type of developed recreation facility. The top five activities pursued on NFS lands are viewing natural features, experiencing general relaxation, hiking, viewing wildlife, and pleasure driving (FS 2008a). Downhill skiing also is a popular activity in some regions.

Many of the facilities and services associated with FS recreation opportunities are free (FS 2008b). Some require fees or permits to help maintain, manage, and improve sites and facilities. Recreation permits may be required when extra measures are needed to protect natural or cultural resources. A Special Use Permit, which may include a fee, grants rights or privileges of occupancy and use to the holder. Examples include reserving a public site for a wedding party or holding a bicycle race on NFS lands. These permits contain specific terms and conditions that the holder must follow. Before Special Use Permits are issued, the FS must determine that the proposed use complies with all management plans and laws, that there is a demonstrated need for the activity, and that the use is appropriate on NFS lands. Special Use Permits are a temporary authority.

Bureau of Land Management

Public lands offer a number of diverse recreational opportunities. On more than 258 million acres of public lands, people enjoy several types of outdoor adventure, including camping, hunting, fishing, hiking, horseback riding, boating, whitewater rafting, hang gliding, off-highway vehicle driving, mountain biking, birding and wildlife viewing, taking photography, climbing, engaging in all types of winter sports, and visiting natural and cultural heritage sites. Recreational use on BLM-managed lands also helps support the economies of western communities and states. More than 22 million people now live within 25 miles of public lands, and two-thirds of public lands are within 50 miles of an urban area (BLM 2008g). Visits to recreation sites on public lands have significantly increased over the years, from just more than 51 million in 2001 to over 55 million in 2006, an almost 8-percent increase.

The BLM's outdoor recreation mission is to sustain healthy land and water resources while providing quality visitor services (BLM 2008f). The BLM's overall vision for outdoor recreation is "Visitors renewing their relationships with the land and respecting local cultures while enjoying quality recreation activities." The BLM provides resource-dependent recreational opportunities in a variety of settings that typify the vast western landscapes of the project area (BLM 2008f). These diverse settings range from Alaska's tundra to the deserts of the Southwest, and from the old growth forests of the Northwest to the plateaus and plains of the Rocky Mountain states. As a national provider of recreation, the BLM focuses on providing resource-based versus facilities-based recreation and tourism opportunities. Tourism generated by the recreation and leisure opportunities on public lands contributes significantly to the national economy, as well as to local economies (BLM 2008f). The BLM provides recreation opportunities in areas having national, regional, and local importance.

Recreational opportunities of regional and local importance are provided in a variety of settings on project area public lands: non-fee sites, rivers not in the National Wild and Scenic Rivers System (5,763 miles), and inventoried trails not in the National Trail System (7,468 miles) (BLM 2008f). While the BLM's focus is on providing resource-based recreation and tourism opportunities, the BLM provides facilities where necessary to protect resources and to serve as staging areas for resource-based recreation use. For the most part, however, facilities are not the attraction in and of themselves. In some areas, visitors are charged a recreation use fee or entrance fee to help cover the cost of facility maintenance and resource protection. The Federal Lands Recreation Enhancement Act (Public Law 108-447, Section 804) grants recreation fee authority to federal agencies including the BLM and FS to maintain and improve the quality of visitor amenities and services (BLM 2008h). It authorizes three fee categories: standard amenity fees, expanded amenity fees, and special recreation permits.

All public lands are allocated as a Special Recreation Management Area or an Extensive Recreation Management Area. A Special Recreation Management Area is a unit where specific recreation/tourism interests have expressed a desire for certain kind of activities, experiences, and other benefits. As such, these units are managed intensively for recreation, and the setting character in these units is a high priority. Areas with a Special Recreation Management Area allocation typically see investments in recreation facilities and visitor services. An Extensive Recreation Management Area is a unit with no identifiable market demand for structured recreation opportunities. Rather, an Extensive Recreation Management Area emphasizes the traditional dispersed recreation use of public lands. Extensive Management Areas are managed custodially; resources committed are generally limited and include provisions for visitor health and safety, and those aimed at reducing damage and mitigating user conflict. Visitors who want to avoid areas of intensive recreation activities generally prefer Extensive Recreation Management Areas. By default, anything not allocated as a Special Recreation Management Area becomes part of an Extensive Recreation Management Area.

Recreation Areas

The BLM and FS manage a diversity of recreation areas in the project area. These areas are managed and maintained for public use and offer a variety of opportunities such as camping, hiking, boating, interpretive programs, fishing, horseback riding, and wildlife viewing. Table 3-5, Number of BLM and FS Recreation Areas in the Project Area by State, lists the number of recreation areas managed by the BLM and FS in each state; these include campsites, trails not listed as nationally historic or scenic, sites at rivers and creeks not included in the National Wild and Scenic Rivers System, reservoirs, picnic sites, day-use areas, and certain multi-use recreational areas.

Table 3-5
Number of BLM and FS Recreation Areas in the Project Area by State[1]

State	Total # of BLM Recreation Areas in the Project Area	Total # of FS Recreation Areas in the Project Area[1]
Alaska	9	13
Arizona	38	49
California	41	298
Colorado	14	116
Idaho	50	103
Montana	4	55
Nevada	32	20
New Mexico	48	21
Oregon	49	107
Utah	83	153
Washington	11	98
Wyoming	38	52
Total	417	1,085

[1] Specially designated areas omitted from calculations include the following: Designated Critical Habitat, National Conservation Areas, National Game Refuge and Wildlife Preserves, National Historic Districts, National Historic and Scenic Trails, National Monuments, National Preserves, National Primitive Ares, National Protections Areas, National Recreation Areas, National Scenic Areas, National Scenic Research Areas, National Volcanic Monument Areas, National Wild and Scenic Rivers, (National) Wilderness Areas, Rental units (including cabins, lookouts, yurts, stations, kitchens, bunkhouses and A-frames), State Parks (Anasazi), Visitor, Discovery, and Information Centers, and Wilderness Study Areas.
Source: Recreation.gov (2008)

3.3 GEOLOGIC RESOURCES AND SEISMIC SETTING

The project area's geology is the result of large scale tectonic activity over hundreds of millions of years. The center of the North American continent, including central Canada and the central US, has been stable for over 600 million years. At the western edge, other pieces of crust have been added to the North American continent. The processes by which these pieces were added deformed the existing crust. The physiography (terrain texture, rock types, and geologic structure and history) of the western US is primarily a product of these additions and deformations.

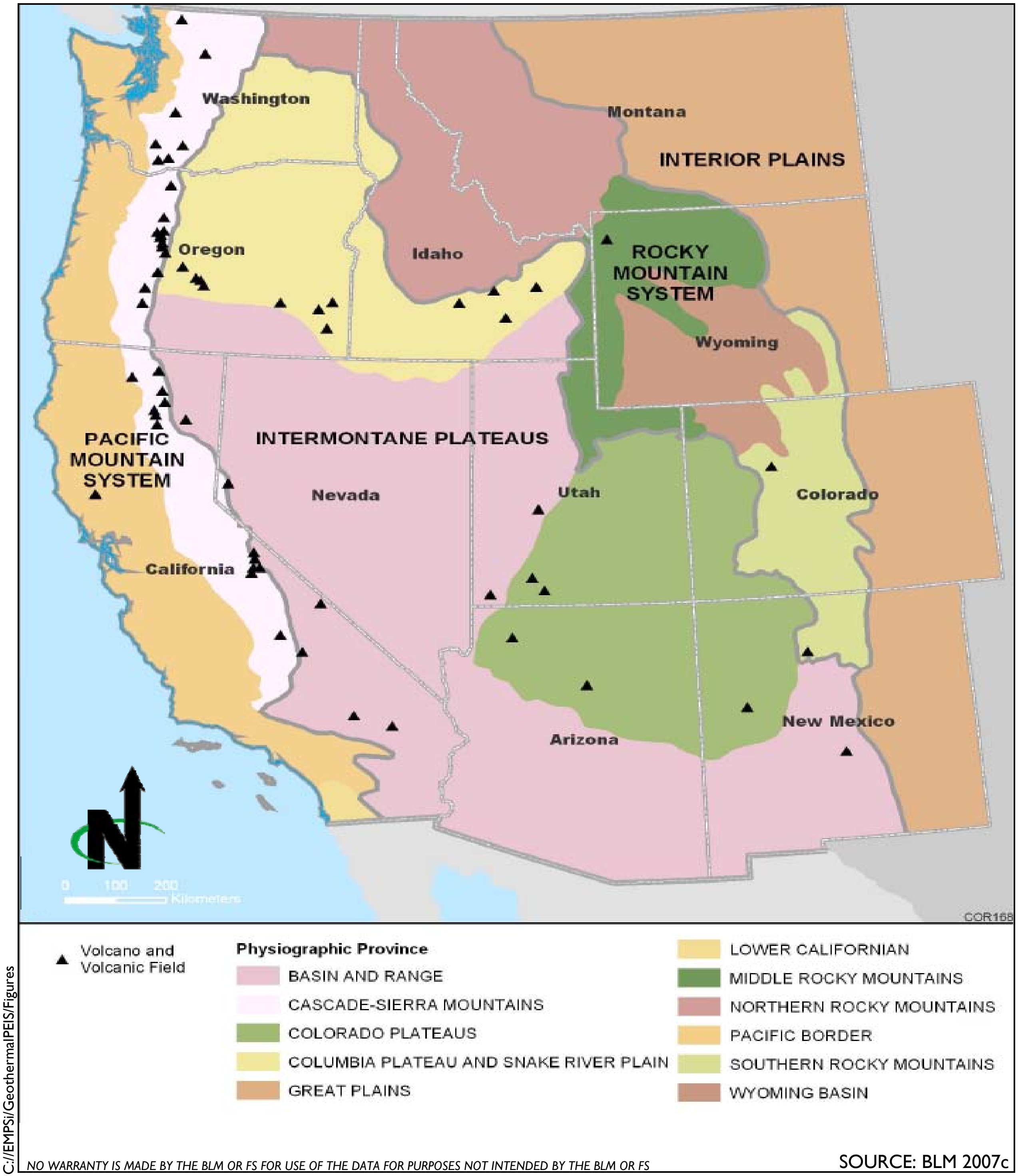
The western states are made up of several physiographic provinces with generally similar terrain and geologic characteristics. These physiographic provinces include the Great Plains, Southern Rocky Mountain, Wyoming Basin, Middle Rocky Mountain, Northern Rocky Mountain, Basin and Range, Colorado Plateau, Columbia Plateau, Cascade-Sierra Mountains, Pacific Border, and Lower California provinces. The characteristics of the physiographic provinces and Alaska are discussed below (Figure 3-1).

Regional Geologic History

During the last half of the Mesozoic Era, much of today's California, Oregon, and Washington were added to the North American continent. As slabs of ocean crust sank beneath the western edge of the continent, some pieces of continental crust were added to the continent, while other pieces were carried along with the sinking ocean slab (USGS 2004a). About 200 to 300 miles inland, magma generated above the sinking ocean slab rose into the North American continental crust erupting out of dozens of individual volcanoes. Volcanic mountain ranges grew as lava and ash erupted, and great masses of molten rock were injected and hardened in place beneath the surface (USGS 2004a).

For 100 million years, the effects of plate collisions were focused very near the edge of the North American continent. Three major mountain-building episodes reshaped the western US from about 170 to 40 million years ago (Jurassic to Cenozoic Periods). It was not until 70 million years ago that these effects began to reach the Rocky Mountains, resulting in raising mountains far inland from the western edge of the continent (USGS 2004a).

The southwestern US is beginning to be pulled apart by extensional forces. These forces are due to molten rock flowing in the earth's mantle beneath the solid crust. The extension results in a thinning of the crust over the mantle. The volcanism in the Basin and Range and the Rio Grand Rift is associated with this crustal extension and thinning. The crustal extension and associated volcanic activity, although slow, is ongoing and is the source of much geothermal heat (USGS 2003a).



C://EMPSi/GeothermalPEIS/Figures

There are 11 Physiographic Provinces in the 11 Western States

Physiographic Provinces of the 11 Western States

Figure 3-1

3.3.1 Characteristic by Physiographic Province

Great Plains

Physiography

The Great Plains physiographic province includes the west-central US, including eastern Montana, eastern Wyoming, eastern Colorado, and eastern New Mexico within the project area (Figure 3-1).The province is characterized by flat to rolling prairie with scattered hills and bluffs gradually rising westward to abruptly give way to the frontal ranges of the Rocky Mountains in the Southern Rocky Mountain and Basin and Range physiographic provinces (USGS 2002). With the exception of the Black Hills of South Dakota, with altitudes of 7,000 feet, the entire region has low relief (USGS 2002, USGS 2004b).

Geology

The Great Plains is a vast region that spreads across the stable core of North America. This area formed when several small continents collided and welded together over a billion years ago during the Precambrian. Precambrian metamorphic and igneous rocks form the basement of the Great Plains and make up the stable nucleus of North America. The province has experienced more than 500 million years of relative tectonic stability, remaining relatively unaffected by the mountain-building tectonic collisions suffered by the western and eastern margins of the continent (USGS 2004b).

During part of the Jurassic (208 to 144 million years ago), rising seas flooded the low-lying areas of the continent. Much of the Great Plains eventually lay submerged beneath shallow seas with sediments eroding from the rising Rocky Mountain deposited as layered wedges of fine debris. As sand, mud, and clays accumulated, the seas retreated northward. Once again, during the Cretaceous (144 to 65 million years ago), record high sea levels flooded the continental interior with shallow seas (USGS 2004b). The flatness of the Great Plains is a reflection of the platform of mostly flat-lying marine and stream deposits laid down in the Mesozoic and Cenozoic Eras (USGS 2004b). Uplifts, such as the Black Hills Uplift in eastern Wyoming and western South Dakota, are places where the Paleozoic and younger sedimentary rocks have been eroded away and crystalline rocks are exposed (USGS 2002).

Southern Rocky Mountains

The Southern Rocky Mountains are part of the Rocky Mountain System, a discontinuous series of mountain ranges that extend from central New Mexico northwest to the Canadian border (Figure 3-1). The system also includes the Middle Rocky Mountain, Northern Rocky Mountain, and Wyoming Basin provinces (USGS 2003a).

Physiography

West of the frontal ranges in Colorado and northern New Mexico are additional and higher mountain ranges generally oriented north-south but with many spurs and extensions oriented in other directions. These ranges are separated by valleys and high mountain parks. The ranges include 54 mountain peaks higher than 14,000 feet. Most of these high peaks are located near the Continental Divide, which extends approximately north-south through central Colorado and western New Mexico. The altitude of the divide decreases in southern New Mexico to less than 4,500 feet in some areas (USGS 2002).

Geology

The last major mountain-building event affecting the western US (about 70 to 40 million years ago) is responsible for raising the Rocky Mountains (USGS 2004a). Prior to the mountain-building uplifts, most of the area was covered by an extensive layer of sediments that had been deposited during the previous millions of years. These layers of sediment were gradually buried and altered to form layers of rock. The Great Plains province to the east of the Southern Rocky Mountains is still underlain by a relatively flat and undeformed sequence of these rocks (USGS 2002).

The uplift of the Rocky Mountains faulted, deformed, and elevated the land surface and the underlying ordered layers of rock. Faulting was prevalent, and a few faults developed more than 20,000 feet of vertical offset. As uplift continued, erosion removed the uppermost rocks and, in some areas, exposed the underlying crystalline-rock core of the mountains (USGS 2002). Many of the individual ranges that make up the Rocky Mountains are made up of a core of uplifted Precambrian granite surrounded by Paleozoic and Mesozoic sedimentary rocks that once overlay the uplifted blocks. Erosion throughout the Tertiary period exposed the uplifted blocks and filled valleys with deposits derived from both the Paleozoic and Mesozoic rocks and the Precambrian cores (USGS 2003a).

Rocks of various geologic age have a wide surficial distribution because of the depositional history and deformation of the area. Deformation caused extensive faulting, and faults commonly separate adjacent geologic units (USGS 2002).The Southern Rocky Mountains province is beginning to be pulled apart by extensional forces. The physiographic feature associated with this extension is the Rio Grande Rift, a long fault-bounded basin through which the upper Rio Grande River flows southward through New Mexico. Volcanism accompanies this extension. Inside the Rio Grande Rift, lava from a source deep in the mantle has periodically erupted. Among the larger volcanoes is the Valles Caldera in north-central New Mexico (USGS 2003a). The crustal extension and associated volcanic activity, although slow, is ongoing and is the source of much of the geothermal heat present in New Mexico and southern Colorado (USGS 2003a).

Wyoming Basin

Physiography

The Wyoming Basin is primarily in south-central Wyoming but also extends into northern Colorado (Figure 3-1). The Basin consists of a series of broad intermountain basins lying between isolated hills and low mountains between the Southern and Middle Rocky Mountains (BLM 2003a) The major basins within this province include the Greater Green River, Wind River, Laramie, and Hanna Basins. Within each of the major basins, there are numerous sub-basins.

Geology

During Paleozoic time, present-day Wyoming and much of the Rocky Mountain west were located along a fairly stable continental shelf with the land areas to the east. The area was generally inundated by shallow seas and fluctuations in sea level, which resulted in the deposition or erosion of sediments. Uplift and erosion of the Ancenstral Rocky Mountains during the Pennsylvanian resulted in the deposition of sandstones before a return of a shallow marine environment with repeated fluctuations in sea level (BLM 2003b).

Near the end of the Cretaceous, mountain building began again in the western Wyoming-eastern Idaho Thrust Belt. As the mountains were uplifted, erosion occurred and sediment was shed into the shallow seas to the east. At the end of the Cretaceous and the beginning of Tertiary time, another episode of mountain building (the Southern Rocky Mountains) was occurring to the east and southeast of the area involving the uplift of the Precambrian basement (BLM 2003b).

The uplifted blocks of basement rock were eroded and the sediment was deposited in the surrounding basins. In Oligocene and Miocene time, large volcanic eruptions occurred to the west and north of the area depositing thick layers of ash. Also in later Tertiary time, one more episode of uplift occurred, again resulting in the deposition of material in the basins. The late Tertiary deposits were subjected to erosion, and by the end of Tertiary time and the beginning of Quaternary time, the present-day topography began to emerge (BLM 2003b).

Middle Rocky Mountains

Physiography

The ranges of the Middle Rocky Mountain province cover most of northwestern Wyoming and extend north into Montana, west into Idaho, and southwest into Utah and Colorado (Figure 3-1). The province is separated from the Southern Rocky Mountains to the southeast by the Wyoming Basin. The ranges of this province are generally lower and less continuous than those to the south. The highest peaks of the Middle Rockies are Gannet Peak (13,785 feet) in the Wind River Range and Grand Teton (13,766 feet) in the Teton Range (Columbia Encyclopedia, 2007).

Geology

Before the Laramide mountain-building period, the Middle and Southern Rockies were part of a stable platform composed of Precambrian crystalline rocks. The platform received sediments that were transformed into sedimentary rocks, which were then uplifted and eroded during the mountain-building period. Later, volcanic activities produced mountains and high plateaus in many places (US DOE ad BLM 2007).

Tectonic forces that acted on the region produced large areas of subsidence and uplift. The smaller intermontane basins are less than 3,000 feet deep. The amount of uplift in the segment likewise varies considerably (USGS 2002).

Geologic structures, such as faults, anticlines, and synclines, are numerous and complex in the Middle Rocky Mountains in Wyoming. Older rocks have been lifted upward and shifted eastward over younger rocks along thrust faults in the Teton Range. The principal parts are the Wasatch and Teton ranges (which are both great tilted fault blocks); the Yellowstone Plateau and Absaroka Range (both developed on volcanic rocks); and the Bighorn, Beartooth, Owl Creek, and Uinta Mountains, and the Wind River Range (all broad folded mountains). All of these component sections have been eroded down to their Precambrian cores and are rimmed by Paleozoic and Mesozoic sedimentary rocks (Columbia Encyclopedia, 2007). Thick sequences of Paleozoic and younger sedimentary rocks have been downfolded into the numerous basins in the Wyoming Basin. Where these sedimentary rocks have been upfolded into anticlines that separate the basins, the rocks have been partly or completely removed by erosion, and older, mostly crystalline rocks are exposed along the axes of the uplifts or anticlines. In Yellowstone National Park, Quaternary volcanic rocks overlie the crystalline rocks (USGS 2002).

Northern Rocky Mountains

Physiography

The Northern Rocky Mountain province is located in western Montana and northern Idaho (Figure 3-1). The province is characterized by low mountains with summits between 6,900 and 7,874 feet above sea level (US DOE and BLM 2007).

Geology

The Rocky Mountains include fault-bounded uplifts, folded mountains, and highlands formed by volcanism resulting from the mountain-building period that occurred between the middle Cretaceous and late Eocene Periods. The uplift also set the stage for the geomorphic evolution of the Rocky Mountains, producing ridges and plateaus high enough to be glaciated, as well as many of the region's streams and canyons (US DOE and BLM 2007). Geologic structures, such as faults, anticlines, and synclines, are numerous and complex in the Northern Rocky Mountains. Older rocks have been lifted upward and shifted eastward over younger rocks along thrust faults near the Continental Divide and in the Teton Range (USGS 2002).

Precambrian rocks are exposed in western Montana and in Wyoming. Sedimentary rocks of Precambrian age crop out over a wide area in western Montana. In Wyoming and southwestern Montana, Precambrian rocks mostly are plutonic igneous rocks but also include several types of metamorphic rocks. (USGS 2002).

Paleozoic sedimentary rocks are exposed at the land surface mostly in mountainous areas where they flank uplifts or anticlines, or have been displaced upward along faults (USGS 2002a). Mesozoic (chiefly Cretaceous) sedimentary rocks are exposed over wide areas in Montana and Wyoming (USGS 2002). Mesozoic igneous intrusive rocks are common in central Idaho (US DOE and BLM 2007).

Large areas of Tertiary intrusive and volcanic rocks are present in northwestern Wyoming and western Montana (USGS 2002). Tertiary and Quaternary valley-fill deposits occur in western Montana and Wyoming, and Quaternary silicic volcanic rocks are in small areas in northwestern Wyoming and southwestern Montana.

Basin and Range

Physiography

Centered on Nevada and extending from eastern California to central Utah, and from southern Idaho into Sonora, Mexico, the Basin and Range province can be divided into the Great Basin in the north and the Salton Trough, Mojave-Sonoran Desert, Mexican Highlands, and Sacramento Mountains in the south (Figure 3-1) (USGS 2003a , US DOE and BLM 2007). The Basin and Range province has a characteristic topography, with more than 400 evenly spaced, nearly parallel mountain ranges and intervening basins. The mountain ranges are generally abrupt, steeply sloping, and deeply dissected with relief between 3,000 and 5,000 feet above the intermountain basins. The basins are typically broad, gently sloping, and largely undissected with altitudes from below sea level to about 5,000 feet above sea level (US DOE and BLM 2007).

Geology

The Basin and Range province was created about 20 million years ago as the earth's crust stretched, thinned, and then broke into some 400 mountain blocks that partly rotated from their originally horizontal positions (USGS 2003a). Along roughly north-south-trending faults, mountains were uplifted and valleys down-dropped, producing the province's distinctive alternating pattern of linear mountain ranges and valleys or basins (USGS 2002).

The mountain ranges consist of complexly deformed late Precambrian and Paleozoic rocks and some Mesozoic granitic rocks in the western part of the province. Cenozoic volcanic rocks are widespread throughout the province (US DOE and BLM 2007). These uplifted rocks erode and fill the intervening valleys and basins with fresh sediment (USGS 2003a). These basins generally contain an underlying, relatively undeformed sequence of rock that was deposited in the area prior to uplift and an overlying younger layer of rock and sediment that was derived from the erosion of nearby uplifted areas. Some of these basins contain older sedimentary rocks or volcanic rocks, and almost all contain a thick overlying sequence of Tertiary and Quaternary sediment derived from erosion of nearby uplifted blocks (USGS 2002).

Within the province, the earth's crust has been stretched up to 100 percent of its original width. The entire region has been subjected to extension that thinned and cracked the crust as it was pulled apart, creating large faults.

Colorado Plateau

Physiography

The Colorado Plateau includes the High Plateaus of Utah, Uinta Basin, Canyon Lands, Navajo section, Grand Canyon section, and Datil section (Figure 3-1) (USGS 2003a). The province is a vast region of plateaus, mesas, and deep canyons. Uplift of the Colorado Plateaus steepened stream gradients and accelerated the downcutting of the Colorado River and its principal tributaries. Downcutting of the Colorado River in the Grand Canyon has exposed thousands of feet of sedimentary rocks (USGS 2002).

Geology

Ancient Precambrian metamorphic rocks formed during continental collisions over a billion years ago make up the basement of the Colorado Plateau. Igneous rocks were injected millions of years later. These basement level rocks were uplifted and eroded until, by 600 million years ago, they had been beveled off to a smooth surface upon which younger rocks were deposited (USGS 2004a).

During the next 300 million years, the Colorado Plateau region was periodically inundated by tropical seas. Thick layers of limestone, sandstone, siltstone, and shale were laid down in the shallow marine waters. During times when the seas retreated, stream deposits and dune sands were deposited or older layers were removed by erosion (USGS 2004a). About 250 million years ago deposits of marine sediment waned and terrestrial deposits dominated. Eruptions from volcanic mountain ranges to the west buried vast regions beneath ashy debris. Short-lived rivers, lakes, and inland seas left sedimentary records of their passage. The Colorado Plateau is remarkable stable. Relatively little rock deformation (e.g., faulting and folding) has affected this high, thick crustal block within the last 600 million years (USGS 2004a).

Beginning about 20 million years ago, both the Basin and Range and Colorado Plateau regions were uplifted as much as almost two miles. Great tension developed in the crust, probably related to changing plate motions far to the west. As the crust stretched, the Basin and Range province broke up into a multitude of down-dropped valleys and elongate mountains. The neighboring Colorado Plateau preserved its structural integrity and remained a single tectonic block. Eventually, the great block of Colorado Plateau crust rose over one-half mile higher than the Basin and Range. As the land rose, the streams responded by cutting ever deeper stream channels, including the Grand Canyon (USGS 2004a).

Columbia Plateau

Physiography

The Columbia Plateau province includes southeastern Washington, northwestern Oregon, and most of southern Idaho (Figure 3-1). The province includes the Walla Walla Plateau, Blue Mountain section, Payette section, Snake River Plain, and the Harney section (USGS 2003a). The topography of the Columbia Plateau province is dominated by geologically young lava flows that inundated the countryside within the last 17 million years. The province is enveloped by one of the world's largest accumulations of lava (over 193,000 square miles). Over 220 million cubic yards of basaltic lava, known as the Columbia River basalts, covers the western part of the province. The Snake River Plain lies in a distinct depression (USGS 2004c). The Snake River Plain stretches across Oregon, through northern Nevada and southern Idaho, and ends at Wyoming's Yellowstone Plateau. Looking like a great spoon scooped out the earth's surface, the smooth topography of this province forms a striking contrast with the rugged mountainous fabric around it.

Geology

Between 14 and 16 million years ago, fissure volcanic eruptions in eastern Washington, eastern Oregon, and western Idaho produced enormous volumes of molten Columbia River lava that flowed west into eastern Washington and northeastern Oregon, with some lava continuing to flow as far west as the Pacific Ocean via the ancestral Columbia River valley. The lava eventually accumulated to a thickness of more than 6,000 feet. As the molten rock came to the surface, the earth's crust gradually sank into the space left by the rising lava. The subsidence of the crust produced a large, slightly depressed lava plain now known as the Columbia Basin (Plateau) (USGS 2003b). With the end of the outpouring of lava, tremendous forces deep within the earth began to warp the plateau in several places. A general uplift of the mountainous region in the north caused the entire plateau to tilt slightly to the south.

The Columbia River Basalt was created by tremendous eruptions between 17 and 6 million years ago, with most erupting in the first 1.5 million years. In the west, the Columbia River Basalts are almost exclusively black basalt (USGS 2004c).

The western end of the Snake River Plain is formed by a block down dropping between normal faults, known as a horst and graben structure. Although there is extensive faulting at the eastern end, the structure is not as clear. The earliest Snake River Plain eruptions began about 15 million years ago, just as the tremendous early eruptions that created Columbia River Basalt were ending.

But most of the Snake River Plain volcanic rock is less than a few million years old and younger. The Snake River Plain eruptions produced soupy black basaltic lava flows alternated with tremendous explosive eruptions of rhyolite, a light-colored volcanic rock (USGS 2004c).

Volcanic cinder cones dot the landscape of the Snake River Plain, along with calderas (great pits formed by explosive volcanism), low shield volcanoes, and rhyolite hills. Many of these features are obscured by later lava flows (USGS 2004c).

The volcanic activity is thought to be due to a concentrated heat source, or hot spot, that melted the rock beneath the Columbia Plateau province. Scientists have determined that the youngest volcanic rocks are clustered near the Yellowstone Plateau, and that the farther west they investigated, the older the lava rocks. This data led to the theory that an extremely hot plume of deep mantle material has risen and continues to rise to the surface beneath the Columbia Plateau province. It has caused and continues to cause eruptions as the North American plate is moving over it, leaving a record of plate motion rate and direction. The hot spot is thought to currently be under Yellowstone National Park. The steaming fumaroles and explosive geysers are ample evidence of a heat concentration beneath the surface (USGS 2004c). The Yellowstone Caldera is a large crater-like feature covering more than 1,300 square miles. It formed when an underground magma chamber collapsed after an eruption 630,000 years ago (USGS 2003a).

Cascade-Sierra

Physiography

The Cascade-Sierra province includes the Sierra Nevada in central California and Nevada in the south, and the Southern Cascade Mountains, Middle Cascade Mountains, and Northern Cascade Mountains in northern California, Oregon, and Washington (Figure 3-1)(USGS 2003a). The Cascade and Sierra Nevada ranges are part of the large mountain chain stretching more than 12,000 miles from Tierra del Fuego to the Alaskan Peninsula (USGS 2000). Extending from 14,494 feet (Mt. Whitney, the highest peak in the lower 48 states) in the east to near sea level in the west, the Sierra Nevada contains Yosemite and Sequoia National Parks (USGS 2003a).

The great length and strong north-south linearity of the Middle and Southern Cascade ranges, a narrow band extending from southern Washington to northern California (roughly parallel to the Pacific coastline), contrasts sharply with the varied directional trends of other mountain groups to the east and northeast. These mountain ranges contain 13 major volcanic centers with large and geologically recent active volcanoes that dominate the landscape (USGS 2000).

The North Cascade Range is steeper and wetter than most other continental US ranges. The peaks of the North Cascades reach elevations of 7,000 to 8,000 feet, with relatively large uninterrupted vertical distances from valley bottom to mountain top of 4,000 to 6,000 feet (USGS 2000). The deep canyons and sharp peaks are products of profound erosion from water and glaciers (USGS 2000).

Geology

Although the Sierra Nevada and Cascade Range are in a single province, the two ranges have been and continue to be formed by quite different geological forces and processes (USGS 2004d). The Sierra Nevada is a west-tilting 350-mile-long block of granite. The massive granite intruded the crust in Mesozoic time and was uplifted and faulted in the Tertiary during formation of the Basin and Range province to the east. The granitic rocks that underlie the fault blocks of the Sierra Nevada and the volcanic rocks of the southern Cascade Mountains join to form the eastern border of the low-lying California Trough, which contains the Central Valley. Eroded material from the Sierra Nevada has filled California's Central Valley (USGS 2003a).

The Cascade Mountains arose through the plate collisions that have enlarged the western portion of the continent in Tertiary to Quarternary time. The Cascade Mountains are comprised of a band of thousands of very small, short-lived volcanoes that have built a lava and volcanic debris platform. This mountain range contains large and geologically recent active volcanoes such as Rainier, Hood, and Shasta (USGS 2000). The few large volcanoes rise above this volcanic platform (USGS 2004e).

The northern Cascade Mountains includes rocks up to 400 millions years old. The range is a geologic mosaic made up of pieces of islands, ocean floor, and old continents that were carried along by the tectonic plates and added to the North American continent (USGS 2000). These assembled pieces were uplifted, eroded, and in some places buried again. Other pieces were forced deep into the earth to be heated and squeezed before being raised again (USGS 2000). About 35 million years ago volcanoes erupted to cover the older rocks, and large masses of molten rock invaded the older rocks from below. The volcanic arc is still active today (USGS 2000).

Pacific Border

Physiography

The Pacific Border province, also called the Pacific Uplands, consists of several mountain ranges along the Pacific Coast. These ranges are separated from the Cascade-Sierra Nevada province by troughs. The Pacific Border Province includes the Puget Trough, Olympic Mountains, Oregon Coast Range, Klamath Mountains, California Trough, California Coast Ranges, and Los Angeles Ranges (Figure 3-1) (USGS 2003a).

The Olympic Mountains in Washington are the northernmost of the coast ranges. The northwest-southeast trending Olympic-Wallowa Line across southern Washington is a structural zone that includes active earthquake faults (USGS 2003a).

Many volcanoes erupted throughout the region forming the Oregon Coast Range, but most individual craters are small. Among the larger volcanoes in the region is Crater Lake in southwest Oregon, which is part of the Cascade Range (USGS 2003a). The Klamath Mountains in southwestern Oregon and northwestern California include the Salmon and Trinity Mountains.

The California Trough (Central Valley, or Sacramento and San Joaquin Valleys) is a northwest-southeast trending elongate depression between the Sierra Nevada and Coast Ranges to the east and west, respectively (USGS 2003a). The valley is flat and full of material eroded from the surrounding mountains. These sediments contribute to the productive agricultural industry now in the region.

The California Coast Ranges consisting of the Diablo and Santa Lucia Ranges parallel the Pacific Coast in a complex series of ridges and valleys. The Transverse Ranges run perpendicular to the Coast Ranges north of Los Angeles.

Geology

The several mountain ranges underlain by severely folded, faulted, commonly metamorphosed marine and continental sediments form the Coastal Ranges (USGS 2002). Between 100 and 50 million years ago, subduction beneath the western edge of the North American continent resulted in the collision and buildup of belts of oceanic rock that gradually built the continental margin westward. During this subduction, magma rose up, causing the formation of chains of andesitic volcanoes at the surface and plutons of granitic magma beneath them. Plutonic rocks from this period are found in the Klamath Mountains, Sierra Nevada, Basin and Range, Mojave Desert, and Peninsular Ranges. During this time, the subducting plate was consumed beneath the North American plate and, by 100 million years ago, the subduction zone had shifted westward to the approximate position of today's Coast Ranges (Friedel, 2003).

The San Andreas transform fault system developed about 28 million years ago with the collision of the Pacific plate and the North American plate. This collision caused the subduction zone along the coast to cease, and the two plates began to slide past each other (Friedel, 2003). The topographic texture of western California is controlled by the San Andreas Fault system. Since the Tertiary, the shortening and wrinkling the crust due to this movement has created the parallel coastal northwest-southeast mountain ranges (USGS 2003a).

Lower California

Physiography

Several coastal mountain ranges underlain by severely folded, faulted, and commonly metamorphosed marine and continental sediments form the Lower California physiographic province (USGS 2002). The province is an extension of the Baja California peninsula. The province includes rolling mountain and valley terrain in southwestern California (Figure 3-1).

Geology

The Lower California province is comprised of the northern end of a granitic ridge forming the Baja California peninsula. The Lower California province is part of the Pacific plate and is sliding northward past the North American plate. These rocks are exposed on head lands at Point Loma and at La Jolla, California, with stretches of low estuaries filled with drifted sand and other deposits as in Mission Bay, California, and the enclosing sand spits there and along the Silver Strand which forms San Diego Bay California (NPS 2007).

Alaska

Physiography

In Alaska, a belt of mountains forms the South Central Alaska province, leading into the Alaska Peninsula and Aleutian Islands province.

Alaska is geologically and topographically diverse. Most of Alaska is on a large peninsula that forms the northwestern corner of the North American continent and separates the Arctic and Pacific Oceans. Large areas of high, rugged mountains in northern and southern Alaska are extensions of mountain systems in Canada. The Brooks Range in northern Alaska is the western terminus of the Rocky Mountain System. In southern Alaska, the Alaska and the Boundary Ranges, and the Talkeetna, Wrangell, Kenai-Chugach, and St. Elias Mountains are extensions of the Pacific Mountain System. The south peak of Mount McKinley in the Alaska Range is the highest point in the US with an altitude of 20,320 feet above sea level. The Aleutian Range that extends as a long peninsula southwestward from the Alaska mainland is an extension of the Alaska Range. Low mountains, plateaus, and highlands bound the high mountains and are, in turn, bounded by lowland areas (USGS 2002)

Geology

Alaska has a complex geology with a mosaic of geologic terranes (pieces of the Earth's crust), where each terrane's geologic history is different than that of adjacent terranes. All the terranes in Alaska represent blocks of the earth's crust that have moved large or small distances relative to each other. The movement might have been lateral movement with or without any rotation. Some of the terranes may have moved only a short distance, whereas others may have moved laterally for several hundreds of miles or rotated as much as 135 degrees. The pattern of Alaska terranes reflects the interactions of oceanic crustal plates with the North American plate. Large-scale lateral and rotational movements, rifting, and volcanic activity result from these interactions.

3.3.2 Geologic Hazards

Geologic hazards include earthquakes, volcanoes, landslides, and subsidence.

Seismic Risk. Earthquakes are the result of large masses of rock moving against each other along fractures called faults. The shaking due to earthquakes can be significant a dozen or more miles from the actual point where they occurred depending on type of earthquake and the type of rock and soils beneath a given location.

Crustal earthquakes, the most common, typically occur along faults, or breaks in the earth's crust, at shallow depths of 6 to 12 miles. Great subduction zone earthquakes occur around the world where the tectonic plates that make up the earth's surface collide. When these plates collide, one plate slides (subducts) beneath the other, where it is reabsorbed into the mantle of the earth. This dipping interface between the two plates is the site of some of the most powerful earthquakes ever recorded, often having magnitudes of eight to nine or larger. The 1964 Great Alaska (magnitude 9.2) earthquake was a subduction zone earthquake. Deeper intraplate earthquakes occur within the remains of the ocean floor that is being subducted beneath North America. The magnitude 6.8 intraplate earthquake that struck the Puget Sound area in 2001 was much less destructive than a crustal earthquake of the same magnitude would have been because of its great depth (33 miles). This type of earthquake could occur beneath much of the Northwest at depths of 25 to 37 miles (Oregon Department of Geology and Mineral Industries 2007).

The assessment of risk from earthquakes is complex and is usually expressed as zones of probability for given accelerations due to shaking. Figure 3-2 shows the peak accelerations with a 10-percent chance of being exceeded within the next 50 years for the western US.

Volcanoes. Volcanoes, like most earthquakes, are related to tectonic plate motion. Volcanoes cause a diversity of hazards to human culture, including clouds of hot gasses carrying rock and sand, blast effects, ash falls, and mud flows. However, unlike earthquakes, volcanoes generally give plenty of warning that they are awakening, although the actual moment of eruption may be a surprise (Oregon Department of Geology and Mineral Industries 2007). The presence of high geothermal heat flow is often associated with current and past volcanic activity. Volcanic risk is discussed below in terms of the location of volcanoes in the region. Figure 3-2 shows the location of volcanoes and volcanic fields within the western US.

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SOURCE: BLM 2007c

The assessment of risk from earthquakes is expressed as zones of probability for given accelerations due to shaking.

LEGEND:
Peak Ground Acceleration (g)

- 0-0.1
- >0.1-0.2
- >0.2-0.4
- >0.4-1.0

Peak Horizontal Ground Acceleration of the 11 Western States

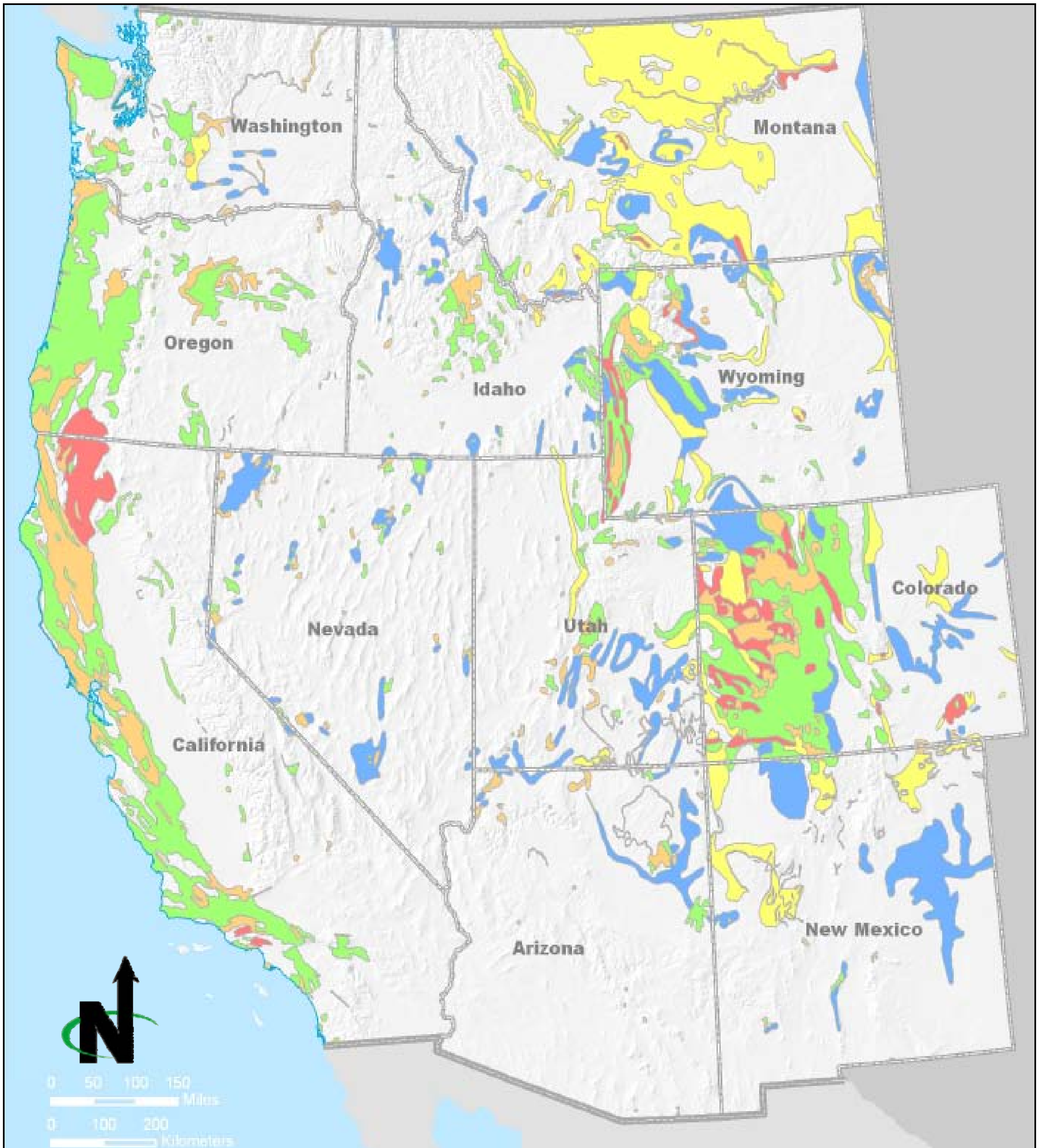
Lands with a 10% probability of exceedance within 50 years

Figure 3-2

Landslides. Landslides are the downslope movement of rock, soil, or related debris; however, the term generally implies a quick movement. Geologists use the term "mass movement" to describe a great variety of processes such as rock fall, creep, slump, mudflow, earth flow, debris flow, and debris avalanche regardless of the time scale. In most mass movement, water plays a pivotal role by assisting in the decomposition and loosening of rock, lubricating rock and soil surfaces to enhance the beginning of movement, adding weight to an incipient landslide, and imparting buoyancy to the individual particles.

Mass movements can be triggered by other natural geologic disasters or human activity. Volcanic eruptions and earthquakes can initiate earth movement on a grand scale. Lahars, debris flows made up of volcanic ash and water, are often the major hazard experienced in a volcanic episode. Although earthquakes can initiate debris flows, a major cause of mass movements is continuous rains that saturate soils. Mass movements are also frequently the direct consequence of human activity. Seemingly insignificant modifications of surface flow and drainage may induce mass movements (Oregon Department of Geology and Mineral Industries 2007). Areas at risk for mass movements include areas with steep slopes and areas with slighter slopes and unstable soils (Figure 3-3).

Subsidence. Subsidence is the slow, downward sinking of the land surface. It can occur naturally in areas that are tectonically active such as volcanic regions and fault zones. Subsidence can also occur in areas where sedimentary basins are filled with unconsolidated sands, silts, clays and gravels. Subsidence can also occur as a result of the extraction of subsurface fluids, including groundwater, hydrocarbons, and geothermal fluids. In these cases, a reduction in reservoir pore pressure reduces the support within the reservoir rock itself and for the rock overlying the reservoir, resulting in a copaction of the reservoir rock potentially leading to a slow, downward deformation of the land surface. Figure 3-8 shows the areas in the western US with major unconsolidated aquifers where pumping of groundwater could result in subsidence. In Alaska, subsidence is associated with soils rich in organic carbon when they are drained for agriculture or other purposes. Microbial decomposition, under drained conditions, readily converts the organic carbon to carbon dioxide gas and water causing a reduction in soil volume (Kagel et al. 2007).



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SOURCE: BLM 2007c

Areas at risk for mass movements include areas with steep slopes and areas with slighter slopes and unstable soils.

LEGEND:

Landslide Potential

- High Incidence and High Susceptibility
- High Incidence
- Moderate Incidence
- High Susceptibility
- Moderate Susceptibility

Landslide Hazard Potential of the 11 Western States

Figure 3-3

3.4 ENERGY AND MINERAL RESOURCES

Public and NFS lands are managed for recreation, timber harvesting, livestock grazing, oil and gas production, mining, wilderness protection and other purposes (US DOE and BLM 2007). In this section, energy and mineral resources are discussed, along with their association with geothermal resources.

On federal lands, mineral resources are governed by the General Mining Law of 1872, as amended; those portions of the Federal Land Policy and Management Act of 1976, as amended (FLPMA) that affect the General Mining Law; and the Surface Resources Act of 1955 and The Mining and Minerals Policy Act of 1970. Oil, Gas leasing is guided by the Energy Policy Act of 2005. Geothermal leasing is guided by the Geothermal Steam Act of 1970 (30 USC 1004), as amended by the Energy Policy Act of 2005.

The BLM manages Oil and Gas leases under Title 43 CFR part 3100, exploration under part 3150. Geothermal leasing is managed under Part 3200, mineral materials under 3600 regulations, mining claims for locatable minerals under 3800 regulations and solid leasable minerals other than coal or oil shale under Part 3500. The FS manages oil and gas operations on NFS lands under 36 CFR subpart E. Mineral leasing operations are guided by Forest Service Manual 2820 and mineral prospecting, including geophysical activities is guided by Forest service manual 2860. Locatable minerals and surface management regulations fall under 36 CFR 228 Subpart A and Forest Service Manual 2810. Mineral materials are regulated under 36 CFR 228 Subpart C and Forest Service Manual 2850.

Wind, solar, and biomass are considered renewable energy resources, along with geothermal energy resources. These resources all have different requirements related to economic development. However, some issues are common to all, including distance to existing power transmission facilities and compatibility with existing federal land use.

3.4.1 Solar Energy Resources

Solar energy is a renewable energy resource that has excellent potential for generating electricity in a large part of the western US. Installation of solar energy facilities on public and NFS lands requires a right-of-way permit instead of a lease. There are two basic types of solar energy installations that produce electrical power: photovoltaics systems and concentrating solar power. These can be combined with natural gas or other fossil fueled power systems to form hybrid systems.

Photovoltaic Systems

Photovoltaic systems use semiconductor materials similar to those used in computer chips to capture the energy in sunlight and convert it directly into electricity. Photovoltaic cells are connected into an array. The size of the array depends on the amount of sunlight and the needs of the customer. Large photovoltaic electrical generating systems have not generally been used for commercial utility applications due to the high upfront cost. Most photovoltaic applications are small, use little or no land, and have minimal or no environmental impact because electricity created is generally used on site or as part of an existing authorized use. They generally provide power to individual homes and small buildings. They are also found in rural areas on communication towers, water pumps, and road and traffic signs.

Concentrating Solar Power Systems

Concentrating solar power plants are generally large systems that use mirrors to focus sunlight to create high temperatures. The high temperatures generated by the focused sunlight are used to generate electricity either by a heat engine causing gas to expand moving a piston or a conventional power cycle using boiling water to create steam that turns a turbine.

There are currently three different types of centralized concentrating solar power systems: parabolic trough, solar "power tower," and solar dish. These systems require relatively flat land with slopes not exceeding three percent to accommodate the solar collectors. The area of land required depends on the type of plant, but is about five acres per produced megawatt. It is anticipated that a commercial scale concentrating solar power facility may be in the range of 100 megawatts or larger and will require in excess of 500 acres.

To work effectively, the solar installations require consistent levels of sunlight (solar insolation). Solar insolation is a measurement that has become increasingly more accurate in evaluating specific sites for solar energy installations. Solar insolation is the amount of sunlight hitting an area on the surface of the earth over a specific period of time. The higher the exposure of sun measured on an annual basis, the more electrical power that can be produced. Solar energy resources are classified based on the amount of solar radiation that contacts the ground surface in a specified area. Solar radiation is measured in units of watt-hours per square meter per day. The amount of solar energy resource available at a specific location varies with the latitude of that location, the season, and the time of day.

Solar energy resource maps were prepared by the US Department of Energy, National Renewable Energy Laboratory. In addition to varying by latitude, season, and time of day, the amount of solar radiation available at known occurrences of solar energy resources is dependent on the type of collector used. The two basic designs of solar collectors are flat-plate collectors and solar concentrators.

Flat-Plate Collectors

The flat-plate collector is a fixed panel containing photovoltaic cells or solar water heaters. The flat-plate panels collect sunlight and convert it to electricity or heat. The flat panel is installed where no obstructions will block sunlight from reaching the panel. A flat-plate collector generally receives the most sun when it is tilted towards the south at an angle equal to the latitude of the location.

Solar Concentrators

The solar concentrator is a flat panel of photovoltaic cells or a concave arrangement of mirrors that concentrate sunlight onto a collector. The concentrator is attached to a motor-driven tracking mechanism. It is installed where no obstructions will block sunlight from reaching the concentrator, and uses the tracking mechanism to follow the sun as it crosses the sky each day. The tracking mechanism adjusts for seasonal variations in the Sun's azimuth and allows the solar concentrator to collect the maximum amount of direct sunlight. The flat-plate collector is more effective at collecting solar radiation than the solar concentrator.

Data concerning solar resources are collected for both concentrating solar power and photovoltaic systems. The US Department of Energy, National Renewable Energy Laboratory has developed a national solar resource assessment for the US at a resolution of approximately 25 by 25 miles. These data are updated periodically.

For photovoltaic systems, data for flat-plate collectors were used. This is typical for a photovoltaic panel oriented due south at an angle from horizontal equal to the latitude of the collector's location. Figure 3-4 shows the photovoltaic resources for the western US.

The concentrating solar power analysis used direct normal data. These data are pertinent to concentrating systems that track the sun throughout the day, such as trough collectors or dishes. Figure 3-5 shows the concentrating solar power resources in the western US.

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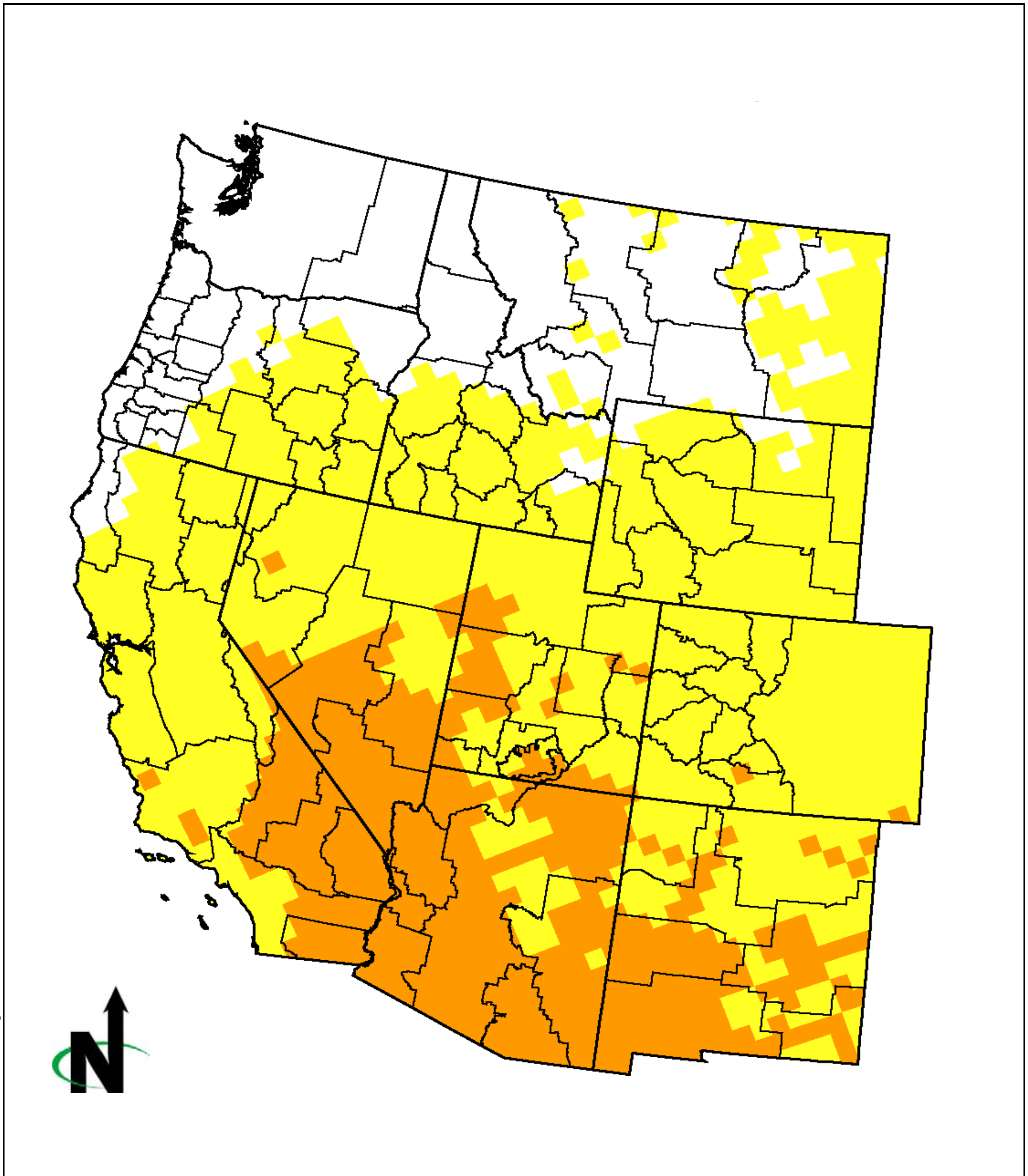

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Source: BLM 2003c

The flat-plate collector is a fixed panel containing photovoltaic cells or solar water heaters. Solar resources are available for flat plate collectors through the 11 western states, but are highest in the southwest.

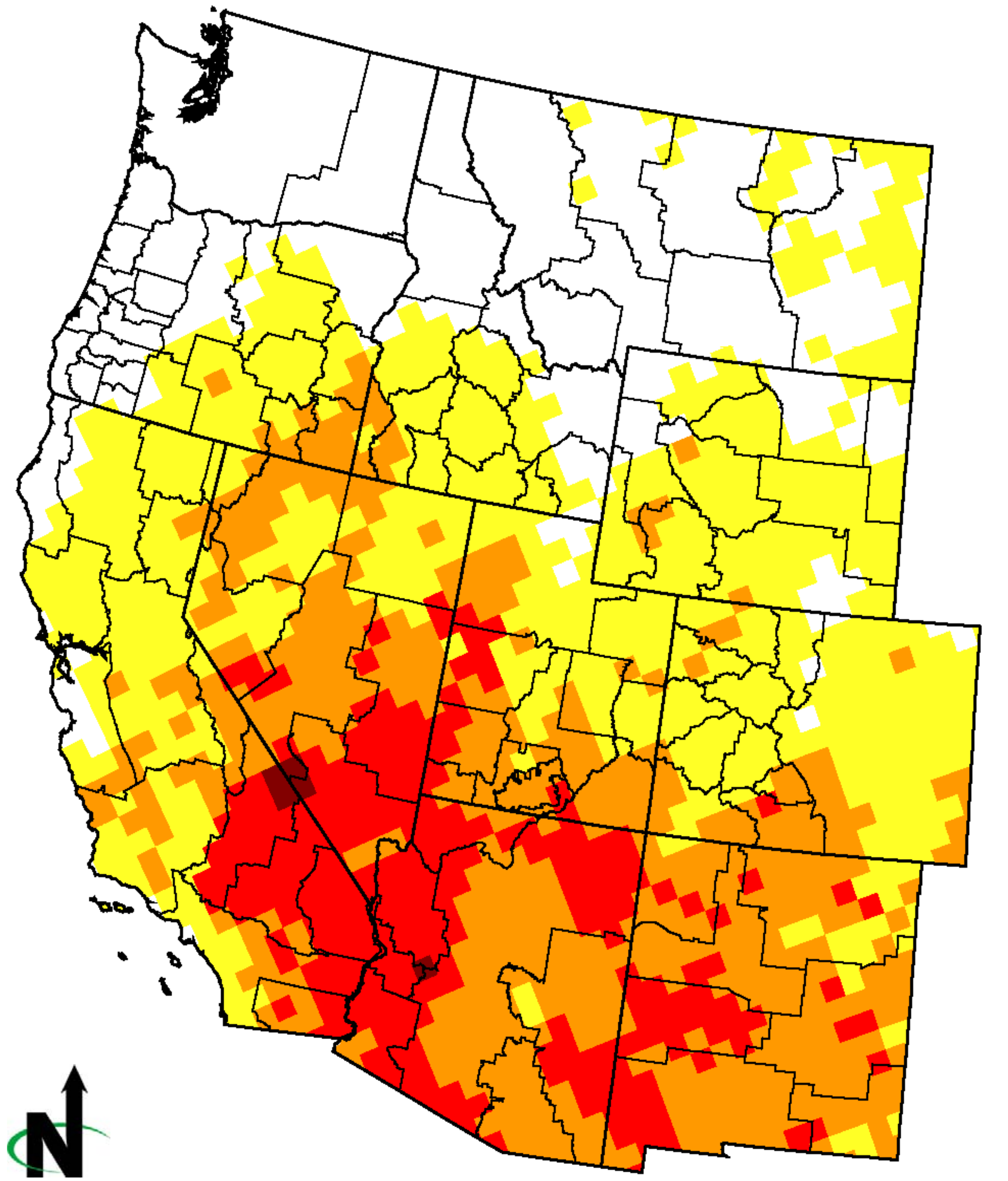
LEGEND:

Photovoltaic
Solar resources
kWh/m²/day

5
6

Yearly Average Solar Energy Resources available for flat-plate photovoltaic systems

Figure 3-4



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SOURCE: BLM 2003c

These data are pertinent to concentrating systems that track the sun throughout the day, such as trough collectors or dishes. Solar resources are available for flat plate collectors through the 11 western states, but are highest in the southwest.

LEGEND:
Concentrating
Solar Resource
kWh/m²/day

5
6
7
8

Yearly Average Solar Energy Resources Available for Concentrating Solar Power Systems

Figure 3-5

3.4.2 Wind Resources

Wind energy is a renewable energy resource that has excellent potential for generating electricity. The BLM Wind Energy Programmatic EIS (BLM 2005a) has determined which areas on public lands have high, medium, or low potential for wind energy development based on the typical wind speed measured at a location. The wind power classification used in the EIS had seven wind classes based on the wind power density at a height of 164 feet (50 meters), measured in watts per square meter (Table 3-6).

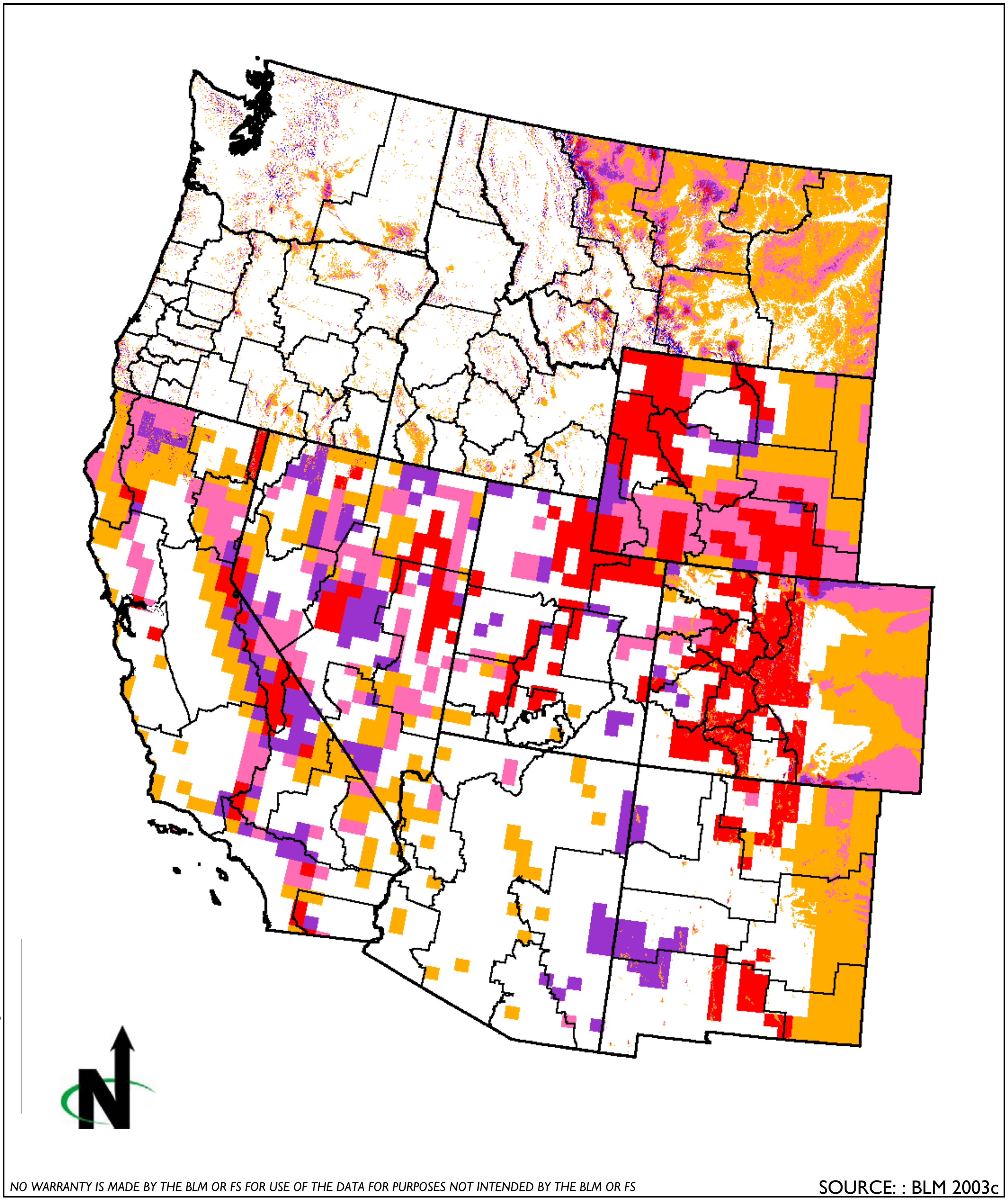
Table 3-6
Wind Power Classification/Energy Development Potential

Wind Power Class	Energy Development Potential	Wind Power Density: Watts per square meter at 164 feet (50 meters) above Ground Level	Wind Speed[a]: Miles per hour at 164 feet (50 meters) above Ground Level
1	Low	0 – 200	0.0 – 12.5
2	Low	200 – 300	12.5 – 14.3
3	Medium	300 – 400	14.3 – 15.7
4	High	400 – 500	15.7 – 16.8
5	High	500 – 600	16.8 – 17.9
6	High	600 – 700	17.9 – 19.7
7	High	>800	>19.7

[a] Mean wind speed is estimated by assuming a sea level elevation and a Weibull distribution of wind speeds with a shape factor (k) of 2.0. The actual mean wind speed may differ from the estimated values shown here by as much as 20 percent, depending on the actual wind speed distribution (or Weibull k value) and elevation above sea level.
Source: BLM 2003c

Wind power is considered economic for large turbines (commercial utilities scale) at Class 3 and higher, although a small noncommercial turbine can be used at Class 1. Figure 3-6 shows public lands and FS lands wind resources greater than Class 3.

Installation of wind energy facilities on public lands and FS lands requires a right-of-way permit instead of a lease. Rental costs may be calculated by tower installation and/or permitted acreage.



Wind power is considered economic for large turbines (commercial utilities scale) at Class 3 and higher. This map contains high (.4-1km) and low (25 km) resolution wind resource assessments.

LEGEND:

Wind Resource Power Class

- 3
- 4
- 5
- 6
- 7

Public Land and FS Wind Energy Resources

Wind Resource Power Class ≥ 3

Figure 3-6

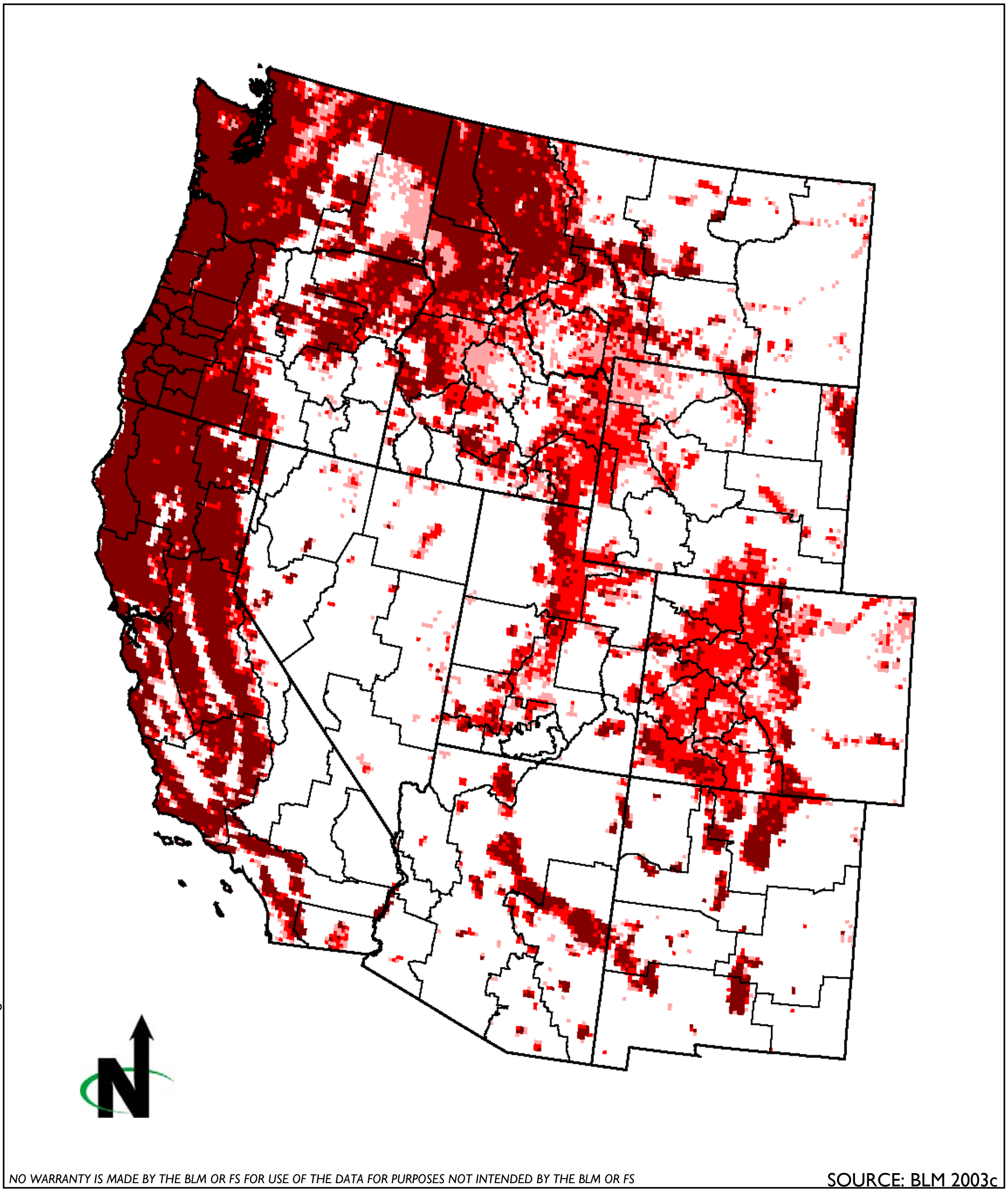
3.4.3 Biomass

Biomass power is power obtained from the energy in plants and plant-derived materials, such as food crops, grassy and woody plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes. Biomass can be used for direct heating (such as burning wood in a fireplace or wood stove), for generating electricity, or can be converted directly into liquid fuels to meet transportation energy needs (US DOI 2007).

Electricity generated from biomass is also called biopower. Biopower facilities use many different technologies; the most common is burning of wood or other biomass feed stocks to produce steam, which then is used to drive turbines and produce electricity. Some generators use a mix of biomass and fossil fuels to generate electricity, while others burn methane, a product of the natural decay of organic materials. In the US, the pulp and paper industries are major producers of biopower using residues from paper production to produce electricity for industrial plant use (US DOI 2007).

Wood has been used for energy longer than any other biomass source and remains the largest biomass energy resource. The largest source of energy from wood is pulping liquor or "black liquor," a waste product from processes of the pulp, paper, and paperboard industry. Biomass energy can also be derived from waste and from alcohol fuels. Biofuels are liquid fuels produced from plants. The two most common types of biofuels are ethanol and biodiesel. Ethanol is made by fermenting any biomass high in carbohydrates. The majority of ethanol produced in the US is made from corn. Biodiesel is made by processing vegetable oil, animal fat, or recycled cooking grease with alcohol or other chemicals. It can be used as an additive (typically 20 percent) or in its pure form as a renewable alternative fuel for diesel engines (US DOI 2007).

The availability of biomass materials was assessed using the monthly Normalized Difference Vegetation Index computed from the National Aeronautics and Space Administration's Advanced Very High Resolution Radiometer Land Pathfinder satellite program. The Normalized Difference Vegetation Index satellite data have a resolution of five by five miles. Figure 3-7 shows the availability of biomass on public and NFS lands in the Western US.



Biomass power is obtained from the energy in plants and plant-derived materials. Biomass availability in the 11 Western States is highest in forested regions, including portions of California and the Pacific Northwest.

LEGEND:
Number of Months with NDVI ≥ .4
4
5
6

Biomass Availability

Assessed using monthly Normalized Difference Vegetation Index satellite data

Figure 3-7

3.4.4 Energy Minerals

Coal

Coal deposits can be found in all 12 project area western states; however, large deposits are only found within Alaska, Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming (National Mining Association 2007). Together with North and South Dakota, the project area provides 45 percent of the nation's total production. The federal government is by far the largest owner of the nation's coal beds. In the west, the federal government owns 60 percent of the coal and indirectly controls another 20 percent. Coal companies must lease the land from the federal government in order to mine this coal (National Mining Association 2007).

The northern Rocky Mountain region and the Northern Great Plains of Wyoming, Montana, and North Dakota contain vast amounts of strippable coal. This region includes the 14 largest coal mines in the US, each having production of over 10 million short tons. More than 25 percent of US coal production is from 25 mines developing the Wyodak-Anderson, Anderson-Dietz, and Rosebud coal beds or zones in the Powder River Basin. These coals are relatively clean, containing less sulfur and ash than coals produced from other regions in the continuous US (USGS 1996).

Oil, Gas and Geothermal

The Northern Alaska physiographic province accounts for almost half of the oil and more than half of the undiscovered conventional gas assessed on onshore federal lands. Oil and gas resources extracted in Alaska are predominantly from the North Slope. As of 2005, Alaska accounted for 17 percent of the crude oil discovered in the US (BLM 2007c). Significant oil reserves are located throughout the Colorado Plateau. The Powder River Basin and the Wyoming Thrust Belt provinces of the Rocky Mountains and Northern Great Plains regions have the second-largest concentrations (behind Alaska) of undiscovered conventional oil and gas, respectively, assessed on federal lands (BLM 2007c). In California, oil and natural gas extraction is predominant in the San Joaquin, Ventura/Santa Barbara, Los Angeles, and Santa Maria regions. There are no significant oil, natural gas, or coal resources within the coastal areas and mountains of Washington and Oregon, in Nevada, or in Utah. There are limited oil and gas reserves in southern Arizona and southwest New Mexico (BLM 2007c).

BLM and FS consider geothermal resources to be a fluid mineral resource along with oil and natural gas. Therefore, while land closures or restrictions to fluid leasable minerals are primarily meant for oil and gas exploration and development, they apply to geothermal exploration and development as well.

Oil and gas drilling and development share other aspects with geothermal resources. Much of the data on geothermal resources comes from oil and gas well drilling. Also, there is consideration of using oil and gas infrastructure to enhance geothermal resources and vice versa (Western Governors' Association 2006).

The cost of drilling to develop geothermal resources is often the most decisive factor in determining the economic viability of proposed geothermal power plants. Yet, the thousands of oil and gas wells that are typically drilled to even greater depths (accessing even hotter zones) have scarcely been considered for use in geothermal systems. This potential applies to the deep sedimentary basins of the western US (Western Governors' Association 2006).

Many oil fields are nearing the end of the reserves that can be extracted economically. Higher oil prices and new technologies, such as enhanced oil recovery techniques and drilling microholes with less expensive rigs, can significantly increase the percentage of oil recovered profitably. The cost of electricity to operate oil fields is also an important factor in determining the economic life of those fields. Measures to reduce electrical costs, like utilizing renewable resources (wind, solar, and geothermal), can also increase the amount of profitable reserves (Western Governors' Association 2006).

Ideas being discussed in the industry include converting nearly-depleted oil and gas fields into geothermal assets using several proven technologies in unique combination. Initially, solar energy is transferred as heat to aging oil and gas reservoirs in a pattern designed to increase the recovery of remaining oil and gas, at the same time building up the heat content of the reservoir. Ultimately, the banked solar energy would be extracted using naturally occurring brines to drive geothermal power plants and local heating systems (Western Governors' Association 2006)

3.4.5 Non-Energy Minerals

Metallic Minerals

Major copper deposits are located throughout the project area, except for California and Oregon. United States copper production largely comes from deposits in southern Arizona, southern New Mexico, and Utah. Currently, most of the copper production in the US is derived from large, relatively low-grade hydrothermal mineral deposits that formed beneath composite volcanoes. Important, undeveloped hydrothermal copper deposits are hosted by sedimentary rocks in Montana; these deposits are also enriched in silver. Copper often occurs with other metals including cobalt and the platinum group elements: palladium, platinum, rhodium, ruthenium, iridium, and osmium. Major copper-cobalt deposits occur in central Idaho, and a major copper-nickel-platinum group elements deposit is located in Montana. The US ranks first in world production of molybdenum and has a large proportion of the world reserve base. Generally, molybdenum is produced as a byproduct of mining copper and, in particular, porphyry copper deposits. Therefore, the major deposits occur in essentially the same locations as copper, described above (Zientek and Orris 2005).

About 10 percent of total gold discovered in the world is in the US. Over 80 percent of the gold produced in the US in 2002 came from Nevada mines. These mines also produced approximately 30 percent of the US output of silver. Most of the major gold deposits are concentrated in Nevada, northern California, and southern Arizona. Significant deposits also occur throughout Alaska, Colorado, Idaho, Montana, New Mexico, Oregon, and Washington (Zientek and Orris 2005).

About 21 percent of total world silver discovered is in the US. More than two-thirds of the world's silver resources are associated with copper, lead, and zinc deposits. The remainder is associated with hydrothermal gold deposits. Over 40 percent of the significant and major deposits are in Nevada; significant deposits also occur in Alaska, Arizona, California, Colorado, Idaho, Montana, New Mexico, Oregon, Utah, and Washington (Zientek and Orris 2005).

Major lead and zinc deposits, sometimes with other metals, are located in Colorado and Utah, with some others in Alaska, Arizona, Nevada, Montana, Idaho, and Washington. Molybdenum deposits (Zientek and Orris, 2005).

3.4.6 Nonmetallic (Industrial) Minerals

The nonmetallic minerals include barite, garnet, bentonite, kaolinite, phosphates, diatomite, borax, gypsum, and potash. Most of the barite mined in the US comes from bedded barite deposits in Nevada. 95 percent of the world's high-quality abrasive-grade garnet, is found in the large North Creek, New York, deposit. Concentrations of garnet in Idaho and Montana are, however, great enough to form a placer garnet deposits than can be economically developed (Zientek and Orris 2005).

Bentonite is a rock consisting of clay minerals. Almost half of the world production of bentonites is from the US. Major sodium bentonite deposits are found in two districts in the western US: the Hardin district (Montana and Wyoming) and the Black Hills district (Montana, Wyoming, and South Dakota). Kaolin is a term for a group of clays that might best be described as kaolinite-bearing clays. Kaolin deposits are located in Utah, northern Nevada, and southern California. Major phosphorite deposits in the US are related to zones of oceanic upwelling that took place along the western coast of North America in the Permian (forming the western phosphate field in Wyoming, Idaho, Montana, and Utah). There is also a major phosphate deposit in northern Alaska. Diatomite is a sedimentary rock consisting chiefly of the fossilized, silica-rich skeletons of single-celled aquatic plants called diatoms. The largest production of high-purity diatomite comes from the extensive deposits near Lompoc, California. Numerous other deposits occur throughout the US, although most productive deposits are found in the west (Zientek and Orris 2005).

Borates are extracted primarily in California. The majority of boron production in California is from Kern County, California, with the balance from San Bernardino and Inyo Counties. Gypsum is mined primarily in southern Nevada, southern California, and central New Mexico. Potash refers to a group of water-soluble salts that contain the element potassium. Of the five sedimentary basins that host major potash deposits in the US, two are within the western US: the Gulf Coast Basin that covers parts of Alabama, Arkansas, Florida, Mississippi, eastern Texas, Louisiana, and extends into Mexico; and the Permian Basin that covers parts of Colorado, Kansas, New Mexico, Oklahoma, and western Texas. Most domestic production is from evaporite deposits in the Permian Basin near Carlsbad, New Mexico (Zientek and Orris 2005).

Aggregates are sand, gravel, stone, pumice, pumicite, cinders, and ordinary clay used for construction and decorative purposes. Each state in the western US develops its own aggregate resources areas, as transportation is a great part of the cost of the materials. Industrial minerals such as aggregate, limestone, and shale dominate mineral extraction throughout most of California. In southeastern California, southern Arizona, and southern New Mexico, the minerals predominantly extracted include construction aggregate including construction sand, gravel, and crushed stone. Raw, nonfuel minerals extracted throughout Nevada, southern Idaho, southwestern Oregon, and most of Utah include aggregate, gypsum, limestone, trona, shale, and stone. Construction aggregate (including crushed stone and common clay) is the dominant mineral extracted throughout Colorado (BLM 2007c).

3.5 PALEONTOLOGICAL RESOURCES

This analysis involved a review of scientific literature concerning the types and significance of paleontological resources known to occur on public and NFS lands in the project area (Baars 2000, BLM 2007d, Cooper et al. 1990, FS 1996, King 1977, Murphey and Daitch 2007, Peterson et al. 1973, and Reed et al. 2005). It also included a review of paleontological resource sections (if present) of 101 BLM RMPs for 62 BLM field offices in 12 states, which resulted in paleontological resources information for approximately half of the BLM field offices in the project area (Appendix E). Because of the large size of the project area, combined with the inherently discontinuous geographic distribution of geothermal resources, a list of potentially affected geologic units (formations and members thereof) was not compiled for this programmatic analysis. However, as appropriate, paleontological resources described in this section are discussed with reference to the Potential Fossil Yield Classification (PFYC) that was recently revised and adopted as policy by the BLM (BLM IM 2008-009) (Appendix E). The basis for the BLM's resource management classification scheme was the similar PFYC produced and still employed by the FS (FS 1996). Paleontological sensitivity maps based on the PFYC are available for only two of the affected states: Colorado and Utah. The BLM's preparation of additional PFYC maps for the other 10 states is ongoing.

The project area is known to contain some of the most fossiliferous sedimentary rock units in North America. Because of their fossil content, these rocks and correlative strata elsewhere in western North America have been the focus of continuous scientific interest and inquiry for approximately the last 135 years. The rich fossil record of the area ranges in age from the Archean Eon to the Upper Pleistocene Epoch, and represents a temporally discontinuous span of approximately 2.9 billion years. Collectively, these units (formations and members thereof) have produced an estimate of millions of scientifically significant fossil specimens from thousands of fossil localities.

Paleontologic and associated geologic fieldwork in the project area has produced an unprecedented amount of scientific data that continues to be used to study a wide variety of aspects of Phanerozoic biotas, including aspects of their evolution, biostratigraphy, paleobiogeography, paleoenvironments, taphonomy, and paleoecology. Fossils include highly diverse assemblages of vertebrates (fishes, amphibians, reptiles, birds, and mammals), invertebrates (mollusks, arthropods, insects, and many others), and plants (including algae), and include the holotypes of many presently recognized fossil taxa. Housed in museums throughout the US, fossils of western North America have been the subject of thousands of published scientific studies. Much knowledge of Paleozoic through Pleistocene climates, environments, and biotas of North America comes from studies of project area fossils and geology. In addition, individual fossils may also provide information on variation in the species and thereby provide insight on its evolution.

3.5.1 Definition and Significance of Paleontological Resources

Paleontology is a multidisciplinary science that combines elements of geology, biology, chemistry, and physics in an effort to understand the history of life on earth. Paleontological resources, or fossils, are the remains, imprints, or traces of once-living organisms preserved in rocks, sediments, and caves. These include mineralized, partially mineralized, or unmineralized bones and teeth, soft tissues, shells, wood, leaf impressions, footprints, burrows, and microscopic remains. The fossil record is the only evidence that life on earth has existed for more than 3.6 billion years. Fossils are considered nonrenewable resources because the organisms they represent no longer exist. Thus, once destroyed, a fossil can never be replaced. Fossils are important scientific and educational resources because they are used to:

- Study the phylogenetic relationships among extinct organisms, as well as their relationships to modern groups;
- Elucidate the taphonomic, behavioral, temporal, and diagenetic pathways responsible for fossil preservation, including the biases inherent in the fossil record;
- Reconstruct ancient environments, climate change, and paleoecological relationships;
- Provide a measure of relative geologic dating, which forms the basis for biochronology and biostratigraphy, and which is an independent and corroborating line of evidence for isotopic dating;
- Study the geographic distribution of organisms and tectonic movements of land masses and ocean basins through time;
- Study patterns and processes of evolution, extinction, and speciation; and
- Identify past and potential future human-caused impacts on global environments and climates (Murphey and Daitch 2007).

3.5.2 Paleontology and Geologic History of the Western United States

The geologic record of the history of earth, along with the associated history of life contained within the fossil record, has been subdivided into a series of eons, eras, periods, and epochs that define and encompass the entire 3.8 billion years of earth's history based on the geologic record. The following is a description of the paleontological and geologic history of western North America, including Alaska, with an emphasis on the project area. The discussion is divided into time periods from oldest to youngest, beginning with the Archean Eon of the Precambrian, from which the oldest known fossils in western North America date. It includes descriptions of the types of fossils present in western North America and their general provenance and scientific importance, major associated events in the history of life, the pale geography of western North America, and paleoenvironmental conditions of this region through time.

3.5.3 Archean and Proterozoic Eons of the Precambrian

Most of the history of life occurred during the vast stretch of time known as the Precambrian, which includes the older Archean Eon (3.8 to 2.5 billion years ago) and the younger Proterozoic Eon (2.5 billion to 543 million years ago). The oldest known fossils from western North America are of Archean age and consist of stromatolites that are approximately 2.8 billion years old. Stromatolites are lithified organosedimentary structures in which laminations are formed by communities of cyanobacteria trapping and binding sediments. Locally, these fossils form spectacular reefs in places such as the Medicine Bow Mountains in Wyoming. Stromatolites are also known from much younger rocks although modern forms are rare. Other fossils of Precambrian age in western North America consist of palynomorphs and algal filaments and globules known from 800 million year old sedimentary rocks of the Uinta Mountains in Utah. Precambrian (Archean and Proterozoic) life forms consisted of a diversity of unicellular prokaryotic (cells lacking nuclei) bacteria. The oldest known eukaryotic cells (cells with nuclei) have been reported from the Neoproterzoic of Australia, and are approximately 900 million years old. The close of the Precambrian is marked by the first appearance of multicellular life forms in the late Neoproterozoic. Known as the Ediacaran fauna, fossils of these enigmatic organisms include imprints of soft bodied forms and the first exoskeletons of marine invertebrates. Fossils of the Ediacaran fauna are now known from a number of localities around the world, although North American localities are known only from the east coast.

Fossils of Precambrian age are rare in western North America, although this is in large part because noncrystalline unmetamorphosed sedimentary rocks of this age are uncommon. The antiquity of Precambrian-age fossils and the information they provide about the origins of life makes them highly significant scientifically. In western North America, sedimentary rocks of this age occur in parts of Montana, Wyoming, Utah and Arizona, and are generally recommended for designation as PFYC Class 3 (Moderate or Unknown: Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential) (Appendix E).

3.5.4 Paleoezoic Era

The Paleozoic Era lasted from approximately 543 to approximately 242 million years ago. It is subdivided into seven periods including, from oldest to youngest, the Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian.

A major adaptive radiation took place during the Cambrian Period that resulted in the evolution of most of the known phyla (broad groupings of organisms) as well as other phyla that have since become extinct. This geologically rapid appearance of diverse multicellular life is referred to as the Cambrian explosion, and is best documented in the fauna of the Burgess Shale (Middle Cambrian-age

Stephan Formation) of British Columbia. One of the most widespread and diverse groups of animals, the trilobites, first appeared at the beginning of the Cambrian, diversifying and evolving throughout most of the Paleozoic. Although the Cambrian fossil record is dominated by trilobites, other groups that evolved during this period include brachiopods, mollusks, echinoderms, porifera (sponges), and cnidaria (corals), as well as numerous extinct phyla.

At the beginning of the Cambrian Period, the landmass that would later become North America (referred to as Laurentia) was situated directly over the equator. East of Laurentia were several small continental masses that would eventually become Siberia, northern Europe, and Kazakhstan. Further east was the super-continent Gondwana, which included the combined land masses of South America, Africa, Antarctica, Australia, and China. During the Cambrian, the North American landmass was oriented at 90 degrees from its present orientation so that the paleoequator was on a line roughly from Texas to Hudson Bay, and the Canadian Shield formed highlands surrounded by ocean. Western North America was largely under water during this time, and was located north of the Canadian Shield between approximately 5 and 20 degrees north latitude. Sediments of Cambrian age in western North America include quartz-rich sandstone and limestone deposited in a shallow carbonate sea and muddy shale that was deposited in deeper waters. Cambrian-aged rocks are exposed in the Grand Canyon area, in parts of Colorado Utah and Idaho, in north-central Nevada, and in parts of California and the Pacific Northwest.

By the end of the early Ordovician Period, the uninterrupted sequence of carbonate deposition associated with the shallow seas of the Cambrian ended, and a period of craton-wide erosion lasted throughout much of the rest of the Ordovician. By the late Ordovician, the Laurentide landmass (that would later form North America) was centered just south of the paleoequator and was again almost completely covered with a shallow carbonate sea. This Late Ordovician marine transgression resulted in an explosive radiation and diversification of marine organisms shells of calcium carbonate. This fauna was dominated by brachiopods but also included crinoids, echinoderms, gastropods, trilobites, nautiloid cephalopods, and graptolites.

During the middle Ordovician, the earliest radiation of vertebrates was underway (modern vertebrates include animals with backbones including fishes, amphibians, reptiles, birds, and mammals). These early vertebrates are preserved in sandstone beds of the Harding Formation on public lands in south-central Colorado, and consist of scales and teeth of primitive jawless fishes called agnathans, a group that first appeared during the latest Cambrian.

During the middle Ordovician and early Silurian periods, a range of mountains was uplifted in the northern part of the Appalachian region of the eastern US, and shallow carbonate seas covered much of the cratonic interior of North America. Coral reefs were common and resulted in widespread deposition of limestone and dolomite. Silurian shallow-marine fossil faunas are dominated by articulate brachiopods, but also include bryozoans, cephalopods, crinoids, corals, ostracods, conodonts, and eurypterids (sea scorpions). The Silurian Period also saw the initial evolution of land plants. Rocks of Silurian age are more common in the eastern US but occur locally in the west with relatively widespread exposures in Nevada.

By the early Devonian Period, Laurentia had coalesced with Baltica (a slightly smaller landmass east of Laurentia that would later become western Europe), and the two were closely associated with the southern supercontinent Gondwana. Land that would later become western North America was located just south of the paleoequator, and was mostly covered by a shallow carbonate sea. A narrow chain of island mountains (the Antler Mountains) was present from what is today southern Nevada to northern Idaho. The area northwest of these mountains (the area that would later become the pacific coast of North America) was occupied by a deep, muddy ocean. Devonian seas contained reef systems and marine faunas similar to those of the Ordovician, and major radiations of both ammonoids and conodonts occurred during this time. A major diversification of vertebrate life was occurring simultaneously, with five classes of fish appearing by the Early Devonian (often referred to as the "age of fish"). This radiation of fishes included the agnathans (jawless fish that are represented today by the hagfish and lamprey), the Acanthodii (all extinct), the armored Placoderms (all extinct), the Chondrichthyes (sharks, skates and rays), and the Osteichthyes (bony fishes). The first land vertebrates (tetrapods) evolved during the Late Devonian and consisted of amphibians. This heralded what would be a dramatic evolutionary radiation and diversification of land vertebrates during the Carboniferous. The land plants that first appeared in the Silurian diversified and became abundant by the Early Devonian. Devonian-age rocks in western North America are present from New Mexico, Arizona, and Nevada north into Canada. Important fossil bearing rocks of Devonian age rocks in western North America are located in Nevada, Idaho, and southwestern Canada.

By the early Mississippian Period, Laurentia remained in an equatorial position and most of western North America remained under a shallow carbonate sea. The Appalachian Mountains extended from Georgia north into Labrador (their uplift having been a result of a continental collision with Gondwana along the southern margin of Laurentia), but land in western North America was limited to a small arc of highlands that developed from continued uplift of the Antler Mountains. These highlands consisted of a narrow swath of land that extended from southern California to northern Idaho. East of the Antler Highlands, a broad shallow carbonate sea extended east to the Great Lakes region, while west of the highlands were deeper ocean waters. The Antler Highlands provided a source material for thick deposits of Mississippian aged shale in Utah and deposits of sandstone and conglomerate in northern and eastern Nevada. Mississippian marine deposits now form extensive limestone deposits in

Montana, Wyoming, Utah, eastern Idaho, and Colorado, and comprise the red cliff limestone walls of Arizona's Grand Canyon. Fossil crinoids are abundant in Mississippian limestone, and the Mississippian Period has been referred to as the "age of crinoids." Other characteristic fossils include bryozoans, brachiopods, echinoderms, and foraminifera. Land plants of the Mississippian include forms that are transitional between those of the Silurian and Pennsylvanian Periods.

During the Pennsylvanian Period, all of the land masses on the globe were in the process of coalescing into a single massive supercontinent called Pangaea. The Appalachian mountain range and associated lowlands in the south and east provided source material for broad areas of sedimentation to the west. In the middle Pennsylvanian, the Ouachita Mountains formed in a narrow swath from central Texas to Louisiana. The end of uplift that had earlier produced the Antler Mountains coincided with the beginning of the Colorado Orogeny in the area of Colorado, Utah, and New Mexico. These new mountains, together with the Antler Mountains, formed isolated islands in a shallow sandy and muddy sea that covered most of the interior of North America, with a deep ocean on the western margin of the part of Pangaea that would later become North America. An island arc that extended from the location of northern California to southern Alaska, along what is now the Pacific coast, was the only land west of the Antler Mountains. Subsidence in areas adjacent to the ancestral Rocky Mountains resulted in thick sequences of Pennsylvanian-aged nonmarine shale, sandstone, and conglomerate in Colorado, and temporally equivalent sequences of marine limestone and sandstone in Colorado and Utah. Pennsylvanian-age rocks form extensive deposits throughout much of the central and western US from eastern Kansas to western Nevada and north to Montana.

The Pennsylvanian Period is associated with two major events in the history of life. The first was the development of vast cycads and tree fern forests including those along the western flank and adjacent lowlands of the Appalachian Mountains, resulting in a dramatic diversification of plant life that would ultimately be preserved as the rich coal beds of eastern and central North America. The second event was the evolution of reptiles during the lower Pennsylvanian which are first known from Nova Scotia. A large inland sea still covered much of the western US, and fossils from western North America are predominantly marine in origin.

The Permian Period marks the end of predominantly marine environments over much of North America, and is associated with both the regression of continental seas and the gradual emergence of the North American continent. By the late Permian, the Appalachian and Ouachita mountains had joined to form a single extensive range that extended from western Texas to Labrador roughly along a line that would become the Gulf and Atlantic coasts. However, western North America remained largely under shallow and deep seas. The volcanic island arc that had developed during the Pennsylvanian now extended from Baja California north to Alaska. Vast barrier reefs formed in the vicinity of west Texas. A broad phosphorite basin formed in an area that extended from northern Nevada to British Columbia, and these phosphate deposits are exposed today in Wyoming, Utah, Montana, and Idaho. Extensive deposits of Permian-age red sandstone and mudstone beds in the Rocky Mountain region indicates deposition on coastal mudflats and alluvial floodplains.

During the Permian Period, reptiles diversified and increased in abundance, assuming an ecological role as the dominant land vertebrates. The mammal-like reptiles, or therapsids, which included the ancestors of true mammals, were diversifying. The most dramatic paleontological event of the Permian was the massive global terminal Permian extinction event, the largest documented extinction event in the entire Phanerozoic. As many as 90 percent of all marine invertebrate families, including such dominant forms as the trilobites, went extinct by the end of the Permian. Large numbers of terrestrial animal and plant species also went extinct.

Sedimentary rocks of Cambrian, Ordovician, and Silurian age contain diverse fossil invertebrate assemblages but few vertebrate fossils. These are generally recommended for designation as PFYC Class 3 (Moderate or Unknown) (Appendix E). Sedimentary rocks of Devonian through Permian age have the potential to produce well-preserved and scientifically significant vertebrate fossils, although vertebrate occurrences are typically localized and uncommon. Locally abundant and well-preserved marine invertebrate fossils are also known. Sedimentary rocks of these time periods could range in sensitivity from PFYC Class 3 through 5 (Appendix E).

3.5.5 Mesozoic Era

The Mesozoic Era lasted from approximately 242 to 65.5 million years ago. It is subdivided from oldest to youngest into the Triassic, Jurassic, and Cretaceous periods. Generally, the Mesozoic Era is characterized by the evolution, diversification, and eventual extinction of dinosaurs, as well as the evolution of mammals, birds, and flowering plants.

During the Early Triassic, deposition of red beds similar to those of the Permian took place in much of North America. The North American continent remained near the equator in a similar orientation as during the Permian, and much of western North America was covered by seas. A sandy and muddy alluvial plain extended far west and north from the Ouachita-Appalachian Mountains, and a shallow muddy and sea with numerous barrier islands at its eastern margin extended from southern New Mexico north to Alaska. The Sonoma Orogeny resulted in a series of highlands and mountains that extended from northern Baja California to northern British Columbia. The Sonoma Mountains were surrounded by deep muddy waters and the extensive western volcanic arc remained to the west of the Sonoma range. Late Triassic-age sedimentary rocks of marine origin are present in southern Alaska and in the Brooks Range to the north.

The picturesque red and variegated beds of the Triassic-aged Moenkopi and Chinle formations are exposed throughout much of western North America, particularly on the Colorado Plateau. These rocks units are known to preserve a variety of vertebrate fossils such as terrestrial amphibians and reptiles, including primitive dinosaurs. They also yield locally abundant fossil plants and a variety of fossil trackways. The oldest mammal fossils are also known from the Triassic. Marine life during the Triassic was associated with a dramatic diversification of ammonoid cephalopods. These fossils are abundant in the marine fossil record and are biostratigraphically important. Triassic reefs were formed by new and more complex forms of reef building organisms that evolved in the wake of the late Permian extinctions. By the end of the Triassic Period, reptiles were not only abundant in terrestrial ecosystems, but had also evolved into aquatic forms such as plesiosaurs and ichthyosaurs.

By the beginning of the Jurassic, most of the North American continent was above water, and plate tectonics had caused a northward migration of the continent. The Appalachian Mountains and low-relief highlands extended west to roughly the present location of the Mississippi River. West of these highlands were alluvial lowlands and coastal plains that extended all the way west to Nevada. The Westernmost portion of North America including all of Alaska remained under waters of the Sundance Sea. Early Jurassic rocks in the western US typically consist of thick sequences of cross-bedded sandstone. The eolian sand dune deposits of the Navajo Sandstone are the best known example. In the westernmost portion of North America, Jurassic-age rocks consist of dark shale, bedded chert, graywacke, and conglomerate. By late Jurassic time, the volcanic island arc present along the western margin of North America had collided with the continent (the Nevadan Orogeny). Continued subduction along the western margin of the continent resulted in the deposition of Jurassic and Cretaceous aged marine rocks in the California Coast Ranges and to the east in the Great Valley of California. The Nevadan Orogeny marked the beginning of a protracted series of mountain building events known as the Cordilleran Orogeny that would continue throughout the remainder of the Mesozoic and into the Cenozoic. During the late Jurassic, the Sundance Sea east of the Cordilleran highlands experienced a major regression that coincided with deposition of the terrestrial highly fossiliferous Morrison Formation over a vast area of the western US.

The Morrison Formation contains abundant and diverse assemblages of fossil vertebrates, invertebrates, and plants, and characterizes the broad diversification of dinosaurs during the Jurassic. It also preserves smaller vertebrates including frogs, salamanders, lizards, crocodiles, and primitive fossil mammals, and is one of the most heavily researched formations in the world by paleontologists. During the Jurassic, vertebrates evolved the ability to fly as represented by the earliest birds and the reptilian pterosaurs. Marine reptiles such as plesiosaurs and ichthyosaurs were also more abundant than during the Triassic. Marine life during the Jurassic was dominated by mollusks and ammonoids with abundant crinoids and echinoids.

By the beginning of Cretaceous time, the rifting and break up of the supercontinent Pangaea was well underway. By the mid-Cretaceous, the North American continent had moved northward and was centered at near 40 degrees north latitude, with Alaska situated near the North Pole. Continued oceanic plate subduction along the western margin of the US during the Cretaceous resulted in a range of mountains and highlands that extended from Mexico to Alaska. A trangression of marine waters from both the Gulf of Mexico and the Arctic during early Cretaceous time resulted in the development of the broad (900-mile-wide) Cretaceous Interior Seaway that extended from Utah east to Ohio, and completely separated the western highlands from those to the east. By late Cretaceous time, the primarily marine sediments of the early and middle Cretaceous that covered much of the western interior were giving way to estuarine and coastal plain sediments as the seaway retreated. By latest Cretaceous time, the Laramide Orogeny, which resulted in the uplift of the Rocky Mountains, was underway. Terrestrial and marine rocks of Cretaceous-age are common throughout western North America.

Cretaceous marine deposits contain abundant and diverse invertebrate fossils typically including ammonoids, bivalves, gastropods, echinoderms, corals, and bryozoans. Marine vertebrates were also common and include giant fishes, mosasaurs (marine lizards), plesiosaurs, pliosaurs, and turtles as large as 13 feet long. Terrestrial vertebrate faunas were dominated by abundant and diverse dinosaurs such as *Triceratops*, *and Tyrannosaurus*. Pterosaurs attained wingspans of up to 30 feet. Birds diversified during the Cretaceous, as did mammals, although many mammals remained small and shrew-like in appearance. Plant evolution during the Cretaceous was marked by the appearance of angiosperms (flowering plants) that evolved during the early Cretaceous and coevolved with insects throughout this period, ultimately dominating plant communities by the end of the Cretaceous. The end of the Cretaceous Period is marked by the well known Cretaceous-Tertiary boundary event that resulted in the mass extinction of many animal and plant species 65.5 million years ago, and is widely accepted to have been caused largely by an asteroid impact. Included in the extinction were both marine and terrestrial organisms including dinosaurs (with the exception of birds), mosasaurs, plesiosaurs, pterosaurs, and many species of plants and invertebrates.

Sedimentary rocks of Triassic, Jurassic, and Cretaceous age may contain diverse and locally abundant assemblages of scientifically significant fossil vertebrates, invertebrates, and plants. These rock units generally could meet PFYC Class designations of 3, 4, or 5 (Appendix E).

3.5.6 Cenozoic Era

The Cenozoic Era lasted from 65.5 million years ago to the present and includes two periods, the Tertiary and Quaternary. The Tertiary Period is divided into the Paleogene and Neogene periods. The Paleogene includes the Paleocene, Eocene, and Oligocene epochs, and the Neogene includes the Miocene and Pliocene epochs. The Quaternary Period is divided into the Pleistocene and the Holocene. The Cenozoic Era is associated with the diversification of mammals following the extinction of nonavian dinosaurs and their dominance of terrestrial faunas, as well as the development of modern ecosystems and climatic regimes during the Quaternary. The youngest fossils are generally considered by paleontologists to date to the end of the Pleistocene Epoch, approximately 10,000 years ago. Accordingly, fossils are not considered to be present in sedimentary deposits of Holocene age, which contain only the unfossilized remains of modern species of animals and plants.

By the beginning of the Cenozoic Era, the North American continent was nearing its present geographic orientation and location. The Laramide Orogeny of the Late Cretaceous and early Cenozoic marked the final stages of the Cordilleran Orogeny. The Cordilleran Orogeny, which began during the Jurassic, had progressed eastward throughout the Mesozoic, resulting in the final uplift of the central Rocky Mountains by the end of the Cretaceous. This period also marked the end of marine environments within the western interior of North America. During the Laramide Orogeny, intermontane basins developed as a result of down-warping between Rocky Mountain uplifts, and surrounding highlands provided source material for thick sequences of Tertiary-aged fluvial and lacustrine sediments that accumulated in these basins. Also deposited in these basins were the organic remains of animals and plants that would eventually become the rich fossil record that documents the ecosystems of the early and middle part of the Cenozoic. In addition to extensive deposits of limestone, shale, mudstone, siltstone, and sandstone, significant amounts of volcaniclastic sediment were deposited throughout western North America during the Cenozoic. The west coast of North America is the leading edge of the North America continent and, as such, is tectonically more dynamic, resulting in a highly complex distribution of formations. A confusing array of deep marine, shallow marine, and nonmarine sediments of varying ages have been thrust, accreted, and shifted along the Pacific coast of North America. As a result, a wide variety of Cenozoic-aged sedimentary rocks with abundant fossils of both terrestrial and marine organisms are exposed along the Pacific Coast and in adjacent areas. Cooling and drying of global climates began during the Eocene and continued throughout the Oligocene, Miocene, Pliocene, and into the Pleistocene ice ages. The cool wet climates of the Pleistocene resulted in massive glacial expansion in the northern portion of the North American continent and in mountainous areas, while a vast lake system developed in the Midwest. Glacial till, eolian sand, alluvium, and colluvium are common types of Pleistocene-aged sedimentary deposits that occur in western North America.

The fossil record of the Cenozoic Era is extremely well preserved in rock units in western North America. Following the extinction of the dinosaurs at the end of the Cretaceous, mammals rapidly radiated and diversified into their respective modern groups, as well as several archaic groups that went extinct during the early part of the Tertiary. Eocene forests were inhabited by a host of mammals including insectivores, primates, marsupials, bats, rodents, small and large carnivores, tapirs, horses, rhinos, and many others. By the late Eocene, all the modern orders of mammals had evolved and were represented by species that were ancestral to the modern forms known today. As climates cooled, the tropical and subtropical forests of the Paleocene and early Eocene gave way to more open woodlands, and tropical species of animals including some types of fishes, turtles, alligators, crocodiles, and primate mammals, retreated south or went extinct in North America. Continued global cooling and drying led to the evolution of grassland ecosystems during the Miocene. General adaptive strategies for mammalian groups at this time included an increase in body size, the ability to digest grasses, and a trend towards greater cursoriality (skeletal modifications to become more effective runners). The diverse perissodactyls (odd-toed ungulates such as horses, rhinos, tapirs, brontotheres, and chalichotheres) of the early Tertiary steadily diminished in diversity as the artiodactyls (even-toed ungulates such as oreodonts, deer, bison, pronghorn, sheep, and goats) diversified throughout the Cenozoic. The first appearance of many modern mammal species can be traced back to the Pleistocene. However, many animals that were adapted to cooler climates went extinct as temperatures warmed at the end of the Pleistocene, although warmer temperatures were not necessarily the cause of the late Pleistocene extinctions. Extinct Pleistocene mammals include mammoth and mastodon, cave bear, North American lion, North American cheetah, saber tooth tiger, ground sloth, dire wolf, giant beaver, and the giant *Bison antiquus*.

Sedimentary rocks of Tertiary age are known to contain diverse and locally abundant assemblages of scientifically significant fossil vertebrates, invertebrates, and plants. As a result, these rock units are generally recommended for designation as PFYC Class designations of 3, 4, or 5 (Appendix E). Quaternary (Pleistocene) vertebrate, invertebrate, and plant fossils are typically uncommon and poorly preserved in most surficial sediments, although localized rich accumulations are known in western North America from cave deposits and other unusual settings such as tar pits. Pleistocene-age surficial deposits are generally recommended for designation as PFYC Class 2 (Low: Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils) (Appendix E) unless prior local discoveries warrant a higher class designation.

3.5.7 Review of BLM Resource Management Plans

A review of BLM RMPs for field offices in the project area was conducted to determine if paleontological resources had been previously addressed and, if so, if the paleontological sensitivity of the geologic units within each BLM field office could be estimated given the information provided. If sufficient information was available, an attempt was made to equate the information provided to the PFYC recently adopted as policy by the BLM (BLM Instruction Memorandum 2008-009) (BLM 2007d) (Appendix E). There was insufficient information to estimate PFYC subclasses a or b for PFYC Classes 3 through 5.

A total of 101 RMPs were reviewed from 62 BLM field offices in the 12-state project area (Appendix E) (Table 3-7). Resource Management Plans were not available for 57 of the BLM field offices within the project area. In cases where paleontological resources were not addressed, estimates of paleontological sensitivity could not be made. Of the 101 RMPs reviewed, 32 contained sufficient information on fossil occurrences or geologic formations to estimate sensitivity and tentatively assign PFYC classes for the geologic units within the field office (Table 3-7).

Table 3-7
Project Area BLM RMPs Reviewed & Tentative PFYC Classes

State	RMPs Reviewed	RMPs with Sufficient Information to Tentatively Assign PFYC Classes
Alaska	4	3
Arizona	5	4
California	11	1
Colorado	10	3
Idaho	13	4
Montana	10	8
New Mexico	9	3
Nevada	6	1
Oregon	4	0
Utah	13	5
Washington	3	0
Wyoming	13	0
Total	**101**	**32**

3.6 SOIL RESOURCES

Soil resources are categorized into *land resource units* that consider significant geographic differences in soils, climate, water resources, or land use. Land resource units are generally several thousand acres in size and typically coextensive with state general soil map units. Geographically associated land resource units are grouped into *major land resource areas*, which are in turn grouped into *land resource regions*. These large areas are used in statewide agricultural planning, as well as interstate, regional, and national planning (USDA Natural Resource Conservation Service 2006).

Soils in the project area are diverse and range from the arid, saline soils of the southwest, to the clayey glaciated soils of Montana, to the cold, wet permafrost soils of Alaska. Soils are the result of complex interactions between parent material (geology), climate, topography, organisms, and time. Soils are classified by the degree of development into distinct layers or horizons and their prevailing physical and chemical properties. Similar soil types are grouped together into soil orders based on defining characteristics, such as organic matter and clay content, amount of mineral weathering, water and temperature regimes, or other characteristics that give soil unique properties, such as the presence of volcanic ash or permafrost (BLM 2007c).

3.6.1 Description of Soil Orders and Classifications

Soil Orders

Alfisols can be found throughout the mountains of western Montana and Wyoming and in central Colorado and California. They are characterized by subsurface clay accumulations and nutrient-enriched subsoil. Alfisols commonly have a mixed vegetative cover and are productive for most crops, including commercial timber (BLM 2007c).

Andisols occur in Washington, Oregon, Idaho and along the Cascades in Northern California. In Alaska they are found in the southwest part of the Alaskan Peninsula and in the Aleutians (University of Idaho 2007). They are soils that have formed on volcanic ash deposits. They have high amounts of volcanic glass and organic matter, giving them a light, fluffy texture (BLM 2007c). As a group, Andisols tend to be highly productive soils (USDA Natural Resource Conservation Service 2006).

Aridisols occur across wide parts of the western US in Nevada, Arizona, New Mexico, central Wyoming, southern Idaho, and southern California. These soils are characterized by an extreme water deficiency. They are light colored, low in organic matter, and may have subsurface accumulations of soluble materials, such as calcium carbonate, silica, gypsum, soluble salts, and exchangeable sodium. Vegetation on these soils includes scattered desert shrubs and short bunchgrasses, which are important resources for livestock. Aridisols are generally not very productive without irrigation and may be prone to salinity buildup. Surface mineral deposits often form physical crusts that impede water infiltration (BLM 2007c).

Entisols occur extensively in eastern Montana and western Colorado, Wyoming, Utah, and central California. They are young, weakly developed mineral soils that lack significant profile development (soil horizons). They are often found in lower-elevation, arid, and semiarid environments supporting desert shrub and sagebrush communities. Entisols can include recent alluvium, sands, soils on steep slopes, and shallow soils. Soil productivity ranges from very low in soils forming in shifting sand or on steep rocky slopes to very high in certain soils formed in recent alluvium. Productivity is often limited by shallow soil depth, low water-holding capacity, or inadequate available moisture. However, these soils support rangeland vegetation and may support trees in areas of higher precipitation (BLM 2007c).

Gelisols occur almost exclusively in the tundra regions of Alaska. They are underlain by permanently frozen ground (permafrost). Some gelisols in wet environments have developed large accumulations of organic matter, particularly in areas of bogs and wetlands. Soil-forming processes take place very slowly above the permafrost in the active layer that thaws seasonally. These soils support tundra vegetation of lichens, grasses, and low shrubs that grow during brief summers. Plant productivity is low and limited by the northern latitudes' extremely short growing season, low levels of solar radiation, and poor water drainage. Bare rock is also common in Alaska, comprising nearly 8 million acres (BLM 2007c).

Histosols occur in limited areas in northern Washington, Central Colorado, and southwestern Alaska (University of Idaho 2007). They are organic soils that typically form in lowland areas with poor water drainage. Areas containing these soils are commonly called bogs, moors, peats, or mucks. The soils form in decomposed plant remains that accumulate in water, forest litter, or moss faster than they decay (USDA, Natural Resources Conservation Service 2006). While not extensive, Histosols are often associated with riparian or wetland resources and can be very important locally (BLM 2007c).

Inceptisols are found in northern Idaho and parts of Washington, Oregon, and Montana, as well as southwestern Alaska. They are generally young mineral soils but have had more time to develop profile characteristics than Entisols. They principally occur in very cool to warm, humid, and subhumid regions and in most physiographic conditions, and often support coniferous and deciduous forests, as well as rangeland vegetation. They may form in resistant rock or thin volcanic ash on steep mountain slopes or depressions, on top of mountain peaks, or next to rivers. Productivity is varied and may be high where moisture is adequate (BLM 2007c).

Mollisols in the project area are found in northern Montana, eastern Oregon, Washington, and Idaho, where they have developed from basalt and loess parent materials. These soils typically support grasslands and are mineral soils with thick, dark-colored surface horizons rich in organic matter from the dense root systems of prairie grasses. They are one of the most productive soils on public lands, and their high organic matter content helps reduce the risk of groundwater contamination by herbicides. Mollisols extend from upland areas to the prairie grasslands, where they are most abundant. Mollisols support a variety of plant communities, including grasslands, chaparral-mountain shrub, and forests. Since they have developed primarily under grassland vegetation, mollisols have been used extensively for livestock grazing (BLM 2007c).

Spodosols occur in northern Washington, central Colorado, and central Alaska (University of Idaho 2007). They are highly leached, acid**ic** soils that typically form on sandy soils under cold, humid conditions at high elevations (BLM 2007c). They are characterized by a subsurface accumulation of humus that is complexed with aluminum and iron (University of Idaho 2007). These soils commonly occur in areas of coarse textured deposits under coniferous forests of humid regions. They tend to be acid and infertile and require additions of lime in order to be productive agriculturally (USDA, Natural Resources Conservation Service 2006).

Ultisols occur in southwestern Washington, western Oregon and in the coastal mountains and the Cascade Range in California. They are formed through fairly intense weathering and leaching processes that result in a clay enriched subsoil. They are found primarily in humid temperate forest areas, typically on older, stable landscapes. These soils are low in nutrients, but, with soil additives, they are productive for row crops (University of Idaho 2007, USDA, Natural Resources Conservation Service 2006).

Vertisols occur in central and eastern Montana, and sporadically throughout the Western U.S. They have large amounts of expanding clay that causes them to have high shrinking and swelling characteristics (BLM 2007c). When wet, these soils swell, transmitting water very slowly, therefore, they have undergone little leaching and tend to be high in natural fertility (USDA, Natural Resources Conservation Service 2006).

Further soil classification includes suborder, great group, subgroup, family, and series. These classifications are based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Where further classification is discussed below, appropriate definitions have been included in the glossary.

Farmlands

The purpose of the Farmland Protection Policy Act (Public Law 97-98, 7 USC 4201) is to minimize the extent to which federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses, and to assure that federal programs are administered in a manner that, to the extent practicable, will be compatible with state and local government and private programs and policies to protect farmland. The term "farmland" includes all land defined as follows:

- Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion, as determined by the Secretary of Agriculture. Prime farmland includes land that possesses the above characteristics but is being used currently to produce livestock and timber. It does not include land already in or committed to urban development or water storage;
- Unique farmland is land other than prime farmland that is used for production of specific high-value food and fiber crops, as determined by the Secretary of Agriculture. It has the special combination of soil quality, location, growing season, and moisture supply needed to economically produce sustained high quality or high yields of specific crops when treated and managed according to acceptable farming methods; and
- Farmland, other than prime or unique farmland, that is of statewide or local importance for the production of food, feed, fiber, forage, or oilseed crops, as determined by the appropriate state or unit of local government agency or agencies, and that the Secretary of Agriculture determines should be considered as farmland for the purposes of the Farmland Protection Policy Act.

Cropland of statewide importance is land, in addition to prime farmlands, that is of statewide importance for the production of food, feed, fiber, forage and oilseed crops. Criteria for defining and delineating this land are to be determined by the appropriate State agency or agencies. Generally, additional farmlands of statewide importance include those that are nearly prime farmland and that economically produce high yields of crops when treated and managed according to acceptable farming methods.

Prime and unique farmlands, as well as farmlands of statewide importance are discussed for specific lease sites as farmlands soils are identified and managed by local soil conservation districts. The exception is where loss of farmland soils has been identified as a regional priority.

Biological Soil Crusts

Biological soil crusts (also known as cryptogamic, microbiotic, cryptobiotic, or microphytic crusts) are commonly found in semiarid and arid environments.

They provide important functions, such as improving soil stability and reducing erosion, fixing atmospheric nitrogen, contributing nutrients to plants, and assisting with plant growth (BLM 2007c).

Crusts are composed of a highly specialized nonvascular plant community consisting of cyanobacteria, green and brown algae, mosses, and lichens, as well as liverworts, fungi, and bacteria. Biological soil crusts occupy open spaces between the sparse vegetation of the Great Basin, Colorado Plateau, Sonoran Desert, and the inner Columbia Basin, and occur in agricultural areas, native prairies, and Alaska (BLM 2007c).

Biological soil crusts can reach up to several inches in thickness and vary in terms of color, surface topography, and surficial coverage. Crusts generally cover all soil spaces not occupied by vascular plants, which may be 70 percent or more in arid regions. They are well adapted to severe growing conditions but are influenced by physical disturbances, fire, and application of herbicides. Disturbance of biological crusts results in decreased soil organism diversity, nutrients, stability, and organic matter (BLM 2007c).

Soil Erosion and Compaction

Soil erosion is a concern throughout the project area, particularly in semiarid rangelands. The quantity of soil lost by water or wind erosion is influenced by climate, topography, soil properties, vegetative cover, and land use. While erosion occurs under natural conditions, rates of soil loss may be accelerated by human activities (BLM 2007c).

Tundra lands in Alaska are susceptible to erosion if the thick vegetative mat overlying permafrost is disturbed or removed. Trails quickly turn into widely braided ruts, especially in wetlands and at stream bank crossings. The resulting gully erosion can rapidly erode substantial quantities of previously frozen soils. Erosion from ice is also a concern due to spring-breakup flood events leaving disturbed stream channels. These events cause previously stable riparian areas to form a long-lasting sequence of extensively braided channels, especially in glacial soils (BLM 2007c).

Rangelands are affected by all four types of water erosion: sheet, rill, gully, and stream bank, as well as by wind erosion. Sheet erosion is relatively uniform erosion from the entire soil surface and is therefore often difficult to observe, while rill erosion is initiated when water concentrates in small channels as it runs off the soil. Sheet and rill erosion can reduce the productivity of rangeland soils but often go unnoticed. Gully and stream bank erosion is far more visible and may account for up to 75 percent of erosion in desert ecosystems. Changes in water flow patterns in arid areas resulting from thunderstorms and fire events can increase the size and frequency of runoff events and sediment yield to local water sources. Wind erosion is most common in arid and semiarid regions where lack of soil moisture greatly reduces soil's adhesive capability (BLM 2007c).

Soil compaction occurs when moist or wet soil aggregates are pressed together and the pore space between them is reduced. Compaction changes soil structure, reduces the size and continuity of pores, and increases soil density. Wheel traffic, large animals, vehicles, and people can cause soil compaction. Compaction becomes a problem when the increased soil density limits water infiltration, increases runoff and erosion, or limits plant growth or nutrient cycling (BLM 2007c).

3.6.2 Characteristics by Land Resource Region

Northwestern Forest, Forage, and Specialty Crop Region

In the project area, this region covers 90,165 square miles in parts of Oregon (42 percent), Washington (39 percent), and California (19 percent). It is comprised of the Northern Pacific Coast Range, Foothills, and Valleys, Willamette and Puget Sound Valleys, Olympic and Cascade Mountains, Sitka Spruce Belt, Coastal Redwood Belt, Siskiyou-Trinity Area, Cascade Mountains, and Eastern Slope major land resource areas (USDA, Natural Resources Conservation Service 2006). The dominant soil orders in this region are Alfisols, Andisols, Entisols, Inceptisols, Spodosols, and Ultisols. Soils on the hilly and steep uplands are mostly Andisols and Inceptisols. These soils are shallow to very deep and are well drained. Soils on the marine and glacial outwash terraces are dominantly Andisols and Spodosols. These soils are shallow or moderately deep to cemented materials or are deep or very deep. They are poorly drained to well drained. Entisols and Inceptisols are on floodplains and estuaries. These soils are very deep and typically are very poorly drained or poorly drained. Alfisols and Ultisols are on the mountains slopes. They are moderately deep or deep and are well drained. Mollisols are in the Willamette Valley. These soils are moderately deep to very deep and typically are moderately well drained. Most of the soils formed in colluvium or residuum weathered from siltstone and sandstone, but some formed in colluvium weathered from basalt or other volcanic rocks. The soils have a mixed mineralogy (USDA, Natural Resources Conservation Service 2006).

Northwestern Wheat and Range Region

This region covers 81,255 square miles in parts of Idaho (44 percent), Washington (29 percent), and Oregon (27 percent). A very small part is in Utah. It is comprised of the Columbia Basin, Columbia Plateau, Palouse and Nez Perce Prairies, Central Rocky and Blue Mountain Foothills, Snake River Plains, Lost River Valleys and Mountains, and Eastern Idaho Plateaus major land resource areas (USDA, Natural Resources Conservation Service 2006). The dominant soil orders in the region are Mollisols and Aridisols. Other soil orders that occur in the region are Alfisols, Andisols, Entisols, and Inceptisols. Mollisols and Aridisols formed in a deep mixture of loess and ash deposits overlying the basalt flows in this region. The other soil orders formed in alluvium on terraces and floodplains or in residuum and colluvium on foothills and mountain slopes. Most of the soils are deep or very deep, well drained, and loamy (USDA, Natural Resources Conservation Service 2006).

California Subtropical Fruit, Truck, and Specialty Crop Region

This region is entirely in California and covers 62,350 square miles (USDA, Natural Resources Conservation Service 2006). It is made up of the Central California Coastal Valleys, Central California Coast Range, California Delta, Sacramento and San Joaquin Valleys, Sierra Nevada Foothills, Southern California Coastal Plain, and Southern California Mountains major land resource areas (USDA, Natural Resources Conservation Service 2006). The soils in this region are dominantly Alfisols, Entisols, Mollisols, and Vertisols. Fluvents, Orthents, and Ochrepts on floodplains and alluvial fans are the most important soils used for agricultural purposes in this region. The soils in the region dominantly have mixed or smectitic mineralogy (USDA, Natural Resources Conservation Service 2006).

Many of the soils on floodplains and low terraces in the San Joaquin River valley are affected by salts and must be skillfully managed for good crop production. The agricultural drainage water in this valley commonly has a high salt load, and the salinity in receiving streams typically increases in a downstream direction. Soil resource concerns throughout this agriculturally rich region include controlling rainfall- and irrigation-caused water erosion and maintaining the soils' organic matter content. Wind erosion is a hazard in the San Joaquin River valley and in some of the coastal valleys. Irrigation water management is a priority in this populous region, where agriculture and urban areas compete for good-quality water. Salinity and the intrusion of saltwater into aquifers are management concerns in the coastal valleys (USDA, Natural Resources Conservation Service 2006).

Western Range and Irrigated Region

This region is the largest of all the land resource regions in land area, covering 549,725 square miles in parts of Arizona (21 percent), Nevada (20 percent), California (14 percent), New Mexico (13 percent), Utah (11 percent), Wyoming (7 percent), Texas (5 percent), Oregon (4 percent), Colorado (3 percent), Idaho (2 percent), and Montana (less than 1 percent) (USDA, Natural Resources Conservation Service 2006). It includes the following major land resource areas: Klamath and Shasta Valleys and Basins; Sierra Nevada Mountains; Southern Cascade Mountains; Malheur High Plateau; Humboldt Area; Owyhee High Plateau; Carson Basin and Mountains; Fallon-Lovelock Area; Great Salt Lake Area; Central Nevada Basin and Range; Southern Nevada Basin and Range; Mojave Desert; Lower Colorado Desert; Northern Intermountain Desertic Basins; Cool Central Desertic Basins and Plateaus; Warm Central Desertic Basins and Plateaus; Colorado Plateau; Southwestern Plateaus, Mesas, and Foothills; Mogollon Transition; Arizona and New Mexico Mountains; Sonoran

Basin and Range; Southeastern Arizona Basin and Range; and Southern Desertic Basins, Plains, and Mountains (USDA, Natural Resources Conservation Service 2006). The soils in this region are dominantly Aridisols, Entisols, and Mollisols. The dominant suborders are Argids and Calcids on plains and in basins; Orthents on plains, on plateaus, and in valleys throughout the region; and Xerolls and Ustolls on mountain slopes. The soils in the region dominantly have a mixed mineralogy (USDA, Natural Resources Conservation Service 2006).

Rocky Mountain Range and Forest Region

This region covers 236,510 square miles in parts of Montana (28 percent), Colorado (20 percent), Idaho (16 percent), Wyoming (13 percent), Utah (10 percent), Oregon (5 percent), Washington (4 percent), and New Mexico (3 percent). It includes the following major land resource areas: Northern Rocky Mountains, Central Rocky Mountains, Blue and Seven Devils Mountains, Northern Rocky Mountain Valleys, Northern Rocky Mountain Foothills, Wasatch and Uinta Mountains, Southern Rocky Mountains, Southern Rocky Mountain Parks, Southern Rocky Mountain Foothills, and High Intermountain Valleys (USDA, Natural Resources Conservation Service 2006). The soils in this region are dominantly Alfisols, Entisols, Inceptisols, and Mollisols. The dominant suborders are Ustepts, Ustolls, and Xerolls in valleys and on the lower mountain slopes, and Cryalfs and Orthents on the upper mountain slopes and crests. The soils in the region dominantly have a mixed mineralogy (USDA, Natural Resources Conservation Service 2006).

Northern Great Plains Spring Wheat Region

This region covers 142,225 square miles in the northern part of Montana and most of the Dakotas. Approximately 23 percent of this region lies within the project area in northern Montana. In Montana, the major land resource areas include Brown Glaciated Plain, Northern Dark Brown Glaciated Plains, and a small amount of Rolling Soft Shale Plain (USDA, Natural Resources Conservation Service 2006). Much of this region has been topographically smoothed by continental glaciation and is blanketed by undulating till and level to gently rolling lacustrine (lake) deposits. The surficial geology in the southwestern part of the region consists mainly of residual sediments weathered from sedimentary rocks. Alluvial deposits are along drainage ways (USDA, Natural Resources Conservation Service 2006). The soils in this region are dominantly Mollisols. Ustolls and Aquolls are the dominant suborders. Ustolls are on uplands, and Aquolls are in low wet areas and along streams. Aquolls are extensive in the Red River Valley. Some of the Ustolls have a high content of sodium, and some of the Aquolls have a high content of sodium and lime. Other important soils are Orthents on the steeper slopes. The soils in the region dominantly have mixed or smectitic mineralogy (USDA, Natural Resources Conservation Service 2006).

Western Great Plains Range and Irrigated Region

In the project area, this region covers 213,945 square miles in Montana (22 percent), New Mexico (16 percent), Colorado (15 percent), Nebraska (15 percent), and Wyoming (14 percent). The relevant major land resource areas in the southeastern part of Montana, eastern quarter of Wyoming , eastern part of Colorado, and central part of New Mexico include the following: Northern Rolling High Plains, Northern Part; Pierre Shale Plains; Pierre Shale Plains, Northern Part; Black Hills Foot Slopes; Black Hills; Mixed Sandy and Silty Tableland and Badlands; Central High Plains, Northern Part; Central High Plains, Southern Part; Upper Arkansas Valley Rolling Plains; Canadian River Plains and Valleys; Upper Pecos River Valley; Central New Mexico Highlands; and Southern Desert Foothills.

The soils in this region are dominantly Entisols and Mollisols. Other notable orders are Alfisols, Aridisols, Inceptisols, and some Vertisols. The dominant suborders are Ustorthents, Torriorthents, Haplustolls, and Argiustolls. Other notable suborders are Haplargids, Haplustalfs, and Haplustepts. Most have mixed or smectitic mineralogy, but some have carbonatic mineralogy (USDA, Natural Resources Conservation Service 2006). The major soil resource concerns in this region are overgrazing and the wind erosion and water erosion that occur where the ground cover has deteriorated. The invasion of undesirable plant species is a concern on rangeland. Wind erosion, water erosion, maintenance of the content of organic matter in the soils, and soil moisture management are major resource concerns on cropland. The quality of surface water also is a concern. Sediment, nutrients, pesticides, and organic material are the major nonpoint sources of surface and ground water pollution. Control of saline seeps on rangeland and salt management on irrigated land are needed in some areas (USDA, Natural Resources Conservation Service 2006).

The Denver, Fort Collins, Greeley, Fort Morgan, Limon, and Springfield, Colorado, urban areas are part of the Central High Plains, Southern Part major land resource area. A major soil resource concern in this major land resource area is the loss of prime farmland and cropland of statewide importance through conversion to urban use. Additional concerns are wind erosion, water erosion, surface compaction, increased salinization and overall degradation of soil quality caused by tillage and irrigation practices.

Central Great Plains Winter Wheat and Range Region

This region covers 219,740 square miles in Texas, Kansas, Oklahoma, Nebraska, New Mexico, and Colorado. Approximately 7 percent of this region lies inside the project area in far eastern New Mexico and Colorado, and a very small part of southeastern Wyoming. The relevant major land resource areas in the project area include the following: Central High Tableland; Southern High Plains, Northwestern Part; Southern High Plains, Southern Part; and Southern High Plains, Southwestern Part (USDA, Natural Resources Conservation Service 2006).The soils in this region are dominantly Mollisols, but significant acreages of

Alfisols, Entisols, and Inceptisols also occur. The dominant soil suborder is Argiustolls. Other notable suborders include Haplustolls, Ustipsamments, Calciustolls, Paleustolls, and Paleustalfs. Mineralogy is dominantly mixed but is smectitic or carbonatic in some soils (USDA, Natural Resources Conservation Service 2006).

The major resource concerns on the grassland in this region are overgrazing and invasive plants and noxious weed spread. The major resource concerns on cropland are wind erosion, water erosion, maintaining soils' organic matter content, and managing soil moisture. The quality of surface water also is a concern. Sediment, nutrients, pesticides, and salinity are the major nonpoint sources of surface and ground water pollution. Control of saline seeps on rangeland and salt management on irrigated land are concerns in some areas of the region (USDA, Natural Resources Conservation Service 2006).

Southern Alaska

This region covers 95,210 square miles in the southern part of Alaska. It includes the arc of coastal lowlands and mountains along the Gulf of Alaska from the Alexander Archipelago in the southeast to Kodiak Island and the southern portion of the Alaska Peninsula in the west. It also includes the lowlands and mountains of Cook Inlet. It is made up of the Alexander Archipelago-Gulf of Alaska Coast, Kodiak Archipelago, Southern Alaska Coastal Mountains, Cook Inlet Mountains, Cook Inlet Lowlands, and Southern Alaska Peninsula Mountains major land resource areas (USDA, Natural Resources Conservation Service 2006). The soils in this region dominantly have mixed or amorphic mineralogy. Gelepts and Cryepts occur on steep mountain slopes. Cryods, Cryands, Aquands, and Cryepts are on the lower slopes, foothills, and moraines. While Spodosols and Andisols intergrade in some areas, Andisols are dominant in the areas closer to volcanic sources. These areas include the Alaska Peninsula, Kodiak Island, the southern Kenai Peninsula, Kruzof Island, and Baranof Island. The Cryepts on the younger surfaces include Eutrocryepts and Dystrocryepts. Fluvents and Aquents are dominant on flood plains and low terraces. Histosols and Histic subgroups of other orders occur throughout the region. They are on level and depressional landforms and even on the steeper slopes along the coast and in the southeast. The Histosols include Fibrists, Hemists, Saprists, and Folists (USDA, Natural Resources Conservation Service 2006).

Aleutian Alaska

This region covers 10,670 square miles and includes the southwest part of the Alaska Peninsula, the Aleutian Islands, and the Pribilof Islands. The region includes the Aleutian Islands-Western Alaska Peninsula major land resource area (USDA, Natural Resources Conservation Service 2006). The dominant soils are Andisols, primarily Cryands that formed in volcanic ash or scoria. The soils in the area have an amorphic or mixed mineralogy. Soil textures grade from coarse scoria and cinders to fine sand with increasing distance from the volcanoes. Bare rock and rubble occur on the steep slopes of volcanic cones, peaks, and high ridges. Histosols, especially Fibrists, occur in depressions and on broad valley bottoms (USDA, Natural Resources Conservation Service 2006).

Interior Alaska

This region covers 259,260 square miles and includes the vast interior of Alaska, from the south slope of the Brooks Range to the north slope of the Alaska Range. It also includes the Copper River Basin and its surrounding mountains. It is made up of the following major land resource areas: Copper River Basin, Interior Alaska Mountains, Interior Alaska Lowlands, Yukon-Kuskokwim Highlands, Interior Alaska Highlands, Yukon Flats Lowlands, Upper Kobuk and Koyukuk Hills and Valleys, and Interior Brooks Range Mountains (USDA, Natural Resources Conservation Service 2006).

This region is in the zone of discontinuous permafrost. Not all of the soils have permafrost in their profile. With a temperature near 30 degrees F (-1 degree C), the permafrost in this region is warmer than that in the Northern Alaska Region (land resource region Y). Distribution of the permafrost-affected soils is determined by landform position, particle size, and moisture content of the soils. Much of the area on the flanks of the Brooks Range and Alaska Range is covered by rock, snow, and ice. Gelisols and Inceptisols are the dominant soils. The soils in the region have a dominantly mixed mineralogy. In areas on mountain slopes, Orthels and Turbels are intermixed with Gelepts and Gelolls. In these areas, the soils that are not affected by permafrost formed in the coarser textured materials on the steeper slopes. Orthels and Turbels are intermixed with Cryepts on low hills and mountains. An even mixture of Gelisols and Inceptisols dominates the basins. The Inceptisols have a more recent history of fire than the Gelisols. Wildfires disturb the insulating organic material at the surface, lowering the permafrost layer and eliminating perched water tables from these former Gelisols. Depending on the frequency of the fires, landform position, and particle size, these Inceptisols may or may not revert back to Gelisols. Histosols are in depressions throughout the region. Organic soils include Histels with permafrost and Hemists without permafrost. Spodosols and Andisols are of limited extent in the region. Cryods are in scattered areas in some of the mountainous parts of the region. Cryands are in parts of the Yukon-Kuskokwim Highlands (USDA, Natural Resources Conservation Service 2006).

Western Alaska

This region covers 91,300 square miles in the western part of Alaska. It is near the Bering Sea from the Alaska Peninsula and Bristol Bay lowlands to the southern Seward Peninsula. The region includes the northern Bering Sea islands. It is made up of the Northern Alaska Peninsula Mountains, Bristol Bay-Northern Alaska Peninsula Lowlands, Ahklun Mountains, Yukon-Kuskokwim Coastal Plain, Northern Bering Sea Islands, and Nulato Hills-Southern Seward Peninsula Highlands major land resource areas (USDA, Natural Resources Conservation Service 2006). Gelisols, which have permafrost in their profile, occur throughout the region and comprise about 45 percent of the soil types. Orthels and Turbels are on level to sloping coastal plains and terraces as well as on foot slopes and in swales in the hills and mountains. Mollorthels and Molliturbels are typical in the limestone uplands of the northern Bering Sea islands. Histels are in most of the depressions throughout the region. Coarse textured Gelepts and Gelolls are on steep slopes in the mountainous areas. Well-drained Cryepts and Cryolls are on moraines and outwash plains. Cryands are in areas where volcanic ash and loess mantle older landforms and in areas along the flanks of cinder cones. Well-drained Cryods are in scattered areas on uplands throughout the region. Fluvents are on floodplains and levees, and Psamments are in dune areas (USDA, Natural Resources Conservation Service 2006).

Northern Alaska

This region covers 125,550 square miles in the northern part of Alaska. It includes the northern slope of the Brooks Range, the western Brooks Range, and the northern and western Seward Peninsula. The region is made up of the Seward Peninsula Highlands, Northern Seward Peninsula-Selawik Lowlands, Western Brooks Range Mountains, Foothills, and Valleys, Northern Brooks Range Mountains, Arctic Foothills, and Arctic Coastal Plain major land resource areas (USDA, Natural Resources Conservation Service 2006). This area is in the zone of continuous permafrost. Permafrost is shallow or moderately deep, except on steep, coarse-textured soils in the high mountains. Most of the soils in the region are Gelisols, having permafrost within their soil profile. Orthels and Turbels, the dominant suborders, occur on all landforms in the region. Aquorthels and Histoturbels are on the gentler slopes and on poorly drained hillsides. Glacic subgroups occur near the coasts. Mollorthels are on some well-drained, south-facing slopes, and Psammorthels are on dunes. Fibristels formed in thick deposits of organic material in depressions throughout the region. Coarse textured Gelepts and Gelorthents are on some steep hill slopes and ridges. They have a mean annual soil temperature below 32 degrees F (0 degrees C) but do not have permafrost in their soil profile (USDA, Natural Resources Conservation Service 2006).

3.6.3 Climate Change

Some predicted effects of climate change include increased duration and frequency of droughts and an increase in extreme precipitation events. This combination can result in an increase in surface soil erosion and gullying beyond current levels. Continental scale shifts in precipitation may lead to areas where there are increases and decreases in soil moisture. Prolonged drought would also affect soil respiration, resulting in a decreased soil carbon pool (IPCC 2008).

3.7 WATER RESOURCES AND QUALITY

Geothermal resources primarily involve the presence and characteristics of available heat and groundwater. Groundwater is the primary water resource that is potentially affected by geothermal exploration and development. Potential effects to surface water are more limited in area and scope to the immediate vicinity of geothermal exploration and development activities; surface water effects are discussed in detail on a lease-by-lease basis.

Groundwater and surface water rights are not discussed in this section. Water rights are very specific to individual locations, aquifers, landowners, and local jurisdictions. Geothermal developers must obtain the appropriate water rights and state permits, in addition to the Federal lease for the resource.

There are about 26 major aquifer systems in the project area's 11 contiguous western states, excluding Alaska (Figure 3-8). There is little known about aquifers in Alaska except near the towns and cities. Each of these aquifers is unique in that the source, volume, and quality of water flowing through it depends on:

- its hydrogeological conditions (e.g., hydraulic conductivity, effective porosity, and hydraulic gradient);
- external factors (e.g., rates of precipitation, recharge, evaporation, and transpiration);
- the location and hydrologic connection with streams, rivers, springs, reservoirs, and wetlands; and
- overlaying human activities (BLM 2007c).

In general, the aquifers occur in six types of permeable geologic materials: unconsolidated deposits of sand and gravel, semiconsolidated sand, sandstone, carbonate rocks, interbedded sandstone and carbonate rocks, and basalt and other types of volcanic rocks. Rocks and deposits with minimal permeability, which are not considered aquifers, consist of intrusive igneous rocks, metamorphic rocks, shale, siltstone, evaporite deposits, silt, and clay. As such, there is a direct relationship between permeability and type of geologic material. For this reason, the aquifers are categorized according to their general geologic character (USGS 2002b).

In addition, sole-source aquifers are identified in this section. A sole-source aquifer is defined by the US EPA as supplying at least 50 percent of the drinking water consumed in the area overlying the aquifer, where the surrounding area has no alternative drinking water source(s) that could physically, legally, and economically supply all those who depend upon the aquifer for drinking water (US DOE and BLM 2007).

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SOURCE: BLM 2007c

There are about 26 major aquifer systems in the project area's 11 contiguous western states, excluding Alaska.

Principal Aquifers in the 11 Western States

Figure 3-8

Although the boundaries of groundwater and surface water resources do not always coincide, the discussion below is organized by surface water (hydrologic) regions. As shown on Figure 3-9, nine hydrologic regions have been identified in the project area: Alaska, Arkansas-White-Red, California, Great Basin, Lower Colorado, Missouri, Pacific Northwest, Rio Grande, and Upper Colorado (BLM 2007c). Within the project area hydrologic regions, the areas of greatest interest are public and NFS lands within the planning area. Most public and NFS lands occur in arid to semiarid environments in the Great Basin and Colorado drainage basins (BLM 2007c).

For this PEIS, a hot spring is defined as a spring with water temperatures above 50 °C (122 °F). Warm springs have temperatures between 20 to 50 °C (68 to 122 °F) and are not discussed. Hot and warm springs in the project area are detailed in Appendix F (US Department of Commerce, NOAA 2008).

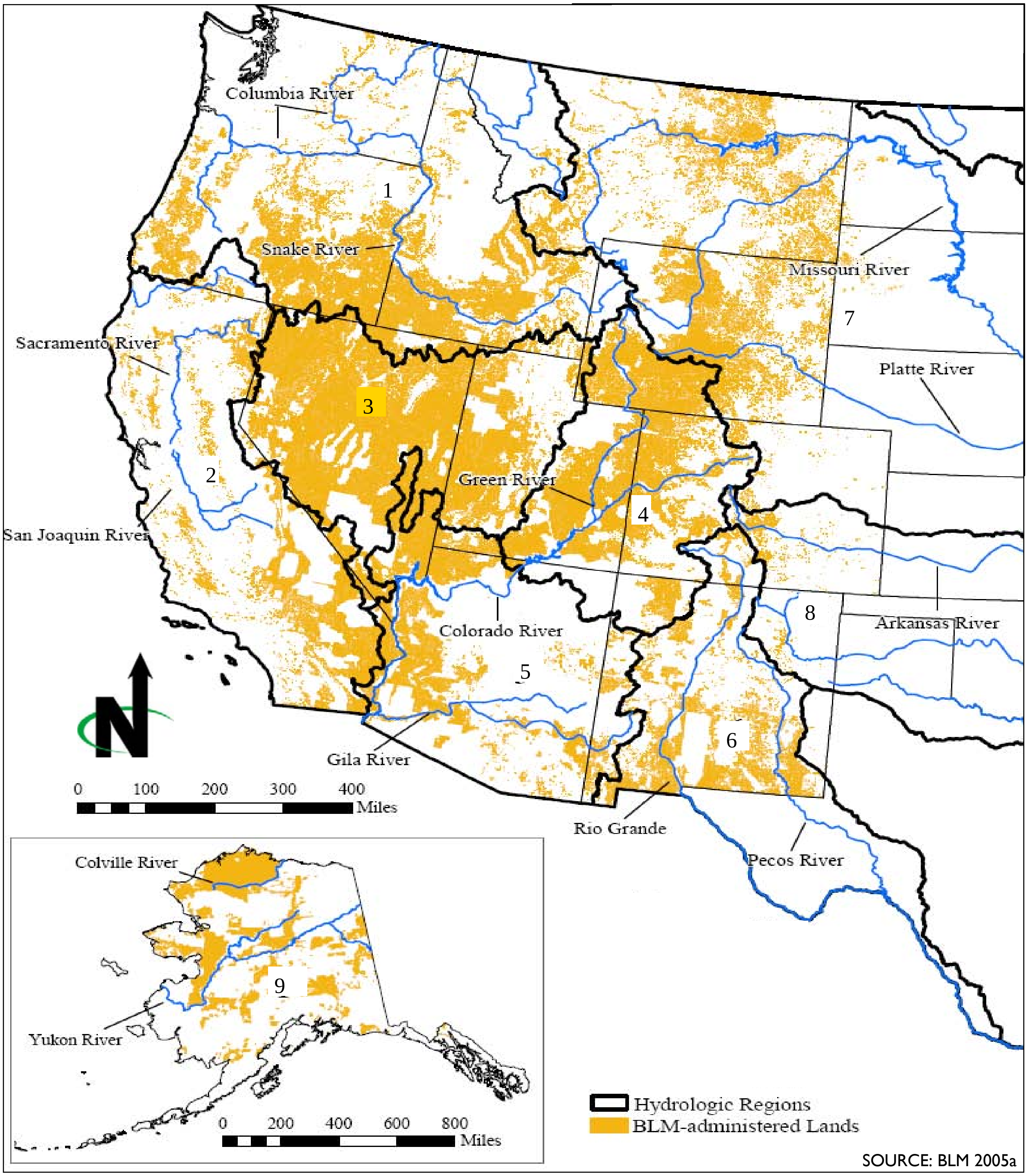
Characteristics by Hydrologic Region

Pacific Northwest Hydrologic Region

The Pacific Northwest Hydrologic Region includes the wet coastal areas of Oregon and Washington, as well as the semiarid Columbia Plateau in eastern Washington, Oregon, and southern Idaho (BLM 2007c). In this region, planning area public and NFS lands are along the Cascade Range, in central Washington, in all of Oregon except the coastal areas, and in all of Idaho except the panhandle. The Pacific Northwest Hydrologic Region encompasses the Puget-Willamette Lowland, Columbia Plateau, Northern Rocky Mountain Intermontane Basins, and the Snake River Plain regional aquifer systems. In addition, there are unconsolidated aquifers, Pliocene and younger basaltic rock aquifers, volcanic and sedimentary rock aquifers, Miocene basaltic rock aquifers, and aquifers in pre-Miocene rocks (USGS 2002b).

The area is geologically and topographically diverse and contains a wealth of ground and surface water resources that generally are suitable for all uses including drinking water (USGS 2002b). The southernmost portion of this hydrologic region extends down to the northern portion of the Great Basin. This area is geologically very new and contains extensive areas of lava and other volcanic rock. The rock substrata are very permeable; therefore, streams tend to lose much of their flow through percolation. (BLM 2007c).

Surface Water. Generally, streams that flow year-round east of the Cascade Range are fed by snowmelt from higher elevations or by groundwater discharge from aquifers recharged during periods of abundant precipitation (BLM 2007c). Tributary streams are short and have steep gradients, creating rapid surface water runoff with relatively short-term water storage, limiting recharge (BLM 2007c). Most of the region is drained by the Columbia River, its tributaries, and other streams that discharge to the Pacific Ocean.



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There are 9 total Hydrologic Regions within the 11 Western States and Alaska.

KEY HYDROLOGIC REGIONS

1. Pacific Northwest
2. California
3. Great Basin
4. Upper Colorado
5. Lower Colorado
6. Rio Grande
7. Missouri
8. Arkansas-White-Red
9. Alaska

Hydrologic Regions in the 11 Western States and Alaska

Figure 3-9

The Columbia River has 10 major tributaries—the Kootenay, Okanagan, Wenatchee, Spokane, Yakima, Snake, Deschutes, Willamette, Cowlitz, and Lewis Rivers (BLM 2007c). The Columbia River Basin extends roughly from the crest of the Coast Ranges of Oregon and Washington, east through Idaho, to the Continental Divide in the Rocky Mountains of Montana and Wyoming; and from the headwaters of the Columbia River in Canada to the high desert of northern Nevada and northwestern Utah. Its main stem, the Columbia River, originates in two lakes that lie between the Continental Divide and the Selkirk Mountain Range in British Columbia. After flowing a circuitous path for approximately 1,200 miles, it joins the Pacific Ocean near Astoria, Oregon (BLM 2007c).

Aridity progressively increases and precipitation decreases east of the Cascade Range because of rain-shadow effects caused by the mountains (BLM 2007c). Only large rivers that lie below the water table contain substantial flows year round. In most years, abundant precipitation along the western side of the Cascade Range produces abundant surface water flow in streams flowing off the Cascade Range to the Pacific Ocean (BLM 2007c). Those streams that do not flow to the Pacific flow to closed basins in southeastern Oregon (USGS 2002b). Many of these systems are rain driven and influenced primarily by winter rain storms (BLM 2007c).

Surface water is abundant in Idaho, Oregon, and Washington, though not always available when and where needed. In some places, surface water provides much of the water used for public-supply, domestic and commercial, agricultural (primarily irrigation and livestock watering), and industrial purposes. In arid parts of the region, however, surface water has long been fully appropriated, chiefly for irrigation. Most irrigation is on lowlands next to streams and on adjacent terraces. Generally, lowlands within a few miles of a main stream are irrigated with surface water diverted by gravity flow from the main stream or a reservoir and distributed through a system of canals and ditches. In some areas, water is pumped to irrigate lands farther from the stream at a higher altitude. (USGS 2002b). Groundwater is used when and where surface water supplies are lacking (USGS 2002b).

Aquifers and streams are in direct hydraulic connection in some places, particularly where the aquifers in the stream valleys consist of unconsolidated deposits. Water can move either from the aquifer to the stream or from the stream to the aquifer, depending on the altitude of the water level in the stream and the aquifer (USGS 2002b).

Groundwater. Groundwater is an important resource in this hydrologic region for domestic consumption and irrigation. It is generally contained in shallow alluvial aquifers along major streams and their valleys (BLM 2007c). Most of the groundwater is produced from aquifers in unconsolidated alluvial sand and gravel deposits that fill large to small basins in the region. These aquifers are virtually independent but share common hydrologic characteristics. These aquifers are important water sources for public-supply, domestic and commercial, agricultural, and industrial needs because of their location in generally flat lowlands where human activities are concentrated. Many large-yield public-supply and irrigation wells and thousands of domestic wells are completed in these types of aquifers, generally in areas of privately owned land (USGS 2002b).

All aquifers in this region were assigned to one of five general types depending on their geologic and hydrologic characteristics: unconsolidated aquifers, Pliocene and younger basaltic rock aquifers, volcanic and sedimentary rock aquifers, Miocene basaltic rock aquifers, and aquifers in pre-Miocene rocks (USGS 2002b).

Unconsolidated-deposit aquifers, which consist primarily of Holocene-, Pleistocene-, Pliocenene-, and Miocene- age sand and gravel, are the most productive and widespread aquifers in the region. These aquifers are prevalent along present and ancestral stream valleys and in lowlands are associated with structural or erosional basins. These unconsolidated-deposit aquifers provide freshwater for most public-supply, domestic, commercial, and industrial purposes. They also are important sources of water for agricultural (primarily irrigation) purposes. The unconsolidated deposits are mostly alluvial deposits, but in places, they consist of eolian, glacial, or volcanic deposits (USGS 2002b).

Pliocene and younger basaltic-rock aquifers consist primarily of thin, basaltic lava flows and beds of basaltic ash, cinders, and sand. The aquifers are most productive in the Snake River Plain of Idaho. These aquifers yield freshwater that is used mostly for agricultural (primarily irrigation) purposes (USGS 2002b).

Volcanic- and sedimentary-rock aquifers consist of a variety of volcanic and sedimentary rocks. These aquifers are not as productive as the aquifers described above. The volcanic rocks that compose the aquifers consist primarily of Pliocene and younger basaltic rocks on the eastern side of the Cascade Range in Oregon and Washington, and silicic volcanic rocks in southern Idaho and southeastern Oregon. Unconsolidated volcanic deposits included in the aquifers are ash and cinders. The sedimentary rocks that compose the aquifers consist primarily of semiconsolidated sand and gravel eroded mostly from volcanic rocks. The aquifers generally yield freshwater but locally yield saltwater. About 30 percent of the fresh groundwater withdrawals are used for public-supply, about 20 percent are used for domestic and commercial, and about 50 percent are used for agricultural (primarily irrigation) purposes (USGS 2002b).

Aquifers in pre-Miocene rocks consist of undifferentiated volcanic rocks, undifferentiated consolidated sedimentary rocks, and undifferentiated igneous and metamorphic rocks that are distributed throughout the region, principally in the mountainous areas. In some places, the thickness of the volcanic rocks might be as much as about 5,000 feet, and that of the consolidated sedimentary rocks might be as much as about 15,000 feet. East of the Cascade Range, the aquifers generally yield freshwater but locally yield saltwater. Within the Cascade Range and west of it, these aquifers commonly yield saltwater. Fresh groundwater withdrawals are used mostly for domestic and commercial purposes (USGS 2002b).

Miocene basaltic-rock aquifers consist primarily of thick basaltic lava flows underlying Pliocene and younger rocks in much of the intervening areas between outcrops. The aquifers are most productive in the Columbia Plateau of northeastern Oregon and southeastern Washington where the aquifers are thickest. The maximum thickness of the aquifers is estimated to be as much as about 15,000 feet in the southern part of the Columbia Plateau. These aquifers generally yield freshwater but locally yield saltwater. Most of the fresh groundwater withdrawals are used for agricultural (primarily irrigation) purposes (USGS 2002b).

The Puget-Willamette Lowland, Columbia Plateau, Northern Rocky Mountain Intermontane Basins, and the Snake River Plain regional aquifer systems are made up of the five types of aquifers discussed above. In southern Oregon and Idaho, these aquifers are part of the extensive basin-fill Basin and Range aquifers. These aquifers are described in more detail as part of the Great Basin Hydrologic Region, described below.

The Snake River Plain, the Columbia Plateau, and the Puget-Willamette Trough aquifer systems consist of extensive sets of aquifers and confining units that might locally be discontinuous but that function hydrologically as a single aquifer system on a regional scale. The major aquifers that compose the Puget-Williamette Trough regional aquifer system are unconsolidated-deposit and Miocene basaltic-rock aquifers in deep basins (USGS 2002b). The Columbia Plateau Regional Aquifer System consists of unconsolidated and Miocene basaltic rock aquifers in northeastern Oregon and southeastern Washington. Permeable zones are at the tops and the bottoms of the basaltic lava flows (USGS 2002b).

In the Snake River Plain of southern Idaho and southeastern Oregon, the aquifers consist of the unconsolidated and the Pliocene and younger basaltic rock aquifers. The layers of lava flows, beds of volcanic ash and tuff, basalt, silicic volcanic rocks, and semiconsolidated to consolidated sedimentary rocks that contain small to large quantities of volcanic material are complexly interbedded, and their permeability is extremely variable. Permeable zones at the tops and the bottoms of these flows yield large volumes of water to irrigation wells. These aquifers also discharge about one million gallons per day to springs in the walls of the Snake River Canyon (USGS 2002b).

The Northern Rocky Mountains Intermontane Basins aquifer systems consists of mainly aquifers in pre-Miocene rocks with some unconsolidated aquifers. They are present mostly in mountainous areas, and water from wells completed in these aquifers is used mostly for domestic and agricultural (livestock watering) supplies (USGS 2002b).

Groundwater Quality. Groundwater in Idaho, Oregon, and Washington generally is fresh (dissolved-solids concentration of 1,000 milligrams per liter or less) and chemically suitable for most uses. Because of sparse settlement in much of the area, little groundwater has been contaminated as the result of human activities, except locally. Measured concentrations of dissolved solids in groundwater exceed 1,000 milligrams per liter only in scattered areas throughout the region (USGS 2002b).

Dissolved-solids concentrations that exceed 500 milligrams per liter are common near coastal areas and in deep aquifers in Idaho, Oregon, and Washington. Most deep aquifers are overlain by shallower aquifers that contain water with smaller dissolved-solids concentrations. However, in some irrigated areas, water in shallow aquifers contains a large dissolved-solids concentration that resulted from percolation of the irrigation water. In central parts of closed basins, evaporation concentrates minerals in shallow groundwater (USGS 2002b).

Areas where dissolved-solids concentrations exceed 500 milligrams per liter reflect: irrigation, chiefly on the Snake River Plain and the Columbia Plateau; saltwater in underlying consolidated marine sedimentary rocks in Oregon and Washington; evaporation in closed basins in south-central Oregon; and geothermal water leaking into the cold freshwater system, chiefly in Idaho and Oregon (USGS 2002b). Table 3-8 identifies the sole-source aquifers in the Pacific Northwest Hydrologic Region as determined by the EPA.

Table 3-8
Pacific Northwest Hydrologic Region Sole-Source Aquifers

Sole-Source Aquifer	Location
Spokane Valley-Rathdrum Prairie Aquifer	WA, ID
Camano Island Aquifer	WA
Whidbey Island Aquifer	WA
Cross Valley Aquifer	WA
Newberg Area Aquifer	WA
Troutdale Aquifer System	WA
North Florence Dunal Aquifer	OR
Cedar Valley Aquifer	WA
Lewiston Basin Aquifer	WA, ID
Eastern Snake River Plain Aquifer	ID, WY
Central Pierce County Aquifer System	WA
Marrowstone Island Aquifer System	WA
Vashon-Maury Island Aquifer System	WA
Guemes Island Aquifer System	WA
Missoula Valley Aquifer	MT

Source: US EPA 2008a

Hot Springs. There are 179 hot springs within the Pacific Northwest Hydrologic Region. Most are in Idaho (3) and Oregon (40), with 14 in Washington, 7 in Montana, 5 in Nevada, and 2 in Wyoming (Appendix F) (US Department of Commerce, NOAA 2008).

California Hydrologic Region

The California Hydrologic Region includes nearly the entire state of California and parts of southern Oregon (BLM 2007c). In this region, the planning area public and NFS lands are in northeastern California and southern Oregon, along the eastern border of California, in scattered areas in southern California, and in a few small areas along the California coast. The California Hydrologic Region encompasses the Basin and Range basin-fill aquifers and carbonate rock aquifers, Central Valley aquifer system, Coastal Basin aquifers, Northern California basin-fill aquifers, and Northern California volcanic rock aquifers, (USGS 2002b). Water needs in California are very large, and the state leads the US in agricultural and municipal water use. The demand for water exceeds the natural water supply in many agricultural and nearly all urban areas. As a result, water is impounded by reservoirs in areas of surplus and transported to areas of scarcity by an extensive network of aqueducts (USGS 2002b).

Surface Water. The California region is drained by rivers such as the Sacramento and San Joaquin. Storms that bring moisture to the region are most frequent in winter. Surface water flow in streams is derived mainly from snowmelt in the mountainous areas during the spring months. Runoff is greater than 40 inches per year in many mountainous areas. During the remainder of the year, many streams have no flow or intermittent flow that follows major storms (BLM 2002).

In southern California, nearly all streams that head in the mountains are ephemeral and lose flow to alluvial aquifers within a short distance of where the streams leave the mountains and emerge onto the valley floors. The basins in the arid parts of southeastern California have virtually zero runoff because most precipitation that falls is evaporated almost immediately. However, high-intensity storms or rapid snowmelt in the mountains that border the basins may cause flash floods that reach the basin floors (USGS 2002b).

Before the inception of agriculture, the largest rivers in California's vast Central Valley overflowed their banks during periods of peak winter flows and formed extensive marshlands. An elaborate flood-control system and the lowering of the water table by withdrawals for irrigation now keep these rivers within their banks (USGS 2002b).

Groundwater. Groundwater in the mountainous areas is relatively deep and is contained in sedimentary units that continue under the intermountain basins and form a deep reservoir that is seldom tapped because of its depth. Shallow groundwater can be found in sands and gravels that fill the basins between the mountain ranges. This groundwater is fed by infiltration of surface water from streams that flow off the mountain ranges. Groundwater in southeastern California is the main source of water for domestic consumption and agricultural irrigation (BLM 2007c).

The Basin and Range aquifers are located in the southern California desert. The water-yielding materials in this area are in valleys and basins, and consist primarily of unconsolidated alluvial-fan deposits. However, locally, floodplain and lacustrine (lake) beach deposits may yield water to wells. Also, the consolidated volcanic and carbonate rocks that underlie the unconsolidated alluvium are a water source if the consolidated rocks are sufficiently fractured or have solution openings. Many of these valleys and basins are internally drained where water from precipitation that falls within the basin recharges the aquifer and ultimately discharges to the land surface and evaporates within the basin. Rarely, basins might be hydraulically connected in the subsurface by fractures or solution openings in the underlying bedrock. Also, several basins or valleys may develop surface-water drainage that hydraulically connects the basins, and groundwater flows between the basins, mostly through the unconsolidated alluvial stream/floodplain sediments (USGS 2002b).

The Central Valley aquifer system occupies most of a large basin in central California between the Sierra Nevada and the Coast Range Mountains. The Central Valley is the single-most important source of agricultural products in the US, and groundwater for irrigation has been essential in the industry's development. The basin contains a single, large, basin-fill aquifer system, the largest such system in the US. Although the valley is filled with tens of thousands of feet of unconsolidated sediments, most of the fresh groundwater is at depths of less than 2,500 feet (USGS 2002b).

The Coastal Basins aquifers occupy a number of basins in coastal areas from northern to southern California. These basins are in structural depressions formed by folding and faulting, filled with marine and alluvial sediments, and drained by streams that contain water at least part of the year. Nearly all the large population centers in California are located in these basins, and the available groundwater is used primarily for municipal supplies. In most of the basins, local groundwater supplies are no longer adequate, and surface water must be transported from distant sources. Seawater intrusion is a common problem in nearly all the Coastal Basins aquifers (USGS 2002b).

The most productive and highly-utilized aquifers in interior northern California are the northern California basin-fill aquifers. These aquifers are in unconsolidated alluvial sediments. However, in some basins, wells drilled into underlying volcanic rocks might produce large quantities of water. Most groundwater demand is for agricultural irrigation (USGS 2002b). The northern California volcanic-rock aquifers consist of volcanic rocks that yield water primarily from fractures and locally from intergranular spaces in porous tuffs.

Water-yielding zones in these rocks are unevenly distributed; however, in some areas, wells completed in the volcanic-rock aquifers yield large volumes of water. The northern California volcanic-rock aquifers are relatively unexplored and undeveloped (USGS 2002b). Table 3-9 identifies the sole source aquifers in the California Hydrologic Region as determined by the EPA.

Table 3-9
California Hydrologic Region Sole-Source Aquifers

Sole-source Aquifer	Location
Fresno County Aquifer	CA
Santa Margarita Aquifer, Scotts Valley	CA
Campo/Cottonwood Creek	CA
Ocotillo-Coyote Wells Aquifer	CA

Source: US EPA 2008b

Hot Springs. There are 75 hot springs within the California Hydrologic Region. Seventy of them are in California, and five are in Oregon (Appendix F) (US Department of Commerce, NOAA 2008).

Great Basin Hydrologic Region

The Great Basin Hydrologic Region includes the Great Basin and encompasses nearly the entire state of Nevada, as well as western Utah (BLM 2007c). In this region, the planning area public and NFS lands include almost the entire region. The Great Basin Hydrologic Region encompasses the Basin and Range basin-fill aquifers and carbonate rock aquifers, the southern Nevada volcanic rock aquifers, and a minor amount of the Colorado Plateau aquifers (USGS 2002b).

Surface Water. The Great Basin Hydrologic Region of Nevada and Utah is an arid region located in the rain-shadow of the Sierra Nevada Mountains. The region is characterized by northerly trending mountain ranges and intermountain valleys with closed drainage. None of the streams that originate within this basin have an outlet to the ocean. The Great Basin's internal drainage results from blockage of water movement by high fault-created mountains and lack of sufficient water flow to merge with larger drainages outside of the Great Basin. This internally drained area occupies approximately 200,000 square miles, including most of Nevada, a large part of Utah, and portions of Idaho, California, and Oregon (USGS 2004f).

This region's surface water sources evaporate or percolate before they can flow to the ocean (USGS 2004f). Precipitation generally falls as rain and mountain snowfall. Streams flowing from the mountains carry water to the basins, which infiltrates into the alluvial sediments and provides the only substantial recharge to basin groundwater. Surface water flow in the basins is derived almost entirely from the mountain streams (BLM 2007c). Any water that falls as rain or snow into this region does not leave (USGS 2004f).

Apart from major rivers (e.g., the Humboldt and Truckee Rivers), surface water flow in the basins of Utah and Nevada is intermittent along the mountain fronts and ephemeral in the basins themselves. Surface water flow in the mountainous areas is limited mainly to late spring snowmelt in the higher areas. Agricultural diversions of major streams exiting the mountains are common, and major rivers are used extensively for irrigation. Surface water flow in northern Nevada has been affected by groundwater pumping from mining areas into the rivers. The Humboldt River, from Battle Mountain to Winnemucca, Nevada, is dominated by mine discharge (BLM 2007c).

Groundwater. The water-yielding materials in the Basin and Range aquifers are in valleys and basins, consisting primarily of unconsolidated alluvial-fan deposits. Local floodplain and lacustrine (lake) beach deposits may also yield water to wells. Also, the consolidated volcanic and carbonate rocks that underlie the unconsolidated alluvium are a water source if the consolidated rocks are sufficiently fractured or have solution openings. Many of these valleys and basins are internally drained where water from precipitation that falls within the basin recharges the aquifer and ultimately evaporates within the basin. Rarely, basins might be hydraulically connected in the subsurface by fractures or solution openings in the underlying bedrock. Also, several basins or valleys may develop surface water drainage that hydraulically connects the basins, and groundwater flows between the basins, mostly through the unconsolidated alluvial stream/floodplain sediments (USGS 2002b).

Within the Basin and Range Province, aquifers are not continuous, or regional, because of the complex faulting in the region. Three principal aquifer types are collectively called the Basin and Range aquifers: volcanic-rock aquifers, carbonate-rock aquifers, and basin-fill aquifers. The volcanic-rock aquifers, located in south-central Nevada, are primarily tuff, rhyolite, or basalt of Tertiary age. The carbonate-rock aquifers, which are primarily limestones and dolomites of Mesozoic and Paleozoic age, underlie many of the alluvial basins in eastern Nevada, western Utah, and southeastern Idaho. Conditions indicate that the carbonate rock is cavernous. The basin-fill aquifers are primarily unconsolidated sand and gravel of Quaternary and Tertiary age. The most permeable basin-fill deposits are present in the depressions created by late Tertiary to Quaternary block faulting and can be classified by origin as alluvial-fan, lake-bed, or fluvial deposits. Any or all three aquifer types may be in, or underlie, a particular basin and constitute three separate sources of water; however, the aquifers may be hydraulically connected to form a single source. Other rock types within the region have low permeability and act as boundaries to the flow of fresh groundwater (USGS 2002b).

In the extreme eastern part of the region, in central Utah, the region encompasses a small part of the Colorado Plateau aquifers. These aquifers are described in the Upper Colorado Hydrologic Region section, below.

Shallow groundwater in the alluvium of the basins is the main source of water for domestic consumption, irrigation, and power plant cooling. Some areas of the Great Basin, particularly in northern Nevada, have geothermal reservoirs that underlie the shallow groundwater reservoirs. These geothermal waters have been tapped, often inadvertently, by open pit mining and dewatering of areas used for gold mining. The Great Basin contains many of the largest groundwater reservoirs in the US. These reservoirs are largely untapped at present, but major urban areas like Las Vegas, Nevada, are actively pursuing their development (BLM 2007c).

Groundwater Quality. The dissolved solids concentrations in the water in the basin-fill aquifers are generally less than 1,000 milligrams per liter but exceed 10,000 milligrams per liter in the Great Salt Lake Desert and near the Great Salt Lake. The Western Uinta Arch Paleozoic Aquifer System is the only sole-source aquifer identified by the EPA in the Great Basin Hydrologic Region (US EPA 2008b).

Hot Springs. There are 139 hot springs within the Great Basin Hydrologic Region. Most are in Nevada (115), with 12 in Utah, 8 in California, and 4 in Idaho (Appendix F) (US Department of Commerce, NOAA 2008).

Upper Colorado Hydrologic Region

The Upper Colorado Hydrologic Region includes southwestern Wyoming, eastern Utah, western Colorado, northeastern Arizona, and northwestern New Mexico (BLM 2007c). In this region, the planning area public and NFS lands include southwestern Wyoming, eastern Colorado, and northwestern New Mexico. The Upper Colorado Hydrologic Region encompasses the Colorado Plateau aquifer (USGS 2002b).

Surface Water. Perennial surface water flow occurs in major rivers (e.g., Green and Colorado Rivers). The upper reaches of the Colorado River and its tributaries drain this region. Precipitation varies greatly with elevation and occurs as winter snows and heavy autumn rainstorms. In southwestern Colorado, summer monsoonal flow produces ample rain. Major streams are fed by snowmelt in mountainous areas. The larger rivers in Colorado are perennial, but the smaller rivers and streams are either intermittent or ephemeral. Dams serve as flood control, domestic supply, and power generation for the major urban centers, as well as providing surface water for irrigation. Farming and ranching are usually limited to stream valleys, where irrigation water comes mostly from surface water (BLM 2007c).

Groundwater. Groundwater is found in most of the sedimentary rocks of the Colorado Plateau and is the major source of water for domestic and municipal use. Seeps and springs are an historic source of water for Native American tribes and a current source of water for smaller ranches (BLM 2007c). The distribution of aquifers in the Colorado Plateau is controlled in part by the structural deformation and erosion that has occurred since deposition of the sediments that compose the aquifers. The principal aquifers in younger rocks are present only in basins such as the Uinta, Piceance, and San Juan. In uplifted areas, younger rocks have been eroded away, and aquifers are present in older rocks that underlie more extensive parts of the Colorado Plateau area (USGS 2002b). Major aquifer systems are not present.

In general, the aquifers in the Colorado Plateau area are composed of permeable, moderately to well-consolidated sedimentary rocks. These rocks range in age from Permian to Tertiary and vary greatly in thickness, lithology, and hydraulic characteristics. Many water-yielding units in the area have been grouped into four principal aquifers for purposes of discussion. These include the Uinta-Animas aquifer, the Mesaverde aquifer, the Dakota-Glen Canyon aquifer system, and the Coconino-De Chelly aquifer. Most widespread and productive water-yielding units are included in these aquifers; however, there are some locally productive water-yielding units (USGS 2002b).

The Uinta-Animas aquifer primarily is composed of Lower Tertiary rocks in the Uinta Basin of northeastern Utah, the Piceance Basin of northwestern Colorado, and the San Juan Basin of northwestern New Mexico. Aquifers in each basin are present in different parts of the stratigraphic section. Some formations are considered to be an aquifer in more than one basin; however, some formations vary so much in their hydraulic characteristics that they are considered to be an aquifer in one basin and a confining unit in another (USGS 2002b).

The Mesaverde aquifer comprises water-yielding units in the Upper Cretaceous Mesaverde Group, its equivalents, and some adjacent Tertiary and Upper Cretaceous formations. The Mesaverde aquifer is at or near land surface in extensive areas of the Colorado Plateaus and underlies the Uinta-Animas aquifer. The aquifer is of regional importance in the Piceance, Uinta, Kaiparowits, Black Mesa, and San Juan Basins and is of lesser importance in the Wasatch Plateau and High Plateaus areas. Some of the rocks that form the Mesaverde aquifer contain coal beds, some of which have been mined for at least a century. The hydrologic effects of mining have been of increasing concern in the areas underlain by the aquifer. The quality of the water in the Mesaverde aquifer is extremely variable (USGS 2002b).

The Dakota-Glen Canyon aquifer system is defined here as those water-yielding rocks ranging in age from late Cretaceous to Triassic underlying most of the Colorado Plateau area. These rocks contain a series of aquifers and confining units. These aquifers are grouped together as an aquifer system because they are separated everywhere from overlying and underlying aquifers by thick confining units, and because some hydraulic connection exists between each of the aquifers in the system at some point in the Colorado Plateau area. In much of the area underlain by the aquifer system, the great depth to the aquifers or poor water quality makes the aquifers unsuitable for development. However, in areas where an aquifer is near land surface, the aquifer may be an important water source (USGS 2002b).

The rocks referred to as the Coconino-De Chelly aquifer are water-yielding rocks of Early Permian age underlying the southern part of the Colorado Plateau. The formations that comprise the Coconino-De Chelly aquifer are the Coconino, De Chelly, and Glorieta Sandstones; the San Andres Limestone; and the Yeso and Cutler Formations (USGS 2002b).

Relatively impermeable confining units separate each of the four principal aquifers in the Colorado Plateau. Thinner and less-extensive confining units separate some water-yielding zones within the principal aquifers; however, these units generally form less-effective barriers to groundwater movement. Where the intra-aquifer confining units are thin or absent, water can move between adjacent water-yielding zones within an aquifer (USGS 2002b).

Groundwater Quality. Although the quantity and chemical quality of water in the Colorado Plateau aquifers are extremely variable, much of the land in this sparsely populated region is underlain by rocks that contain aquifers capable of yielding usable quantities of water of a quality suitable for most agricultural or domestic use (USGS 2002b). Table 3-10 identifies the sole-source aquifers in the Upper Colorado Basin Hydrologic Region as determined by the EPA.

Table 3-10
Upper Colorado Hydrologic Region Sole-Source Aquifers

Sole-source Aquifer	Location
Glen Canyon Aquifer	UT
Castle Valley Aquifer	UT

Source: US EPA 2008c

Hot Springs. There are 14 hot springs within the Upper Colorado Hydrologic Region, 11 of which are in Colorado and 3 of which are in Utah (Appendix F) (US Department of Commerce, NOAA 2008).

Lower Colorado Hydrologic Region

The Lower Colorado Hydrologic Region includes almost all of Arizona, western New Mexico, and parts of southeastern Nevada, southeastern California, and southwestern Utah (BLM 2007c). In this region, planning area public and NFS lands are in southwestern Arizona, western New Mexico, and parts of southeastern Nevada, Southeastern California, and Southwestern Utah. The

Upper Colorado Hydrologic Region encompasses the Basin and Range basin-fill aquifers and carbonate rock aquifers, Colorado Plateau aquifers, and a minor portion of the Rio Grande Aquifer system (USGS 2002b).

Surface Water. This hydrologic region is comprised of the lower reaches of the Colorado River in the desert southwest of Arizona, New Mexico, and southern Nevada. In this region, public lands are mainly restricted to the arid valleys, while many of the upland areas are administered by the FS. The climate is arid, and precipitation is limited to the winter months and periods of heavy storms. Most precipitation during summer evaporates before it can infiltrate into the desert sands (BLM 2007c).

Surface water flow in the arid basins of the southwest is ephemeral to nonexistent most of the year. Spring snowmelt and periods of heavy winter rain result in surface water flow in the mountainous areas and along the intervening basins' mountain fronts. During the rest of the year, surface water flow is absent except after major storms, where flash floods are common along mountain fronts. Only major rivers draining the Colorado Plateau or the Mogollon Rim, such as the Gila and Bill Williams Rivers, have perennial flow. (BLM 2007c)

Groundwater. The Basin and Range basin-fill aquifers, Basin and Range carbonate rock aquifers, and the Colorado Plateau aquifers are described previously. The Rio Grande Aquifer is described as part of the Rio Grande Hydrologic Region section, described below.

Groundwater is found in the alluvium of basins and in the bedrock of mountainous areas (i.e., reservoirs to many thousands feet deep). Groundwater is recharged by precipitation in the mountains and infiltration of stream flow along the base of the mountains. The shallow groundwater reservoirs are used extensively for irrigation and domestic consumption. Irrigation demand and mine dewatering have substantially lowered the water levels in the shallow groundwater reservoirs of the Arizona basins. However, groundwater levels in the basins of southern New Mexico have not been substantially affected by irrigation. Many of the basins have shallow groundwater surfacing in playa lakes (BLM 2007c).

Groundwater Quality. The concentration of dissolved fluoride in groundwater in southern Arizona is close to or exceeds the US EPA Drinking Water Regulations Maximum Contaminant Level for dissolved fluoride (4 milligrams per liter) for drinking-water supplies in parts of some basins in Arizona. (USGS 2002b). Table 3-11 identifies the sole-source aquifers in the Lower Colorado Basin Hydrologic Region as determined by the EPA.

Table 3-11
Lower Colorado Hydrologic Region Sole-Source Aquifers

Sole-source Aquifer	Location
Upper Santa Cruz and Avra Basin Aquifer	AZ
Bisbee-Naco Aquifer	AZ

Source: US EPA 2008b

Hot Springs. There are 13 hot springs within the Lower Colorado Hydrologic Region, including 6 in New Mexico, 6 in Arizona, and 1 in Nevada (Appendix F) (US Department of Commerce, NOAA 2008).

Rio Grande Hydrologic Region

The Rio Grande Hydrologic Region includes almost all of New Mexico, as well as south-central Colorado (BLM 2007c). In this region, planning area public and NFS lands are in parts of south-central Colorado, north central New Mexico, and southern New Mexico. The Rio Grande Hydrologic Region encompasses the Rio Grande Aquifer system, the Pecos River Basin alluvial aquifer, the Roswell Basin Aquifer, the southeastern portion of the Colorado Plateau aquifers, and the northern extremes of the Pecos River Basin alluvial aquifer (USGS 2002b).

Surface Water. The Rio Grande and Pecos River are major surface water resources that derive their water from the mountainous regions of southern Colorado and flow through New Mexico and Texas to the Gulf of Mexico. The Rio Grande is the largest river in the area and has perennial flow through most of its length in Colorado and New Mexico. The river flows across the broad basin-fill deposits in Colorado, through deep canyon and small intermountain basins in northern New Mexico, and through a series of broad basins and narrow valleys to the state line in southern New Mexico (USGS 2002b). Most basins along the Rio Grande have surface drainage to the river and are topographically open basins. The northern end of the San Luis Valley and most other basins distant from the river have internal surface-water drainage and generally do not contribute stream flow to the Rio Grande (USGS 2002b).

Surface water flow is present year round in the Rio Grande. Much of the stream flow in the more-mountainous northern part of the Rio Grande is derived from mountain snowmelt runoff. Stream flow in the southern part of the river system is derived from upstream flow, groundwater discharge, and summer thunderstorm runoff (USGS 2002b). Agricultural diversions account for approximately 90 percent of surface water use and may result in practically no flow during the summer months (BLM 2007c).

Groundwater. The Rio Grande aquifer system is the principal aquifer in a 70,000-square-mile area of southern Colorado and central New Mexico. The aquifer system consists of a network of hydraulically interconnected aquifers in basin-fill deposits located along the Rio Grande Valley and nearby valleys (USGS 2002b). These aquifers are generally composed of unconsolidated sediment deposits present in intermountain basins between discontinuous mountain ranges in southern New Mexico and between mountains and tablelands in northern New Mexico. High mountains border the aquifers in southern Colorado (USGS 2002b). Groundwater recharge primarily originates as precipitation in the mountainous areas surrounding the basins, while most of the precipitation that falls in the valleys is lost to evaporation and transpiration (BLM 2007c).

Most groundwater withdrawal occurs as discharge from pumping wells, of which about 90 percent is used for irrigation of commercial crops. Most cities and communities in the area, such as Albuquerque, Las Cruces, and Santa Fe, New Mexico, rely on groundwater for municipal use. Groundwater withdrawals in closed basins have caused long-term water level declines, while withdrawals from wells located near the Rio Grande or its perennial tributaries generally do not cause long-term water level declines in the aquifer (BLM 2007c).

The Roswell Basin aquifer system consists of an underlying carbonate-rock aquifer and a hydraulically connected, overlying alluvial aquifer. The carbonate-rock aquifer primarily has been formed by solution openings in extensive limestone and dolomite formations of Permian age. The alluvial aquifer is in unconsolidated gravel, sand, silt, and clay that overlies the eastern part of the carbonate-rock aquifer. The alluvial aquifer hydraulically connects the carbonate-rock aquifer with surface flow in the Pecos River, which flows through the Roswell Basin (USGS 2002b).

Thick and extensive alluvial deposits of Cenozoic age compose the Pecos River Basin alluvial aquifer in extreme southeastern New Mexico and western Texas. The topography in the area consists mostly of flat to rolling plains that slope gently toward the Pecos River. Groundwater in the Cenozoic alluvium is of major importance in this area where average annual rainfall is less than 12 inches (USGS 2002b). The Espanola Basin Aquifer System is the only sole-source aquifer identified by the EPA in the Rio Grande Hydrologic Region (US EPA 2008d).

Hot Springs. There are 11 hot springs within the Rio Grande Hydrologic Region, of which 8 are in New Mexico and 3 are in Colorado (Appendix F) (US Department of Commerce, NOAA 2008).

Missouri Hydrologic Region

The Missouri Hydrologic Region includes most of Montana and Wyoming, as well as northwestern Colorado. In this region, planning area public and NFS lands are in parts of southwestern Montana, the basins of central Wyoming, and small parts of central Colorado. The Missouri Hydrologic Region encompasses the Northern Great Plains aquifer, the Central Midwest (Great Plains) aquifer system, the High Plains aquifer, and the Denver Basin aquifer. A small part of the western edge of the region (bordering Idaho) includes the Northern Rocky Mountains Intermontane Basin aquifer system. This aquifer system is described under the Pacific Northwest Hydrologic Region, as described previously (USGS 2002b).

Surface Water. This hydrologic region encompasses the eastern front of the Rocky Mountains stretching to the Great Plains, most of which is drained by the Missouri and Platte Rivers and their tributaries (BLM 2007c). The Missouri River system and the North Platte River drain eastward and southeastward to the Mississippi River, which discharges to the Gulf of Mexico (USGS 2002b). These rivers and their tributaries are an important source of water for public-supply, domestic and commercial, agricultural, and industrial uses. Much of the surface water has long been appropriated for agricultural use, primarily irrigation, and for compliance with downstream water pacts. Reservoirs store some of the surface water for flood control, irrigation, power generation, and recreational purposes (USGS 2002b). The demand for water is directly related to the distribution of people. The more densely populated areas are on lowlands near major streams. Many of the mountain, desert, and upland areas lack major population centers, particularly in Montana and Wyoming, where use of much of the land is controlled by the federal and withdrawal of groundwater is restricted (USGS 2002b).

Surface water resources are dominated by the major rivers and their tributaries. Average annual runoff in the region varies greatly (USGS 2002b). Precipitation is generally sparse in the summer and fall months, and surface water flow is generally dependent on snowmelt in the mountainous areas. Rivers flow mainly from late spring to early fall and can be dry in some parts of the region during the winter months (BLM 2007c). In arid and semiarid areas of the region, most precipitation replenishes soil moisture, evaporates, or is transpired by vegetation, and only a small part of the precipitation is left to maintain stream flow or recharge aquifers (USGS 2002b). Surface water is directly connected to groundwater through shallow alluvial aquifers that are found along all the major rivers and their tributaries (BLM 2007c). Runoff is affected in some areas by reservoirs that have been constructed on major streams to mitigate flooding and to store water for irrigation, electrical power generation, and recreation. Water stored in reservoirs during times when runoff is great is subsequently released during drier periods to maintain downstream flow (USGS 2002b).

Groundwater base flow supplies stream and river flow in the late summer and fall. Surface water is the main source of municipal and irrigation water in the Rocky Mountain region, and irrigation return flow is a major component of surface water flow (BLM 2007c).

Groundwater. Groundwater in Wyoming and western Montana is found both in the igneous rocks of the uplifts and the thick sedimentary fill in the basins, although groundwater in the uplifts is generally not used. Groundwater is used extensively for irrigation, much of it becoming irrigation return water that flows into major streams and their tributaries. In addition to irrigation, groundwater is also used for municipal and domestic water supplies. Recharge comes only from stream infiltration and spring snowmelt (BLM 2007c). The High Plains, Northern Great Plains, and Central Midwest aquifer systems in the region are extensive sequences of aquifers and confining units, which are usually, but not always, arranged as stacks of layers, that might be discontinuous locally but function regionally as a single aquifer systems (USGS 2002b).

High Plains. The High Plains aquifer underlies parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. The aquifer is the principal source of water in one of the major agricultural areas of the US. Most wells completed in the High Plains aquifer system obtain water from upper Tertiary aquifers that consist of the Ogallala Formation of Miocene age and the Arikaree Formation of Miocene and Oligocene age. The unconsolidated sand and gravel beds of the Ogallala Formation yield water much more readily than the sandstone beds of the Arikaree Formation. The consolidated siltstone and sandstone of the Brule Formation of Oligocene age yield highly variable volumes of water; yields are greatest where the beds have been fractured. Valley-fill and dune deposits of Quaternary age are hydraulically connected to the aquifers in Tertiary rocks and are included in the High Plains aquifer system. These permeable deposits are important recharge areas because they readily absorb and temporarily store precipitation before it percolates downward to recharge underlying permeable beds. Except for dune sands, which were deposited by wind, all the rocks and deposits that compose the High Plains aquifer system were deposited by streams. The streams probably were braided streams that flowed eastward from the Rocky Mountains and constantly shifted their channels across a broad plain that sloped gently to the east. Depth to water in the High Plains aquifer system ranges from less than 50 to almost 300 feet (USGS 2002b).

Water quality in the High Plains aquifer system in South Dakota and Wyoming is suitable for most uses practically everywhere. Locally, dissolved-solids concentrations in the water exceed the 500-milligram-per-liter secondary maximum contaminant level recommended for drinking water by the US EPA (USGS 2002b).

Northern Great Plains. The Northern Great Plains aquifer system underlies most of North Dakota and South Dakota, about one-half of Montana, and about one-third of Wyoming. The permeable rocks of the Northern Great Plains aquifer system have been grouped into five major aquifers. From shallowest to deepest, these are lower Tertiary, upper Cretaceous, lower Cretaceous, upper Paleozoic, and lower Paleozoic aquifers. All or parts of several geologic formations are included in each of the five major aquifers (USGS 2002b).

The aquifer system is mostly within the Williston Basin in eastern Montana and the western Dakotas, the Powder River Basin in northeastern Wyoming, and areas of structural uplifts that flank these basins. The major aquifers of the Northern Great Plains aquifer system are sandstones of Tertiary and Cretaceous age and carbonate rocks of Paleozoic age. These aquifers, along with regional confining units that separate some of them, form one of the largest confined aquifer systems in the US. In some places, local confining units separate the major aquifers into smaller, individual aquifers, but each major aquifer can be treated regionally as a single, large aquifer (USGS 2002b).

Regional movement of water in the Northern Great Plains aquifer system is from recharge areas at high altitudes, down the dip of the aquifers, and then upward to discharge into shallower aquifers or to the land surface. Much of the water moves into and through the Powder River and the Williston Basins. Much of the discharge from the aquifer system is by upward leakage of water into shallower aquifers where the hydraulic head in the shallower aquifer is less than that of a deeper aquifer. Some discharge from the Northern Great Plains aquifer system also is by withdrawals from wells or from flowing wells in places where artesian pressure is sufficient to allow water in confined aquifers to rise above the land surface (USGS 2002b).

Central Midwest. The Central Midwest aquifer system encompasses the eastern half of Colorado and small parts of northeastern New Mexico and southeastern Wyoming. The Central Midwest regional aquifer system includes the Great Plains aquifer subsystem. The Great Plains aquifer subsystem consists of two sandstone aquifers separated by a shale-confining unit, all of which are in Lower Cretaceous rocks. The aquifer system is overlain by a thick sequence of Upper Cretaceous shale beds that are part of several geologic formations but which function together as a single confining unit, the Great Plains confining system (USGS 2002b).

The upper aquifer, the Maha aquifer, consists chiefly of Dakota, Newcastle, or Muddy Sandstones or equivalent rocks. The lower aquifer, the Apishapa aquifer, consists mostly of the Cheyenne Sandstone or its equivalent, the Inyan Kara Group. The confining unit that separates the two aquifers is mostly the Skull Creek or the Thermopolis Shales or equivalent shale beds (USGS 2002b).

The Denver Basin aquifer system consists of a layered sequence of four aquifers in beds of permeable conglomerate, sandstone, and siltstone. Layers of relatively impermeable shale separate the aquifers and impede the vertical movement of groundwater between the aquifers. The northern part of this aquifer system underlies the surficial aquifer of the South Platte River. Although the Denver Basin aquifer system and the surficial aquifer are hydraulically connected in part of this area, they primarily function as separate aquifer systems (USGS 2002b). The Elk Mountain Aquifer in Wyoming is the only sole-source aquifer identified by the EPA in the Missouri Hydrologic Region (US EPA 2008c).

Hot Springs. There are over 100 hot springs within the Missouri Hydrologic Region. Most are in the Yellowstone National Park area, which has over 90 known hot springs. Three other hot springs are in Wyoming outside of Yellowstone National Park, and 13 others are in Montana (Appendix F) (US Department of Commerce, NOAA 2008).

Arkansas-White-Red Hydrologic Region

In the western US, the Arkansas-White-Red Hydrologic Region includes southeastern Colorado and northeastern New Mexico. In this region, there are only sporadic small parcels of planning area public and NFS lands. The region encompasses the High Plains aquifer system.

Surface Water. This hydrologic region occupies the drainage of the Arkansas, Canadian, and Red River basins above the points of the highest backwater effect of the Mississippi River. It includes all of Oklahoma and parts of Colorado, New Mexico, Texas, Kansas, Missouri, and Louisiana. Only a relatively small proportion of public and NFS lands are found in this region, primarily concentrated near the headwaters of the Arkansas River in central Colorado and near the headwaters of the Canadian River in northeastern New Mexico (BLM 2007c). Surface waters generally originate from precipitation falling in the eastern Rocky Mountains. Precipitation is relatively sparse in the summer and fall months, and surface water flow is typically dependent on snowmelt in the mountainous areas. Surface water resources are used extensively for agricultural irrigation (BLM 2007c).

Groundwater. The High Plains aquifer underlies the western edges of Colorado and New Mexico. The High Plains aquifer is described previously for the Missouri Hydrologic Region.

Surficial aquifers present in many parts of the region generally contain the shallowest groundwater in the area. These aquifers consist of Quaternary deposits of alluvial gravel, sand, silt, and clay or Quaternary deposits of eolian sand and silt. The alluvial and eolian deposits of the Arkansas River Valley are moderately thick and extensive and contain a major surficial aquifer (USGS 2002b). There are no sole-source aquifers identified by the EPA in the Arkansas-White-Red Hydrologic Region (US EPA 2008c, US EPA 2008d)

Hot Springs. There are two hot springs within this region, one in New Mexico and one in Colorado (Appendix F) (US Department of Commerce, NOAA 2008).

Alaska Hydrologic Region

The Alaska Hydrologic Region occupies the entire state of Alaska. In this region, planning area public and NFS lands are in an east-west band across the middle of the state, along the Aluetian Island mountain chain in the south, and on the southeastern coast.

Surface Water. This hydrologic region occupies all of Alaska and is characterized by abundant water resources. Major river systems, such as the Yukon, drain the mountain ranges, and extensive wetlands dot the low-lying plains and coastal regions (BLM 2007c). Alaska is geologically and topographically diverse and contains abundant natural resources, including groundwater and surface water of chemical quality that is generally suitable for most uses (USGS 2002b).

The Yukon and Kuskokwim River drainages are two of the dominant drainages in Alaska. Central Alaska is drained by the Yukon River, which drains an area of more than 330,000 square miles, making it the fourth-largest drainage basin in North America. Its main stem, the Yukon River, originates in northwestern Canada and extends through central Alaska, discharging into the Bering Sea. Major tributaries of the Yukon River include the Tanana, Nenana, Koyukuk, Tanana, and Chena Rivers (BLM 2007c).

The Kuskokwim River drains a large part of southwestern Alaska is the state's second-largest drainage. The glacially turbid main stem is approximately 900 miles long, originating from the interior headwaters of the Kuskokwim Mountains and the shadows of the Alaska Range. The Kuskokwim River flows in a southwest direction to the Bering Sea (BLM 2007c).

The Noatak River in northwestern Alaska discharges into the Chukchi Sea. Major rivers in southern Alaska include the Susitna and the Matanuska Rivers, which discharge into Cook Inlet, and the Copper River, which discharges into the Gulf of Alaska. North of the Brooks Range, the Colville and the Sagavanirktok Rivers and numerous smaller streams discharge into the Arctic Ocean (USGS 2002b).

Low mountains, plateaus, and highlands bound the high mountains and are, in turn, bounded by lowland areas. The lowlands are primarily along the courses of major streams and in coastal areas. Most of the population is concentrated in the cities of Anchorage, Fairbanks, and Juneau, all of which are located in lowland areas. The mountains, the frozen Arctic desert, the interior plateaus, and the areas covered with glaciers lack major population centers. Large parts of Alaska are uninhabited, and much of the state is federal land (BLM, National Park Service, and USFWS). Groundwater development has not occurred over most of these remote areas (USGS 2002b).

Groundwater. Information on subsurface geology, groundwater, and permafrost is sparse in Alaska. In large parts of the state, the surface geology is not well known. Local variations in geologic and permafrost conditions significantly affect the occurrence and movement of groundwater (USGS 2002b).

Hydrologic processes are strongly affected by the presence of permafrost, which may thaw seasonally or be continuous throughout the year, particularly on the

North Slope. In central Alaska, permafrost is discontinuous, and an active layer at the surface that thaws during the summer months can supply groundwater for domestic use. The major river valleys have alluvial aquifers with an active layer in the summer months that also supplies good-quality groundwater. During the winter, permafrost generally extends to the surface, impeding water infiltration and groundwater recharge (BLM 2007c).

The aquifers of Alaska have never been mapped, except in the immediate vicinity of some of the towns and cities such as Kenai, Anchorage, Juneau, and Fairbanks. In other places, data from widely scattered drill holes, combined with maps of the surficial geology, allow some inference about the availability of groundwater. In many areas, deposits of coarse-grained, unconsolidated alluvial and glacial-outwash deposits of Quaternary age, such as the Tanana River basin, comprise thick aquifers that yield large quantities of water to wells. In other areas, such as the Copper River basin, widespread Quaternary deposits consist mostly of lacustrine (lake) silt and clay that are underlain by saline water and do not comprise aquifers. In the coastal area between Norton Sound and Bristol Bay, Quaternary deposits extend over large areas but are generally too fine grained to yield significant amounts of water. However, sand and gravel deposits, such as those that provide the water supply for Bethel, locally form productive aquifers. From the Brooks Range northward to the Arctic Ocean, Quaternary deposits contain continuous permafrost and, therefore, are not aquifers. In the northern part of the discontinuous permafrost zone, the alluvial and outwash deposits are frozen during much of the year, and exploration for local sources of groundwater has generally not been conducted. In this region, however, scattered occurrences of large surface accumulations of ice during the winter indicate the presence of local aquifers (USGS 2002b).

Unconsolidated Quaternary deposits may locally be as thick as 1,000 feet in large basins such as the Yukon, Kuskokwim, Tanana, and Copper Rivers. The entire thickness, however, does not yield water. Igneous, metamorphic, and sedimentary rocks underlie about 70 percent of Alaska. Although these rocks generally yield smaller water amounts to wells than coarse-grained alluvial and outwash deposits, they are important aquifers in some parts of the state. In the Fairbanks area, approximately half the residents obtain water from wells completed in bedrock. Large springs issue from carbonate rocks in the eastern part of the Brooks Range. Carbonate bedrock on Admiralty Island in southeastern Alaska also yields large quantities of water from well-developed cave systems (USGS 2002b). There are no identified sole-source aquifers identified by the EPA in the Alaska Hydrologic Region (US EPA 2008a).

Hot Springs. There are 78 hot springs within the Alaska Hydrologic Region, approximately a third of which are located in the Aleutian Island mountain chain (Appendix F) (US Department of Commerce, NOAA 2008).

3.7.1 Climate Change

Some effects on water resources resulting from climate change include changes in stream systems, such as flow, temperature, and turbidity, as well as effects on glacial systems, which are advancing or receding, depending on local conditions (IPCC 2007).

3.8 Air Quality and Atmospheric Values

3.8.1 Applicable Plans, Policies and Regulations

The Clean Air Act was passed in 1970 (and amended in 1990) to reduce air pollution across the US. Specific air pollutants associated with harming human health were identified as criteria pollutants. The criteria pollutants were assigned acceptable airborne concentration levels, and collectively the list was named the National Ambient Air Quality Standards. Under the Clean Air Act, the US EPA is responsible for revising these standards when necessary as new air quality data and related impacts on the human environment become available. The Act also mandates the US EPA approve state implementation plans to ensure that local agencies comply with the Act.

More recently, the US EPA issued two new air quality regulations to control air pollution in the US. On March 15, 2006, they issued the Clean Air Mercury Rule to permanently cap and reduce mercury emissions from coal-fired power plants for the first time.

3.8.2 Criteria Pollutants

The US EPA established National Ambient Air Quality Standards for the following six criteria pollutants to protect public health and welfare: sulfur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), ozone (O3), lead (Pb), and particulate matter (PM).

Particulate matter, or particulate pollution, is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. The size of particles is directly linked to their potential for causing health problems. The US EPA regulates particles that are 10 micrometers in diameter or smaller because those are the particles that generally pass through the throat and nose and enter the lungs. Once inhaled, these particles can affect the heart and lungs and cause serious health effects. The US EPA groups particulate pollution into two categories:

- Inhalable coarse particles, such as those found near roadways and dusty industries, are larger than 2.5 micrometers and smaller than 10 micrometers in diameter (PM10).
- Fine particles, such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller (PM2.5). These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.

The National Ambient Air Quality Standards (Table 3-12) and are divided into primary and secondary categories. Primary standards set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. Averaging periods vary by criteria pollutants based on potential health and welfare effects of each pollutant. The National Ambient Air Quality Standards are enforced by the states via local air pollution agencies. Some states have adopted their own air quality standards that are either as stringent as, or more stringent than, the National Ambient Air Quality Standards.

Table 3-12
National Ambient Air Quality Standards

Pollutant	Averaging Times	Ambient concentration standard[1]	Primary (P) or Secondary (S) standard[2]
Carbon monoxide	1 hour	35 ppm (40 mg/m^3)	P
	8 hours	9 ppm (10 mg/m^3)	P
Lead	Quarterly Average	1.5 μg/m^3	P,S
Nitrogen dioxide	Annual	0.053 ppm (100 μg/m^3)	P,S
PM_{10}	24 hours	150 μg/m^3	P
	Annual	Revoked	P
$PM_{2.5}$	24 hours	35 μg/m^3	P
	Annual	15 μg/m^3	P,S
Ozone	1 hour	0.12 ppm	P,S
	8 hours	0.08 ppm	P,S
Sulfur dioxide	3 hours	0.5 ppm	S
	24 hours	0.14 ppm	P
	Annual	0.03 ppm	P

[1] ppm = parts per million; mg/m3 = milligrams per cubic meter; μg/m^3 = micrograms per cubic meter
[2] P = primary standard (health-based); S = secondary standard (welfare-based)
Source: 40 CFR, Part 50

The US has been divided into air management units that have been classified based on their status in attaining the National Ambient Air Quality Standards. In an area where ambient concentrations of a particular pollutant are below the National Ambient Air Quality Standards, the US EPA designates that area as being in attainment. Likewise, areas are designated as being in nonattainment if criteria pollutant concentrations violate the National Ambient Air Quality Standards. Formerly nonattainment areas that are now in compliance with the National Ambient Air Quality Standards are designated as maintenance areas. Nonattainment areas must implement a plan to reduce ambient concentrations below the National Ambient Air Quality Standards. Areas where insufficient data are available to determine attainment status are designated as unclassified and are treated as attainment areas for regulatory purposes.

In addition to criteria pollutants, the US EPA, together with the states, also controls air toxics, or hazardous air pollutants. Such substances, if present in the surrounding air, are thought to have serious health impacts. Lists of substances identified as air toxics have been issued by the US EPA and some individual states. The details of the list and regulations applied to the hazardous air pollutants may vary among jurisdictions. Due to its minute emissions, an operating geothermal energy development would most likely be exempt from air toxics emissions regulations, depending on the types of technology and local attainment status.

3.8.3 Attainment Status in the Project and Planning Areas

Existing air quality conditions across the project and planning areas are described in terms of attainment status. Ambient pollutant levels are expected to be low in the undeveloped regions of public and NFS lands and negligible in remote areas. Project and planning areas with high pollutant levels are typically those with either large amounts of human development or high winds and dusty soil types with little vegetation.

Counties in the project and planning areas with public or NFS lands that are designated as nonattainment or maintenance areas for each criteria pollutant are listed in Table 3-13. Levels of PM_{10}, ozone, and nitrogen dioxide are expected to be higher near industrial areas and cities, which are associated with greater fossil fuel combustion. High sulfur dioxide concentrations are most commonly observed in areas with coal-fired power plants, smelters, and refineries.

Table 3-13
Project Area Counties that are Designated Nonattainment or Maintenance Areas for Criteria Pollutants

Pollutant	State	Nonattainment (Project Area)	Nonattainment (Planning Area)	Maintenance (Project Area)	Maintenance (Planning Area)
PM_{10}	AK	Anchorage Municipality[1], Juneau City and Borough[1]	None	None	None
	AZ	Pima[1], Gila[1], Pinal[1], Santa Cruz[1], Cochise[1], Maricopa[1], Yuma[1]	Pima[1], Gila[1], Pinal[1], Santa Cruz[1], Cochise[1], Maricopa[1], Yuma[1]	Mohave[1], Gila[1]	Mohave[1], Gila[1]
	CA	Riverside[1], Inyo[1], Imperial[1], Los Angeles[1], Orange, Riverside[1], San	Riverside[1], Inyo[1], Imperial[1], Los Angeles[1], Orange, Riverside[1], San	Kern[1]	Kern[1]

Table 3-13
Project Area Counties that are Designated Nonattainment or Maintenance Areas for Criteria Pollutants

Pollutant	State	Nonattainment (Project Area)	Nonattainment (Planning Area)	Maintenance (Project Area)	Maintenance (Planning Area)
		Bernardino[1], Mono[1], Inyo[1], Sacramento, Kern[1], Kings[1], Madera[1], San Joaquin[1], Stanislaus[1], Tulare[1],	Bernardino[1], Mono[1], Inyo[1], Sacramento, Kern[1], Kings[1], Madera[1], San Joaquin[1], Stanislaus[1], Tulare[1],		
	CO	None	None	Pitkin[1], Fremont[1], Adams[1], Araphoe[1], Boulder[1], Broomfield, Denver, Douglas, Jefferson, Prowers[1], Archuleta[1], Routt[1], San Miguel[1]	Pitkin[1], Fremont[1], Adams[1], Araphoe[1], Boulder[1], Denver, Douglas, Jefferson, Prowers[1], Archuleta[1], Routt[1], San Miguel[1]
	ID	Bonner[1], Bannock[1], Power[1], Shoshone[1]	Bannock[1], Power[1]	Ada[1], Bannock[1], Power[1]	Ada[1], Bannock[1], Power[1]
	MT	Silver Bow[1], Flathead[1], Rosebud[1], Lincoln[1], Missoula[1], Lake[1], Sanders[1]	Silver Bow[1], Rosebud[1], Lincoln[1], Missoula[1], Sanders[1]	None	None
	NV	Clark[1], Washoe[1],	Clark[1], Washoe[1]	None	None
	NM	Dona Ana[1]	Dona Ana[1]	None	None
	OR	Lane[1]	Lane[1]	Josephine[1], Klamath[1], Union[1], Lake[1], Jackson[1]	Klamath[1], Union[1], Lake[1], Jackson[1]
	UT	Weber[1], Salt Lake, Utah	Weber[1], Salt Lake, Utah	None	None
	WA	None	None	King[1], Thurston[1], Pierce[1], Spokane[1], Walla Walla[1], Yakima[1]	King[1], Thurston[1], Pierce[1], Walla Walla[1], Yakima[1]
	WY	Sheridan[1]	Sheridan[1]	None	None
Sulfur Dioxide	AZ	Pinal[1]	Pinal[1]	Pima[1], Cochise[1], Gila[1], Greenlee[1]	Pima[1], Cochise[1], Gila[1], Greenlee[1]
	MT	Lewis and Clark[1], Yellowstone[1]	Lewis and Clark[1], Yellowstone[1]	None	None
	NV	None	None	White Pine[1]	White Pine[1]
	NM	None	None	Grant[1]	Grant[1]
	UT	Salt Lake, Tooele[1]	Salt Lake, Tooele[1]	None	None

Table 3-13
Project Area Counties that are Designated Nonattainment or Maintenance Areas for Criteria Pollutants

Pollutant	State	Nonattainment (Project Area)	Nonattainment (Planning Area)	Maintenance (Project Area)	Maintenance (Planning Area)
Nitrous Dioxide	--	None	None	None	None
Carbon Monoxide	AK	None	None	Anchorage Municipality[1], Fairbanks North Star Borough[1]	Fairbanks North Star Borough[1]
	AZ	None	None	Maricopa[1], Pima[1]	Maricopa[1], Pima[1]
	CA	None	None	Kern[1], Butte[1], Fresno[1], Placer[1], El Dorado[1], Los Angeles[1], Orange, Riverside[1], San Bernardino[1], Stanislaus[1], Sacramento[1], Yolo[1], San Diego[1], Alameda[1], Contra Costa[1], Marin[1], Napa[1], San Francisco[1], San Mateo[1], Santa Clara[1], Solano[1], Sonoma[1], San Joaquin[1]	Kern[1], Butte[1], Fresno[1], Placer[1], El Dorado[1], Los Angeles[1], Orange, Riverside[1], San Bernardino[1], Stanislaus[1], Sacramento[1], Yolo[1], San Diego[1], Alameda[1], Contra Costa[1], Marin[1], Napa[1], San Francisco[1], San Mateo[1], Santa Clara[1], Solano[1], Sonoma[1], San Joaquin[1]
	CO	None	None	El Paso[1], Teller[1], Adams[1], Araphoe[1], Boulder[1], Broomfield, Denver, Douglas[1], Jefferson[1], Larimer[1], Weld[1], Boulder[1], Weld[1]	El Paso[1], Teller[1], Adams[1], Araphoe[1], Boulder[1], Denver, Douglas[1], Jefferson[1], Larimer[1], Weld[1]
	ID	None	None	Ada[1]	Ada[1]
	MT	Missoula[1]	Missoula[1]	Yellowstone[1], Cascade[1]	Yellowstone[1]
	NV	Clark[1], Washoe[1]	Clark[1], Washoe[1]	Carson City[1], Douglas[1], Washoe[1]	Carson City[1], Douglas[1], Washoe[1]

Table 3-13
Project Area Counties that are Designated Nonattainment or Maintenance Areas for Criteria Pollutants

Pollutant	State	Nonattainment (Project Area)	Nonattainment (Planning Area)	Maintenance (Project Area)	Maintenance (Planning Area)
	NM	None	None	Bernalillo	Bernalillo
	OR	Marion[1], Polk[1]	Marion[1], Polk[1]	Lane[1], Josephine[1], Klamath[1], Jackson[1], Clackamas[1], Multnomah[1], Washington[1]	Lane[1], Klamath[1], Jackson[1], Clackamas[1], Multnomah[1], Washington[1]
	UT	None	None	Weber[1], Utah[1], Salt Lake[1]	Weber[1], Utah[1], Salt Lake[1]
	WA	None	None	King[1], Pierce[1], Snohomish, Spokane[1], Clark[1], Yakima[1]	King[1], Pierce[1], Snohomish, Clark[1], Yakima[1]
Ozone	AZ	Maricopa[1], Pinal[1]	Maricopa[1], Pinal[1]	None	None
	CA	Amador, Calaveras, Butte[1], Imperial[1], Kern[1], Los Angeles[1], Orange[1], Riverside[1], San Bernardino[1], Mariposa, Tuolumne, Nevada, El Dorado[1], Placer[1], Sacramento[1], Solano[1], Sutter[1], Yolo[1], San Diego[1], Alameda[1], Contra Costa[1], Marin[1], Napa[1], San Francisco[1], San Mateo[1], Santa Clara[1], Solano[1], Sonoma[1], Fresno[1], Kings[1], Madera[1], Merced[1], San Joaquin[1], Stanislaus[1], Tulare[1], Sutter[1], Ventura[1]	Butte[1], Imperial[1], Kern[1], Los Angeles[1], Orange[1], Riverside[1], San Bernardino[1], Nevada, El Dorado[1], Placer[1], Sacramento[1], Solano[1], Yolo[1], San Diego[1], Alameda[1], Contra Costa[1], Marin[1], Napa[1], San Francisco[1], San Mateo[1], Santa Clara[1], Solano[1], Sonoma[1], Fresno[1], Kings[1], Madera[1], Merced[1], San Joaquin[1], Stanislaus[1], Tulare[1], Ventura[1]	None	None
	CO	Adams[1], Araphoe[1], Boulder[1], Broomfield[1], Denver[1], Douglas[1], Jefferson[1], Larimer[1], Weld[1]	Adams[1], Araphoe[1], Denver[1], Douglas[1], Jefferson[1], Larimer[1], Weld[1]	None	None
	NV	Clark[1]	Clark[1]	None	None
Lead	MT	Lewis and Clark[1]	Lewis and Clark[1]	None	None

[1] only a portion of the county is in nonattainment

Source: US EPA 2007b

3.8.4 National Air Quality and Emissions Trends

Air quality based on concentrations of the criteria pollutants has improved nationally since 1980. Such trends are observed by using measurements from air quality monitoring stations located across the country. The US EPA expects the long-term trend of air quality improvement to continue as the Clean Air Mercury Rule, state plans to attain national air quality standards, and other national programs and clean air requirements targeting mobile sources are implemented (US EPA 2007a).

The US EPA also estimates nationwide emissions of ambient air pollutants and the pollutants they are formed from (their precursors). Such estimates are based on actual monitoring data or engineering calculations of the amounts and types of pollutants emitted by vehicles, factories, and other sources. Many factors are taken into consideration when calculating emissions estimates, including levels of industrial activity, technological developments, fuel consumption, vehicle miles traveled, and other activities that cause air pollution (US EPA 2007a). While emissions are trending downwards, human-caused air pollutants are still directly connected a number of air quality issues. It is estimated that 137 million tons of pollution are emitted into the atmosphere each year nationwide. These emissions mostly contribute to the formation of ozone and particles, the deposition of acids, and visibility impairment (US EPA 2007a).

3.8.5 Climate Change

Ongoing scientific research has identified the potential impacts of anthropogenic (manmade) greenhouse gas (GHG) emissions and changes in biological carbon sequestration due to land management activities on global climate. Through complex interactions on a regional and global scale, these GHG emissions and net losses of biological carbon sinks cause a net warming effect of the atmosphere, primarily by decreasing the amount of heat energy radiated by the earth back into space. Although GHG levels have varied for millennia, recent industrialization and burning of fossil carbon sources have caused CO2(e) concentrations to increase dramatically and are likely to contribute to overall global climatic changes. The Intergovernmental Panel on Climate Change (IPCC) recently concluded that “warming of the climate system is unequivocal” and “most of the observed increase in globally average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.”

Global mean surface temperatures have increased nearly 1.8°F from 1890 to 2006. Models indicate that average temperature changes are likely to be greater in the Northern Hemisphere. Northern latitudes (above 24° N) have exhibited temperature increases of nearly 2.1°F since 1900, with a nearly 1.8°F increase since 1970 alone. Without additional meteorological monitoring systems, it is difficult to determine the spatial and temporal variability and change of climatic conditions, but increasing concentrations of GHGs are likely to accelerate the rate of climate change.

In 2001, the IPCC indicated that by the year 2100, global average surface temperatures would increase 2.5 to 10.4°F above 1990 levels. The National Academy of Sciences has confirmed these findings, but also has indicated there are uncertainties regarding how climate change may affect different regions. Computer model predictions indicate that increases in temperature will not be equally distributed, but are likely to be accentuated at higher latitudes. Warming during the winter months is expected to be greater than during the summer, and increases in daily minimum temperatures is more likely than increases in daily maximum temperatures. Increases in temperatures would increase water vapor in the atmosphere and reduce soil moisture, increasing generalized drought conditions, while at the same time enhancing heavy storm events. Although large-scale spatial shifts in precipitation distribution may occur, these changes are more uncertain and difficult to predict.

As with any field of scientific study, there are uncertainties associated with the science of climate change. This does not imply that scientists do not have confidence in many aspects of climate change science. Some aspects of the science are known with virtual certainty, because they are based on well-known physical laws and documented trends (EPA 2008).

Several activities contribute to the phenomena of climate change, including emissions of GHGs (especially carbon dioxide and methane) from fossil fuel development, large wildfires, and activities using combustion engines; changes to the natural carbon cycle; and changes to radiative forces and reflectivity (albedo[1]). It is important to note that GHGs will have a sustained climatic impact over different temporal scales. For example, recent emissions of carbon dioxide can influence climate for 100 years.

Information is not available to reasonably discern whether global climate change is already affecting resources within the planning areas. Projected changes are likely to occur over several decades to a century; therefore, many of the projected changes associated with climate change described below may not be measurably discernable within the reasonably foreseeable future.

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[1] Changes in reflectivity (albedo) and related effects on climate are not discussed beyond this point. This is in part due to the fact that understanding is limited as to the relationship between albedo and climate change. In addition, the great variability in existing albedo across the planning area renders a programmatic discussion useless; without site- and project-specific information, albedo impacts are not determinable. For example, only if one were to know that a particular geothermal project would result in deforestation of a densely vegetated area and would expose light-colored soil or gravel roads would one know that albedo would be likely to increase. Similarly, only where one knew that a project would involve the laying of black asphalt in a desert environment would one know that albedo would likely decrease.

Existing and anticipated effects of climate change on resources in the planning area are incorporated into the relevant sections below. The following resources have been or are anticipated to be affected by climate change:

- Soil resources;
- Water resources;
- Vegetation;
- Fish and wildlife;
- Threatened and endangered species;
- Wild horses and burros (through changes in vegetation and soil);
- Livestock grazing (through changes in vegetation and soil); and
- Tribal interests (through changes in vegetation and soil and their effects on availability of traditionally used plants).

3.8.6 Typical Emissions Associated with Geothermal Energy

Air emissions from geothermal power plants are very small compared to emissions from fossil fuel plants. Geothermal plants emit small amounts of nitrogen oxides and carbon dioxide and nearly no sulfur dioxide or particulate matter (Geothermal Energy Association 2007b). The primary pollutant of geothermal power plants is hydrogen sulfide, which is naturally present in most geothermal reservoirs. Hydrogen sulfide emissions are maintained below the most stringent standards with the use of sophisticated abatement equipment. Studies carried out in the past few decades estimating emissions from geothermal power plants have concluded that geothermal energy emissions are small and have been reduced by advanced technologies and energy-saving techniques.

Steam from a geothermal plant is condensed when passing through a turbine; however, noncondensable gases in the reservoir fluid such as carbon dioxide, hydrogen sulfide, sulfur dioxide, mercury, and several others pass through the turbine without condensing and are released into the atmosphere. The amount of noncondensable gases present and emitted depends on factors such reservoir fluid composition, temperature, method of power generation (flash, binary, or combined cycle), and equipment efficiency (Bloomfield et al. 2003).

Carbon Dioxide

Carbon dioxide is a noncondensable gas present in geothermal fluids. Of the five percent noncondensable gases present in geothermal steam, 75 percent or more of that volume is occupied by carbon dioxide. The amount of carbon dioxide in the geothermal fluid depends on the location of the reservoir, and the amount released into the atmosphere depends on the technology used by the power plant. For example, geothermal fluids in a closed-loop binary plant are never exposed to the atmosphere and emit no carbon dioxide. Additionally, improved and increased injection technologies have resulted in lower carbon dioxide emissions from geothermal power plants. Such variation in fluid composition and integrated technology makes it difficult to make generalizations about the amount of carbon dioxide released by geothermal plants but one estimate is at 0.20 pounds per kilowatt hour. This estimate weighted average values of all geothermal power plants, including binary plants, which represent 14 percent of the total capacity. This estimate is comparable to the value reported by the Executive Director of the International Geothermal Association, which is approximately 0.29 pounds per kilowatt hour for 85 geothermal plants operating in 11 countries (Bloomfield et al. 2003).

As shown in Table 3-14, geothermal energy production produces between 10 to 15 percent the carbon dioxide emissions that are realized from fossil fuel energy sources.

Table 3-14
Comparison of Geothermal and Fossil Fuel Carbon Dioxide Emissions for Electrical Generation

	Geothermal	Coal	Petroleum	Natural Gas
Emissions (pounds carbon dioxide per kilowatt hour)	0.20	2.095	1.969	1.321

Source: Bloomfield et al. 2003

Hydrogen Sulfide

Of all geothermal power plant emissions, hydrogen sulfide emissions are of greatest concern. Hydrogen sulfide is considered a nuisance pollutant and may be lethal in high doses. Because of such concerns, hydrogen sulfide emissions have been thoroughly studied, and abatement technology has been extensively researched and effectively employed. Abatement systems such as Streford and LO-CAT convert more than 99.9 percent of the hydrogen sulfide from geothermal gases to elemental sulfur, resulting in hydrogen sulfide being reduced to approximately 1 percent of noncondensable gases emitted by geothermal power plants. Binary geothermal power plants do not emit any hydrogen sulfide, while steam and flash power plants produce minimal hydrogen sulfide emissions. A study done by Tiangco et al. in 1995 compared emissions from all types of geothermal power plants, and reported an average hydrogen sulfide emission of 0.29 pounds per megawatt hour for dual-flash plants. In this report, the authors point out that hydrogen sulfide emission from California geothermal plants are measured below the limits set by the state's air pollutions control districts, which are often below federal standards. Considering all types of geothermal power plants, hydrogen sulfide emissions average was reported around 0.187 pounds per megawatt hour (Bloomfield et al. 2003).

Sulfur Dioxide

Geothermal plants do not emit sulfur dioxide directly, but hydrogen sulfide emissions eventually form sulfur dioxide in the atmosphere. These indirect sulfur dioxide emissions from flash geothermal plants are measured at 0.35 pounds per megawatt hour (Geothermal Energy Association 2007b).

Particulate Matter

Particulate matter is of little concern in geothermal plants, as emissions are measured well below federal limits. The Geothermal Energy Association (2007b) reviewed a 1995 study that reported PM_{10} emissions from California geothermal plants at zero. Small amounts of particulate matter are emitted from water-cooled geothermal plants, but these emissions are well below federal limits and are quite small compared to emissions from coal or oil plants (Geothermal Energy Association 2007b).

Nitrogen Oxides

Nitrogen oxides form from nitrogen oxidation in the air during high-temperature burning processes such as fuel burning. Geothermal power plants do not burn any fuel; therefore, they emit zero or low amounts of nitrogen oxides. Average nitrogen oxide emissions are reported at zero, yet some geothermal plants do emit small amounts of nitrogen oxides through combustion of hydrogen sulfide in hydrogen sulfide abatement systems.

3.9 VEGETATION

Vegetation is a general term for the plant life of a region; it refers to the ground cover provided by plants and is the most abundant biotic element of the biosphere. The term vegetation does not by itself imply anything regarding species composition, life forms, structure, spatial extent, or any other specific botanical or geographic characteristics. Old-growth redwood forests, sagebrush scrub, sphagnum bogs, desert soil crusts, roadside weed patches, and cultivated farmlands are all encompassed by the term vegetation.

Vegetation serves several critical ecological functions. Vegetation regulates the flow of water, carbon, and nitrogen. It is also of great importance in local and global energy cycles, the process by which energy from the sun is captured and redistributed among plants and animals and may be eventually stored as fossil fuels or released as heat energy. Such cycles are important not only for global vegetation patterns, but also for global climate patterns. Vegetation strongly affects soil characteristics, including soil volume, chemistry, and texture, which feed back to affect various vegetation characteristics, including productivity and structure. Also, vegetation serves as wildlife habitat and a food energy source for animal species (and, ultimately, to those that prey upon them). Vegetation is also critically important to the world economy in the global production of food, wood, fuel and other materials. Vegetation is the primary source of the earth's atmospheric oxygen.

Vegetation as discussed in this section includes everything from mosses and annual grasses to large trees. This section will introduce vegetation types across the western US and discuss vegetation type (tree, shrub, herb), life history (evergreen, deciduous, annual, perennial), percent canopy cover, and hydrologic and climactic requirements.

Vegetative communities occurring within the project area span a great variety of ecosystems, from arid deserts to coastal coniferous forests. Each vegetative community is unique in species composition, richness, diversity, and structure. A wide range of environmental factors influence the presence and development of various types of vegetation throughout the project area, including climate, elevation, aspect, precipitation, and soil type. Because of the great variety and complexity of project area vegetation, the project area can best be represented by ecoregions.

3.9.1 Ecoregions

Ecoregions are large areas of similar climate where ecosystems recur in predictable patterns. Each ecoregion contains a geographically distinct assemblage of natural vegetation and wildlife communities and species. Ecoregions are separated by a hierarchy that groups very large areas together based on climate, similarities in plant occurrence and abundance, soil type, climate, altitude, and precipitation, among other factors (Bailey 1988).

The largest ecosystems are domains. Domains are large areas of related climate differentiated based on precipitation and temperature. There are three domains in the project area: Polar, Dry, and Humid Temperate.

Divisions represent the climates within domains and are differentiated based on precipitation levels and patterns, as well as temperature (Figures 3-10 and 3-11). Ten divisions comprise the project area.

Divisions are subdivided into provinces, which are differentiated based on vegetation or other natural land covers. Provinces in each division are also divided into mountain and non-mountain provinces based on altitude. Twenty-nine provinces make up the project area (Figures 3-12 and 3-13). Table 3-15 lists the domains, divisions and respective provinces found in the project area. Ecoregions are further divided into sections and subsections. Appendix G provides more detail on ecoregions.

Table 3-15
Project Area Ecoregions and Subregions

Domain	Division	Province
Polar	Arctic	Arctic Tundra Brooks Range Tundra Bering Sea Tundra
	Subarctic	Yukon Intermountain Taiga Upper Yukon Taiga Alaska Range Taiga
Humid Temperate	Warm Continental	Alaska Mixed Forest
	Cold Oceanic	Aleutian Meadow
	Marine	Pacific Lowland Mixed Forest Cascade Mixed Forest Pacific Coastal Icefields Pacific Gulf Coast Forest
	Mediterranean	California Coastal Chaparral Forest Shrub California Dry Steppe California Coastal Steppe, Mixed Forest, and Redwood Forest Sierran Steppe—Mixed Forest—Coniferous Forest—Alpine Meadow California Coastal Range Open Woodland—Shrub—Coniferous Forest—Meadow

Table 3-15
Project Area Ecoregions and Subregions

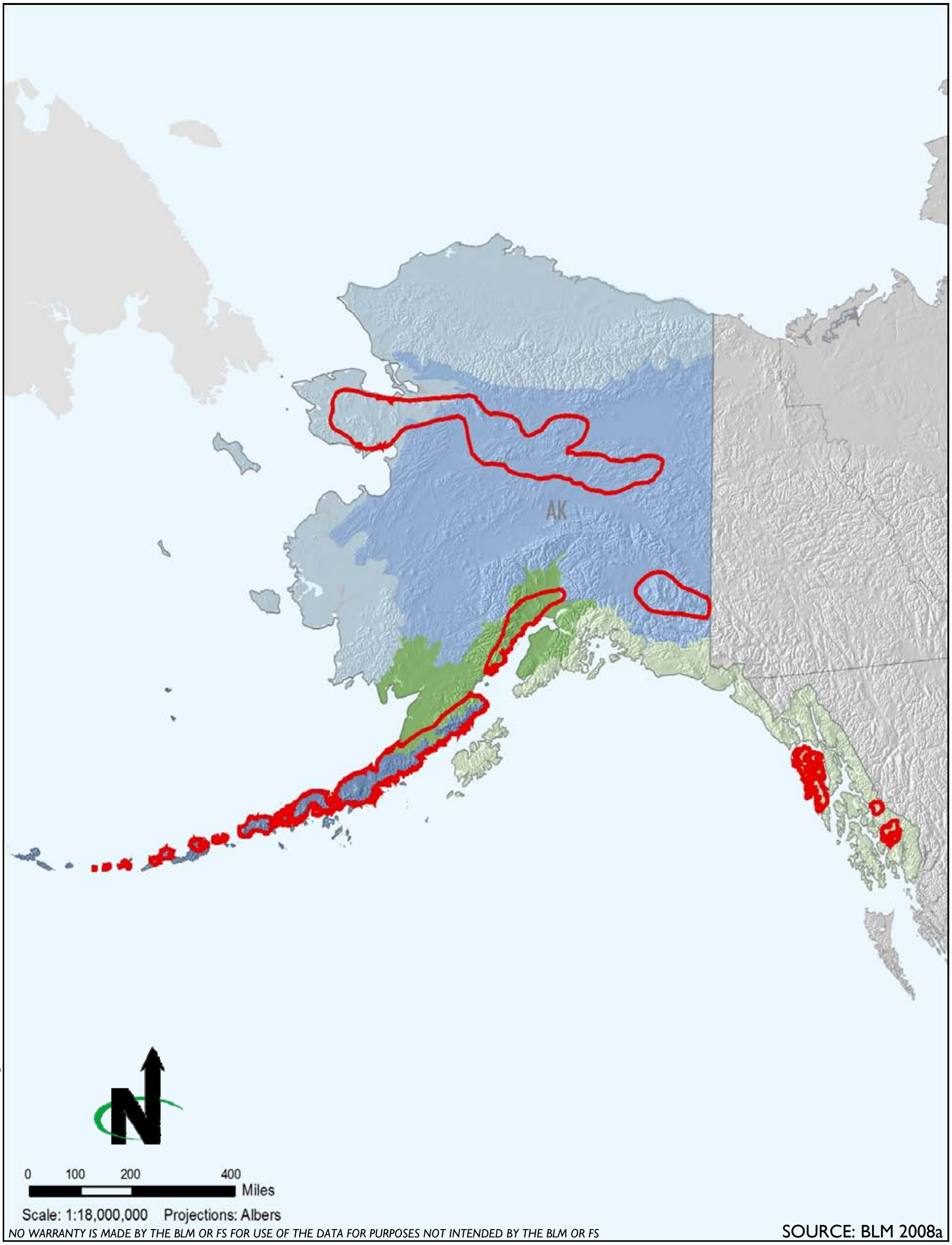
Domain	Division	Province
Dry	Tropical/Subtropical Steppe	Colorado Plateau Semidesert Southwest Plateau and Plains Dry Steppe and Shrub Arizona-New Mexico Mountains Semidesert—Open Woodland—Coniferous Forest—Alpine Meadow
	Tropical/Subtropical Desert	Chihuahuan Semidesert American Semidesert and Desert
	Temperate Steppe	Great Plains- Palouse Dry Steppe Southern Rocky Mountain Steppe—Open Woodland—Coniferous Forest—Alpine Meadow Middle Rocky Mountain Steppe—Coniferous Forest—Alpine Meadow Northern Rocky Mountain Forest-Steppe—Coniferous Forest—Alpine Meadow
	Temperate Desert	Intermountain Semidesert Nevada-Utah Mountains Semidesert—Coniferous Forest—Alpine Meadow Intermountain Semidesert and Desert

Source: Nowacki and Brock 1995, Bailey 1983,

Many federal agencies and private organizations, including the FS, BLM, US EPA, USGS, USFWS, Nature Conservancy, and Sierra Club, use a land classification system based on the ecoregion concept. Projects include biodiversity analysis and landscape- and regional-level forest and habitat planning. General vegetation trends are outlined below for each project area ecoregion division.

Arctic Division

The Arctic Division occurs primarily in northern and western Alaska bordering the Bering Sea (Figure 3-10). The arctic division is best described as tundra. Vegetation consists of grasses, sedges, lichens, and willow shrubs. Moving south, the vegetation changes into birch-lichen woodland, and then into needleleaf forest. A distinct tree line separates forest from tundra in some places. This line coincides approximately with the 50 degrees F isotherm for the warmest month and is the boundary between tundra and subarctic climates (Bailey 1983). Moist and wet tundra communities provide the dominant vegetation. Standing water, mosses, sedges, and low-growing shrubs cover most of the area. Alder, willows, and scattered stands of stunted spruce and birch grow along the major rivers and streams.

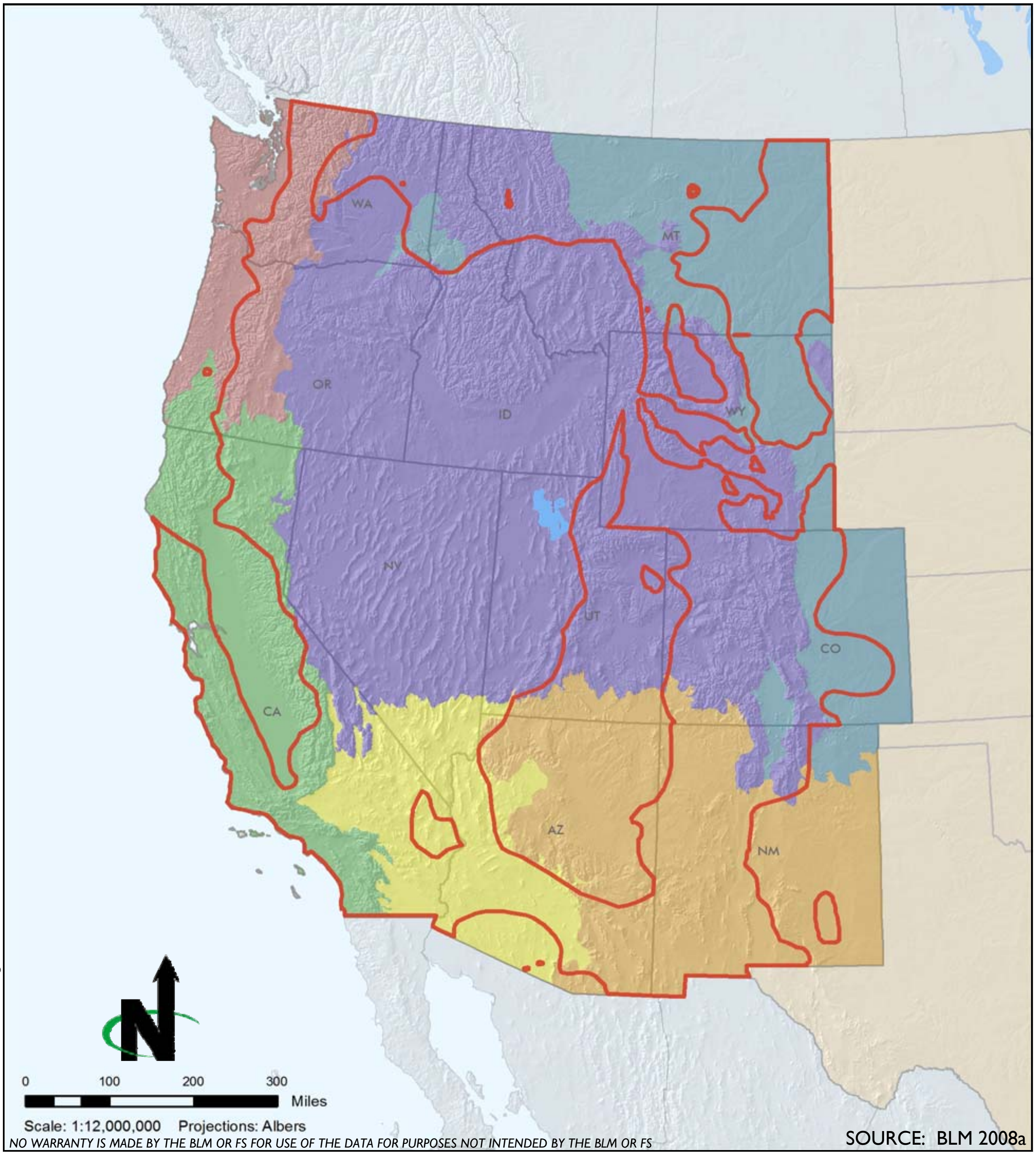


The potential geothermal area contains areas within all five ecoregion divisions in Alaska.

LEGEND:
Potential Geothermal Area
Ecoregion Divisions
Arctic
Subarctic
Cold Oceanic
Marine
Warm Continental

Ecoregion Divisions in Alaska

Figure 3-10



Areas of geothermal potential are found in all six ecoregion divisions of the 11 western states.

LEGEND:

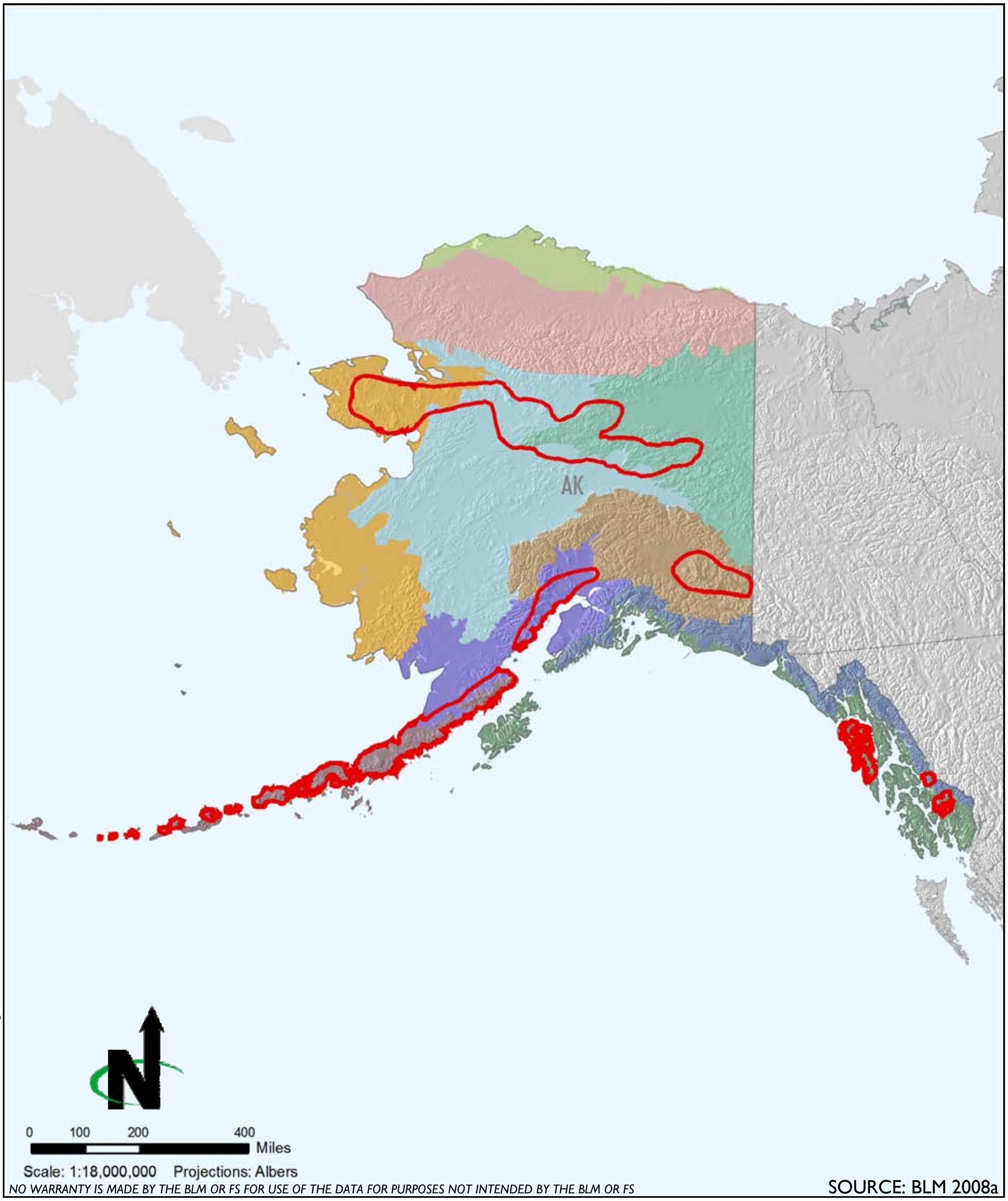
Potential Geothermal Area

Ecoregions

- Marine
- Mediterranean
- Temperate Desert
- Temperate Steppe
- Tropical/Subtropical Desert
- Tropical/Subtropical Steppe

Ecoregion Divisions in the 11 Western States

Figure 3-11



C://EMPSi/GeothermalPEIS/Figures

Potential geothermal area is found within eight of the ten ecoregion provinces in Alaska.

LEGEND:

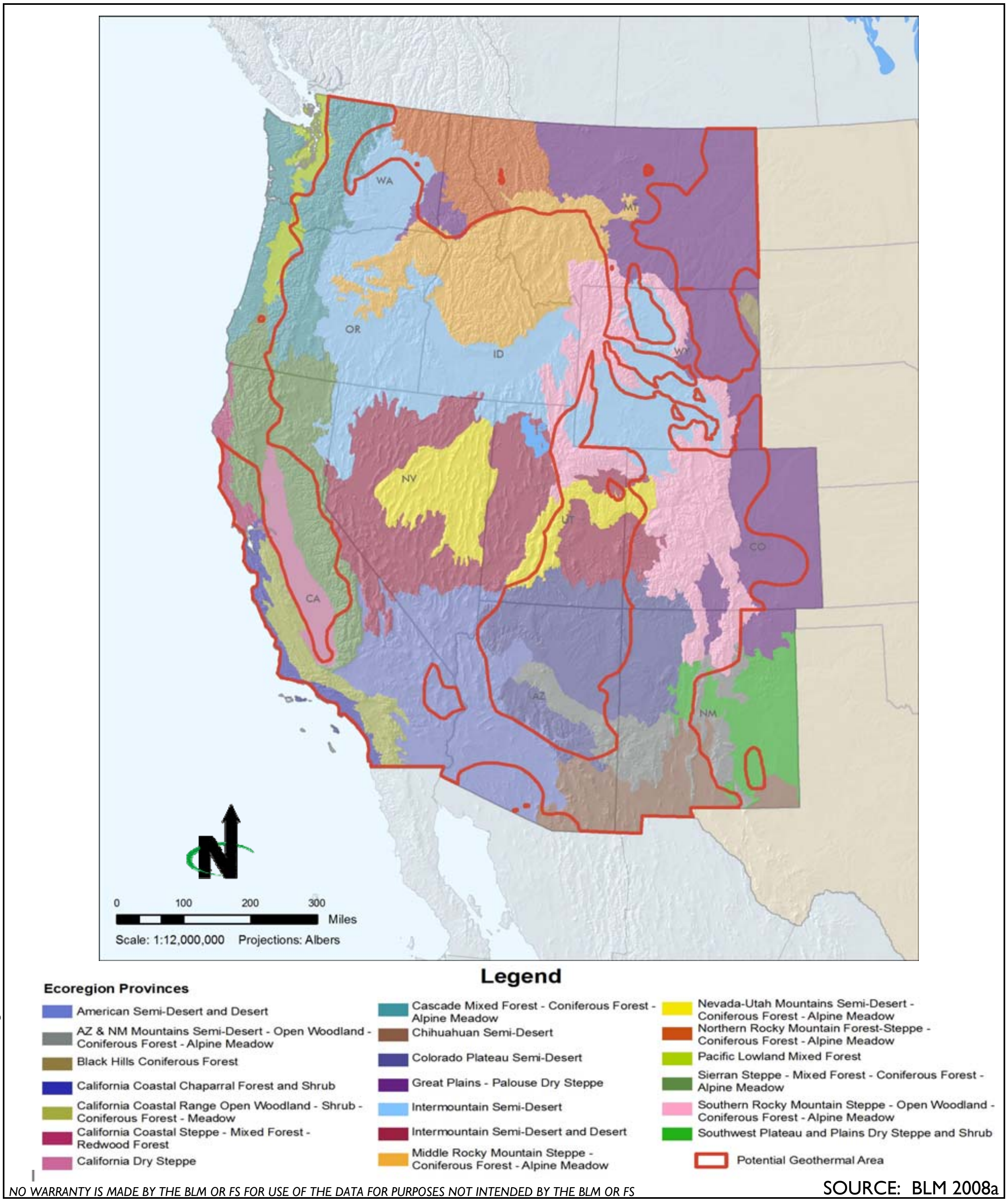
Potential Geothermal Area

Ecoregion Provinces

Bering Sea Tundra Province	Aleutian Meadow Province
Upper Yukon Taiga Province	Pacific Gulf Coast Forest Province
Alaska Range Taiga Province	Alaska Mixed Forest Province
Yukon Intermountain Taiga Province	Arctic Tundra Province
Pacific Coastal Icefields Province	Brooks Range Tundra Province

Ecoregion Provinces in Alaska

Figure 3-12



The 11 Western States are divided into 20 ecoregion provinces.

Ecoregion Provinces in the 11 Western States

Figure 3-13

In the coldest area, permafrost limits the rooting depth of plants and forces surface water to drain by preventing it from seeping into the soil. Extensive marshes and lakes result. Cottongrass-tussock, the most widespread vegetation system in the Arctic, is associated with sedges, dwarf shrubs, lichens, mosses, dwarf birch, Labrador-tea, and cinquefoil. These highly productive systems produce 500 to 1,000 pounds of vegetation per acre and provide an important source of food for caribou and waterfowl. Several forbs flower brightly in the short summer.

Vegetation along the wet coastal areas is chiefly sedge and cottongrass; woody plants grow on higher sites. Birch-willow-alder thickets are extensive in transition zones between beach and forest. The lower Yukon and Kuskokwim Valleys are dominated by white spruce mixed with cottonwood and balsam poplar in tall, relatively dense stands, with a dense undergrowth of thinleaf alder, willow, rose, dogwood, and various species of berry bushes.

Subarctic Division

The Subarctic Division occurs primarily in central Alaska and includes much of the Brooks Range and the Yukon River watershed (Figure 3-10). The subarctic climate zone coincides with a great belt of needleleaf forest, often referred to as boreal forest, and with open lichen woodland known as tiaga. The tiaga forests are largely coniferous and are dominated by larch, spruce, fir, and pine. Although the taiga is dominated by coniferous forests, some broadleaf trees also occur, notably birch, aspen, willow, and rowan. Many smaller herbaceous plants grow closer to the ground.

The major river bottoms support dense white spruce-cottonwood-poplar forests on floodplains and south-facing slopes up to approximately 1,000 feet. The undergrowth is dense shrubbery formed by green and thinleaf alder, willow, dogwood, and berries. The outer valley edges support evergreen and coniferous forests, often with pure stands of black spruce. The undergrowth consists of willow, dwarf birch, crowberry, fern, blueberry, lichens, and mosses. Upland areas are generally covered by a rather dense white spruce-birch-aspen-poplar forest. Pure stands of white spruce grow near streams. Typical undergrowth includes willow, alder, fern, berries, grasses, and mosses. Root systems are shallow. Water balance is likely the factor limiting growth in most of these areas because of the hot, dry summer climate. Old river terraces, ponds, and sloughs contain scattered but extensive bogs where the vegetation is chiefly sphagnum and other mosses, sedges, bog rosemary, and Labrador-tea. Marginal areas may support willow and alder.

Cold Oceanic

The Cold Oceanic division includes much of the Alaska Peninsula and all of the Aleutian Islands. The islands that chiefly make up this province are mountainous, rising steeply from the sea. Trees are absent from the division and vegetation consists of low shrubs of willow, birch, and alder interspersed with lichen, and grass communities. At lower elevations, there is a luxuriant growth of tall grasses, flowering plants, and ferns, with thickets of low willows in some places. A little higher up, several types of heath cover vast areas. The boreal forest and coastal rainforest are slowly encroaching from the east on the area of this province. This is explained by the assumption that the distribution of the vegetation is not yet adjusted to the climatic conditions produced by retreat of the last continental glaciers Alpine tundra is found on mountainsides.

Warm Continental

The Warm Continental Division occurs in coastal areas of southwest Alaska, including part of the Kenai and Alaska peninsulas (Figure 3-10). Moist and wet tundra communities provide the dominant vegetation at the western edge near the coast. Standing water, mosses, sedges, and low-growing shrubs cover most of the area. Alder, willows, and scattered stands of stunted spruce and birch grow along the major rivers and streams. Further to the east and inland vertical vegetational zonation characterizes the Alaska Range and Wrangell Mountains, beginning with dense bottom-land stands of white spruce and cottonwood on the floodplains and low terraces of the Copper and Susitna Rivers. Above the terraces, poorly drained areas up to 1,000 feet support stands of black spruce. Upland spruce-hardwood forests of white spruce, birch, aspen, and poplar, with an undergrowth of moss, fern, grass, and berry, extend to timberline at about 2,500-3,500 feet. Tundra systems of low shrubs and herbaceous plants form discontinuous mats among the rocks and rubble above timberline. White mountain-avens may cover entire ridges in the Alaska Range, associated with moss campion, black oxytrope, arctic sandwort, lichens, grasses, and sedges. These tundra systems stop short of the permanent ice caps on the highest peaks.

Marine Division

The Marine Division occurs primarily in coastal areas from the Gulf of Alaska, including the Alaska panhandle, Kenai Peninsula, and Kodiak Island, to the Oregon border (Figures 3-10 and 3-11). Much of this division was heavily logged. Prior to extensive logging, dense coniferous forest dominated the vegetation. Principal trees are western redcedar, western hemlock, and Douglas-fir. The coniferous forest found further inland is less dense than along the coast and often contains deciduous trees, such as big-leaf maple, Oregon ash, and black cottonwood. Prairie areas support open stands of oaks or are broken by groves of Douglas-fir and other trees; principal indicator species are Oregon white oak and Pacific madrone. Poorly drained sites with swamp or bog communities are abundant.

The timberline is at low elevations, and much of the mountainous area above it is covered with nearly bare rocks, snowfields, and glaciers. Wherever soil has accumulated, however, there are grasses, herbs, and low shrubs. The timberline varies greatly in elevation, depending on slope exposure and other factors. Near

Prince William Sound, for example, the timberline is usually between 1,000 and 2,000 feet but can drop as low as 500 feet.

Mediterranean Division

The Mediterranean Division covers most of the state of California, with exception of the Mojave Desert and high Sierra Nevada mountains (Figure 3-11). The combination of wet winters and dry summers is unique among climate types. This region's montane vegetation consists of species with thick, hard evergreen leaves. The most important evergreen trees of the sclerophyll forest are California live oak, canyon live oak, interior live oak, tanoak, California laurel, Pacific madrone, golden chinkapin, and Pacific bayberry. The interior valleys have sagebrush and grassland communities. A riparian forest with many broadleaf species grows along streams. The coastal areas are wetter during the summer months and include coast redwoods, Douglas-fir, and other conifers. In the higher-altitude regions, the most important trees are ponderosa pine, Jeffrey pine, Douglas-fir, sugar pine, white fir, red fir, and incense cedar; but several other conifers are also present. The giant sequoia is one of the most spectacular species, but it grows only in a few groves on the western slope. Dense chaparral communities of manzanita, buckbrush, and buckthorn may appear after fire, sometimes persisting for years.

Tropical/Subtropical Steppe Division

The Tropical/Subtropical Steppe Division occurs primarily in the eastern half of Arizona and covers most of New Mexico (Figure 3-11). Steppes typically are grasslands of short grasses and other herbs and are present with locally developed shrub and woodland. On the Colorado Plateau, for example, there is pinyon-juniper woodland. To the east, in Texas, the grasslands grade into savanna woodland or semideserts composed of xerophytic shrubs and trees, and the climate becomes semiarid-subtropical. Cactus plants are present in some places. These areas are able to support limited livestock grazing but are not generally moist enough for crop cultivation without irrigation.

The foothill zone, which reaches as high as 7,000 feet, is characterized by mixed grasses, chaparral brush, oak-juniper woodland, and pinyon-juniper woodland. At about 7,000 feet, open forests of ponderosa pine are found, although pinyon and juniper occupy south-facing slopes. In Arizona, the pine forests of this zone are strongly infused with Mexican species, including Chihuahuan and Apache pine. Pine forest is replaced at about 8,000 feet on north-facing slopes by Douglas-fir. Aspen is common, and limber pine grows in places that are rockier and drier. The Douglas-fir zone merges into a zone of Engelmann spruce and corkbark fir at about 9,000 feet. Limber pines and bristlecone pines grow in rockier places. An alpine belt covers relatively small areas above 11,000 feet.

Tropical/Subtropical Desert Division

The Tropical/Subtropical Desert Division occurs primarily in western Arizona and southeast California and includes the Mojave Desert (Figure 3-11). The region is characterized by dry-desert vegetation, a class of xerophytic plants that are widely dispersed and provide negligible ground cover. In dry periods, visible vegetation is limited to small hard-leaved or spiny shrubs, cacti, or hard grasses. Many species of small annuals may be present, but they appear only after rare but heavy rains have saturated the soil.

In the Mojave-Sonoran Deserts (American Desert), plants are often so large that some places have a near-woodland appearance. Well known are the treelike saguaro cactus, the prickly pear cactus, the ocotillo, creosote bush, and smoke tree. But much of the desert of the southwestern US is in fact scrub, thorn scrub, savanna, or steppe grassland. Parts of this region have no visible plants; they are made up of shifting sand dunes or almost sterile salt flats.

A dominant pedogenic process is salinization, which produces areas of salt crust where only salt-loving (halophytic) plants can survive. Calcification is conspicuous on well-drained uplands, where encrustations and deposits of calcium carbonate (caliche) are common.

Temperate Steppe Division

The Temperate Steppe Division covers the high plains of Colorado, Wyoming, and Nevada (Figure 3-11). The vegetation is steppe, sometimes called shortgrass prairie, and semidesert. Typical steppe vegetation consists of numerous species of short grasses that usually grow in sparsely distributed bunches. Scattered shrubs and low trees sometimes grow in the steppe; all gradations of cover are present, from semidesert to woodland. Because ground cover is generally sparse, much soil is exposed. Many species of grasses and other herbs occur. Buffalo grass is typical of the American steppe; other typical plants are the sunflower and locoweed.

The semidesert cover is a xerophytic shrub vegetation accompanied by a poorly developed herbaceous layer. Trees are generally absent. An example of semidesert cover is the sagebrush vegetation of the middle and southern Rocky Mountain region and the Colorado Plateau.

A striking feature of the region is its pronounced vegetation zonation, controlled by a combination of altitude, latitude, direction of prevailing winds, and slope exposure. Generally, the various zones are at higher altitudes in the southern part of the province than in the northern, and they extend downward on east-facing and north-facing slopes and in narrow ravines and valleys subject to cold air drainage. The uppermost (alpine) zone is characterized by alpine tundra and the absence of trees. Directly below it is the subalpine zone, dominated in most places by Engelmann spruce and subalpine fir. Below this area lies the montane zone, characterized by ponderosa pine and Douglas-fir, which frequently alternate. Ponderosa pine dominates on lower, drier, more exposed slopes, and Douglas-fir is predominant in higher, moister, more-sheltered areas.

Temperate Desert Division

The Temperate Desert Division covers the largest portion of the project area and includes the western half of Colorado, Wyoming, and Montana, as well as most of Utah, Nevada, and portions of eastern Oregon and Washington (Figure 3-11). Sagebrush dominates at lower elevations. Other important plants in the sagebrush belt are shadscale, fourwing saltbush, rubber rabbitbrush, spiny hopsage, and horsebrush. All tolerate alkali to varying degrees, essential to their survival on the poorly drained soils widespread in the region. Where salt concentrations are very high, even these shrubs are unable to grow; they are replaced by plant communities dominated by greasewood or saltgrass.

The woodland belt above the sagebrush zone is similar to the corresponding belt on the Colorado Plateau, with juniper and pinyon occupying lower mountain slopes. The belt is frequently interrupted as mountains give way to plains.

In the montane zone above the woodland belt, ponderosa pine generally occupies the lower and more exposed slopes and Douglas-fir the higher and more sheltered ones. Typical species of the subalpine belt are alpine fir and Engelmann spruce. Great Basin bristlecone pine, with some individuals more than 1,000 years old, occupies widely scattered peaks. Only a few mountains in this province rise high enough to support an alpine meadow belt.

Noxious Weeds and Invasive Vegetation

Noxious weeds are invasive plants that are designated and regulated by state and federal laws, such as the Federal Noxious Weed Act, because they are detrimental to agriculture, commerce, and/or public health, and are recognized as a major threat to ecosystems. Noxious weeds are generally nonnative invasive plants that have been either accidentally or intentionally introduced.

Invasive plants and noxious weeds have biological traits that enable them to colonize new areas and successfully compete with native species. They can transform the structure and function of ecosystems through direct competition; changes in nutrient cycling, succession, and disturbance regimes; and shifts in evolutionary selection pressures (Mack and D'Antonio 1998). The spread of invasive plants threatens the structure and function of many ecosystems worldwide. Certain invasive plant species have the ability to spread over large areas or acutely threaten an ecosystem over its continental range (FS 2003a, Hobbs and Humphries 1995). There are estimated to be over 2,000 species of nonnative plants in the US, over half of which are considered invasive species (US Congress Office of Technology and Assessment 1993).

Invasive plants are introduced through a variety of pathways. Some nonnative species were intentionally introduced for beneficial reasons such as erosion control or as ornamental for gardens and later became invasive. Common methods of introduction and dispersal include contaminated seed, feed grain, hay, straw, and mulch; contaminated equipment movement across uncontaminated lands; contaminated animal fur and fleece; spreading of gravel, roadfill, and topsoil contaminated with noxious weed seed; and plants and seeds sold through nurseries as ornamentals (BLM 1996).

It is estimated that invasive plants already infest well over 40 million acres in the project area, and they continue to spread at an estimated rate of 3 million acres annually (BLM 1998). The estimated rate of weed spread on western NFS and public lands in 1996 was 2,300 acres per day (BLM 1996). A recent estimate of weed spread on all western federal lands is 10 to 15 percent annually (Asher and Dewey 2005). The states with the largest weed infestations on federal lands are Utah, Nevada, Arizona, and Oregon (Table 3-16). The most dominant invasive plants consist of grasses in the *Bromus* genus, which represent nearly 70 percent of the total infested area. The FS and BLM have recently adopted new strategies for managing noxious weeds and invasive vegetation (BLM 2007c, FS 2003b). Weed infestations are capable of destroying wildlife habitat; reducing opportunities for hunting, fishing, camping and other recreational activities; displacing many threatened and endangered species; reducing plant and animal diversity because of weed monocultures; increasing the risks of wildfire; and costing millions of dollars in controls and direct losses to land owners.

Table 3-16
Estimated Acres of Weed Infestation on NFS and Public Lands

State	Acres of Weed Infestations	Total Acreage	Percent Infested
Alaska	992	8,659,908	<0.01
Arizona	8,288,637	11,078,970	74.8
California	1,129,000	28,263,036	4.0
Colorado	3,084,000	22,167,004	13.9
Idaho	3,419,500	29,947,638	11.4
Montana	1,281,553	12,998,695	9.8
New Mexico	48,051	51,555,682	0.04
Nevada	9,257,394	17,758,678	52.1
Oregon and Washington	6,407,113	27,702,159	23.1
Utah	10,286,629	13,506,474	76.1
Wyoming	1,658,500	16,299,068	10.2

Source: Peterson 2006; BLM 1996, 2007c

3.9.2 Important Vegetation Communities

Riparian Areas and Wetlands

Riparian areas are the zones along water bodies that serve as interfaces between terrestrial and aquatic ecosystems. Riparian areas are most commonly associated with river and stream corridors, though riparian vegetation can also be found in marshes, wetlands, and along lakesides. The USDA, Natural Resources Conservation Service defines riparian areas in its General Manual (190-General Manual, Part 411) as "ecosystems that occur along watercourses and water bodies. They are distinctly different from the surrounding lands because of unique soil and vegetation characteristics that are strongly influenced by free or unbound water in the soil. Riparian ecosystems occupy the transitional area between the terrestrial and aquatic ecosystems. Typical examples would include floodplains, stream banks, and lakeshores." The USDA, Natural Resources Conservation Service's indicators of riparian areas include:

- Vegetation – The kinds and amounts of vegetation will reflect the influence of free or unbound water from an associated watercourse or water body and contrast with terrestrial vegetation.
- Soils – Soils in natural riparian areas consist of stratified sediments of varying textures that are subject to intermittent flooding or fluctuating water tables that may reach the surface. The duration of the soil-wetness feature is dependent upon the seasonal meteorological characteristics of the adjacent water body.
- Hydrology – Riparian areas are directly influenced by water from a watercourse or water body. Riparian areas occur along natural watercourses, such as perennial or intermittent streams and rivers, or adjacent to natural lakes. They may also occur along constructed watercourses or water bodies such as ditches, canals, ponds, and reservoirs.

Topography, relief, climate, flooding, and soil deposition most strongly influence the extent of water regimes and associated riparian zones. Likewise, a riparian area exerts considerable control on the flows in the landscape, especially on the movement of water, nutrients, sediments, and animal and plant species. Thus, the appearance and boundary of a riparian area vary from site to site. Riparian areas occur as complete ecosystems or as transition zones between aquatic and terrestrial ecosystems. They are more structurally diverse and more productive in plant and animal biomass than adjacent upland areas.

Riparian areas are critical ecosystem components because they provide wildlife cover, transportation corridors, and foraging and nesting habitat, as well as high plant and wildlife species diversity and density. Riparian areas are important in mitigating or controlling nonpoint source pollution. Riparian vegetation can be effective in removing excess nutrients and sediment from surface runoff and shallow ground water. They also can shade streams to optimize light and temperature conditions for aquatic plants and animals. Riparian vegetation, especially trees, is also effective in stabilizing stream banks and slowing flood flows, resulting in reduced downstream flood peaks (Montgomery 1996). Riparian areas are often important for their recreation and scenic values, such as hunting, fishing, boating, swimming, hiking, camping, picnicking, and bird watching.

Some riparian areas meet the criteria established for wetlands (Cowardin et al. 1979). Others do not because they do not possess the necessary hydrologic water regime, a predominance of hydric soils, or a prevalence of hydrophytic vegetation. Even non wetland riparian areas share many characteristics and functions with wetlands. Table 3-17 provides an estimate of the waterways that would be bordered by wetlands in each project area state.

Riparian ecosystems generally compose a small proportion of the landscape. No known comprehensive national inventory has been completed on the status, conditions, or trends of riparian areas. Local inventories have been conducted to provide information for specific needs. The FS and BLM routinely gather riparian information for activities on NFS and public lands, respectively (Montgomery 1996).

Table 3-17
Estimated Waters with Adjacent Riparian Habitat in the Project Area

State	Estimated River, Stream, and Creek (miles)	Estimated Lake, Pond, and Reservoir (acres)
Alaska	365,990	12,787,200
Arizona	90,375	335,590
California	211,513	2,086,230
Colorado	107,403	164,029
Idaho	115,595	Not available
Montana	176,750	844,802
Nevada	15,549	553,239
New Mexico	110,741	997,467
Oregon	114,823	618,934
Utah	85,916	481,638
Washington	69,204	Not available
Wyoming	108,767	325,048

Source: US EPA 2007a, Washington State Department of Environmental Quality 2002

Wetlands are generally defined as areas inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support vegetation that is typically adapted for life in saturated soil. Wetlands include bogs, marshes, shallows, muskegs, wet meadows, estuaries, and riparian areas. According to the US Army Corps of Engineers' Wetland Delineation Manual (Cowardin et al. 1979), an area must exhibit evidence of at least one positive wetland indicator from each of the following parameters to be defined as a wetland (Environmental Laboratory 1987):

- Hydrophytic Vegetation – The land supports predominately hydrophytes. Hydrophytes are macrophytic plants with the ability to grow in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content and depleted soil oxygen levels;
- Hydric Soils – A hydric soil is a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation; and
- Hydrology – Encompasses all hydrologic characteristics of areas that are periodically inundated or have soils saturated to the surface at some time during the growing season. Such characteristics are usually present in areas that are inundated or have soils that are saturated to the surface for sufficient duration to develop hydric soils and support vegetation typically adapted for life in periodically anaerobic soil conditions.

Wetlands are often associated with perennial water sources, such as springs, perennial segments of streams, lakes, or ponds. Wetlands are considered a valuable ecological resource because of their important roles in providing fish and wildlife habitat, maintaining water quality, and flood control. Total wetland area present within any one of the project area states, on the basis of estimates from 1980, ranges from about 385,700 acres in Idaho to 175,000,000 acres in Alaska. (Table 3-18). As throughout the US, wetlands in the western states have experienced a major decline in abundance because of human disturbance; however, data show a recent net gain in wetland acreage (BLM 2006a).

Table 3-18
1980s Estimates of Project Area Wetlands

State	Wetland Area (acres)	Percent of Surface Area
Alaska	175,000,000	43.0
Arizona	600,000	0.8

Table 3-18
1980s Estimates of Project Area Wetlands

State	Wetland Area (acres)	Percent of Surface Area
California	454,000	0.4
Colorado	1,000,000	1.5
Idaho	385,700	0.7
Montana	840,300	0.9
Nevada	236,350	0.3
New Mexico	481,900	0.6
Oregon	1,393,900	2.2
Utah	558,000	1.0
Washington	938,000	2.1
Wyoming	1,250,000	2.0

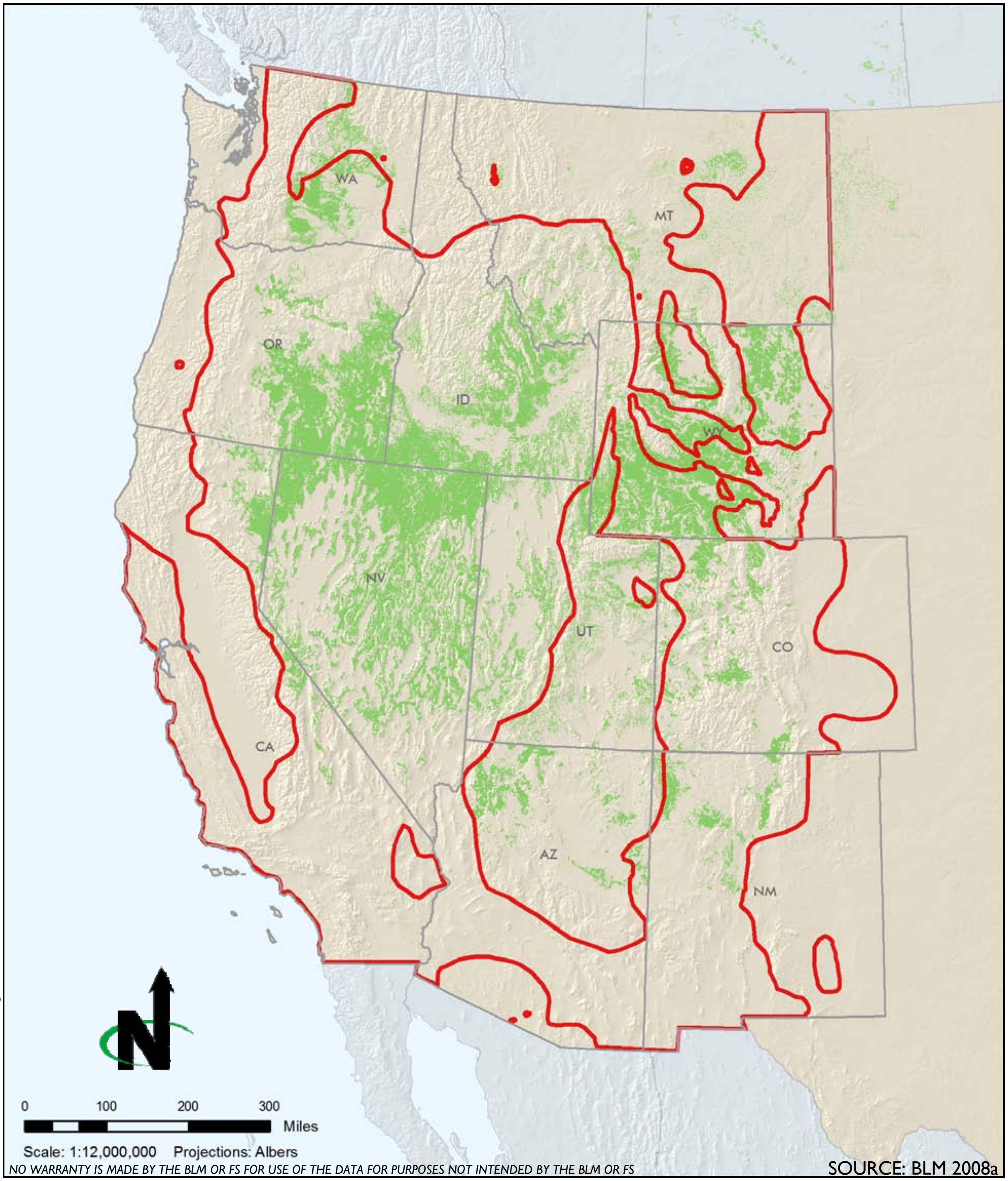
Source: US EPA 2007a, Dahl 1990

Sagebrush

Sagebrush habitats are declining rapidly across western North America. Over 350 associated plant and animal species are at risk of local or regional extirpation resulting from declining sagebrush habitat, including the sage-grouse. Broad concern over the future health of the remaining sagebrush lands has prompted the formation of cooperative partnerships among the BLM, FS, USFWS, and western state (except Alaska) wildlife agencies. (Alaska does not have sagebrush ecosystems.) Together, these partners plan and coordinate actions to conserve and manage sagebrush habitat for the benefit of sagebrush-dependent species, such as the sage-grouse.

Sagebrush ecosystems dominate approximately 118 million acres throughout western North America. Roughly 66 percent of the existing sagebrush habitats are publicly owned and managed by a federal agency. The BLM and FS are the primary agencies responsible for management of public and NFS lands containing sagebrush. The BLM has management authority for one-half of the sagebrush lands in the US. Within the project area states, the percent of sagebrush habitat managed by the BLM ranges from less than 5 percent to greater than 40 percent. The FS has stewardship of eight percent of the sagebrush habitats. Multiple use is the dominant management objective on almost all sagebrush habitats (Connelly et al 2004).

Sagebrush is distributed across every project area western state except Alaska (Figure 3-14). Sagebrush habitats cover approximately 93 million acres in the planning area. Nevada, Idaho, and Wyoming have the largest total area covered by sagebrush; all have over 20 percent of their area dominated by sagebrush.



Sagebrush habitat is found throughout a large portion of the project area. Sagebrush is important to the greater sage-grouse for forage and for roosting cover. The greater sage-grouse cannot survive where sagebrush does not exist.

LEGEND:

Sagebrush Habitat

Potential Geothermal Area

Sagebrush Habitat in the 11 Western States

Figure 3-14

Approximately 12 percent of Washington and 17 percent of Utah is sagebrush habitat. All other states had less than 10 percent of their total area in sagebrush cover (Table 3-19).

Table 3-19
Sagebrush Cover

State	Total Acres	Project Area Sagebrush Cover (acres)	Percent of Total	Planning Area Sagebrush Cover (acres)	Percent of Total
Alaska	368,992,475	0	0	0	0
Arizona	72,776,537	3,740,960	5.1	356,363	0.5
California	100,976,703	3,210,153	3.2	3,162,519	3.1
Colorado	66,624,396	4,690,157	7.0	4,164,066	6.3
Idaho	53,338,876	13,942,093	26.1	12,468,337	23.4
Montana	94,234,060	5,753,029	6.1	3,618,861	3.8
Nevada	70,828,300	26,879,825	38.0	26,879,825	38.0
New Mexico	77,925,123	2,616,138	3.4	2,387,153	3.1
Oregon	62,125,940	14,012,905	22.6	14,009,018	22.5
Utah	54,317,654	9,173,616	16.9	4,478,491	8.2
Washington	43,064,444	4,957,259	11.5	3,388,208	7.9
Wyoming	62,593,028	23,616,814	37.7	16,579,909	26.5

Source: Meinke 2003

The sagebrush biome has changed considerably since European settlement. The current distribution, composition, and disturbance regimes of sagebrush ecosystems have been altered by disturbance, land use, and invasion of exotic plants. The areas where sagebrush habitat is most prevalent have been highly fragmented.

The number and intensity of fires has increased across much of the sagebrush biome. Cheatgrass *(Bromustectorum)* and other exotic plant species have invaded lower elevation sagebrush habitats across much of the western part of the biome, further exacerbating the role of fire in these systems. At higher elevations, juniper and pinyon woodland invasions into sagebrush habitats also have altered disturbance regimes.

Land conversion has fragmenting sagebrush habitats. Sagebrush habitats and dependent species that once were continuous now are separated by agriculture, urbanization, and development. Highly productive regions throughout the sagebrush biome that had deeper soils and higher precipitation have been converted to agriculture. Agriculture influences 49 percent of the sagebrush habitats by fragmenting the landscape or facilitating movements of potential predators and invasive species (Connelly et al. 2004).

Urbanization and increasing human populations have resulted in an extensive network of roads, power lines, railroads, and communications towers, with a resulting expanding influence on sagebrush habitats. Roads and other corridors promote the invasion of exotic plants, provide travel routes for predators, facilitate human access into sagebrush habitats, and increase the chance of human induced fires. Less than five percent of the existing sagebrush habitats are over 1.5 miles from a mapped road (Connelly et al 2004).

The BLM has adopted a National Sage-grouse Habitat Conservation Strategy to guide future actions for conserving sage-grouse and associated sagebrush habitats and to enhance the BLM's ongoing conservation efforts. Sage-grouse inhabit approximately 30 million acres on BLM lands, and another 10 million acres are considered suitable habitat. This strategy includes a partnership with the FS. It provides a framework for future conservation efforts by setting out broad goals and specific actions. The National Sage-grouse Habitat Conservation Strategy is meant to ensure that agencies successfully incorporate sage-grouse habitat conservation measures into all of their ongoing programs and activities, including geothermal leasing, land use planning, grazing, mineral leasing, and other programs (BLM 2007d). The sage-grouse is discussed in more detail below in Section 3.10, Fish and Wildlife.

Old-Growth Forests

Public and scientific interest in US' old-growth forests began in the Pacific Northwest and focused on coastal Douglas-fir and western hemlock forests that were the main habitat of the northern spotted owl. Old-growth forests are those forests that have accumulated specific characteristics related to tree size, canopy structure, snags and woody debris, and plant associations that can only occur over time. Ecological characteristics of old-growth forests emerge through the processes of succession. Old-growth forests support assemblages of plants and animals, environmental conditions, and ecological processes that are not found in younger forests (younger than 150 to 250 years) or in small patches of large, old trees. Old-growth forests often contain rich communities of plants and animals adapted because of long periods of forest stability. These varied species typically depend on the unique environmental conditions occurring exclusively in old-growth forests. Because of this, old-growth forests serve as biodiversity reservoirs for species that cannot thrive or easily regenerate in younger forest. Old-growth forests also sequester large amounts of carbon through photosynthesis, regulate hydrologic processes, and play a critical role in soil and nutrient cycling (Strittholt et al. 2006, Kaufmann et al. 2007).

Old-growth forests are often shaped over time by the natural competitive differences among species and individual trees and by small-scale disturbances affecting one or a few trees at a time. In other forests, plant succession processes are disrupted with some regularity by major biological disturbances, such as fire, insects, wind, or drought, that extend across larger areas (Marcot et al. 1997). There are many different types of old-growth forests for the diverse array of climates, soils, and topography in the western US.

Old-growth forest in the coastal Pacific Northwest and other areas where climates are wet are typical examples of forests driven largely by natural plant succession and small-scale disturbances. Such forests usually have an overstory dominated by large, old trees with multiple layers of younger, smaller trees beneath the overstory ready to replace the large, old trees when they die (Kaufmann et al. 2007).

In drier regions, forest types have evolved more in response to disturbance by fire than in response to successional processes. Old trees become a part of such forests because of adaptations that allow them to survive all but the most severe fires. In Arizona, Colorado, New Mexico, Utah, and drier parts of California, park-like forests with open canopies and grassy understories are typical. Thus, no single definition for old growth is adequate for the broad assortment of old-growth forests in the project area (Kaufmann et al. 2007).

Since the time of European settlement, approximately 72 percent of the original old-growth conifer forest has been lost, largely through logging and other developments. Of the remaining old growth, the central and southern Cascade and Klamath-Siskiyou Mountains account for nearly half. Large areas of old growth forest are also present in the Sierra Nevada, the Rocky Mountains and the Intermountain region. More than 78 percent of old-growth and 50 percent of mature forest are located on federal lands (Strittholt et al. 2006).

Since 1994, approximately 24 million acres of FS and BLM lands have been managed under the Northwest Forest Plan (FS and BLM 1994). The plan shifted federal lands management from predominantly resource extraction toward an ecosystem management approach (Thomas et al. 2006). Recent changes in NFS and public land management plans are intended to provide protection for old-growth forests throughout NFS and public lands in the west (Warbington and Beardsley 2002).

3.9.3 Climate Change

Climate change (warmer/drier summer conditions, warmer winters) may be one of the factors in recently observed changes in forest health involving large areas of tree mortality from a variety of insect agents. Many forest communities are resilient in responding to normal variations in weather and climate to which they are adapted. However, currently occurring increases in forest insect infestations and tree mortality throughout the planning area may be partially due to global climate change acting in concert with other variables such as long-term fire suppression, particularly in areas where stands are overstocked.

Due to changes in climate, grasslands and rangeland could expand into previously forested areas. Additionally, sagebrush habitats may decline sharply throughout the region and be replaced with grasslands. Increasing CO_2 concentrations also lead to preferential fertilization and growth of specific plant species, such as invaders like cheat grass. Climate change may favor certain shrub species, both native and exotic. Increased CO_2 in the atmosphere may favor growth of most woody plants and "cool season" grasses at the expense of "warm season" grasses. These and other differences among species could lead to changes in the composition of rangeland vegetation.

3.10 Fish and Wildlife

The BLM and FS have active wildlife management programs within each of their field or district offices. Wildlife management programs are largely aimed at habitat protection and improvement. The general objectives of wildlife management are to maintain, improve, or enhance wildlife species diversity, while ensuring healthy ecosystems; and to restore disturbed or altered habitat with the objective of obtaining desired native plant communities, while providing for wildlife needs and soil stability. The FS and BLM are primarily responsible for managing habitats, while state agencies (e.g., Colorado Department of Natural Resources, Utah Department of Wildlife Resources, Wyoming Game and Fish Department) have the responsibility for managing the big game, small game, and nongame fish and wildlife species in cooperation with BLM and FS. The USFWS has oversight of migratory bird species and of all federal threatened, endangered, proposed, or candidate species. The NMFS has responsibility for managing anadromous fish species such as salmon and steelhead.

The FS identifies and selects plant and animal species whose population changes are believed to reflect the effects of management activities. These species are referred to as management indicator species, and are identified in the Land and Resource Management Plans of each national forest. They are considered to represent a broader group of species or habitats that occur within each national forest and are considered sensitive to FS management activities. Impacts to these species would be considered in project-specific assessments prepared prior to project development.

The following discussions present general descriptions of the fish and wildlife species that may occur in the project area and planning area.

3.10.1 Fish and Other Aquatic Biota

Aquatic life is present throughout the rivers, streams, lakes, ponds, pools, and desert springs in the project area. The hydrologic regions described in Section 3.7, Water Resources, are used to define the regions of aquatic life found within the project area (Figure 3.-9). Essential fish species and populations are identified for each region. Species and populations presented represent the ecology of the region. They depend on the commonly occurring habitat types found in surface waters throughout each region, and the influence the aquatic and riparian community structure. Many species may occur in more that one region because of similarities in a region's ecology or as the result of human introduction.

Pacific Northwest and Alaska

The Pacific Northwest is best represented by members of the salmonid species that have a significant ecological, cultural, and commercial importance in the region. Salmonids include salmon *(Onchynchus)*, trout, char, grayling, and whitefish. All salmonids require relatively cold freshwater habitats with high water quality and diverse habitat to complete all stages of their life cycle. Thus, the conditions of surrounding forests and rangelands greatly influence salmonid survival (Quinn 2005).

Salmonids typically rely on large rivers and stream systems with direct ocean access because of their ecology. Many salmonids are anadromous, meaning the spend part of their life in freshwater (to spawn and for early development) and part of their life foraging in the ocean. Areas in Alaska within the planning area have several major river systems running through them, including the Yukon, Sustina, and Copper Rivers, as well as hundreds of smaller streams and tributaries. The most significant system in Pacific Northwest is the Columbia River Basin. With its headwaters in British Columbia, Canada, the Columbia River extends over 1,200 miles to the Pacific Ocean.

Salmonids migrate through several habitats while traveling from the ocean to breeding areas in freshwater and use all portions of the watershed, depending on the species. Chinook salmon spawn in larger faster waters, while sockeye and steelhead use headwater streams. Upon emerging from the gravel, individuals either start their migration to the sea within their first year (ocean type) or mature within rivers for two to three years before migrating to sea (stream type). In contrast, resident trout populations, such as rainbow, bull, and cutthroat, may spend their life (five to six years) in various freshwater systems, including small streams or lakes, and do not migrate to the sea (Quinn 2005).

Salmon, steelhead trout, and other native fish species support an active recreational and commercial fishery throughout the Pacific Northwest. However, sport fishing has been promoted in the Pacific Northwest, and to a lesser extent in Alaska, by introduction of various nonnative fish species. Introduced salmonids (such as brook, brown, lake, and hatchery-raised rainbow trout), centrarchids (such as bass and sunfish), and percids (such as walleye) now support much, if not most, of the nonnative sport fishing opportunities within these regions (Richter et al 1997).

A variety of aquatic invertebrates occur in northwest and Alaskan streams. These species can be quite susceptible to in-stream activity (e.g., removal of large woody debris) or disturbances in riparian zones. The diversity of aquatic insects is naturally low in glacier-fed streams. Streams flowing through conifer forest, however, support a diverse aquatic invertebrate fauna, including many mayflies, stoneflies, and caddisflies (Whittier et al. 1988). The diversity of freshwater mollusks is also usually highest in montane, spring-fed streams and pools (Forest Ecosystem Management Assessment Team 1993).

Essential Fish Habitat

Essential Fish Habitat (EFH) is defined in the Magnuson-Stevens Fishery Conservation and Management Act as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. The regulations (50 CFR 600.815[a][1][i]) specify the following requirements for EFH description:

- Fishery management plans must describe and identify EFH in text that clearly states the habitats or habitat types determined to be EFH for each life stage of the managed fish species;
- Fishery management plans should explain the physical, biological, and chemical characteristics of EFH and, if known, how these characteristics influence the use of EFH by the species/life stage;
- Fishery management plans must identify the specific geographic location or extent of habitats described as EFH; and
- Fishery management plans must include maps of the geographic locations of EFH or the geographic boundaries within which EFH for each species and life stage is found.

The mandate for federal agencies to evaluate potential effects on EFH applies to all species managed under a federal fishery management plan. Two fishery management plans for commercial and recreational salmon fisheries exist in the planning area (US Department of Commerce, National Oceanic and Atmospheric Administration 2007). These fishery management plans include Alaska, Washington, Oregon, California, and Idaho. The NMFS and Pacific Fisheries Management Council prepared an EIS to evaluate EFH for areas in Alaska. Appendix D of that EIS provides a description of all EFH for federally managed salmonid species in the Alaska region. Amendment 14 of the Pacific Coast Salmon Plan (Pacific Fishery Management Council 2000) contains a complete identification and description of EFH for the states of Washington, Oregon, California, and Idaho, along with an assessment of actions that could result in adverse impacts and actions to encourage conservation and enhancement of EFH.

The Pacific coast salmon fishery EFH includes those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. In estuarine and marine areas, salmon EFH extends from the near-shore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (200 nautical miles). The EFH extends from Cape Prince of Wales in Alaska, on the western tip of the Seward peninsula, south to Point Conception in central California. The EFH for anadromous salmon also includes freshwater habitats such as streams, lakes, ponds, wetlands, and most historic habitat accessible to salmon (except above certain impassable natural barriers) in Alaska, Washington, Oregon, Idaho, and California.

Salmon typically use large stream and river systems with direct ocean access. However, they also are found in smaller coastal streams. Alaska has the greatest number of salmon-bearing streams and rivers with the large majority of them occurring in the southeast and throughout the southern gulf area. The most significant river system in Pacific Northwest (Washington, Oregon, and Idaho) is the Columbia River Basin. With its headwaters in British Columbia, the Columbia River extends over 1,200 miles to the Pacific Ocean. The Snake River is part of this system. The Sacramento River system is the largest system in California supporting salmon species. The Russian, Eel, and Klamath River systems are also important for salmon in California.

Salmon productivity is dependent on both ocean and freshwater conditions. Suitable habitat in freshwater generally is dictated by flow regime, water quality, habitat structure, and biotic interactions. All salmon require suitable habitat for spawning, incubation, and rearing. Generally, adult salmon require spawning gravel (less than two inches in diameter) and overhead stream bank or vegetative cover from predation and ultraviolet radiation, while eggs and newly hatched salmon (alevins) require stable gravel and cool (less than 57 degree F) water that is well oxygenated (Quinn 2005).

Lower Colorado River, Great Basin, and the Rio Grande

These regions cover most of Nevada, Arizona, New Mexico, and western Utah, as well as areas in eastern California. Grasses and shrubs cover large expanses and are critical for reducing runoff and erosion. Precipitation in these arid regions is extremely seasonal and arrives in intense pulses. Thus, the natural hydrology of the rivers and streams is highly variable and episodic. Native fish populations thrive on these pulsed intermittent flows and the natural flow regimes are considered optimum for sustaining native fish populations (Poff et al. 1997). However, many of the waterways in the southwest have been altered dramatically for water storage, flood abatement, and irrigation purposes.

Fish species distribution is limited because of a lack of habitat continuity. Streams often terminate in closed lakes, desiccate during dry periods, or go subterranean. Springs occur throughout the desert ecosystem, ranging from quiet pools or trickles to active aquifers. Many larger springs emit warm water, with temperatures above the mean annual air temperature, and range from fresh to highly mineralized, carrying large amounts of dissolved materials or extremely low dissolved oxygen levels (Naiman 1981). These pools often harbor endemic species that are found nowhere else.

Nonnative species have been introduced into many areas, and their presence can reduce numbers of native species through competition, hybridization, predation, and spread of pathogens to which they have developed resistance in their home waters, but to which native species have none (Marsh and Douglas 1997).

Many of the rivers in these regions have changed dramatically over the last hundred years. The Colorado River, which was once a warm, silted, swift river, is now a cold, clear series of artificial impoundments such as the Glen Canyon Dam that forms Lake Powell. The impoundments have altered aquatic habitats and species composition within most waterways in these regions. As a result, most native fish populations in many of the waterways have declined substantially. Overall, nonnative fish species in these hydrologic regions now outnumber native species in terms of numbers of species, population densities, and often biomass at many localities (Marsh and Douglas 1997).

The Colorado River is the primary river of the southwestern US, draining approximately 242,000 square miles from portions of Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, and California. The headwaters of the Colorado River are located in Rocky Mountain National Park in Colorado, from which the river flows southwest toward the Gulf of California. The Colorado River Basin is divided into two basins, the lower and upper, with a dividing line near Lee's Ferry, Arizona. The native fish community within the Lower Colorado River hydrologic region is dominated by fishes within the minnow and sucker families. Minnow species include the threatened Colorado pikeminnow and bonytail chub. The threatened razorback sucker is also found here.

Impoundments have had the greatest impacts on these fish communities (Minckley and Deacon 1991).

Bonytail chub was historically common, migrating throughout the main stem of the Colorado River and many of its tributaries, including the Green, Gunnison, Yampa, and Gila Rivers, before the construction of large dams (Kaeding et al. 1986). Although bonytail chub continues to be found in low numbers from several human-made lakes, including Lake Mohave, the temperature and physical and chemical composition of these lakes is very different from those in which the fish evolved (Minckley and Deacon 1991).

The headwaters of the Rio Grande originate in the Rocky Mountains of southwestern Colorado, and the river meanders approximately 1,900 miles across Colorado, New Mexico, and Texas before terminating at the Gulf of Mexico. NFS and public lands within the Rio Grande region are limited to the upper and middle reaches of this drainage. Historically, riparian woodlands in the Rio Grande valley were a mosaic of various-aged stands dominated by cottonwood and willow (Cassell 1998). However, conversion of much of this land to residential and agricultural uses has modified the floodplain, thereby significantly reducing the quantity and quality of aquatic habitat (Cassell 1998). These changes, combined with in-stream modifications, have reduced fish habitat considerably throughout the region.

Prior to the construction of dams like the Cochiti Dam, the Rio Grande had characteristics similar to the Colorado River and was considered a swift, warm, muddy river (Scurlock 1998). The settling effects of dam reservoirs have resulted in slower, clearer, colder water. This modification of water quality has had a debilitating effect on native fish species, such as the Rio Grande silvery minnow that was once wide spread.

Many nonnative fish species have adapted well to the in-stream modifications to both the Lower Colorado River and Rio Grande (Marsh and Douglas 1997). Usually more aggressive than native fish and able to outcompete them for resources, these nonnative species include walleye, bass (large and smallmouth), and rainbow, brook, and brown trout (Marsh and Douglas 1997).

The Great Basin covers an arid expanse of approximately 190,000 square miles and is bordered by the Sierra Nevada Range on the west, the Rocky Mountains on the east, the Columbia Plateau on the north, and the Mojave and Sonoran Deserts on the south. The Great Basin is the area of internal drainage between the Rocky Mountains and the Sierra Nevada Range. Streams in this area never reach the ocean, but are instead confined, draining to the base of the basin, and typically resulting in terminal lakes (such as Mono Lake and the Great Salt Lake), marshes, or sinks that are warm and saline (Moyle 1998).

Many Great Basin fish are adapted to extreme conditions. Trout are predominantly found in lakes and streams at higher elevations (Behnke 1992). Bonneville cutthroat trout have persisted in the isolated, cool mountain streams of the eastern Great Basin, while Lahontan cutthroat trout populations occupy small, isolated habitats throughout the basin. These trout species are unusually tolerant of high and fluctuating temperatures, high pH, and increased levels of dissolved solids.

Water diversions, subsistence harvest, and stocking with nonnative fish (particularly rainbow trout) have caused the extirpation of the Bonneville cutthroat trout from most of its range. Although Lahontan cutthroat trout were once common in desert lakes (including Pyramid, Walker, Summit, and Independence Lakes) and large rivers (such as the Humboldt, Truckee, and Walker Rivers), they have declined in numbers overall, disappearing in many areas (Hudson et al. 2000). The decline of Lahontan cutthroat trout abundance is a result of habitat loss, interbreeding with introduced rainbow trout, and competition with other species of trout. These factors continue to be the primary threats to this species (Coffin and Cowan 1995).

Minnows and pupfish are the dominant fish species at lower elevations and are found in thermal artesian springs and streams (Hubbs 1982). Various native and nonnative minnows, (e.g., dace, chubs, shiners) are common throughout streams and lakes of the basin. Pupfish, however, are very site specific and live, by choice, at the extreme upper limit of their zone of thermal tolerance (Naiman 1981). The most significant problem facing these fish are the limited water supply. Desert fishes have a tenuous hold on survival under natural conditions, occurring only in the few permanent springs, rivers, and lakes, and their existence has been placed in doubt by human activities (Hubbs 1982). Pumping groundwater for agriculture has threatened several pupfish populations, including the Devil's Hole pupfish (Naiman 1981).

The Upper Colorado River Basin

Three distinct aquatic zones have been identified in the Upper Colorado Basin (Joseph et al. 1977). The upper (headwater) zone is characterized by cold and clear water, a high gradient, and a rocky or gravel substrate. Resident salmonid populations are predominant in this zone. An intermediate zone occurs as the stream flows out of the upper zone. Within the intermediate zone, water discharge rates and temperature increase, and water is turbid during spring runoff and after heavy rainfall. The substrate is generally rocky with occasional expanses of sand. The lower (large-river) zone has warm water, meandering sections, and a low gradient in flat terrain. Minnows and suckers are the dominant fish communities of the intermediate and lower zones.

The construction of reservoirs, such as Fontenelle and Flaming Gorge, has had profound effects on water flow and quality throughout the upper basin region; lower summer water temperatures have resulted, and spawning of native fish has virtually ceased (Wullschleger 2000). The humpback chub, for example, prefers deep, fast-moving, turbid waters often associated with canyon bound segments of the rivers (Douglas and Marsh). Historically, this species occurred in great numbers throughout the Colorado River system from the Green River in Wyoming to the Gulf of California in Mexico. Today, due to lower water temperature and migration routes blocked by dams, this species can only be found in limited deep, canyon-bound portions of the Colorado River (Douglas and Marsh 1996).

Native salmonids in the upper zone of the Upper Colorado River Basin, including the Gila and Apache trout, are disappearing with the introduction of rainbow, brook, and cutthroat trout for sport fishing (Behnke 1992). The habitat immediately downstream of constructed reservoirs favors these nonnative salmonids (Platania 2003). Nonnative species are highly competitive for available resources and interbreed with native species causing hybridization. Both actions adversely affect native species (USFWS 1994, Minckley and Deacon 1991). Populations of native species within lakes are also declining as a result of competition with, and predation by, introduced nonnative species, such as carp, northern pike, and red shiner (Rinne 2003).

California

California has two distinct fish habitat regions: northern and southern California. The northern region extends from the Oregon border south to Sacramento (the most southern reaches of salmon distribution in North America). This region includes rain-fed coastal streams, snow-fed streams of western Sierra Nevada and the Central and San Joaquin Valleys. Habitat characteristics are very similar to those observed in the western Pacific Northwest, with a dominance of evergreen forests throughout the area. Streams in the coastal region usually have steep drainages and are characterized by extreme seasonal flow, flooding in the winter and becoming intermittent in summer (Moyle 1976). Water flow in snow-fed streams is more constant than in coastal streams, a condition to which native fish are adapted.

Freshwater fish habitats within southern California are located predominantly within the arid southeast region of the state and include numerous rivers and lakes. Native fish communities, such as pupfish and minnows in the lower elevations and cutthroat trout in the mountainous regions, and their aquatic habitats exhibit characteristics similar to those seen in the Lower Colorado and Great Basin regions.

Missouri River Basin

The Missouri River historically carried a heavy silt load collected from tributaries in the northern part of its drainage. Its wide and diverging channel created shifting sandy islands, spits, and pools, resulting in fish species suited to its turbid and dynamic conditions. Many of the fish communities within the upper reaches of the Missouri River are considered benthic fishes and include sturgeon and minnows (Scarnecchia et al. 2002).

NFS and public lands in Montana occur predominantly in the northeastern portion of the state in the Milk River Basin subsection of the Missouri River Basin. This area has relatively high densities of depressional wetlands, often called prairie potholes, as they are dominated by shortgrass prairies. The upper reaches of the Missouri River and its major tributaries maintain the healthiest fish populations in the basin (Scarnecchia et al. 2002). However, dams built along the main stem of the Missouri River in Montana, such as the Fort Peck Dam, have altered flows and sediment transport and impede fish migration patterns. These changes have contributed to the decline of many native main stem species, including, sturgeon, and several species of chub (family Cyprinidae).

Introduced species, such as rainbow trout, have been stocked throughout Montana. Rainbow trout have adapted well to the wide range of habitats available within the basin. The species has successfully integrated into this aquatic system and has caused a severe reduction in the range of native cutthroat trout through hybridization and competition. Other introduced species that have adapted well to the modifications of the Missouri River drainage in Montana include smallmouth bass, walleye, and white crappi.

Portions of Wyoming east of the Continental Divide are drained by the Missouri River Basin, while southwest portions of the state drain into the Upper Colorado River Basin. Native and introduced salmonids such as rainbow, brook, and cutthroat trout dominate fish communities within these areas. Streams flowing through the arid desert plains of Wyoming are characterized by low gradients and meandering or braided channels with sand and gravel substrates. Riparian vegetation in this area is dominated by cottonwoods, willows, shrubs, and grasses. Central and northern Wyoming are considered high cold desert. Native and nonnative minnows and suckers dominate fish communities in these areas.

Arkansas-White-Red Region

This hydrologic region occupies the drainage of the Arkansas, Canadian, and Red River basins above the points of the highest backwater effect of the Mississippi River. It includes all of Oklahoma and parts of Colorado, New Mexico, Texas, Kansas, Missouri, and Louisiana. Only a relatively small proportion of NFS and public lands are found in this region, primarily concentrated near the headwaters of the Arkansas River in central Colorado and near the headwaters of the Canadian River in northeastern New Mexico. Surface waters generally originate from precipitation falling in the eastern Rocky Mountains. Precipitation is relatively sparse in the summer and fall months, and surface water flow is typically dependent on snowmelt in the mountainous areas. Surface water resources are used extensively for agricultural irrigation.

Fish species in the upper headwaters of these rivers are similar to those in the Upper Colorado, supporting trout and other cold-water species (Behnke 1992). At lower elevations, the species assemblage is comprised primarily of warm-water species, both introduced and native, such as and several species of chub (family Cyprinidae), perches and darters (family Percidae), largemouth bass, black crappie, catfish, and common carp (Lohr and Fausch 1997).

Amphibians and Reptiles

Public and NFS lands in the planning area support a wide variety of amphibians and reptiles. The number of amphibian species reported in these states ranges from as few as 8 species reported in Alaska to 68 species reported in California. The number of reptile species reported from these states ranges from four species (zero terrestrial) in Alaska to 112 species in Arizona (Table 3-20). The amphibians reported from these states include frogs, toads, and salamanders that occupy a variety of habitats that include forested headwater streams in mountain regions, marshes, and wetlands, and xeric habitats in the desert areas of the Southwest. The reptile species include a wide variety of turtles, snakes, and lizards. Amphibian and reptile species that are threatened or endangered are listed in Appendix H.

Table 3-20
Number of Wildlife Species in the Project Area[1]

State	Amphibian	Reptiles	Mammals[2]	Birds
Alaska	8	4[3]	83	445
Arizona	29	112	169	533
California	68	90	182	626
Colorado	18	56	131	478
Idaho	15	24	111	402
Montana	18	17	110	417
Nevada	15	54	125	472
New Mexico	25	96	156	510
Oregon	31	29	137	492
Utah	17	57	136	428
Washington	27	22	116	468
Wyoming	12	27	121	420

[1] Excludes marine species, native species that have been extirpated, and feral domestic species

[2] Includes wild horse and burros

[3] The four (4) reptile species found in Alaska are sea turtles with limited or no terrestrial presence.

Source: Adapted from DOE and DOI 2007 (Table 3.8-2) with additional data provided from Sage 1986, FS 1995a, Igl 1996

Birds

Birds are the most prolific animal family found in the project area (Table 3-20). The number of bird species ranges from 402 in Idaho to 626 in California (Igl

1996). The coastal states (Alaska, California, Oregon, and Washington) include oceanic species such as puffin, frigatebird, and albatross that would not occur in the planning area. Bird species that are threatened or endangered are listed in Appendix H.

Birds of Conservation Concern 2002 is the most recent USFWS effort to accurately identify the migratory and nonmigratory bird species (beyond those already designated as federally threatened or endangered) that represent the highest conservation priorities and draw attention to species in need of conservation action. Birds of Conservation Concern 2002 includes 276 species that are primarily derived from assessment scores from three major bird conservation plans: Partners in Flight, the US Shorebird Conservation Plan, and the North American Waterbird Conservation Plan. Bird species considered for inclusion on lists in this report include nongame birds, game birds without hunting seasons, subsistence-hunted nongame birds in Alaska, and ESA candidate, proposed endangered or threatened, and recently delisted species.

Within the project area, a number of important bird areas have been identified by the National Audubon Society. Important bird areas are locations that provide essential habitats for breeding, wintering, or migrating birds. While these sites can vary in size, they are discrete areas that stand out from the surrounding landscapes. Important bird areas must support one or more of the following:

Species of conservation concern (e.g., threatened or endangered species);

- Species with restricted ranges;
- Species that are vulnerable because their populations are concentrated into one general habitat type or ecosystem; or
- Species or groups of similar species (e.g., waterfowl or shorebirds) that are vulnerable because they congregate in high densities.

The important bird areas program has become a key component of many bird conservation efforts and efforts to identify and recognize important bird areas are ongoing throughout the project area. The current number of important bird areas ranges from 9 in Wyoming to 147 in California. Identification of important bird areas is continuing, and these numbers are expected in increase (National Audubon Society 2007).

Migratory Birds

Many of the bird species in the project area are seasonal residents within individual states and exhibit seasonal migrations. These birds include waterfowl, shorebirds, raptors, and neotropical songbirds. The USFWS has the legal mandate and the trust responsibility to maintain healthy migratory bird populations (USFWS 2004c). The regulatory framework organized to protect the migratory birds includes:

- *Migratory Bird Treaty Act.* The Migratory Bird Treaty Act implements a variety of treaties and conventions between the US, Canada, Mexico, Japan, and Russia. This treaty makes it unlawful to take, kill, or possess migratory birds, as well as their eggs or nests. Most of the bird species reported from the project area are classified as migratory under this Act.
- *Executive Order 13186: Responsibilities of Federal Agencies to Protect Migratory Birds*. Under this Executive Order, each federal agency taking an action that could have, or is likely to have, negative impacts on migratory bird populations must work with the USFWS to develop a memorandum of understanding to conserve those birds. The memorandums of understanding developed by this consultation are intended to guide future agency regulatory actions and policy decisions.

The USFWS has outlined a plan to conserve and protect migratory birds in its Migratory Bird Strategic Plan 2004-2014. The strategy includes direct collaboration with both the FS and BLM in making land use and planning decisions. The protection of migratory bird species of conservation concern is the primary goal of the plan.

The planning area falls within two of the four major North American migration flyways (Lincoln et al. 1998): the Central Flyway and the Pacific Flyway. These pathways are used in spring by birds migrating north from wintering areas to breeding areas, and in fall by birds migrating southward to wintering areas.

The Central Flyway includes the Great Plains–Rocky Mountain routes. These routes extend from the northwest Arctic coast southward between the Mississippi River and the eastern base of the Rocky Mountains and encompass all or most of the states of Wyoming, Colorado, and New Mexico, and portions of Montana, Idaho, and Utah. In western Montana, this flyway crosses the Continental Divide and passes through Utah's Great Salt Lake Valley before turning eastward. The majority of birds make using the central flyway make relatively direct north and south migrations between northern breeding grounds and southern wintering areas (Birdnature.com 2007, Lincoln et al. 1998).

The Pacific Flyway includes the Pacific Coast Route, which occurs between the eastern base of the Rocky Mountains and the Pacific coast of the US. This flyway encompasses Alaska, California, Nevada, Oregon, and Washington, and portions of Montana, Idaho, Utah, Wyoming, and Arizona. Birds migrating from the Alaskan Peninsula follow the coastline to near the mouth of the Columbia River, then travel inland to the Willamette River Valley before continuing southward through interior California (Lincoln et al. 1998). Birds migrating south from Canada pass through portions of Montana and Idaho and then migrate either eastward to enter the Central Flyway, or turn southwest along the Snake and Columbia River Valleys and then continue south across central Oregon and the interior valleys of California (Birdnature.com 2007). This route is not as heavily used as some of the other migratory routes in North America (Lincoln et al. 1998).

Waterfowl, Wading Birds, and Shorebirds

Waterfowl (ducks, geese, and swans), wading birds (herons and cranes), and shorebirds (plovers, sandpipers, and similar birds) are among the more abundant bird groups in the project area. Many of these species exhibit extensive migrations from breeding areas in Alaska and Canada to wintering grounds in Mexico and southward (Lincoln et al. 1998). Most are ground-level nesters, and many sometimes forage in relatively large flocks on the ground or water. Within the region, migration routes for these birds are often associated with riparian corridors and wetland or lake stopover areas (Lincoln et al. 1998).

Waterfowl species are popular game species and are hunted throughout the project area. Ducks, geese, teal, and cranes are all commonly hunted and are managed primarily by state fish and wildlife agencies in conjunction with USFWS. Various conservation and management plans exist for waterfowl, shorebirds, and water birds.

Neotropical Migrants

Songbirds of the order *Passeriformes* represent the most diverse category of birds, with the warblers and sparrows representing the two most diverse groups of passerines. Passerines exhibit a wide range of seasonal movements, with some species remaining as year-round residents and others undergoing migrations of hundreds of miles or more (Lincoln et al. 1998). As the largest and most diverse category of birds, breeding, nesting, and feeding habits vary greatly (Lincoln et al. 1998).

Birds of Prey

The birds of prey include the raptors (hawks, falcons, eagles, kites, and osprey), owls, and vultures. The largest of these birds are the premier avian predators in their respective ecosystems. Raptors and owls species vary considerably with regard to their seasonal migrations. Some species are virtually nonmigratory, and others migrate only in the northern portion of their range while remaining nonmigratory their southern range. Finally, other species migrate throughout their ranges.

The bald eagle and golden eagle are protected under the Bald and Golden Eagle Protection Act (16 USC 668– 668d, 54 Stat. 250, as amended), which prohibits the taking or possession of, or commerce in, bald and golden eagles, with limited exceptions for permitted scientific research and Native American religious purposes. The 1978 amendment authorizes the Secretary of the Interior to permit the taking of golden eagle nests that interfere with resource development or recovery operations. The BLM and FS field or district offices also have specific management guidelines for raptors, including golden eagles.

Raptors forage on a variety of prey, including small mammals, reptiles, other birds, fish, invertebrates, and, at times, carrion. Hunting and foraging varies significantly among species, with some being very active hunters, pursuing prey on the wing, and others foraging from a perch, All forage during the day. Owls forage in a similar manner, although most hunting occurs at night, though some owl species may be active during the day (Sovern et al 1994).

The vultures are represented by three species: the turkey vulture, which occurs in each of the western states; the black vulture, which is reported from Arizona, California, and New Mexico; and the endangered California condor, reported from Arizona and California. These birds are large soaring scavengers that feed on carrion.

Upland Game Birds

Upland game birds that are native to the project area include several native species of grouse, including the greater sage-grouse and Gunnison sage-grouse, and mourning doves. Ring-necked pheasant, chukar, gray partridge, and wild turkey are all nonnative species that have been introduced but are managed as game species. All of the upland game bird species within the project area are year-round residents. Ring-necked pheasants and greater sage-grouse have experienced long-term declines due to the degradation and loss of important sagebrush-steppe and grassland habitats (BLM 2005b).

Most concerns about upland game birds in the project area have focused on the greater sage-grouse. Greater sage-grouse require contiguous, undisturbed areas of high-quality habitat during their four distinct seasonal periods of breeding, summer-late brooding and rearing, fall, and winter (Connelly et al. 2004). Figure 3.10-1 shows the current and historical distribution of sage grouse in the project area.

Sagebrush is important to the greater sage-grouse for forage and for roosting cover, and the greater sage-grouse cannot survive where sagebrush does not exist (Connelly et al 2004). Sagebrush is found throughout and almost exclusively in the temperate desert ecoregion division, although the eastern portions of the sagebrush biome do extend into the temperate steppe ecoregion division. The distance between leks (strutting grounds) and nesting sites can exceed 12 miles (Connelly et al. 2000, Bird and Schenk 2005). The annual movements of migratory populations can exceed 60 miles, and migratory populations can have home ranges that exceed 580 square miles (Bird and Schenk 2005). However, the greater sage-grouse has a high fidelity to a seasonal range. They also return to the same nesting areas annually (Connelly et al. 2000, 2004). Leks are generally areas supported by low, sparse vegetation or open areas surrounded by sagebrush that provide escape, feeding, and cover. They can range in size from small areas of 0.1 to 10 acres to areas of 100 acres or more (Connelly et al. 2000). Nesting generally occurs 1 to 4 miles from lek sites, although it may range up to 12 miles (Connelly et al 2004). Suitable winter habitat requires sagebrush 10 to 14 inches above snow level with a canopy cover ranging from 10 to 30 percent. Wintering areas are potentially the most limiting seasonal habitat for greater sage-grouse (Connelly et al 2004).

While no single or combination of factors have been proven to have caused the decline in greater sage-grouse numbers over the past half-century, the decline in greater sage-grouse populations is thought to be due to a number of factors including drought, oil and gas wells and their associated infrastructure, power lines, predators, and a decline in the quality and quantity of sagebrush habitat (due to livestock grazing, range management treatments, and development activities) (Connelly et al. 2004, Crawford et al. 2004). West Nile virus is also a significant stressor of greater sage-grouse (Naugle et al. 2004). The BLM manages more habitats for greater sage-grouse than any other entity. It has developed a National Sage-Grouse Habitat Conservation Strategy to manage public lands in chorus with the FS and other agencies in a manner that will maintain, enhance, and restore greater sage-grouse habitat while providing for multiple use (Connelly et al 2004). The strategy is consistent with the individual state sage-grouse conservation planning efforts. The purpose of this strategy is to set goals and objectives, assemble guidance and resource materials, and provide more uniform management directions to the multiple federal and state sage grouse conservation effort being led by state wildlife agencies (BLM 2004b). More on sage grouse and sagebrush compatibility with geothermal development can be found in text box 4.10-1.

Big Game

The following presents a generalized overview of the big games species. Table 3-21 presents the conservation status (i.e., whether a species is thriving or is rare or declining) for the big games species within the project area.

Elk (Cervus canadensis). Elk are generally migratory between their summer and winter ranges, although some herds do not migrate (i.e., occur within the same area year-round) (BLM 2004a). Their summer range occurs at higher elevations. Aspen and conifer woodlands provide security and thermal cover, while upland meadows, sagebrush/mixed grass, and mountain shrub habitats are used for forage. Their winter range occurs at mid to lower elevations where they forage in sagebrush/mixed grass, big sagebrush and rabbitbrush, and mountain shrub habitats (BLM 2004b). They are highly mobile within both summer and winter ranges in order to find the best forage conditions. In winter, they congregate into large herds of 50 to more than 200 individuals (BLM 2004a). The crucial winter range is considered to be the part of the local elk

Table 3-21
State Conservation Status Ranks for the Big Game Species in the Project Area

Species	State Conservation Status Rank											
	AK	AZ	CA	CO	ID	MT	NM	NV	OR	UT	WA	WY
Elk (*Cervus canadensis*)	-	NR	AS	S	S	S	V	S	S	AS	S	S
Mule deer (*Odocoileus hemionus*)	NR	S	S	S	S	S	S	S	AS	S	S	S
White-tailed deer (*Odocoileus virginianus*)	-	S	-	S	S	S	AS	-	NR	CI	S	S
Proghorn antelope (*Antilocapra americana*)	-	S	AS	AS	S	S	S	S	AS	AS	PE	S
Bighorn sheep (*Ovis canadensis*)	-	AS	V	AS	V	AS	CI	V	I	V	V	V
Moose (*Alces americanus*)	NR	-	-	E	S	S	-	-	-	V	I	S
American bison *(Bos bison)*	-	E	U	PE	CI	I	NR	PE	PE	I	PE	CI
Caribou (*Rangifer tarandus*)	NR	-	-	-	NR	NR	-	-	-	-	CI	-
Black bear (*Ursus americanus*)	NR	S	S	S	S	S	AS	AS	AS	V	S	S
Grizzly bear (*Ursus arctos*)	NR	PE	PE	PE	CI	I	PE	PE	PE	PE	CI	CI
Cougar (*Puma concolor*)	-	AS	S	AS	S	AS	V	S	AS	AS	AS	AS

– = the state is not within the species' range
U (unranked) – conservation status not yet assessed
AS (apparently secure) – uncommon but not rare, some cause for long-term concern due to declines or other factors
S (secure) – common, widespread, and abundant
V (vulnerable) – vulnerable due to a restricted range, relatively few populations (often 80 or fewer), recent or widespread declines, or other
CI (critically imperiled) – critically imperiled because of extreme rarity (often 5 or fewer occurrences) or because some factors such as very steep declines make it especially vulnerable to extirpation
PE (presumed extirpated) – assumed that a wild population no longer occurs

I (imperiled) – imperiled because of rarity due to a very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it vulnerable to extirpation
E (exotic) – nonnative, present due to direct or indirect human interaction
NR (not ranked)- Nation or state/province conservation status not yet assessed.
Source: NatureServe 2007

range where about 90 percent of the local population is located during an average of five winters out of ten from the first heavy snowfall to spring green-up (BLM 2005b). Elk calving generally occurs in aspen-sagebrush parkland vegetation and habitat zones during late spring and early summer (BLM 2004a). Calving areas are mostly located where cover, forage, and water are in close proximity (BLM 2005b). They may migrate up to 60 miles annually (NatureServe 2007). Elk are susceptible to chronic wasting disease (BLM 2004a).

Mule Deer (Odocoileus hemionus). Mule deer occur within most ecosystems within the region, but attain their highest densities in shrub lands characterized by rough, broken terrain with abundant browse and cover (BLM 2005). Home range size can vary from 74 to 593 acres or more, depending on the availability of food, water, and cover (NatureServe 2007). Some populations of mule deer are resident (particularly those that inhabit plains), but those in mountainous areas are generally migratory between their summer and winter ranges (BLM 2004b; NatureServe 2007). In arid regions, they may migrate in response to rainfall patterns (NatureServe 2007). In mountainous regions, they may migrate more than 62 miles between high summer and lower winter ranges (NatureServe 2007). In western Wyoming, mule deer migrate 12 to 98 miles (Sawyer and Whirter 2005). Their summer range occurs at higher elevations that contain aspen and conifers and mountain browse vegetation. Fawning occurs during the spring while they are migrating to their summer range. This normally occurs in aspen-mountain browse intermixed vegetation (BLM 2004a).

Mule deer have a high fidelity to specific winter ranges where they congregate within a small area at a high density. Their winter range occurs at lower elevations within sagebrush and pinyon-juniper vegetation. Winter forage is primarily sagebrush, with true mountain mahogany, fourwing saltbush, and antelope bitterbrush also being important. Pinyon-juniper provides emergency forage during severe winters (BLM 2004a). Overall, mule deer habitat is characterized by areas of thick brush or trees (used for cover) interspersed with small openings (for forage and feeding areas); they do best in habitats that are in the early stage of succession (Utah Division of Wildlife Resources 2007). Prolonged drought and other factors can limit mule deer populations. Several years of drought can limit forage production, which can substantially reduce animal condition and fawn production and survival. Severe drought conditions were responsible for declines in the population size of mule deer in the 1980s and early 1990s (BLM 2004a). In arid regions, they are seldom found more than 1.0 to 1.5 miles from water (BLM 2004a). Mule deer are also susceptible to chronic wasting disease. When present, up to three percent of a herd's population can be affected by this disease. Some deer herds in Colorado and Wyoming have experienced significant outbreaks of chronic wasting disease (BLM 2004a).

Wintering Areas

Ungulates (such as deer, elk, and caribou) become energetically challenged during the late fall and winter season, especially at higher elevations and latitudes. This is the result of lower-quality and less-accessible food resources combined with harsher environmental conditions, such as cold temperatures, high winds, minimal water, and deep or crusted snow. A reprieve comes in spring when new plant growth becomes available (Eastland et al. 1989, Patterson and Messier 2001).

Survival during the winter season is accomplished by minimizing energy expenditures and utilizing stored body fat reserves as a supplemental energy source. Behavioral adaptations are critical for winter survival. Ungulates will migrate to wintering areas where relatively high-quality and abundant winter food resources are in close proximity to protection from harsh weather and cover from predators. Ungulates also reduce their movement and minimize body heat loss and energy expenditure as much as possible. Finally, they typically congregate in larger winter groups that facilitate trail development in deep snow conditions and improve predator detection and defense (Christianson and Creel 2007).

Winter range is often found in river valleys and riparian areas. These areas possess topographic variation and vegetative productivity that provides adequate cover and good winter browse conditions. South-facing valley slopes have relatively lower snow accumulations and warmer resting sites. Valleys provide protection from high wind chills (Christianson and Creel 2007). However, myriad factors (such as temperature, precipitation, and winter severity) can change from year to year. This can have a direct effect on flora and fauna in and around wintering areas. Thus, winter ranges are subject to boundary changes from year to year, as well as relative use by wintering ungulates (Christianson and Creel 2007).

Key ungulate winter ranges play a disproportionately large role, given their localized size and distribution, in maintaining the overall productivity of regional ungulate populations. These ranges ensure that a significant proportion of the breeding population survives to the next year (Christianson and Creel 2007).

Development, recreation, and resource-extraction activity within and adjacent to key wintering areas adds stress and increases energy drain for animals. They may be forced to move about more than normal and even relocate to less favorable habitat. This becomes an increasingly significant factor as winter progresses. Industrial activity may also create temporary and permanent access that exposes animals to additional non-industrial disturbances and to greater pressure from predators (FS 2001).

Because of the importance of winter ranges, USFWS, FS, BLM, and state fish and game departments manage these areas carefully to ensure proper game management and healthy ecosystems on lands they manage. Traditional high-use and high-quality winter ranges have been identified and mapped by various agencies. Mapping is based of several decades of winter aerial population surveys, supplemented by habitat assessments using air photo interpretation and ground surveys (FS 2001, USFWS 2007a).

White-tailed Deer (Odocoileus virginianus). White-tailed deer inhabit a variety of habitats, but are often associated with woodlands and agricultural lands (Colorado Division of Wildlife 2007). Within arid areas, they are mostly associated with riparian zones and montane woodlands that have more mesic conditions. They can also occur within suburban areas.

Urban areas and very rugged mountain terrain are unsuitable habitats (NatureServe 2007). White-tailed deer occur in two social groups: adult females and young; and adult and occasionally yearling males. However, adult males are generally solitary during the breeding season except when with females (NatureServe 2007). The annual home range of sedentary populations can average as high as 1,285 acres, while some populations can undergo annual migrations of up to 31 miles. In some areas, the density of white-tailed deer may exceed 129 per square mile (NatureServe 2007).

Snow accumulation can have a major controlling effect on populations (NatureServe 2007). They mostly feed upon agricultural crops, browse, grasses, and forbs, but also consume mushrooms, acorns, fruits, and nuts (Colorado Division of Wildlife 2007, Utah Division of Wildlife Resources 2007). They often cause damage when browsing in winter on ornamental plants around homes (NatureServe 2007).

Pronghorn (Antilocapra americana). Pronghorn inhabit non-forested areas such as desert, grassland, and sagebrush habitats (BLM 2005b). Herd size can commonly exceed 100 individuals, especially during winter (BLM 2004a). They consume a variety of forbs, shrubs, and grasses, with shrubs being of most importance in winter (BLM 2004a). Some pronghorn are year-long residents and do not have seasonal ranges. Fawning occurs throughout the species range. However, some seasonal movement within their range occurs in response to factors such as extreme winter conditions and water or forage availability (BLM 2004a). Other pronghorn are migratory. Most herds range within an area 5 miles or more in diameter, although the separation between summer and winter ranges has been reported to be as much as 99 miles or more (NatureServe 2007). For example, in western Wyoming, pronghorn migrate 72 to 160 miles between seasonal ranges (Sawyer et al. 2005). Pronghorn populations have been adversely impacted in some areas by historic range degradation and habitat loss and by periodic drought conditions (BLM 2005b).

Bighorn Sheep (Ovis canadensis). Rocky Mountain bighorn sheep *(Ovis c. canadensis)* and desert bighorn sheep *(O. canadensis nelsoni)* are considered to be year-long residents within their ranges; they do not make seasonal migrations like elk and mule deer (BLM 2004a). However, they do make vertical migrations in response to an increasing abundance of vegetative growth at higher elevations in the spring and summer and when snow accumulation occurs in high-elevation summer ranges (NatureServe 2007).

Also, ewes move to reliable watercourses or water sources during the lambing season, with lambing occurring on steep talus slopes within one to two miles of water (BLM 2004a). Bighorn sheep prefer open vegetation such as low shrub, grassland, and other treeless areas with steep talus and rubble slopes (BLM 2004b). Unsuitable habitats include open water, wetlands, dense forests, and other areas without grass understory (NatureServe 2007).

The distribution of the bighorn sheep within the project area is mostly within the central north-to-south band of states. Their diet consists of shrubs, forbs, and grasses (BLM 2004a). In the early 1900s, bighorn sheep experienced significant declines due to disease, habitat degradation, and hunting (BLM 2005b). Threats to bighorn sheep include habitat changes due to fire suppression, interactions with feral and domestic animals, and human encroachment (NatureServe 2007). Bighorn sheep are very vulnerable to viral and bacterial diseases carried by livestock, particularly domestic sheep. Therefore, BLM has adopted specific guidelines regarding domestic sheep grazing in or near bighorn sheep habitat (BLM 2004a). In appropriate habitats, reintroduction efforts, coupled with water and vegetation improvements, have been conducted to restore bighorn sheep to their native habitat (BLM 2005b).

Moose (Alces americanus). Although moose range widely among habitat types, they prefer forest habitats where there is a mixture of wooded and open areas near wetlands and lakes (Utah Division of Wildlife Resources 2007). They are primarily browsers upon trees and shrubs such as willow, fir, and quaking aspen, although grasses, forbs, and aquatic vegetation are also consumed during spring, summer, and fall (BLM 2005b, Colorado Division of Wildlife, 2007). They generally occur singly or in small groups. Moose are active throughout day and night, but the peak periods of activity are near dawn and dusk (Utah Division of Wildlife Resources 2007). Some moose make short elevational or horizontal migrations between summer and winter habitats (NatureServe 2007).

Moose breed in late summer to early fall, with calving occurring in late spring (Utah Division of Wildlife Resources 2007). Moose habitat is thought to be improved by annual flooding and habitat management techniques such as prescribed burning (BLM 2005b). In addition to predation by wolves and bears, snow accumulation may have a controlling effect on moose populations. Habitat degradation due to high numbers of moose can lead to population crashes (NatureServe 2007).

American Bison (Bos bison). The American bison inhabits grasslands, semidesert shrublands, pinyon-juniper woodlands, and alpine tundra (Colorado Division of Wildlife 2007). They are grazers with grasses, sedges, and rushes comprising most of their diet (Colorado Division of Wildlife 2007). American bison are diurnal, being especially active during early morning and late afternoon. They have several grazing periods that are interspersed with periods of loafing and ruminating (NatureServe 2007). Within the project area, American bison are often found in managed herds that are often closely confined (Colorado Division of Wildlife 2007). Only a few remnant wild populations occur in US and Canadian national parks (NatureServe 2007). Pre-1900 herds migrated up to several hundred miles between summer and winter ranges, but herds that currently exist either make short migrations or do not migrate (Utah Division of Wildlife Resources 2007).

***Caribou (Rangifer tarandus*).** Caribou inhabit arctic tundra, subarctic taiga, mature coniferous forest, semi-open and open bogs, rocky ridges with jack pine, and riparian zones throughout all habitats. Migratory herds in Alaska winter in boreal forest and summer in tundra. Caribou are gregarious and in tundra form loose herds of about 1,000. Tundra caribou may travel extensively in summer in attempt to avoid bothersome insects (Eastland et al. 1989).

Caribou often incur high calf loss, mostly due to predation by wolves (Bergerud et al. 1984). The Porcupine Herd of northeastern Alaska give birth on patches of bare ground within snowfields (Eastland et al. 1989) and cows select areas north of the foothills (snow conditions permitting), thereby reducing exposure of calves to predators. In northeastern Alaska and adjacent Canada, first-year survival of calves was 51 percent; mean annual survival rate was 84 percent for adult females and 83 percent for adult males; and hunting mortality for the herd averaged 2 to 3 percent annually (NatureServe 2007).

American Black Bear (Ursus americanus). American black bear is found mostly within forested or brushy mountain environments and woody riparian corridors (Utah Division of Wildlife Resources 2007). They are omnivorous. Depending upon seasonal availability, they will feed on forbs and grasses, fruits and acorns, insects, small vertebrates, and carrion (Colorado Division of Wildlife 2007). Breeding occurs in June or July, with young born in January or February (Utah Division of Wildlife Resources 2007). American black bears are generally nocturnal, and have a period of winter dormancy (Utah Division of Wildlife Resources 2007). They are locally threatened by habitat loss and disturbance by humans (NatureServe 2007). The home range size of American black bears varies depending on area and gender and has been reported to be from about 1,250 to nearly 32,200 acres (NatureServe 2007).

Grizzly Bear (Ursus arctos). Brown bear are found mostly in arctic tundra, alpine tundra, and subalpine mountain forests. They were once found in a wide variety of habitats, including open prairie, brushlands, riparian woodlands, and semidesert scrub, but have since been extirpated these areas. Sustainable populations require huge areas of suitable habitat (Craighead 1976). Diet is highly variable and consists of fruits, nuts, large and small mammals, fish, insects, and tuberous roots. Grizzly bears are common only where food is abundant and concentrated (e.g., salmon runs, caribou calving grounds). Grizzly bears become dormant during the winter. Young are born in the den and emerge in spring (NatureServe 2007).

Cougar (Puma concolor). Cougars (also known as mountain lions) inhabit most ecosystems in the project area, but are most common in the rough, broken terrain of foothills and canyons, often in association with montane forests, shrublands, and pinyon-juniper woodlands (Colorado Division of Wildlife 2007). They mostly occur in remote and inaccessible areas (NatureServe 2007). Their annual home range can be more than 560 square miles, while densities are usually not more than 10 adults per 100 square miles (NatureServe 2007). The mountain lion is generally found where its prey species (especially mule deer) are located. In addition to deer, they prey upon most other mammals (which sometimes include domestic livestock) and some insects, birds, fishes, and berries (Colorado Division of Wildlife 2007). They are active year round. Their peak periods of activity are within two hours of sunset and sunrise, although their activity peaks after sunset when they are near humans (NatureServe 2007, Utah Division of Wildlife Resources 2007). They are hunted on a limited and closely monitored basis in some states (BLM 2004a, NatureServe 2007).

3.10.2 Climate Change

Changes in climate can influence the timing and length of seasons, which in turn can have a direct effect on plants and animals. This includes changes in ranges, abundances, phenology (timing of an event such as breeding), morphology and physiology, and community composition, biotic interactions, and behavior. Changes are being seen in all different types of taxa, from insects to mammals, in North America as well as on many other continents.

3.11 THREATENED, ENDANGERED AND SPECIAL STATUS SPECIES

In the project area, there are over 2,000 species considered threatened, endangered, or of special concern at national, regional or state level (all referred to as special status) occurring on or near public and NFS lands (Table 3-22), Plants, Invertebrates, Fish, and Wildlife Listed under the Endangered Species Act Occurring on or near Public and NFS Lands in the Project Area). Species considered special status are either federally listed as threatened or endangered under the Endangered Species Act (see below), are proposed for future listing, or considered special status by the BLM, FS, or individual states programs. The number of species considered for special status is dynamic and could change throughout the time period considered by the PEIS. The number of special status species occurring in the planning area cannot be accurately accessed because species occurrences are not always reported or known, species can be rare, location and accurate range are not always well defined, and habitats may change over time. For the purposes of this analysis, it is assumed that all special status species that occur in the project area would have the potential to occur in the planning area.

Table 3-22
Plants, Invertebrates, Fish, and Wildlife Listed under the Endangered Species Act Occurring on or near Public and NFS Lands in the Project Area

State	Plants	Invertebrates	Fish	Amphibians	Reptiles	Mammals	Birds
Endangered							
Alaska	1	-	-	-	1	4	2
Arizona	11	1	8	1	-	8	6
California	134	26	15	6	3	29	11
Colorado	6	1	4	-	-	2	4
Idaho	-	4	2	-	-	3	1
Montana	-	-	2	-	-	2	3
Nevada	2	1	17	-	-	1	1
New Mexico	7	7	6	-	-	4	4
Oregon	9	1	4	-	1	6	4
Utah	11	1	7	-	-	2	2
Washington	3	-	1	-	1	7	3
Wyoming	-	-	5	1	-	2	1
Threatened							
Alaska	-	-	-	-	-	3	2
Arizona	6	-	8	1	1	1	1
California	45	6	15	2	8	4	6
Colorado	7	1	1	-	-	3	2

Table 3-22
Plants, Invertebrates, Fish, and Wildlife Listed under the Endangered Species Act Occurring on or near Public and NFS Lands in the Project Area

State	Plants	Invertebrates	Fish	Amphibians	Reptiles	Mammals	Birds
Idaho	4	1	4	-	-	3	-
Montana	3	-	1	-	-	2	1
Nevada	7	1	5	-	1	1	-
New Mexico	6	-	7	1	1	1	1
Oregon	6	2	15	-	2	4	3
Utah	13	-	1	-	1	3	1
Washington	6	1	14	-	-	4	3
Wyoming	3	-	-	-	-	3	-
Candidate							
Alaska	1	-	-	-	-	-	1
Arizona	3	4	2	1	1	-	1
California	10	3	-	3	-	2	2
Colorado	6	-	1	-	-	-	2
Idaho	2	-	-	-	-	1	1
Montana	1	1	-	-	-	-	1
Nevada	4	1	-	3	-	-	1
New Mexico	-	4	2	-	1	-	2
Oregon	2	2	-	1	-	2	3
Utah	1	3	-	1	-	-	1
Washington	5	2	-	1	-	10	3
Wyoming	1	-	-	-	-	-	1

Source: USFWS 2008

Special status aquatic animal species are found on public lands throughout the US. A number of listed salmon populations are found in rivers in the Pacific Coast states. In arid habitats, many special status fish species are found in the rare and fragile desert wetlands and springs, as well as in major rivers such as the Colorado and the Rio Grande. In the deserts of the Great Basin and Colorado Plateau, terminal lakes, marshes, and sinks provide important habitats for special status fish species that are adapted to their warm, saline conditions. Special status mollusk species occur predominantly in the Snake River of Idaho and in thermal habitats and small springs and wetlands in New Mexico, Arizona, and Utah. Aquatic arthropods of special status occur predominantly in the vernal pools of California. Special status terrestrial arthropods are largely butterflies that occur mostly in open habitats. Special status amphibians occur in wetland habitats throughout the west, and special status reptiles occur in warm habitats of California and the southwest. Special status birds and mammals use a wide range of habitats found on public and NFS lands throughout the project area.

3.11.1 Endangered Species Act

The Endangered Species Act (ESA) was passed in 1973 to address the decline of fish, wildlife, and plant species in the US and throughout the world. The purpose of the ESA is to conserve "the ecosystems upon which endangered and threatened species depend" and to conserve and recover listed species (ESA 1973, Section 2). The law is administered by USFWS and the US Department of Commerce, National Marine Fisheries Service (NMFS). The USFWS has primary responsibility for terrestrial and freshwater organisms, while the NMFS is primarily responsible for marine species such as salmon and whales.

Under the ESA, species may be listed as either endangered or threatened. The ESA defines an endangered species as any species that is in danger of extinction throughout all or a significant portion of its range (ESA 1973, Section 3[6]). A threatened species is one that is likely to become an endangered species within the foreseeable future throughout all or a significant part of its range (ESA 1973, Section 3[20]). All species of plants and animals, except pest insects, are eligible for listing as endangered or threatened. The ESA also affords protection to critical habitat for threatened and endangered species. Critical habitat is defined as the specific areas within the geographical area occupied by the species at the time it is listed, on which are found physical or biological features essential to the conservation of the species and which may require special management considerations or protection (ESA 1973, Section 3[5][A and B]). Except when designated by the Secretary of the Interior, critical habitat does not include the entire geographical area that can be occupied by the threatened or endangered species (ESA 1973, Section 3[5][C]).

Species may also be candidates for listing (ESA 1973, Section 6[d][1] and Section 4[b][3]). The USFWS defines proposed species as any species that is proposed in the *Federal Register* to be listed under Section 4 of the ESA. Candidate species are those for which USFWS has sufficient information on their biological status and threats to propose them for listing as endangered or threatened under the ESA, but for which development of a listing regulation is precluded by other higher priority listing activities (USFWS 2004a). The NMFS defines candidate species as those proposed for listing as either threatened or endangered or whose status is of concern, but for which more information is needed before they can be proposed for listing. Candidate species receive no statutory protection under the ESA, but by definition these species may warrant future protection under the ESA.

Federally listed species that could occur in the project area are included in Appendix H.

BLM Special Status Species Policy

On public lands, the BLM is required to manage plant and wildlife species that are listed or proposed under the ESA, which has nine sections containing requirements or authorizations that apply to the BLM (ESA Sections 2, 4, 5, 6, 7, 9, 10, 11, and 18). These are addressed in BLM Manual 6840 — Special Status Species Management (BLM 2001), which establishes special status species policy for plant and animal species and the habitats on which they depend. The policy refers not only to species listed under the ESA, but also to those designated by the BLM State Director as sensitive. BLM Manual 6840 defines a sensitive species as a species that could easily become endangered or extinct in the state. Criteria in BLM Manual 6840 for designating a species as sensitive are as follows:

- The species is under ESA status review by the USFWS or NMFS;
- The numbers of individuals of the species are declining so rapidly that federal (ESA) listing may become necessary;
- The species has typically small or widely dispersed populations; or
- The species inhabits an ecological refugium or other specialized or unique habitat.

Under BLM Manual 6840, the BLM is required to use other agencies' lists (such as threatened and endangered lists, watch lists, and species of concern lists issued by various state and federal agencies) (Table 3-23, Plant, Invertebrate, and Fish and Wildlife Considered BLM Special Status in the Project Area). For example, the BLM Utah State Office currently uses the Utah Division of Wildlife Resources' sensitive animals list as the BLM list. The number of sensitive species varies across the project area BLM State Offices (Table 3-23, Plant, Invertebrate, and Fish and Wildlife Considered BLM Special Status in the Project Area). Similarly, which species may occur at a geothermal energy development project in the planning area would depend on the particular state in which the project is located, the species list for that state, and the specific location (and associated habitats) of the proposed project, and would need to be addressed in the site-specific environmental analysis.

Forest Service Threatened, Endangered & Sensitive Species Program

The Threatened, Endangered & Sensitive Species Program is the Forest Service's dedicated initiative to conserve and recover plant and animal species that need special management attention and depend on National Forest and Grassland habitats. In addition to contributing to the recovery of threatened and endangered species, the Forest Service management also conserves habitat for some 3,250 sensitive species. These are species listed by the FS as needing special management to maintain and improve their status on National Forest and Grasslands, and prevent a need for listing under the ESA.

Table 3-23
Plant, Invertebrate, and Fish and Wildlife Considered BLM Special Status in the Project Area

State	Plants	Invertebrates	Fish	Amphibians	Reptiles	Mammals	Birds
Alaska	33	-	6	-	-	2	26
Arizona	44	24	7	-	13	9	2
California	497	13	4	8	11	21	9
Colorado	79	1	4	5	6	4	11
Idaho	161	21	21	8	7	29	50
Montana	98	-	10	6	5	15	29
Nevada	116	74	46	3	7	33	34
New Mexico	179	27	23	6	15	22	32
Oregon	457	59	38	12	2	20	36
Utah	101	28	22	4	13	19	19
Washington	196	2	8	2	4	20	20
Wyoming	37	-	8	4	1	9	13

Source: Alaska Natural Heritage Program 2007; Arizona Game and Fish Department 2007; BLM 2002, 2004a, 2004b, 2006b, 2007c, 2007d, 2007e; Colorado Natural Heritage Program 2007; Keinath et al. 2003; Montana Natural Heritage Program 2006, 2007; New Mexico Department of Game and Fish, Conservation Services Division 2006; New Mexico Rare Plant Technical Council 2005; Nevada Natural Heritage Program 2007; Utah Department of Natural Resources, Division of Wildlife Resources 2006.

The FS Threatened, Endangered & Sensitive program involves a variety of activities conducted by the FS and government, educational, and private organization partners. These include inventory and monitoring, habitat assessments, habitat improvements through land treatments and structure installation, species reintroductions, development of conservation strategies, research, and information and education (FS 2007a). Table 3-24, US Forest Service Special Status Species by Project Area State, provides the numbers of FS plant and wildlife species listed under the program.

State-listed Species

Each of the project area states also has species identified that are of state concern. Some species are listed per a specific definition and afforded protection and/or management under a state regulation. Other species are on some form of watch list; these species are tracked with regard to their abundance and distribution within a state by organizations, such as the state Natural Heritage Program. The species that occur on public or NFS lands in the planning area and that may be affected by a specific geothermal energy development project would depend upon the location of that particular project, and would need to be addressed in the site-specific environmental analysis.

Table 3-24
US Forest Service Special Status Species by Project Area State

State	Plants	Invertebrates	Fish	Amphibians	Reptiles	Mammals	Birds
Alaska	19	-	3	-	-	1	5
Arizona	129	30	10	8	14	47	36
California	377	14	23	20	13	14	9
Colorado	61	5	9	4	1	9	21
Idaho	75	-	5	3	1	5	10
Montana	104	-	6	5	3	14	14
Nevada	96	3	7	2	1	5	7
New Mexico	65	41	14	8	10	54	38
Oregon[1]	428	61	12	12	7	12	25
Utah							
Washington[1]	288	43	13	10	7	13	23
Wyoming	63	-	12	5	1	13	26

[1]For USFS areas spanning more than one state, species are counted under both states when not indicated by USFS which specific state they are found.

Source: Colorado Natural Heritage Program 2007; Keinath *et al.* 2003; Martin 2007; Montana Natural Heritage Program 2006; FS 2000, 2001, 2004b, 2007a, 2007b, 2007c, 2007d, 2007e

3.11.2 Threats to Special Status Species

A variety of factors affect endangered, threatened, and special status species. Some threats are greater for certain taxa or ecosystems, while others, including habitat loss from urbanization and agricultural development, have a wide-spread potential effect. Habitat loss is a primary threat to species and reason for their decline. The loss of suitable habitat is the result of one or more factors, including both direct human impact through urbanization and land and water use and global and regional climate change (McKinney 2002). Invasive species and genetic hybridization can also adversely affect sensitive species.

Land use is also a primary influence on species decline. Urbanization, logging, mining, water diversion, agriculture, and recreation have all historically affected populations of native plants and animals. Land use can reduce and fragment habitat (Donovan and Flather 2002, NatureServe 2008, Newlon 2005). Fragmentation of forests results in reduced habitat for territorial species such as the brown bear *(Ursus arctos)*, which require large home ranges (Campbell 1999). Indirect effects of various land uses include road construction and erosion, which can increase the effect on waterways and riparian habitats and can fragment terrestrial habitats. Land use can result in the introduction of nonnative species and the need for diversion of water for irrigation, and efforts to control potential threats to crops and livestock with the use of chemicals can affect species. Endangered native bunchgrass and sagebrush communities have been diminished by the invasion of introduced species and historical clearing of land for agricultural use. Species that are obligate to these communities, such as the state-listed Gunnison sage grouse *(Centrocercus minimus)*, have consequently experienced population decreases (Johnson, Jr. 2007, NatureServe 2008, USFWS 2004b). In drier ecoregions, such as temperate and sub-tropical desert and steppe, federally endangered Devil's Hole pupfish *(Cyprinodon diabolis)* and other desert organisms endemic to isolated permanent aquatic habitats have historically been threatened by the diversion of water (NVDCNR 2007).

Climate change has a disproportionate effect on special status species. Based on analysis of temperature and precipitation data from the 20th century and models on continued climate change patterns, it is anticipated that global temperatures will continue to rise and weather patterns will become increasingly erratic. This trend is anticipated to result in ongoing increases in precipitation in historically wetter ecoregions and further reduced precipitation in historically drier ecoregions. The broad implications of these changes affect all species but are specifically detrimental to highly specialized species (Diaz 2004, Joyce et al. 2007).

As climate change continues, wetter ecoregions, such as the subarctic and marine, will experience increased levels of precipitation. The increased moisture in these habitat areas will result in greater vegetative biomass and reduced desert habitat. This has the potential to encourage distribution and heighten population levels of invasive plant species, particularly in historical desert areas where native species may be less tolerant of increased precipitation. Desertification has already contributed to the decline of sagebrush and bunchgrass habitat and associated species.

Invasive species are those that are not historically native to a habitat or region. Often they are introduced purposefully for agricultural use, hunting, pest control, or aesthetic purposes. Other times they are unintentionally introduced, traveling in the bilge water of transoceanic ships, shipping containers, or on the wheels and insides of cars. Or they may arrive through accidental release from captivity. The three major threats from nonnative species are competition, predation, and hybridization.

Plant communities may be dramatically altered by the invasion of nonnative species. Sagebrush habitat has been overcome by cheatgrass *(Bromus spp.)*, an invasive plant found in every US state (Chambers et al. 2005, Pendleton et al. 2007, USFWS 2004b). Competition for nonnative species also impacts wildlife. Accidental release of brown trout into federally threatened native bull trout habitat has created competition for food sources (Epifanio et al. 2003).

Predation by non-native species is a common threat to sensitive species of birds, aquatic invertebrates, amphibians and small mammals that have evolved defensive tactics against certain types of predation. Frequently the threat of predation by non-native species is compounded by threats from urbanization and other land use activities.

The threat of hybridization, the process of cross-breeding two closely-related species, is the dilution of the sensitive population's gene pool to the point at which the sensitive species is no longer distinct. Hybridization is not always successful in producing a viable mixed-gene population. The progeny of two distinct species can be sterile, increasing the rate of population decline in the sensitive species (USFWS 2007b).

3.11.3 Climate Change

Changes in climate can influence the timing and length of seasons, which in turn can have a direct effect on threatened and endangered species and their habitat. This may include changes in ranges, abundances, phenology (timing of an event such as reproduction), morphology and physiology, and community composition, biotic interactions, and behavior. Changes are being seen in all different types of taxa, from insects to mammals, in North America as well as on many other continents.

3.12 WILD HORSES AND BURROS

The BLM, in conjunction with the FS, manages wild horses and burros on BLM- and FS-administered lands through the Wild Free Roaming Horse and Burro Act of 1971. Animals are managed within 199 herd management areas with the goals of maintaining the natural ecological balance of public lands and the ability to support multiple herds (BLM 2007h). Herd population management is important for balancing herd numbers with forage resources and other uses of public and adjacent private lands (BLM 2004c, d). Wild horses that are found outside of herd management areas are considered excess and are subject to annual removal. Removed animals are made available for adoption. Unadoptable individuals are destroyed in the most humane manner possible (BLM 2004c). On average, a herd of 10 wild horses or burros uses about 3,600 acres, with most herd management areas occupying 10,000 to 100,000 acres or more (BLM 2007h). Annual home range (the area habitually occupied by a herd over the course of a year) is usually less than 6,178 acres but may be as large as 74,132 acres (NatureServe 2007). As wild horse numbers within a herd can increase up to 25 percent annually, they can affect the condition of their range and increase competitive pressure among wild horses, livestock, and wildlife. Therefore, wild horse and burro herd size is maintained through gathers that are performed every three to five years. A gather is a roundup of wild horses and burros, usually conducted by helicopter. Once gathered, a specialist loads the animals onto trucks for transport to a holding area at the gather site where determinations are made about which animals will be returned to the range and which will be sent to a BLM preparation facility. Gathered horses and burros sent to a BLM preparation facility are placed for adoption through the Wild Horse and Burro Adoption Program or otherwise placed in long-term holding facilities. The BLM is currently researching the use of immuno-contraceptives to slow the reproductive rate of wild horses and burros (BLM 2004d). Issues that make wild horse and burro management difficult include:

- Competition between large game animals (elk, deer, antelope) and horses;
- Herd management areas located within areas where critical soils (i.e., soils that pose salinity problems and/or are very susceptible to erosion) make up more than 50 percent of the area;
- Competition with livestock; and
- Illegal chasing, capturing, and harassment (BLM 2004d).

Wild horses generally occur in common social groups of several females that are led by a dominant male. Young males are expelled from the social group when they are one to three years old and form bachelor groups (NatureServe 2007). They feed on grass and grass-like plants and browse on shrubs in winter. They visit watering holes daily and may dig to water in dry river beds (NatureServe 2007). Wild horses also tend to dominate water sources, driving wildlife away

(BLM 2004b). They are sometimes regarded as a pest because they can foul water, compete with livestock, or displace native ungulates such as pronghorn and bighorn sheep (NatureServe 2007).

Table 3-25 summarizes the wild horse and burro statistics for the project area for fiscal year 2007. Ten of the 12 western states (there are no herds in Alaska or Washington) have a total of 28,563 wild horses and burros, although the appropriate management level (i.e., the maximum number of animals sustainable on a year-long basis) is considered only 27,492 animals (BLM 2007h).

3.12.1 Climate Change

As discussed in Section 3.6 Soils and Section 3.9 Vegetation, climate change can affect both the soils and vegetation that wild horses and burros depend upon for food and habitat. As mentioned above, changes in soil stability increase the challenges with the management of wild horses and burros, particularly when more than 50 percent of the areas on which they are located already have soil issues. Changes in vegetation can pose either advantages or challenges for wild horses and burros in meeting their nutritional requirements, depending on what changes in vegetation occur.

Table 3-25
Project Area Wild Horse and Burro Statistics (Fiscal Year 2007)

State	Herd Areas			Herd Management Areas				Populations			
	BLM Acres	Other Acres	Total Acres	No. Herd Manage-ment Areas	BLM Acres	Other Acres	Total Acres	Horses	Burros	Total	Total Appro-priate Manage-ment Level
Alaska[1]	-	-	-	-	-	-	-	-	-	-	-
Arizona	2,019,932	1,617,998	3,637,930	7	1,756,086	1,327,777	3,083,863	215	1,501	1,716	1,600
California	5,112,778	1,851,661	6,964,439	22	1,946,590	471,855	2,418,445	2,478	635	3,113	2,199
Colorado	658,119	76,572	366,098	4	366,098	38,656	404,754	771	0	771	812
Idaho	428,421	49,235	477,656	6	377,907	40,287	418,194	803	0	803	617
Montana	104,361	119,242	223,603	1	28,282	8,865	37,147	154	0	154	105
Nevada	19,593,299	3,088,027	22,681,326	102	15,778,284	1,695,925	17,474,209	12,467	528	12,995	13,485
New Mexico	88,653	37,874	126,527	2	24,505	4,107	28,612	89	0	89	83
Oregon	3,559,935	785,250	4,345,185	18	2,703,409	259,726	2,963,135	2,092	15	2,107	2,715
Utah	3,236,178	689,176	3,925,354	21	2,462,726	374,614	2,837,340	2,543	195	2,738	2,151
Washington[1]	-	-	-	-	-	-	-	-	-	-	-
Wyoming	7,297,778	3,030,010	10,327,788	16	3,638,330	1,137,121	4,775,451	4,077	0	4,077	3,725
Total	42,099,454	11,345,045	53,444,499	199	29,082,217	5,358,933	34,441,150	25,689	2,874	28,563	27,492

[1] No horse or burro herds are present in Alaska or Washington.

Source: BLM 2007H

3.13 LIVESTOCK GRAZING

The primary laws that govern grazing on public lands are the Taylor Grazing Act of 1934, the FLPMA, and Public Rangelands Improvement Act of 1978. The three enabling statutes that govern grazing on NFS lands are the Organic Administration Act, the Bankhead-Jones Farm Tenant Act, and the Multiple-Use Sustained-Yield Act.

The Taylor Grazing Act directs that occupation and use of the range be regulated to preserve the land and its resources from destruction or unnecessary injury, and to provide for the orderly use, improvement, and development of the range. FLPMA provides authority and direction for managing federal lands on the basis of multiple use and sustained yield and mandates land use planning principles and procedures for federal lands. The Public Rangelands Improvement Act does the following:

- Defines rangelands as public lands on which there is domestic livestock grazing or that are suitable for livestock grazing;
- Establishes a national policy to improve the condition of public rangelands so they will become as productive as feasible for all rangeland values;
- Requires a national inventory of public rangeland conditions and trends; and
- Authorizes funding for range improvement projects.

The BLM manages rangelands on public lands under 43 CFR Part 4100 and BLM Handbooks 4100 to 4180. The BLM conducts grazing management practices through BLM Manual H-4120-1 (BLM 1984). The FS primarily manages grazing and management on NFS lands under 36 CFR 222, Forest Service Manuals (FSM 2200 – Range Management), and Forest Service Handbooks (FSH 2200 – Range Management) (FS 2007f). Under this management, ranchers may obtain a grazing permit for an allotment of public or NFS land on which a specified number of livestock may graze. An allotment is an area of land designated and managed for livestock grazing. The number of permitted livestock on a particular allotment on public land is determined by how many animal unit months that land will support. An animal unit month is the quantity of forage required by one mature cow and her calf (or the equivalent in sheep or horses) for one month. Upper and special limits governing the total number of livestock for which a person is entitled to hold a grazing permit on NFS lands is determined by the Chief of the Forest Service based factor identified in 36 CFR 222.

Approximately 154,897,988 acres of public and 103,129,814 acres of NFS lands are grazed in the project area. Approximately 125,131,307 acres of public and 70,187,293 acres of NFS lands are grazed in the planning area. Table 3-26 lists

Table 3-26
Livestock Grazing Permits, Leases, and Active Animal Unit Months on Public Lands in the Project Area (Fiscal Year 2006)

State	Leases and Permits	Active AUMs	Receipts form Leases, Licenses and Permits
Alaska*	0	0	$0
Arizona	757	660,007	$693,917
California	548	355,726	$318,202
Colorado	1,591	650,168	$649,238
Idaho	1,890	1,348,526	$1,619,808
Montana	3,755	1,281,144	$2,027,960
Nevada	644	2,137,635	$2,277,130
New Mexico	2,275	1,856,795	$2,104,970
Oregon	1,277	1,026463	$1,332,862
Utah	1,499	1,239,786	$1,236,951
Washington	283	33,603	$49,166
Wyoming	2,792	1,960956	$2,332,290
Total	**17,311**	**12,550,809**	**$14,642,494**

* Data does not include reindeer grazing permits. There are approximately 11 case files with open permits issued by the BLM . There are approximately 7.134 animals currently grazing.
Source: BLM 2006c

Table 3-27
Authorized Livestock Permits and Active Animal Unit Months on National Forest System Lands[1] in the Project Area (Fiscal Year 2005)

State	Permits	Active AUMs
Alaska	0	0
Arizona	392	592,856
California	413	381,047
Colorado	710	774,533
Idaho	765	703,784
Montana	802	458,890
Nevada	134	226,066
New Mexico	672	522,065
Oregon	294	341,193
Utah	815	543,670
Washington	108	81,135
Wyoming	463	616,871
Total	**5,568**	**5,242,110**

[1] Forest Service System Lands include National Forests, National Grasslands, Land Utilization Projects, and other federal lands for which the FS has administrative jurisdiction.
Source: FS 2006b

grazing statistics on public lands within the project area. The total number of grazing permits/leases on public lands in the project area was 17,311, with a total of 12.6 million animal unit months authorized. These grazing authorizations produced approximately $14.7 million in grazing fees (BLM 2006c).

Within the planning area approximately 10,138,925 AUMs are available within 125,131,307 acres of public land, and approximately 3,303,980 AUMs are available within 70,187,293 acres of NFS lands.

3.13.1 Climate Change

The consequences of weather and climate change on livestock grazing and grassland use can be subtle and complex. The projected changes in climate–increases in temperature, reductions in soil moisture, and more intense rainfall events–may require changes in livestock management. The availability of feed and water for livestock grazing is extremely vulnerable to drought; hence, the carrying capacity of land may influence livestock management.

3.14 CULTURAL RESOURCES

Cultural resources are past and present expressions of human culture and history in the physical environment and include prehistoric and historic archaeological sites, structures, natural features, and biota that are considered important to a culture, subculture, or community. Cultural resources also include aspects of the physical environment that are a part of traditional lifeways and practices and are associated with community values and institutions. These traditional cultural resources are addressed in a separate chapter on ethnographic resources and tribal trust assets (Chapter 3.15). Cultural resources addressed in this section include the physical remains of prehistoric and historic cultures and activities, such as archaeological sites, historic trails, and boom towns. Historic properties are a subset of these kinds of cultural resources that meet specific eligibility criteria found at 36 CFR 60.4 for listing on the National Register of Historic Places (NRHP).

In this chapter, cultural resources are discussed according to established culture regions: Alaska (Arctic and Subarctic), California, Great Basin, Great Plains, Northwest Coast, Plateau, and Southwest. These are regions where there is continuity across the landscape in cultural adaptations, traditions, environment, and habitats. For consistency, maps defining these regions and the cultural groups within them are derived from the respective volumes of the Smithsonian Handbook of the American Indian and reflect the choices of the authors and editors of this series. These maps generally depict territorial assumptions existing at the approximate time of Native contact with Euro-Americans and may not encompass territorial ranges or ancestral lands as recognized by tribes or archaeologists. For example, important Ancestral Puebloan occupations in Southwestern Colorado are found outside of the tribal ranges for the Southwest region. This is a programmatic level overview and should not be considered a detailed source for the extent of regional cultural influence or tribal interest.

Culture resources of these regions have been organized into prehistoric and historic resources. Prehistoric resources refer to any material remains, structures, and items used or modified by people before Euro-Americans established a presence in the region. Historic resources include material remains and the landscape alterations that have occurred since the arrival of Euro-Americans.

Appendix I provides detailed discussions of the prehistoric and historic cultural resources and patterns of these regions. Within each region's discussion, a table is provided to indicate the languages spoken by ethnographically recorded tribes. Discussions of prehistory within each region are focused on chronological periods that have been established based on the region's prehistoric archaeology. It should be noted that for many of these regions, there are area-specific culture chronologies that have been developed where cultural practices were unique within the larger region. Discussion of such specific time periods is avoided given the programmatic nature of this document and for ease of discussion. Although the culture regions are most appropriately applied to prehistoric populations, historic period resources are also organized by these culture regions for the ease of discussion. Discussions of the history within each region are organized by overall themes of the region. This includes such things as westward expansion, transportation, and mineral development. Because this approach leads to a very general discussion of the culture regions, an effort was made to coordinate with the BLM and FS field, regional, and district offices within the planning area to identify areas sensitive for cultural resources. The discussions in this section are based on the larger overview provided in Appendix I.

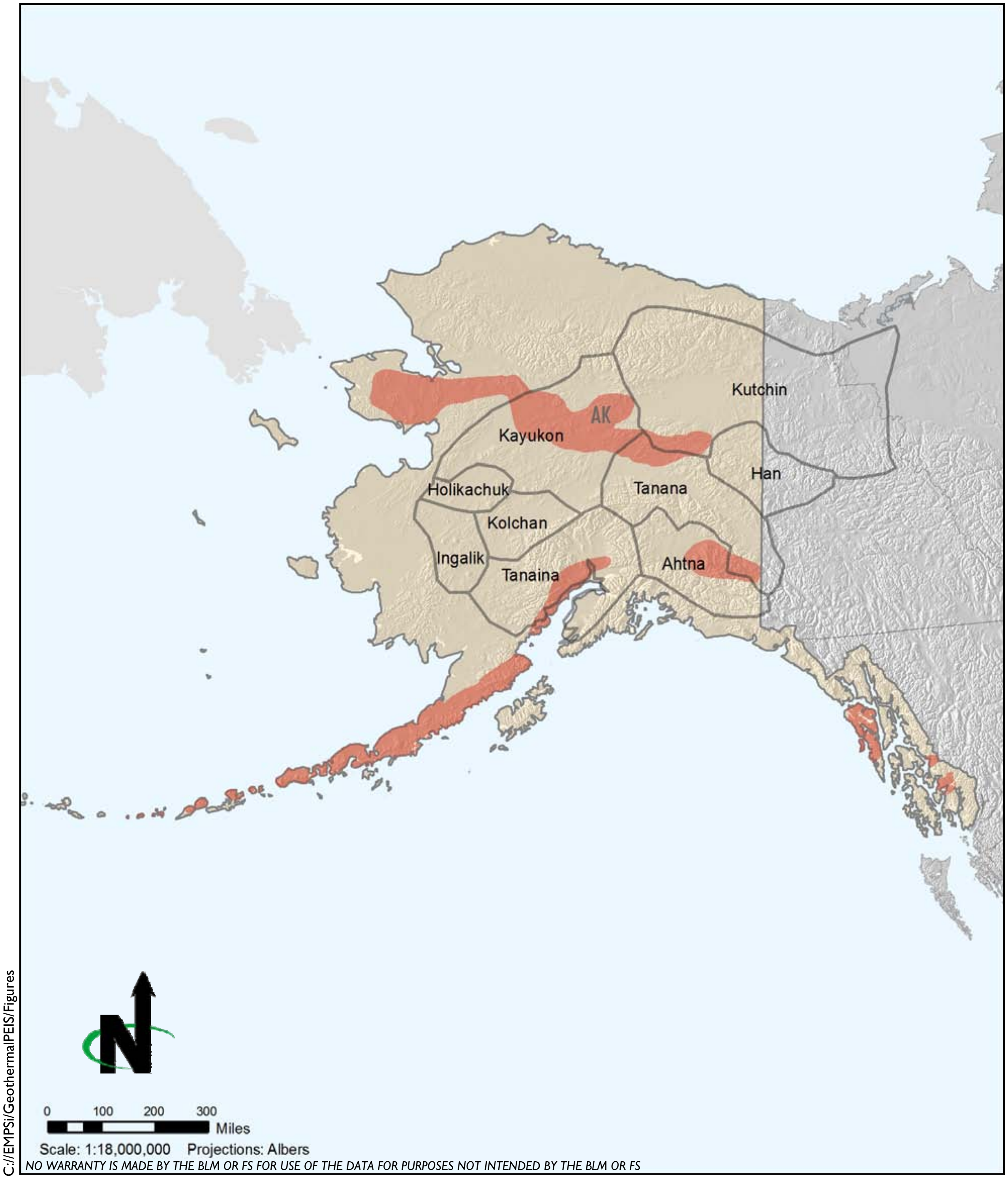
3.14.1 Alaska (Arctic and Subarctic)

Alaska is divided into two culture regions, the Arctic and Subarctic, which are combined into the Alaska culture region for purposes of this discussion (Figure 3-15 – Alaska [Arctic and Subarctic Culture Regions] Tribal Ranges). Within the project area, the Alaska culture region includes most of FS Region 10 and all or portions of the western BLM Field Offices.

Much of Alaska was ice free during the last glacial period, and the archaeology of the area is considered likely to provide important information pertaining to early North American human settlement. However, Pre-Clovis evidence for occupation of Alaska is debatable, and the early coastline has been greatly altered from rising sea levels. The earliest agreed-upon evidence is for a microblade tradition in the Paleoindian Subarctic, similar to that of the Archaic Northwest Coast (Neusius and Gross 2007).

Many of the later prehistoric cultural traditions outlined in Appendix I still occur in modern times within contemporary populations of Alaska. Based on the discussed prehistoric patterns, expected prehistoric sites of the region include isolated fluted points, lithic scatters, shell middens, burials, village sites, camp sites, and resource procurement sites. Most are expected to be situated along the coastline to facilitate marine mammal hunting, rivers to facilitate fishing, and inland in areas that produce game and plants. There are exceptions to this distribution pattern given regional variability.

Historic Alaska witnessed early Russian, Spanish, and English exploration and fur trading, bringing early contact with Native Alaskans. Other historic period activities include commercial whaling and fishing, missionization, gold mining, oil development, railroad construction, and development of other transportation-related routes. Historic-era sites expected within the region include early exploration settlements and camps; trading posts; whaling and salmon fishing facilities and communities; mineral mining, mineral development sites, and transport appurtenances such as pipelines, railroad tracks, and associated boom towns; and trails and associated towns.



Legend

Tribal Boundaries

Potential Geothermal Area

Alaska Tribal Ranges

Arctic and Subarctic Cultural Regions

Figure 3-15

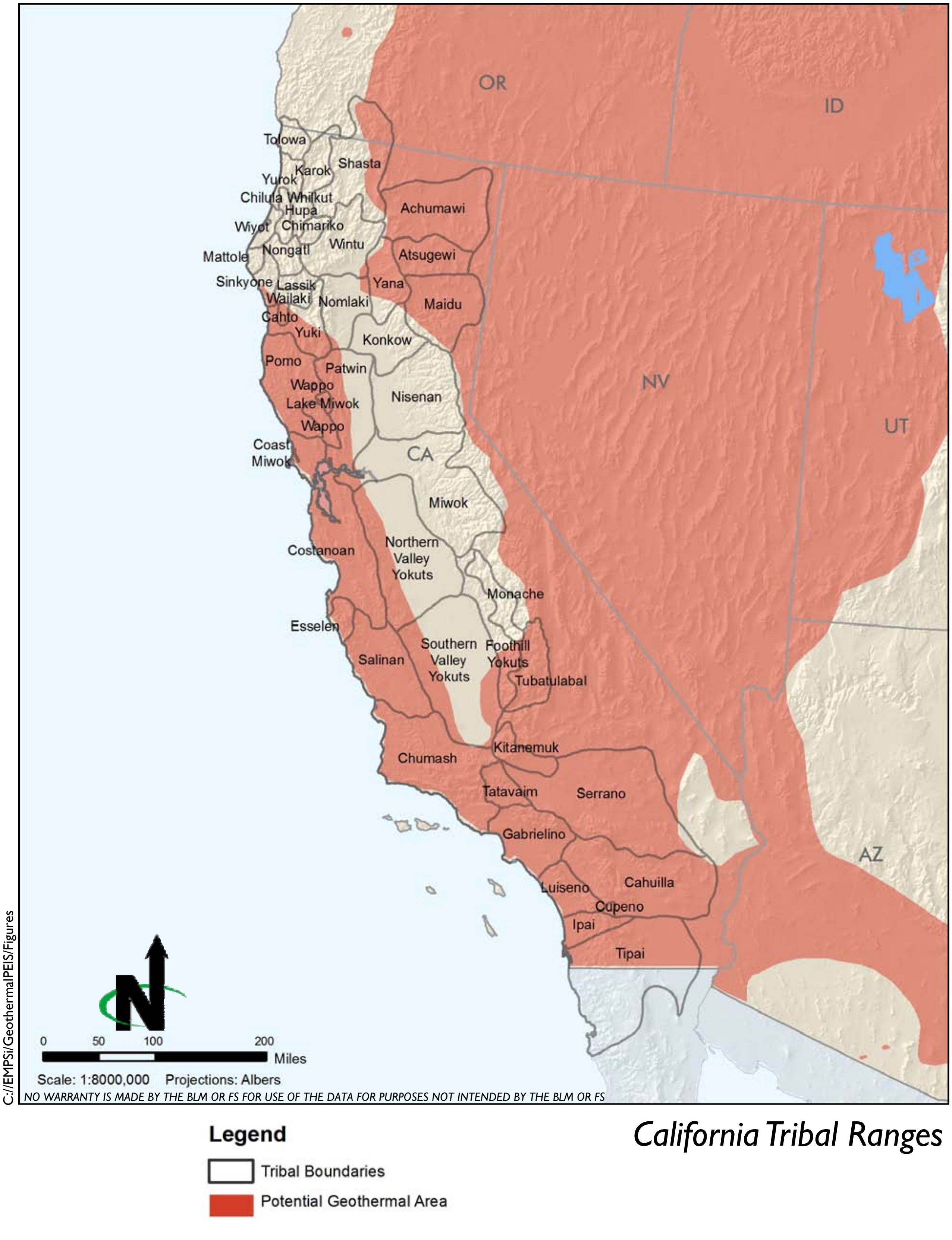
3.14.2 California

The California culture region resembles the modern state; however, it excludes parts of the northwest and northeast corners of the state (Northwest Coast and Plateau culture regions, respectively), as well as the Mojave Desert and areas east of the Sierra Nevada (Great Basin culture region) (Figure 3-16 – California Tribal Ranges). Within the project area, the California culture region includes all of FS Region 5 and a small southern portion of FS Region 6 in Oregon and all or portions of the western BLM Field Offices.

The early prehistory of California has been dramatically affected by post-glacial sea level rise, resulting in coastline inundation and coastal environment alteration. Consequently, any sites formed during the Paleoindian period along the now-submerged coastline would also be submerged or eroded. Additionally, the coastal environments would have been different than what they are today, making it difficult to assign sensitivity for cultural resources based solely on modern coastal environments.

Some of the earliest sites of the California culture region are isolated lithics and lithic scatters found on ground surfaces. A series of such sites have been found along the coastline and associated with coastal rivers, lagoons, and estuaries; a pattern for sites that continued through later periods. Other site types expected in the California region include shell middens, permanent village sites with pithouses, large and small seasonal base camps, smaller seasonal camps, specialized resource procurement sites (such as quarries, rock art, petroglyphs, pictographs, and bedrock milling stations), and cemeteries. Site occurrence can be most expected along the coast on higher ground, such as bluffs and marine terraces, at lagoons and estuaries, along the open coast at permanent bays and wetlands, along creeks and rivers, and in the foothills and mountains.

The largest effect on the Native American populations of California was missionization by the Spanish, who established missions, presidios, and pueblos (towns), primarily along coast and adjacent inland valleys. This affected social organization and subsistence activities of prehistoric populations. Early Euro-American exploration of the California culture region was done not only by the Spanish, but also by Britons, Russians, Mexicans, and later, Americans. Large numbers of Chinese later emigrated to the region, often establishing separate camps and small enclaves across the region. Major historic industries of the region included mining, agriculture, ranching, and railroad construction. Trails and transportation routes were also established and used by the early explorers, emigrants, and industries. Site types to be expected based on these activities include exploration camps, early settlements, Chinese camps and towns, missions, presidios, pueblos, ranches, farms, mines, mining camps, and railroads and trails with their associated boom towns.



California Tribal Ranges

Figure 3-16

3.14.3 Great Basin

The cultural region of the Great Basin is based on the hydrographic region of the same name, but is extended to include the area between the Sierra Nevada and the Rocky Mountains (Figure 3-17 – Great Basin Tribal Ranges). Within the project area, the Great Basin culture region includes portions of FS Regions 1 through 6 and all or portions of the western BLM Field Offices.

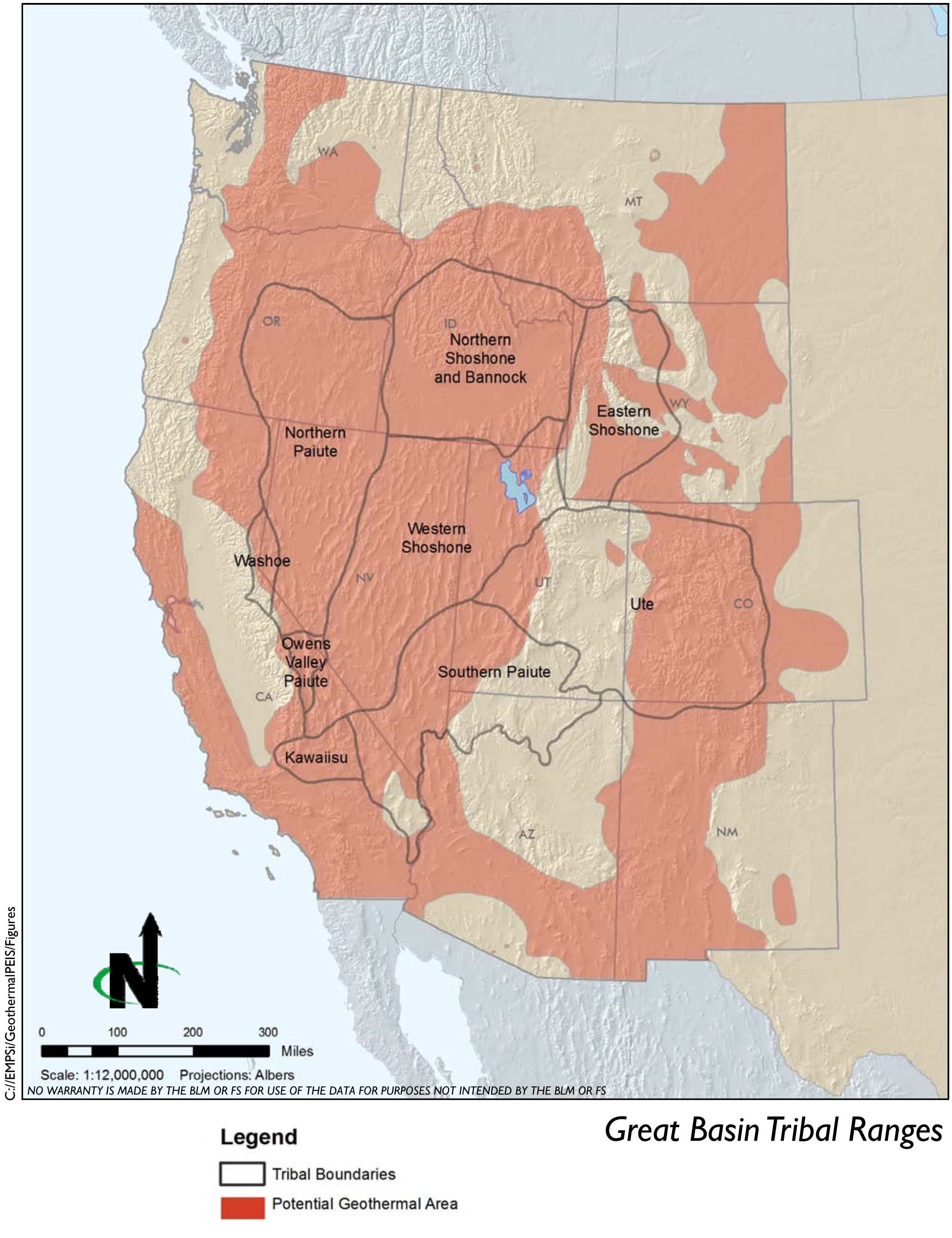
The Great Basin region exemplifies an Archaic stage for nearly all of prehistory. It is varied in landform and climate. These different environments within the region require a variety of adaptations that have resulted in diverse cultural traditions.

Based on prehistoric patterns discussed in Appendix I, expected prehistoric sites of the Great Basin region are as varied as the region. Isolated Paleoindian fluted points could occur throughout the region, particularly in Utah and the western Great Basin. Other site types found in the region include village sites with pithouses and later architecture, seasonal sites, temporary camps, burials, caches, rock art, turquoise mines, and agricultural features such as irrigation ditches. A number of areas and geographic features have been identified as particularly sensitive for one or several of these site types depending on time period and setting. These are discussed in Appendix I. A select few examples include caves, valley floors, and margins of pluvial lakes.

Spanish and Mexican exploration resulted in some early intermittent contact with Native populations of the Great Basin. This was followed by migration of peoples across and through the region but little settlement until after the mid-nineteenth century. Historic period activities include mining, ranching, farming, western expansion, railroad construction, and trail establishment. Historic-era cultural resources expected within the region include early exploration settlements and camps, mineral exploration and mining locales, mining camps, historic farms and ranches, railroad tracks and associated boom towns, and historic trail routes and associated towns.

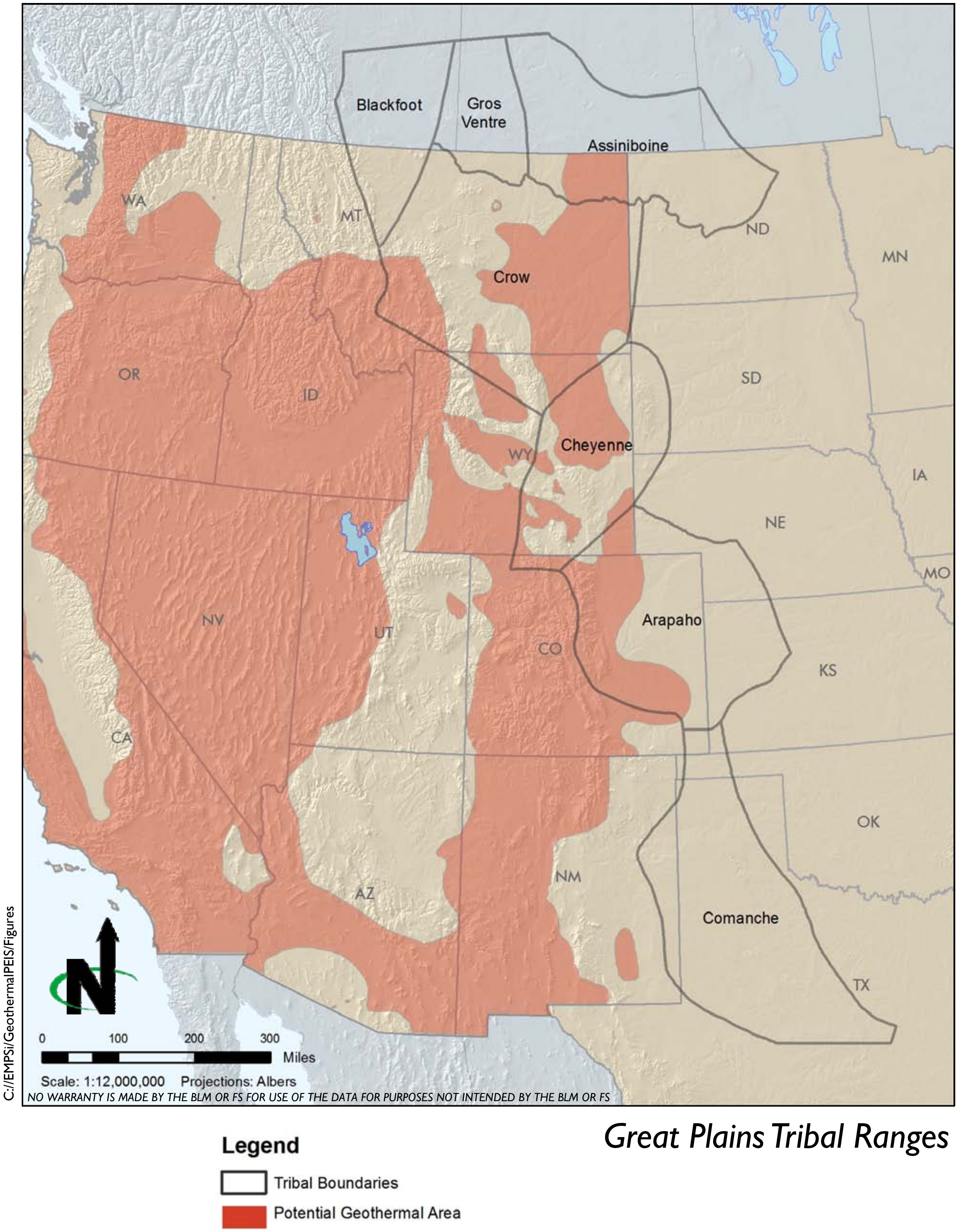
3.14.4 Great Plains

The area between the Saskatchewan River in the north, the Rio Grande in the south, the foothills of the Rocky Mountains in the west, and the upper Mississippi River valley in the east makes up the Great Plains culture region (Figure 3-18 – Great Plains Tribal Ranges). The majority of this culture region is east of the project (and planning) area; project (and planning) area states within the Great Plains culture region include eastern Montana, Wyoming, and Colorado (the easternmost portion of the project (and planning) area in New Mexico is included in the Southwest culture area). Within the project area, the Great Plains culture region includes portions of FS Regions 1 and 2 and all or portions of the western BLM Field Offices.



Great Basin Tribal Ranges

Figure 3-17



Great Plains Tribal Ranges

Figure 3-18

The cultures of the Great Plains region are quite varied, primarily due to the diverse environs it covers. Different environments require unique adaptations by the occupants. However, all cultures of the Great Plains regions have at least one trait in common: bison hunting.

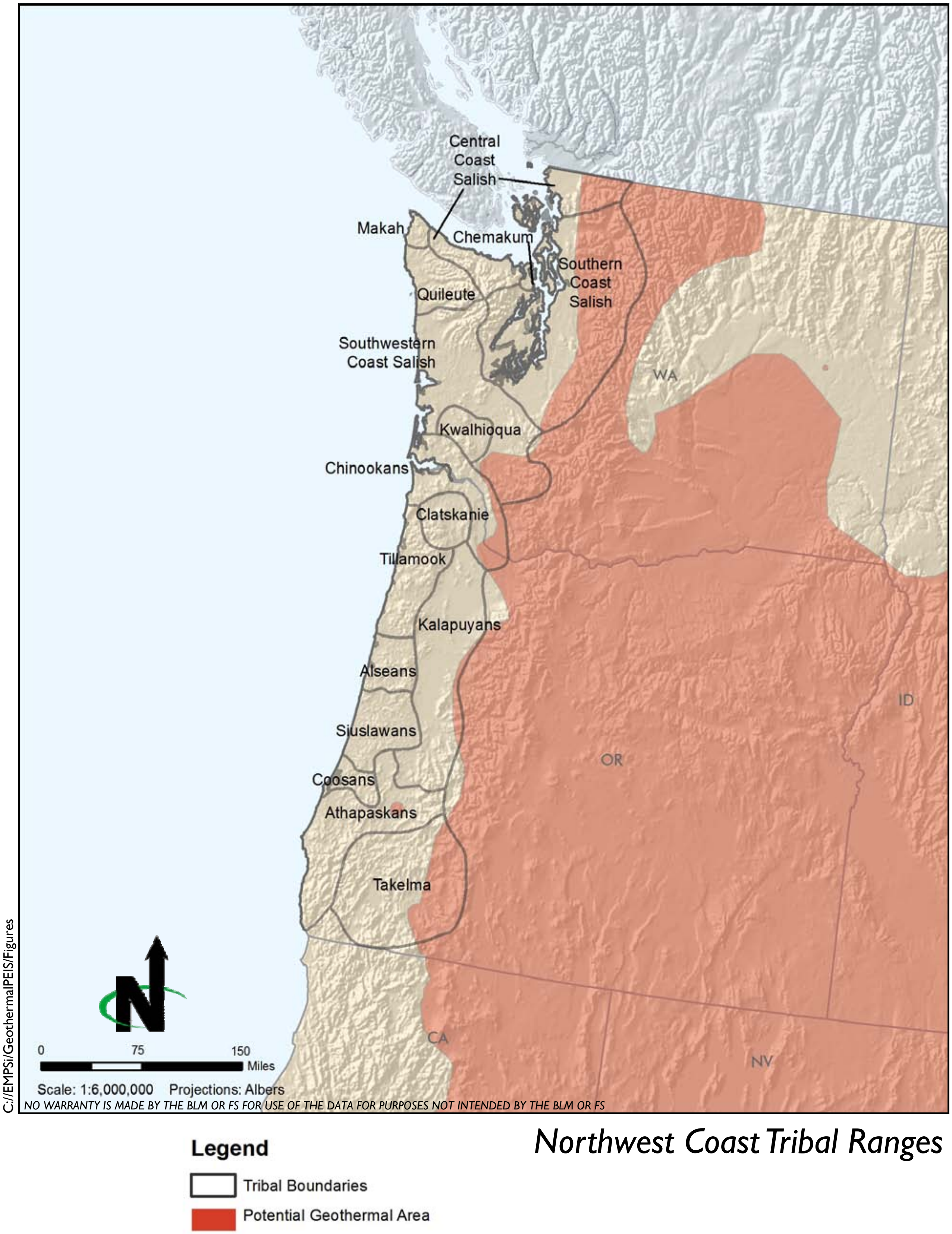
Site types expected to occur within the Great Plains culture region include surface lithic scatters, quarries, blade and biface caches, burials, large game kill sites (such as bison drives, traps, and jump sites), artificial corrals for collecting and killing large game, horticultural areas (particularly in the eastern Great Plains), occupational sites with housepits and associated storage and fire pits, stone rings, petroglyphs, pictographs, and stone cairns and lines. Additionally, horticultural features can be expected to occur in the river valleys of the region, with the exception of the northwest and western-central Great Plains. Great Plains sites can often occur in caves and rockshelters, especially in northern Wyoming and Montana, in mountainous regions, in the high plains, in arroyos, in sand dunes, on steep bluffs, along prehistoric lakeshores created by retreating glaciers, in intermontane basin interiors, in foothills, on butte tops, on barren ridges, on stream terraces, and on raised topographic features in the interior basins and plains.

The Great Plains region of the project area continued to support mobile bison hunters during the historic period, while further east, several migrations and relocations occurred, creating a tangled history of movement in those areas. One of the most significant historic occurrences in the culture region was the introduction of the horse by early Spanish explorers, which affected intertribal relations, social structures within tribes, and economies. The Spanish were followed by other Euro-Americans who developed fur and hide trading in the region. Additionally, ranching, mining, and westward expansion via railroad and trail became notable activities. Based on the discussed activities, historic-era cultural resources that can be expected within this part of the project area include exploration campsites, trading posts, ranches, mines, mining camps, early European and American settlements, and railroads and trails with their associated boom towns.

3.14.5 Northwest Coast

The Northwest Coast culture region covers areas between the crest of the Cascades and the Pacific Ocean from the Copper River delta and Yakutat Bay in Alaska, south to the Winchuck River and Cape Mendocino in California (Figure 3-19 – Northwest Coast Tribal Ranges). Within the project area, the Northwest Coast culture region includes portions of FS Regions 5, 6, and 10 and all or portions of the western BLM Field Offices.

The Northwest Coast culture region is highly varied and divided. Similar to other coastal regions, the early prehistory of the Northwest Coast has been dramatically affected by post-glacial sea level rise, resulting in inundation of the



Northwest Coast Tribal Ranges

Figure 3-19

coastline and altering coastal environments. The entirety of the Northwest Coast was ice free as of 12,000 years ago, although lands immediately adjacent to the Pacific Ocean were never glaciated. The region is unique in that its moist nature has led to excellent preservation in many saturated sites.

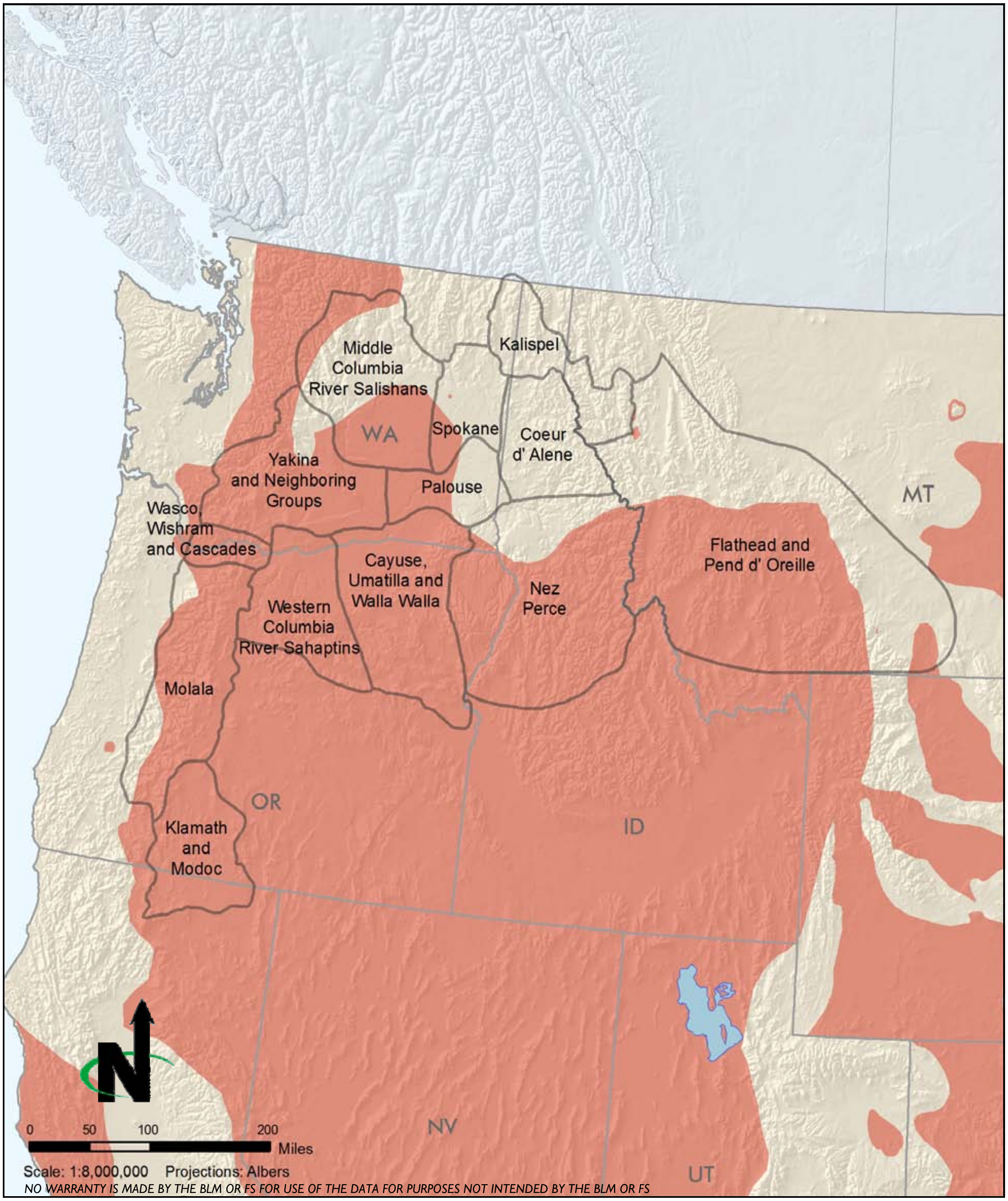
Based on the prehistoric patterns of the Northwest Coast culture region discussed in Appendix I and the environmental conditions discussed above, there is likelihood for submerged sites along coastlines and rivers. Additionally, research has suggested that many early archaeological sites may be ephemeral. Isolated Clovis fluted points could occur throughout the region as surface finds. Other site types include caches, temporary campsites, fishing sites/locales, large and dense middens, villages possibly with pithouses or preserved plank houses, cemeteries, and built fortifications. These are most likely to exist along the coast and rivers, especially the Columbia River; the eastern boundary with the Plateau culture region; and on bluff tops and other defensible locations.

Early explorers from Spain, England, and Russia brought the fur trade to the Northwest Coast culture region. Other historic industries within the region included mining of gold, silver, copper, coal, and other minerals; fishing; timber; and agriculture. A number of trails were established to facilitate exploration, trade, and migration, including the Oregon, Applegate, Cowlitz, and Lewis and Clark Trails. Additionally, railroads, along with rivers and ports, developed in the region to allow for travel and movement of goods. Site types to be expected with these activities include campsites, trading posts, trails and railroads with their associated towns, timber mills, mining camps, farms, and port cities.

3.14.6 Plateau

The Plateau culture region comprises the area drained by the Columbia and Fraser Rivers and includes portions of Oregon, Washington, Idaho, Montana, and northern California, with the exception of some areas within the Great Basin (Figure 3-20– Plateau Tribal Ranges). In general, the area covers parts of British Columbia, eastern Washington, western and northern Oregon, the Idaho panhandle, and western Montana. Within the project area, the Plateau culture region includes portions of FS Regions 1, 4, 5, and 6 and all or portions of the western BLM Field Offices.

The Plateau culture region is highly varied and has established several subregional chronologies to deal with the variety. However, researchers have identified several characteristics that are common throughout the region. These include a subsistence base of fish, game, and roots; use of complex fishing technologies; intermarriage and cooperative use of subsistence resources among groups; relatively uniform mythology, art styles, and religious practices; village and band levels of social organization; institutionalized trade; and linear settlement patterns.



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Plateau Tribal Ranges

Legend

Tribal Boundaries

Potential Geothermal Area

Figure 3-20

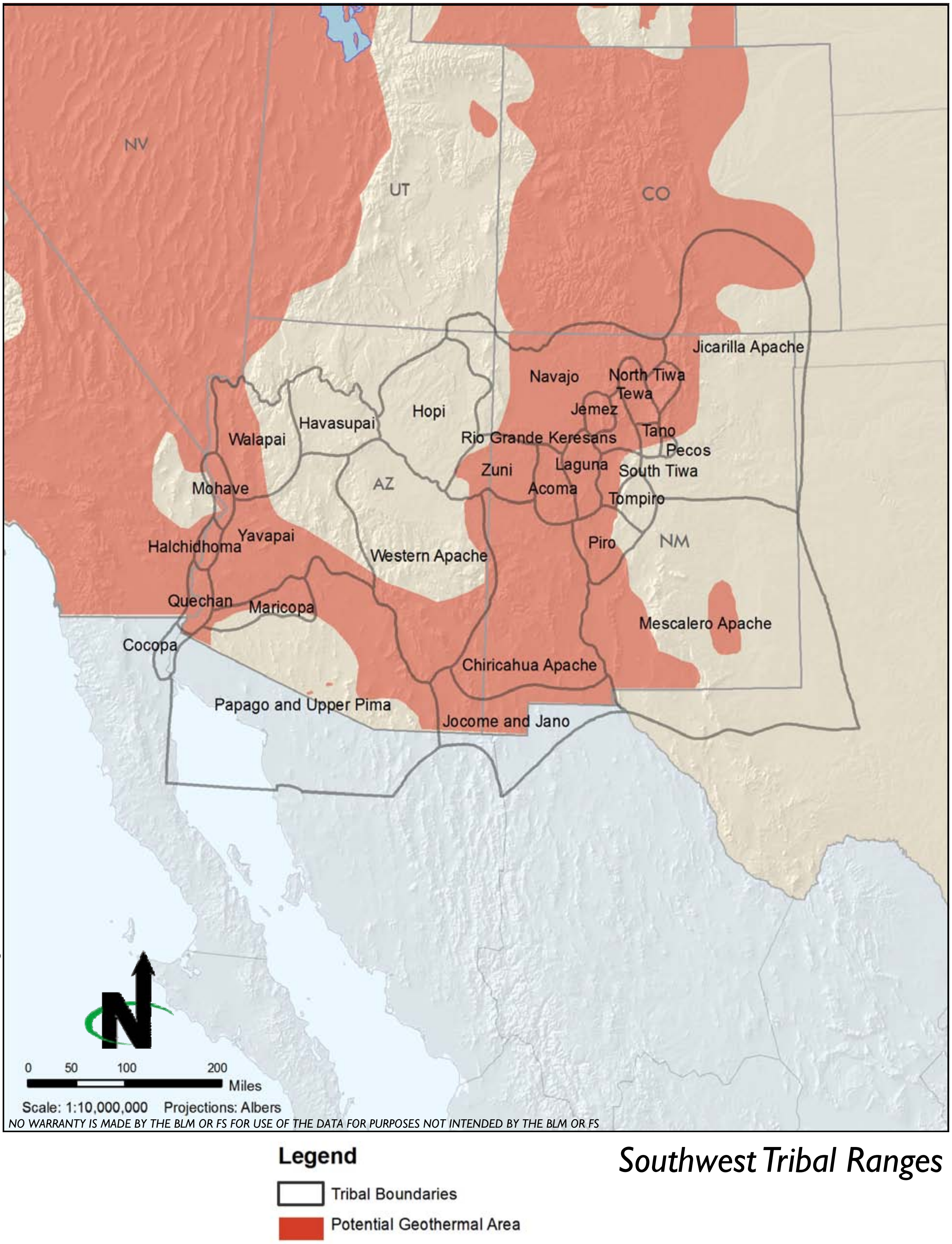
Paleoindian evidence in the Plateau culture region is represented by a single developed site and various scattered surface artifacts across the region. Early sites also indicate a disparity between the north and south, where sites in the north are often ephemeral lithic scatters and sites in the south tend to be short-term occupation sites. Often, permanent habitation sites are found near the steppe-forest margins of the lowlands. Later, village sites with large numbers of pithouses are found in the lower reaches of large rivers. Other site types expected in the region include semi-permanent villages, temporary subsistence camps, burials (sometimes with multiple internments), and bison kill sites. The likelihood of sites to occur within a specific region or topographic area depends on the time period. Sites range from high to low elevations across prehistory, often being located along main rivers.

Russian and Spanish explorers were the first to have contact with Native Americans of the Plateau culture region. Later, the Lewis and Clark expedition crossed the region and Presbyterian, Jesuit, Mormon, and Catholic missionaries settled there. Industries that developed in the region as Euro-Americans became established include the fur trade, mining, agriculture, ranching, logging, and fishing. Exploration and migration into the Plateau culture region was facilitated by the railroad and historic trails that crossed the area. Site types to be expected based on these major historic themes of the Plateau culture region include camps of early explorers, mission establishments, mines, mining camps, trading posts, farms and ranches with associated irrigation features, fisheries and canneries along major rivers, timber mills, trails (such as the Oregon and Lewis and Clark Trails), railroads, and boom towns.

3.14.7 Southwest

The Southwest culture region covers all of Arizona, the western majority of New Mexico, the southern tip of Nevada, southern Utah, extreme southern and western Texas, and parts of southwest Colorado (Figure 3.21 – Southwest Tribal Ranges). Important Ancestral Puebloan occupations in Southwestern Colorado are found outside of the tribal ranges depicted at the time of contact for the Southwest region. The region does include parts of northern Mexico, but since this part of the region is not included in the project area, it is not discussed here. USFS regions included in the Southwest region include portions of Regions 2 and 4 and all of Region 3. BLM field offices in the region include all or portions of all field offices in New Mexico and Nevada, with the exception of the Arizona Strip Office. In addition, the southwestern cultural region includes portions of field offices in southern Colorado.

This is a highly varied region culturally that is rich in cultural resources. Many of the tribes and pueblos may have more in common with neighboring cultural regions because of their shared environmental contexts. As a whole, the Southwest culture region is demanding of its inhabitants and requires extensive adaptations to its environments for survival. This is recognized in the



Southwest Tribal Ranges

Figure 3-21

development of agriculture, domestication, stone and masonry architecture, and irrigation systems, as well as mysterious abandonments in some areas. A wide array of other traditions, some having been adopted from Mesoamerican cultures, also characterizes the cultures of the region. However, because of the diversity of the environments, these adaptations vary among the area's subregions.

Evidence of the earliest human occupation in the Southwest culture region is found throughout in the form of isolated big game kill and butchering sites. More common sites expected include temporary sites with simple houses, seasonal camps, crop fields with associated irrigation features, villages with advanced architecture, pithouses, pueblos, kivas, and cliff dwellings. Sites are most expected to occur in the foothill and mountain areas; in the floors, caves, and rockshelters of valley floors formed by permanent rivers; in dry lake basins; along rivers and drainages; and on river terraces, hilltops, mesas, and other defensible locations; and in arroyo mouths. Important sites were largely abandoned in many areas prior to contact, including the four corners area north into Colorado and Utah. Later populations aggregated in the Rio Grande valley, west-central and eastern New Mexico, and eastern Arizona, making these areas particularly sensitive for later sites.

Spanish explorers entered the Southwest culture region by following the Rio Grande north from Mexico. Early cities and towns were established mostly in river valleys and associated with established Native American communities. Here, missions and military outposts were founded. New Mexico, Arizona, and Texas are particularly sensitive for these resources. Once the area was passed to Mexico and ultimately ceded to the US, development of the region continued with more military posts, stage routes, ranches, mines, and new American settlements. Other activities and site types expected to occur in the culture region include ranches and farms, trading posts, mines, mining camps, ghost towns, trails, railroads, and roads.

3.15 TRIBAL INTERESTS AND TRADITIONAL CULTURAL RESOURCES

This section is an overview of separate but related resource considerations primarily involving Native America Indian tribes and Native Alaskans. Tribal interests include economic rights such as Indian trust assets and resource uses and access guaranteed by treaty rights. Traditional cultural resources or properties include areas of cultural importance to contemporary communities, such as sacred sites or resource gathering areas. While most commonly considered in the context of Native Americans and Native Alaskans, there are traditional cultural resources associated with other ethnic or socially linked groups, such as Hispanics in the Southwest. Although Indian reservations and restricted lands are explicitly excluded from geothermal leasing under this PEIS, there are tribal and Native Alaskan interests and traditional use of public and NFS lands that could be impacted by geothermal leasing and development. Geothermal leasing and development could also impact adjacent or nearby reservations, trust lands, restricted Indian allotments, and federally tribal-dependent Indian communities.

3.15.1 Tribal Interests

The trust responsibility is the US Government's permanent legal obligation to exercise statutory and other legal authorities to protect tribal lands, assets, resources, and treaty rights, as well as a duty to carry out the mandates of federal law with respect to American Indian and Alaska Native Tribes. Federal Indian policy and trust responsibilities have developed from court decisions, congressional laws, and policies articulated by the President. Different departments, branches of government, and agencies have defined responsibilities. The Secretary of the Interior has specific trust responsibilities not delegated to any other department or agency, including holding land in trust and maintaining monetary accounts for tribes and individual tribal members.

For the BLM and FS, trust responsibilities are essentially those duties that relate to the reserved rights and privileges of federally recognized tribes as found in treaties, executive orders, laws, and court decisions that apply to public and NFS lands. Trust responsibilities for the BLM are found in DOI Secretarial Order No. 3215 (US DOI 2000), 512 Department Manual Chapter 2 (US DOI 1995), and BLM Manual H-8160-1 (BLM 1994). For FS activities, trust responsibilities are defined primarily by the authorities listed Forest Service Manual 1563.01 and by treaties that may apply to specific areas of the National Forest System. As federal land managing agencies, the BLM and FS have the responsibility to identify and consider potential impacts of plans, projects, programs, or activities on Indian lands, trust resources, and treaty rights. When planning any proposed project or action, the agencies must ensure that all anticipated effects on Indian lands, trust resources, and treaty rights are addressed in the planning, decision, and operational documents prepared for each project. Federal agencies must ensure that meaningful consultation and coordination are conducted on a government-to-government basis with federally recognized tribes.

Much of the public domain land in the lower 48 states was originally obtained by treaties made with Indian tribes. Approximately 60 tribes have treaties that contain some rights to off-reservation lands and resources. Other laws define the subsistence rights of Alaskan Natives to use natural resources on federal land (FS 1997). Treaties are negotiated contracts made pursuant to the US Constitution and take precedence over any conflicting state laws because of the Constitution's supremacy clause (Article 6, Clause 2). Treaty rights are not gifts or grants from the US, but are bargained-for concessions from sovereign governments. Other sources of defined reciprocal rights and obligations assumed by the federal government and Indian tribes include congressional and executive branch actions to acquire Indian lands, establish reservations, provide federal recognition of tribes, and remove Indian peoples to reservations or rancherias. Rights on federal lands are interpreted and applied by the federal courts. Some federal statutes, congressional acts, and executive orders do not distinguish between federally and non-federally recognized tribes and bands.

Indian tribes and Native Alaskans often view these rights and resource uses as holistically interconnected with culture, tradition, and spiritual practice. Among many groups, land, water, geologic features, landscapes, and other seemingly inanimate objects are considered sacred. Federal land policy and legal precedents, however, make distinctions between economic rights and resource uses and those that are cultural or spiritual.

Indian trust assets are legal interests in assets held in trust by the federal government for federally recognized Indian tribes or nations or for individual Indians. Assets are anything owned that has monetary value. A legal interest refers to a property interest for which a legal remedy, such as compensation or injunction, may be obtained if there is improper interference. A trust has three components, including the trustee, the beneficiary, and the trust asset. The beneficiary is also sometimes referred to as the beneficial owner of the trust asset. In the Indian trust relationship, the US is the trustee and holds title to these assets for the benefit of an Indian tribe or nation or for individuals.

These assets can be real property, physical assets, or intangible property rights. Examples include lands, minerals, water rights, gathering rights, hunting and fishing rights, rights to other natural resources and forest products, money, or claims. They need not be owned outright, but can include other types of property interest, such as a lease or a right to use something. Some treaties express a priority right for a resource; others express a proportional, or in common, right. Indian trust assets cannot be sold, leased, or otherwise alienated without federal approval.

Indian trust assets do not include things in which a tribe has no legal interest. Without a treaty or act of Congress specifying otherwise, land ownership can affect the determination of whether or not a resource is an Indian trust asset. For example, an off-reservation resource-gathering area in which a tribe has no legal property interest would generally not be considered an Indian trust asset. In this case, if religious or cultural resources could be affected by the federal action, these interests would be addressed as part of the cultural resources or social impact assessment because of the lack of legal property interest. The same resource on a reservation, trust, or ceded land may be an Indian trust asset, as determined on a case-by-case basis.

The DOI's Departmental Manual Part 303, Indian Trust Assets, defines general DOI policy and principles for managing Indian trust assets. Department of the Interior agencies are required to protect and preserve Indian trust assets; ensure their use promotes the interests of the beneficial owner; enforce leases; promote tribal control; manage and distribute income; maintain good records; and protect treaty-based fishing, hunting, gathering, and similar rights of access and resource use on traditional tribal lands.

Several tribes are also interested in recovering ownership of lands that were part of their original land base and, therefore, would be concerned about committing lands to other uses. The federal government has the authority to convey land to federally recognized tribes under different authorities. The FS exchanges land, BLM transfers land, and Congress may legislatively restore or create tribal land out of federal land. Land has been conveyed in recent years through these means.

Some tribes that were parties to unratified treaties did not surrender any land or resources to the US. Although these cases were settled, some individuals and tribes did not accept the land settlement money. The DOI, through the Bureau of Indian Affairs, holds accounts for those who have not extinguished their aboriginal claims to land and who continue to reserve the right to pursue further legal action.

Other tribal interests include general concerns about ecosystem management, maintaining healthy lands and water, and restoring the natural resource base. Tribal and Native Alaskan communities and regional entities often request that their local knowledge be included in resource management decisions.

3.15.2 Traditional Cultural Resources

Traditional cultural resources or properties are places associated with the cultural practices or beliefs of a living community. They can be considered a subset of the broader category of cultural resources, which are discussed in Section 3.14. Traditional cultural properties are rooted in the community's history and are important in maintaining cultural identity. Examples of traditional cultural properties include natural landscape features, ceremonial and worship places, plant gathering locations, traditional hunting and fishing locations, ancestral archaeological sites, artisan material locations, rock art and communal resources such as community-maintained irrigation systems. The boundaries of these resources and impact areas are often difficult to assess. Resources tied to particular locations and that meet the criteria for eligibility can be listed on the National Register of Historic Places. Some traditional cultural resources have values that do not have a direct property referent and may not manifest themselves by distinguishable physical remains, but still are subject to consideration in planning. It is the continuity of their significance and importance to the maintenance of contemporary traditions that is important.

While many traditional cultural resources are well known, some locations or resources may be privileged information that is restricted to specific practitioners or clans. For tribes, maintaining confidentiality and customs regarding traditional knowledge may take precedence over identifying and evaluating these resources, unless they are in imminent danger of damage or destruction. In some cases, the connections of contemporary communities with a particular location or an ancestral site may have been lost, but are rediscovered or recognized during the planning process. A person with traditional knowledge may associate a place or site with a tradition, practice, oral history, ancestral use, or belief important to the community's cultural life. For identification of traditional cultural resources, field visits are usually required. Systematic field survey could be needed to locate resources, such as ancestral archaeological sites. Ethnographic studies could be necessary to ensure issue identification. Multiple tribes may have interests potentially affected in a particular lease area. Agencies must be flexible in making a good-faith effort to consult with tribes when their actions could affect these resources. Consultation must be conducted in a manner that is sensitive to different world views, time frames, communication modes, and information confidentiality.

3.15.3 Tribal Interests and Traditional Cultural Resources

Project Area

Tribal Interests and traditional cultural resources are identified primarily through consultations with federally recognized Indian tribes on a government-to-government basis (Executive Order 13084 and Executive Memorandum of April 29, 1994, on Government-to-government Relations with Native American Tribal Governments). In the case of non-federally recognized tribes and other potentially affected communities, direct consultations are also necessary to identify traditional cultural resources.

Typically the tribal government is the primary point of contact for identifying Indian trust and treaty rights, but the US Bureau of Indian Affairs and the Interior Office of the Special Trustee are also often consulted. In the lower 48 states, there are 46.2 million acres of Indian trust land and 8.9 million acres of individual trust allotments (FS 1997). There is no comprehensive list of all Indian trust assets for tribes and individual Indians. If needed, further information on the nature of the trust asset is determined by examining government documents, such as treaties, court decisions, water rights adjudication proceedings, and reservation-establishing proclamations. Since trust and treaty rights are often subject to interpretation and are often contested, agency legal counsel is usually consulted.

For the purposes of this PEIS, in September 2007, an initial contact letter was sent via certified US Mail by the Deputy Director of the BLM and Deputy Chief of the FS to over 400 tribes and Alaskan Native groups in the project area. The letter described the PEIS process and pending lease locations and invited recipients to consult on the project. Previously, in June 2007, these groups were also sent a newsletter announcing the project. To date, responses have been received from seven tribal representatives. Four respondents requested that their groups be consulted on the project if lease areas fall within their areas of interest. Two respondents requested consultation and to participate in the PEIS process. One respondent noted that no lease applications were in their area of interest. Additional contact efforts are planned, and agency consultation will be conducted with those tribes and Native Alaskan groups who have requested inclusion. Consultation and coordination efforts are described further in Chapter 6.

Planning Area

In the planning area, there is extensive geographic, environmental, historic, economic, social, ethnic, and religious diversity that is reflected in the tribal interests and traditional cultural resources that may be valued by Native American, Native Alaskans, and other potentially affected communities. There is no comprehensive way to define all of the resources on this broad scale, especially where confidentiality is often required. There is also considerable overlap between what an outsider or another group might define as economic interests and natural resource issues, and ones that have religious and cultural meaning to a group. Throughout the western US, the BLM and FS have established programs and relationships with tribes that provide the means to further engage tribes on their interests, values, concerns, and priorities on a more-local level and project-specific basis. Continued consultations and ethnographic studies would be necessary to identify issues specific to locations considered for geothermal leasing in the planning area. Some common categories of these interests and resources are presented here.

The planning area includes Indian trust or restricted lands in which the title is held by the US in trust for an Indian or an Indian tribe, or lands in which the title is held by Indians or an Indian tribe but is subject to restriction by the US against transfer. These lands can be on or off reservations. The BLM is prohibited from issuing leases on these properties, but trust assets need to be identified. There may be conflicts with agencies about existing trust assets, tribal treaty rights, or ownership claims. Tribes may have interests in converting public and FS land to trust land or in reestablishing portions of their ancestral land base.

There are tribal interests and traditional cultural resources associated with water rights and the uses of water sources, such as rivers, lakes, and springs.

Although Indian-reserved water rights are not expressed in treaties, they are inherent or implied rights. The reserved water right as applied to Indians is derived from Winters v. US 1908. This Supreme Court case held that, "sufficient water was implicitly reserved to fulfill the purposes for which the reservation was established." The Winters Doctrine provides that tribes have senior water rights. Recent court cases have found that Indian reservations have priority water rights on federal lands, including public and NFS lands. Water rights and priority claims for reservation and off-reservation uses are likely to occur in the planning area. Additionally, these rights and claims often are in the same geographic area where tribes could have concerns about enhancing flows for fish, maintaining plant and wildlife riparian habitat, and preserving cultural locations' use and setting (FS 1997). Among many tribes, all water and water sources are associated with power and essential life forces. Water sources are considered sacred, and hot springs are especially important. Springs are places where prayers are said, ceremonies are held, and offerings are made. The hot mineral water and mud from hot springs are often used for healing (Bengston 2003).

Resource-gathering areas are a broad category that can include trust assets; treaty and subsistence rights and resources; and culturally significant plants, animals, fish, and minerals. Plant resources can include foods that were established as part of a traditional seasonal round. Examples include traditions of gathering acorns in California, pine nuts in Nevada, camas roots in the Pacific Northwest, berries in the Plateau region, mesquite pods in the Southwest, and a variety of seed plants west-wide. Other examples of plant resources include fibers used for basketry and weaving in the eastern Sierra, and wood for building, carving, and fuels. Many plants are gathered for medicinal and religious use. Plant gathering is often a communal activity with cultural and religious significance. Loss of access to these plants or gathering locations, or losing the ability to maintain their habitats, can affect religious and ceremonial uses.

Hunting and fishing rights are often guaranteed by treaties, and many traditionally used locations and habitats are prized. Wildlife and fish are also important in the cosmology of many Native American groups and in exercising traditional lifeways. In Alaska, for example, some hunting and butchering is often a community-based traditional activity as well as a subsistence right. In the Pacific Northwest, salmon continues to be a large part of most Columbia River tribes' culture and is connected to sustaining life and culture. For some groups, animal species are considered ancestors or spiritual beings, which are treated with respect and taken for food or fur only after the hunter establishes a relationship through rituals and offerings. Traditionally used fishing and hunting locations can be important, as can be the lands and waters that support wildlife and fish habitat. Other interests include tribal grazing rights that could be included in treaties or agreements, as well as gathering locations for rocks, minerals, and soils. For example, in the Southwest and elsewhere, clays for pottery and minerals for glazes and pigments are gathered from public and NFS lands.

Most American Indian tribes and individual tribal members conceive of spirituality, or sacred sites and daily activities, as interconnected. The spiritual and natural worlds are not separate from everyday life (FS 1997). Many of the resource uses and use areas described above also have a spiritual or sacred dimension. Sacred sites can also include places that are an expression of belief systems in the land or nature. For some sacred areas, there may be no observable cultural function to an outsider or even to tribal members who have not been entrusted with the information. Indian people determine what is of spiritual importance to them. Locations such as landscape features, mountain tops, trails, water courses, springs, caves, offering areas, shrines, and rock art sites often figure in these groups' oral traditions concerning their origins, mythology, and the nature of the world. There are frequently active or ancestral ceremonial locations that are treasured. Archaeological sites, burials, and historic sites are often seen as important ties to ancestors and traditions that are not to be disturbed (Bengston 2003).

Based on comments on the Draft PEIS, in addition to the physical components of the environment described above, the quality of the natural environment, such as clean water and a pure, untainted airshed are basic Tribal cultural values.

3.15.4 Climate Change

The status of the local ecosystem, including but not limited to vegetation composition and any wildlife, is integral to many native cultures. Potential changes in local ecosystems associated with effects of climate change may alter the availability of plants, wildlife, or other natural resources for traditional uses.

3.16 NATIONAL SCENIC AND HISTORIC TRAILS

3.16.1 Background

The National Trails System Act of 1968 (16 USC 1241-51) established the framework for the National Trails System. The purpose of this Act is to accommodate the outdoor recreation needs of an increasing population, while preserving the environment, history, and natural aesthetics of open areas (BLM 2006d). National Scenic Trails and National Historic Trails are congressional designations given to protected areas in the US that contain trails and surrounding areas of particular natural beauty and historic significance. National trails are officially established under the authorities of the National Trails System Act (16 USC 1241-51). The National Trails System is made up of National Scenic Trails, National Historic Trails, and National Recreation Trails.

National Scenic Trails are 100 miles or longer, continuous, primarily nonmotorized routes of outstanding recreation opportunity. National Historic Trails commemorate historic and prehistoric routes of travel that are of significance to the entire nation. National Historic Trails have as their purpose the identification and protection of the historic route and its historic remnants and artifacts for public use and enjoyment (US DOI, National Park Service 2006a). They must meet three criteria listed in Section 5(b)(11) of the National Trails System Act:

- They must follow actual documented route of historic use;
- They must be of national significance; and
- They must possess significant potential for public recreation and/or interpretation.

National Scenic Trails and National Historic Trails may only be authorized by Congress. National Recreation Trails, also authorized in the National Trails System Act, are existing regional and local trails recognized by either the Secretary of Agriculture or the Secretary of the Interior upon application.

Administration of each trail is officially assigned to or shared among the US DOI, National Park Service, BLM, and/or the FS. Subject to available funding, the administering agencies exercise trail-wide responsibilities under the Act for that specific trail. Such responsibilities include coordination among and between agencies and partner organizations in planning, marking, certifying, preserving and protecting resources, interpreting, establishing cooperative / interagency agreements, and offering financial assistance to other cooperating government agencies, landowners, interest groups, and individuals.

National trails cross numerous jurisdictions, with various segments managed by a variety of landowners or agencies. On-site management responsibilities often include inventorying of resources and mapping, planning and developing trail segments or sites, ensuring compliance, making provisions of appropriate public access, offering site interpretation, maintaining trails, marking trails, preserving or protecting resources, protecting viewsheds, and managing visitor use.

In the project area, the BLM manages public lands in 10 western states that include 2 National Scenic Trails and 11 National Historic Trails (Table 3-28). In the project area, the FS manages NFS lands that include portions of one National Historic Trail and two National Scenic Trails (Table 3-28). Figure 3-22 shows the distribution of National Scenic and Historic Trails throughout the project area, identifying each trail by name. There are approximately 15,280 miles of National Historic Trails and National Scenic Trails within the project area. Within the planning area, National Scenic Trails and National Historic Trails traverse approximately 3,005 miles of public land and approximately 3,168 miles of NFS land.

Table 3-28
Project Area National Trails

Trail Name	Type	Project Area (approx. miles)	Planning Area (approx. miles)	Public (BLM) or NFS (FS) Lands Affected	Administering Agency (if BLM or FS)
California	National Historic Trail	3,296	1,844	Public lands	other
Continental Divide	National Scenic Trail	1,775	1,453	Public lands; NFS lands	FS
El Camino Real de Tierra Adentro	National Historic Trail	645	249	Public lands	BLM (with US DOI, National Park Service)
Iditarod	National Historic Trail	78	1.5	Public lands	BLM
Juan Bautista de Anza	National Historic Trail	1,039	218	Public lands	other
Lewis and Clark	National Historic Trail	1,321	420	Public lands	other
Mormon Pioneer	National Historic Trail	57	99	Public lands	other
Nez Perce	National Historic Trail	539	421	Public lands; NFS lands	FS
Old Spanish	National Historic Trail	2,615	1566	Public lands	BLM (with US DOI, National Park Service)
Oregon	National Historic Trail	1,133	436	Public lands	other
Pacific Crest	National Scenic Trail	1,598	1,394	Public lands; NFS lands	other
Pony Express	National Historic Trail	1,263	617	Public lands	other
Santa Fe	National Historic Trail	unknown	unknown	Public lands	other

Source: BLM 2006d; US DOI, National Park Service 2006a, 2006b.

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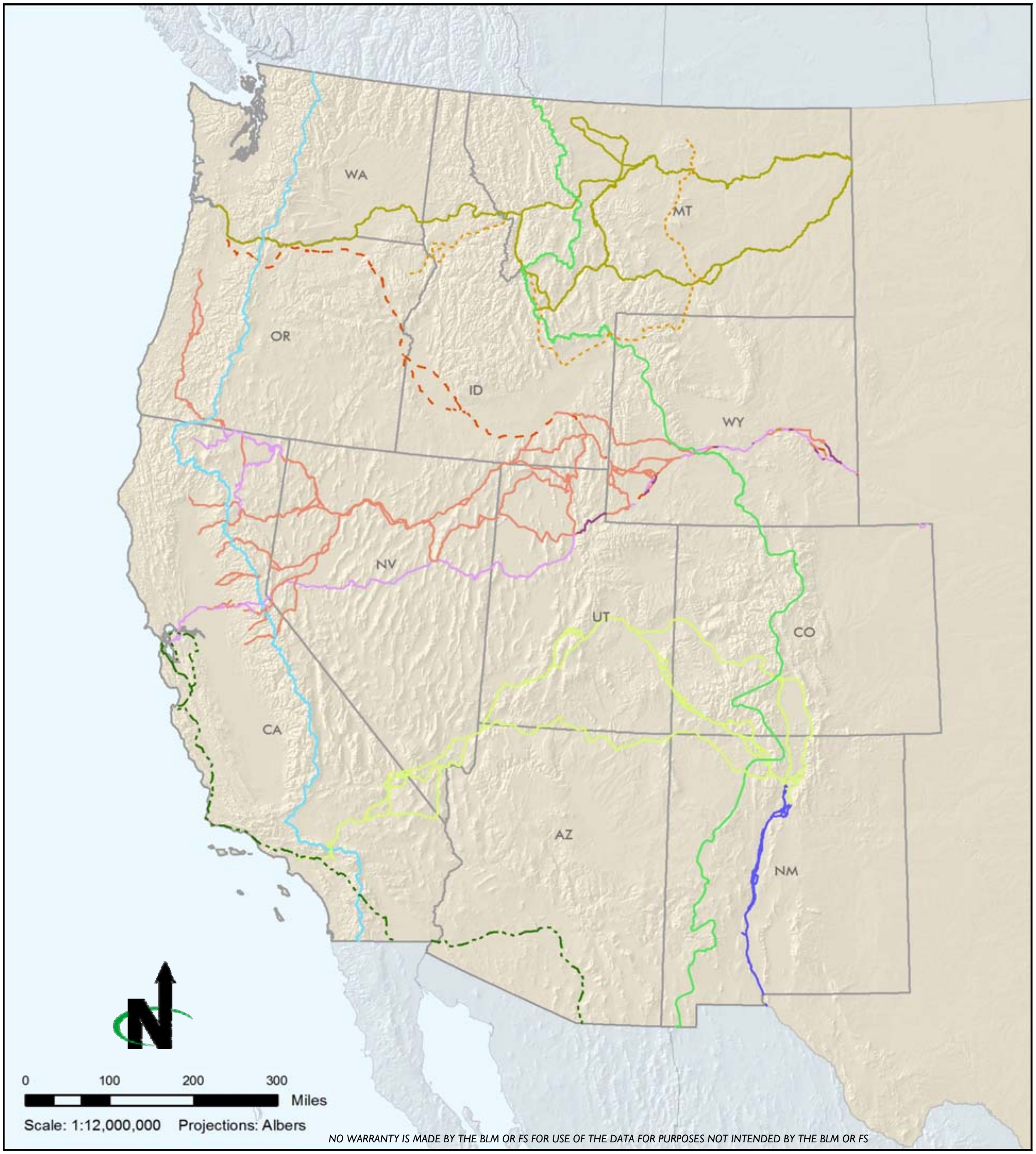


11 National Scenic and Historic Trails are located in the project area. Alaska has one trail in the planning area.

National Scenic and Historic Trails in the 11 Western States

Figure 3-22

3.16.2 National Historic Trails

California Trail

The trail was used by over 250,000 farmers and gold seekers during the 1840s and 1850s. The route starts along the Missouri River and then converges on the Great Platte River Road, overlaps with the Oregon Trail, and continues through the Rocky Mountains. After crossing the Rockies, many routes were used to get to and cross the Sierra Nevada. The total system of trails that make up the California Trail is approximately 5,664 miles (US DOI, National Park Service 2007c). Within the project area, there are approximately 3,296 miles of the California Trail. The California Trail crosses approximately 1,039 miles of public land and approximately 261 miles of NFS land within the planning area.

El Camino Real de Tierra Adentro

This trail dates back to the Spanish Colonial era of the sixteenth to nineteenth centuries when it was the primary route between Mexico City, the capital of New Spain, and other Spanish provincial capitals (National Park Service, 2006c). From Mexico, the trail crosses briefly into west Texas and then north through New Mexico to Santa Fe. The trail was used for trade and interaction among Europeans, Spaniards, Mexicans, and Native Americans and affected settlement and development within the southwest (National Park Service, 2006c). Within the project area, there are approximately 645 miles of the El Camino Real de Tierra Adentro Trail. The trail crosses approximately 66 miles of public land and approximately 8 miles of NFS land within the planning area.

Iditarod Trail

The Iditarod Trail, located in Alaska, was a path originally used by Native American hunters and Russian explorers. In the twentieth century, gold seekers used the trail to reach the mines, and the trail was improved. Several towns, such as Seward, Iditarod, and Nome, grew up around the mining districts, where miners would buy supplies from local stores and markets and would stay overnight in tents before going to the mines. The trail begins in two places, Seward and Nome, and the two legs eventually met at the Iditarod Mining District. It was officially surveyed by the US Army's Alaska Road Commission in 1908 and was heavily used until 1924, when the airplane became common for travel. The trail was not well used again until the 1960s, when dog sledding became an interest; the first dog sled race took place in 1967. The total length of the Iditarod trail in the project area is approximately 938 miles. Within the planning area, there are approximately 1.5 miles of the Iditarod Trail. Overall trail administration has been delegated by the US DOI to the BLM, and the trail includes approximately 85 miles of BLM lands and an additional 52 miles of State and Native Lands that the BLM is currently administering (Krantz 2008). The route includes no NFS land.

Nez Perce (Nee Me Poo)

This trail extends from Wallowa Lake in Oregon to Bear Paw Mountain in Montana. It is named for the Nez Perce Tribe of Native Americans who were forced to leave their lands and move to a reservation. During the travels, fighting occurred between the Nez Perce and white settlers. The US Army was called, and the Nez Perce attempted to flee to Canada. Approximately 750 Nez Perce men, women, and children traveled over 1,170 miles through the mountains on a journey that lasted from June to October of 1877 (FS 2007h). From Wallowa Lake, the trail extends east through the Snake River at Dug Bar, entering Idaho at Lewiston, and then entering north-central Idaho at Bannock Pass. The trail then travels back to the east into Montana at Targhee Pass to cross the Continental Divide. It bisects Yellowstone National Park in Wyoming, and then follows the Clark Fork River out of Wyoming into Montana. The trail then heads north into Bearpaw Mountains and ends forty miles from the Canadian border (FS 2007h). Approximately 539 miles of the Nez Perce Trail traverses the project area. Within the planning area, this trail crosses approximately 74 miles of public land and approximately 183 miles of NFS land.

Juan Bautista de Anza

This trail was used by a party of 300 Spanish colonists, led by Colonel San Juan Bautista, from Mexico to California in 1775. The party intended to establish a mission and presidio (military post) in Alta, California, to secure the area from the Russians and British, who also had claimed the land. It was the first overland trail that connected New Spain with Alta, California (US DOI, National Park Service 2007b). The party contained 30 families, a dozen soldiers, cattle, mules, and horses. The trail is over 1,200 miles long, and it took the party three months to follow the trail through the southwest desert before reaching the California coast. It took another three months to travel from the southern coast up the northern coast to present-day San Francisco (FS 2007i). There are approximately 1,039 miles of the Juan Bautista de Anza Trail within the project area. Within the planning area, the trail crosses approximately 84 miles of public land and 11 miles of NFS land.

Lewis and Clark

This trail runs along the early explorations of Meriwether Lewis and William Clark on behalf of the US. The trail follows the Missouri River upstream, eventually reaching the Pacific Ocean at the mouth of the Columbia River. The route goes through Idaho and western Montana for a total of approximately 1,321 miles within the project area. There are approximately 28 miles on public land and 49 miles on NFS land within the planning area.

Mormon Pioneer Trail

One of the major forces of settlement in the West was Mormon emigration. Sixteen hundred Mormons left Illinois in February 1846, crossing into Iowa to escape religious persecution (Billington 1963). Their leader, Brigham Young, opted not to follow the Oregon Trail but instead forged a new route just north of the Platte River. This was because the route was better suited to wagon travel and he wished to avoid other travelers from Missouri who frequented the Oregon Trail (Billington 1963). The Mormons crossed Mississippi and established temporary headquarters there, then went on to Missouri, and through the Great Plains, where they spent an icy winter and lost 600 people from their party (Billington 1963). They reached the Valley of the Great Salt Lake, where they settled, in June 1847. There are approximately 57 miles of the Mormon Pioneer Trail within the project area. Within the planning area, the trail crosses public land for approximately 8 miles. It does not cross any NFS lands within the planning area.

Old Spanish

Before there was the Old Spanish Trail, an overland southern route to California from New Mexico did not exist. This trail was first established by a Mexican trader, Antonio Armijo, in 1829. He traveled from Santa Fe, New Mexico, to Los Angeles, California, on a commercial caravan, carrying Mexican woolen goods and planning to bring horses back from California (US DOI, National Park Service 2007c). Portions of the trail had been used as a Native American footpath, an early trade route, and a horse and mule trail. The trail runs through present-day Colorado, Utah, Arizona, Nevada, and California (Cultures and Histories of the American Southwest 2007). There are approximately 2,615 miles of the Old Spanish Trail within the project area. Within the planning area, it crosses public land for approximately 750 miles and NFS land for 275 miles.

Oregon Trail

Fur trappers and traders used this trail to access the Northwest Coast. The Oregon Trail was used by settlers traveling to the Plateau Region or to pass through en route to more westerly points. The trail began as an unconnected series of trails used by Native Americans. Fur traders expanded the route to bring pelts to trading posts in the early 1800s. The route extends roughly 2,000 miles west, from Missouri toward the Rocky Mountains to the Willamette Valley; a trail to California digressed from the route in Idaho (BLM 2008k). Several groups followed the route over time, including large populations of settlers, moving from the eastern portion of the US to settle the west between 1800 and the 1880s (BLM 2008k).

Missionaries used the trail during the 1830s, traveling along the Platte and Snake Rivers to settle churches in the Northwest. Mormons, headed toward the Great Salt Lake in Utah, used the trail beginning in 1847, and the discovery of gold in California caused many gold miners to use the trail in 1849. It is estimated that 4,000 emigrants followed the trail west in 1847 (Schwantes 1989), many in small caravans of wagons. Military posts and spur roads were established off the Oregon Trail. The trail was the major connection between the east and western portions of the US. It was used as a cattle driving trail eastward for a brief time as well. The construction of the Central Pacific Railroad, connecting California to the rest of the continent in 1869, decreased use of the Oregon Trail. By the early twentieth century, railroad lines paralleled the trail, and it was no longer used as a major transportation corridor (BLM 2008k and Schwantes 1989). There are approximately 1,133 miles of the Oregon Trail within the project area. Within the planning area, it crosses approximately 176 miles of public land and approximately 46 miles of NFS land.

Pony Express National Historic Trail

This began in 1860 as a mail route connecting the eastern US with California. It was privately financed and was used only for 18 months before the telegraph system was constructed and replaced the Pony Express. Riders on horseback transported mail from Missouri to California in ten days, traveling over 1,800 miles. The transcontinental railroad later followed much of this route (US DOI, National Park Service 2007b). Within the project area, there are approximately 1,263 miles of the Pong Express Trail. Within the planning area, it crosses approximately 448 miles of public land and approximately 187 miles of NFS land.

Santa Fe Trail (Kansas to Santa Fe)

This trail was used for trade and commerce between 1821 and 1880 (US DOI, National Park Service 2008). It extended from Missouri to New Mexico, branching into the Mountain Route and the Cimarron Route (Santa Fe 2008). Except for a short hiatus during the Mexican-American War between 1846 and 1848, the trail provided international passage of goods and travelers. Both during and after the war, the Santa Fe Trail was used heavily for freighting of military supplies to forts in the southwest. Once the railroad extended into the southwest territory, the trail was no longer used. The 1,203 miles of trail are managed by the NPS (US DOI, National Park Service 2006b) and do not cross public or NFS lands.

3.16.3 National Scenic Trails

Continental Divide

Congress designated this 3,100-mile scenic trail in 1978, extending from Canada to Mexico, crossing Montana, Idaho, Wyoming, Colorado, and New Mexico (Continental Trail Alliance 2005). The trail runs along the Continental Divide of the North America. There are approximately 1,775 miles of the trail within the project area. It crosses approximately 191 miles of public land and approximately 1,099 miles of NFS land within the planning area.

Pacific Crest

This trail runs from the Cascade and Sierra Nevada Mountains, from Canada to Mexico. It was inspired by the 1930s idea of a long-distance mountain trail and passes through 25 National Forests and 7 National Parks. It was completed in Oregon and Washington in 1987 (FS 2007i). Within the project area, it runs for approximately 1,598 miles. It traverses approximately 141 miles of public land and 1,049 miles of NFS land within the planning area.

3.17 VISUAL RESOURCES

This section describes visual resources in the project area and planning area, as well as regulations associated with visual resources.

General Visual Setting

The project area encompasses a wide variety of landscape types that can be categorized into ecological regions (or ecoregions). Attributes used to characterize an ecoregion include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology, all of which influence visual resources (US EPA 2007d). Visual resources are generally homogenous within an ecoregion. The coverage of an ecoregion within any one state varies greatly. A description and figure of the project and planning area ecoregions is provided in Section 3.9, Vegetation, and Appendix G.

Although the population is not evenly distributed across the project area or planning area, human influences have altered much of the visual landscape, especially with respect to land use and land cover. In some places, intensive human activities, such as mineral extraction and energy development, have significantly altered the natural visual landscape. Large, fast-growing cities also contain heavily altered landscapes, with urban sprawl spreading into what were recently relatively undisturbed landscapes.

3.17.1 US Department of the Interior, Bureau of Land Management Visual Resources

In accordance with FLPMA, the BLM is entrusted with the multiple-use management of natural resources on public land, which contain many outstanding qualities, including scenic landscapes. In managing public lands for multiple uses, the BLM is constrained by the legal mandate to "protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archaeological values…and provide for…human occupancy and use" (BLM 2008j).

The BLM's Visual Resource Management (VRM) system guides visual resources management on public lands (BLM 2007j). Visual resources are defined as the visible physical features on a landscape (e.g., land, water, vegetation, animals, structures, and other features). There are three stages of the VRM system: inventory (visual resource inventory), assigning VRM Management Classes, and analysis (visual resource contrast rating).

The visual resource inventory process provides BLM managers with a means for determining visual values. The process involves a scenic quality evaluation, sensitivity level analysis, and a delineation of distance zones. The process is described in detail in BLM Handbook H-8410-1, Visual Resource Inventory. Based on these three factors, BLM-administered lands are placed into one of four visual resource inventory classes. These inventory classes represent the relative value of the visual resources. Classes I and II being the most valued, Class III representing a moderate value, and Class IV being of least value. The inventory classes provide the basis for considering visual values in the resource management planning (RMP) process. Visual Resource Management classes are established through the RMP process for all BLM-administered lands. During the RMP process, the class boundaries are adjusted as necessary to reflect the resource allocation decisions made in RMP's.

Visual management objectives are established for each class. The VRM class objectives for visual resources on public lands are:

- VRM Class I Objective: To preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention.
- VRM Class II Objective: To retain the existing character of the landscape. The level of change to the characteristic landscape should be low.
- VRM Class III Objective: To partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate.
- VRM Class IV Objective: To provide for management activities which require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high.

Where a project is proposed and there are no RMP-approved VRM objectives, interim visual management classes are established (BLM 2007k). Interim classes are developed using the guidelines in Section I to V of BLM Handbook H-8410-1, Visual Resource Inventory, and must conform with the land-use allocations set forth in the RMP which covers the project area. The establishment of interim VRM classes will not require a RMP amendment, unless the project that is driving the evaluation requires one. The analysis stage (visual resource contrast rating) involves determining whether the potential visual impacts from proposed surface-disturbing activities or developments will meet the management objectives established for the area, or whether design adjustments will be required (BLM 2007j). A visual contrast rating process is used for this analysis, which involves comparing the project features with the major features in the existing landscape using the basic design elements of form, line, color, and texture. The analysis is also influenced by the number of and proximity of receptors sensitive to visual resources. This process is described in BLM Handbook H-8431-1, Visual Resource Contrast Rating. The analysis can then be used as a guide for resolving visual impacts. Once every attempt is made to reduce visual impacts, BLM managers can decide whether to accept or deny project proposals; attaching additional mitigation stipulations to bring the proposal into compliance; or change the VRM management classification through an RMP amendment.

General Description of Visual Resources by VRM Class

Visual Resource Management Class I

VRM Class I is assigned to those areas where a management decision has been made previously to maintain a natural landscape (BLM 2007k). This includes areas such as national wilderness areas, the wild section of rivers in the National Wild and Scenic Rivers System, and other congressionally and administratively designated areas where decisions have been made to preserve a natural landscape. Class I provides for natural ecological changes; however, it does not preclude very limited management activity. VRM Class I areas are typically more remote and unaltered by human disturbances than VRM Class II, III, and IV areas.

Areas with special designations (such as rivers in the National Wild and Scenic Rivers System, wilderness areas, wilderness study areas, scenic roadways, and National Park System lands) have valuable scenic resources. These areas are typically minimally developed and have greater restrictions on the types of allowable activities in order to, for example, preserve the area's visual resources. Section 3.2, Land Use, Recreation, and Special Designations describes these areas and their management.

Visual Resource Management Classes II, III, and IV

VRM Classes II, III, and IV are assigned based on a combination of scenic quality, sensitivity level, and distance zones (BLM 2007k). In VRM Class II areas, management activities may be seen but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape. In VRM Class III areas, management activities may attract attention but should not dominate the view of the casual observer. Changes should also repeat the basic elements found in the predominant natural features of the characteristic landscape. In VRM Class IV areas, management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements. Typically, VRM Class IV areas are noticeably modified by surface disturbances (such as highways and wildland-urban interface areas) or involve land-intensive activities (such as cross-country, or open, off-highway vehicle use).

3.17.2 US Department of Agriculture, Forest Service Visual Resources

The Scenery Management System, described in FS Agriculture Handbook 701, outlines the process for inventorying and analyzing aesthetic values on NFS lands (FS 1995b). Scenic resources are defined as attributes, characteristics, and features of landscapes that provide varying responses from, and varying degrees of benefits to, humans.

Scenic integrity is the state of naturalness or, conversely, the state of disturbance created by human activities or alteration (FS 1995b). Integrity is stated in degrees of deviation from the existing landscape character in a National Forest. Scenic integrity is a continuum ranging over the following five scenic integrity levels:

- Very high (unaltered): Refers to landscapes where the valued landscape character is intact with only minute, if any, deviations. The existing landscape character and sense of place is expressed at the highest possible level.
- High (appears unaltered): Refers to landscapes where the valued landscape character appears intact. Deviations may be present but must repeat the form, line, color, texture, and pattern common to the landscape character so completely and at such scale that they are not evident.
- Moderate (slightly altered): Refers to landscapes where the valued landscape character appears slightly altered. Noticeable deviations must remain visually subordinate to the landscape character being viewed.
- Low (moderately altered): Refers to landscapes where the valued landscape character appears moderately altered. Deviations begin to dominate the valued landscape character being viewed, but they borrow valued attributes such as size, shape, edge effect, and pattern of natural openings; vegetative type changes; or architectural styles outside the landscape being viewed. They should not only appear as valued character outside the landscape being viewed but compatible or complimentary to the character within.
- Very low (heavily altered): Refers to landscapes where the valued landscape character appears heavily altered. Deviations may strongly dominate the valued landscape character. They may not borrow from valued attributes such as size, shape, edge effect, and pattern of natural openings; vegetative type changes; or architectural styles within or outside the landscape being viewed. However, deviations must by shaped and blended with the natural terrain (landforms) so that elements such as unnatural edges, roads, landings, and structures do not dominate the composition.

There is also an unacceptably low scenic integrity level. It refers to landscapes where the valued landscape character being viewed appears extremely altered. Deviations are extremely dominant and borrow little, if any, form, line, color, texture, pattern, or scale from the landscape character. Landscapes at this level of integrity need rehabilitation. This level should only be used to inventory existing integrity and should not be used as a management objective.

General Description of Scenic Resources by Scenic Integrity Level

Both very high and high scenic integrity levels are for areas where primitive scenic resources are found. Typically, the foreground, middleground, and background distance zones have an undisturbed appearance. These areas are more remote and are used for low impact activities, such as hiking.

Moderate scenic integrity level areas are for areas where relatively natural scenic resources are found. Typically, the distant middleground and background distance zones have alterations to scenic resources that are visible but difficult to identify. Some effort is needed to access these areas.

Both low and very low scenic integrity levels are for areas where scenic resources are altered by human activities and structures. Typically, the foreground, middleground, and background distance zones have disturbances to scenic resources that are readily noticeable. These areas are readily accessible due to the presence of roads and are used for high-impact activities, such as OHV recreation.

Scenic integrity level objectives outlined in forest plans identify how scenic resources are to be managed. The objectives vary depending on the location, quality, uniqueness, sensitivity, and desired use of the scenic resources.

3.17.3 Other Visual Resources

Management of visual resources on non-BLM and non-FS lands is likely to be influenced by local planning documents. For example, county general plans typically contain elements that address, for example, conservation of natural resources or open space. In areas with hilltops and ridgelines, general plans can include actions that restrict development that would result in skylining (or silhouetting) of structures on hilltops and ridgelines. In areas with scenic roadways, general plans can include actions intended to maintain the attractiveness of the roadway. Also, in areas with valleys or expansive vistas, general plans can include actions to protect structures from blocking or altering these views. Furthermore, local planning documents have recently begun addressing nighttime lighting in order to minimize light pollution, as well as to conserve energy. Light pollution can be defined as any adverse effect of artificial light, including sky glow, glare, light trespass, light clutter, and decreased visibility at night.

3.18 SOCIOECONOMICS AND ENVIRONMENTAL JUSTICE

3.18.1 Socioeconomic Influences of Geothermal Development and Operation

The construction and operation of geothermal power plants contributes to local, state, and national economies through the creation of jobs, generation of property taxes, payments of revenues, and voluntary contributions to local communities. The construction of direct-use facilities also contributes to economies through job creation and property tax generation. While estimates on the economic impacts of direct-use facilities are not available, a description of the impacts of geothermal electrical generation on economies is described below.

Jobs

Areas of high geothermal potential are often located in rural areas, which typically have chronic, high unemployment rates. The development of geothermal resources in such rural areas can improve local socioeconomic conditions. The construction of a 50-megawatt geothermal power plant could create several hundred temporary construction and related development jobs that would last from two to three years. Between 30 and 50 permanent, high-skilled, full-time jobs at the facility would pay well above minimum wage. Such a development project should provide approximately 90 to 150 new full-time jobs in the community after considering the economic multiplier effect; the idea that a single expenditure in an economy can have repercussions throughout the entire economy The long lifetime of geothermal plants means that they can become a stable, reliable part of a community's economic base (National Geothermal Collaborative 2007).

Property Tax

The development of a geothermal power plant represents a large capital investment in the county in which it is constructed. These plants can generate substantial property taxes for the local county, and considering that many geothermal development locations are in rural areas, the additional revenue stream can result in a substantial increase in the county's tax base (National Geothermal Collaborative 2007). Property taxes are based on the estimated value of the company assets. In 2003, the Geysers, the largest complex geothermal power plant in the world (located north of San Francisco), paid property taxes to two counties totaling more than $11 million. At the geothermal power plants in Inyo County, California, plant owners pay approximately $6 million annually, of which roughly two-thirds is used to fund schools (Kagel 2006). The 10 geothermal power plants installed in Imperial County, California, have a capacity of 330 megawatts and generate approximately $10 million annually in property tax, which represents 20 percent of the county's total property tax revenue (National Geothermal Collaborative 2007).

Revenue Payments

Revenues are monies paid by a geothermal developer to the owner of the leased land on which a power plant operates. Revenues include lease sales and rental fees, bonus bids, and royalties or direct use fees. Royalties are based on a percentage of a developer's revenues, currently set at 1.75 percent of gross revenue from electricity sales for the first 10 years of a lease, and 3 percent thereafter for federal lands for competitive geothermal leases issued under the Energy Policy Act of 2005 and non-producing leases that elect to convert to the new royalties. Producing leases and those noncompetitive lease applications that were grandfathered and those producing leases that do not convert to the new royalty rate will continue to pay a royalty of 10 percent of net proceeds. The 1970 Geothermal Steam Act mandates that in states where the federal government collects geothermal revenues, 50 percent of the total shall be returned to the state in which the resource is located. Based on 2005 amendments, the remaining 50 percent will be equally divided between the county and federal government (Federal Register 2007). As an example of the scale of revenues being generated, in fiscal year 2007, Nevada had approximately 235 megawatts of geothermal electric-generating capacity on government lands, which provided 5.5 percent of the state's power. In that year alone, Nevada received $8.8 million in revenues (competitive lease sales = $5.7 million, royalties = $2.5 million, and lease rentals = $623.8 thousand) of which the counties received $4.4 million (US DOI MMS 2007, BLM 2007a).

Voluntary Payments

Geothermal companies often donate funds to the communities in which they are located. In California, the Mammoth Pacific power plant has been designated a "good neighbor" by many locals for its financial contributions to local groups and for building a new community center from the power plant's proceeds (Kagel 2006).

3.18.2 Socioeconomic Influences of Existing Geothermal Power Plants

As of 2004, geothermal represented approximately one percent of the electricity-generating capacity in the project area, excluding Alaska, equating to approximately 3,195 megawatts (Western Governors' Association 2006). By using the relationships described above between the size of power plants and produced economic stimulus, the following are estimates of the existing contribution of geothermal power plants to economies in the project area:

- Jobs: between 1,917 and 3,195 permanent, full-time jobs that pay above minimum wage, using the ratio of approximately 30 to 50 full-time jobs for a 50-megawatt power plant, as described above;
- Property taxes: approximately $96.8 million annually at the rate generated in Imperial County, California, as described above; and
- Revenue Payments: approximately $230 million annually at the rate generated in Nevada, as described above.

3.18.3 Existing Project Area Socioeconomic Conditions

The use of project area public and NFS lands for geothermal energy development affects the demographic characteristics and economies of the project area. Additionally, social structure and values within the project area shape the demand and opportunities created by public and NFS lands. For these reasons, demographic, economic, and social data for the project area are presented in this section.

Socioeconomic resources include historic, current, and forecasted population statistics, race/ethnicity, age distribution, housing, and poverty. Such data provide background on population growth, distribution of racial/ethnic minorities and low-income groups, and population aging. These factors are reflected in the project area's economics and social values. Economic development is measured through employment, personal income, tax revenues (sales and state income), gross state product, and government revenues and expenditures. For each development measure, data is presented for a selection of years with available data between 1990 and 2006 to provide historical trends for the project area. Forecasts for each measure provide future expectancy of each measure. It should be noted that the forecasts presented are estimates based on past annual rates only and do not attempt to factor in the variety of economic and social factors that are likely to influence future growth in each development measure. In addition, dollar amounts presented are not adjusted for inflation.

Due to the nature of Census data, economic statistics could not be obtained specifically for the planning area; trends for the planning area are assumed to reflect the same general trends seen in the project area.

Population

Total project area population was estimated at 68.3 million in 2006 and is expected to reach over 80 million by 2015 and 95 million by 2025. California had the highest population concentration in the project area with more than 53 percent of the project area's total population in 2006. Table 3-29, Total Project Area Population (in millions), displays population trends from 1990 to 2006, as well as population forecasts for 2015 and 2025.

The project area's population grew at an annual average rate of 2 percent between 1990 and 2006. The largest population growth occurred in Nevada with a 6.7-percent increase, while the lowest growth occurred in Montana and Wyoming, with .7 and .8 percent increases, respectively. Relatively high growth rates in the remaining states were estimated for Arizona (3.3 percent), Utah (2.6 percent), Idaho (2.6 percent), and Colorado (2.4 percent). Close-to-average growth occurred in New Mexico (1.8 percent), Oregon (1.8 percent), and Washington (1.7 percent), with lower-than-average growth rates in the remaining states.

Table 3-29
Total Project Area Population (in millions)

State	1990	2006	Average Annual Growth Rate 1990-2006 (%)	2015 (Projected)	2025 (Projected)
Alaska	0.6	0.7	1.0	0.7	0.8
Arizona	3.7	6.2	3.3	7.5	9.5
California	29.8	36.5	1.3	40.0	44.3
Colorado	3.3	4.8	2.4	5.0	5.5
Idaho	1.0	1.5	2.6	1.6	1.9
Montana	0.8	0.9	0.7	1.0	1.1
Nevada	1.2	2.5	4.7	3.1	3.9
New Mexico	1.5	2.0	1.8	2.0	2.1
Oregon	2.8	3.7	1.8	4.0	4.5
Utah	1.7	2.6	2.7	2.8	3.2
Washington	4.9	6.4	1.7	7.0	8.0
Wyoming	0.5	0.5	0.8	0.5	0.6
Project Area	**51.5**	**68.3**	**1.8**	**80.0**	**95.0**

Source: US Bureau of the Census 2007a

Age Distribution

As illustrated in Table 3-30, Project Area Age Distribution (2006), the project area's median age in 2006 was 32.4 years, with Montana (39.2 years) and Utah (28.3 years) having the highest and lowest median ages, respectively. Approximately 24 percent of the project area's population was children (under 18 years of age), while slightly over 10 percent of the project area's population were older than 65 years. Utah, at 31.1 percent, possessed the highest percentage of children in 2006, followed by Idaho (26.9 percent), Alaska (26.8 percent), Arizona (26.4 percent), California (26.1 percent), and New Mexico (26.1 percent). The number of children in the remaining states was close to the project area average (within 2 percentage points). Alaska and Utah, at 6.8 percent and 8.8 percent, respectively, contributed to the smallest population percentage whose age was over 65 years, while Montana (at 13.8 percent) had the highest number of elderly in the project area. The remaining states had an elderly population near the project area's average.

Table 3-30
Project Area Age Distribution (2006)

State	Median Age	Percent Children (under 18 Years of Age)	Percent Elderly (over 65 Years of Age)
Alaska	33.4	26.8	6.8
Arizona	34.6	26.4	12.8
California	34.4	26.1	10.8
Colorado	35.4	24.6	10.0
Idaho	34.2	26.9	11.5
Montana	39.2	23.1	13.8
Nevada	35.5	25.4	11.1
New Mexico	35.3	26.1	12.4
Oregon	37.5	23.2	12.9
Utah	28.3	31.1	8.8
Washington	36.7	23.9	11.5
Wyoming	37.1	23.5	12.2
Project Area	**35.13**	**25.59**	**11.22**

Source: US Bureau of Census 2007a

Vacant Housing

Table 3-31, Project Area Available Housing Units (in thousands), shows the number of vacant housing units in 1990 and 2000, with the percent change over the 10-year period, as well as the projected vacant housing of the project area in 2010. The number of total vacant housing units in the project area was estimated at 1.9 million in 2000; vacant housing units are expected to drop off to 1.8 million by 2010. California, with the largest population in the project area, also had the largest number of available housing units. Vacant housing units in California were estimated at 711,700 in 2000 (almost 40 percent of the project area's total), but are expected to decrease to 633,500 by 2010. Arizona, with 288,000 units, and Washington, with 180,000 units, had the next-largest numbers of vacant units after California.

There was a slight decline in the number of vacant housing units between 1990 and 2000, with a total annual growth rate of -0.26 percent for the project area. Most states experienced a decline in available housing units between 1990 and 2000. States with higher-than-average annual drops in vacant units were Colorado (-2.6 percent), Wyoming (-1.4 percent), California (-1.2 percent), and Alaska (-1.0 percent), while states such as Nevada (3.8 percent), Oregon (2.8 percent), and New Mexico (1.4 percent) experienced fairly large increases in vacant housing units.

Table 3-31
Project Area Available Housing Units (in thousands)

State	1990	2000	Average Annual Growth Rate 1990-2000 (%)	2010 (Projected)
Alaska	43.7	39.4	-1.0	35.5
Arizona	290.6	287.9	-0.1	285.2
California	801.7	711.7	-1.1	631.8
Colorado	194.9	149.8	-2.3	114.9
Idaho	52.6	58.2	1.1	64.6
Montana	55.0	54.0	-0.1	53.0
Nevada	52.6	76.3	4.5	110.6
New Mexico	89.3	102.6	1.4	117.9
Oregon	90.3	119.0	3.2	157.0
Utah	61.1	67.3	1.0	74.1
Washington	160.0	179.7	1.2	201.8
Wyoming	34.6	30.2	-1.3	26.3
Total	**1926.4**	**1876.1**	**-0.26**	**1,827.8**

Source: US Bureau of Census 2007a

Employment

Between 1990 and 2006, project area labor force and employment grew by 1.7 percent, while unemployment dropped slightly. Tables 3-32, Project Area State Labor Force and Employment (in millions), and 3-33 Project Area State Unemployment (in millions), show employment and unemployment data for the project area, between 1990 and 2006. Employment growth rates were highest in Nevada (4.4 percent) and Arizona (3.2 percent) than the rest of the project area. Growth rates in Montana (1.4 percent) and California (1.1 percent) were less than the project area's average growth.

Almost 53 percent (16.9 million) of all project area (32.2 million) employment was concentrated in California. Employment in Washington, Arizona, and Colorado in 2006 stood at 3.1 million, 2.8 million, and 2.1 million respectively; the remaining states supported less than 7 million jobs. Employment in the project area as a whole is projected to increase to 37 million in 2014; California is expected to provide 50 percent (18.4 million) of project area employment by 2014. Unemployment rates dropped for all states except Oregon; the highest drop in unemployment rates occurred in Wyoming and Montana.

Table 3-32
Project Area State Labor Force and Employment (in millions)

State	Labor Force 1990	Labor Force 2006	Labor Force Average Annual Growth Rate 1990-2006 (%)	Employment 1990	Employment 2006	Employment Average Annual Growth Rate 1990-2006 (%)	Employment 2014 (Projected)
Alaska	0.27	0.35	1.6	0.25	0.32	1.5	0.4
Arizona	1.8	2.9	3.8	1.7	2.8	3.1	3.6
California	15.0	17.8	1.1	14.2	16.9	1.1	18.4
Colorado	1.7	2.6	2.7	1.7	2.5	2.4	3.0
Idaho	0.5	0.7	2.1	0.5	0.7	2.1	0.8
Montana	0.4	0.5	1.4	0.4	0.5	1.4	0.6
Nevada	0.6	1.3	5.0	0.6	1.2	4.3	1.7
New Mexico	0.7	0.9	1.6	0.7	0.9	1.6	1.0
Oregon	1.5	1.9	1.5	1.4	1.8	1.6	2.0
Utah	0.8	1.3	3.1	0.8	1.2	2.5	1.5
Washington	2.5	3.3	1.8	2.4	3.1	1.6	3.5
Wyoming	0.2	0.3	2.6	0.2	0.3	2.5	0.4
Total	**26.0**	**33.9**	**1.7**	**24.9**	**32.2**	**1.6**	**36.9**

Source: US Department of Labor 2007a, 2007b

Table 3-33
Project Area State Unemployment (in millions)

State	1990 Unemployment	1990 Unemployment Rate	2006 Unemployment	2006 Unemployment Rate
Alaska	0.02	7.2	0.02	7.0
Arizona	0.09	5.1	0.10	4.4
California	0.80	5.1	0.90	5.1
Colorado	0.01	5.2	0.10	4.7
Idaho	0.03	5.3	0.03	3.7
Montana	0.02	6.0	0.02	3.5
Nevada	0.03	4.7	0.05	4.1
New Mexico	0.05	6.7	0.04	4.7
Oregon	0.08	4.9	0.10	5.5
Utah	0.03	4.3	0.04	3.4
Washington	0.10	5.1	0.20	4.9
Wyoming	0.01	5.7	0.01	3.0
Total	**1.3**	**5.0**	**1.61**	**4.9**

Source: US Department of Labor 2007a, 2007b

Personal Income

Table 3-34, Project Area State Personal Income indicates that personal income in the project area grew by 5.9 percent between 1996 and 2006. Growth rates in personal income were highest in Nevada (8.4 percent) over the 10-year period; growth rates in the remaining 11 states were within 1.7 percent of the project area's average rate of 5.9 percent.

California, with a personal income growth rate at 5.9 percent in the 10-year period, generated almost 60 percent of the project area's personal income, producing almost $1.4 trillion in 2006. Personal income in California is expected to reach $1.8 trillion by 2010. For the project area as a whole, personal income is expected to increase from $2.5 trillion in 2006 to $3.2 trillion in 2010.

Table 3-34
Project Area State Personal Income (in billions of dollars*)

State	1996	2006	Average Annual Growth Rate 1996-2006 (%)	2010 (Projected)
Alaska	15.7	25.9	5.1	31.6
Arizona	95.5	197.0	7.5	263.2
California	810.4	1,434.9	5.9	1,803.3
Colorado	100.2	188.2	6.5	242.2
Idaho	24.4	43.9	6.1	55.5
Montana	16.9	29.2	5.6	36.3
Nevada	43.5	97.4	8.4	134.5
New Mexico	33.3	58.1	5.7	72.6
Oregon	76.0	123.1	4.9	149.3
Utah	40.4	75.9	6.5	97.7
Washington	139.7	243.5	5.7	304.1
Wyoming	10.7	20.9	6.9	27.3
Total	**1406.5**	**2,538.0**	**5.9**	**3186.07**

* not adjusted for inflation
Source: US Department of Commerce 2007b

Gross State Domestic Product

The total value of goods and services produced in each state, or gross state product, was estimated at $3,080 billion for the project area in 2006 and is expected to reach $3,866 billion by 2010 (Table 3-35, Project Area Total Gross Domestic Product). More than 56 percent ($1,727 billion) of total gross state product was produced in California in 2006.

Table 3-35
Project Area Total Gross Domestic Product (in billions of dollars*)

State	1990	2006	Growth Rate 1990-2006 (%)	2010 (Projected)
Alaska	24.9	41.1	3.2	47.0
Arizona	69.3	232.5	7.9	314.7
California	788.3	1,727.4	5.0	2,101.7
Colorado	74.2	230.5	7.3	306.0
Idaho	17.8	49.9	6.7	64.6
Montana	13.4	32.3	5.7	40.2
Nevada	31.8	118.4	8.7	164.4
New Mexico	26.9	75.9	6.7	98.3
Oregon	57.3	151.3	6.3	192.9
Utah	31.4	97.7	7.4	129.8
Washington	115.6	293.5	6.0	370.5
Wyoming	13.1	29.6	5.2	36.3
Total	**1264.0**	**3080.1**	**5.57**	**3,866.0**

* not adjusted for inflation
Source: US Department of Commerce 2007a

Total project area production grew at a rate of 5.57 percent between 1990 and 2006. The gross state product growth rate was uneven across the project area states, with higher-than-average rates for Nevada (8.7 percent), Arizona (7.9 percent), Utah (7.4 percent), and Colorado (7.3 percent). Below-average growth rates occurred in Wyoming (5.2 percent), California (5.0 percent), and Alaska (3.2 percent).

State Income Tax Revenues

As shown in Table 3-36, Project Area State Income Tax Revenues, the majority of the project area experienced moderately large annual increases in income tax revenues between 1996 and 2006. Increases in California (13.3 percent) were higher than the project area average (12.2 percent); whereas Idaho (7.5 percent) and Montana (8 percent) experienced relatively slow increases in income tax revenues. While increases in Alaska were high at, 16.6 percent, it should be noted that Alaska has no personal tax income, therefore this data reflects only corporate tax income data.

In 2006, California produced $61.5 billion in income taxes, generating 74 percent of total state income tax revenues in the project area. Oregon was the second-largest state income tax producer with $5.9 billion in 2006. Revenues for the entire project area are projected to increase from $83.4 billion in 2006

Table 3-36
Project Area State Income Tax Revenues (in billions of dollars*)

Including Personal and Corporation Income tax unless otherwise noted

State	1996	2006	Average Annual Growth Rate 1996-2006 (%)	2010 (Projected)
Alaska[1]	0.3	0.8	16.6	1.2
Arizona	1.9	4.1	8.0	5.6
California	26.6	61.5	13.1	86.0
Colorado	2.5	4.7	8.8	6.1
Idaho	0.8	1.4	7.5	1.8
Montana	0.5	0.9	8.0	1.1
Nevada[2]	-	-	-	-
New Mexico	0.8	1.5	8.7	1.9
Oregon	3.1	5.9	9.0	7.6
Utah	1.3	2.6	10.0	3.4
Washington[2]	- [a]	-	-	-
Wyoming[2]	- [a]	-	-	-
Total	**37.8**	**83.4**	**12.1**	**114.5**

* Not adjusted for inflation

[1]There are no personal or corporate state income taxes in Nevada, Washington, Wyoming.

[2]There are no personal state income taxes in Alaska, data reflects corporation net income tax only.

Source: US Bureau of Census 2007b

to $114.5 billion in 2010. Revenues in California are expected to reach $86 billion in 2010.

Sales Tax Revenues

Total sales tax revenues for the project area are projected to grow from $57.7 billion in 2006 to $74.8 billion in 2010 (Table 3-37, Project Area State Sales Tax Revenues)Between 2002 and 2010, sales tax revenues are expected to grow for each individual state, with revenues in the largest generating state, California, projected to reach $40 billion in 2010.

During the period from 1997 to 2002, higher-than-average annual growth in sales tax revenues occurred in Arizona (9.6 percent), Wyoming (10.0 percent), Nevada (10 percent), and California (6.9 percent). The average annual growth rate for the project area as a whole during this period was 6.7 percent.

Table 3-37
Project Area General State Sales Tax Revenues (in billions of dollars*)

State	1996	2006	Growth Rate 1997-2006 (%)	2010 (Projected)
Alaska[1]	-	-	-	-
Arizona	2.7	5.3	9.6	7.20
California	19.0	32.1	6.9	40.0
Colorado	1.3	2.1	6.1	3.3
Idaho	0.9	1.1	5.1	1.5
Montana[1]	-	-	-	-
Nevada	1.6	3.2	10.0	4.7
New Mexico	1.3	1.7	3.1	1.9
Oregon	-	-	-	-
Utah	1.2	1.9	5.8	2.4
Washington	6.2	10.0	6.1	12.7
Wyoming	0.3	0.6	10.0	.88
Total	**34.5**	**57.7**	**6.7**	**74.8**

* not adjusted for inflation
[1]There are no general state sales taxes in Alaska, Montana or Oregon.
Source: US Bureau of Census 2007b

State and Local Government Expenditures

Funding for state and local government services for the project area in 2002 was concentrated in California at $293.3 billion, 60 percent of the total amount of $504.9 billion for the project area (Table 3-38, Project Area Total State and Local Government Expenditures). Other states with relatively large state and local government expenditure are Washington ($50.4 billion), Colorado ($32.4 billion), Arizona ($31.9 billion), and Oregon ($27.7 billion).

Annual growth rates in state and local government expenditures have increased fairly rapidly throughout the project area, with an overall annual average rate of 8.0 percent over the period of 1997 to 2002. Colorado's growth rate at 9.5 percent was more than one percentage point higher than the project area average, while growth rates in Alaska (4.6 percent) and Montana (5.0 percent) were relatively low during the period.

Table 3-38
Project Area Total State and Local Government Expenditures (in billions of dollars*)

State	1997	2002	Average Annual Growth Rate 1997-2002 (%)	2010 (Projected)
Alaska	7.5	9.4	4.6	13.5
Arizona	21.2	31.9	8.5	61.3
California	196.0	293.3	8.4	559.0
Colorado	20.6	32.4	9.5	66.9
Idaho	5.4	7.6	7.1	13.1
Montana	4.4	5.6	5.0	8.2
Nevada	9.2	14.0	8.8	27.4
New Mexico	9.3	12.7	6.4	20.9
Oregon	19.9	27.7	6.8	47.0
Utah	10.8	15.5	7.5	27.6
Washington	36.1	50.4	6.9	86.0
Wyoming	3.2	4.3	6.1	6.9
Total	**343.6**	**504.9**	**9.3**	**934.2**

* not adjusted for inflation
Source: US Bureau of Census 2007c

Alternative Economic Values

In addition to traditional development that provides employment and income to the rural west, an economic value can be attributed to the project area for its amenities. Likewise, some cost can be attributed for the protection of these values. Amenities are those features, either developed or undeveloped, that attract visitors to an area (e.g., recreation opportunities, wildlife viewing, solitude, etc.). Recreation (both individual and commercial) and tourism support local and niche businesses throughout public and FS lands. This type of income is dependant on the open space to support the amenities that attract recreationists and others in search of this locale.

State and Local Government Employment

State and local government employment data for 1995 and 2006 have been recorded in Table 3-39, Project Area Total State and Local Government Employment (in thousands). As shown in the table, growth in government employment in the project area has been varied over the 11-year period. The overall annual employment growth for the project area stood at 1.8 percent over the period, while states such as Nevada increased their employment by 3.1 percent, with a slightly smaller but still large increase in Arizona (2.4 percent).

Table 3-39
Project Area Total State and Local Government Employment (in thousands)

State	1995	2006	Average Annual Growth Rate 1995-2006 (%)	2010 (Projected)
Alaska	45.6	52.6	1.4	55.4
Arizona	218.8	285.1	2.4	313.9
California	1,479.6	1,818.7	1.9	1,960.4
Colorado	204.9	255.0	2.0	276.1
Idaho	67.1	79.4	1.5	84.4
Montana	56.3	54.2	-.3	53.5
Nevada	73.5	103.3	3.1	116.9
New Mexico	110.7	127.9	1.3	134.8
Oregon	166.1	181.7	.8	187.7
Utah	104.8	128.8	1.9	138.8
Washington	283.2	333.2	1.5	353.5
Wyoming	37.9	45.8	1.7	49.1
Total	**2,848.5**	**3,465.7**	**1.8**	**3,721.9**

Source: US Bureau of Census 2007c

The majority of the states were within half a percentage point of the total project area growth, while Oregon (.8 percent) saw slower growth and Montana (-.3 percent) experienced a decline in government employment.

California's government employment stood at 1.8 million in 2006, holding 52 percent of project area's total, and is expected to reach 2.0 million in 2010. Other states with relatively large totals of government employees in 2006 were Washington (333,200), Arizona (285,100), and Colorado (255,000). Total employment in the project area was more than 3.4 million in 2006 and is expected to exceed 3.7 million in 2010.

Environmental Justice

As required by NEPA, and specifically in accordance with Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations, federal agencies must incorporate environmental justice as part of their missions. This section addresses topics related to environmental justice, providing specific information on economic, racial, and demographics in and around the project area to identify areas of low-income and high-minority populations.

A summary of the geographic distribution of low-income and minority populations, based on the demographic data from the 2006 American Community Survey (US Bureau of the Census 2007a) for each project area state is presented in Table 3-40, Project Area Minority and Low-income Population Composition. For the data presented in this table, the following definitions describe low-income and minority population categories:

- Minority: The minority category includes persons who classify themselves as belonging to any of the following racial groups: Hispanic or Latino, Black or African American, American Indian or Alaskan Native, Asian, Native Hawaiian or Other Pacific Islander, and some other race (non-White). The term minority includes all persons classifying themselves in various racial categories, except those identifying themselves as not of Hispanic origin and as White or Other Race (US Bureau of Census 2007a).
- Low-Income: The Bureau of Census determines which families or individuals are poor using a set of money income thresholds, taking into account family size and composition. Those families or individuals that fall below their relevant poverty threshold are considered low income.

In 2006, the project area minority population was estimated at 30 million (44.3 percent of total project area population). Some individual states hosted a relatively large number of minority individuals. Of total population in New Mexico, 57.6 percent were considered minority, followed by 57.2 percent in California, 41.4 percent in Nevada, and 40.5 percent in Arizona. In each of the above states, as well as the project area as a whole, the Hispanic population dominated the minority ethnic groups. Of all the states, New Mexico and California have minority populations that exceed the project area minority population, as well as exceeding half of the total population of each state. Montana (11.4 percent), Wyoming (12.0 percent), Idaho (13.7 percent), Utah (17.2 percent), and Oregon (19.2 percent) have minority populations well (more than 20 percentage points) below the project area average.

The project area poverty (low-income) rate is estimated at 12.9 percent, exceeding the poverty rates of more than half of the project area states. States with poverty rates higher than the average for the project area are New Mexico (18.5 percent), Arizona (14.2 percent), Oregon (13.3 percent), Montana (13.6 percent), and California (13.1 percent). Out of all the project area states, New Mexico (at 18.5 percent) holds the highest poverty rate, while Wyoming has the lowest poverty rate (9.4 percent).

Table 3-40
Project Area Minority and Low-income Population Composition

Parameter	Alaska	Arizona	California	Colorado	Idaho	Montana
Total Population	670,053	6,166,318	36,457,549	4,753,377	1,466,465	944,632
White, Non-Hispanic	443,944	3,668,571	15,600,175	3,400,011	1,265,241	836,541
Hispanic or Latino	37,498	1,803,377	13,074,155	934,410	138,871	20,513
Non-Hispanic or Latino Minorities	188,611	694,370	7,783,219	418,956	62,353	87,578
One race	140,871	610,190	7,065,079	340,937	37,384	70,035
Black or African American	20,419	198,854	2,201,043	170,995	6,105	4,327
American Indian or Alaskan Native	86,688	252,214	168,486	29,223	13,708	58,034
Asian	29,622	139,386	4,424,529	127,082	14,884	5,509
Native Hawaiian or Other Pacific Islander	3,526	9,326	120,837	3,700	2,021	763
Some other race	616	10,410	150,184	9,937	666	1,402
Two or more races	47,740	84,180	718,140	78,019	24,969	17,543
Total minority	226,109	2,497,747	20,857,374	1,353,366	201,224	108,091
Low-income	73,036	875,617	4,775,939	570,405	184,774	128,470
Percent minority	33.7	40.5	57.2	28.5	13.7	11.4
Percent low-income	10.9	14.2	13.1	12.0	12.6	13.6

Table 3-40
Project Area Minority and Low-income Population Composition

Parameter	Nevada	New Mexico	Oregon	Utah	Washington	Wyoming	Project Area
Total Population	2,495,529	1,954,599	3,700,758	2,550,063	6,395,798	515,004	*68,070,145*
White, Non-Hispanic	1,463,452	828,965	2,989,235	2,112,440	4,886,203	453,251	*37,948,029*
Hispanic or Latino	610,051	860,687	379,034	286,113	580,027	35,732	*18,760,468*
Non-Hispanic or Latino Minorities	422,026	264,947	332,489	151,510	929,568	26,021	*11,361,648*
One race	366,233	243,503	244,073	118,698	752,915	19,189	*10,009,107*
Black or African American	178,999	35,849	60,985	21,303	211,333	3,269	*3,113,481*
American Indian or Alaskan Native	26,393	176,968	36,631	27,061	83,313	10,497	*969,216*
Asian	146,075	23,557	134,601	47,871	418,886	4,311	*5,516,313*
Native Hawaiian or Other Pacific Islander	9,871	1,053	7,934	18,958	26,691	350	*205,030*
Some other race	4,895	6,076	3,922	3,505	12,692	762	*205,067*
Two or more races	55,793	21,444	88,416	32,812	176,653	6,832	*1,352,541*
Total minority	1,032,077	1,125,634	711,523	437,623	1,509,595	61,753	*30,122,116*
Low-income	257,040	361,601	492,201	270,307	754,704	48,410	*8,792,504*
Percent minority	41.4	57.6	19.2	17.2	23.6	12.0	*44.3*
Percent low-income	10.3	18.5	13.3	10.6	11.8	9.4	*12.9*

Source: US Bureau of Census 2007a

3.19 HEALTH AND SAFETY

This section describes health and safety concerns associated with geothermal energy development. Also discussed is the regulatory framework around health and safety of workers involved with geothermal energy development.

3.19.1 Applicable Plans, Policies and Regulations

Occupational health and safety issues pertaining to geothermal resource development include exposure to geothermal gases, confined spaces, heat, and noise. Occupational health and safety rights for individuals are protected through the federal Occupational Safety and Health Act (29 USC 651 et seq.). Under this act, Congress created the Occupational Safety and Health Administration (OSHA), an agency of the US Department of Labor. The OSHA's mission is to assure the safety and health of America's workers by setting and enforcing standards; providing training, outreach, and education; establishing partnerships; and encouraging continual improvement in workplace safety and health. States may have additional laws and regulations that build on the Occupational Safety and Health Act.

Hazardous and toxic substances would be used and generated during the various phases of geothermal resource development. These substances have hazardous physical and chemical properties (e.g., ignitability, corrosivity, reactivity) and may also have high toxicity. There are numerous federal laws that regulate hazardous and toxic substances. Of these laws, the most far reaching are discussed below. States may also have additional laws that regulate the management of hazardous and toxic substances.

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a hazardous substance is any material the US EPA has designated for special consideration under the Clean Air Act, Clean Water Act, Toxic Substances Control Act, or Resource Conservation and Recovery Act (US EPA 2007e). The US EPA also may designate additional substances as being hazardous under CERCLA. Hazardous wastes or substances can be hazardous to human health or the environment when they are improperly managed and possess at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity) or appear on other EPA lists of substances deemed to be hazardous in some way.

The Resource Conservation and Recovery Act is a federal law enacted in 1976. Three primary goals of the Act are to protect human health and the environment from the potential hazards of waste disposal, to reduce the amount of waste generated, and to ensure that wastes are managed in an environmentally sound manner (US EPA 2006). In 1984, Congress enacted the Hazardous and Solid Waste Amendments, which expanded the scope of the Act by implementing management for hazardous wastes from their manufacture all the way through to their final disposal.

3.19.2 Typical Hazards of the Geothermal Industry

There are physical hazards associated with all phases of geothermal development: exploration, development, operation, and close out. Many of the hazards associated with geothermal energy development are shared by other energy industries. Existing hazards are usually associated with site excavation, road building, exploration drilling, flow testing, well venting, power plant construction, power plant operation, and transmission line construction. Thermal hazards are also present whenever working with heated fluids. Adherence to safety standards and use of protective equipment can reduce occupational hazards and the chance of burns from geothermal fluids, but work-related injuries and fatalities can still occur.

Chemical hazards associated with naturally occurring contaminants may also be present in geothermal fluids. Human exposure may occur during the exploration, development, operation, or close out phases of a geothermal project. Health effects may be acute or chronic, and exposure may be via inhalation of geothermal steam or ingestion of geothermal fluids (drinking contaminated water). Watson and Etnier (1981) report that the most frequent and severe of reported injuries to geothermal workers is dermal exposure to caustic sludges produced by H_2S abatement systems.

Inhalation of Noncondensable Gases

The primary human health issue within the geothermal energy working environment is the inhalation of noncondensable gases that form when geothermal fluids turn to steam. Steam is produced during drilling, flow testing, well venting, and cooling of geothermal fluids as part of standard power plant operations. The primary gas of concern is hydrogen sulfide, while others such as mercury, radon, and benzene are also present but are typically not at levels considered hazardous to human health.

Total noncondensable gas emissions from geothermal resources typically comprise less than five percent of the total steam emitted (Reed and Renner 1995). Binary power plants reinject all geothermal fluids into the reservoir, thereby eliminating emissions concerns; however, emissions do occur during flow testing and well venting.

Hydrogen Sulfide

Hydrogen sulfide emissions have resulted in complaints of odor annoyance and health impairment. The OSHA has established an acceptable maximum concentration of 20 parts per million (ppm) for hydrogen sulfide in the workplace, with a maximum level of 50 ppm allowed for 10 minutes maximum if no other measurable exposure occurs. The National Institute for Occupational Safety and Health has set a maximum recommended exposure limit ceiling value of 10 ppm for 10 minutes maximum (Agency for Toxic Substances and Disease Registry 2006).

Anspaugh and Hahn (1979) evaluated occupational hazards at the Geysers in California. While this information is nearly 30 years old, the more significant hazards at that time were exposure to toxic chemicals, hazardous materials, and noise. The most significant cause of illness was exposure to the chemicals and wastes associated with hydrogen sulfide abatement. Anspaugh and Hahn concluded that, on a comparative basis, geothermal energy is a relatively benign source of energy. The chemical exposure issues mentioned above are shared by many other energy technologies including oil and gas, oil shale, and nuclear.

Anspaugh and Hahn (1979) also reviewed public health concerns related to the Geysers Geothermal Power Plant. Residents of communities near the Geysers filed public health complaints, most of which were related to annoyance effects, particularly to odor annoyance from hydrogen sulfide. Some residents appeared at hearings held by the California Public Utilities Commission and voiced complaints of headaches, nausea, and sinus congestion. The concentrations of hydrogen sulfide that appear to be responsible for these complaints were about 0.1 ppm, or 100 times lower than the recommended standard for occupational exposure. Whether such low concentrations of hydrogen sulfide can produce actual health effects remains to be proven, but the possibility does exist that some individuals are particularly sensitive.

While abatement systems can reduce levels of hydrogen sulfide, some abatement systems have their own suite of chemicals and wastes, exposure to which can also result in occupational illness. Chemicals used in hydrogen sulfide abatement systems include hydrogen peroxide, caustic soda, and catalytic compounds containing iron and nickel. Waste is primarily sludge made of noncommercial quality sulfur with lesser amounts of other chemicals (Anspaugh and Hahn 1979).

Mercury

Mercury levels vary between geothermal resources and are not present in all geothermal fluids. In those resources containing mercury, power production could result in mercury emissions, depending upon the type of plant. Binary plants do not emit any mercury because all geothermal fluids are reinjected into the geothermal reservoir. Mercury abatement technology is available for power plants using resources with elevated mercury content. State and local governments have introduced measures to reduce mercury emissions from a variety of sources and have resulted in the presence of mercury abatement measures at most geothermal facilities currently in production (Geothermal Energy Association 2007b).

Radon

Radon is a toxic radioactive gas with no color, odor, or taste that forms from the normal decay process of uranium, which is present in most rocks and soil. Radon is present in geothermal fluids and is released to the air from cooling towers. It is generally only a concern in indoor areas where concentrations can build up over time. A study of radon levels at the Geysers concluded that the cooling towers had no discernible effect on ambient radon levels in either nearby communities or in the plant environment itself (Layton and Anspaugh 1981).

Benzene

Benzene is a known carcinogen that is present in some geothermal fluids, but levels are generally within acceptable ranges. The Heber geothermal facility in southern California was required to conduct quarterly benzene cooling tower analysis as a permit condition; however, levels have never been high enough to trigger risk assessments under the California Environmental Protection Agency exposure level standards (Geothermal Energy Association 2007b).

Drilling Hazards

Due to limited research of the geothermal industry, extensive hazard data for geothermal drilling activities are not available. However, drilling hazards associated with the geothermal industry are generally similar to hazards experienced with the well-documented hazards of drilling for the oil and gas industry. Table 3-41 provides a description of the common types of hazards associated with oil and gas drilling.

Table 3-41
Oil and Gas Industry Drilling Hazards that May be Present in the Geothermal Industry

Hazard	Source
Struck by	Falling/moving pipe; tongs and/or spinning chain, kelly, rotary table, etc.; high-pressure hose connection failure causing employees to be struck by whipping hose; tools/debris dropped from elevated location in rig; vehicles
Caught in/between	Collars and tongs, spinning chain, and pipe; clothing gets caught in rotary table/drill string
Fire/Explosion/High pressure release	Well blowout, drilling/tripping out/swabbing etc. results in release of gas that may be ignited if not controlled at the surface; welding/cutting near combustible materials, uncontrolled ignition sources near the well head, e.g., heater in the doghouse, unapproved or poorly maintained electrical equipment; aboveground detonation of perforating gun
Rig collapse	Overloading beyond the rated capacity of the rig; improper anchoring/guying; improper raising and lowering the rig; existing maintenance issues with the rig structure that impacts the integrity

Table 3-41
Oil and Gas Industry Drilling Hazards that May be Present in the Geothermal Industry

Hazard	Source
Falls	Fall from elevated areas of the rig, i.e., stabbing boar, monkey board, ladder, etc.; fall from rig floor to grade
Hydrogen sulfide exposure	Hydrogen sulfide release during drilling, swabbing, perforating operations, etc. resulting in employee exposures; production tank gauging operations, gaugers sometimes exposed to hydrogen sulfide

Source: OSHA 2007

Contamination of Drinking Water Supplies

Another human health concern related to geothermal projects is the potential contamination of underground and surface drinking water supplies with geothermal fluids. The common contaminants in geothermal fluids that are of concern to public health through consumption in drinking water are arsenic, boron, and mercury.

Most geothermal reservoirs are found deep underground, well below groundwater reservoirs. Drilling activities can result in the pollution of shallower water aquifers with drilling fluids as wells are bored through them, although this effect is limited to the duration of drilling. Well casing is used upon well completion, which separates geothermal fluids from any shallower aquifers that a drilled well may pass through. Groundwater contamination can occur in rare situations involving a well casing break or the percolation of surface-discharged geothermal fluids.

Surface water bodies can be contaminated from either surface discharges or spills of geothermal fluids, or underground contamination of springs that feed a surface water body. Surface discharges are regulated through state and local permits, and abatement technologies are installed as necessary to reduce contaminants to acceptable levels.

Construction, Operation, and Maintenance Plan

Construction, operation, and maintenance plans are used to establish procedures and protocols for the safe construction, operation, and maintenance of geothermal resource developments. These plans typically address worker and site safety, emergency response protocols, and procedures for managing hazardous and toxic substances. A construction, operation, and maintenance plan is prepared by the operator of the geothermal energy operation prior to any geothermal resource development. Furthermore, a plan is also used to identify procedures for safely abandoning and properly reclaiming a site during close out.

3.20 NOISE

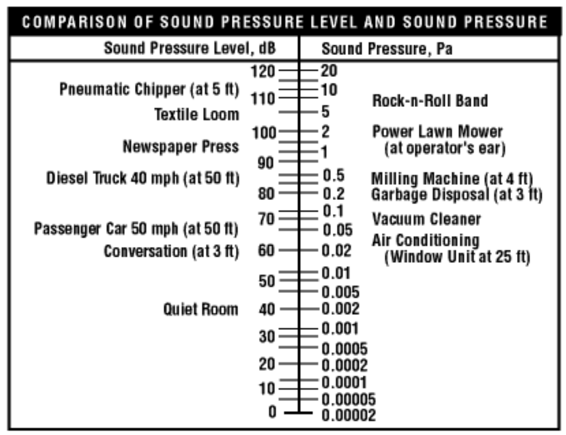
This section describes the environmental noise fundamentals, background noise levels, noise propagation, and noise standards and guidelines related to geothermal resource development.

3.20.1 Fundamentals

Noise is defined as any undesirable sound. Sound is any pressure variation that the ear can detect. Sound pressure levels are measured in units of decibels. Any time a sound level (or sound pressure level) is referred to, a decibel notation is implied.

Audible sounds range from 0 decibel, considered the quietest sound that can be heard by an average person, called the "threshold of hearing," to about 130 decibels, which is considered so loud that it causes pain, and is called the "threshold of pain" (Figure 3-23), Comparison of Sound Pressure Level and Sound Pressure). The perceived pitch of a sound, which characterizes the sound as being high or low when heard, is determined by its frequency. Low-pitched or bass sounds have low frequencies, and high-pitched or treble sounds have high frequencies. A healthy, young person can hear sounds with frequencies ranging from approximately 20 to 20,000 cycles per second (hertz). The sound of human speech is typically in the range 300 to 3,000 hertz (Canada's National Occupational Health and Safety Resource 2008).

Figure 3-23
Comparison of Sound Pressure Level and Sound Pressure[1]



[1] dB = decibel
Source: Canada's National Occupational Health and Safety Resource 2008.

The A-weighted decibel scale estimates the range of human hearing by filtering out lower frequency noises, which are not as damaging as high frequencies. This scale is widely used in noise standards, guidelines, and ordinances, and is widely accepted in analyzing noise and its impacts on humans. Table 3-42, Comparison between Noise Source and Sound Level, provides a comparison between sound pressure levels associated with some familiar sources and geothermal operations.

Table 3-42
Comparison between Noise Source and Sound Level

Noise Source	Sound Level (A-weighted decibel scale)
Near leaves rustling from breeze	25
Whisper at six feet	35
Inside average suburban residence	40
Near a refrigerator	40
Inside average office, without nearby telephone ringing	55
Speech at 3 feet, normal voice level	60
Automobile (60 miles per hour) at 100 feet	65
Vacuum cleaner at 10 feet	70
Garbage disposal at 3 feet	80
Electric lawn mower at 3 feet	85
Food blender at 3 feet	90
Auto horn at 10 feet	100

Source: Geothermal Energy Association 2007a

Although an A-weighted sound may adequately indicate the level of sound at a given instant, it does not account for the duration of the sound or that sound levels can vary with time. To assess these variations, two descriptors are often used, L_{dn} and L_{EQ}. The day-night average sound level (L_{DN} or DNL) is the average A-weighted sound level during a 24-hour period with 10 decibels added to nighttime levels (between 10:00 p.m. and 7:00 a.m.). This adjustment is added to account for the fact that human sensitivity increases during the nighttime hours when people are involved in more noise-sensitive activities (e.g., sleeping). The equivalent continuous sound pressure level (L_{EQ}) is a sound level that, if maintained continuously during a specific time period, would contain the same total energy as sound that varied over that time. Statistical values of noise levels are also frequently used to describe time-varying characteristics of environmental noise measured in A-weighted decibel scale. The L_{eq} values typically used are L_{10}, L_{50}, and L_{90}, representing noise levels that are exceeded at 10, 50, and 90 percent of the time, respectively. L_{10} represents a sound level considered intrusive, L_{50} is the median noise level, and L_{90} corresponds to background noise.

Noise effects on humans fall into three categories:

- Subjective effects such as annoyance, nuisance, and dissatisfaction;
- Interference with activities such as speech, sleep, and learning; and
- Physiological effects such as anxiety, tinnitus, or hearing loss.

Determining if a noise is objectionable depends on the type of noise (tonal, broadband, low frequency, or impulsive), in addition to the circumstance and individual sensitivity of the person who hears it. Typically, the levels associated with environmental noise only produce effects in the first two categories. However, workers subjected to noise in environments such as industrial plants or airports may experience noise effects similar to those described under the third category. Table 3-43, Subjective Response to Changes in Sound Level, illustrates how differences in sound magnitudes are perceived by humans.

Table 3-43
Subjective Response to Changes in Sound Level

Change in Sound Level	Perceived Change in Loudness
±1 decibel	Requires close attention to noise
±3 decibels	Barely perceptible
±5 decibels	Quite noticeable
±10 decibels	Dramatic; sounds nearly twice or half as loud
±20 decibels	Striking; fourfold change in loudness

Source: Berendt, Corliss, and Ojalvo 2000

3.20.2 Background Noise Levels

Background noise is the noise from all other sources than the source of interest (e.g., geothermal operations). The background noise level can vary considerably depending on the location. There is currently no available information defining existing noise levels in areas of geothermal potential on public and NFS lands, which would be recorded as background noise levels at any given project site. Natural background noises expected to exist in such areas include agricultural activities, recreation activities (including mechanized and motorized uses), oil and gas development, and aircraft over flights.

3.20.3 Noise Propagation

Predicting the noise level at a receptor location depends on a complex combination of source characteristics and site-specific factors (Anderson and Kurze 1992) that include:

- Source characteristics such as sound power, directivity, and configuration;
- Geometric spreading (geometric divergence) as the sound moves away from the source to the receptor;
- Atmospheric air absorption, which depends strongly on the sound frequency and relative humidity, less strongly on temperature, and slightly on pressure;
- Ground effects due to sound reflected by ground surfaces interfering with the sound propagating directly from the source to the receptor;

- The topography, structures, and other natural or human-made barriers between the source and the receptor; and
- Meteorological factors such as turbulence and variations in vertical wind speed and temperature.

Most screening applications only consider geometric spreading when predicting noise levels. A detailed analysis of noise levels would require a sound propagation model that integrates most of the sound attenuation mechanisms identified above; however, this type of analysis would require detailed source characteristics and site-specific data (e.g., as vegetation types, topography, and meteorological data). Moreover, the effects of variables such as vertical wind and temperature gradients can also have considerable impacts on such an analysis.

At short distances (less than 160 feet), the wind has a minor effect on the sound level. For locations at greater distances from a given source, wind can cause considerable differences in sound levels. Wind speed typically increases with height, and this variation focuses it in the downwind direction and creates a shadow in the upwind direction. Therefore, upwind sound levels will be lower, and downwind levels higher, than if there were no wind.

Changes in temperature with height also play a major role in sound propagation. During the day, air temperature decreases with height. In contrast, on a clear night, the temperature often increases with height (a condition known as a temperature inversion). The speed of sound varies with temperature so that generally sound bends (refract) upward during the day, leading to reduced sound levels on the ground, and bends downward during inversions, leading to higher sound levels on the ground. Such temperature effects are uniform in all directions, differing from those of wind that affect mostly upwind and downwind direction.

3.20.4 Noise Standards and Guidelines

The federal law that directly affects noise control is the Noise Control Act of 1972, as amended by the Quiet Communities Act of 1978 (42 USC 4901-4918). This Act delegates to the states the authority to regulate environmental noise. It also directs government agencies to comply with local community noise statutes and regulations, and to conduct their programs to promote an environment free of any noise that could jeopardize public health or welfare. More specifically, BLM regulations mandate that noise at one-half mile—or at the lease boundary, if closer—from a major geothermal operation shall not exceed 65 A-weighted decibels (43 CFR 3200.4[b]).

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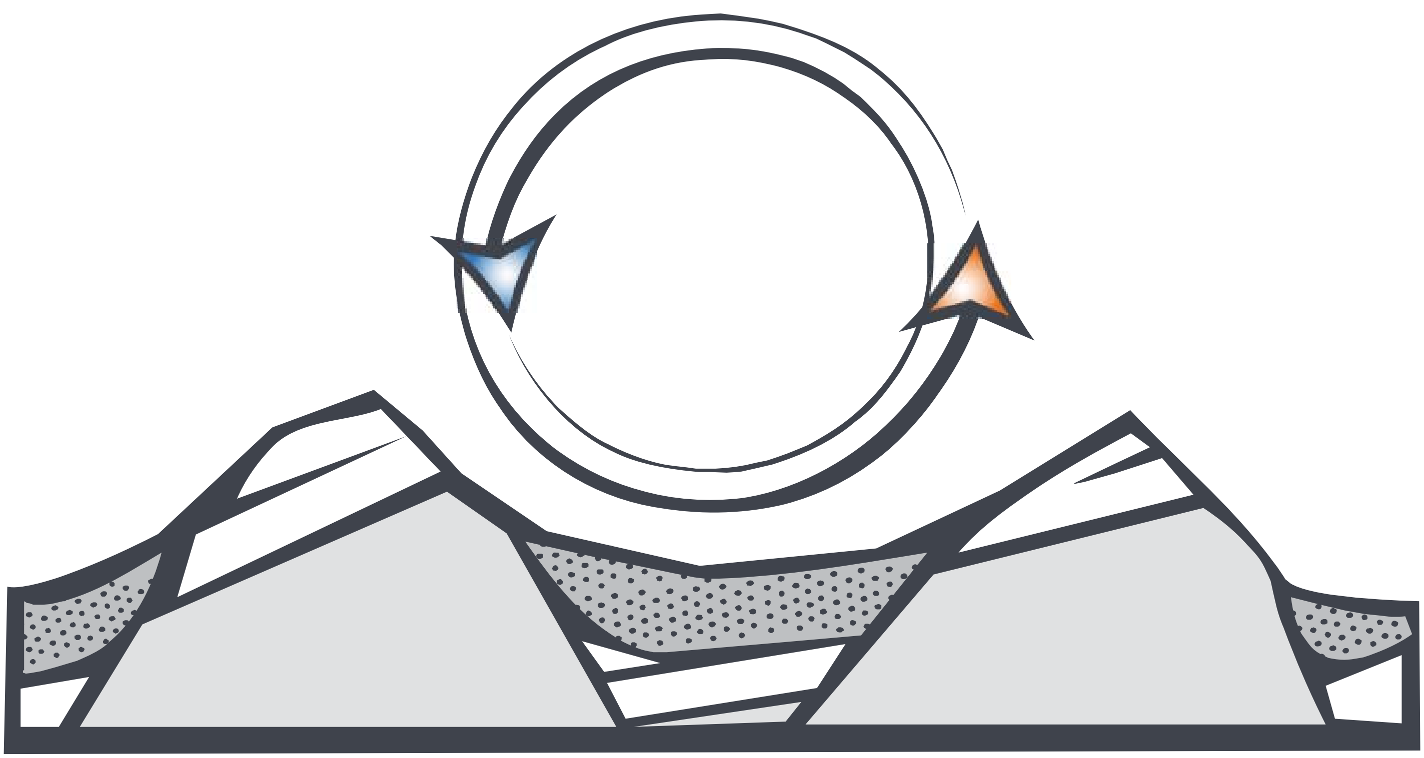

Chapter 4

Environmental Consequences

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CHAPTER 4
ENVIRONMENTAL CONSEQUENCES

4.1 INTRODUCTION

This chapter analyzes the environmental consequences of impacts expected to occur as a result of implementing any future actions (including but not limited to any decisions to lease and/or develop geothermal resources) that may be taken consistent with the three alternatives: Alternative A (the No Action Alternative), Alternative B (the Proposed Action), and Alternative C (leasing within 10 miles from the centerline of existing transmission lines and 15 miles outside of the Yellowstone National Park boundary). The scope of the analysis is commensurate with the detail of the alternatives and the availability of data, and is at a programmatic level as discussed in Section 1.9 – Scope of Analysis. Current conditions of the planning area, as described in Chapter 3, provide the baseline for assessing impacts.

4.1.1 Methods of Impact Analysis

Issuance of a geothermal lease has no direct impacts on the environment; however, it is a commitment of the resource for potential future exploration, drilling operations and development, utilization, and reclamation and abandonment, subject to environmental review and permits. Therefore, an analysis is provided of the potential impacts of these various stages that may follow a leasing decision along with the potential cumulative impacts throughout the entire planning area.

The methodology for the following impact assessment conforms to the guidance found in the following sections of the CEQ regulations for implementing NEPA: 40 CFR 1502.24 (Methodology and Scientific Accuracy); 40 CFR 1508.7 (Cumulative Impact); and 40 CFR 1508.8 (Effects). CEQ regulations require that agencies "rigorously explore and objectively evaluate" the impact of all alternatives. Since the action alternatives presented in this PEIS propose allocating public and NFS lands as open or closed to geothermal leasing and amending land use plans, none of which has any effects as explained below, rather than project level exploration, development, and utilization of the resource, the focus of this analysis is on the impacts of these stages, which may follow leasing.

The Proposed Action and alternatives do not specifically propose development of a geothermal resource. For this reason, the analysis relies on the RFDs, which projects future geothermal leasing and development on public and NFS lands within the western US over the next 20 years based on best professional judgment. The RFD scenario assumes all lands are available for leasing, and therefore, does not consider any allocations (lands open or closed to geothermal leasing) prescribed under any of the alternatives. Its purpose is to demonstrate the level of expected development and show where the potential development might occur. It is important to note that the magnitude and extent of impacts on any resource or resource use will vary depending on the amount of land apportioned for each lease. A lease can range in size from 640 acres up to 5,120 acres.

Allocating lands and amending land use plans, in and of itself, does not cause any direct impacts as defined by the CEQ regulations, which state that such effects "are caused by the action and occur at the same time and place" (40 CFR 1508.8(a)). Prior to any ground disturbance or other future actions that would occur consistent with implementing the plan, further decision making would be required. This decision making must take place prior to future actions and involves consideration of a wide variety of factors, including, but not limited to, policy initiatives about timing of actions, whether any applications are submitted, whether funding is available, and compliance with other authorities and policies.

Similarly, lease issuance itself does not cause direct effects. The regulations governing geothermal leasing and development provide for several decision stages prior to any ground-disturbing activities taking place and may include further compliance with applicable authorities during these decision stages. Under this regulatory scheme, until BLM receives and adjudicates an application for a permit to drill or other authorization that includes specific information about a particular project, impacts of actual development that might follow lease issuance are speculative, as so much is unknown as to location, scope, scale, and timing of that development. At each decision stage, the BLM retains the authority to approve, deny, or approve subject to conditions any permit, based on compliance with applicable authorities and policies. Therefore, the analysis of effects of development in this Final PEIS reflects a more general, programmatic approach.

Any future development of geothermal resources, if and when it does take place, would result in effects. It is reasonable, therefore, to foresee that on-the-ground impacts would occur if the BLM issues geothermal leases. Those impacts would not occur, however, until some point in the future and following several decision stages. The following analysis, therefore, focuses primarily on both direct and indirect impacts of future development of geothermal resources based on the foreseeable on-the-ground actions, taking into consideration the stipulations, BMPs, and procedures outlined in Chapter 2. These impacts cannot be analyzed site-specifically, but they can be analyzed in general terms for the leasing area based on the RFD scenario.

Consideration of the effects of future actions that might occur under the alternatives described in this chapter also takes into account the phenomena of greenhouse gas (GHG) emissions, carbon sequestration, and climate change generally. The tools necessary to quantify climatic impacts are presently unavailable (US Geological Survey 2008). As a consequence, impact assessment of specific effects of anthropogenic activities and specific levels of significance cannot be determined. Therefore, climate change analysis for the purpose of this document is limited to accounting for and disclosing GHG emissions (and other factors that contribute to climate change) that may result from future activities that may be taken to implement the plan amendments proposed and analyzed in this document. Qualitative and quantitative evaluations of potential factors that may result from the future actions that may be taken to implement each alternative within the Planning Area are included, where appropriate and practicable.

Some of the GHGs associated with geothermal exploration and development will be naturally sequestered, while the balance of those emissions will accumulate with GHG concentrations in the atmosphere. This, in turn, is believed to contribute to further manifestations of climate change. However, since geothermal energy is a renewable energy with low carbon output compared with nonrenewable sources that currently dominate the US energy landscape, the development of geothermal energy projects can result in a net decrease in GHG emissions if the energy supplied to the grid allows fossil fuel-based power production, and its related GHG emissions, to be reduced.

While the GHG emissions of future actions that may be taken under each of the alternatives analyzed in this chapter can be estimated, current science does not permit quantification (or in some cases, even articulation) of the relationship between these emissions and the phenomena associated with global climate change. That is, while the relationship appears on a global level, it is not possible to make the connections between GHG emissions and global climate change on a local or even regional level (US Geological Survey 2008).

It is projected that the Alternative A *status quo* approach to land use allocation and leasing would result in the least amount of geothermal development, the least amount of new, clean energy being brought online, and the least potential for reducing GHG emissions. It is expected that projects developed consistent with Alternative B would result in the greatest amount of geothermal development, the greatest amount of new, clean energy being brought online, and the greatest potential for reducing GHG emissions. Projects developed consistent with Alternative C are expected to result in amounts of new, clean energy coming online and potential reductions in GHGs that are somewhere in between Alternatives A and B. As such, as much as a relationship can be drawn between GHG emissions and climate change, it is expected that the approach reflected in Alternative A would have the least beneficial impact on climate change and that the approach reflected in Alternative B would have the greatest beneficial impact on climate change.

Alternative C was developed such that projects would occur closer to existing transmission lines, meaning that on average, projects developed consistent with Alternative C would generally have less of a construction footprint (when considering transmission line length) and theoretically lower GHG emissions during the development phase. Therefore, while the approach to development reflected in Alternative B is expected to result in the greatest overall potential for reduction in GHG emissions, each project developed consistent with Alternative C may result in the greatest potential for GHG emissions on a *per project* basis.

4.1.2 Organization of Chapter 4

Because it is not possible to identify specific impacts from the decision to approve a geothermal lease or designate federal lands as open or closed to geothermal leasing, the evaluation of environmental resources has focused on those resources most likely to be affected during future geothermal development activities. Therefore, this chapter provides a programmatic presentation of common impacts from indirect and direct geothermal development by analyzing the RFD scenario and assessing potential impacts during the four sequential phases of geothermal development: (1) exploration, (2) drilling operations, (3) utilization, and (4) reclamation and abandonment. The discussion of impacts from geothermal development activities is general in nature and would occur regardless of the alternative.

Following the discussion of impacts associated with the RFDs and common impacts associated with each phase of geothermal resource development, a programmatic analysis illustrates the nature and magnitude of the impact to the resource that would be associated with any anticipated future action taken consistent with each of the respective alternatives.

4.2 LAND USE, RECREATION, AND SPECIAL DESIGNATIONS

4.2.1 What did the Public Say about Impacts on Land Use?

Comments received during the scoping period requested that development of geothermal energy on federal lands be executed in a manner compatible with other multiple use resource values and with BLM and FS management objectives. Comments also requested the use of standard best management practices to ensure minimal fragmentation of ecosystems and an analysis of additional road and transmission line construction. Industry comments recommended the analysis of impacts from exploration practices.

4.2.2 How Were the Potential Effects of Geothermal Leasing on Land Use Evaluated?

The geothermal planning area encompasses the 12 western states, including Alaska. Under Alternative A, the no action alternative, no geothermal leasing areas would be identified. All BLM- and FS-managed lands would be open to geothermal leasing unless closed in accordance with existing land use plans or congressional designation. Under Alternative B, approximately 197,225,000 acres are identified as open to geothermal leasing (118,000,000 acres of public land and 79,000,000 acres of NFS land), narrowing the scope of analysis down from approximately 243 million acres of federal lands in the planning area. Under Alternative C, fewer indirect use lands (approximately 61,200,000 indirect use acres on public land and 37,900,000 acres on NFS lands) would be open to geothermal leasing, further narrowing the scope of the analysis.

Potential impacts on land use could occur if reasonably foreseeable future actions were to:

- Conflict with management goals and objectives set forth by the BLM or FS in order to sustain the health, productivity, and diversity of these federal lands; or
- Result in proposed uses that are incompatible with existing or adjacent land uses.

4.2.3 What are the Common Impacts to Land Use Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on land use from geothermal resource development. Issuing geothermal leases would not create any surface disturbances, and current activities on federal lands could continue as long as they did not interfere with the rights of the geothermal lessee. On lands where geothermal development is likely to occur, current uses include recreation, mining, hunting, energy development, communication sites, and right-of-way corridors.

The Reasonable Foreseeable Development Scenario for Land Use

According to the RFD scenario, it is estimated that 111 power plants could be constructed by 2015, and another 133 power plants could be constructed by 2025. The greatest development is expected to occur in California and Nevada, with the least development occurring in Arizona, Colorado, Wyoming, and Montana. The typical acreage of disturbance in a geothermal resource development phase is 53 to 367 acres. Therefore, total land use disturbance would be approximately 5,883 acres to 40,737 acres by 2015 and 12,932 acres to 89,548 acres by 2025.

BLM and FS manage approximately 676,000,000 acres in the western US, so these estimates would account for less than one percent of the total lands managed by both the BLM and FS.

Exploration

The exploration phase includes surveying and drilling temperature gradient wells. Surveying activities would impact land uses if additional roads or routes are developed to survey the potential geothermal sites. Additional roads could improve motorized and non-motorized access to previously inaccessible areas, impacting activities such as grazing and recreation. The magnitude and extent of the impact would depend on the current land use in the area. Following surveying activities, all roads and routes would be reclaimed to BLM and FS standards, thereby minimizing any long-term impacts on land uses.

Impacts on land uses from drilling temperature gradient wells would be short term and minor. Similar to surveying activities, roads would be required to access wells. Impacts from creating additional roads would be similar to those impacts described above. Several wells could be drilled per lease, and each drill site could disturb approximately 0.9 acres. Impacts would occur on lands directly under the well sites; drilling well sites may involve some leveling or grading, but impacts are primarily limited to the duration of the drilling and reclamation activities (several weeks). The drilling sites and access routes would be reclaimed to BLM and FS standards, thereby minimizing any long-term impacts on land uses.

Drilling Operations

The drilling operations phase would require production wells, injection wells, fluid sump pits, and new access roads to accommodate larger equipment. This development would impact any land use activity that is displaced as a result of the new roads and would affect land use activities that are sensitive to increases in motorized traffic (e.g., grazing).

The drilling operations phase also includes drill site development, which on average requires a 5-50 acre well pad per plant. Land under the well pad would be impacted, eliminating all other potential uses of the 5-50 acres site while the well pad is in operation.

Utilization

Geothermal utilization would result in long-term impacts on land use. Any land use activity such as grazing, recreation, hunting, mining, and other energy development activity would be impacted if the land was converted for geothermal use, displacing current activities and uses from these lands.

The utilization phase would require additional access roads for accessing the power plant and supporting well field equipment. The well field equipment consists of pipelines that vary from 24 to 36 inches in diameter. Where feasible, pipelines would parallel access roads and existing roads, minimizing the impacts on land uses. Pipelines are constructed with above-ground supports, which would minimize surface disturbance, but could affect any land use activity occurring above the ground. A power plant requires approximately 15 to 25 acres to accommodate all the needed equipment. Similar to other construction required during this phase, this would result in a direct loss of land use, displacing any current activities and uses from these lands. Installing electrical transmission lines from the power plant would disturb approximately one acre per mile of transmission line. Short-term minor impacts on land uses would occur during the installation of the powerlines; however, long-term impacts from wooden poles on land use would be minimal to negligible depending on existing land uses.

Impacts on land uses during operations within the utilization phase of geothermal resource development would be minimal. Short-term minor impacts would occur from standard operation and maintenance activities such as maneuvering construction and maintenance equipment and vehicles associated with these activities. No additional impacts would be recognized during this phase unless an additional drill site is required. Impacts from additional drill sites would be the same as those discussed under the exploration and drilling operations phases, above.

Reclamation and Abandonment

Reclamation and abandonment activities include abandoning the well after production ceases and reclaiming all disturbed areas. All disturbed lands would be reclaimed in accordance with BLM and FS standards, and land uses and activities could resume.

4.2.4 What are the Potential Impacts to Land Use Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, geothermal leasing for direct and indirect use would continue to occur on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. The number of acres likely to be affected under this alternative is unknown.

Issuing geothermal leases on a case-by-base basis is not expected to affect land use. However, issuing a geothermal lease is an inherent commitment of the resource, and it is anticipated that impacts on land use would occur during geothermal exploration, drilling operations, and utilization phases, subject to environmental reviews and permits. In the absence of designating geothermal potential areas as open or closed, individual sites could be located in a number of locations and each would result in various long- and short-term impacts on land uses. Under this alternative, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as a consistent guidance for future geothermal leasing and development. This would result in fragmented and segregated planning for land uses, which could increase recognized environmental impacts. Due to the uncertainty of total acreage considered for geothermal leasing and development under this alternative, it is not possible to quantify the total acreage affected on Federal lands.

Impacts under Alternative B

Under Alternative B, geothermal leasing for direct and indirect use would be open on approximately 197,225,000 acres. In the 12 western US states, this accounts for 54 percent of public and NFS lands (53 percent of public lands and 57 percent of NFS lands). Lands identified as open to geothermal leasing for direct and indirect use could be open with possible moderate to major constraints, depending on environmental conditions identified during site-specific reviews conducted by field offices and ranger districts prior to issuing the leases. Approximately 25,150,000 acres of public lands and 24,370,000 acres of NFS lands would be closed to geothermal leasing for direct and indirect use because these lands were found to be incompatible with geothermal leasing, exploration, and development. Areas identified as incompatible to geothermal leasing for direct and indirect use (Section 2.2.1, Allocating Lands for Leasing) include, but are not limited to, congressional designations (e.g., Wilderness Areas, National Conservation Areas) and administrative designations (e.g., Areas of Critical Environmental Concern and Inventoried Roadless Areas). Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. Relevant stipulations (Section 2.2.2) designed to protect existing land uses include controlled surface use in areas that have the potential for adverse impacts on residential areas, schools, or other adjacent urban land uses. In addition, in accordance with the identified BMPs (Appendix D), BLM and operators would contact appropriate agencies, property owners, and other stakeholders early in the planning process to identify potentially sensitive land uses and issues. It is expected that these measures would effectively avoid or minimize impacts on land uses by identifying conflicts early in the process and requiring specific measures to maintain public uses and values.

Impacts under Alternative C

Under Alternative C, geothermal leasing for indirect use would be open on 99,073,000 acres. All federal lands identified as open for indirect use under this alternative are within 10 miles of the centerline of existing transmission lines. Restricting the placement of indirect use geothermal resource development to nearby existing transmission lines would minimize impacts on land uses by concentrating land uses associated with energy development into designated areas.

Areas open to direct use geothermal lease applications and impacts from their anticipated subsequent development would be the same as identified under Alternative B.

4.2.5 What did the Public Say about Impacts on Special Designations?

Comments received during scoping requested that geothermal leasing and projects be prohibited in and adjacent to special designation areas. Requests were also made for examination of direct and indirect impacts on special designation areas.

4.2.6 How Were the Potential Effects of Geothermal Development on Special Designations Evaluated?

Potential effects of geothermal development on special designations were evaluated by analyzing all Congressionally designated areas in the planning area, in addition to examining all areas identified by the BLM and FS in land use plans as special administrative designation areas. Impacts on these areas resulting from any future actions taken consistent with each alternative were then considered and described.

Potential impacts on special designations could occur if reasonably foreseeable future actions were to:

- Conflict with management goals and objectives set forth by the BLM or FS in order to categorize, protect, and manage special designation areas;
- Conflict with conservation goals for the area; or
- Result in proposed land uses that are incompatible with existing or adjacent special designation areas.

4.2.7 What are the Common Impacts on Special Designations Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on special designations from geothermal resource development.

The Reasonable Foreseeable Development Scenario for Special Designations

According to the RFD scenario, it is estimated that 111 power plants could be constructed by 2015, and another 133 power plants could be constructed by 2025. The greatest development is expected to occur in California and Nevada, with the least occurring in Arizona, Colorado, Wyoming, and Montana. Most congressionally designated areas in the planning area are withdrawn from leasing; therefore, it is anticipated that no reasonable foreseeable development activities would occur in these areas. Geothermal leasing is not precluded from administrative designations, however, and any activities that would affect the values and resources identified for protection under these designations would be prohibited. As such, it is anticipated that both impacts on special designations from reasonable foreseeable development activities would be negligible.

Exploration

Congressionally-designated areas are typically withdrawn from geothermal development, so no impacts on congressional designations are anticipated from geothermal exploration. Administrative designations are not automatically withdrawn from geothermal development; however, activities likely to affect the resources and values identified for protection under these designations would be precluded.

If exploration was permitted in either type of designation, prior to any activity occurring resources and values identified for protection under the designation would be analyzed for potential impacts. Activities affecting resources and values identified for protection in these areas would be prohibited. The effects of geothermal exploration on special designations are expected to be negligible.

Drilling Operations

Impacts on congressional and administrative designations during geothermal drilling operations would be similar to those described above under exploration. Drilling operations are not expected to occur in special designations. If drilling is permitted in either type of designation, prior to any activity occurring resources and values identified for protection under the designation would be analyzed for potential impacts. Activities affecting resources and values identified for protection in these areas would be prohibited. The effects of geothermal drilling operations on special designations are expected to be negligible.

Utilization

Impacts on congressional and administrative designations during geothermal utilization would be similar to those described above under exploration. Since geothermal development is not expected to occur in special designations, utilization is not anticipated. If geothermal development is permitted in either type of designation, prior to any activity occurring, resources and values identified for protection under the designation would be analyzed for potential impacts. Utilization activities affecting resources and values identified for protection in these areas would be prohibited. The effects of utilization on special designations are expected to be negligible.

Reclamation and Abandonment

Impacts on congressional and administrative designations during geothermal reclamation and abandonment would be similar to those described above under exploration. Since geothermal development is not expected to occur in special designations, reclamation and abandonment activities are not anticipated. If geothermal development is permitted in either type of designation, prior to any reclamation and abandonment activity occurring resources and values identified for protection under the designation would be analyzed for potential impacts. Reclamation and abandonment activities affecting resources and values identified for protection in these areas would be prohibited. The effects of reclamation and abandonment on special designations are expected to be negligible.

4.2.8 What are the Proposed Impacts on Special Designations Associated with Geothermal Development?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under Alternative A, geothermal leasing for direct and indirect use would continue to occur on a case-by-case basis, which has historically occurred at a very slow pace. Most congressionally designated areas in the planning area are withdrawn from geothermal leasing; therefore, it is anticipated that impacts on congressional designations would be negligible. In administrative designations, where geothermal leasing for direct and indirect use is not automatically precluded, field offices and ranger districts would determine if geothermal leasing would be in conformance with the prescriptions outlined in the relevant land use plan(s).

If geothermal leasing for direct and indirect use was permitted in either type of designation, prior to any activity occurring resources and values identified for protection under the designation would be analyzed for potential impacts. Activities affecting resources and values identified for protection in these areas would be prohibited, resulting in negligible impacts on special designations.

Impacts under Alternative B

Under Alternative B, the proposed action, the BLM and FS would designate a geothermal potential area (approximately 530 million acres) allocating all public and NFS lands in this area as open or closed to geothermal leasing for direct and indirect use. Congressional and administrative designations in this area that are incompatible with geothermal leasing, exploration, and development activities would be closed. As a result, approximately 25,150,000 acres of public lands and 24,370,000 acres of NFS lands would be designated as closed, excluding these areas from future geothermal leasing for direct and indirect use. As identified in Section 2.2.1 Allocate Lands for Leasing, congressional designations that would likely be closed include Wilderness Areas, National Conservation Areas, and National Monuments. Types of administrative designation closures could include Wilderness Study Areas and some Areas of Critical Environmental Concern. Appendices I and J provide a list of congressional and administrative designations and associated acreages[1].

The following are exceptions for areas closed to geothermal leasing for direct and indirect use:

Congressional Designations

- California Desert Conservation Area (25 million acres, of which half is BLM-administered public lands) would remain open to geothermal leasing. The California Desert Conservation Area establishes long-term goals for protection and use of the California Desert. However, public lands within the designation fall under one of four multiple-use classes. Management in these classes ranges from Class C (Controlled), where lands are managed for preservation and protection, to Class I (Intensive Use), where lands are managed for concentrated use to meet human needs (grazing, mining, energy, and utility development). Over 1.67 million acres are considered to have potential for geothermal resources within the California Desert Conservation Area, however, the multiple-use class would determine whether leasing would be permitted and to what extent.

Administrative Designations

- On either public or NFS lands, if the prescription for an administrative designation, as described in the applicable land use plan(s), allows for geothermal leasing, then at the discretion of the field office or range district, these areas could remain open to geothermal leasing.
- On NFS lands, an Inventoried Roadless Area designation would not prohibit geothermal leasing; however, a nondiscretionary restriction would be placed on any leases within the designation. As a result, these areas generally may not contain geothermal development due

[1] The sum of acres for special designations (as identified in **Appendices I and J**) does ***not*** equal total acres closed to geothermal leasing under this alternative. Federal land parcels may contain more than one special designation, so adding the acreages for each designation would result in double counting.

to restrictions on road construction and reconstruction. This stipulation would cover about 80,596,000 acres.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. Relevant stipulations (Section 2.2.2) designed to protect special designated areas include (1) no surface occupancy on designated and eligible river segments for wild and scenic river status, and on designated or eligible sites for the National Register of Historic Places; and (2) controlled surface use for protection of National Landmarks and National Register Districts. Under the proposed leasing procedures (Section 2.2.2), other special management areas would be evaluated prior to leases using existing land use plans and environmental documentation. In addition, in accordance with BMPs (Appendix D), BLM and operators would contact appropriate agencies, property owners, and other stakeholders early in the planning process to identify potentially sensitive land uses and issues. It is expected that these measures would effectively avoid or minimize impacts to special designated areas by requiring protection and/or maintenance of the relevant and important characteristics and values of these areas.

Impacts under Alternative C

Under Alternative C, impacts on special designations from indirect use geothermal development would be similar to those described under Alternative B; however, under this alternative the geothermal potential area for indirect use is limited to areas located within 10 miles of the centerline of existing transmission lines and 15 miles from of the Yellowstone National Park boundary. The indirect use geothermal potential area would be 99,073,000 acres, which is a 50 percent decrease from Alternative B. Similar to Alternative B, the list of areas closed to geothermal leasing for indirect use under this alternative include congressional and administrative designations that are incompatible with geothermal leasing, exploration, and development activities within 10 miles of the centerline of existing transmission lines, in addition to all areas outside of the transmission line buffer. As a result, approximately 81,950,000 acres of public lands and approximately 65,710,000 acres of NFS lands would be closed to indirect use leasing.

Areas open to direct use geothermal lease applications and impacts from their subsequent development would be the same as identified under Alternative B.

4.2.9 What did the Public Say about Impacts on Recreation?

Comments received during the scoping period requested that impacts on outdoor recreation and consequences for non-mechanized, mechanized, and motorized recreation be studied and discussed. Commentors also asked that recreational impacts from the development of land tracts and their subsequent uses be analyzed.

4.2.10 How Were the Potential Effects of Geothermal Development on Recreation Evaluated?

This section examines the typical short- and long-term impacts on recreation areas and activities from geothermal development. Potential impacts on recreation could occur if reasonably foreseeable future actions were to:

- Conflict with existing recreational uses of the area; or
- Diminish existing recreational benefits and opportunities by altering the recreational setting or activity that is allowed in an area.

4.2.11 What are the Common Impacts on Recreation Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on recreation from geothermal resource development. Since issuing geothermal leases would not create surface disturbances, current recreation activities could continue until site-specific geothermal operations begin.

The Reasonable Foreseeable Development Scenario for Recreation

According to the RFD scenario, it is estimated that 111 power plants could be constructed by 2015, and another 133 power plants could be constructed by 2025. The greatest development is expected to occur in California and Nevada. The BLM and FS combined manage approximately 1,500 recreation areas, with the greatest percentage of recreation areas located in California (23 percent). Recreation users in designated areas, as well as dispersed recreation users, would be affected by geothermal development. The development of geothermal resources would alter the physical, social, and operational character of the recreation setting, thereby altering an individual's experiences.

Exploration

Surveying and drilling activities that occur during the exploration phase of geothermal development would result in the physical restriction of recreation areas, temporarily reducing the amount of land available for recreational use and accessible trails. This would displace some recreation users and limit recreation activities. Exploration activities would be completed in one to five years, at which time recreation activities could resume.

During exploration activities, recreation users participating in activities near sites would realize a diminished recreation experience. Recreation users could experience an increase in noise, vibration, and dust. Additionally, exploration could shift the ROS setting, by varying degrees, towards an urban setting to capture the addition of visual impacts such as wells, rigs, support equipment, water trucks and other vehicles, and backhoes that would become part of the landscape.

New access roads required for exploration could increase public access to previously inaccessible areas, thereby increasing recreational opportunities for some users. However, this would also alter the experience for people seeking a more remote experience in those same areas.

Drilling Operations

The drilling operations phase would result in long-term impacts on recreation resources. Similar to effects described above under the exploration phase, drilling operations could also shift the ROS setting, by varying degrees, towards a more urban setting.

Impacts on recreation resources from new access roads required for drilling operations would be similar to those impacts described above under the exploration phase.

Utilization

Impacts on recreation resources during the utilization phase of geothermal resource development would be similar to those discussed above under the drilling operations phase. The conversion of recreation lands for geothermal utilization would displace recreation users and limit activities in some areas. People engaged in activities such as hiking, camping, birding, and hunting would be most affected by construction activities within the utilization phase. During operations within the utilization phase, recreation resources would experience short-term minor impacts from standard operation and maintenance activities such as maneuvering construction and maintenance equipment and vehicles associated with these activities, which may interfere with traffic flow of recreational visitors.

Reclamation and Abandonment

Reclamation and abandonment activities include abandoning the well after production ceases and reclaiming all disturbed areas. Increased traffic from reclamation and abandonment activities could affect timely public access as described above under the utilization phase. All disturbed lands would be reclaimed in accordance with BLM and FS standards, and recreation activities could resume, improving recreational opportunities.

4.2.12 What are the Proposed Impacts on Recreation Associated with Geothermal Development?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, geothermal leasing for direct and indirect use would continue to occur on a case-by-case basis. The number of acres likely to be affected under this alternative is unknown; however, it is anticipated that minimal changes would occur in intensity to current recreational uses due to the historically slow pace of issuing geothermal leases on federal lands.

In the absence of designating geothermal potential areas as open or closed, individual sites could be developed in a number of locations and each would result in various long-term and short-term impacts on recreation activities. Under this alternative, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as a consistent guidance for future geothermal leasing and development for direct and indirect use. This would result in fragmented and segregated planning for recreational uses, which could increase conflicts among recreation users and increase environmental impacts.

Impacts under Alternative B

Under Alternative B, the proposed action, BLM and FS would identify all public and NFS lands as open or closed to direct and indirect use within the geothermal planning area (530 million acres). Under this alternative, all designated recreation areas (Table 3-5) and lands containing dispersed recreation opportunities would be open to geothermal leasing (direct and indirect use). This includes all public lands allocated as either a Special Recreation Management Area (SRMA) or an Extensive Recreation Management Area (ERMA). National Recreation Areas, managed by BLM and FS, however are congressional designations and would be closed to geothermal leasing for direct and indirect use. (Please refer to Section 2.2.1 for complete listing of lands designated as closed to geothermal leasing.)

The action of designating lands, coupled with issuing geothermal leases, would not create any surface disturbances and therefore would not impact recreation resources. However, issuing a geothermal lease for direct or indirect use is an inherent commitment of the resource for potential future exploration, drilling, utilization, reclamation, and abandonment, subject to environmental review and permits; therefore, it is anticipated that impacts on recreation resources would occur during the geothermal exploration, drilling operations, and utilization phases.

Once geothermal development for direct or indirect use begins under this alternative, there would be minor to moderate impacts on recreation resources. As described in Section 4.1.11, What are the Common Impacts Associated with Geothermal Leasing and Development, recreation activities could be disrupted through the physical restriction of recreational areas and user trails.

Throughout various phases of geothermal development, users' enjoyment of the area could also be impacted by noise, vibration, dust, and visual impacts. Impacts on recreation resources would occur until the reclamation and abandonment phase, at which time recreation activities could resume.

In areas where SRMA boundaries overlay open geothermal potential areas, recreation users would likely be displaced to other areas. Activities related to geothermal development would alter the recreational setting within these areas, hindering the capability of the settings to continue to produce the desired existing recreation opportunities and facilitate the recreation experience and benefit opportunities. Opportunities for visitors to the SRMA would be impacted.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. Relevant stipulations (Section 2.2.2) designed to minimize conflicts with recreation include (1) no surface occupancy on developed recreational facilities, special-use permit recreation sites, and areas with significant recreational use with which geothermal development is deemed incompatible (excluding direct use applications), and for designated important viewsheds; and (2) controlled surface use in areas that have the potential for adverse impacts to recreational values (both motorized and non-motorized) and the natural setting associated with the recreational activity. In addition, in accordance with BMPs (Appendix D), BLM and operators would contact appropriate agencies, property owners, and other stakeholders early in the planning process to identify potentially sensitive recreational areas and issues.

It is expected that these measures would effectively avoid or minimize impacts to recreation and recreational areas by protecting the most significant recreation resources, maintaining recreational opportunities and recreational experience, reducing user and resource conflicts, and in some instances improving recreational opportunities (i.e., allowing access via new roads, etc.).

Impacts under Alternative C

Impacts from anticipated future actions consistent with implementation of Alternative C related to indirect use would be similar to those impacts described under Alternative B; impact intensity would vary depending on the percentage of recreation areas and lands identified for dispersed recreation uses that fall within 10-miles of the centerline of existing transmission lines. Stipulations and BMPs would be applied with similar effects as under Alternative B.

Areas open to direct use geothermal lease applications and impacts from their anticipated subsequent development would be the same as identified under Alternative B.

4.3 Geologic Resources and Seismic Settings

4.3.1 What did the Public Say about Impacts on Geologic Resources and Seismic Setting?

The public was especially concerned with protecting and preserving the resources of Yellowstone Park. Commentors offered the following suggestions to protect these resources:

- Avoiding any geothermal feature or system hydraulically liked to Yellowstone's aquifer;
- Banning geothermal resource development within 15 miles of the park;
- Expanding the protected area to include the Island Park Geothermal Area and the areas defined in the Yellowstone Compact; and
- Banning development on federal land and on private lands with federal mineral rights within the area when not absolutely sure there would be no impact to the geothermal resources within the park.

Other comments were received on the effects of geothermal fluid withdrawal (e.g., subsidence) and injection (e.g., increasing seismic activity, triggering volcanic eruptions at Yellowstone Park).

4.3.2 How Were the Potential Effects of Geothermal Development on Geologic Resources and Seismic Setting Evaluated?

The potential effects of geothermal development were evaluated by assessing the effects that anticipated future actions consistent with the alternatives would have on the geology and unique geologic resources of the project area. Geothermal leasing itself would have no direct impacts on geologic resources. Indirect impacts could occur from subsequent development activities, including large-scale surface disturbances such as mining, erosion, diversion of the heat and energy resulting in reduction of surface thermal features, off-road vehicles, excavation, and vandalism; damage and vandalism are usually concentrated near roads and trails.

Specific geologic features may have value to paleontological, scenic, recreational, or cultural resources, and impacts on these resources are discussed in their respective sections. In this section, impacts to geologic features are evaluated only from the perspective of scientific value. Effects are quantified where possible; in the absence of quantitative data, best professional judgment was used.

Seismic risk is more likely to impact geothermal facilities than operation of geothermal facilities is to increase seismic risk. The high pressure injection of fluids directly into faults zones has been related to increases in seismic activity in some cases. However, the high pressure injection of fluids from outside the geologic system is not the same as where geothermal fluid withdrawn from the resources is used and then reinjected back into the system for a near zero net change. The near zero net change would represent much lower risk of increasing seismic activity.

Subsidence can occur where groundwater is pumped from underground aquifers at a rate exceeding the rate that it is replenished. Most of the geothermal development includes reinjection of the geothermal fluid after the heat is utilized. Therefore, the potential for subsidence is low.

4.3.3 What are the Common Impacts on Geologic Resources and Seismic Setting Associated with Geothermal Development?

Large-scale unique geologic features (e.g., the Yellowstone area, Grand Canyon) are protected through units of the national park and national monument systems. Smaller-scale unique geologic features (e.g., natural arches, caves, sources of unique geologic specimens) that are outside the park and monument systems could be impacted by geothermal resource development activities.

The potential impacts on geologic resources from geothermal development mainly concern physical disturbance (e.g., movement, removal or destruction). These impacts are considered long term, as they cannot be reclaimed. In most BLM resource management plans, and in FS policy, leasing and associated roads and other physical disturbance must avoid sensitive geologic resources in order to be approved. Additional indirect impacts would result from greater public access to formerly inaccessible areas. Greater public access can result in increased wear and vandalism of sensitive geologic features. These impacts can be short term if roads are reclaimed.

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on geologic resources from geothermal resource development. The RFD scenario for geothermal resource use involves four sequential phases: exploration, drilling operations, utilization, and reclamation and abandonment.

The Reasonable Foreseeable Development Scenario for Geologic Resources and Seismic Setting

According to the RFD scenario, it is estimated that 111 power plants could be constructed by 2015, and another 133 power plants could be constructed by 2025. The most development is expected to occur in California and Nevada, and the least is expected to occur in Arizona, Colorado, Wyoming, and Montana. The typical acreage of disturbance in a complete buildout for geothermal resource development is 53 to 367 acres. Therefore, total land use disturbance would be approximately 5,883 acres to 40,737 acres by 2015 and 12,932 acres to 89,548 acres by 2025.

Exploration

The exploration phase includes surveying and drilling temperature gradient wells. Surveying activities would directly impact geologic resources through disturbance at seismic survey pulse sites. Detonation of explosives would greatly disturb a small area around each detonation. Any delicate geologic resources (e.g., natural arches, balancing rocks, cave formations) within the blast area would be disturbed. The use of thumper trucks would not impact sensitive geologic resources. While the area of disturbance at each seismic pulse site would be small, a large seismic survey could include many sites. New roads or routes may be needed to allow survey equipment to access the potential geothermal sites. Roads would disturb any geologic resources within the right-of-way. The impacts of surveying activities would be short term.

The impacts to geologic resources from drilling temperature gradient wells would be minor. The siting of the wells would not likely impact geologic resources, as clear flat areas are preferable for drilling sites. Similar to surveying activities, roads would be required to access wells, which would impact any geologic resources within the right-of-way. Several wells could be drilled per lease, and each drill site could disturb approximately 0.9 acres. Impacts would occur on lands directly under the well sites.

By following BLM and FS guidelines, sensitive geologic resources would be avoided. The long-term impacts would be minor. The impacts of increased public access due to new road construction would be short term, as the roads allowing the increased public access would be reclaimed after exploration activities are complete.

Drilling Operations

The drilling operations phase would result in long-term impacts to any geologic resources within the area of disturbance. The drilling operations phase would require additional access roads to accommodate larger equipment to drill production and injection wells and to construct sump pits. Roads to accommodate production wells are typically between 0.5 and 4 miles long and 30 feet wide, for a disturbance of between 2 and 15 acres. The drilling operations phase includes drill site development, which on average requires a 5-50 acre disturbance from well pads.

Spent or used geothermal fluids may be reinjected back into the geothermal resource, evaporated in sumps or lagoons, or used for potable and nonpotable domestic and municipal uses depending on the water quality of the geothermal fluid, shallow groundwater quality, and surface water conditions. If the proposed geothermal resource development includes high-pressure reinjection, there is a small chance that seismic activity could increase along any faults intersected by the injection well.

Any geologic resource within the areas of disturbance described above would be impacted. These impacts would be long term, as they could not be reclaimed. Impacts resulting from increased public access would also be long term for the life of the development.

Utilization

Impacts on geologic resources during initial buildout of the utilization phase of geothermal resource development would be greater than the other phases of development because of the increased footprint. The utilization phase requires construction of additional roads, wells, and structures to support full buildout of a direct use or indirect use facility. The utilization phase would require access roads to accommodate larger equipment, plus additional roads for accessing the power plant. The well field equipment includes pipelines with a disturbance zone approximately 40 feet wide. Where feasible, pipelines would parallel access roads and existing roads. The disturbance would include the pads for pipeline supports as well as the access and maintenance roads along the pipeline.

A power plant requires approximately 15 to 25 acres to accommodate all the needed equipment. Similar to other construction required during this phase, this would result in a direct disturbance of any geologic resources within the footprint of the facility. Installing electrical transmission lines from the power plant would disturb approximately one acre per mile of transmission line for lengths from 5 to 50 miles. The disturbance would include the pads for powerline support structures as well as the access and maintenance roads along the powerline.

The initial areas disturbed during construction of the utilization phase would continue to be used sporadically during standard operation and maintenance activities, such as maneuvering construction and maintenance equipment and the vehicles associated with these activities. No additional impacts would be recognized during this phase unless an additional drill site is required. Impacts from additional drill sites would be the same as discussed under the drilling operations phase, above.

Reclamation and Abandonment

Reclamation and abandonment activities include abandoning the wells after production ceases and reclaiming all disturbed areas. All disturbed lands would be reclaimed in accordance with BLM and FS standards. If the roads are reclaimed, the impacts resulting from greater public access would decrease.

4.3.4 What are the Potential Impacts on Geologic Resources and Seismic Setting Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. The number of acres likely to be affected under this alternative is unknown.

Issuing geothermal leases for direct and indirect use on a case-by-base basis includes avoiding potential impacts from anticipated future actions on unique geologic resources in many BLM field offices and FS ranger districts. In addition, unique geologic resources may receive protection through avoidance and mitigation measures for other resources, where those resources include unique geologic features. Examples include features that are part of a Class I visual landscape, features of cultural importance to Native Americans, or caves with bat populations.

Under this alternative, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as consistent guidance for future geothermal leasing and development. The leasing approvals and stipulations would continue to be varied, as would mitigation and reclamation levels. Overall potential impacts to geologic resources from anticipated future actions would be similar to those identified in the four phases of development in Section 4.3.3, above, on a case-by-case basis.

Impacts under Alternative B

Under Alternative B, the Island Park Geothermal Area would be closed to direct and indirect geothermal resource development. The BLM or FS would apply lease stipulations (Section 2.2.2) to protect the integrity of geothermal resource features, such as springs and geysers, in areas open to geothermal resource development. The BLM or FS would include lease stipulations to protect any significant thermal features of a National Park System unit that could be adversely affected by geothermal development. In addition, any leases that contain thermal features (e.g., springs or surface expressions) would have a stipulation requiring monitoring of the thermal features during any exploration, development, and production of the lease to ensure that there are no impacts to water quality or quantity. Unique geologic resources in areas open to geothermal leasing and development for direct and indirect use would also be protected through avoidance and mitigation measures for other resources, where those resources include unique geologic features (e.g., visual and cultural resources). Alternative B includes many comprehensive closures, stipulations, and BMPs (Appendix D) affecting these other resources that would result in more protection for associated unique geologic features than under Alternative A. It is expected that these measures would effectively avoid or minimize impacts to geologic resources and seismic settings by protecting the most sensitive areas and monitoring for and maintaining the unique resource values of all other geologic features.

Impacts under Alternative C

Alternative C focuses geothermal leasing and development for indirect use on public lands and NFS lands that are within 10 miles of the centerline of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary. The public and NFS lands outside of these areas would be closed to indirect use leasing.

The comprehensive list of stipulations, best management practices, and procedures discussed under Alternative B would be applied to those areas open for direct and indirect use under Alternative C. Potential impacts from anticipated future actions within the transmission line area are expected to be minimal because of the previous disturbance to geologic resources during construction of the existing transmission lines. Areas open to direct use geothermal lease applications and impacts from their anticipated subsequent development would be the same as identified under Alternative B.

4.4 Energy and Mineral Resources

4.4.1 What did the Public Say about Impacts on Energy and Minerals?

Public comments included whether to close particular types of public lands (e.g., National Parks, FS roadless areas) to geothermal development, consideration of existing and proposed transmission line routes, discussion of other power sales agreements in the proposed development areas, and the past reclamation of subsurface minerals and energy resource claims in the area.

The discussion of other power sales agreements in the proposed development areas is outside the scope of this PEIS. The presence of and plans for other power generation or transmission facilities near the proposed development sites are evaluated as part of the cumulative impacts analysis (Chapter 5).

The track record of past reclamation activities is outside the scope of this PEIS. The status and condition of past reclamation efforts for other energy and mineral resource developments was included in the affected environment discussion for the various environmental resources in each specific leasing area. The conditions associated with reclamation of the subject geothermal developments are included in the discussions for each environmental resource.

4.4.2 How Were the Potential Effects of Geothermal Development on Energy and Minerals Evaluated?

The potential effects of geothermal development were evaluated by assessing the effects that anticipated future actions consistent with implementation of the alternatives described in Chapter 2 would have on energy and mineral resources. Geothermal leasing itself would have no direct impacts on energy and mineral resources. Impacts would occur from subsequent development activities.

Potential impacts on energy and mineral resources could occur if reasonably foreseeable future actions were to:

- Result in the construction of transmission lines that would affect the feasibility of other energy development along the transmission corridor; or
- Develop roads that would encourage other energy and mineral exploration in otherwise undeveloped areas.

4.4.3 What are the Common Impacts on Energy and Minerals Associated with Geothermal Development?

Developing energy and mineral resources on federal lands is subject to location and operational constraints resulting from national, regional, and local laws, regulations, policies, and guidelines associated with protecting other environmental resources (e.g., endangered species). These protections include withdrawing or closing lands to energy and mineral resource activities, exclusion areas, buffer zones around sensitive areas, limitations on surface occupancy, seasonal limitations, and other permit stipulations. Changes in these regulations and policies have the direct effect of increasing or decreasing the land available for energy and resource development and associated costs.

The impacts on energy and mineral resources from potential geothermal exploration and development activities would be greatly dependent on the local presence and characteristics of energy and mineral resources. Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on energy and mineral resources from geothermal resource development.

Common impacts from geothermal energy development include vegetation loss, air quality impacts from fugitive dust and diesel exhaust, noise emissions, soil erosion and compaction, and hazardous waste generation.

The Reasonable Foreseeable Development Scenario for Energy and Minerals

In general, any infrastructure improvements (e.g., roads, transmission lines, pipelines) associated with the exploration and development of geothermal resources would have a minor to major advantage for the exploration and development of other energy and mineral resources within the immediate area.

Any land being used for exploration and development activities would become unavailable for developing other mineral resources (e.g., aggregates, solid minerals).

Exploration

Improving existing roads and constructing new roads for geothermal resource exploration would have a negligible to minor impact on the exploration for other energy and mineral resources in the immediate area. The degree of impact would depend on the existing limits to access in the area and the distance of the roads to the other mineral resources.

Drilling Operations

The cost of improving roads would be less for later developments because roads accessing the general area will have already been developed. These impacts would be reduced with increased distance from the new roads. Drilling operations would preclude developing any other energy or mineral resources on the same land.

Utilization

Introducing new transmission lines would encourage developing other energy resources along the transmission line. Mineral resource developments would be encouraged due to the new availability of power for their operations. These impacts would be reduced with increased distance from the power plant, roads, and transmission lines.

During the utilization phase, other operations in the immediate area of the power plant might be able to take advantage of the downstream heat from the power plant. Utilization of the geothermal resources would have minor or no impact on other energy or mineral resources.

Reclamation and Abandonment

Upon reclamation and abandonment of geothermal operations, any other ongoing operations in the area would have to take over maintenance of shared facilities (e.g., roads, transmission lines). Reclamation and abandonment of geothermal resources would have minor or no impact on other energy or mineral resources.

4.4.4 What are the Potential Impacts on Energy and Minerals Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. Geothermal resources are managed by BLM and FS as fluid leasable minerals, which includes oil and gas. Therefore, policies on closure of land to fluid minerals leasing or restrictions on the fluid minerals activities apply to both geothermal and oil and gas resources.

Some of the land classifications listed in Section 2.2.1 (e.g., ACECs, roadless areas) do not include automatic closure to fluid minerals leasing and therefore do not include closure to geothermal leasing for direct or indirect use. Other lands have exclusion or buffer zones (e.g., National Historic Trails) that vary from field office to field office based on local conditions. Where these constraints vary, they are applied or expanded at the discretion of the individual field offices. No surface occupancy/no ground disturbance constraints and other mitigation and reclamation requirements are applied on a case-by-case basis and are often dependent on site-specific conditions. The number of acres likely to be affected under this alternative is unknown.

Impacts under Alternative B

Under Alternative B, the amount of land closed to geothermal leasing for direct and indirect use would increase compared to Alternative A. Some lands currently open, or open with stipulations, to fluid minerals leasing would be closed to geothermal leasing for direct and indirect use. Buffer zones around other features would increase as they are applied to geothermal resource leasing for direct and indirect use. These restrictions would be applied uniformly throughout the western states.

Under Alternative B, the stipulations listed in Section 2.2.2 and the BMPs listed in Appendix D would be required, with exceptions granted on a case-by-case basis. Under Alternative A, stipulations and BMPS are applied only on a case-by-case basis, as there are no consistent guidelines across field offices.

There would be less land available for exploration and development of geothermal resources for direct and indirect use under Alternative B when compared to Alternative A. The increased restrictions would result in increased operational costs.

These increased constraints would not apply to fluid minerals leasing other than geothermal resources (e.g., oil and gas leasing) or to other energy developments (e.g., solar and wind). The amount of land available to other fluid minerals leasing would not change. Those constraints that are applied on a case-by-case basis at the discretion of the field offices would not be changed to general restrictions.

There would be no immediate impact on the availability of lands for exploration and development of other energy and fluid mineral resources under Alternative B. There would be no associated increase in operational costs. However, there is potential that these additional closures and higher levels of restrictions would establish new precedents and would subsequently affect the policies and practices guiding all energy resource development and fluid minerals leasing on federal lands. Should this occur, the amount of land available to other energy resource development and fluid minerals leasing would decrease to the same degree as geothermal leasing. The increased restrictions would increase the associated operational costs.

Impacts under Alternative C

Under Alternative C, only those lands within 10 miles of the centerline of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary would be available for indirect use geothermal resource development. The standardized stipulations and constraints discussed under Alternative B would be applied to these lands. The lands outside of the existing transmission line buffer would be closed to indirect use geothermal development.

There would be less land available for exploration and development of geothermal resources for indirect use than under Alternatives A or B. The increased restrictions would result in increased operational costs within the existing transmission line buffer.

These increased constraints would not apply to other energy resource development and fluid minerals leasing other than geothermal resources (e.g., oil and gas leasing). The amount of land available to other energy resource development and fluid minerals leasing would not change. There would be no associated increase in operational costs.

Areas open to direct use geothermal lease applications and impacts from their subsequent development would be the same as identified under Alternative B.

4.5 Paleontological Resources

4.5.1 What did the Public Say about Impacts on Paleontological Resources?

No comments pertaining to impacts on paleontological resources were received.

4.5.2 How Were the Potential Effects of Geothermal Development on Paleontological Resources Evaluated?

The loss of any fossil that could yield information important to prehistory, or that embodies the distinctive characteristics of a type of organism, environment, period of time, or geographic region, would be an impact on paleontological resources. Paleontological resource impacts primarily concern the potential destruction of nonrenewable fossil resources and the loss of information associated with these resources. This includes destruction as the result of surface disturbance and the unlawful or unauthorized collection of fossil remains.

Paleontological resources are preserved in sedimentary geologic units of Precambrian to Pleistocene age. Geothermal resources are, by nature, located in tectonically active areas with topographic and structural complexities that are typically characterized by extensive formational exposures that may include fossiliferous rocks. The potential for impacts on both surface and subsurface paleontological resources is directly proportional to the amount of surface disturbance associated with a proposed action. At this programmatic level of analysis, it is not possible to identify and evaluate areas of higher paleontological sensitivity with respect to locations of proposed surface disturbance. Therefore, potential impacts on paleontological resources under each alternative can only be generally estimated, and they correlate directly to the amount of anticipated surface disturbance proposed under each alternative.

To the extent possible at this level of analysis, potential impacts on paleontological resources were evaluated using the recently revised Potential Fossil Yield Classification system (PFYC, BLM 2008-009). This evaluation of potential effects on paleontological resources assumes that geothermal leasing alternatives associated with the largest acreage of disturbance correlate with the greatest likelihood of impacts on paleontologically sensitive (PFYC Class 3-5) geologic formations. This assumption may prove to be inaccurate once lease-specific analyses are undertaken, but it is appropriate for a programmatic level of analysis.

Potential impacts on paleontological resources could occur if reasonably foreseeable future actions were to result in the following:

- Result in the disturbance of paleontologically sensitive geologic formations (PFYC Class 3-5); or

- Conflict with paleontological resource management objectives and guidelines established by the BLM and FS.

4.5.3 What are the Common Impacts on Paleontological Resources Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on paleontological resources from geothermal resource development.

Impacts on nonrenewable surface or subsurface paleontological resources result from destruction by breakage and crushing during surface-disturbing actions. Surface disturbance related to geothermal development has the potential to impact an unknown quantity of fossils that may occur on or underneath the surface in areas containing paleontologically sensitive geologic units. Without mitigation, these fossils, as well as the paleontological data they could provide if properly salvaged and documented, could be destroyed, rendering them permanently unavailable. Impacts can typically be mitigated to below a level of significance by implementing paleontological mitigation. Mitigation also results in the salvage of fossils that may never have been unearthed as the result of natural processes. With mitigation, these newly exposed fossils become available for scientific research, education, display, and preservation into perpetuity at a public museum.

Impacts also result from the continuing implementation of management decisions and associated activities. For paleontological resources, impacts most commonly occur as the result of management actions that increase the accessibility of public lands, increasing the potential for loss of paleontological resources by vandalism and unlawful collecting (poaching). These impacts are difficult to mitigate to below the level of significance, but they can be greatly reduced by increasing public awareness about the scientific importance of paleontological resources through education, community partnerships, and interpretive displays, and by informing the public about penalties for unlawful destruction or unlawful collection of these resources from public lands.

Cumulative impacts result from individually minor but collectively significant actions taking place over a period of time. In general, if previously unrecorded, scientifically significant paleontological resources are present within the Planning Area, the potential cumulative impacts would be low, so long as mitigation was implemented to salvage the resources. The use of stipulations, best management practices, and paleontological resources management plans as described under Alternative B in this section would effectively recover the value to science and society of significant fossils that would otherwise have been destroyed by ground-disturbing actions.

Because paleontological resources are nonrenewable, impacts that result in their loss are considered to be long term.

The Reasonable Foreseeable Development Scenario for Paleontological Resources

The four RFD phases of geothermal development include exploration, development, production, and closeout. According to the RFD scenario, it is estimated that 111 power plants could be constructed by 2015, and another 133 power plants could be constructed by 2025. The greatest development is expected to occur in California and Nevada, with the least occurring in Arizona, Colorado, Wyoming, and Montana. The typical acreage of disturbance in a geothermal resource development phase is 53 to 367 acres. Therefore, total geothermal surface disturbance would be approximately 5,883 acres to 40,737 acres by 2015 and 12,932 acres to 89,548 acres by 2025.

Exploration

Geothermal exploration is anticipated to last from one to five years and involves first surveying and then drilling for temperature gradient wells. Surface disturbance resulting from geothermal surveys is primarily the result of access road construction and seismic and resistivity surveys. Drilling for temperature gradient wells results in surface disturbance during construction of wells and access roads.

Impacts on surface and subsurface paleontological resources could occur wherever grading for access roads and drilling sites takes place in paleontologically sensitive geographic areas or geologic units. Seismic and resistivity surveys have the potential to impact surface occurrences of paleontological resources where these activities take place in paleontologically sensitive areas/geologic units. Additional impacts could occur as the result of increased public access to previously remote paleontologically sensitive areas.

Drilling Operations

This phase requires grading for additional access roads, developing drill sites (average of two acres per well pad), and constructing pipelines, additional wells (production and injection), and sump pits.

As previously stated, impacts on surface and subsurface paleontological resources could occur wherever surface-disturbing actions related to geothermal development take place in paleontologically sensitive geographic areas or geologic units. Additional impacts could occur as the result of increased public access to previously remote paleontologically sensitive areas.

Utilization

Construction within the drilling operations phase involves assembling the infrastructure needed to use the underground geothermal reservoir and would last from two to ten years. Construction within the drilling operations phase involves the greatest amount of surface disturbance and therefore has the greatest potential for impacting paleontological resources. This phase requires grading for access roads, developing drill sites (average of 5-50 acre well-pad disturbance per plant), and constructing pipelines, transmission lines, and power plants (approximately 15 to 25 acres per plant site).

Operations within the utilization phase lasts from ten to thirty years and involves the ongoing operation and maintenance of the geothermal field, including developing new drilling sites, as needed.

Reclamation and Abandonment

Reclamation and abandonment activities include reclamation of all disturbed areas after production ceases. Assuming that no new surface disturbance occurs during the closeout phase, no new impacts on surface or subsurface paleontological resources would be anticipated.

Following the reclamation and abandonment phase, paleontologically sensitive areas that are reclaimed and that become less accessible to the public would lower the future likelihood of loss through vandalism and unlawful collection, thus lowering future impacts associated with these activities to pre-geothermal leasing levels.

4.5.4 What are the Potential Impacts on Paleontological Resources Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. The number of acres likely to be affected under this alternative is unknown.

Due to the uncertainty of the total acreage and specific locations considered for geothermal leasing and development for direct and indirect use under this alternative, it is not possible to quantify the total acreage of potentially affected paleontologically sensitive formations. However, issuing geothermal leases on a case-by-base basis is not expected to result in different effects on paleontological resources than Alternatives B and C. In the long term, if case-by-case leasing for direct and indirect use results in a larger cumulative geographic area of surface disturbance than Alternatives B and C, then Alternative A may have a greater likelihood of impacts on paleontological resources using the assumptions made in Section 4.5.2.

Impacts under Alternative B

Under Alternative B, the proposed action, approximately 118,000,000 acres of public land and 79,000,000 acres of FS land would be designated as open to geothermal leasing for direct and indirect use.

As stated above, due to the uncertainty of total acreage and specific locations considered for geothermal leasing and development for direct and indirect use under Alternative A, it is not possible to quantifiably compare the potential for paleontological resource impacts between anticipated future actions consistent with each of the alternatives. However, due to the Alternative C proposal that indirect use geothermal leasing be further restricted to within a 10-mile distance of the centerline of existing transmission lines, Alternative B has a higher likelihood of anticipated future actions with impacts on paleontological resources than Alternative C using the assumptions made in Section 4.5.2.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. In accordance with BMPs (Appendix D), operators would determine whether paleontological resources exist in a project area on the basis of the sedimentary context of the area, a records search of past paleontological finds in the area and/or, depending on the extent of existing information, paleontological survey. If paleontological resources are present at the site, or if areas with high potential have been identified, a paleontological resources management plan would be developed that identifies appropriate monitoring and protection measures. Unexpected discovery of paleontological resources during geothermal development would be brought to the attention of the responsible BLM authorized office immediately and work would be halted in the vicinity of the finds to avoid further disturbance while the finds are evaluated and appropriate mitigation measures are developed. It is expected that these measures would effectively avoid, minimize or mitigate impacts on paleontological resources by protecting and conserving significant paleontological resources as they are discovered on public lands.

Impacts under Alternative C

Under Alternative C, approximately 61,200,000 acres of public land and 37,900,000 acres of NFS land would be designated as open to geothermal leasing for indirect use. Alternative C differs from Alternative B in that the BLM and FS would only consider indirect use leasing within 10 miles from the centerline of existing 60 kV to 500 kV transmission lines.

Due to the uncertainty of the total acreage and specific locations considered for geothermal leasing and development for direct and indirect use under Alternative A, it is not possible to quantifiably compare the potential for paleontological resource impacts from anticipated future actions consistent with Alternative A and those anticipated future actions consistent with Alternatives B and C, respectively. However, due to the Alternative C proposal that geothermal leasing for indirect use be further restricted to within 10 miles from the centerline of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary, Alternative C has a lower likelihood of anticipated future actions with potential impacts on paleontological resources than Alternative B using the assumptions made in Section 4.5.2. Impacts within the transmission line area are expected to be minimal because of the previous disturbance to paleontological resources while constructing the existing transmission lines.

Areas open to direct use geothermal lease applications and impacts from anticipated future actions consistent with Alternative C would be the same as identified under Alternative B.

4.6 SOIL RESOURCES

4.6.1 What did the Public Say about Impacts on Soil Resources?

Commentors requested that direct and cumulative impacts on steep, unstable, easily eroded, and saline soils be assessed. Other commentors requested that the analysis include spill prevention, planning, and cleanup measures for geothermal resource development activities.

4.6.2 How Were the Potential Effects of Geothermal Development on Soil Resources Evaluated?

Chapter 3 discussed the types of soil resources (orders) and their general characteristics present in the areas with potential for geothermal development. Impacts on soil resources are discussed in generic terms of amount of disturbance typically associated with geothermal resource development. Impacts on specific soil types, including prime and unique farmlands and farmlands of statewide importance, are discussed for each proposed lease. The amount of disturbance that would be associated with the reasonably foreseeable development scenario was assessed for the soil resources present in each specific lease area.

Potential impacts on soil resources could occur if reasonably foreseeable future actions were to result in the following:

- Remove prime farmlands from production;
- Take place on slopes of greater than 40 percent;
- Increase the mid- to long-term erosion of soil resources in the area;
- Cause soil resource compaction where soil crusts are present; or
- Result in spills of hazardous materials.
- Remove forest land from production

The potential impacts of the alternatives were evaluated on the basis of amount of area that would be open for exploration and development and the general presence of soil crusts, easily eroded soils, and prime farmlands.

4.6.3 What are the Common Impacts on Soil Resources Associated with Geothermal Development?

The potential impacts on soil resources from geothermal development include physical disturbance (e.g., movement or removal), compaction, changes to erosion patterns, and changes in current use as farmland. Any development or infrastructure (e.g., wells, roads, or pipelines) on steep slopes would increase erosion and could increase risk of landslides.

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on soil resources from geothermal resource development. This RFD scenario involves four sequential phases: exploration, drilling operations, utilization, and reclamation and abandonment.

The Reasonable Foreseeable Development Scenario for Soil Resources

According to the RFD scenario, it is estimated that 111 power plants could be constructed by 2015, and another 133 power plants could be constructed by 2025. The most development is expected to occur in California and Nevada and the least is expected to occur in Colorado, Arizona, Wyoming, and Montana. The typical acreage of disturbance in a complete geothermal resource development is 53 to 367 acres. Therefore, total land use disturbance would be approximately 5,883 acres to 40,737 acres by 2015 and 12,932 acres to 89,548 acres by 2025.

Exploration

The exploration phase includes surveying and drilling temperature gradient wells. Surveying activities would impact soil resources through disturbance at seismic survey pulse sites. Detonation of explosives would greatly disturb a small area around each detonation. The soil resources beneath each thumper truck site would be compacted. While the area of disturbance at each seismic pulse site would be small, a large seismic survey could include many sites. New roads or routes may be needed to allow survey equipment to access the potential geothermal sites. The impacts of survey activities would be short term. Following surveying activities, all roads and routes would be reclaimed to BLM and FS standards, thereby minimizing any long-term impacts on land uses.

The impacts on soil resources from drilling temperature gradient wells would be minor. Similar to surveying activities, roads would be required to access wells. Several wells could be drilled per lease, for an area of disturbance of approximately 0.9 acres. Impacts would occur on lands directly under the well sites; however, impacts last only the duration of the drilling and reclamation activities (several weeks). The drilling sites and access routes would be reclaimed to BLM and FS standards, thereby minimizing any long-term impacts on soil resources.

Drilling Operations

The drilling operations phase of development would result in short-term impacts on soil resources. The drilling operations phase would require access roads to accommodate larger equipment. Roads for the production wells are typically between 0.5 and 4 miles long and 30 feet wide, for a disturbance of between 2 and 15 acres. New roads would impact any soil resources within their rights-of-way.

The drilling operations phase also includes drill site development, which on average requires a two-acre well pad. Soil resources under each well pad would be impacted.

Utilization

The utilization phase of development would result in long-term impacts on soil resources. The utilization phase would require additional access roads to accommodate larger equipment and for accessing the power plant. Well field equipment and support structures would be constructed. The well field equipment includes pipelines with a disturbance zone approximately 40 feet wide and typically one to four miles in length. Where feasible, pipelines would parallel access roads and existing roads, minimizing the impacts on soil resources. Pipelines are constructed on supports above ground, which would minimize surface disturbance. The disturbance would include the pads for pipeline supports and the access and maintenance roads along the pipeline.

A power plant requires approximately 15 to 25 acres to accommodate all the needed equipment. Similar to other construction required during this phase, this would result in a direct disturbance of the soils within the footprint of the facility.

Installing electrical transmission lines from the power plant would disturb approximately 24-240 acres with a 40-foot-wide disturbance area along transmission line for lengths from 5 to 50 miles long. The disturbance would include the pads for powerline support structures and the access and maintenance roads along the powerline.

Impacts on soil resources during the operation of the geothermal power plant would be minimal. The initial areas disturbed during construction would continue to be used sporadically during standard operation and maintenance activities, such as maneuvering construction and maintenance equipment and the vehicles associated with these activities. No additional impacts would be recognized during this phase unless an additional drill site is required. Impacts from additional drill sites would be the same as those impacts discussed under the exploration and drilling operations phases, above.

Reclamation and Abandonment

Reclamation and abandonment activities include abandoning the wells after production ceases and reclaiming all disturbed areas. All disturbed lands would be reclaimed in accordance with BLM and FS standards.

4.6.4 What are the Potential Impacts on Soil Resources Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. The number of acres likely to be affected under this alternative is unknown.

Issuing geothermal leases for direct and indirect use on a case-by-base basis is not expected to affect soil resources. Impacts on soil resources would occur during subsequent exploration, drilling operations, and utilization phases. These activities at each individual site would incur various long- and short-term impacts on soil resources. Under this alternative, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as consistent guidance for future geothermal leasing and development. The leasing approvals and stipulations would continue to be varied, as would mitigation and reclamation levels.

While all disturbed lands would be required to be reclaimed in accordance with BLM and FS standards, these standards may be applied in a varied manner for individual field offices and ranger districts. Due to the uncertainty of total acreage considered for geothermal leasing and development for direct and indirect use under this alternative, it is not possible to quantify the total acreage affected on federal lands.

Impacts under Alternative B

Under Alternative B, the proposed action, geothermal leasing for direct and indirect use would be open on 118,000,000 acres of public lands and 79,000,000 acres of NFS lands in the western US and Alaska. Lands identified as open to geothermal leasing for direct and indirect use could include moderate to major constraints to reduce potential impacts on soil resources, depending on the environmental conditions identified during site-specific reviews conducted by field offices and ranger districts prior to issuing the leases. Approximately 25,150,000 acres of public lands and 24,370,000 acres of NFS lands would be closed to geothermal leasing for direct and indirect use because the lands are incompatible with geothermal leasing, exploration, and development. Additional lands could be closed to geothermal resource leasing for direct and indirect use due to local conditions at the discretion of the individual field offices and ranger districts.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. Relevant stipulations (Section 2.2.2) designed to minimize impacts on soil resources include 1) no surface occupancy on slopes in excess of 40 percent and/or soils with high erosion potential; and 2) controlled surface use on slopes greater that 30 percent and/or erosive soils as defined as severe or very severe erosions classes based on Natural Resources Conservation Service mapping. In accordance with BMPs (Appendix D), operators would identify unstable slopes and local factors that can induce slope instability. Special construction techniques would be used where applicable in areas of steep slopes, erodible soil, and stream channel crossings. Operators would also be required to adhere to a plan of development that includes spill prevention and cleanup provisions. It is expected that these measures would effectively avoid and/or minimize impacts on soil resources by protecting the most sensitive areas, minimizing erosion, maintaining soil productivity, and minimizing surface disturbance from authorized activities.

Impacts under Alternative C

Under Alternative C, geothermal leasing for indirect use would be open on 61,200,000 acres of public lands and on 37,900,000 acres of NFS land in the western US and Alaska. Geothermal resource development for indirect use would be encouraged within 10 miles of the centerline of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary.

The comprehensive list of stipulations, best management practices, and procedures discussed under Alternative B would be applied to those areas within the transmission line buffer areas. Areas open to direct use geothermal lease applications and impacts from their subsequent development would be the same as identified under Alternative B.

4.7 WATER RESOURCES AND QUALITY

4.7.1 What did the Public Say about Impacts on Water Resources and Quality?

Commentors asked that the impacts on surface water resources from geothermal development activities be discussed in the PEIS, including changes to drainage in development areas, discharges, onsite containment, water additives, stormwater discharge permits, 404 permits and waters of the US in the development areas, and impacts on water hydrology and stream channel morphology, water quality, pools, and hot springs.

Commentors asked that the impacts on groundwater resources from geothermal development activities be discussed in the PEIS, including preventing the accidental discharge of geothermal fluids with toxic chemical properties into the environment, water needs for geothermal resource development, impacts on water quantity and quality, methods of water discharge, and differences with shallow groundwater.

4.7.2 How Were the Potential Effects of Geothermal Development on Water Resources and Quality Evaluated?

Leasing land does not involve ground-disturbing activities or any type of construction, so there would be no direct impact on water resources. Impacts would result from activities pursued after leasing.

This section discusses the potential impacts of anticipated future actions consistent with each of the alternatives on the water resources in the Planning Area. Potential impacts on water resources could occur if reasonably foreseeable future actions were to result in the following:

- Involved surface disturbance such as building roads or preparing drill sites or plant sites that could increase erosion and sedimentation;
- Substantially depleted groundwater supplies or interfered substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level;
- Uses or facilities that would substantially degrade surface or groundwater quality; or
- Changing conditions such that the geothermal resource itself was degraded.

Water quality and quantity is of interest to other resources as well. Biological resources, cultural resources, and recreation may be impacted by changes to water quantity and quality. In this section, impacts on water resources are evaluated only from the perspective of changes to water availability and quality.

Impacts from the perspective of other values (e.g., impacts of water quality on livestock, or reduced flow from a sacred spring) are discussed in sections for the other resources. Effects are quantified where possible; in the absence of quantitative data, best professional judgment was used. While the development of geothermal resources would be intricately linked with groundwater and surface water rights, those rights are very specific to individual locations, aquifers, landowners, and local jurisdictions.

4.7.3 What are the Common Impacts on Water Resources and Quality Associated with Geothermal Development?

Geothermal fluids can be steam or fluid or a mixture under pressure. The geothermal fluids are extracted from the resource, and the heat is used either directly to heat air or water or indirectly to generate electrical power. Once the heat in the geothermal fluid has been used, it is considered "spent." Direct-use systems are smaller and have less impact than indirect uses. Indirect uses are discussed below.

Direct-use geothermal systems use low- to moderate-temperature fluids. Binary power systems use higher temperature geothermal fluids or use heat exchangers with lower boiling point working fluids. The steam and flash steam power plants use the mixed geothermal fluids and pure steam.

The spent geothermal fluid is usually reinjected into the geothermal resource, but it may be evaporated in lagoons or discharged to surface water depending on the relative water quality and temperature. In rare cases, the spent geothermal fluid may be potable and used for agricultural or domestic purposes. The dry steam power plants emit the steam after it has been used and reinject any condensed fluids.

Developing geothermal resources includes using surface water or groundwater for operations, mostly as cooling water. The US Environmental Protection Agency estimates that each megawatt-hour of electricity generated from geothermal resources consumes approximately 200 to 300 gallons of water (US EPA 2008f). This water is primarily used for cooling the operating steam (used to turn turbines) back into a liquid state so that it can be reinjected into the geothermal reservoir. For a given amount of electricity generated, geothermal power plants require less cooling water than fuel combustion boilers and nuclear boilers for the following reasons:

- Geothermal power plants have lower steam temperatures and therefore require less water to bring the steam (used to turn turbines) back into a liquid state.
- Cooling water from geothermal power plants is injected into the geothermal reservoir at a much higher temperature than cooling water from fuel combustion and nuclear boilers, which is typically discharged

into surface water bodies that often support aquatic ecosystems. This additional cooling of water for power facilities discharging to natural surface water bodies is necessary to minimize impacts on the ecosystems supported by those water bodies. To achieve this additional cooling to temperatures that are usually only slightly above that of the receiving water, combustion- and nuclear-based power plants often use larger volumes of cooling water.

The amount of cooling for each geothermal plant depends on the temperature and type of geothermal fluids, the methods used to generate power, the throughput, and the type of cooling used. Air cooling uses very little water. Most binary power plants do not use any water.

The chemical and thermal properties of the geothermal fluid can pose potential threats to surface water and groundwater quality. Geothermal water can contain a variety of dissolved compounds, including silica, sulfates, carbonates, metals, and halides. Any mixing of geothermal fluids with surface or groundwater where the chemical and thermal qualities of the geothermal fluids would degrade the other water in the area would potentially damage aquatic ecosystems and contaminate drinking water supplies.

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on water resources from geothermal resource development. The degree of impact would vary greatly depending on local conditions including presence of sole source aquifers, hot springs, and the existing water quality.

The Reasonable Foreseeable Development Scenario for Water Resources and Quality

In general, any ground disturbance activities associated with geothermal resource development (roads, transmission lines, pipelines) would have a minor to negligible impact on surface water and groundwater resources within the immediate area. However, if an area is already heavily impacted due to existing operations or conditions, even these minor impacts could be substantial.

Exploration

Survey activities would have little to no impact on surface or groundwater. Exploration drilling would involve some ground-disturbing activities such as road and drilling pad construction. This could lead to an increase in soil erosion, with the result that more soil might be transported in surface runoff. Best management practices (see Appendix D) to reduce sediment erosion and to prevent sediment from being transported to surface water areas would be implemented in compliance with stormwater pollution prevention requirements of the Clean Water Act. By following BLM and FS guidelines, impacts on water resources would be avoided. The long-term impacts would be minor. The short-term impacts would be moderate and mitigable.

Drilling Operations

Geothermal fluids in the resource can be under high pressures. Drilling can create pathways for these fluids into the groundwater at shallower depths or commingling between aquifers of differing quality. The impacts of these pathways can alter the natural circulation of the geothermal fluids and impact the usefulness of the resource. Subsurface pathways also can allow the natural contaminants in the geothermal fluids to impact the shallow groundwater quality if mixing were to occur. The degree of impact depends on aquifer characteristics and whether special conditions (e.g., sole source aquifers) are present. Proper drilling practices and closure and capping of the wells can reduce this potential.

During normal operations, liquid wastes from drilling activities are stored in lined sumps before being properly disposed of in accordance with state regulations. Geothermal fluid production and associated waste production is likely to occur for short periods as wells are tested to determine reservoir characteristics. If geothermal fluids are discovered in commercial quantities, development of the geothermal field is likely. During the initial stages of testing, one well is likely to be tested at a time. If testing is successful and the well and reservoir are sufficient for development, well heads, valves, and control equipment would be built on top of the well casing to prepare for the utilization phase.

Release of geothermal fluids during well testing can cause temporary impacts on surface waters within the immediate area of the test wells if not contained. These impacts include thermal changes and changes in water quality depending on the differences in the geothermal fluid and the surface waters. Accidental spills of geothermal waters may occur due to well blowouts during drilling, leaking piping or well heads, or overflow from sump pits.

BLM and FS guidelines and state regulations for maintaining and plugging and capping wells to prevent blowouts and mandating proper well casing and drilling techniques would minimize the risk of impacting surface water and groundwater in the immediate area.

Groundwater extraction and injection wells are installed and pumped to cycle geothermal fluids within the geothermal reservoir to remove heat energy. To be effective, it is desirable to create an efficient circulation system where the injected (cool) fluid is resident in the formation long enough to heat up to the maximum temperature without significantly altering subsurface pressures. This requires a highly permeable geothermal aquifer that is preferably isolated from any shallow cool water or potable water aquifer above it. High injection pressures can fracture rock, with resultant leakage of geothermal fluids.

Typically these fluids are highly mineralized, so geothermal production systems could contaminate shallow freshwater aquifers and heat could be lost to the surface.

Extracting geothermal fluids could result in drawdowns in connected shallower groundwater aquifers, with the resulting potential to affect streams or springs that are in turn connected to the water table aquifer. The potential for these types of adverse impacts is reduced through extensive aquifer testing, which is the basis for designing the geothermal plant and for locating, designing, and operating the extraction and injection wells. Combined with the requirement to comply with state and federal regulations that protect water quality and with limitations imposed by water rights issued by the state engineer, the impacts on water quality and the potential for depleting water resources is expected to be minimized. There is a medium risk for moderate to high impacts on groundwater supplies from the use of groundwater for geothermal activities.

Utilization

During construction, ground-disturbing activities such as road and foundation pad construction and utility installation could lead to an increase in soil erosion, with the result that more soil might be transported in surface runoff. Construction activities may also increase the risk of fire which could also result in increased erosion. Best management practices to reduce sediment erosion (see Appendix D) and to prevent sediment from being transported to surface water areas would be implemented in compliance with nonpoint (stormwater) pollution prevention requirements of the Clean Water Act.

Geothermal resource utilization could affect groundwater resources because of consumption of water by evaporation and the need to reinject water to replenish the geothermal reservoir. The magnitude of the effects would vary depending on groundwater conditions and availability within the basin and on the type of geothermal plant. Availability of water resources could be a limiting factor, affecting the expansion of geothermal resource development in a given area.

During normal operations and when production wells are tested, geothermal plants produce wastewater from cooling tower blowdown. This is the spent water that is periodically discharged from the cooling system. Makeup water is used to replace or make up for the evaporative losses and blowdown in a water-cooled system. The quantity of cooling tower blowdown depends on the size of the power plant, the quality of the makeup water (lower quality water requires more frequent cycling), the nature of the additives to prevent mineral scale, and the number of times the water is cycled. The source of cooling water could be either surface water or groundwater.

Production of geothermal fluids could be expected to vary from 1to 6 million gallons per day per well. Assuming 5 million gallons per day per well as an average production figure, a lease with two producing wells would produce 10 million gallons of fluid per day.

Once a plant is operational, most geothermal fluids produced are reinjected back into the geothermal reservoir via reinjection wells. In flash steam facilities, about 15 to 20 percent of the fluid would be lost due to flashing to steam and evaporation through cooling towers and ponds. Binary power plants are non-consumptive and use a closed loop system. Fluids could also be lost due to pipeline failures or surface discharge for monitoring and testing the geothermal reservoir. In dry steam facilities, where steam is the only geothermal fluid, very little of the steam can be cooled for reinjection.

The cooling water could be discharged either to the ground or to an evaporation pond. Discharging cooling tower blowdown or water from testing geothermal production wells could affect shallow groundwater quality if the discharged water percolated to a shallow aquifer. Discharging cooling tower blowdown water would be subject to a National Pollution Discharge Prevention System permit issued by the appropriate state oversight agency, which would require testing to ensure that the water met the discharge requirements and did not degrade groundwater quality. The state would likely require that the cooling water be discharged to a lined pond to prevent infiltration. Therefore, the potential for water quality impacts on surface water from operational discharges of a geothermal plant are expected to be minor or mitigable.

The original coolant water and the replenishment water contain salts that become concentrated in the cooling system over time, requiring that the coolant be periodically replaced. The cooling water may also contain metals or other constituents introduced from corroding pipes or from chemical additives used to inhibit corrosion or microbial growth in the system. Low-toxicity additives are available that could be used in the cooling towers to lower the potential for impacts from this source.

Air-cooled systems use less cooling water and are more common in arid regions. Air-cooled systems would have fewer impacts associated with cooling water.

During operations, geothermal fluids are kept as part of a closed loop until they are reinjected into the geothermal resource. However, small amounts of these contaminants can be accidentally released into the surface environment from venting steam to eliminate excessive pressure or through mechanical breakdowns like broken pipes. The temporary release of fluids from tests and accidents would have minor impacts on any surface waters in the immediate area.

Hot springs are surface features that indicate the presence of geothermal features deep within the earth. These springs can be part of sensitive ecosystems, recreation areas, or traditional cultural properties. The geothermal resources that would be developed are usually at greater depths than the shallow groundwater associated with the hot springs. However, withdrawing shallow groundwater or surface water for cooling water purposes could affect nearby springs.

Reclamation and Abandonment

The reclamation and abandonment phase would involve plugging and capping production and injection wells. Improper abandonment could allow the wells to serve as pathways for geothermal fluids to migrate to other aquifers, affecting both the geothermal resource and other groundwater quality. Proper well closure and capping would reduce the risk of these impacts.

4.7.4 What are the Potential Impacts on Water Resources and Quality Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. The restrictions and stipulations on geothermal exploration and development activities for direct and indirect use would also be determined by the individual field offices and ranger districts on a case-by-case basis. The number of acres likely to be affected under this alternative is unknown.

Issuing geothermal leases for direct and indirect use on a case-by-base basis includes avoiding impacts on water resources in many BLM field offices and FS ranger districts. In addition, water resources may be protected through avoidance and mitigation measures for other resources where those resources include water resources. Examples include wetlands, designated wild and scenic rivers, endangered species habitat, and springs of cultural importance to Native Americans.

Under this alternative, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as consistent guidance for future geothermal leasing and development. The leasing approvals and stipulations would continue to be varied, as would mitigation and reclamation levels.

Impacts under Alternative B

Under Alternative B, Designated Wild Rivers under the Wild and Scenic River Act and The Island Park Geothermal Area (includes NFS lands in Idaho and Montana) would be closed to geothermal leasing for direct and indirect use.

Geothermal leasing for direct and indirect use would be open on 118,000,000 acres of public lands and on 79,000,000 acres of NFS land in the western US and Alaska. Lands identified as open for geothermal leasing for direct and indirect use could have moderate to major constraints related to potential impacts on water resources, depending on environmental conditions identified during site-specific reviews conducted by field offices and ranger districts prior to issuing the leases. Approximately 25,150,000 acres of public land and 24,370,000 acres of NFS land would be closed to geothermal leasing for direct and indirect use because these lands were found to be incompatible with geothermal leasing, exploration, and development. Additional lands might be closed to geothermal resource leasing for direct and indirect use due to local conditions at the discretion of the individual field offices and ranger districts.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. Relevant stipulations (Section 2.2.2) designed to minimize impacts on water resources and water quality include (1) no surface occupancy on water bodies, riparian areas, wetlands, playa, and 100-year floodplain; and (2) controlled surface use within 500 feet of riparian or wetland vegetation to protect the values and functions of these areas. In accordance with BMPs (Appendix D), operators would be required to gain a clear understanding of the local hydrology and would avoid creating hydrologic conduits between aquifers. Operators would also develop a storm water management plan for the site to ensure compliance with applicable regulations and to prevent off-site migration of contaminated water or increased soil erosion. It is expected that these measures, along with the measures outlined to protect soil resources, would effectively minimize impacts on water resources and quality by protecting sensitive surface and ground water resources, protecting wetland and riparian habitats, reducing water quality degradation (i.e., contamination and sedimentation), and meeting applicable water quality standards.

Impacts under Alternative C

Under Alternative C, approximately 61,200,000 acres of public land and 37,900,000 acres of NFS land would be identified as open to geothermal leasing for indirect use. Alternative C differs from Alternative B in that the BLM and FS would only consider indirect use leasing within 10 miles from the centerline of existing 60 kV to 500 kV transmission lines and at least 15 miles outside of the Yellowstone National Park boundary.

The comprehensive list of stipulations, best management practices, and procedures discussed under Alternative B would be applied to those areas within the transmission line buffer.

Areas open to direct use geothermal lease applications and impacts from their subsequent development would be the same as identified under Alternative B.

4.8 Air Quality and Atmospheric Values

4.8.1 What Did The Public Say About Impacts on Air Quality and Atmospheric Values?

Comments received during scoping requested that BMPs such as emissions monitoring, diesel exhaust abatement, dust control, and a requirement for Equipment Emissions Mitigation Plans be incorporated into lease terms. Comments included requests for the PEIS to discuss the criteria pollutants expected to be emitted from the various sources typically associated with geothermal projects as well as the timeframe for these emissions over the various project phases. From a regulatory standpoint, commentors requested that the PEIS discuss the applicability of General Conformity, New Source Review, and Operating Permits to geothermal projects. Commentors also requested that the PEIS address the reduction of regional air emissions that would be expected by expanding geothermal energy use.

4.8.2 How Were the Potential Effects of Geothermal Development on Air Quality and Atmospheric Values Evaluated?

Methodology

Potential effects of geothermal development on air quality were evaluated by examining the typical air emissions associated with the various stages of geothermal development, and comparing those emissions with areas of nonattainment across the planning area (shown in Table 3-13, Counties within the Planning Area that are Designated Nonattainment or Maintenance Areas for Criteria Pollutants). While geothermal leasing itself would not impact air quality, the impacts of development on leased areas could affect air quality in the future. These potential effects on air quality are those that may result from pollutants that are typically generated by geothermal development.

Other regulatory requirements that would likely be required at the project-specific phase of analysis and permitting are examined here and were considered in determining both the impact criteria and in developing the impact analysis.

A secondary analysis was conducted to estimate the carbon dioxide emissions that would be generated by geothermal power development, compared with conventional, fossil-fuel based energy production. This analysis was conducted using the estimates of mass of carbon dioxide generated per kilowatt hour by geothermal, natural gas, petroleum, and coal power production, as shown in Table 3-14.

Conformity Requirements

Section 176(c) of the Clean Air Act, 42 USC § 7506(c), requires federal agencies to ensure that actions undertaken in nonattainment areas are consistent with the Clean Air Act and with federally enforceable air quality management plans.

The EPA has promulgated separate rules that establish conformity analysis procedures for transportation-related actions and for other (general) federal agency actions. The EPA general conformity rule applies to federal actions occurring in nonattainment areas when the total direct and indirect emissions of nonattainment pollutants (or their precursors) exceed specified thresholds. The emission thresholds that trigger requirements of the conformity rule are called de minimis levels.

At project level analysis and permitting, the BLM and FS would need to ensure that any proposed action, including construction emissions subject to state jurisdiction, conform to an approved State Implementation Plan (SIP). Emissions authorized by a Clean Air Act permit issued by the state or by the local air pollution control district would not be assessed under general conformity but through the permitting process.

Air Permitting

The Clean Air Act and its subsequent amendments require the permitting of stationary sources. Permitting requirements for major air sources are contained in two different programs. The first program is the New Source Review program, which consists of two preconstruction programs: The Prevention of Significant Deterioration program for permitting sources in attainment areas, and the nonattainment area permitting program. The second program is the Operating Permits Program, for permitting a source once it is in operation.

New Source Review

Congress established the New Source Review permitting program as part of the 1977 Clean Air Act Amendments. New Source Review permitting is a preconstruction permitting program that:

- Ensures that air quality is not significantly degraded from the addition of new and modified factories, industrial boilers, and power plants. In areas with unhealthy air, New Source Review permitting assures that new emissions do not slow progress toward cleaner air. In areas with clean air, especially pristine areas like national parks, New Source Review permitting assures that new emissions do not significantly worsen air quality.
- Assures people that any large new or modified industrial source in their neighborhoods will be as clean as possible, and that advances in pollution control occur concurrently with industrial expansion.

New Source Review permitting permits are legal documents to which facility owners/operators must abide. The permits specify what construction is allowed, what emission limits must be met, and often how the source must be operated. They may contain conditions to make sure that the source is built to match parameters in the application that the permit agency relied on in their analysis.

For example, the permit may specify stack heights that the permit agency used in their analysis of the source. Some limits in the permit may be there at the request of the source to keep them out of other requirements. For example, the source may take limits in a minor New Source Review permitting permit to keep the source out of Prevention of Significant Deterioration permit. To assure that sources follow the permit requirements, permits also contain monitoring, recordkeeping, and reporting requirements.

The New Source Review permitting process includes a public involvement component. Members of the public can use the New Source Review permitting program to ensure that sources are complying with the requirements that apply to them. New Source Review permitting gives the public the opportunity to:

- Comment on and request a public hearing on permits before they are issued.
- Appeal permits issued pursuant to the State Implementation Plan. The appeal procedures will depend on the state the source is located in.
- Appeal EPA-issued permits or permits issued by state or local agencies that are issuing the permit on behalf of the EPA to the Environmental Appeals Board and the federal courts.

Authority to Construct and Permit to Operate

For a specific project, the local air district would issue an Authority to Construct permit during the drilling operations stage of a project to address air emissions from stationary sources, which at that stage of development would be the production wells. For a power plant, an Authority to Construct is usually initially acquired for the power plant, including the wells. Once the power plant is operational and any initial operational problems have been worked out, the air district then issues a Permit to Operate. Depending on the type of project and the amount and type of air emissions, abatement systems may be required by the local air district during this phase of permitting.

The EPA's Operating Permits Program was established through Title V of the Clean Air Act Amendments of 1990 and is considered to be the most important procedural reform in the amendments and the centerpiece for compliance with the entire act. Title V requires the establishment of an operating permit program for major stationary sources that would ensure compliance by industry with all applicable requirements of the act, enhance EPA's ability to enforce the Clean Air Act, generate state and tribal revenue to administer the program, enhance the ability of a permitting agency to track compliance and evaluate a source's air quality, ensure public involvement by allowing review and comment of draft permits, and increase certainty for industry by providing all source requirements in one permit document.

Impact Criteria

Potential impacts on air quality could occur if reasonably foreseeable future actions were to result in the following:

- Conflict with or obstruct implementation of the applicable air quality attainment plan;
- Violate any stationary source air quality standard or contribute to an existing or projected air quality violation; or
- Expose sensitive receptors (e.g., concentrations of children, elderly, or persons with respiratory conditions) to major pollutant concentrations.

4.8.3 What are the Common Impacts on Air Quality and Atmospheric Values Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on air quality from geothermal resource development.

The nature and extent of geothermal-related development activities that would affect air quality would vary by project, depending on several factors: 1) whether the project is for direct use or indirect use; 2) the size of the project; and 3) for indirect projects, which type of power plant technology is used. Potential air quality impacts would be evaluated on a project-specific basis, as NEPA would be conducted for each of the potential phases of geothermal development activity: exploration, drilling operations, utilization, and reclamation and abandonment. Air permits would also be obtained, as necessary, for each individual phase, and activities at all sites would need to be carried out in conformance with the applicable SIPs. This section will qualitatively address the air quality impacts typically associated with each phase of development, and then examine the role the development of geothermal energy applications is likely to play in air quality nationwide.

Some activities resulting in air quality emissions are common to all phases of a geothermal project lifecycle, while others are specific to certain phases. Table 4-1 summarizes the activities and the criteria pollutants of concern related to those activities. Emissions from each phase of development are discussed in the following text.

The Reasonable Foreseeable Development Scenario for Air Quality and Atmospheric Values

As stated in the RFD scenario, it is estimated that 111 power plants would be constructed across the 12-state project area by 2015, and a further 133 power plants would be constructed by 2025. The average capacity of these power

Table 4-1
Activities and Related Pollutants from Geothermal Project Phases

Activity	Pollutant	Project Phase	Factors
Exhaust from vehicular traffic	Carbon monoxide, carbon dioxide, oxides of nitrogen, volatile organic compounds, particulates, sulfur dioxide, air toxics	All	Vehicle-miles traveled (VMT)
Fugitive dust from vehicle traffic on paved and unpaved roads	Particulates	All	VMT, road conditions
Fugitive dust from earth-moving activities	Particulates	All	Acres disturbed, soil conditions
Exhaust from construction equipment	Carbon monoxide, carbon dioxide, oxides of nitrogen, volatile organic compounds, particulates, sulfur dioxide, air toxics	All	Volume of fuel used, engine/abatement technology
Release of geothermal fluid vapor	carbon dioxide, hydrogen sulfide, mercury, arsenic, boron	Exploration, drilling operations, utilization	Chemical composition of geothermal resource, duration and volume of flow testing, frequency, duration, and volume of well blow-outs, type of power plant

plants is estimated to be 50 megawatts. For direct use, it is estimated that by 2015, applications could be developed in the amount of 1,600 thermal megawatts; by 2025, applications could be developed in the amount of 4,200 thermal megawatts. For indirect use, the RFD scenario estimates that up to 40,737 acres of land would be disturbed by 2015, and up to 89,548 acres of land would be disturbed by 2025. Such disturbances would be spaced both temporally across approximately 15 years, and spatially across the 12-state project area.

Exploration

Air quality impacts associated with exploration are short term and generally limited to the release of fugitive dust from surface disturbance and emissions from vehicles and construction and drilling equipment. Initial exploration activities such as surveying and sampling would have minimal air quality impacts from accessing exploration sites in roadless areas and from disturbing small areas of land for the placement of surveying equipment. Secondary exploration activities, specifically site clearing, exploration well pad development, and the drilling of temperature gradient wells would have more intensive exhaust-related emissions and would last for longer periods of time. Total time for exploration activities typically ranges between one and five years.

Drilling Operations

Air emissions during the drilling operations phase of a geothermal project include fugitive dust and emissions from combustion engines, as described above, but as successful wells are drilled, the new source of potential air pollution is from the venting of geothermal fluids to the atmosphere. Well venting introduces the potential for release of hydrogen sulfide, carbon dioxide, mercury, arsenic, and boron when these compounds are contained in the geothermal resource. The local air district may require establishing an air monitoring program, particularly if the well is proposed as a power generation project. Hydrogen sulfide is generally the primary pollutant of concern for air districts considering permitting a geothermal well.

The following specific activities during the drilling operations phase would result in emissions of fugitive dust and exhaust from combustion engines:

- Vehicle traffic on access roads (worker vehicles, equipment, watering trucks, materials delivery trucks);
- Removing vegetative cover;
- Constructing roads, well pads, lay-down areas, and landscaping involving excavation, moving soils, and grading;
- Drilling production wells – Drilling times vary considerably with the type of rock and depth of resource. Drilling rates of approximately 150 feet per day have been reported (Finger and Hoover 2003), bringing drill rig operating times into an estimated range of 10 days for a 1,500 foot well to nearly 70 days for a 10,000 foot well;
- Drilling injection wells; and
- Constructing fluid sump pits.

Utilization

Constructing a geothermal power plant and its associated infrastructure during the onset of the utilization phase would create the greatest amount of fugitive dust and exhaust from combustion engines.

By the onset of operations within the utilization phase, particularly for indirect use applications, an air monitoring system is usually already in place from the drilling operations phase. Such a monitoring system has typically been collecting pertinent baseline data about the nature of the emissions from the wells and later, for indirect uses, the power plant(s) over the course of development and construction.

Direct use applications likely have very few wells (typically one or two) and no emissions. Similarly, for a binary power plant, no emissions are realized during operations in the utilization phase, except for during well venting during maintenance activities, or leaks in the heat exchangers, which could result in the release of volatile organic compounds. Flash and dry steam power plants emit geothermal vapors to the atmosphere, potentially releasing the range of pollutants listed above under the drilling operations phase.

Fugitive dust and exhaust from combustion engines during operations within the utilization phase would be generally limited to worker and maintenance vehicle traffic.

Table 4-2 shows the carbon dioxide emission estimates from the projected 2015 and 2025 geothermal power plant electricity generation detailed in the RFD scenario, and compares it with estimated emissions for the same power generation from traditional fossil fuel sources. Calculations were based on the rate of carbon dioxide production per kilowatt-hour shown in Section 3.8, Air Quality for the various energy sources, derived from Bloomfield *et al.* (2003).

As shown in Table 4-2 it is estimated that development of the number of geothermal power plants estimated in the RFD scenario would result in emissions of approximately 554 tons of carbon dioxide per hour in 2015, and 1,216 tons of carbon dioxide per hour in 2025. Were the same electrical capacity to be produced by natural gas, petroleum, or coal, carbon dioxide emissions would be six-fold, nine-fold, and ten-fold, respectively.

Direct use applications are also expected to reduce carbon dioxide emissions through energy consumption offsets; however, it is difficult to quantify such offsets since in some cases, access to geothermal resources for direct use applications may actually stimulate economic growth around the resource and result in other types of emissions in a location that would otherwise not have the same degree of development and emission-generating activities.

Table 4-2
Hourly Carbon Dioxide Emissions at 2015 and 2025

	Geothermal (0.20 lbs. CO_2/kWh)	Coal (2.095 lbs. CO_2/kWh)	Petroleum (1.969 lbs. CO_2/kWh)	Natural Gas (1.321 lbs. CO_2/kWh)
2015 emissions per hour (5,540 MW)	554[1] tons	5,760 tons	5,410 tons	3,630 tons
2025 emissions per hour (12,160 MW)	1,216 tons	12,670 tons	11,910 tons	7,990 tons

[1]Sample calculation:
(5,540 MW) x (1,000 kW/MW) x (0.2 lbs CO_2/kW-h) x (0.0005 ton/lb) = 550 tons

Reclamation and Abandonment

Air quality impacts during reclamation and abandonment activities would be generally limited to emissions from vehicles and construction equipment and to fugitive dust from the movement of vehicles. Depending on the flow and temperature of the geothermal fluids or steam at the well heads at the time of abandonment, well capping could result in the potential release of the range of pollutants listed above under the drilling operations section.

4.8.4 What are the Potential Impacts on Air Quality and Atmospheric Values Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

The relationship between GHG emissions and climate change is discussed earlier, under Section 4.1. The discussion here is limited to a comparison in terms of possible GHG emissions and the potential for offsets between the respective approaches to development reflected in each of the alternatives.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. Under Alternative A, the pace of development of geothermal power plants or direct use projects would be lower than under Alternatives B and C, making it more likely that fossil-fuel based power plants would continue to be developed and that emissions at 2015 and 2025 would more closely resemble the estimates in the fossil-fuel based columns than in the geothermal column of Table 4-2. Compared with the other alternatives, Alternative A is expected to have the least beneficial effect on reducing GHG emissions.

Impacts under Alternative B

Alternative B would be expected to provide larger-scale and longer-term opportunities for improvements in air quality and reductions in greenhouse gases than Alternative A. At the project-level NEPA analysis, Clean Air Act conformity requirements would apply only to those lease areas within maintenance and nonattainment areas.

The large-scale development of geothermal energy applications for direct and indirect use across the western US has the potential to offset substantial emissions of criteria pollutants at the national level. Such development would help individual states meet their renewable portfolio standards and their increasing energy needs, while maintaining or improving air quality. The air quality impacts of geothermal exploration, drilling operations, utilization, and reclamation and abandonment are considered to be much less than the impacts associated with the alternative—development of nonrenewable energy sources such as oil, natural gas, and coal.

The wide-scale development of geothermal energy applications for direct and indirect use would at the least decrease the need for future development of more-polluting energy-generating applications, such as oil, natural gas, and coal, and would slow the increase in greenhouse gases being generated by the US. At best, the wide-scale development of geothermal energy applications for direct and indirect use would be an integral part of a shifting energy landscape in the US to renewable energy sources that would result in an overall decrease in greenhouse gas emissions.

Under Alternative B, emissions resulting from development at 2015 and 2025 would more closely resemble the estimates in the geothermal columns than in the fossil-fuel columns of Table 4-2. Compared with the other alternatives, anticipated future actions consistent with Alternative B are expected to have the greatest beneficial effect on reducing GHG emissions because of the greater potential for GHG offsets, as described in Section 4.8.3.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. In accordance with BMPs (Appendix D), operators would be required to minimize air quality impacts from fugitive dust, vehicle exhaust, and equipment operations. Operators would prepare and submit to the BLM an Equipment Emissions Mitigation Plan. Requirements for emissions controls would be incorporated into the terms of individual geothermal leases. It is expected that these measures would effectively minimize impacts on air quality and atmospheric values by reducing sources of air quality degradation including particulates and hydrocarbons.

Impacts under Alternative C

Impacts from anticipated future actions consistent with Alternative C would be greater than those consistent with Alternative A, but less than those consistent with Alternative B, since smaller land areas would be available for indirect use development, and less development would be likely to occur. While Alternative C would allow for a more expeditious achievement of offsets than Alternative A for states within the project area, Alternative C would be inferior to Alternative B in this regard.

Under Alternative C, emissions at 2015 and 2025 would likely be somewhere between the estimates in the geothermal columns and in the fossil-fuel columns of Table 4-2. Compared with the other alternatives, anticipated future actions following leasing under Alternative C are expected to have a greater beneficial effect on reducing GHG emissions than Alternative A, and a lesser beneficial effect than Alternative B.

Areas open to direct use geothermal lease applications and impacts from their subsequent development would be the same as identified under Alternative B.

At the project-level NEPA analysis, Clean Air Act conformity requirements would apply only to those lease areas within maintenance and nonattainment areas.

4.9 VEGETATION

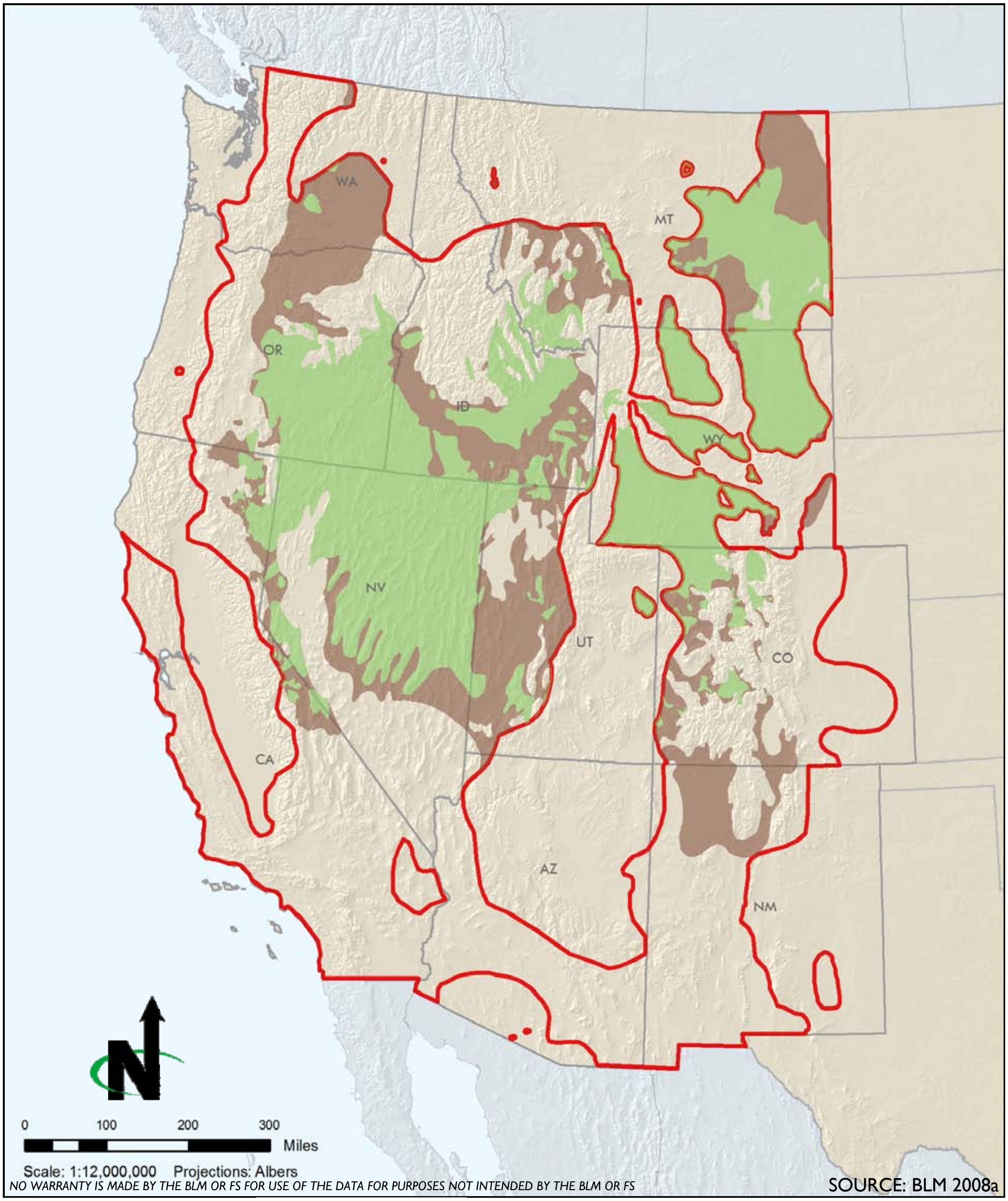
4.9.1 What did the Public Say about Impacts on Vegetation and Important Habitats and Communities?

Comments collected during scoping relating to vegetation and important habitats requested that the analysis of impacts address riparian and wetland habitat, important sagebrush habitats, winter range habitat, important terrestrial and aquatic plant and animal habitat, and the potential for introduction of invasive species. The effects of fragmentation and removal on these areas were the main concern addressed during scoping.

4.9.2 How Were the Potential Effects of Geothermal Development on Vegetation and Important Habitats and Communities Evaluated?

Leasing geothermal resources would not affect vegetation or important habitats and communities. These resources would be affected only by development of specific geothermal development projects that occurred subsequent to the leasing action. Potential impacts of geothermal development were evaluated based on the typical disturbance of geothermal projects for the various stages of development and then assessed based on projected location and intensity, as described in the RFD. The types of vegetation and important habitats and communities that could be affected by geothermal development on public and NFS lands depend on the ecoregions they exist and the specific location of the proposed project.

Figures 3-10 through 3-13 show the distribution of public and NFS lands with a potential for geothermal development, relative to ecoregion divisions and provinces that occur in the 12 western states. The types of vegetation, habitats, and communities that could be affected by geothermal development depend on the ecoregion in which the project is located (Appendix G provides more information on ecoregions). Specific impacts of a project depend on the types of vegetation and habitats present at the project location within the ecoregion province. The ecoregion provinces with the greatest extent of areas with medium to high potential for geothermal development are the Intermountain Semi-Desert and Desert and the American Semi-Desert and Desert (Figure 3-12 and 3-13). The vegetation communities in these ecoregions are largely arid and semiarid grass and shrub lands, including sagebrush (Figure 3-14). There is a notable decrease is distribution of sage brush obligate species, including sage grouse (Figure 4-1), which highlights the importance of the sagebrush community. Appendix G presents descriptions of the vegetation found within public and NFS lands with a potential for geothermal development across ecoregions of the 12 western states.



C:/EMPSi/GeothermalPEIS/Figures

Greater sage grouse require contiguous, undisturbed areas of high-quality habitat during their four distinct seasonal periods of breeding, summer-late brooding and rearing, fall, and winter.

Current and Historical Sage Grouse Distribution in the Western United States

Figure 4-1

Impacts discussed are associated with the elimination and degradation of habitat occurring at project sites, in immediately adjacent areas, or within the individual project watershed(s). Potential impacts on vegetation and important habitats could occur if reasonably foreseeable future actions were to result in the following:

- Affect a plant species, habitat, or natural community recognized for ecological, scientific, recreational, or commercial importance;
- Affect a species, habitat, or natural community that is specifically recognized as biologically significant in local, state, or federal policies, statutes, or regulations;
- Establish or increase noxious weed populations;
- Destroy or extensively alter habitats or vegetation communities in such a way that would render them unfavorable to native species; or
- Conflict with BLM or FS management strategies.

4.9.3 What are the Common Impacts Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on vegetation and important habitats from geothermal resource development.

The nature and extent of geothermal-related development activities that would affect vegetation and important habitats and communities would vary by project, depending on several factors: 1) whether the project is for direct use or indirect use; 2) the size of the project; 3) the geographic location; and 4) for indirect use, the type of plant. Potential vegetation and important habitat impacts would be evaluated on a project-specific basis, as NEPA would be conducted for each of the potential phases of geothermal development activity: exploration, development, operation, and closeout. This section will qualitatively address the impacts on vegetation and important habitats and communities.

The Reasonable Foreseeable Development Scenario for Vegetation and Important Habitats and Communities

The RFD scenario estimates 111 power plants would be constructed across the 12-state project area by 2015, and an additional 133 power plants would be constructed by 2025. The average capacity of these power plants is estimated to be 50 megawatts. This estimate assumes that up to 40,737 acres of land would be disturbed by 2015, and up to 89,548 acres would be disturbed by 2025 as part of indirect use geothermal projects. For direct use, it is estimated that applications could be developed in the amount of 1,600 thermal megawatts by 2015 and 4,200 thermal megawatts by 2025. Disturbance from development would be spaced both temporally across approximately 15 years, and spatially across the 12-state project area.

Regardless of the location of geothermal development projects, the nature of the impacts from exploration and development to vegetation and important habitats and communities would be similar in all ecoregions. Vegetation would be affected by direct destruction and removal, fugitive dust, exposure to contaminants, and the introduction of invasive species. The extent of the impacts is typically associated with the size of the area that is disturbed and the types of vegetation habitats and communities present. The ability of an area to recover from disturbance also affects the extent of the damage.

Impacts common to all vegetation and important habitats are discussed below, followed by an analysis of how those impacts might affect important habitats and communities within the planning area. Finally, any impacts that are specific to a certain stage of geothermal development (exploration, development, operation, or closeout) are discussed. Geothermal activities can cause the following stressors and associated impacts on vegetation and important habitats. Table 4-3, Potential Impacts of Vegetation and Important Habitats, provides a breakdown of the likelihood for impacts to occur during each phase of geothermal development (exploration, development, production, and closeout).

- Habitat disturbance - Site clearing, well drilling, constructing access roads and geothermal facilities, and maintenance and operational activities would disturb habitat, which would cause mortality and injury, increase the risk of invasive species, and alter water and seed dispersion and wildlife use, which can further affect vegetation communities.
- Direct Removal and Injury - Vegetation would be cleared for roadways, vehicle staging, buildings, pipelines, and transmission lines. Activities could result in loss of soil, loss of seed bank in soil, deposition of dust, and destruction of biological soil crusts. Maintenance around project components such as drill pads, buildings, pipelines, or other facilities would involve mowing, herbicide treatment, and other mechanical or chemical means of removal and control. This would result in a net loss of important habitats and communities throughout the planning area.
- Invasive Vegetation - Disturbance and access by vehicles and human foot traffic may expose areas to colonization by invasive and nonnative species, making it more difficult for endemic species to reestablish in disturbed areas and threatening the continued existence of endemic species (BLM 2007c).

Table 4-3
Potential Impacts of Vegetation and Important Habitats

Ecological Stressor	Geothermal Activity	Impact	Potential Level of Impact			
			Exploration	Drilling Operations	Utilization	Reclamation and Abandonment
Habitat disturbance	Site clearing and grading; well drilling and construction; pipelines, access road, and ancillary facility construction; construction and maintenance vehicle travel	Loss of vegetation, increase risk of invasive species, alter water and seed dispersion	Moderate	Moderate	Moderate to high	Low
Direct removal and Injury	Site clearing and grading; well drilling and construction; pipelines, access road, and ancillary facility construction; construction and maintenance vehicle travel	Direct destruction of vegetation, increase of invasive species	Moderate to high	Moderate to high	High	Low to moderate
Invasive vegetation	Site clearing and grading; well drilling and construction; pipelines, access road, and ancillary facility construction; construction and maintenance vehicle travel	Change species composition, increase risk of fire, eliminate native species	Low to moderate	Low to moderate	Moderate to high	Low to moderate

Table 4-3
Potential Impacts of Vegetation and Important Habitats

Ecological Stressor	Geothermal Activity	Impact	Potential Level of Impact			
			Exploration	Drilling Operations	Utilization	Reclamation and Abandonment
Fire	Site clearing and grading; well drilling and construction; construction and maintenance vehicle use; cigarette smoking	Direct mortality to vegetation, loss of seed bank, erosion, increased potential for invasive species, loss of species diversity	Low	Low	Moderate to high	Low
Erosion	Site clearing and grading; well drilling and construction; pipelines, access road, and ancillary facility construction; construction equipment travel	Reduced habitat quality, direct loss of vegetation, loss of topsoil and seed bank, increased risk of invasive species	Low to moderate	Low to moderate	Moderate	Moderate
Exposure to contaminants	Accidental spill during equipment refueling; accidental release of stored fuel or hazardous materials; drilling mud spill or accidental spill of geothermal fluids and working fluids; accidental spill of herbicides	Growth impairment, direct mortality, changes in species composition	Low	Low	Low	Low

The assessment of impact level is based on the RFD; and activities and projected disturbance associated with each stage geothermal development, as well evaluation of the efficacy of BMPs, stipulations and procedures available to eliminate or mitigate the potential impacts. Duration of the impact as well as potential for accidents factor into the assessment.

Low- The activities involved in geothermal development do not present a risk or have effective precautions, stipulations and BMPs, that would minimize the potential, intensity, and duration of impact associated the prospective ecological risk factor.

Moderate- The activities involved in geothermal development have a greater potential for impacts on wildlife, including accidents, unavoidable removal of habitat, and indirect disturbance. Impacts may be unavoidable and may endure beyond the conclusion of the activity.

High- The activities involved in geothermal activities would have direct and unavoidable impacts. BMPs and stipulations are not available to eliminate impacts. Additionally, the risk of accident may be higher or the duration of the impact may be last well beyond the conclusion of the geothermal activities.

- Fire – Equipment operation, increased vehicular and human traffic, using drilling muds, and extracting geothermal fluids can increase the risk of fires. Vehicles, electrical lines, and smoking can all result in accidental fires. Fires destroy vegetation and can aid in the establishment of invasive species.
- Erosion - Containment basins, site clearing, grading, constructing access roads, site runoff, and vehicle and human foot traffic cause erosion. The effects of erosion include top soil removal, seed bank loss, native vegetation loss, invasive species establishment, stream sedimentation, and flooding (which can affect riparian vegetation and riparian habitats).
- Exposure to Contaminants - Vehicle fuel, hydraulic fluid, solvents, cleaners, and geothermal fluids can all be harmful to vegetation and important habitats. Accidental spills can contaminate soils and water and directly harm vegetation. Licensed herbicide use would control vegetation around geothermal facilities and support structures. Spills of herbicides or acute exposure to herbicides can have adverse effects on non-target vegetation.

Riparian and Wetland Habitat

Riparian and wetland habitats are of high value to fish and wildlife and perform critical environmental functions such as flood control and water purification (NRC 1995). These habitats may be affected by activities associated with all phases of geothermal projects. Impacts on wetlands are regulated under the River and Harbors Act and Section 404 of the Clean Water Act. US Army Corp of Engineers permitting would be required for each project that disturbs wetlands under its jurisdiction, both within and outside of corridors. In addition, Executive Order 11990, Protection of Wetlands, requires all federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands.

Riparian and wetland habitat may be cleared to provide access to geothermal sites, and water may be extracted from groundwater sources to support geothermal exploration, production, and operation. Habitat removal may result in increased stream temperatures, reduced wildlife presence, increased erosion, and sedimentation. Water extraction may result in lowered groundwater tables, which can affect stream flows and duration and can dewater wetland and marsh habitat. Changes in riparian and wetland hydrology can affect vegetation species assemblages and may eventually alter the wildlife species composition. Accidental spill of fuel, solvents, or geothermal working fluids could degrade water quality and affect riparian vegetation.

Riparian and wetland habitat can be adversely affected by invasive species such as salt cedar and Russian olive, which can be introduced during disturbance. Salt cedar is highly tolerant of high salinity soils, low water tables, wildfires, livestock browsing, and conventional weed controls. Native plant species are damaged by unusually large guilds of insects and plant pathogens, but salt cedar has few natural insect or plant pathogens in the planning area. Salt cedar and other invasive riparian plants can lower water tables, and they often establish soon after disturbance.

Riparian and wetland habitat in California, Nevada, and Idaho would be more susceptible to geothermal development than other states based on projections for geothermal development on public and NFS lands (Section 2.4, Reasonably Foreseeable Development Scenario). This would include ecoregions provinces in the Mediterranean, temperate desert, and tropical/subtropical desert divisions (Figures 3-11 and 3-13). However, geothermal development in California, Nevada, and Idaho would likely occur in drier areas where the riparian and wetland habitats are less abundant. Therefore, geothermal projects are less likely to be located directly adjacent to these habitats. Riparian and wetland habitats are relatively scarce throughout the west and are very important in drier ecoregions, thus should be avoided. The BLM and FS have best management practices intended to limit the impacts of actions that occur on public and NFS lands. Additionally, wetlands and riparian habitat are protected under the Clean Water Act and regional land use and forest plans.

Sagebrush

Sagebrush habitat is spread across almost the entire project area (with the exception of Alaska) and covers approximately 93 million in the western US, of which about 66 percent is on public and NFS lands (Connelly et al 2004). Within the planning area about 36 percent of the lands have sagebrush habitat. Sagebrush habitat is found throughout and is almost exclusive to the temperate desert ecoregion division, although sagebrush within the planning area is also found in the temperate steppe ecoregion division. The states with the greatest sagebrush cover within the planning area are Idaho (23 percent), Nevada (38 percent), Oregon (23 percent), and Wyoming (27 percent). The RFD scenario forecasts that by 2025 geothermal development would affect up to 89,548 acres over the 12-state planning area. If all geothermal development were to occur on sagebrush habitat, it would affect approximately 0.1 percent of the sagebrush habitat in the planning area. If geothermal development were to occur proportionately within all habitats, then forecasted development would affect 0.04 percent of sagebrush habitat within the planning area. Based on RFD scenarios, the amount of sagebrush habitat that would be disturbed is likely somewhere between the two forecasted estimates, as a greater proportion of development is forecasted to occur in states with a greater percentage of sagebrush habitat in areas of geothermal potential (Connelly et al. 2004).

Sagebrush habitat would be cleared for roadways, drill pads, buildings, and other infrastructure. Sagebrush is susceptible to fire and can take from 15 to 30 years to reestablish to pre-burn density and cover following a fire (Miller and Rose 1999). Invasive species increase the incidence and intensity of fires in sagebrush habitat (Connelly et al. 2004). Native sagebrush communities may not reestablish after intense or frequent fires, and conditions favorable to native sagebrush species may not be available in the future in these areas (BLM 2004e). Frequently repeated fires reduce or prevent reestablishment of sagebrush seedlings from nearby unburned plants. Fires may kill some seeds of native grasses in upper soil layers, significantly reducing seedling emergence in burned areas (BLM 2004e).

Both the BLM and FS maintain a list of best management practices meant to protect important habitats such as sagebrush during development. The BLM has developed specific guidance for managing sagebrush communities meant to protect and conserve sagebrush habitat during land use and development projects (BLM 2004e). More information on the compatibility of geothermal development with sagebrush communities and sage grouse can be found in Text Box 4.10-1 in Chapter 4.10, Fish and Wildlife.

Old Growth Forests

Geothermal projects occurring in old growth forests would require forest clearing. Old growth forests on federal lands are managed under FS and BLM forest plans. Both the FS and BLM have shifted their management of forested lands away from resource extraction and toward ecosystem management to protect old growth forests (Thomas et al. 2006). Old growth forests on public lands are found predominately in the Pacific Northwest (the marine ecoregion division), the Southern Sierra Nevada Mountains (Mediterranean and temperate desert ecoregion divisions), the Rocky Mountains (temperate desert division), and scattered areas through the southwest.

Old growth forests, which may have never been physically disturbed by activities such as logging, typically contain centuries-old trees or other plants that cannot be reestablished and would be permanently lost. Loss of such habitat would be considered a greater impact than loss of previously disturbed habitat. Most sensitive and high quality habitats, such as old growth forests, are found in the areas being excluded under the proposed action such as roadless areas, wilderness areas, and ACECs. Based on the RFD scenario, many of the areas within the planning area containing old growth forests are not expected to see development. Should development occur in areas with old growth forests, the development would not conflict with the applicable forest management plan and would undergo site-specific analysis prior to site development. In most cases, old growth forests would be avoided during development. In all cases, site-specific NEPA evaluation would occur to assess the impacts of projects within old growth forests. This would include compliance with the Endangered Species Act, which protects habitat for listed species such as the spotted owl, for which old growth forests are considered critical habitat.

Exploration

Exploration would disturb small areas of vegetation and habitat during the construction of access roads and drill pads. Habitat would be removed, and vegetation would likely be destroyed. Surveying and drilling activities could result in impacts from weed infestation. If the area is not used for development and production, it would be reclaimed within three years. Native species would be used to revegetate the area.

Drilling Operations

Large areas of vegetation would be cleared for expanded well pads, (to accommodate production wells, injection wells and sump pits), roadways, and other critical infrastructure. This would destroy vegetation, create erosion potential, and increase incidence of invasive weed infestation. Drilling operations would require increased vehicle traffic, which would require staging areas and parking areas. Increased traffic would create more fugitive dust and pollutants and would increase the potential for fuel spills and other contaminants associated with vehicle use.

Water used for drilling activities could affect wetland and riparian areas in surrounding areas, depending on how it is accessed. Drilling requires large amounts of water, and local drawdown of water tables can have a direct effect on wetlands and groundwater flows, which can directly affect riparian vegetation.

Utilization

The greatest amount of disturbance, vegetation clearing and injury would occur during the initial construction within the utilization phase. Large areas of vegetation would be cleared for well pads, power plants, pipelines, roadways, and other critical infrastructure. This would destroy vegetation, create erosion potential, and increase incidence of invasive weed infestation. Drilling operations would require increased vehicle traffic, which would require additional staging areas and parking areas. Increased traffic would create more fugitive dust and pollutants and would increase the potential for fuel spills and other contaminants associated with vehicle use.

Drilling operations could increase the spread of invasive species that can outcompete and alter the plant species assemblages in surrounding habitat through direct and indirect effects. The dispersal of invasive plant seeds by vehicles may affect native plant communities. In such cases, plant communities dominated by native vegetation may be replaced with plant communities dominated by invasive species. Other adverse impacts from the spread of invasive species may include the following:

- A decrease in biological diversity of ecosystems;
- A reduction in water quality and availability for wildlife species;

- A decrease in the quality of habitats for wildlife;
- Alterations in habitats needed by threatened and endangered species; and
- Health hazards, because some species are poisonous to humans, wildlife, and livestock.

Wetland and riparian areas would be affected by roadways and bridges that may be built to access drilling operation areas. Runoff from construction could increase turbidity in streams, and potential spills of fuels and other contaminants from vehicles and on-site construction activities could affect water quality. Water used for drilling activities could affect wetland and riparian areas in surrounding areas, depending on how it is accessed. Drilling requires large amounts of water, and local drawdown of water tables can have a direct effect on wetlands and groundwater flows, which can directly affect riparian vegetation.

Vegetation and important habitats would be affected by site maintenance activities that involve mowing or cutting vegetation, exposure to contaminants and herbicides, decreased water quality due to surface runoff, vehicle traffic that produces fugitive dust, and direct injury from human and vehicle traffic. Water tables could also be affected by the withdrawal of geothermal fluids that, over time, could reduce groundwater storage and potentially affect stream flows.

Wetlands and aquatic resources could be affected by human activities associated with increased access to public and NFS lands in the immediate vicinity of a geothermal project site. Potential impacts from increased access may include disturbance of vegetation in wetland and aquatic habitats and the introduction of invasive vegetation.

Site maintenance activities at geothermal project sites would likely include the licensed application of herbicides to control vegetation along access roads and around buildings and power plant structures for indirect-use projects. The accidental spill of herbicides may affect native vegetation in surrounding areas. Potential effects of such exposure are discussed in the following section.

Increased human activity associated with the utilization phase would increase the potential for fire. The potential for wildland fires would be greatest in the arid and semiarid ecoregions and would be expected to occur most often in summer and autumn, when native and invasive grasses have died back and fuel loads are at their greatest. Sagebrush is especially vulnerable to fires and may incur both short- and long-term effects (BLM 2004e). Big sagebrush plants are readily killed by fire, while native grasses and forbs are generally unharmed by fires (BLM 2004e).

Access roads and maintenance activities would increase vehicle and human traffic, which may result in direct injury to vegetation and increased incidence of invasive plants. Clothing and vehicles tires can carry seeds that spread invasive species (Marsh and Douglas 1997).

Reclamation and Abandonment

Reclamation and abandonment could have similar impacts as those described for construction as buildings and structures are removed, but on a smaller scale. Fire, erosion, and invasive vegetation would be the predominant potential impacts during the reclamation and abandonment phase. After all buildings and facilities are removed, the affected areas would be reclaimed and vegetation and habitats would be restored.

4.9.4 What are the Potential Impacts Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing each of the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. The number of acres that could impact vegetation and important habitats is unknown; however, impacts would be site-specific and similar to the impacts under the four phases of geothermal development identified under Section 4.9.3. Under this alternative, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as consistent guidance for all future geothermal leasing and development for direct and indirect use. This would result in fragmented and segregated planning for vegetation and important habitats which often exponentially increases impacts. Development of the individual leasing approvals, stipulations, and best management practices would also continue to vary per site and delay application processing time.

Impacts under Alternative B

Under this alternative, the land closed to geothermal leasing for direct and indirect use would increase. The BLM and FS would close approximately 25,150,000 acres of public lands and 24,370,000 acres of NFS lands that are incompatible with geothermal leasing, exploration, and development.

These closed lands would protect vegetation and important habitats, specifically high-value habitats such as old growth forests and wetland and riparian areas, more than the no action alternative (Alternative A). Additionally, major constraints would be applied to leases to protect vegetation and important habitats from adverse impacts. For lands not closed to direct and indirect use leasing, potential geothermal development could still occur as forecasted in the RFD scenario.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. Relevant stipulations (Section 2.2.2) designed to minimize impacts on vegetation include (1) no surface occupancy on water bodies, riparian areas, and wetlands; (2) controlled surface use in areas that would adversely impact the continuity of migration corridors or important habitat; and 3) controlled surface use within 500 feet of riparian or wetland vegetation to protect the values and functions of these areas. In accordance with BMPs (Appendix D), operators would review existing information on species and habitats in the vicinity of the project area to identify potential concerns. Operators would also employ timing restrictions and design features (outlined in the BMPs in Appendix D) to avoid, minimize, or mitigate negative impacts on sensitive habitats. It is expected that these measures would effectively minimize impacts on vegetation by reducing human caused disturbance to species and habitats; indentifying revegetation, soil stabilization, and erosion reduction measures; managing for invasive/weed species; and promoting the enhancement and/or restoration of existing habitat conditions when appropriate.

Impacts under Alternative C

Under this alternative, 61,200,000 acres of public land and 37,900,000 acres of NFS lands within 10 miles of the centerline of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary would be open to leasing for indirect use and subject to major and moderate constraints as detailed in Chapter 2. Approximately 81,950,000 acres of public land and 65,710,000 acres of NFS lands would be closed to leasing for indirect use.

There would be less land available for exploration and development of geothermal resources for indirect use than under Alternatives A or B.

Under this alternative there would be less impact on vegetation and important habitats and communities than the other alternatives, as large areas would be closed to leasing for indirect use. Lands open to leasing within 10 miles of the centerline of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary would be subject to constraints that are intended to protect vegetation and important habitats. Additionally, lands within existing transmission line ROWs often have existing access and maintenance roads constructed that could potentially be used for geothermal development, further limiting the potential impacts on vegetation and important habitats.

Areas open to geothermal lease applications for direct use and impacts from their anticipated subsequent development would be the same as identified under Alternative B.

4.10 FISH AND WILDLIFE

4.10.1 What did the Public Say about Impacts on Fish and Wildlife?

Comments collected during scoping focused on the potential impacts on big game species, sagebrush-dependent species, the potential for habitat fragmentation and disturbance, and risks to seasonal habitat such as wintering areas. Other comments were directed toward impacts on important habitats such as riparian habitat, wetlands, and old growth forest that are also addressed in Section 4.9, Vegetation.

4.10.2 How Were the Potential Effects of Geothermal Development on Fish and Wildlife Evaluated?

Leasing of geothermal resources does not affect fish and wildlife. These resources would be affected only by development of specific geothermal projects. Potential impacts of geothermal development were evaluated based on the typical disturbance of geothermal projects for the various stages of development and then assessed based on projected location and intensity, as described in the RFD scenario. The types of fish and wildlife that could be affected by geothermal development on public and NFS lands depend on the specific location of the proposed project, the time of year, the project design, and its environmental setting.

Specific impacts of a geothermal project depend on the size of the project and the methods used for construction. Impacts on wildlife are associated strongly with impacts on wildlife habitat. Wildlife depend on specific habitats for foraging, breeding, migration, and cover. General impacts on vegetation, riparian, wetland, sagebrush, and old growth habitats are discussed in Section 4.9, Vegetation. The wildlife present in and the extent of impacts depends on the ecoregion in which geothermal activities occur. Impacts discussed in this section are associated with the elimination and degradation of wildlife habitat at project sites, in immediately adjacent areas, or within the watershed, as well as impacts on wildlife from noise disturbance, displacement, mortality from vehicle collisions, and effects from invasive species. Potential impacts on fish and wildlife could occur if reasonably foreseeable future actions were to result in the following:

- Adversely affect a population by substantially reducing its numbers, causing a fish or wildlife population to drop below self-sustaining levels, or causing a substantial loss or disturbance to habitat. Such effects could include vehicle impacts and crushing, increased predation, habitat fragmentation, or loss of seasonal habitat;
- Have a substantial adverse impact on nesting migratory birds, including raptors, as protected under the Migratory Bird Treaty Act;
- Interfere with the movement of any resident or migratory fish or wildlife species, or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites;

and conflict with the wildlife management strategies of the BLM or FS.

4.10.3 What are the Common Impacts on Fish and Wildlife Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on fish and wildlife from geothermal resource development.

The nature and extent of geothermal-related development activities that would affect fish and wildlife would vary by project, depending on several factors: 1) whether the project is for direct use or indirect use; 2) the size of the project; 3) the geographic location; and 4) for indirect use, the type of plant. Fish and wildlife and wildlife habitat would be evaluated on a project-specific basis, as NEPA would be conducted for each of the potential phases of geothermal development activity: exploration, drilling operations, utilization, and reclamation and abandonment. This section will qualitatively address the impacts on fish and wildlife.

Impacts common to fish and wildlife across the entire planning area are discussed below, followed by impacts that are specific to a certain stage of geothermal development (exploration, drilling operations, utilization, or reclamation and abandonment).

The Reasonable Foreseeable Development Scenario for Fish and Wildlife

The public and NFS lands that would be affected within the planning area cover approximately 246,736,368 acres. The RFD scenario estimates that by 2025 less than 0.1 percent (89,548 acres) of that land would be disturbed by geothermal projects. The disturbance would be spread both spatially and temporally across the planning area. Many of these disturbed areas would be reclaimed shortly after disturbance.

The effects of implementing the RFD scenario would have very little effect on most species populations. The fish, reptile, amphibian, bird, and mammal populations in the planning area are diverse and widespread and typically have high rates of mortality and natality. Thus, implementing the RFD scenario would affect relatively small areas of habitat and would typically affect individual species instead of large populations. The instances where individuals, communities, or populations can be affected from geothermal activities involve the following stressors and associated impacts on vegetation and important habitats:

- Habitat disturbance - The fragmentation of wildlife habitat for species requiring large contiguous tracts can be affected by site clearing, well drilling, construction of access roads and geothermal facilities, and maintenance and operational activities that would disturb habitat. These activities could cause disruption of breeding and migration, mortality and injury, increased risk of invasive species, and alteration of water and seed dispersion and wildlife use, which can further affect vegetation communities.

- Invasive Vegetation - Disturbance and access by vehicles and human foot traffic may expose areas to colonization by invasive and nonnative species, making it more difficult for endemic species to reestablish in disturbed areas and threatening the continued existence of endemic species (BLM 2007c). This can affect wildlife by reducing habitat quality and species diversity, thereby affecting foraging and breeding behavior.
- Injury or Mortality - Wildlife could be injured or killed during roadway clearing, vehicle staging, building construction, and other activities. Small or less mobile animals such as reptiles, amphibians, and rodents would be most susceptible to injury or mortality from geothermal activities. Maintenance around project components such as drill pads, buildings, pipelines, or other facilities would involve mowing, herbicide treatment, and other mechanical or chemical means of controlling vegetation that could directly affect species that depend on that vegetation for food, cover, or other habitat needs.
- Erosion and runoff - Site clearing, grading, access roads construction, containment basins, site runoff, and vehicle and human foot traffic cause erosion. The effects of erosion include the loss of habitat for terrestrial species and increased turbidity, which can directly affect fish and other aquatic biota.
- Fire – Increased vehicular and human traffic, equipment operation, and geothermal fluid extraction can increase the risk of fire. Vehicles, electrical lines, and smoking can all result in accidental fires. During fires, wildlife can be killed or injured. After fires, wildlife may be forced to move to other habitats or may be without suitable habitat for important behavioral activities.
- Noise - Constructing and operating geothermal facilities can produce noise far above normal ambient levels. Many species are sensitive to increases in noise that may cause disruption of breeding, migration, wintering, foraging, and other behavioral activities.
- Exposure to Contaminants - Vehicle fuel, hydraulic fluid, solvents, cleaners, and geothermal fluids can all be harmful to fish and wildlife. Accidental spills can contaminate soils and water and indirectly harm wildlife. Licensed herbicide use would likely be used to control vegetation around geothermal facilities and support structures. Spills of herbicides or acute exposure to herbicides can have adverse effects on wildlife.

Fish and Aquatic Biota

Impacts on fish and aquatic biota from geothermal projects are directly linked to impacts on riparian and wetland habitats in most cases. Impacts would result primarily from activities occurring near or in water bodies. Potential causes include ground disturbance, vegetation removal, groundwater withdrawal, road construction and excavation, structure and other facility installation (e.g., transmission towers or pipelines), and release of water contaminants. The effects of such actions could include changes in hydrology, increased turbidity, changes in water quality (e.g., temperature, dissolved oxygen, pollutants), loss of riparian vegetation (an indirect aquatic food source), restriction of fish movement and migration, and changes in predator and human use of the aquatic habitat. Impacts would vary in severity based on the type of aquatic habitat, the density, type, and number of species, and the method and stage of geothermal development.

Disturbance of adjacent ground and direct stream disturbance could result in increased turbidity. Sediments resulting from geothermal development would settle on the stream bottom downstream of the disturbance. The size of the particles and the stream flow would dictate how far the sediment is carried. Some fish such as salmonids and some aquatic insects are highly susceptible to increased turbidity. Particles in water can impair their ability to absorb oxygen, decrease survival of eggs, larvae, and fry, interfere with feeding and spawning, and decrease their ability to elude predators.

Stream flow rates are affected by the upland vegetation and adjacent terrain; therefore, geothermal development could alter stream flows and affect aquatic species and habitat. Typically, BMPs are instituted to control, reduce, or eliminate impacts on fish and aquatic biota by limiting how close development can occur and the grade of the slope that can be developed and by reclaiming areas immediately following the commencement of geothermal activities.

The severity of impacts associated with sedimentation depends largely on the receiving waters and the timing of the sedimentation event. Waters that are typically clear and cold are most susceptible to increased turbidity. These waters include higher mountain streams, often at more northern latitudes. These waters are more common to salmonid species (salmon, trout, char, and whiting). Some fish and aquatic species are adapted to large pulse events that occur seasonally and often are associated with large amounts of runoff and sediment. These species are found primarily in warmer waters and in desert climates were monsoons are normal.

Removal of riparian vegetation can increase water temperatures in adjacent streams. Trees and overhanging shrubs limit the amount of solar heat radiation that reaches the water and help maintain microclimates of higher humidity and lower temperatures. Increased water temperatures can impair growth, limit reproduction, alter competitive advantage (sometimes favoring invasive species), and limit survival in the affected area during periods of elevated temperature. Water temperatures for cold-water species (trout and salmon) cannot exceed 68˚F for more than short periods of time. Warm-water species are also subject to increases in water temperatures where waters have reached the upper bounds of the tolerable range. Small streams and water bodies are more susceptible to increased temperatures resulting from removal of vegetation. The BLM and FS have best management practices that limit the amount of riparian vegetation that can be removed. This includes a stream buffer that typically excludes development and surface disturbance.

Streams, rivers, and other waterways are at risk of exposure to toxic materials (fuel, herbicides, hydraulic fluid, drilling muds, geothermal working fluids) present as part of geothermal projects. The severity of impacts caused by toxics would depend on the type and amount introduced to the waterway, as well as on the time, location, and nature of the water body. Toxics are not expected to enter waterways, as stipulations and best management practices are intended to protect waterways from fuel spills and accidental releases.

Geothermal development can also cause impacts on fish and aquatic biota by facilitating access to areas. Human traffic may increase as the result of new roadways. Increased use can cause erosion and compaction of soil and may increase fishing or harvesting pressure.

Essential Fish Habitat (EFH) for salmonids within the planning area is found in Alaska, California, Idaho, Oregon, and Washington. EFH for salmonids consists predominately of coastal streams and rivers that lie north of Point Conception in Central California to Cape Prince of Whales in Alaska. EFH could be affected by the same activities and stressors mentioned above that affect other fish and riparian and wetland habitats. Erosion from project activities can cause increased turbidity in waterways. Changes in stream flows resulting from water use can also affect EFH, as can contaminants such as spilled fuel or herbicides that make their way into waterways.

Wildlife

Wildlife would be affected by the alteration, removal, reduction, or fragmentation of habitat. Habitat at drilling pads, facilities, roadways, and transmission corridors would be affected. The extent of the disturbance would be a function of the level of preexisting disturbance, the size, scale, and phase of geothermal development, and the type and quality of habitat. Geothermal development would have the greatest impact on wildlife if it were to affect specialty habitats such as riparian areas, wetlands, or wintering and breeding areas.

Fragmentation would affect wildlife by altering how wildlife species use the habitat. Fragmentation can separate wildlife populations into smaller populations, making them more vulnerable to predation, drought, and disease and limiting genetic diversity within breeding groups. Movement between habitat tracts is more difficult after fragmentation. Roads have been shown to impede the movements of invertebrates, reptiles, and small and large mammals (Strittholt et al. 2006. Habitat fragmentation can create increased edges for access by predators and invasive species and can facilitate access by hunters, reducing the density and diversity of wildlife species found in the original habitat (Anderson et al. 1977). Habitat fragmentation and degradation is considered a causal factor for the decline in sage grouse throughout most of its range (Strittholt et al. 2006). Text box 4.10-1 provides more information on sage grouse impacts and compatibility with geothermal development on public and NFS lands.

Animals displaced by fragmentation would occupy nearby habitats, which could lead to an increase in competition for resources and result in decreased health and potentially death for less fit individuals. The impacts resulting from displacement after habitat removal and fragmentation depend on many factors, including the sensitivity of a species to edge and area effects, the duration and rate of habitat loss and fragmentation, and the proximity of a chosen habitat to the disturbed area (Hagan et al. 1996).

Areas adjacent to disturbance resulting from geothermal development would likely be avoided by wildlife; therefore, the amount of habitat actually affected from disturbance and fragmentation extends beyond the habitat disturbed. The effective habitat loss (amount of habitat actually used by wildlife) due to new roadways was reported to be 2.5 to 3.5 times as great as actual habitat loss (Reed et al. 1996).

Fragmentation can facilitate the spread and introduction of invasive plant species (a more thorough discussion of effects on vegetation is found earlier in this section). Roads and other corridors can facilitate the dispersal of invasive species by altering existing habitat conditions, stressing or removing native species, and allowing easier movement by wild or human vectors (Trombulak and Frissell 2000).

Wildlife can be affected by invasive vegetation. Invasive plant species may be unpalatable for native animal species, making it difficult for them to forage. This can alter the population structure of entire habitats. Birds are most directly affected by invasive plants, as their food source is often seeds from native grasses and shrubs. Invasion of exotic species on public lands has been estimated at more than 5,000 acres per day. Cheatgrass is expected to dominate or completely convert more than half of the native sagebrush habitat in the United States (Strittholt et al. 2000); thus, sage grouse can be directly affected by cheatgrass infestations on sagebrush habitats.

Wildlife habitat in riparian areas is especially vulnerable to devastation by weeds because of the extra moisture and seed transport into these areas. Perennial pepperweed, leafy spurge, Russian knapweed and tamarisk (also known as salt cedar) easily form monocultures along riparian areas and adjacent uplands. Purple loosestrife forms solid stands, crowding out food plants needed by ducks and geese and reducing suitable nesting sites. Muskrats and long-billed marsh wrens leave infested areas (Thompson et al 1987). Tamarisk has been able to outcompete willow and other riparian plants in many locations, greatly diminishing the quantity and quality of riparian habitat for migrant songbirds and vegetation-dependent birds like the endangered Yuma clapper rail at the Salton Sea and elsewhere (Dudley 1995).

The direct injury and mortality of wildlife would likely occur as a result of geothermal development associated with the RFD scenario. Equipment used for clearing vegetation, roadways, well pads, and facility sites and vehicles used during operation and closeout would affect wildlife that are not mobile enough to avoid construction operations. Reptiles, amphibians, and small mammals would be most susceptible. More mobile wildlife species such as deer, birds, and large predators may avoid the initial clearing activity by moving into habitats in adjacent areas. Some of these animals may not survive if surrounding areas are at carrying capacity, or they may outcompete current residents.

Access road development increases land use by recreationalists and other users of public and NFS lands. This increases the amount of human presence and the potential impacts on wildlife from hunting, vehicle collision, harassment, and legal or illegal taking of wildlife. Access roads not needed for maintenance would be removed following exploration and development, and public use of these access roads would be restricted; therefore, roadkills would not be expected to result in a significant impact from a wildlife population perspective.

Noise from geothermal activities can have adverse impacts on wildlife. Principal sources of noise from geothermal activities would include trucks and the operation of drilling rigs and heavy machinery. The most adverse impacts associated with noise could occur if critical lifecycle activities were disrupted (e.g., mating and nesting). All wildlife could be disturbed by noise. Disturbance occurring during mating, nesting, or rearing of young can cause wildlife to abandon mating and nesting activities and can strand young, leaving them susceptible to predation and starvation.

On the basis of the types of equipment that would likely be used such as drill rigs and graders, the noise levels associated with the equipment would range from about 80 to 90 dBA within 50 feet; site preparation noise would be at the mid-40-dB level approximately 0.25 mile from the site (Section 3.19 Noise).

Hazardous materials resulting from accidental fuel spills, drilling muds, geothermal fluids, or releases of hazardous materials could result in the exposure of wildlife at the geothermal project sites. Potential impacts on wildlife would vary according to the material spilled, the volume of the spill, the location of the spill, and the species that could be exposed. Spills could contaminate soils and surface water and could affect wildlife associated with these media. A spill would be expected to have a population-level adverse impact only if the spill was very large or contaminated a crucial habitat area where a large number of individual animals were concentrated. The potential for accidental spills to have adverse effects on wildlife populations is unlikely, because the amounts of fuels and hazardous materials are expected to be small, so an uncontained spill would affect only a limited area (much less than one acre). In addition, wildlife use of the area would be minimal, greatly reducing the potential for exposure.

The location and timing of geothermal activities (especially exploration and development) may affect the migratory and other behavioral activities of some species. Construction activities could affect local wildlife by disturbing normal behavioral activities such as foraging, mating, and nesting. Wildlife may cease foraging, mating, or nesting or may vacate active nest sites in areas where geothermal activities are occurring; some species may permanently abandon the disturbed areas and adjacent habitats. In addition, active exploration and development may affect movements of some birds and mammals; for example, they may avoid a localized migratory route because of ongoing construction (BLM 2005b).

Reptiles and Amphibians

Geothermal activities may result in increased erosion and runoff from cleared and graded sites. This erosion and runoff could reduce water quality in on-site and surrounding water bodies that are used by amphibians, thereby affecting reproduction, growth, and survival. Water quality impacts during exploration, development, and closeout would be short term. Any impacts on amphibian populations would be localized to the surface waters receiving site runoff. Although the potential for runoff would be temporary, pending the completion of activities and the stabilization of disturbed areas with vegetative cover, erosion could result in significant impacts on local amphibian populations if an entire recruitment class is eliminated (e.g., complete recruitment failure for a given year because of siltation of eggs or mortality of aquatic larvae).

As mentioned above, reptiles and amphibians would have a difficult time vacating areas under geothermal development and could be crushed or injured during geothermal site and access roadway clearing. Following habitat removal or degradation, reptiles and amphibians may become more susceptible to predators or may be forced into adjacent habitats were the areas have reached carrying capacity.

Birds

The birds that are most susceptible to being adversely affected by geothermal projects are those whose mating or nesting habitats may be directly affected by geothermal activities. Birds that use the areas for foraging or migration would be relatively unaffected, as they would fly to adjacent habitat. Sagebrush species such as sage grouse would be directly affected.

Sage Grouse and Geothermal Development

Most concerns about the effects of geothermal development on sage grouse have focused on the potential impacts associated with reducing, fragmenting, and modifying grassland and shrubland habitats, particularly sagebrush. The Gunnison sage grouse (*Centrocercus minimus*) and particularly the greater sage grouse (*C. urophasianus*) are of concern relative to sagebrush habitat reduction and fragmentation that is occurring within every state in the planning area except Alaska. Sagebrush habitat in the planning area, as mentioned above, is found almost exclusively in the temperate desert ecoregions province, though some areas in the far eastern portion of the planning area can be found in the temperate steppe ecoregion division.

The Gunnison sage grouse is restricted to southwestern Colorado and southeastern Utah, while the greater sage grouse inhabits every planning area state except Alaska, Arizona, and New Mexico. The following discussion emphasizes the more widely distributed greater sage grouse. Figure 4.10-1 shows current and historic sage grouse distribution throughout the project area. Table 4-4 shows the percentage of lands occupied by sage grouse when compared to historical distribution within the planning area.

Table 4-4
Percentage of Lands Occupied by Sage Grouse vs. Historic Distribution within the Planning Area

State	Percent of Historic
Alaska	N/A
Arizona	0% (extirpated)
California	70.2%
Colorado	64.6%
Idaho	78.3%
Montana	85.8%
Nevada	19.1%
New Mexico	0% (extirpated)
Oregon	46.0%
Utah	25.2%
Washington	3.82%
Wyoming	4.6%

Source: Shroeder 2002

Populations of greater sage grouse can vary from nonmigratory to migratory (having either one-stage or two-stage migrations) and can occupy an area that exceeds 1,040 square miles on an annual basis. The distance between leks (areas used for courtship) and nesting sites can exceed 12.4 miles (Connelly et al. 2004). Nonmigratory populations can move 5 to 6 miles between seasonal habitats and have home ranges up to 40 square miles. The distance between summer and winter ranges for one-stage migrants can be 9 to 30 miles apart. Two-stage migrant populations make movements between breeding habitat, summer range, and winter range. Their annual movements can exceed 60 miles. The migratory populations can have home ranges that exceed 580 square miles (Bird and Schenk 2005). The greater sage grouse has a high fidelity to a seasonal range. They also return to the same nesting areas annually (BLM 2004e; Connelly et al. 2004).

The greater sage grouse needs contiguous, undisturbed areas of high-quality sagebrush habitat. They are omnivorous and consume primarily sagebrush and insects. Over 99 percent of their diet in winter consists of sagebrush leaves and buds. Sagebrush is also important as roosting cover, and the greater sage grouse cannot survive where sagebrush does not exist (Connelly et al. 2004).

Leks are generally areas supported by low, sparse vegetation or open areas surrounded by sagebrush that provide escape, feeding, and cover. They can range in size from small areas of 0.1 to 10 acres to areas of 100 acres or more (Connelly et al. 2000). The lek/breeding period occurs March through May, with peak breeding occurring from early to mid-April. Nesting generally occurs 1 to 4 miles from lek sites, although it may range up to 11 miles (BLM 2004e). The nesting/early brood-rearing period occurs from March through July. Tall, dense grass combined with tall shrubs at nest sites decreases the likelihood of nest depredation. Hens have a strong year-to-year fidelity to nesting areas (BLM 2004e). The late brood-rearing period occurs from July through October (BLM 2004). The greater sage-grouse occupies winter habitat from November through March. Suitable winter habitat requires sagebrush 10 to 14 inches above snow level with a moderate canopy cover. Wintering grounds are potentially the most limiting seasonal habitat for greater sage grouse (BLM 2004e; Connelly 2000).

Loud, unusual sounds and noise from construction and human activities disturb sage grouse and birds in general and can reduce sage grouse use of leks (Connelly et al. 2004). Disturbance at leks appears to limit reproductive opportunities and may result in regional population declines. Most observed nest abandonment is related to human activity (NatureServe 2007). Thus, site construction, operation, and site maintenance activities could be a source of auditory and visual disturbance to sage grouse.

Geothermal facilities, well pads, transmission lines, pipelines, and access roads may adversely affect habitats important to sage grouse by causing fragmentation, reducing habitat value, or reducing the amount of habitat available (Connelly et al. 2004). Geothermal facilities, transmission lines, pipelines, and other structures can also provide perches and nesting areas for raptors and ravens that may prey upon sage grouse. Sage grouse are also susceptible to vehicular collision along dirt roads because they are sometimes attracted to the dirt roads to take dust baths (Strittholt et al. 2000).

Measures that have been suggested for managing sage grouse and their habitats (Connelly et al. 2000) that have pertinence to geothermal projects include the following:

- Identify and avoid both local (daily) and seasonal migration routes.
- Consider sage grouse and sagebrush habitat when designing, constructing, and utilizing project access roads and trails.
- Avoid siting geothermal developments in breeding habitats.
- Adjust the timing of activities to minimize disturbance to sage grouse during critical periods.
- When possible, locate geothermal-related facilities away from active leks or near other sage grouse habitat.
- When possible, restrict noise levels to 10 dB above background noise levels at lek sites.
- Minimize nearby human activities when birds are near or on leks.
- As practicable, do not conduct surface-use activities within crucial sage grouse wintering areas from December 1 through March 15.
- Maintain sagebrush communities on a landscape scale.
- Provide compensatory habitat restoration for impacted sagebrush habitat.
- Avoid the use of pesticides at sage grouse breeding habitat during the brood-rearing season.
- Develop and implement appropriate measures to prevent the introduction or dispersal of noxious weeds.
- Avoid creating attractions for raptors and mammalian predators in sage grouse habitat.
- Consider measures to mitigate impacts at off-site locations to offset unavoidable sage grouse habitat alteration and reduction at the project site.

The BLM manages more sage grouse habitat than any other entity; therefore, it has developed, in conjunction with the NFS and state agencies, a National Sage Grouse Habitat Conservation Strategy for BLM-administered public lands to manage public lands in a manner that would maintain, enhance, and restore sage grouse habitat, while providing for multiple uses of BLM-administered public lands (BLM 2004e). The strategy is consistent with the individual state sage grouse conservation planning efforts. The purpose of this strategy is to set goals and objectives, assemble guidance and resource materials, and provide more uniform management direction (BLM 2004e). The strategy includes guidance for addressing sagebrush habitat conservation in BLM land use plans and for managing sagebrush plant communities for sage grouse conservation. This guidance is designed to support and promote the conservation of sagebrush habitats for sage grouse and other sagebrush-obligate wildlife species on public lands, and presents a number of suggested management practices (SMPs). These SMPs include management or restoration activities, restrictions, or treatments that are designed to enhance or restore sagebrush habitats. BMPs that are or may be pertinent to geothermal projects include the following:

- Develop monitoring programs and adaptive management strategies;
- Control invasive species;
- Prohibit or restrict ATV activity;
- Consider sage-grouse habitat needs when developing restoration plans;
- Avoid placing facilities in or next to sensitive habitats such as leks and wintering habitat.
- Locate or construct facilities so that facility noise does not disturb grouse activities or leks;
- Consolidate facilities as much as possible;
- Initiate restoration practices as quickly as possible following land disturbance;
- Install antiperching devices on existing or new powerlines in occupied sage grouse habitat; and
- Design facilities to reduce habitat fragmentations and mortality to sage grouse.

In addition to BLM's National Sage Grouse Habitat Conservation Strategy, the Western Association of Fish and Wildlife Agencies has produced two documents that together comprise a Conservation Assessment for Greater Sage Grouse. The first is the Conservation Assessment of Greater Sage-Grouse and Sagebrush Habitats (Connelly et al. 2004). The second document is the Greater Sage-Grouse Comprehensive Conservation Strategy (Stiver et al. 2006).

The density of several forest-dwelling bird species can increase within a forest stand soon after the onset of fragmentation, as a result of displaced individuals moving into remaining habitats (Hagan et al. 1996). Nests along habitat edges created from geothermal projects could be more vulnerable to predators. The developed geothermal areas may also encourage population expansion of invasive bird species such as the house sparrow and European starling, which compete with many native species. Fragmenting forests into small patches is detrimental to many migrant songbird species (Parker et al. 2005).

Noise can have direct effects on birds of all species by affecting their ability to hear, defend territory, identify predators, and learn songs (Larkin 1996). Studies have examined the effects of continuous noise on bird populations, including the effects of traffic noise, coronal discharge along electricity transmission lines, and turbines. Results indicate reduced densities as far as two miles from noise sources (Larkin 1996), with threshold effects at a level of 47 dBA for all species combined and 42 dBA for the most sensitive species; the observed reductions in population density were attributed to a reduction in habitat quality caused by elevated noise levels (Reijinen et al. 1996). This threshold sound level is at or below the sound levels generated by truck traffic that would likely occur at distances of 250 feet or more from access roads or geothermal project sites, and equivalent to that of construction noise almost 2,500 feet away.

Big Game

Geothermal projects could reduce the amount of suitable winter cover and forage available to big game, depending on their location. Long-term displacement of elk, mule deer, pronghorn, or other species from crucial winter habitat or calving areas due to habitat disturbance would directly impact these animals. An inability to use calving or wintering areas can directly affect populations because they may be unable to reproduce or may become stressed during harsh winter months, which can lead to death or decreased fitness.

Big game animals may also be affected if a geothermal facility, pipeline, or access road were to interfere with migratory movements. Herd animals, such as elk, deer, and pronghorn, could potentially be affected if projects affect migration paths between winter and summer ranges or in calving areas. Large predators, such as grizzly bear and mountain lion, require access to prey species and rely on migration corridors to follow prey species and hunt. Loss of habitat continuity along migration routes could severely restrict the seasonal movements necessary to maintain healthy big game and large predator populations (Watson 2005).

Exploration

The overall impact of geothermal exploration on fish and wildlife populations at a geothermal project site would depend on the type and amount of wildlife habitat at the site, as well as the amount of area that would be disturbed. The main impacts on wildlife during exploration are habitat removal, the potential for direct injury and mortality from vehicle travel, temporary noise impacts, and long-term effects from invasive species that may be introduced during exploration or reclamation of the affected area. Exploration activities are short term, and impacts on fish and wildlife would be temporary, with the exception of invasive species. Exploration activities often have very little disturbance on wildlife and wildlife habitat, as they may use existing roadways and disturbed areas during drilling of temperature gradient wells. Impacts from exploration would be similar to those described for development, but to a lesser extent and over a shorter time frame. The severity of impacts during each stage of a geothermal project (exploration, drilling operations, utilization, and reclamation and abandonment) is listed below in Table 4-5.

Drilling Operations

The overall impact of drilling operation activities on wildlife populations at a geothermal project site would depend on the type and amount of wildlife habitat that would be disturbed, the nature of the disturbance (e.g., complete, permanent reduction because of structures or drill pads, or temporary disturbance in construction support areas), and the wildlife that occupy the project site and surrounding areas.

Clearing and grading activities would result in the direct injury or death of wildlife that are not mobile enough to avoid construction operations (e.g., reptiles, small mammals, and young), that use burrows (e.g., ground squirrels and burrowing owls), or that are defending nest sites (e.g., ground-nesting birds). Although more mobile species of wildlife, such as deer and adult birds, may avoid the initial clearing activity by moving into habitats in adjacent areas, it is conservatively assumed that adjacent habitats are at carrying capacity for the species that live there and could not support additional biota from the construction areas. The subsequent competition for resources in adjacent habitats would likely preclude the incorporation of the displaced individual into the resident populations.

Sump pits could impact wildlife species by providing a catch basin for rainwater (an assumed water source). Sump pits often contain high concentrations of minerals and chemicals from the drilling fluids, which can be toxic to wildlife. In addition, smaller species of wildlife may drown in the sump pits, which are often lined with plastic to prevent seepage and vegetation growth, making it difficult for wildlife to escape.

Utilization

Constructing a geothermal project and its ancillary facilities may impact wildlife through the reduction, alteration, or fragmentation of habitat, which represents the greatest impact on wildlife. All existing habitat within the drilling operations footprint, along new access road corridors, and within new utility right-of-ways would be disturbed. The amount of habitat that would be disturbed would be a function of the size of the proposed geothermal project and would range from approximately 53 acres to 367 acres (RFD) for indirect-use projects. Direct-use applications typically would disturb far less habitat, potentially less than one acre. The existing degree of disturbance already present in the project site area would also affect the total disturbed area resulting from geothermal drilling operations. Wildlife and wildlife habitat adjacent to disturbed areas could also be affected. Clearing and grading activities would impact wildlife greater than under the drilling operations phase due to the increased footprint of full build out.

Table 4-5
Impacts on Wildlife and Wildlife Habitat during Full Buildout of a Geothermal Development

Ecological Stressor	Geothermal Activity	Impact	Potential Level of Impact			
			Exploration	Drilling Operations	Utilization	Reclamation and Abandonment
Habitat disturbance	Site clearing and grading; well drilling, construction; pipelines, access road, and ancillary facility construction; construction and maintenance vehicle travel; operational noise	Disruption of breeding, migration, wintering, and foraging behavior	Moderate	Moderate	Moderate to high	Low to moderate
Invasive vegetation	Site clearing and grading; well drilling, construction; pipelines, access road, and ancillary facility construction; construction and maintenance vehicle travel	Reduced habitat quality and species diversity. Alter habitat use for foraging and breeding	Low to moderate	Low to moderate	Moderate to high	Low to moderate
Injury or mortality	Site clearing and grading; well drilling, construction; pipelines, access road, and ancillary facility construction; construction and maintenance vehicle travel	Destruction and injury of wildlife, mostly those with limited mobility	Low to moderate	Low to moderate	Moderate	Low to moderate

Table 4-5
Impacts on Wildlife and Wildlife Habitat during Full Buildout of a Geothermal Development

Ecological Stressor	Geothermal Activity	Impact	Potential Level of Impact			
			Exploration	Drilling Operations	Utilization	Reclamation and Abandonment
Erosion and runoff	Site clearing and grading; well drilling, construction; pipelines, access road, and ancillary facility construction; construction equipment travel	Reduced reproductive success of amphibians using on-site surface waters; drinking water affected. May limit survival of fish eggs and fry, increase predation, and reduce fish survival	Moderate	Moderate	Moderate to high	Moderate
Fire	Site clearing and grading; well drilling, construction; pipelines, access road, and ancillary facility construction; construction and maintenance vehicle travel	Direct injury and mortality, loss of habitat, loss of food source, and loss of cover	Low to moderate	Low to moderate	Moderate	Low
Noise	Site clearing and grading; well drilling, construction; pipelines, access road, and ancillary facility construction; construction and maintenance vehicle travel	Disruption of breeding, migration, wintering, and foraging behavior	Moderate to high	Moderate to high	High	High

Table 4-5
Impacts on Wildlife and Wildlife Habitat during Full Buildout of a Geothermal Development

Ecological Stressor	Geothermal Activity	Impact	Potential Level of Impact			
			Exploration	Drilling Operations	Utilization	Reclamation and Abandonment
Exposure to contaminants	Accidental spill during equipment refueling; accidental release of stored fuel or hazardous materials; drilling mud spill or accidental spill of geothermal fluids and working fluids	Exposure may affect survival, reproduction, development, or growth of fish and wildlife	Low	Low	Low	Low

The assessment of impact level is based on the RFD; and activities and projected disturbance associated with each stage geothermal development, as well evaluation of the efficacy of stipulations and BMPs available to eliminate or mitigate the potential impacts. Duration of the impact as well as potential for accidents factor into the assessment.

Low- The activities involved in geothermal development do not present a risk or have effective precautions, BMPs, and stipulations that would minimize the potential, intensity, and duration of impact associated the prospective ecological risk factor.

Moderate- The activities involved in geothermal development have a greater potential for impacts on wildlife, including accidents, unavoidable removal of habitat, and indirect disturbance. Impacts may be unavoidable and may endure beyond the conclusion of the activity.

High- The activities involved in geothermal activities would have direct and unavoidable impacts. BMPs and stipulations are not available to eliminate impacts. Additionally, the risk of accident may be higher or the duration of the impact may be last well beyond the conclusion of the geothermal activities.

Any effects of habitat reduction, disturbance, or fragmentation on wildlife would be related to the type and abundance of the habitats affected and to the wildlife that occur in those habitats. Large developments (367 acres) could represent a significant impact on local wildlife, especially to species whose affected habitats are uncommon and not well represented in the surrounding landscape. However, smaller projects and geothermal projects on previously disturbed lands or accessible by existing roadways would affect far less habitat.

Noise from drill rigs and construction activities during the utilization phase can disturb wildlife in adjacent habitats up to 2,500 feet away. Noise can cause wildlife to avoid habitats, disrupt behavioral patterns, and potentially cause a long-term decline in wildlife populations.

Wildlife habitat could also be impacted if invasive vegetation becomes established in the construction-disturbed areas and adjacent off-site habitats. The establishment of invasive vegetation could reduce habitat quality for wildlife and could locally affect wildlife occurrence and abundance.

During operations within the geothermal utilization phase, grass mowing and brush cutting may be required once every few years. These activities would result in minor impacts on wildlife. Mobile animals would be displaced to adjacent undisturbed habitats. Less mobile wildlife could be killed or injured during mowing and cutting; however, the overall significance of such impacts on local wildlife populations would likely be minor, because of the likely limited quality and carrying capacity of the maintained habitats.

The presence of a geothermal facility could disrupt movements of terrestrial wildlife, particularly during migration. Herd animals such as elk, deer, and pronghorn antelope could potentially be affected by power plants, pipelines, facilities, or drill pads that are placed along migration paths between winter and summer ranges or in calving areas. The geothermal facility and associated structures and access roads would be maintained as areas of low vegetation that may hinder or prevent movements of some wildlife species.

Increased human activity also increases the potential for fires. Fire may affect wildlife through direct mortality, reduction of habitat, and/or a reduction in habitat quality. In general, short-term and long-term fire effects on wildlife are related to fire impacts on vegetation, which in turn affect habitat quality and quantity, including the availability of forage and cover.

The licensed use of pesticides and herbicides at a geothermal development would not be expected to adversely affect local wildlife. Applications of these materials would be conducted by following label directions and in accordance with applicable permits and licenses. However, accidental spills or releases of these materials could impact exposed wildlife.

Reclamation and Abandonment

The impacts associated with reclamation and abandonment would be similar to those associated with the drilling operations phase but to a lesser extent and for a shorter time period. Reclamation and abandonment activities would include vehicle traffic and structure removal, which would cause noise and may damage adjacent wildlife habitat. Reclamation and abandonment would also increase the potential for runoff and erosion, as lands would be disturbed during the removal of buildings, structures, pipelines, and transmission towers. Once all structures are removed, geothermal wells would be capped, and disturbed areas would be reclaimed with native vegetation to provide habitat for wildlife.

4.10.4 What are the Potential Impacts on Fish and Wildlife Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. The number of acres that could impact fish and wildlife is unknown; however, impacts would be site-specific and similar to the impacts under the four phases of geothermal development identified under Section 4.10.3. Under this alternative, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as consistent guidance for all future geothermal leasing and development for direct and indirect use. This would result in fragmented and segregated planning for wildlife and wildlife habitats which often exponentially increases impacts. Development of the individual leasing approvals, stipulations, and mitigation levels would also continue to vary per site and delay application processing time.

Impacts under Alternative B

Under this alternative, the land closed to geothermal leasing for direct and indirect use would increase. The BLM and FS would close approximately 25,150,000 acres of public land and 24,370,000 acres of NFS lands to geothermal leasing that are incompatible with geothermal leasing, exploration, and development.

These closed lands would protect wildlife and wildlife habitats from potential development. Wildlife in closed areas would not be affected by geothermal development. This alternative would have fewer impacts on fish and wildlife and their habitats, specifically in important wildlife habitats such as roadless areas, wilderness areas, and areas of critical environmental concern, than Alternative A.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. Relevant stipulations (Section 2.2.2) designed to minimize impacts on fish and wildlife include (1) no surface occupancy on water bodies, riparian areas, and wetlands; (2) controlled surface use in areas that would adversely impact the continuity of migration corridors or important habitat; and 3) controlled surface use within 500 feet of riparian or wetland vegetation to protect the values and functions of these areas. In accordance with BMPs (Appendix D), operators would review existing information on species and habitats in the vicinity of the project area to identify potential concerns. Operators would also employ timing restrictions and design features (outlined in the BMPs in Appendix D) to avoid, minimize, or mitigate negative impacts on vulnerable fish and wildlife while maintaining or enhancing habitat values for other species. It is expected that these measures would effectively minimize impacts on fish and wildlife by protecting and maintaining key habitats, reducing habitat fragmentation, reducing human caused disturbance to species and habitats, managing for invasive/weed species, and promoting the enhancement and/or restoration of existing habitat conditions when appropriate.

Impacts under Alternative C

Under this alternative, approximately 61,200,000 acres of public land and 37,900,000 acres of NFS lands within 10 miles of the centerline of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary would be open to leasing for indirect use subject to major and moderate constraints as detailed in the Chapter 2. About 81,951,000 acres of public land and 65,712,000 acres of NFS lands would be closed to leasing for indirect use.

There would be less land available for exploration and development of geothermal resources for indirect use than under Alternatives A or B.

Under this alternative, there would be less impact on fish and wildlife and their habitats than the other alternatives, as large areas would be closed to leasing for indirect use. Lands open to leasing within the corridors would be subject to constraints that are intended to protect wildlife and wildlife habitats.

Additionally, lands that contain existing transmission lines often have existing access and maintenance roads constructed that could potentially be used during geothermal development, further limiting the potential impacts on fish and wildlife species.

Areas open to direct use geothermal lease applications and impacts from their subsequent development would be the same as identified under Alternative B.

4.11 THREATENED AND ENDANGERED SPECIES AND SPECIAL STATUS SPECIES

4.11.1 What did the Public Say about Impacts on Threatened and Endangered and Special Status Species?

Comments collected during scoping relating to threatened and endangered and special status species addressed a general concern for all special status species and requested that impacts on special status species be addressed. Concerns related to special status species found in sagebrush habitats and the potential impacts resulting from geothermal development were included in public comments. Comments also addressed the need to provide adequate analysis related to loss and fragmentation of habitat and requested that measures be included to protect special status species potentially affected by geothermal projects. Concerns related to how geothermal development might affect several specific species were expressed.

4.11.2 How Were the Potential Effects of Geothermal Development on Threatened and Endangered and Special Status Species Evaluated?

Potential impacts on threatened and endangered and special status species could occur if reasonably foreseeable future actions were to result in the following:

- Violate the ESA, Bald and Golden Eagle Protection Act, MBTA, or applicable state laws; or
- Adversely affect any individual or population of federally listed species.

4.11.3 What are the Common Impacts on Threatened and Endangered and Special Status Species Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on threatened and endangered and special status species from geothermal resource development.

The Reasonable Foreseeable Development Scenario for Threatened and Endangered and Special Status Species

Geothermal exploration, drilling operations, utilization, and reclamation and abandonment could affect threatened, endangered, and sensitive species in the same manner that vegetation, wildlife, and aquatic resources could be affected (see Section 4.10, Fish and Wildlife). Threatened and endangered species, including federal and state-listed species and BLM and FS special status species, could be affected as a result of 1) habitat disturbance, 2) the introduction of invasive vegetation, 3) injury or mortality, 4) erosion and runoff, 5) fugitive dust, 6) noise, 7) exposure to contaminants, and 8) interference with behavioral activities. Which species may be at risk to construction-related effects would depend on the ecoregion in which the project is located (Figure 3-11) and the specific habitat present at or near the site. An important distinction regarding impacts on special status species is that impacts on small localized areas or affecting only a few individuals can have adverse impacts on special status species. Many special status species are dependent on unique habitats or have small remaining populations. Impacts that directly affect these unique habitats or individuals, even when small, can have significant impacts on special status species.

Impacts on threatened, endangered, and sensitive wildlife species could include injury or mortality or could involve reduction or fragmentation of habitat, reduction or displacement of habitat features such as cover and forage, exposure to contaminants (e.g., diesel fuel or geothermal working fluid) from a spill, and destruction of individual biota (e.g., from drilling and clearing activities or from vehicle collisions). Because of the regulatory requirements of the ESA and various state regulations, and the requirements specified in BLM Manual 6840 Special Status Species Management and other resource-specific regulations and guidelines, appropriate survey, avoidance measures would be identified and implemented prior to any geothermal activities to avoid adversely affecting any sensitive species or the habitats on which they rely.

4.11.4 What are the Potential Impacts on Threatened and Endangered and Special Status Species Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. The number of acres that could impact threatened, endangered, and special status species is unknown; however, impacts would be site specific and similar to the impacts under the four phases of geothermal development identified under Section 4.11.3. Under this alternative, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as consistent guidance for all future geothermal leasing and development for direct and indirect use. This would result in fragmented and segregated planning for threatened, endangered, and special status species, which often exponentially increases impacts. Development of the individual leasing approvals, stipulations, and best management practices would also continue to vary per site and delay application processing time. Section 7 consultation under the ESA would be required under this and all alternatives and is meant to limit potential impacts on listed species and their habitat.

Impacts under Alternative B

Anticipated future actions taken consistent with implementing Alternative B would impact threatened, endangered, and special status species less than Alternative A. Under this alternative, the land closed to geothermal leasing for direct and indirect uses would increase. The BLM and FS would close approximately 25,150,000 acres of public land and 24,370,000 acres of NFS land to geothermal leasing for direct and indirect use that are incompatible with geothermal leasing, exploration, and development. Lands closed to leasing would protect special status species and their habitat. Many of the areas that would be closed for leasing include high-value habitats for many special status species such as old growth forests and wetland and riparian areas.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. Relevant stipulations (Section 2.2.2) designed to minimize impacts on Threatened and Endangered Species and Special Status Species include no surface occupancy for designated or proposed critical habitat for listed species under the Endangered Species Act (ESA) of 1973 (as amended) if it would adversely modify the habitat. For listed or proposed species without designated habitat, no surface occupancy would be implemented to the extent necessary to avoid jeopardy. Lease stipulations would also be included that limit disturbance or activities to specific seasonal or temporal time frames that are meant to protect Threatened or Endangered Species and Special Status Species. These stipulations are routinely used to protect breeding, nesting, and wintering behaviors that are critical for survival. Section 7 consultation under the ESA would be required under this and all alternatives and is meant to minimize potential impacts on ESA-listed species and their habitat. For agency designated sensitive species (e.g. sage grouse), lease stipulations would be imposed for those portions of high value species habitat where other existing measures are inadequate to meet agency management objectives. It is expected that these measures would effectively minimize impacts on Threatened and Endangered Species and Special Status Species by maintaining habitats necessary for the survival and recovery of these species; minimizing human caused habitat destruction, degradation and fragmentation; and minimizing human interaction with these species at critical times and locations.

Impacts under Alternative C

Under this alternative, approximately 61,200,000 acres of public land and 37,900,000 acres of NFS lands within the corridor would be open to leasing for indirect use and subject to major and moderate constraints, as detailed in Chapter 2. About 81,951,000 acres of public land and 65,712,000 acres of NFS land would be closed to leasing for indirect use.

Under this alternative there would be less potential for impacts on threatened and endangered and special status species than the other alternatives, as large areas would be closed to leasing for indirect use, many of them important habitat areas for these species. Lands open to leasing within 10 miles of the centerline of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary would be subject to major and minor constraints meant to protect specific resources, including threatened, endangered, and special status species. A major constraint of no surface occupancy or no ground disturbance would be placed on areas adjacent to potential habitat for threatened, endangered, and special status species and areas of high value for these species.

Under this alternative, lease stipulations may also be included that limit disturbance or activities to specific seasonal or temporal time frames that are meant to protect special status species. These stipulations are routinely used to protect breeding, nesting, and wintering behaviors that are critical for survival.

Additionally, those lands leased for indirect use of geothermal resources within existing transmission corridors often have existing access and maintenance roads constructed that could potentially be used for geothermal development, further limiting the potential impacts on special status species. Section 7 consultation under the ESA would be required under this and all alternatives and is meant to limit potential impacts on listed species and there habitat.

Areas open to direct use geothermal lease applications and impacts from their anticipated subsequent development would be the same as identified under Alternative B.

4.12 WILD HORSES AND BURROS

4.12.1 What did the Public Say about Impacts on Wild Horses and Burro?

No public comments were received regarding impacts on wild horses or burros.

4.12.2 How Were the Potential Effects of Geothermal Development on Wild Horses and Burros Evaluated?

Impacts on wild horses and burros were evaluated by: 1) considering the acreages of herd areas and herd management areas contained within the planning area; 2) considering the types of impacts that geothermal projects may have on wild horse and burro populations; and 3) describing both the impacts and the relative land areas that could be impacted by anticipated future actions consistent with the three alternatives described in Chapter 2.

Potential impacts on wild horses and burros could occur if reasonably foreseeable future actions were to result in the following:

- Conflict with management goals and objectives set forth by the BLM for protecting and managing wild horses and burros; or
- Interfere with the movement of wild horses and burros.

4.12.3 What are the Common Impacts on Wild Horses and Burros Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on wild horses and burros from geothermal resource development. Issuing geothermal leases would not disturb wild horse and burro populations or habitat, so the discussion is limited to impacts related to anticipated future actions.

The Reasonable Foreseeable Development Scenario for Wild Horses and Burros

According to the RFDs, it is estimated that 111 power plants could be constructed by 2015, and another 133 power plants could be constructed by 2025. For direct use, it is estimated that by 2015, applications could be developed in the amount of 1,600 thermal megawatts and by 2025, applications could be developed in the amount of 4,200 thermal megawatts. For indirect use, the RFD scenario estimates that up to 40,737 acres of land would be disturbed by 2015, and up to 89,548 acres of land would be disturbed by 2025. Wild horse and burro populations are found on public lands in 10 of the 12 western states included in the planning area. Population numbers and acreages of herd areas and herd management areas vary by state (see Table 3-25 Project Area Wild Horse and Burro Statistics).

Exploration

Activities and noise associated with exploration could alter wild horse and burro travel routes and grazing grounds. Surveying activities could alter migration routes if additional roads or routes are developed to survey potential geothermal sites and if fence construction blocks travel paths. Additional roads would improve human access to previously inaccessible areas, creating potential for habitat degradation. Noise from vehicles and drilling could disrupt grazing activities and encourage change in travel routes if animals react by avoidance. The magnitude and extend of the impact would depend on current land use in the area.

Drilling Operations

Impacts on wild horses and burros during the drilling operations phase could include noise disturbance and the alteration of travel routes and grazing grounds, as described above for exploration. Additional long-term impacts could result from installing additional access roads, production wells, injections wells, and sump pits. Sump pits could impact wild horses and burros by providing a catch basin for rainwater (an assumed water source). Sump pits often contain high concentrations of minerals and chemicals from the drilling fluids, which can be toxic to wild horses and burros. Acreage dedicated to well pads and needed equipment would reduce habitat. Pipelines placed aboveground could pose minimal-to-moderate obstacles in migration, depending on placement and size.

Utilization

Additional long-term impacts could result from installing added access roads, power lines, and other utilities needed for power plants and direct use facilities. Acreage dedicated to well pads and needed equipment would reduce habitat. Pipelines placed above ground could pose minimal-to-moderate obstacles in migration, depending on placement and size.

Noise disturbance from standard operation and maintenance activities would occur. No additional impacts would be recognized during this phase unless an additional drill site is required. Impacts from additional drill sites would be the same as those impacts discussed above under the drilling operations phase.

Reclamation and Abandonment

Impacts on wild horses and burros from reclamation and abandonment activities would be limited to noise disturbance, as described above under exploration. All disturbed lands would be reclaimed in accordance with BLM standards and would be made available as habitat unless otherwise planned.

4.12.4 What are the Potential Impacts on Wild Horses and Burros Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2. In the absence of site-specific data, including site location and timing, impacts on wild horses and burros would vary by lease area.

Under Alternative B, the potential area open for geothermal leasing is 197 million acres of public and NFS lands. Approximately 45 percent of wild horse and burro Herd Management Area lands occur within the potential area. Under Alternative C, even fewer Herd Management Area lands (approximately 30 percent of wild horse and burro Herd Management Area lands) occur on lands open to geothermal leasing, further narrowing the scope of the analysis.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. The acreage used by wild horses and burros and likely to be affected under this alternative is unknown.

Impacts on wild horses and burros could occur during the exploration, drilling operations, and utilization phases. By not designating geothermal potential areas as open or closed, individual geothermal projects could be developed in a number of locations, each resulting in various long- and short-term impacts on wild horse and burro populations. Under this alternative, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as consistent guidance for future geothermal leasing and development for direct and indirect uses. This could result in inconsistent planning on lands designated as herd areas and herd management areas. Due to the uncertainty of lands considered for direct and indirect use geothermal leasing and development under this alternative, it is not possible to quantify the total habitat acreage or number of animals that would be affected on Federal lands.

The Wild Free-Roaming Horses and Burros Act of 1971 dictates that one responsibility of the BLM is to protect, manage, and control wild horses and burros. As such, additional stipulations and mitigation measures may be applied on a case-by-case basis to leases where direct and indirect use geothermal resource development will impact these species.

Impacts under Alternative B

Under Alternative B, geothermal leasing for direct and indirect use would be open on approximately 197 million acres. Lands identified as open for geothermal leasing for direct and indirect use could be open with moderate to major constraints, depending on environmental conditions identified during site-specific reviews conducted by field offices prior to issuing the leases. Approximately 45 percent of wild horse and burro Herd Management Area land in the project area would be open for geothermal leasing for direct and indirect use.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. In accordance with BMPs (Appendix D), employees, contractors, and site visitors would be instructed to avoid harassment and disturbance of wild horses and burros during reproductive (e.g., breeding and birthing) seasons. Observations of potential problems regarding wild horses or burros would be reported to the authorized officer immediately. As described under the no action alternative, additional stipulations and mitigation measures may be applied on a case-by-case basis by the BLM if wild horses or burros are present within the proposed leasing area. Stipulations and mitigation measures could include requiring a habitat restoration plan to avoid (if possible), minimize, or mitigate negative impacts. It is expected that these measures would effectively avoid or minimize impacts on wild horses and burros by avoiding human interaction with wild horses and burros at key times and locations and minimizing habitat impacts.

Impacts under Alternative C

Under Alternative C, geothermal leasing for indirect use would be open on approximately 99 million acres. All federal lands identified as open to geothermal leasing for indirect use under this alternative are within 10 miles of the centerline of existing transmission lines. Restricting the placement of geothermal resource development for indirect use to within 10 miles of the centerline of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary would minimize impacts on wild horse and burro populations by concentrating land uses associated with energy development into designated areas and limiting opportunity for development in herd areas and herd management areas.

Areas open to geothermal lease applications for direct use and impacts from their anticipated subsequent development would be the same as identified under Alternative B.

4.13 LIVESTOCK GRAZING

4.13.1 What did the Public Say about Impacts on Livestock Grazing?

No public comments specifically addressed impacts on livestock grazing on public or NFS lands from the proposed action. The US EPA requested that the EIS identify and analyze areas with potential use conflicts, in which livestock grazing would be included.

4.13.2 How Were the Potential Effects of Geothermal Development on Livestock Grazing Evaluated?

Potential impacts on livestock grazing could occur if reasonably foreseeable future actions were to result in the following:

- Decrease acreages available to grazing;
- Decrease AUM number or forage; or
- Cause harassment or death of livestock.

4.13.3 What are the Common Impacts on Livestock Grazing Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on livestock grazing from geothermal resource development. Issuing leases would not impact livestock grazing operations on federal lands, so the discussion focuses on impacts related to anticipated future actions following leasing.

The Reasonable Foreseeable Development Scenario for Land Use

The four phases of geothermal development involve different levels of geothermal activity. The varying levels of geothermal activity influence the level of impact on livestock grazing. Direct and indirect use of geothermal resources would have similar impacts.

Exploration

Geothermal exploration affects large areas of grazing in the short term during temporary construction of well pads, exploration wells, and roads. Impacts would include loss of forage, reduced forage palatability because of dust on vegetation, and displacement of livestock from construction noise. Additional roads could also impact livestock by opening up areas that were not previously accessible, thereby increasing disturbance or harassment of livestock. However, creating new access roads to areas where livestock graze would help livestock operators manage their stock more efficiently.

Drilling Operations

Geothermal drilling operations affect larger areas of grazing in the longer term during construction of additional production wells, injection wells, and sump pits after exploration.

Sump pits could impact livestock grazing by providing a catch basin for rainwater (an assumed water source). Sump pits often contain high concentrations of minerals and chemicals from the drilling fluids, which can be toxic to grazing animals.

Utilization

Impacts during initial construction within the utilization phase are similar to but greater than the drilling operations phase and include loss of forage, reduced forage palatability because of dust on vegetation, restriction of livestock movement from pipelines and protective fencing surrounding the development area, harassment of livestock from additional access to livestock grazing areas, and temporary displacement of livestock from construction noise.

In the long term, a smaller amount of permanent grazing acreage is lost during geothermal operation than under the exploration, drilling operations, or initial construction during the utilization phases. No new construction would take place, as the project footprint would already be designated. Impacts would be similar to but less than the impacts identified under drilling operations, above. The length of time that impacts would occur depends on the availability of the geothermal resource itself.

Reclamation and Abandonment

Impacts on livestock grazing during the reclamation and abandonment phase would be short term and limited to the footprint of developed areas. Impacts would include increased noise and dust from demolition of existing pipelines and facilities. In the long term, restored vegetation would provide forage for grazing that was originally lost in development.

4.13.4 What are the Potential Impacts on Livestock Grazing Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. The number of acres that could impact livestock grazing practices is unknown; however, impacts would be site-specific and similar to the impacts under the four phases of geothermal development identified under Section 4.13.3. Under this alternative, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as consistent guidance for all future geothermal leasing and development for direct and indirect use. Development of the individual leasing approvals, stipulations, and best management practices would continue to vary per site and delay application processing time. Depending on the constraints identified by the leasing officer and identified within existing land use plans, areas identified as open or closed to leasing for direct and indirect use could create or take away conflicts that might result between grazing and geothermal development practices (such as harassment of livestock and other impacts identified under Section 4.13.3, above). It is important to note that some land use plans may be outdated and may not address geothermal leasing or development for direct or indirect use.

Impacts under Alternative B

Under Alternative B, planning area lands within grazing allotments would be identified as open or closed to geothermal leasing for direct and indirect use (See Table 4-6). Approximately 82 percent of available grazing allotments within public lands would be open to geothermal leasing for direct and indirect use, and approximately 95 percent of available grazing allotments within NFS lands would be open to geothermal leasing for direct and indirect use under Alternative B.

Table 4-6
Acreages of Grazing Allotments Open and Closed to Geothermal Leasing within the Planning Area under Alternative B

	Acres of Grazing Allotments on Public Lands	Acres of Grazing Allotments on NFS lands
Open to Leasing (Direct and Indirect Use)	102,179,879	66,455,039
Closed to Leasing (Direct and Indirect Use)	22,951,428	3,732,254
Total	125,131,307	70,187,293

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. In accordance with BMPs (Appendix D), operators would employ dust control measures to reduce impacts on livestock forage during construction and demolition. Litter and noxious weeds would be controlled and removed regularly during construction and operation. BMPs would also require that geothermal development be designed to minimize the number of structures. In addition geothermal companies should work with livestock permittees to mitigate impacts on water by producing off-site water developments. If appropriate, produced water from geothermal operations could be made available to livestock for use if water quality were sufficient. This additional water could increase livestock distribution and available forage for livestock that would otherwise be lost to development. It is expected that these measures would effectively minimize impacts on livestock grazing by reducing impacts on forage.

Impacts under Alternative C

Under Alternative C, impacts on grazing are analyzed within areas open to leasing for indirect use within 10 miles of the centerline of existing transmission lines. Approximately 43 percent of available grazing allotments within public lands would be open to geothermal leasing for indirect use, and approximately 40 percent of available grazing allotments within NFS lands would be open to geothermal leasing for indirect use under Alternative C (see Table 4-7). Impacts within 10 miles of the centerline of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary would be similar to Alternative B, but less area would be designated as open to geothermal leasing for direct use, and potential impacts from geothermal operations would be decreased and centralized to already disturbed transmission line areas. Areas open to direct use geothermal lease applications and impacts from their subsequent development would be the same as identified under Alternative B (see Tables 4-6 and 4-7).

Table 4-7
Acreages of Grazing Allotments Open and Closed to Geothermal Leasing under Alternative C

	Acres of Grazing Allotments on Public Lands	Acres of Grazing Allotments on NFS Lands
Open to Leasing for Indirect Use	53,772,871	28,120,522
Closed to Leasing for Indirect Use	71,358,436	42,066,771
Total	125,131,307	70,187,293
Open to Leasing for Direct Use	102,179,879	66,455,039
Closed to Leasing for Direct Use	22,951,428	3,732,254
Total	125,131,307	70,187,293

4.14 CULTURAL RESOURCES

4.14.1 What did the Public Say about Impacts on Cultural Resources?

Several comments from agencies and the public specifically addressed cultural resources. These are summarized below.

- The Idaho Conservation League and Utah Environmental Congress requested that the PEIS examine direct and cumulative impacts resulting from reasonably foreseeable geothermal development on sensitive historical or cultural resources, including sites eligible for the National Register of Historic Places and Native American respected sites and their settings (which encompass the viewsheds visible from the site).
- The Save Medicine Lake Coalition stated that the National Forests' timber stands, clean air, pure waters, cultural sites, and wildlife habitats cannot continue to be torn apart and put in harm's way by experimental or inexact geothermal technology.
- The Wilderness Society and Western Resource Advocates provided the following comments:
  - The agencies should specifically outline the environmental issues this PEIS will analyze in detail and include archaeological, cultural, or historic resources in the analysis. Should the agencies decide not to analyze any of these issues in detail, they should provide a detailed explanation of the grounds for not considering these issues, including how a failure to analyze them is not a violation of NEPA.
  - For both the setting of cultural resources and the enjoyment of recreation opportunities, the PEIS should consider preserving the scenic values associated with these areas.
  - The PEIS should acknowledge the likelihood of the presence of cultural resources and sacred sites in areas with geothermal energy potential and commit to both a Class III inventory and proactive consultation prior to leasing an area or permitting development.
  - The PEIS should include a commitment not to permit leasing or siting of geothermal energy projects in or immediately adjacent to areas with important cultural and archaeological resources.
- Ormat, Inc. stated that the PEIS should analyze exploration impacts, including analyzing at least three well pads for each of the resources considered. The effects of well drilling and testing are well known. The analysis of exploration drilling should be included and covered in the PEIS such that the lessee would only need to conduct site-specific cultural and season-appropriate biological surveys and

implement standard mitigation measures in order to construct the well pad and drill and test the wells.

- The US EPA stated that when identifying the areas of moderate to high potential for geothermal resources, the PEIS should also identify environmentally sensitive areas and areas with potential use conflict, including areas that are affiliated with Native American tribes, historic properties, Native American sacred sites or sensitive areas, and cultural resources. The scope of impacts on cultural resources should include the direct, indirect, and cumulative impacts on historic properties, districts, or landscapes.
- Individuals offered the following comments:
  - Consideration must be given to protecting outstanding historic, recreational, and biological resources that might be impacted. The PEIS should consider these impacts and should develop alternatives that would protect each of these resources.
  - With respect to the PEIS, information on potential cultural sites and issues should be included.

4.14.2 How Were the Potential Effects of Geothermal Development on Cultural Resources Evaluated?

This section addresses impacts on prehistoric and historic archaeological sites, structures, and buildings only. Native American Traditional Cultural Properties, sacred sites, and other concerns are addressed in Section 4.15, Tribal Interests and Traditional Cultural Resources. Historic trails are addressed under Section 4.16, National Scenic and Historic Trails. Consultations on programmatic actions including allocating areas as open or closed to leasing and determining lease stipulations are ongoing. These allocations do not grant any rights or authorize any activities affecting cultural resources. Impact analysis focuses on the anticipated future actions consistent with the implementation of the alternatives described in Chapter 2.

Methods

The authorized surface administrative unit of the BLM or FS would consult with Tribes and State Historic Preservation Officers regarding historic and cultural resources per Section 106 of the National Historical Preservation Act. The presence of archaeological sites and historic properties in the lease area would be determined on the basis of a records search of recorded sites and properties in the area and, depending on the extent and reliability of existing information, an archaeological survey. Archaeological sites and historic properties present in the leasing area would be reviewed to determine whether they meet the criteria of eligibility for listing on the National Register of Historic Places. Additional specific consultation requirements would be determined on a project-by-project level and during the ADP process.

Impact Criteria

Potential impacts on cultural resources could occur if reasonably foreseeable future actions were to:

- Conflict with management goals and objectives set forth by the BLM or FS in order to sustain cultural resources and their qualities;
- Result in proposed uses that are incompatible with maintaining and identifying cultural resources and their qualities; or
- Have an adverse affect on historic properties under Section 106 of the National Historic Preservation Act (36 CFR 800).

Assumptions

The PEIS includes standard NSO/NGD stipulations to protect cultural resources. An authorizing officer could grant exemptions to these stipulations on a case-by-case basis after determining that NSO/NGD is not warranted to achieve resource protection. Additional NSO/NGD stipulations could be applied by the authorizing officer to address specific location resource concerns. The following areas would have NSO/NGD stipulations:

- Within the setting of National Register eligible sites, including traditional cultural properties, where setting is critical to their eligibility; and
- Areas with important cultural and archaeological resources, including Native American sacred sites.

4.14.3 What are the Common Impacts on Cultural Resources Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on cultural resources from geothermal resource development.

The Reasonable Foreseeable Development Scenario for Cultural Resources

According to the RFD scenario, it is estimated that 111 power plants could be constructed by 2015, and another 133 power plants could be constructed by 2025. A representative amount of disturbance for one plant is 53 to 367 acres. Land directly disturbed in the project area would be approximately 5,883 acres to 40,737 acres by 2015 and 12,932 acres to 89,548 acres by 2025. The impacts of each phase of development are discussed below.

Exploration

The exploration phase includes surveying and drilling temperature gradient wells. Surveying activities would impact cultural resources if additional roads or routes are developed across or within a resource's historic landscape in order to survey the potential geothermal sites. Additional roads could lead to increased disturbances within a resource's boundaries or within a resource's historic landscape, possibly leading to increased illegal collecting and vandalism. The magnitude and extent of the impact would depend on the current state of the resources and their eligibility for the National Register of Historic Places. Any permanent construction or ground disturbances within a resource's boundaries or within its historic landscape would be long-term impacts.

The magnitude and extent of impacts on cultural resources from drilling temperature gradient wells would depend on the current condition of the resources and their eligibility for the National Register of Historic Places. Similar to surveying activities, roads would be required to access wells, and impacts would be similar to those described above for surveying. Several wells could be drilled per lease, and drill sites could disturb approximately 0.9 acres. Impacts would occur on lands directly under the well sites. If wells and appurtenances are constructed within the boundaries of an archaeological site or within its historic landscape, impacts would be long term. If wells and appurtenances are constructed within the boundaries of building or structural resources or their historic landscape, impacts would be considered short term if the modern construction is temporary and long term if the modern construction is permanent.

Drilling Operations

Geothermal drilling operations would result in long-term impacts on cultural resources if allowed within the boundaries of an archaeological deposit or its historic landscape. If new construction would be removed during reclamation and abandonment, impacts from the drilling operations phase on historic buildings or structures would be limited to the period of operation. The drilling operations phase would require access roads to accommodate larger equipment. New roads would have similar impacts to those identified during the exploration phase.

The drilling operations phase includes drill site development, which on average would require ground disturbance within a two-acre area plus a buffer to accommodate additional production wells, injection wells, and fluid sump pits. Any cultural resources or historic landscapes of cultural resources would be directly impacted by the ground disturbance.

Utilization

A power plant would require ground disturbance over approximately 15 to 25 acres and would impact any cultural resources within that area. The new power plant itself would represent a large modern development on a historic landscape. Installing electrical transmission lines from the power plant would disturb approximately one acre per mile of transmission line. Ground disturbance from the transmission line towers would impact cultural resources within their footprint and adjacent areas. Similar to the power plant, the towers and lines themselves could represent a large modern development on a historic landscape. Where feasible, pipelines would parallel access roads and existing roads, which presumably would have already disturbed cultural resources within proximity. However, if the existing road was designed to avoid cultural resources, a new pipeline may impact a previously undisturbed cultural resource. Long-term impacts on cultural resources would result from constructing these modern developments within the boundaries of archaeological sites. If the modern developments were within the viewshed of historic structures and buildings, impacts on those cultural resources would be long term if the developments would remain after closeout and short term if they would be removed.

Reclamation and Abandonment

Reclamation and abandonment activities include abandoning the well after production ceases and reclaiming all disturbed areas. All disturbed lands would be reclaimed in accordance with BLM and FS standards. Impacts on archaeological sites from previous phases would remain, and additional impacts could occur if reclamation and abandonment activities extend beyond previously disturbed areas. Unless the development and changes from exploration, drilling operations, and utilization phases are removed and the preexisting conditions are reestablished, all impacts on historic buildings and structures from previous phases would continue as well.

4.14.4 What are the Potential Impacts on Cultural Resources Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2. In the absence of site-specific data, including site location, only a general analysis of impacts on cultural resources is possible at this time. Under all alternatives, the NSO/NGD stipulations described in 4.14.2 would be applied.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. The number of acres likely to be affected under this alternative is unknown.

Issuing geothermal leases for direct and indirect use on a case-by-base basis is not expected to affect cultural resources. The case-specific studies required prior to issuance of a lease would be expected to prevent impacts on cultural resources. Under this alternative, however, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as consistent guidance for future geothermal leasing and development and protection of cultural resources. This would result in fragmented and segregated planning for preventing impacts, which often exponentially increases recognized environmental impacts. Due to the uncertainty of total acreage considered for geothermal leasing and development under this alternative, it is not possible to quantify the total acreage affected on federal lands.

Impacts under Alternative B

Under Alternative B, geothermal leasing for direct and indirect use would be closed on 25,150,000 acres of public land and on 24,370,000 acres of NFS land, protecting cultural resources in those areas. In areas identified as open to leasing for direct and indirect use, impacts would be concentrated in those areas identified in Section 3.14 as containing cultural resources. States identified in the RFD as having the majority of development, including California, Idaho, Nevada, and Oregon, would be expected to incur the greatest cultural resource impacts from direct and indirect geothermal uses.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. Relevant stipulations (Section 2.2.2) designed to minimize impacts on cultural resources include no surface occupancy within the setting and boundary of properties designated or eligible for the National Register of Historic Places, including National Landmarks and National Register Districts and Sites; and additional lands outside the designated boundaries to the extent necessary to protect values where the setting and integrity is critical to their designation or eligibility. Under the proposed leasing procedures (Section 2.2.2), the authorized officer of the BLM or FS would be required to consult with the appropriate Native American Tribes, Alaska Natives, and State Historic Preservation Officers regarding historic and cultural resources per Section 106 of the National Historical Preservation Act prior to leasing. The presence of archaeological sites and historic properties would be determined on the basis of a records search and literature review of recorded sites and properties in the proposed lease area and a buffer around the lease area, if appropriate. Additional historical, cultural or ethnographic research, consultation and/or inventories may be required to identify resources, determine effects, mitigate adverse effects and complete the Section 106 process.

In accordance with BMPs (Appendix D), if cultural resources are present at the site, or if areas with a high potential to contain cultural material have been identified, a cultural resource management plan would be developed that identifies appropriate monitoring and protection measures. Unexpected discovery of cultural resources during geothermal development would be brought to the attention of the responsible BLM authorized office immediately and work shall be halted in the vicinity of the finds to avoid further disturbance while the finds are evaluated and appropriate mitigation measures are developed. It is expected that these measures would effectively avoid and/or minimize impacts on cultural resources by identifying, preserving and protecting significant cultural resources, districts and landscapes; and maintaining viewshed of important cultural resources as appropriate; and reducing indirect impacts from land uses on cultural resources.

Impacts under Alternative C

Under Alternative C, geothermal leasing would be closed to indirect use on 81,951,000 acres of public land and on 65,712,000 acres of NFS land, protecting cultural resources in those areas. This would protect cultural resources on greater acres than under Alternative B. Impacts on cultural resources within the 99,073,000 acres that would remain open to leasing for indirect use would be similar to those described under Alternative B, although the area of impact would be less.

Areas open to direct use geothermal lease applications and impacts from their anticipated subsequent development would be the same as identified under Alternative B.

4.15 TRIBAL INTERESTS AND TRADITIONAL CULTURAL RESOURCES

4.15.1 What did the Public Say about Impacts on Tribal Interests and Traditional Cultural Resources?

Several general comments were made regarding avoiding sensitive areas, cultural resources, heritage resources, and sites eligible for the National Register of Historic Places.

The Idaho Conservation League and Utah Environmental Congress requested that the PEIS specifically address impacts on "... *Native American respected (sic) sites, and their settings."*

The Wilderness Society and Western Resource Advocates advised that *"...hot springs are often the sites for important cultural resources, while also serving as popular recreation areas. For both the setting of cultural resources and the enjoyment of recreational opportunities, preserving the scenic values associated with these areas must be considered. ...The PEIS should acknowledge the likelihood of the presence of cultural resources and sacred sites in areas with geothermal energy potential and commit to both a Class III inventory and proactive consultation prior to leasing an area or permitting development."*

In extensive comments, the United States Environmental Protection Agency wrote that *"the PEIS should describe the process and outcome for government-to-government consultation between the BLM, the USFS, and each of the tribal governments within the project area, issues that were raised (if any), and how those issues were addressed in the selection of the proposed alternatives."*

The agency also recommended *"...that BLM and USFS initiate consultation with the potentially affected tribes specific to their interests and concerns about cultural resources. The scope of impacts on cultural resources should include the direct, indirect, and cumulative impacts on*

- *sacred sites;*
- *traditional cultural properties or landscapes;*
- *hunting, fishing, gathering areas (including impacts on the ecosystems that support animals and plants and that are, or once were, part of the Tribes and tribal descendants traditional resource areas;*
- *access to traditional and current hunting, fishing and gathering areas and species;*
- *changes in hydrology or ecological conditions of springs, seeps, wetlands, and streams, that could be considered sacred or have traditional resource use associations;*

- *travel routes that were historically used and travel routes that may be currently used; and*
- *historic properties, districts or landscapes."*

The agency recommends that *"the PEIS should address the existence of Indian sacred sites in the project area. It should address Executive Order 13007, distinguish it from Section 106 of the NHPA, discuss how BLM and the USFS will avoid adversely affecting the physical integrity of sacred sites if they exist, and address other requirements of the Executive Order."*

The agency recommends that *"that if adverse effects to traditional cultural properties, sacred sites, or other areas of cultural resource concern are identified, any Memorandum of Agreement (MOA) developed to resolve these concerns ...should be fully executed before the ROD is issued, and the ROD should provide for implementation of the MOA's terms."*

4.15.2 How Were the Potential Effects of Geothermal Development on Tribal Interests and Traditional Cultural Resources Evaluated?

Methods

As described in Section 3.15, tribal interests and traditional cultural resources are identified primarily through consultations with federally recognized Indian tribes on a government-to-government basis. Direct consultations are also needed to identify traditional cultural resources in the case of non-federally recognized tribes and other potentially affected communities. In some cases, ethnohistorical research or focused ethnographic studies are used to gather information and oral traditions related to particular locations and resource uses. These studies usually focus on researching the historical uses of the area, defining the important traditional places, natural resources and landscape features, identifying named places and documenting contemporary tribal uses of the project area. Field visits can be arranged for elders or persons with traditional knowledge who may associate a place or site with a tradition, practice, oral history, ancestral use, or belief important to the community's cultural life. Contemporary ties may be rediscovered to ancestral archaeological sites recorded as part of the planning process..

Tribal governments, along with the BIA and the Interior Office of the Special Trustee for American Indians, are sources for identifying Indian trust and treaty rights. Initial contacts have been made by the BLM and FS, and some responses have been received. Generally, specific tribal interests, and especially traditional cultural resources and sacred sites, cannot be identified on a programmatic basis, as analysis of specific impacts on these resources cannot be conducted at this scale. Coordination through BLM and FS tribal liaisons and other established programs would continue. Tribes and other parties would be engaged to identify interests and traditional cultural resources in the individual lease areas that may be impacted by geothermal development.

While not fully defined, tribal interests, trust resources, reserved treaty rights, and traditional cultural resources are present in the planning area. The potential effects of geothermal development were evaluated by consulting existing planning and guidance documents, ethnographic literature, local knowledge, and input from BLM, FS, and contractor staff and cultural resource specialists. Potential effects on common tribal interests and resource types are described to allow comparison of the programmatic alternatives, with the knowledge that site-specific consultation would be necessary to provide a full accounting of affected interests and resources and to define the context and intensity of impacts.

Impact Criteria

Potential impacts on tribal interests or traditional cultural resources could occur if anticipated future actions consistent with implementing the alternatives described in Chapter 2 were to:

- Conflict with land uses, management, and economic well being of adjacent or nearby reservations, trust lands, restricted Indian allotments, and federally tribal-dependent Indian communities;
- Conflict with the exercise of off-reservation treaty and reserved rights, including grazing rights, hunting and fishing rights, gathering rights and interests, and water rights;
- Conflict with the exercise of Alaska Native Subsistence Rights;
- Conflict with federal trust responsibilities to tribes and individual Indians regarding real property, physical assets, or intangible property rights;
- Conflict with existing court decisions, laws, policies, executive orders, and agency agreements with tribes regarding land and resource use;
- Result in proposed uses that are incompatible with maintaining and identifying cultural resources and their qualities;
- Have an adverse effect on historic properties or their settings, especially traditional cultural properties and cultural landscapes under Section 106 of the NHPA (36 CFR 800);
- Impact or restrict access to traditionally used hunting, fishing, and gathering areas and species;
- Change or reduce access to traditionally used or culturally important water sources and hot springs;
- Impact culturally important trails or trail systems; or

- Impact sacred sites or their settings, access, or use.

Assumptions

In accordance with 43 CFR 2301.11, the BLM is prohibited from issuing leases on Indian trust or restricted lands within or outside the boundaries of Indian reservations. These are lands in which the title is held by the United States in trust for an Indian or an Indian tribe or lands in which the title is held by Indians or an Indian tribe but is subject to restriction by the United States against transferring such property.

The authorized surface administrative unit of the BLM or FS would coordinate with Indian Tribal governments to identify issues regarding the lease and potential for geothermal energy development, including issues related to the presence of cultural properties, access rights, disruption to traditional cultural practices, and impacts on visual resources important to the tribe(s).

The authorized surface administrative unit of the BLM or FS would coordinate with tribes and State Historic Preservation Officers regarding historic and cultural resources per Section 106 of the NHPA. The presence of archaeological sites and historic properties in the lease area shall be determined on the basis of a records search of recorded sites and properties in the area and, depending on the extent and reliability of existing information, an archaeological survey. Archaeological sites and historic properties present in the leasing area shall be reviewed to determine whether they meet the criteria of eligibility for listing on the NRHP. Additional specific consultation requirements would be determined on a project-by-project level and during the ADP process.

The PEIS includes standard NSO/NGD stipulations to protect cultural resources. An authorizing officer could grant exemptions to these stipulations on a case-by-case basis after determining that NSO/NGD is not warranted to achieve resource protection. Additional NSO/NGD stipulations could be applied by the authorizing officer to address specific location resource concerns. The following areas would have NSO/NGD stipulations:

- Within the setting of National Register-eligible sites, including traditional cultural properties, where setting is critical to their eligibility; and
- Areas with important cultural and archaeological resources, including Native American sacred sites.

4.15.3 What are the Common Impacts on Tribal Interests and Traditional Cultural Resources Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on tribal interests and traditional cultural resources from geothermal resource development.

Areas proposed for leasing would likely include lands where there are tribal interests and traditional cultural resources that are not currently identified. The BLM or the FS would coordinate with Indian Tribal governments to identify issues and concerns regarding the lease and potential for geothermal energy development. Agency staff also may be aware of locally sensitive areas and resources from previous consultation and identification efforts of tribal trust and treaty concerns. However, affected groups may not wish to enter into direct consultation or may prefer not to discuss specific traditional use areas or sacred sites until development plans are proposed and there is a perception that interests or resources would be threatened.

Issuing geothermal leases confers on the lessee a right to future exploration and development of geothermal resources within the lease area. Thus, it is a conditional commitment or granting of a right that may interfere with other uses or interests such as land-into-trust applications by tribes, or acquisition (restoration) of a tribe's ancestral land base or resources. There may also be unidentified conflicts with existing tribal treaty rights or claims of ownership related to hot springs and water sources.

Leasing does not confer on the lessee the right to conduct any ground-disturbing activities to explore for or develop geothermal resources without further review and permitting. Impacts may be minimized or avoided through any required consultations, environmental review, and NSO/NGD stipulations. Types of impacts that could occur from exploration, drilling operations, utilization, and reclamation and abandonment include direct disturbance of locations or landscapes associated with traditional beliefs, resource gathering areas, hunting and fishing areas, water sources, hot springs, ancestral sites, human remains, and trails. Other impacts could result from alterations of visual, aural, or other aspects of setting both on the lease site and in adjacent areas; increased access and vandalism; decreased access or interference with the exercise of treaty rights or cultural uses; and the potential for erosion, pollution, habitat loss, and less tangible changes to natural features and resources that tribal members may consider sacred.

Consultation and review at the different stages of exploration and development would avoid or address many potential impacts; however, there may be residual effects on traditional cultural resources that may be difficult or impossible to adequately mitigate.

The Reasonable Foreseeable Development Scenario for Tribal Interests and Traditional Cultural Resources

According to the RFD scenario, it is estimated that 111 power plants could be constructed by 2015, and another 133 power plants could be constructed by

2025. The most development is expected to occur in California and Nevada, with the least occurring in Colorado, Arizona, Wyoming, and Montana. A representative amount of disturbance of the geothermal resource development phase is 53 to 367 acres. Land directly disturbed would be approximately 5,883 acres to 40,737 acres by 2015 and 12,932 acres to 89,548 acres by 2025. This is only a small percentage of the land managed by the BLM and FS in the western US.

Surface exposures of geothermal resources such as hot springs are commonly very important to tribes and are often connected with ritual use and spiritual meaning. Exploration, drilling operations, and utilization from these sources would likely impact traditional cultural resources and could possibly impact other tribal interests. Impacts could include loss of access, interference with use, and changes in flow or temperature of hot springs. Since the thermal water in these springs is often considered sacred, there is a potential for loss of sacred sites, and the healing energy and power they provide to the tribal users who value them.

Also relevant are impacts on the setting and cultural landscapes of tribal interests and traditional cultural properties, which can extend far beyond the land that is directly disturbed. Consultation, review, and permitting are required for the exploration, drilling operations, and utilization phases.

Exploration

The exploration phase includes surveying and drilling temperature gradient wells. Surveying can include a variety of field studies and sampling. Surveying and drilling temperature gradient wells would likely require some minor surface disturbance for site access, site investigations, and placement of several small well sites. Grading typically would not be required at well sites, but land would be disturbed by equipment use. Drilling wells would require temporary equipment placement and would generate noise.

Potential impacts could result if tribal interests or traditional cultural resources are located on lands disturbed by road, sampling, and well locations. Access roads, investigations, and establishing well sites can also lead to impacts from vandalism, unauthorized collection of ancestral sites, alteration of cultural landscapes, noise, and interference with traditional religious or cultural practices such as resource gathering or hunting. The context and intensity of the impact would depend on the resources that may be present and identified, and whether the resources can be avoided. Impacts may be minimized or avoided through any required consultations, environmental review, and NSO/NGD stipulations. Compared to the other phases of geothermal development, exploration involves the least potential for permanent, long-term impacts.

Drilling Operations
Potential impacts are similar to the exploration phase, with additional construction to accommodate injection wells and sump pits.

Utilization
The utilization phase, combined with drilling operations above, would directly disturb 51 to 350 acres to accommodate construction, well pads, power plants, additional roads, pipelines for direct use applications, and electrical transmission lines. Landscapes would be changed by the addition of large structures, security lighting, transmission lines, and steam plumes and by the loss of natural cover, landforms, and habitats. Construction would require heavy equipment use and many workers on-site and would result in noise, vehicular traffic, and fugitive dust.

Potential impacts could result if tribal interests or traditional cultural resources are located on land disturbed or converted to other uses by the construction. Exercise of tribal treaty rights and use of traditional cultural resources, resource gathering areas, and sacred sites on adjacent lands may not be possible due to intrusions to setting, loss of habitat, and security fencing. Areas considered sacred and the qualities that make them important to traditional practitioners may be permanently lost. Creating access roads and introducing large numbers of workers on-site may impact resources through vandalism, unauthorized collection, and damage of ancestral sites. Impacts on setting, important view sheds, and cultural landscapes may extend far beyond the project area. The context and intensity of the impact would depend on the resources that may be present and identified and whether the resources can be avoided. Impacts may be minimized or avoided through any required consultations, environmental review, and NSO/NGD stipulations. The utilization phase involves the most potential for permanent, long-term impacts.

Short-term minor impacts would occur from standard operation and maintenance activities, such as maneuvering construction and maintenance equipment and vehicles associated with these activities. Additional impacts could occur during this phase if production is expanded or if an additional drill site is required. Consultation and monitoring may be required to ensure that commitments regarding exclusion zones and access for traditional users are maintained.

Reclamation and Abandonment
Reclamation and abandonment activities include abandoning the well after production ceases and reclaiming all disturbed areas. All disturbed lands would be reclaimed in accordance with BLM and FS standards. In some areas, land may be reused for other purposes rather than restored.

While visual and aural settings could be restored and it may be possible to restore some habitats, it is unlikely that some cultural or sacred uses could be restored. Changes in flow or temperature of hot springs would not be restored, and cultural uses and religious value may be permanently lost.

4.15.4 What are the Potential Impacts on Tribal Interests and Traditional Cultural Resources Associated with the Proposed Action and Alternatives?

The following discussion analyzes the general environmental consequences expected to occur as a result of implementing the alternatives described in Chapter 2. Impacts are discussed generically, because the presence, absence, or location of tribal interests and traditional cultural resources and their relation to potential geothermal development are not known.

Impacts under Alternative A

Under the no action alternative, geothermal leasing for direct and indirect use would continue to occur on a case-by-case basis. Geothermal leases for direct and indirect use would be issued based on existing land use plans and future amendments and revisions. Many current land use plans do not specifically address geothermal leasing and its effects on tribal interests and traditional cultural resources.

Under this alternative, areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. Standardized protections through closures, lease stipulations, best management practices, or procedures for tribal interests and traditional cultural resources would not be implemented for public and NFS lands in the western states. Similar protections for other resource values that can also preserve tribal interests and traditional cultural resources would not be implemented. Because uniform standards would not apply, there may be inconsistent identification and consideration of impacts on tribal interests and traditional cultural resources.

The BLM would still be prohibited from issuing leases for direct and indirect use on Indian trust or restricted lands within or outside of the boundaries of Indian reservations. Compliance with NEPA, NHPA, and Executive Orders 13007 and 13084 would still be required, reducing the potential for impacts. Issuing geothermal leases for direct and indirect use on a case-by-base basis or through land use plan provisions could result in higher or lower levels of protection and consideration of tribal interests and traditional cultural resources than through the PEIS. The types of impacts that could occur would be similar to those described in Section 4.15.3, above, for each phase of the RFD scenario. The number of acres likely to be affected under this alternative is unknown.

Impacts under Alternative B

Under Alternative B, the proposed action, geothermal leasing for direct and indirect use would be open on approximately 118,000,000 acres of public land and 79,000,000 acres of National Forest System land in the 12 western states. Lands identified as open for geothermal leasing for direct and indirect use could be open with moderate to major constraints, depending on environmental conditions identified during site-specific reviews conducted by field offices and ranger districts prior to issuing leases. Approximately 48,520,000 acres would be closed to geothermal leasing for direct and indirect use because these lands were found to be incompatible with geothermal leasing, exploration, and development. Existing land use plans would be amended to reflect the leasing standards of this PEIS, but individual field offices and ranger districts could modify these standards in keeping with pre-existing agreements on resource protections. Higher or lower levels of protection and consideration of tribal interests and traditional cultural resources could result in areas where development is currently governed through land use plan provisions or agreements.

Under Alternative B, the potential for impacts on tribal interests and traditional cultural resources would be the same as described for each phase of the RFD scenario described in Section 4.15.3. Impacts on tribal interests and resources on most public and NFS lands would be minimized or avoided through consistent guidance for future geothermal leasing, including closures, any required consultations, environmental reviews, and stipulations. Indian trust or restricted lands within or outside the boundaries of Indian reservations would remain closed to leasing for direct and indirect use. For all lands open to geothermal leasing, compliance with NEPA, NHPA, and Executive Orders 13007 and 13084 would be required reducing the potential for impacts. No surface occupancy would be allowed in areas with important cultural and archaeological resources, such as traditional cultural properties and Native American sacred sites, as identified through any required government-to-government consultation with tribes (Section 2.2.2). It is expected that these measures, along with the measures outlined under cultural resources, will minimize impacts on tribal interests and traditional cultural resources, however there may be residual effects that are difficult or impossible to adequately mitigate.

Impacts under Alternative C

Under Alternative C, approximately 61 million acres of public lands and 38 million acres of NFS lands would be identified as open for indirect use leasing within 10 miles of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary.

Potential impacts on tribal interests and traditional cultural resources would be similar in type to those described in Section 4.15.3 for each phase of the RFD scenario. Indirect use geothermal leasing would be concentrated and encouraged primarily within transmission line buffers, reducing the need to disturb additional lands and visual settings and reducing potential impacts in other areas. By locating leases and future development in places that may already have some level of disturbance, it is less likely that certain kinds of tribal interests and traditional cultural resources would be present or impacted.

Areas open to direct use geothermal lease applications and impacts from their subsequent development would be the same as identified under Alternative B.

4.16 National Scenic and Historic Trails

4.16.1 What did the Public Say about Impacts on National Scenic and Historic Trails?

Although several comments pertained to cultural resources in general, only three specifically addressed National Scenic and Historic Trails. The California Wilderness Coalition, The Wilderness Society, and The Wilderness Society and Western Resource Advocates all requested that no permitting be allowed in or adjacent to designated National Scenic and Historic Trails.

4.16.2 How Were the Potential Effects of Geothermal Development on National Scenic and Historic Trails Evaluated?

Potential impacts on National Scenic and Historic Trails could occur if reasonably foreseeable future actions were to:

- Conflict with management goals and objectives set forth by the agency or agencies responsible for trail-wide management and by the BLM or FS with on-site jurisdiction in order to sustain these resources and their visual or historic qualities;
- Result in proposed uses that are incompatible with maintaining and identifying National Scenic and Historic Trails and their qualities within and adjacent to their boundaries;
- Utilize all or any portion of a National Scenic and Historic Trail during any phase of geothermal development; or
- Install facilities or transmission lines within a National Scenic and Historic Trail's historic or scenic landscape.

Assumptions

The analysis assumes that land occupied by National Scenic and Historic Trails would be closed to leasing and that controlled surface use stipulations (CSUs) to leases would be used to apply BLM VRM Class II management objectives, unless otherwise designated. Some trail segments are currently protected by larger surface occupancy or visual buffers, and the BLM field office or FS ranger district with on-site jurisdiction would have the discretion to retain more restrictive buffers. Some trail segments are collocated with modern highways or other disturbances, and BLM VRM Class II management objectives may not be appropriate.

4.16.3 What are the Common Impacts Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on National Scenic and Historic Trails from geothermal resource development.

The Reasonable Foreseeable Development Scenario for National Scenic and Historic Trails

According to the RFD scenario, it is estimated that 111 power plants could be constructed by 2015, and another 133 power plants could be constructed by 2025. The typical acreage of disturbance in a complete geothermal resource development is 53 to 367 acres. Therefore, total land use disturbance would be approximately 5,883 acres to 40,737 acres by 2015 and 12,932 acres to 89,548 acres by 2025. The four phases of geothermal development involve different levels of geothermal activity. The varying levels of geothermal activity influence the level of impact on National Scenic and Historic Trails. Impacts for each phase for a typical plant are discussed below.

Exploration

The exploration phase includes surveying and drilling temperature gradient wells.

Surveying activities would impact historical and scenic trails if additional roads or routes are developed across or within the trail's historic or scenic landscape. Additional roads could lead to increased disturbances along trails and within their landscapes. The magnitude and extent of the impact would depend on the current modern uses in the area. Any permanent construction or disturbances would be long-term impacts.

The magnitude and extent of impacts on National Scenic and Historic Trails from drilling temperature gradient wells would again depend on the current modern uses in the area. Similar to surveying activities, roads would be required to access wells, and impacts would be similar. Several wells could be drilled per lease, and drilling activity could disturb approximately 0.9 acres. Ground disturbances would occur on lands directly under the well sites, which does not typically involve leveling or grading; these impacts would last only the duration of the drilling and reclamation activities (several weeks). If wells and appurtenances are constructed within the route of a National Scenic and Historic Trail or within a trail's historic or scenic landscape, impacts would be considered short term if structures are temporary and long term if structures are permanent.

Drilling Operations

Geothermal drilling operations would result in impacts on National Scenic and Historic Trails if allowed within the boundaries of a trail or its landscape. The drilling operations phase would require access roads to accommodate larger equipment. New roads would have similar impacts to those identified during the exploration phase.

The drilling operations phase also includes drill site development, which on average requires a two-acre well pad to accommodate additional production wells, injection wells, and sump pits. Land under the well pad may include a portion of a National Scenic or Historic Trail route and would be impacted by ground disturbance.

Utilization

Construction of a geothermal power plant and its associated infrastructure (e.g., well field equipment) during the onset of the utilization phase would create impacts if a portion of a National Scenic or Historic Trail route would be impacted by ground disturbance. These impacts would be limited to the construction period.

The well field equipment consists of pipelines that vary from 24 to 36 inches in diameter. Where feasible, pipelines would parallel access roads and existing roads, some of which may be National Scenic and Historic Trails. A power plant requires approximately 15 to 25 acres to accommodate all the needed equipment and would represent a large modern development on a historic or scenic landscape. Installing electrical transmission lines from the power plant would disturb approximately one acre per mile of transmission line. Lines may cross trails and their landscapes. Long-term impacts on National Scenic and Historic Trails would result from construction of these modern developments within the route or historic or scenic landscape of the affected trail.

Reclamation and Abandonment

Reclamation and abandonment activities include abandoning the well after production ceases and reclaiming all disturbed areas. All disturbed lands would be reclaimed in accordance with BLM and FS standards. Unless the development and changes from the exploration, drilling operations, and utilization phases are removed and the preexisting conditions are reestablished, all impacts on National Scenic and Historic Trails from those previous phases would continue.

4.16.4 What are the Potential Impacts Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2. In the absence of site-specific data, including site location, only a general analysis of impacts on National Scenic and Historic Trails is possible at this time.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. The number of acres likely to be affected under this alternative is unknown.

Issuing geothermal leases for direct and indirect use on a case-by-base basis is not expected to affect National Scenic and Historic Trails. The case-specific studies required prior to issuance of a lease would be expected to prevent many impacts on National Scenic and Historic Trails. Development would require construction of facilities and transmission lines, which could alter the historic or scenic landscape of the affected trails. Under this alternative, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as a consistent guidance for future geothermal leasing and development. This would result in fragmented and segregated planning for preventing impacts on National Scenic and Historic Trails, which often exponentially increases recognized environmental impacts. Due to the uncertainty of total acreage considered for geothermal leasing and development under this alternative, it is not possible to quantify the total acreage affected on federal lands.

Impacts under Alternative B

Under Alternative B, the proposed action, geothermal leasing for direct and indirect use would not be allowed on National Scenic or Historic Trails, and BLM VRM Class II management objectives would be applied. This would prevent or reduce impacts from occurring within the route of a designated trail and its historic or scenic landscape. Development would require construction of facilities and transmission lines, which could alter the historic or scenic landscape of the affected trails. Approximately 6,173 miles of National Scenic and Historic Trails traverse the planning area and would be afforded additional protections under Alternative B. However, if a trail's associated historic or scenic landscape extends farther than one mile from the route, the trail could be impacted by the various phases of geothermal development.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. Relevant stipulations (Section 2.2.2) designed to minimize impacts on National Scenic and Historic Trails include (1) no surface occupancy within the setting and boundary of properties designated or eligible for the National Register of Historic Places, including National Landmarks and National Register Districts and Sites; and additional lands outside the designated boundaries to the extent necessary to protect values where the setting and integrity is critical to their designation or eligibility; and (2) controlled surface use in sensitive viewsheds within the visual setting of National Scenic and Historic Trails to maintain VRM Class II objectives, unless otherwise designated.. In addition, in accordance with BMPs (Appendix D), BLM and operators would contact appropriate agencies, property owners, and other stakeholders early in the planning process to identify potentially sensitive recreational areas and issues such as trails. It is expected that these measures would effectively avoid or minimize impacts on National Scenic and Historic Trails by protecting the most significant trails, maintaining recreational opportunities and recreational experience, and reducing user and resource conflicts.

Impacts under Alternative C

Under Alternative C, geothermal leasing for direct and indirect use would not be allowed on National Scenic or Historic Trails, and BLM VRM Class II management objectives would be applied to scenic and historic landscapes. This would result in impacts similar to those under Alternative B, but with fewer landscapes afforded the additional standard protections around designated trails during leasing and development for indirect use. Leasing and development would presumably be more likely to occur in areas that may be already altered by transmission lines, and new disturbances to scenic or historic landscapes may be avoided.

4.17 VISUAL RESOURCES

This section analyzes impacts on visual resources as a result of activities described in the RFD scenario, which involves the four sequential phases of geothermal development: 1) exploration, 2) drilling operations, 3) utilization, and 4) reclamation and abandonment.

4.17.1 What did the Public Say about Impacts on Visual Resources?

Scoping was conducted to determine issues of concern with respect to the proposed project. The following issues of concern relating to visual resources were identified during scoping:

- Effects on scenic resources from road and other transmission corridor developments;
- Effects on open space from development;
- Effects on scenic values associated with cultural resources and recreation from geothermal development; and
- General and specific BMPs to preserve scenic quality.

4.17.2 How Were the Potential Effects of Geothermal Development on Visual Resources Evaluated?

Potential impacts on visual resources are based on interdisciplinary team knowledge of public lands and National Forest System lands, review of literature, and information gathered from the public during the planning process. To the extent practical, spatial data were used to compare environmental conditions with the alternatives. Various actions that might create changes to the basic landscape elements (such as form, line, color, and texture) were considered in identifying potential impacts. Effects are quantified where possible. In the absence of quantitative data, best professional judgment was used to describe impacts using qualitative terms. Impacts were assessed according to the following assumptions:

- Scenic resources would remain in demand on public lands and NFS lands;
- The demand for recreational use would continue to increase, thereby increasing the value of open spaces and undeveloped landscapes containing scenic resources;
- Any new surface-disturbing geothermal activities would be subject to further NEPA analysis, which would include an analysis to determine consistency with applicable visual resource objectives. NEPA analysis within VRM Management Class I, II, and III would include contrast rating evaluations and photo simulations in accordance with BLM Handbook H-8431-1, Visual Resource Contrast Rating; and

- Proposed activities that would not initially meet applicable visual resource objectives for an area would be mitigated to the extent needed to meet the objectives. Those proposed activities that could not be mitigated would not be authorized.

Impacts on visual resources can be either positive or negative, depending on the type and degree of visual contrasts introduced to a landscape. Where modifications repeat the general elements of the natural landscape, the degree of visual contrast is lower, and the impacts are generally perceived less negatively. Where modification introduces pronounced changes, the degree of contrast is greater, and impacts are often perceived more negatively.

The potential risk of impacts on visual resources is assessed for five significance criteria. Potential impacts on visual resources could occur if reasonably foreseeable future actions were to result in the following:

- Have adverse effects on a scenic vista;
- Damage a scenic resource within a scenic roadway;
- Degrade the existing visual character or quality of the site and its surroundings;
- Create a new source of light or glare; or
- Be incompatible with the VRM system, the SMS, or other applicable visual resource objectives.

Receptors sensitive to disturbances of visual resources are varied and depend on the landscape's visual resources; the project's location; the view distance, angle, and duration; the location of travel routes; public areas of interest; the season; the topography; recreation activities; and the number of viewers. Because of this, it is important to note that site-specific impact assessment is needed to thoroughly assess impacts on visual resources from a particular project. Without precise information about a specific project, it is not possible to detail the visual impacts. However, by using the RFD scenario as a general description of expected geothermal resource development activities, a generalized assessment of the possible impacts on visual resources can be made by describing the range of expected visual changes.

4.17.3 What are the Common Impacts on Visual Resources Associated with Geothermal Development?

Future actions based on the RFD scenario could result in impacts on visual resources. Due to the inability to predict precise future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on visual resources from geothermal resource development. The exact level of impact would depend on the actual intensity of geothermal resource development activity.

The Reasonable Foreseeable Development Scenario for Visual Resources
The four sequential phases of geothermal development involve different levels of geothermal activity. The varying levels of geothermal activity influence the level of impact on visual resources.

Exploration
Exploration can involve field surveys and temperature gradient well activities. Field surveys are typically conducted on foot or by using four-wheel drive vehicles and involve collecting data pertaining to the local geothermal resource. Temperature gradient wells are typically drilled using a truck-mounted rig and support equipment. The temperature gradient wells range from 200 feet to over 4,000 feet deep. No permanent structures are constructed for field surveys or temperature gradient wells. As a result of field surveys and temperature gradient well activities, the following alterations to visual resources would occur during the exploration phase:

- Vegetation damage;
- Scarring of the terrain from vehicles;
- Truck-mounted drilling rig and support equipment detracting from the natural environment; and
- Lighting during drilling and for safety.

Minimal reclamation is needed to return visual resources to pre-disturbance conditions, because exploration activities are limited in duration and are relatively small in physical size and areal extent. The BLM and FS would develop and approve reclamation requirements. Compared to the other phases of geothermal development, exploration involves the least amount of permanent, long-term disturbance to the visual environment.

Stipulations involving NSO/NGD would be applied to public lands designated as VRM Class I and National Forest System lands designated as Very High in order to protect scenic resources. Activities that would not comply with NSO/NGD stipulations would not be allowed on those lands.

National Forest System lands designated as High involve landscapes where the valued landscape character appears intact. Deviations may be present but must repeat the form, line, color, texture, and pattern common to the landscape character so completely and at such scale that they are not evident. National Forest System lands designated as Moderate involve landscapes where the valued landscape character appears slightly altered. Noticeable deviations must remain visually subordinate to the landscape character being viewed.

The objective of VRM Class II public land is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low.

Management activities may be seen but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

The impacts on visual resources from the exploration phase on these three types of lands would be evident and would create a landscape that does not appear intact, mostly from the use of a truck-mounted drilling rig. A drilling rig would be a noticeable deviation and would attract the attention of casual observers. It is assumed that BLM and FS best management practices, standard operating procedures, and requirements for geothermal explorations would be implemented for all land designations to reduce impacts on visual resources. Also, at the very least, mitigation measures would be necessary for National Forest System lands designated as High and Moderate and public lands designated as VRM Class II to further reduce impacts on visual resources. Mitigation may also be necessary for lands with visual resources of lesser quality once site-specific analysis is conducted.

Drilling Operations

Drilling operations can involve assembling infrastructure in order to use the geothermal resource. For indirect use, the infrastructure can include roads, sump pits, production-size wells, injection wells, well field equipment, and reclamation around wells. The production-size wells can be over two miles (10,560 feet) deep. As a result of assembling infrastructure, the following alterations to visual resources would occur during the drilling operations phase:

- Visibility of activities involving construction work;
- Vegetation damage;
- Altering the natural landform or contours;
- Clearing of vegetation for roads;
- Building new roads;
- Scarring of the terrain from construction work;
- Fugitive dust from construction activities and newly exposed soils; and
- Lighting during construction.

Furthermore, depending on the location, this phase of geothermal activity could also alter a scenic vista or scenic roadway, fragment the open space of the landscape, or reduce the aesthetics of recreation or cultural areas.

Reclamation would occur after development activities to return visual resources to pre-disturbance conditions. Areas where reclamation would occur include temporary roads, staging areas, and well head areas. The BLM and FS would develop and approve reclamation requirements.

Stipulations involving NSO/NGD would be applied on public lands designated as VRM Class I and National Forest System lands designated as Very High in order to protect scenic resources. Activities that would not comply with NSO/NGD stipulations would not be allowed on those lands.

The impacts on visual resources on National Forest System lands designated as High and Moderate and public lands designated as VRM Class II would be the same as those described above under exploration. National Forest System lands designated as Low involve landscapes where the valued landscape character appears moderately altered. Deviations begin to dominate the valued landscape character being viewed, but they borrow valued attributes such as size, shape, edge effect, and pattern of natural openings; vegetative-type changes; or architectural styles outside the landscape being viewed. They should not only appear as valued character outside the landscape being viewed but should be compatible or complimentary to the character within. The objective of VRM Class III public lands is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.

The impacts on visual resource from the drilling operations phase on these two types of lands would dominate the valued landscape and the view of the casual observer. It is assumed BLM and FS best management practices, standard operating procedures, and requirements for geothermal development would be implemented for all land designations to reduce impacts on visual resources. Also, mitigation measures would be necessary for National Forest System lands designated as Low and public lands classified as VRM Class III to further reduce impacts on visual resources. Mitigation may also be necessary for lands with visual resources of lesser quality once site-specific analysis is conducted.

Utilization

The utilization phase involves final construction of infrastructure in order to use the geothermal resource. Infrastructure can include roads, sump pits, production-size wells, injection wells, well field equipment, power plant facilities, and transmission lines. For indirect use, utilization also involves additional production well development and the operation and maintenance activities at the geothermal site. The utilization phase could last from 10 to 30 years. For direct use, utilization can involve similar activities; however, the utilization phase typically lasts for several decades, if not longer. The infrastructure needed for direct use of the geothermal reservoir also includes piping to convey the high-temperature water.

As a result, the following alterations to visual resources would occur during the utilization phase:

- Visibility of activities involving construction work;
- Vegetation damage;
- Alteration of the natural landform or contours;
- Clearing of vegetation for additional production wells;
- Building new structures and roads;
- Scarring of the terrain from construction work;
- Fugitive dust from construction activities and newly exposed soils;
- Release of steam plumes;
- Conversion of undeveloped land to land with human-made structures; and
- Lighting during construction.

Furthermore, depending on the location, this phase of geothermal activity could alter a scenic vista or scenic roadway, fragment the open space of the landscape, or reduce the aesthetics of recreation or cultural areas. These potential impacts would be an advancement of the impacts that occurred during the drilling operations phase.

Stipulations involving NSO/NGD would be applied to public lands designated as VRM Class I and National Forest System lands designated as Very High in order to protect scenic resources. Activities that would not comply with NSO/NGD stipulations would not be allowed on those lands.

The impacts on visual resources on National Forest System lands and public lands would be greater than those described above under the drilling operations phase.

Reclamation and Abandonment

For indirect and direct use, reclamation and abandonment involves abandoning the well after production ceases and reclaiming all disturbed areas in conformance with BLM and FS standards. As a result, the following alterations to visual resources would occur during the reclamation and abandonment phase:

- Visibility of activities involving demolition work and removal of surface structures and equipment;
- Regrading disturbed areas to pre-disturbance contours;
- Fugitive dust from demolition activities and newly exposed soils; and
- Removing weeds and replanting native vegetation.

Furthermore, depending on the location, this phase of geothermal activity could also enhance a scenic vista, a scenic roadway, the landscape's open space, or the aesthetics of recreation or cultural areas to pre-geothermal project conditions. It could also restore these types of visual resources to pre-geothermal development conditions, assuming no other project developments or activities were initiated in the surrounding area during the lifespan of the geothermal project that further degraded the visual resources associated with scenic vistas, roadways, open space, or recreation or cultural areas.

Stipulations involving NSO/NGD would be applied to public lands designated as VRM Class I and National Forest System lands designated as Very High in order to protect scenic resources. Activities that would not comply with NSO/NGD stipulations would not be allowed on those lands. The level of disturbance to visual resources on public lands and National Forest System lands with other visual resource objectives would be commensurate with the objectives for visual resources.

It is assumed BLM and FS best management practices, standard operating procedures, and requirements for geothermal reclamation and abandonment would be implemented for all land designations to protect visual resources during reclamation and abandonment activities. This phase is expected to result in a more long-term, natural appearance to the landscape.

4.17.4 What are the Potential Impacts on Visual Resources Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. Older land use plans may fail to properly address potential geothermal resource development for direct or indirect use, thereby threatening visual resources from potential geothermal resource development activity that was not taken into consideration when the land use plan was originally prepared. Case-by-case evaluation could require additional NEPA documentation and possibly amendments to individual land use plans. The amendments to individual land use plans could be similar to or different from the alternatives analyzed in this PEIS, resulting in greater opportunities to degrade or protect visual resources, depending on local conditions.

Impacts under Alternative B

Under the proposed action, approximately 118 million acres of public land and 79 million acres of National Forest System lands would be open to geothermal leasing for direct or indirect use subject to existing laws, regulations, formal orders, and the terms and conditions of the standard lease form. The impacts under this alternative are the same as the impacts described above under Section 4.17.3.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. Relevant stipulations (Section 2.2.2) designed to protect the existing visual resources include (1) no surface occupancy for public lands designated as VRM Class I and NFS lands with a Scenery Management System integrity level of Very High; and (2) controlled surface use for sensitive viewsheds, including public lands with a VRM Class II, NFS lands with a Scenery Management System integrity level of High, or near National Historic Trails or residential areas. In addition, in accordance with the identified BMPs (Appendix D), BLM, FS, and operators would use site-design and other measures to achieve the appropriate VRM and Scenery Management System objectives. It is expected that these measures would effectively avoid or minimize impacts on visual resources by evaluating proposed surface disturbing activities for impacts on visual resources and incorporating appropriate visual resource design techniques to mitigate impacts.

Impacts under Alternative C

The impacts under this alternative are the same as the impacts described under Alternative B. However, the amount and degree of impacts on visual resources would be less under this alternative. Under Alternative C, the BLM and FS would only consider leasing lands for indirect use geothermal development within 10 miles from the centerline of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary. All lands within this buffer would be designated as open and closed to leasing for indirect use using the criteria outlined in Chapter 2.

Approximately 61 million acres of public land and 38 million acres of National Forest System lands would be open to leasing for indirect use. Compared to Alternative B, there would be fewer impacts, because less land would be available for geothermal leasing for indirect use. Due to the proximity of the land to transmission lines, it is assumed that the land has moderate to low scenic value or has other human-made structures and detractions that have altered the natural landscape. As a result, the degree of change to visual resources would be less under Alternative C, because the land being considered for potential geothermal resource development is assumed to already be altered to some extent. This would not be the case for Alternative B, because land with potentially higher scenic value due to its distance from existing infrastructure (i.e., transmission lines) would be considered for potential geothermal resource development (for both direct and indirect use).

Areas open to direct use geothermal lease applications and impacts from their subsequent development would be the same as identified under Alternative B.

4.18 SOCIOECONOMICS AND ENVIRONMENTAL JUSTICE

4.18.1 What did the Public Say about Impacts on Socioeconomics and Environmental Justice?

A number of comments relevant to socioeconomics and environmental justice were received.

The California Wilderness Coalition requested that the PEIS describe and discuss the costs associated with allowing and maintaining geothermal leases for each alternative.

The Idaho Conservation League and Utah Environmental Congress stated that the leasing plan needs to ensure that each geothermal power plant is cost effective and guarantee that the most kilowatts will be produced with the least amount of environmental impact. In addition, they requested that the PEIS examine direct and cumulative economic impacts for the RFD, including the economic costs of loss or degradation of public lands, wildlife habitats, quality of life, and infrastructure strains that accompany oil and gas development. They suggested that the BLM's Economic Profile System be used for this analysis.

Ormat, Inc. noted that the PEIS should recognize the numerous important long-term benefits of expanding geothermal energy, including creating new jobs, rural economic development, and income to state and local governments.

The Wilderness Society and Western Resource Advocates provided detailed recommendations for socioeconomic analysis. They suggested that the PEIS provide the following components in the analysis:

- Data and analysis that fully accounts for negative impacts from habitat fragmentation, loss of quality of life, and loss of quality recreation that geothermal development might have on tourism, recreation, hunting, and fishing; and
- An analysis of the income and jobs associated with recreation, hunting, and fishing for each alternative.

The organizations provided suggested references to guide the economic analysis of geothermal energy development.

In an extensive comment, the US Environmental Protection Agency directed the PEIS to evaluate minority and low-income populations in the project area and address the potential for disproportionate impacts on these populations. The letter also included detailed recommendations for facilitating public involvement with these populations. In addition, the EPA suggested that the procedure used for distributing royalties be outlined in the PEIS.

4.18.2 How Were the Potential Effects of Geothermal Development on Socioeconomics and Environmental Justice Evaluated?

Impacts were analyzed in terms of the predicted increase in megawatts of geothermal energy and the associated changes expected in employment, income, tax revenue, royalties, public infrastructure needs, and other socioeconomic factors. Quantitative estimates were provided, when available, based on the best available data. Where quantitative data were not available, professional judgment was used to describe impacts using qualitative terms.

In discussion of the RFD scenario, impacts are described for a standard 50-megawatt plant. Quantitative estimates are provided for selected economic indicators for the state and project area based on megawatt estimates.

When secondary impacts are discussed, an economic multiplier effect of 2.5 is applied, based on standard multiplier effects observed in the geothermal industry (US DOE 2006b). This means that one dollar of investment in a geothermal venture produces $2.50 in economic activity, or for every job created at a geothermal plant an additional 2.5 jobs are created. Only some of the secondary impacts would occur in the local community.

The degree of future geothermal development and the associated economic impacts are related to a number of uncertain economic factors. The existence of state- or federal-level renewable energy portfolios may increase the demand for renewable energy in the future. Section 1.8.3, Climate Change Policy, describes the current status of renewable energy standards. In addition, federal production tax credits may make renewable energy more cost competitive in the future. Current production tax credits provide a 1.9 cent tax credit for each kilowatt-hour of power produced by an eligible facility (or $19 per megawatt-hour), as adjusted annually for inflation. The current production tax credit is set to expire on December 31, 2008, but if extended it would likely increase the amount of geothermal development.

Potential impacts on socioeconomics and environmental justice could occur if reasonably foreseeable future actions were to result in the following:

- Impact other land uses that currently create revenue;
- Impact local industry that supports other land uses such as recreation and hunting;
- Impact the nonmarket values of open space;
- Affect expenditures or income within the study area associated with the project;
- Induce growth or population concentrations;
- Displace a proportion of available residences in a community;

- Create a demand for additional housing that could not be sustained within the project area;
- Cause a decrease in local or project area employment;
- Displace or disrupt businesses;
- Generate student enrollment that exceeds the school district's capability to accommodate students; or
- Have a disproportionately high and adverse impact on minority or low-income populations.

4.18.3 What are the Common Impacts on Socioeconomics and Environmental Justice Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on socioeconomics and environmental justice from geothermal resource development.

The Reasonable Foreseeable Development Scenario for Socioeconomics and Environmental Justice

According to the RFD scenario, it is estimated that 111 power plants could be constructed by 2015, and another 133 power plants could be constructed by 2025. The greatest development is expected to occur in California and Nevada, with the least occurring in Arizona, Colorado, Wyoming, and Montana. Each power plant is predicted to have 50 megawatts of production capacity by 2025. Based on these estimates, direct economic impacts of geothermal plants and secondary impacts of new plant development are described below for the different phases of geothermal development. Table 4-8 provides a summary of the effects of RFD geothermal electricity generation broken down by state.

The largest impact on socioeconomics from power plants would result from employment and income directly associated with geothermal electricity plant construction and operation. Estimates for these impacts are discussed for each phase below. Currently, the government and government enterprise; retail trade; health care and social assistance; and accommodation and food services sectors provide the largest source of jobs for most states in the project area (Bureau of Economic Analysis 2007). Geothermal power plants may impact employment and incomes in these and other sectors. Impacts are discussed for each phase of development below.

Geothermal power plants can also generate substantial property taxes for the local county. Property taxes are based on the estimated value of the company assets. At the rate generated in Imperial County, California, as described in Chapter 3, an additional 367 million dollars in property tax may be produced in the project area annually under the RFD scenario. Land values for private tracts

Table 4-8
Direct Economic Impacts of Geothermal Electricity Generation under the Reasonably Foreseeable Development Scenario

	California	Nevada	Idaho	Oregon	Utah	Washington	New Mexico	Alaska	Arizona	Colorado	Montana	Wyoming	Total
Estimated Geothermal Electrical Generation by 2025 (MW)	4,730	2,880	1,670	1,250	620	600	170	150	50	50	n/a	**0**	**12,170**
Total Construction Jobs (temporary jobs)[1]	14,663	8,928	5,177	3,875	1,922	1,860	527	465	155	155	n/a	0	**37,727**
Construction Income (million $)[2]	851.4	518.4	300.6	225.0	111.6	108.0	30.6	27.0	9.0	9.0	n/a	0	**2,190.6**
Operations and Maintenance Jobs (permanent full-time jobs)[3]	3,500	2,131	1,236	925	459	444	126	111	37	37	n/a	0	**9,006**
Operations and Maintenance Income (million $)[4]	302.7	184.3	106.9	80.0	39.7	38.4	10.9	9.6	3.2	3.2	n/a	0	**778.9**
Property Tax Estimate (annual, in million $)[5]	143.3	87.3	50.6	37.9	18.8	18.2	5.2	4.5	1.5	1.5	n/a	0	**368.9**
Federal royalty estimate (30-year total, in million $)[6]	1,513.6	912.6	534.4	400	198.4	192	54.4	48	16	16	n/a	0	**3894.4**

[1] Assuming an average of 3.1 total construction jobs/MW, as discussed in Hance 2005.
[2] Assuming a rate of $9 million for 50-MW plant, as discussed in BLM 2007.
[3]Assuming a rate of .74 permanent full-time jobs per MW, as discussed in Hance 2005.
[4] Assuming a rate of $3.2 million annually for a 50-MW plant, as discussed in BLM 2007.
[5] At rate generated in Imperial County (NRC 2007).
[6] With average electricity price of 6 cents/kWh and 95 percent capacity factor, following Kagel 2006.

of land bordering geothermal development areas could also change, based on the development potential and possible profitability exhibited on adjacent geothermal lands. Potential increased land values could in turn provide additional revenue for counties. Secondary jobs and expenditures in the community are also likely to increase sales tax, providing extra income for the state and county government.

Royalties are another revenue stream for governments. Over 30 years, a 50-megawatt power plant would contribute an estimated $16 million to federal, state, and local governments in the form of royalties (Table 4-8). This calculation is based on Geothermal Steam Act royalty collection rates, as described in Chapter 3, and assumes an average electricity price of 6 cents per kilowatt-hour and 95 percent capacity factor. Without adjusting for inflation, every year for the first ten years a 50-megawatt geothermal plant would contribute $218,453 to the state, $109,226 to the federal government, and $109,226 to the county government. From the eleventh year on, without adjusting for inflation, every year the plant would contribute $436,905 to the state, $218,452 to the federal government, and $218,452 to the county (Kagel 2006). It should be noted that royalties are set as a percent of revenue and would therefore be dependant on future electricity prices, which are difficult to predict. An additional source of revenues come from bonus bids paid to acquire leases and lease rental fees. These fees vary by location, but can constitute an important source of revenue for states and counties during the period prior to production.

For direct use, it is estimated that applications could be developed in the amount of 1,600 thermal megawatts by 2015 and 4,200 thermal megawatts by 2025. Using low-temperature geothermal resources (between 70°F and 300°F) may generate revenue and creates jobs for some states. For example, four commercial geothermal greenhouses in rural, southern New Mexico employed up to 400 people. In 2002, these projects generated nearly $23 million in sales and paid more than $6 million in payroll. A one-million-square-foot greenhouse in rural Utah employs between 80 and 120 people throughout the year (National Geothermal Collaborative 2007).

Direct use of geothermal energy can offset the cost of heating and cooling associated with electricity. On average, geothermal heat pumps use 25 to 50 percent less electricity than conventional heating or cooling systems (US DOE 2006b). At four elementary schools in Lincoln, Nebraska where geothermal heat pumps have been installed, the heating and cooling savings total about $144,000 yearly, with total energy cost savings of 57 percent (NREL 1998).

The specific economic impacts of direct use are more difficult to predict than the impacts of power plants, as they are highly variable. Estimates are not available for direct-use phases of development.

Exploration

The exploration phase includes surveying and drilling temperature gradient wells. Activities such as gradient well drilling and seismic surveys could provide temporary jobs for the local community near geothermal resources. Expenditures for fuel, lodging, food, and other needs would provide a stimulus to the local economy.

Other land uses would generally not be impacted during the exploration phase; therefore, no long-term economic impact on these uses would occur. No long-term increases in population or growth would occur in this phase, and demand for schools would not increase.

The impacts on socioeconomic or environmental justice in this phase are expected to be low throughout the project area.

Drilling Operations

Drilling operations can involve assembling infrastructure in order to use the geothermal resource. For indirect use, the infrastructure can include roads, production-size wells, injection wells, well field equipment, and fluid sump pits.

Geothermal resource drilling operations would impact socioeconomics. The level of impact would vary depending on the size and location of geothermal development.

Air quality, water quality, noise, cultural resource, geological resource, and hazardous material impacts potentially resulting from geothermal development could impact minority or low-income populations on private lands adjacent to leasing areas. These potential environmental justice impacts would be mitigated through best management practices applied to specific project leases. Areas open to potential geothermal leasing may include lands of tribal concern, or having traditional cultural resources or sacred sites. Intergovernmental coordination with affected tribes prior to specific leases should limit negative impacts on Native American populations. Tribal consultation is further discussed in Section 4.15, Tribal Interests and Traditionally Cultural Resources.

Utilization

The utilization phase involves finalizing construction of infrastructure in order to use the geothermal resource. For indirect use, the infrastructure can include additional roads, sump pits, production-size wells, well field equipment, power plants, electric transmission lines, and reclamation around wells. For direct use, the infrastructure can include piping to convey the high-temperature water.

Construction employment for installing access roads, pipelines, transmission lines, drill sites, and power plants would likely occur, though the amount would vary depending on the resource potential. The type of employment and number of available jobs would also vary as the construction proceeds. Construction employment is expressed in person-month or person-year units. One person-month corresponds to the employment of one person during one month. Similarly, one person-year corresponds to the employment of one person during one year. Construction of a new geothermal plant averages 17 to 33 months and requires 37.4 person-months per megawatt, or 3.1 person-years per megawatt of power capacity installed (Hance 2005a). Based on these numbers, construction of a typical 50-megawatt power plant and the associated transmission lines would require 1,870 person-months, or 155 person-years. The personnel involved in well and transmission line construction would be temporary. Due to the variation in jobs available at different stages in construction, average employment would vary at any one time. Based on the estimates for construction worker income as described in the Truckhaven Geothermal Leasing EIS (BLM 2007l), income for construction jobs is estimated to be $9 million for a 50-megawatt plant (Table 4-8). Based on project area megawatt predictions, an estimated 37,727 total construction jobs and $2,190.6 million in construction income may be added by geothermal development under the RFD scenario.

Expenditures for equipment, materials, fuel, lodging, food, and other needs would stimulate the local economy over the duration of development. Applying a standard economic multiplier, development of a 50-megawatt power plant is estimated to create an additional 387 jobs and $22.5 million in income. The level of these impacts would vary depending on the community; therefore, this is a general estimate only. Some of the secondary impacts would occur in the local communities in which geothermal development occurs, while others would occur at a regional or national level.

The cost of geothermal plant development would vary depending on size and location of plants. A review of costs for current plants determined that average capital costs for new geothermal plant development is $1,969 per kilowatt or $98 million for a 50-megawatt plant (Hance 2005b).

Some economic impacts may occur should income and employment associated with ranching, recreation, hunting, mining, or other land use activities be altered by geothermal development. Constructing geothermal facilities will alter the landscape and nonmarket values of the immediate area, however the extent of impact would vary with each project. In the short term, other land uses and income derived from these uses may be displaced by geothermal development. In the long term, many other land uses may be compatible with geothermal use due to the small footprint of geothermal plants; however the aesthetic value would be permanently altered.

Habitat fragmentation created from constructing geothermal roads and pipelines in areas that contain wilderness characteristics could impact recreation, hunting, and wildlife viewing associated with these areas. Due to the fragmentation of the recreation and tourism industry, it is difficult to measure the effects to local businesses and economies. However, studies have shown that recreation and tourism development contributes to rural well-being, increasing local employment, wage levels, and income, reducing poverty, and improving education and health (USDA 2005). Public and forest service lands are both primary destinations and places of transition to other recreational destinations on Federal, State, or private lands, affecting economies both inside and outside of the project area. Recreation can be a significant source of income for some rural communities, especially communities adjacent to public lands or NFS lands. Congressionally closed areas discussed in Section 1.5, Leasing and Development Process of Geothermal Resources on Federal Lands would generally be closed to geothermal leasing; therefore, impacts on pristine wilderness environments would be minimal. As stated above, geothermal construction could impact values of areas that may contain wilderness characteristics adjacent to these wilderness areas. In general, while the recreational setting may change due to development in some areas, other recreational opportunities would become available due to increased accessibility. Therefore, the overall impact on recreation-related economics should be minimal. Please refer to Sections 4.2 Land Use, Recreation, and Special Designations and 4.13, Livestock Grazing for a detailed discussion of the impacts of geothermal development on these land use activities. The level of local economic impact of geothermal development activities on other land uses would vary depending on the location, timing, and size of geothermal development; therefore, specific impacts on jobs or incomes in these industries cannot be determined for the RFD scenario.

Another possible impact would be to broaden the economic base of the communities within the region of influence of geothermal resource area. This impact is particularly relevant in rural communities where employment sectors have typically been limited and unemployment rates are high.

Construction activities may require the in-migration of workers for certain occupational categories, which in turn could affect rental housing markets and schools and could create the need for additional state and local government expenditures and employment. Construction could also impact local businesses by pulling workers away from local positions to work on the temporary buildout. The population growth and need for additional infrastructure in a community would depend on a number of factors related to specific geothermal development sites, including skill level of local workers, unemployment rate in the local area, and existing state of rental market and public infrastructure.

For indirect use, operations could last from 10 to 30 years. For direct use, operations can involve similar activities; however, the utilization phase typically lasts for several decades, if not longer. During operations, jobs would continue to be available, but the high levels of construction jobs seen during the initial period of this phase would be reduced.

Based on employment numbers in a 2005 survey of the geothermal industry, an average of .74 person-years per megawatt annually is required for geothermal power plant operation and maintenance (Hance 2005a). Using this ratio, a 50-megawatt geothermal plant would require approximately 37 person-years annually or 37 permanent, full-time jobs. Using Truckhaven EIS estimates, payroll for these employees is estimated at $3.2 million annually (BLM 2007l) (Table 4-8). Based on RFD scenario megawatt predictions, 9,006 jobs and $778.9 million in payroll income is anticipated for operations and maintenance activities in 2025.

As during initial construction during the utilization phase, expenditures for equipment, materials, fuel, lodging, food, and other needs would stimulate the local economy over the duration of plant operation. Applying a standard economic multiplier, operations during the utilization phase of a 50-megawatt power plant are estimated to create an additional 93 jobs and $8 million in income. The exact level of these impacts would vary depending on the community; therefore, this is a general estimate only. Some of the secondary impacts would occur in the local communities in which geothermal development occurs, while others would occur at the regional or national level.

The operation of power plants may require the in-migration of workers for certain occupational categories. The population growth and need for additional infrastructure in a community would depend on specific projects and communities, but impacts would generally be less than those seen during the initial construction of the drilling operations phase, where a greater number of workers would be required.

Cost of geothermal plant operation would vary depending on the size and location of plants. The Western Governors Association estimated an average operation and maintenance cost of 22 cents per megawatt-hour (Western Governors' Association 2006b).

The potential impacts on economic streams for other land uses are the same as discussed in the drilling operations phase, above.

As with the drilling operations phase, the waste management and disposal associated with operation and additional well development could impact minority or low-income populations on lands adjacent to geothermal development areas. These potential environmental justice effects would be mitigated through best management practices.

Reclamation and Abandonment

Reclamation and abandonment activities include abandoning the well after production ceases and reclaiming all disturbed areas. All disturbed lands would be reclaimed in accordance with BLM and FS standards. The closeout phase would likely involve additional construction jobs for reclaiming disturbed areas. As in other phases, expenditures for equipment, materials, fuel, lodging, food, and other needs would stimulate the local economy. Best management practices would be used to minimize dust, noise, and other disturbance adjacent to communities so that potential environmental justice effects would be avoided. Reclamation could increase the aesthetic value and bring back income to local industry that supports use of that land for recreation and other uses.

4.18.4 What are the Potential Impacts on Socioeconomics and Environmental Justice Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans.

The specific economic impacts of this alternative cannot be determined. Employment, tax income, and other economic factors would likely continue to reflect the trends discussed in Chapter 3.

Under this alternative, no comprehensive list of stipulations, best management practices, or procedures would be distributed to serve as consistent guidance for future geothermal leasing and development for direct and indirect use. This would result in fragmented and segregated planning for socioeconomics and environmental justice, which often exponentially increases impacts.

Impacts under Alternative B

Under the proposed action, approximately 118 million acres of public land and 79 million acres of NFS lands would be identified as open to geothermal leasing for direct and indirect use subject to existing laws, regulations, formal orders, and the terms and conditions of the standard lease form. The impacts under this alternative are the same as the impacts described above in Section 4.18.3, What are the Common Impacts Associated with Geothermal Development.

Under Alternative B, a comprehensive list of stipulations, best management practices, and procedures would be provided to serve as consistent guidance for future direct and indirect use geothermal leasing. By designating specific areas as open or closed to geothermal leasing for direct and indirect use, implementing major and minor constraints and other measures focusing on best management practices, negative impacts on socioeconomics or environmental justice would be minimized.

Impacts under Alternative C

Under Alternative C, geothermal leasing for indirect use would be open on 61 million acres of public land and 38 million acres of NFS land. All federal lands identified as open for indirect use geothermal leasing under this alternative are located within 10 miles of the centerline of existing transmission lines and at least 15 miles outside of the Yellowstone National Park boundary.

The specific economic impacts of anticipated future actions consistent with this alternative on indirect use development cannot be determined. The general impacts are the same as discussed under Alternative B; however, the amount and degree of the impacts would be less under this alternative. Restricting the placement of indirect use geothermal resource development to existing transmission line areas would likely minimize impacts on socioeconomics and environmental justice by concentrating energy development into designated areas. Due to the proximity of the land to existing transmission lines, the land being considered for potential geothermal resource development under Alternative C is assumed to already be altered to some extent and to be closer to existing communities. Geothermal development on these lands is less likely to impact other land uses. Areas open to direct use geothermal lease applications and impacts from their subsequent development would be the same as identified under Alternative B.

4.19 HEALTH AND SAFETY

4.19.1 What did the Public Say about Impacts on Health and Safety?

Comments were related to the inclusion of appropriate BMPs and the consideration of using a Health Impact Assessment if concerns about potential health impacts from individual projects are identified.

4.19.2 How Were the Potential Effects of Geothermal Development on Health and Safety Evaluated?

Methodology

Potential effects of geothermal development on human health and safety were evaluated by examining the typical hazards associated with the various stages of geothermal development.

Impact Criteria

Potential impacts on health and safety could occur if reasonably foreseeable future actions were to:

- Create a hazard to the public through the routine transport, use, or disposal of hazardous materials;
- Create a hazard to the public through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment;
- Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within 0.25 mile of an existing or proposed school; or
- Be located on a site that is included on a list of hazardous materials sites compiled by the federal or state government and, as a result, would create a hazard to the public.

4.19.3 What are the Common Impacts on Health and Safety Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on human health and safety from geothermal resource development.

Impacts on human health and safety from geothermal development projects could include:

- Exposure of individuals to drilling mud and geothermal fluid or steam during exploration and development drilling activities;

- Exposure of individuals to hydrogen sulfide contained in geothermal fluid or steam during exploration, development, and operation phases;
- Exposure of individuals to hazardous materials used and stored at facilities, such as petroleum, oil, lubricants, paints, solvents, and herbicides;
- Exposure of individuals to electrical fires or wildfires caused by project activities;
- Exposure of individuals to electric shock involved in maintenance of transmission lines and substations;
- Vehicular accidents due to increased traffic on local roads;
- A variety of potential accidents inherent in drilling operations, as listed in Section 3.19, Health and Safety; and
- A variety of potential accidents inherent to industrial facilities.

The Reasonable Foreseeable Development Scenario for Health and Safety

As stated in the RFD scenario, it is estimated that 111 power plants would be constructed across the 12-state project area by 2015, and a further 133 power plants could be constructed by 2025. The average capacity of these power plants is estimated to be 50 megawatts. For direct use, it is estimated that by 2015, applications could be developed in the amount of 1,600 thermal megawatts and by 2025, applications could be developed in the amount of 4,200 thermal megawatts. Each of these individual projects would introduce at least some of the aforementioned potential impacts on human health and safety.

Exploration

Potential health and safety impacts during the exploration phase would include those described above in Section 4.20.3 that are related to exposure of individuals to: 1) drilling mud during drilling activities; 2) hazardous materials used such as petroleum, oils, and lubricants; and 3) a variety of potential accidents inherent in drilling operations, as listed in Section 3.20, Health and Safety. Potential health and safety impacts would last for the duration of exploration activities, which is estimated to be between one and five years for an individual project.

Drilling Operations

Potential health and safety impacts during the drilling operations phase would include those described above in Section 4.20.3 that are related to exposure of individuals to: 1) drilling mud and geothermal fluid or steam during drilling activities; 2) hydrogen sulfide contained in geothermal fluid or steam; 3) hazardous materials used such as petroleum, oils, and lubricants; 4) wildfires caused by project activities; 5) vehicular accidents due to increased traffic on local roads; and 6) a variety of potential accidents inherent in drilling operations, as listed in Section 3.20, Health and Safety. Potential health and safety impacts during the drilling operations phase would range from two to ten years for an individual project. Additional potential impacts could arise from construction activities that were not present during exploration such as exposure to paints, solvents, herbicides, electrical fires, and other hazards typical of construction activities.

Utilization

Potential health and safety impacts during the utilization phase would include those described above in Section 4.20.3 that are related to exposure of individuals to: 1) geothermal fluid or steam during system failures, maintenance activities, or well blowouts; 2) hydrogen sulfide contained in geothermal steam emissions; 3) hazardous materials used such as petroleum, oils, lubricants, paints, solvents, and herbicides; 4) electrical fires and wildfires caused by project activities; 5) electric shock involved in maintenance of transmission lines and substations; and 6) vehicular accidents due to increased traffic on local roads. Potential health and safety impacts would last for the duration of operational activities, which is estimated to be between 10 and 30 years for an individual project.

Reclamation and Abandonment

Potential health and safety impacts during the reclamation and abandonment phase would include those described above in Section 4. 20.3 that are related to exposure of individuals to: 1) heat and hydrogen sulfide from geothermal fluid or steam during well capping; 2) hazardous materials used during dismantling of structures and reclamation of site such as petroleum, oils, and lubricants; 3) electrical fires or wildfires; 4) vehicular accidents; and 5) a variety of potential accidents inherent to demolition activities.

4.19.4 What are the Potential Impacts on Health and Safety Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. Impacts would be site specific and similar to the impacts under the four phases of geothermal development identified under Section 4.20.3.

Impacts under Alternative B

There would be no impact on human health and safety from implementation of Alternative B; however, impacts resulting from anticipated future actions consistent with implementing Alternative B would be greater than such impacts under Alternative A. Alternative B would be expected to provide greater opportunities for large-scale and long-term improvements in air quality-related health indicators than Alternative A.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. In accordance with BMPs (Appendix D), operators would be required to implement actions that would protect public health and safety. For example, operators would be required to minimize air quality impacts, develop hazardous material management plans, develop waste management plans, establish safety zones, and develop fire management strategies. It is expected that these measures would effectively minimize impacts to health and safety from geothermal related actions.

Impacts under Alternative C

There would be no impact on human health and safety from implementation of Alternative C; however, impacts resulting from anticipated future actions consistent with implementing Alternative C would be greater than under Alternative A but less than under Alternative B, since fewer individual projects would likely be developed than under Alternative B. While Alternative C would allow greater opportunity than Alternative A for states within the project area to improve air quality regionally and therefore improve air quality-related health indicators, Alternative C would be inferior to Alternative B in this regard.

4.20 NOISE

4.20.1 What did the Public Say about Impacts on Noise?

No comments relating to noise were received during scoping.

4.20.2 How Were the Potential Effects of Geothermal Development on Noise Evaluated?

Methodology

Potential effects of geothermal development on noise were evaluated by examining the typical noise generation at the various stages of geothermal projects and the existing regulations and public health and safety guidance regarding noise exposure.

Regulations

Local city and county noise ordinances vary from site to site. As long as geothermal projects operate in compliance with the applicable regulations, they are not considered a noise nuisance in surrounding residential communities. All power facilities must meet local noise ordinances according to the phase of construction and operation.

Once geothermal operation sites are established, a further examination of state-specific laws and regulations would be required to ensure compliance with all noise pollution regulations.

Impact Criteria

Potential impacts on noise could occur if reasonably foreseeable future actions were to:

- Generate new sources of substantial noise;
- Increase the intensity or duration of noise levels to sensitive receptors; or
- Result in exposure of more people to high noise levels.

4.20.3 What are the Common Impacts on Noise Associated with Geothermal Development?

Due to the inability to predict future development scenarios, including types of development, timing, and location, the following impact analysis provides a general description of common impacts on air quality from geothermal resource development. Common noise impacts associated with each phase of development are described below.

The Reasonable Foreseeable Development Scenario for Noise

Noise pollution from geothermal power plants is typically considered during exploration, drilling operations, and utilization phases (Geothermal Energy

Association 2007a), with less emphasis on reclamation and abandonment. Direct use applications, due to the typically fewer wells and lack of electrical transformers, are considered to be less noise-generating, with most noise occurring during exploration and development.

Exploration

Noise generated during exploration is temporary in nature and is related to surveying and well drilling. Some temporary construction-related noise from access road and well-pad construction is also likely. The well drilling, stimulation, and testing phases of exploration produce noise levels ranging from about 80 to 115 decibels A-weighted at the site fence boundary. Exploration-related noise generation can last from one to five years (Massachusetts Institute of Technology 2006).

Drilling Operations

Noise generated during drilling operations would be similar to that under exploration, although longer durations of the noise related to the well drilling, simulation, and testing phase would be expected. In addition, construction of injection wells and sump pits would increase local noise in the short term.

Utilization

Construction of the direct use facility or power plant would generate noise for an estimated two to ten years.

Normal operations of a geothermal power plant typically generate noise levels in the 71 to 83 decibel range at a distance of one-half mile. Noise levels can be further reduced by the addition of mufflers or other soundproofing. Individual noise-generating components of operation include the transformer, the power house, and the cooling tower. Cooling towers are relatively tall and have noise-generating fans at the top, making them frequently the main source of noise during operation (Massachusetts Institute of Technology 2006).

Direct use applications do not have the noise-generating components of transformers, power houses, or cooling towers. Noise sources are generally limited to fluids moving through pipes and any pumping facilities associated with extraction and injection of geothermal fluids.

Reclamation and Abandonment

Noise associated with reclamation and abandonment activities would be limited to noises typical of any construction site, as facilities are dismantled and removed and the site is reclaimed.

4.20.4 What are the Potential Impacts on Noise Associated with the Proposed Action and Alternatives?

The following discussion analyzes the environmental consequences or impacts expected to occur as a result of anticipated future actions consistent with implementing the alternatives described in Chapter 2.

Impacts under Alternative A

Under the no action alternative, lease applications would continue to be processed on a case-by-case basis. Areas closed to geothermal leasing by statute, regulation, or orders would remain closed, and discretionary closed areas would be assessed based on local land use plans. Direct use and indirect use geothermal projects can be expected to continue to come online and generate noise at the existing pace of development.

Impacts under Alternative B

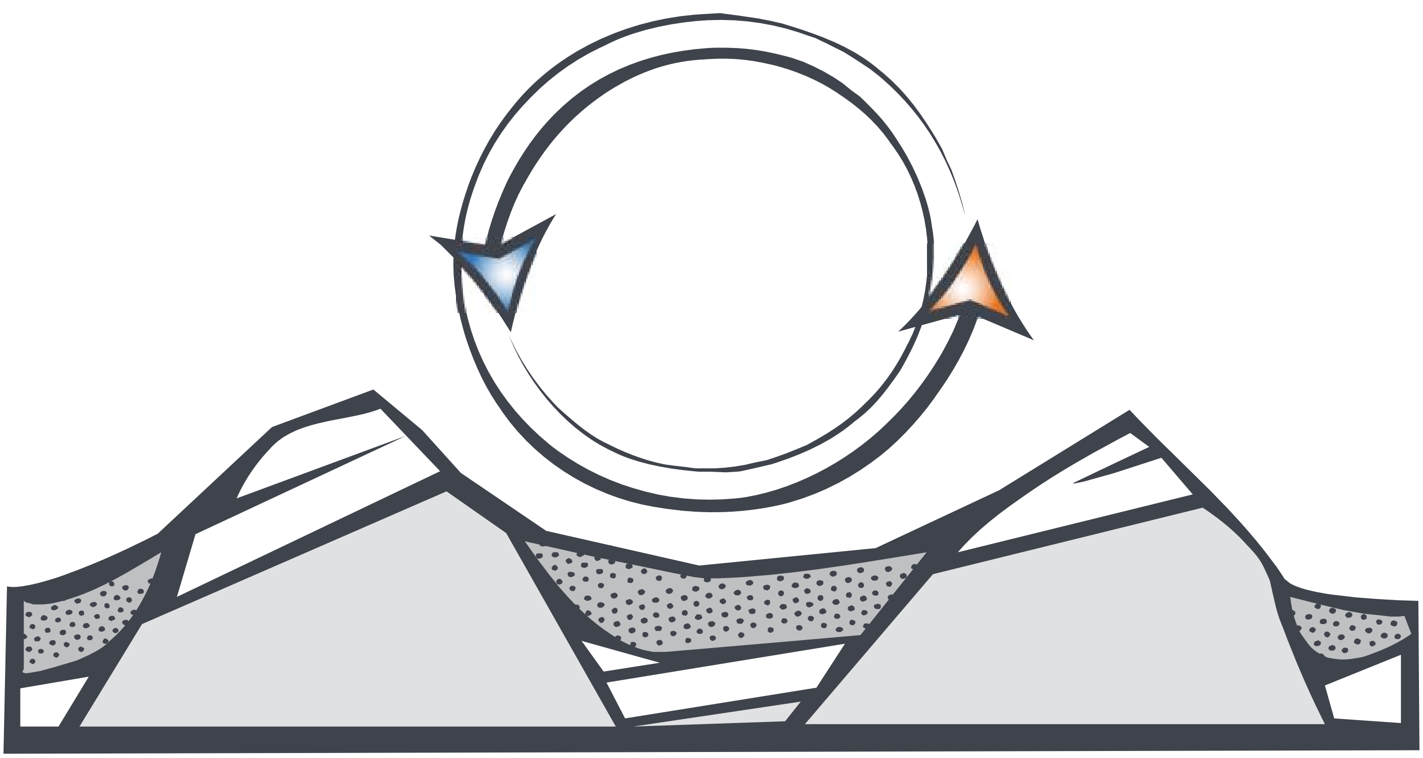
Impacts resulting from anticipated future actions consistent with implementing Alternative B would be greater than such impacts under Alternative A. Widespread geothermal leasing and development for direct and indirect use across the planning area would introduce many new noise sources; however, sensitive receptors such as schools, hospitals, and churches are typically not located on public lands, making it unlikely that such sensitive receptors would be exposed to noise resulting from geothermal development. Operations would have minimal noise impacts in most areas on federal lands; however, areas with minimal noise sources (i.e., remote areas) would experience a greater change in the noise characteristics. Projects would be required to meet state-specific regulations, reducing any impacts on off-lease area sensitive receptors or residential areas. Impacts on onsite workers would be minimal through the use of required hearing protection in noise-intensive operations.

Under this alternative, the BLM and FS would issue a comprehensive list of stipulations, best management practices, and procedures to serve as consistent guidance for future geothermal leasing for direct and indirect use. In accordance with BMPs (Appendix D), operators would be required to implement actions that would minimize impacts associated with noise. For example, operators would be required to take measurements to assess the existing background noise levels at a given site and compare them with anticipated noise levels. Operators would adequately muffle and maintain construction equipment and would notify nearby residents in advance of blasting or other noisy activities. It is expected that these measures would effectively minimize impacts on noise from geothermal related activities.

Impacts under Alternative C

Impacts resulting from anticipated future actions consistent with implementing Alternative C would be greater than such impacts under Alternative A, but less than such impacts under Alternative B since smaller land areas would be available for development and less development for indirect use would be likely to occur.

Areas open to direct use geothermal lease applications and impacts from their subsequent development would be the same as identified under Alternative B.



Chapter 5

Cumulative Impacts and Other Considerations

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CHAPTER 5
CUMULATIVE IMPACTS AND OTHER CONSIDERATIONS

5.1 INTRODUCTION

The analysis presented in this chapter, as required by Council on Environmental Quality regulations (40 CFR 1500-1508), addresses the potential cumulative impacts associated with Alternatives B (Proposed Action) and C (Leasing On Lands near Transmission Lines). Impacts associated with allocating public and NFS lands as open or closed to geothermal leasing and amending land use plans are placed into a broader context that takes into account the full range of impacts from reasonably foreseeable future actions in the 12-state project area. The Council on Environmental Quality regulations state that the cumulative impact analysis should include the anticipated impacts to the environment resulting from "the incremental impact of [an] action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or nonfederal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over time" (40 CFR 1508.7).

Sections 5.2.2 through 5.2.5 describe the methodology, regions of interest, time frame, and reasonably foreseeable future actions for the cumulative impact assessment. Section 5.3 describes the types of actions and trends occurring on all (federal and nonfederal) lands in the project area. The cumulative impact analyses for each resource and resource use is presented in Section 5.4. Analysis on other type of impacts is provided in Section 5.5, unavoidable impacts; Section 5.6, short-term uses and long-term productivity; and Section 5.7, irreversible and irretrievable commitment of resources.

5.2 WHAT IS THE PROCESS OF ASSESSING CUMULATIVE IMPACTS?

The cumulative impact analysis in the following sections builds upon the analyses of the direct and indirect impacts of anticipated future actions to be taken consistent with Alternatives B and C. These analyses are presented in Chapter

4. In addition to those incremental impacts of anticipated future actions to be taken consistent with Alternatives B and C, the cumulative impact analysis considers other past, present, and reasonably foreseeable future actions' impacts on natural resources, ecosystems, and human communities in the 12-state project area.

5.2.1 What is the Methodology?

The cumulative effects analysis focuses on the natural resources, ecosystems, and human communities that could be affected by the impacts from Alternatives B and C (allocating public and NFS lands as open or closed to geothermal leasing and amending land use plans), in combination with other past, present, and reasonably foreseeable future actions, regardless of who undertakes them.

The Council on Environmental Quality discusses the assessment of cumulative effects in detail in its report, "Considering Cumulative Effects under the National Environmental Policy Act" (Council on Environmental Quality 1997). Because the allocation of lands as open or closed and the decision to lease do not have any direct impacts (see discussion at Section 4.1.1, Methods of Impact Analysis), the cumulative analysis focuses primarily on the cumulative impacts associated with the development of geothermal resources. That is, this analysis considers future actions anticipated to be taken consistent with the Proposed Action and the alternatives analyzed in this PEIS because it is more informative for the decision-making process. Based on the CEQ's report and this approach to informing the decision-making process, the following methodology was developed for assessing cumulative impacts:

1. The geographic scope (i.e., regions of influence) is defined for the analysis. The regions of influence encompass the areas of affected resources and the distances at which impacts associated with anticipated future actions to be taken consistent with Alternatives B and C may occur. The regions of influence are discussed in Section 5.2.3.
2. The time frame for the analysis is defined. The temporal aspect of the cumulative impacts analysis generally extends from the past history of impacts on each resource through the anticipated life of the project (and beyond, for resources having more long-term impacts). The time frame of the actions to be evaluated in the cumulative analysis is presented in Section 5.2.4.
3. Past, present, and reasonably foreseeable future actions are identified. These include projects, activities, or trends that could impact human and environmental resources within the defined regions of influence during the defined time frame. Past and present actions are generally accounted for in the analysis of direct and indirect impacts for each resource and are carried forward to the cumulative impacts analysis. Foreseeable future actions are described by type in Section 5.3.

4. The baseline conditions of resources are characterized. Baseline characteristics are described in the affected environment sections for each resource in Chapter 3.
5. Direct and indirect impacts on resources from anticipated future actions that may be taken consistent with the respective alternatives are characterized at a level appropriate for a programmatic analysis such as presented in this PEIS. Direct impacts are caused by anticipated future actions to be taken consistent with implementing an alternative, and they occur at the same time and place as those actions. Indirect impacts are caused by anticipated future actions to be taken consistent with the alternative but occur later in time or farther in distance from those actions and are still reasonably foreseeable. These impacts are detailed in the environmental consequences sections of Chapter 4 for each resource.
6. The potential impacting factors of each past, present, or reasonably foreseeable future action or activity are determined. Impacting factors are the mechanisms by which an action affects a given resource. Anticipated future actions to be taken consistent with both Alternatives B and C could also generate factors that could impact resources; these individual contributions form the basis of the cumulative impacts analysis.
7. The cumulative impact assessment focuses on past, current, and reasonably foreseeable future actions, including commercial uses, regardless of who undertakes them and regardless of where they are located in the 12-state project area. In other words, the assessment considers other uses on all lands in the 12-state project area regardless of land ownership. The descriptions of the other reasonably foreseeable future actions considered (Section 5.2.4) address all lands and, as such, the data include public and NFS lands. The data do not specifically break out public and NFS lands.
8. Cumulative impacts on resources are evaluated by considering the impacting factors for each resource and the incremental contribution of anticipated future actions to be taken consistent with implementing Alternatives B and C to the cumulative impact. The analysis for each resource is presented in Section 5.4.

In cases where the contributions of individual actions to an impacting factor were uncertain or not well known, a qualitative evaluation of cumulative impacts was necessary. A qualitative evaluation covers the locations of actions, the times they would occur, the degrees to which the impacted resource is at risk, and the potential for long-term and/or synergistic effects.

5.2.2 What are the Regions of Influence?

To determine which other actions should be included in a cumulative impacts analysis, the regions of influence must first be defined. These regions should not be limited to only the geographic areas of resources addressed by Alternatives B and C, but they should also take into account the distances that cumulative impacts may travel and the regional characteristics of the affected resources.

Because this PEIS addresses allocating public and NFS lands as open and closed to geothermal leasing and amending land use plans at a programmatic level, the region of influence for each resource evaluated by the cumulative impacts analysis is, unless otherwise noted, the 12-state project area. Of all the geothermal uses, commercial electrical generation would have the greatest impacts (see Chapter 4). In general, most commercial electrical generation in the near term would occur in northern Nevada, northeastern and southern California, Oregon, Idaho, and along the Cascade mountain range.

5.2.3 What is the Time Frame of the Action Alternatives?

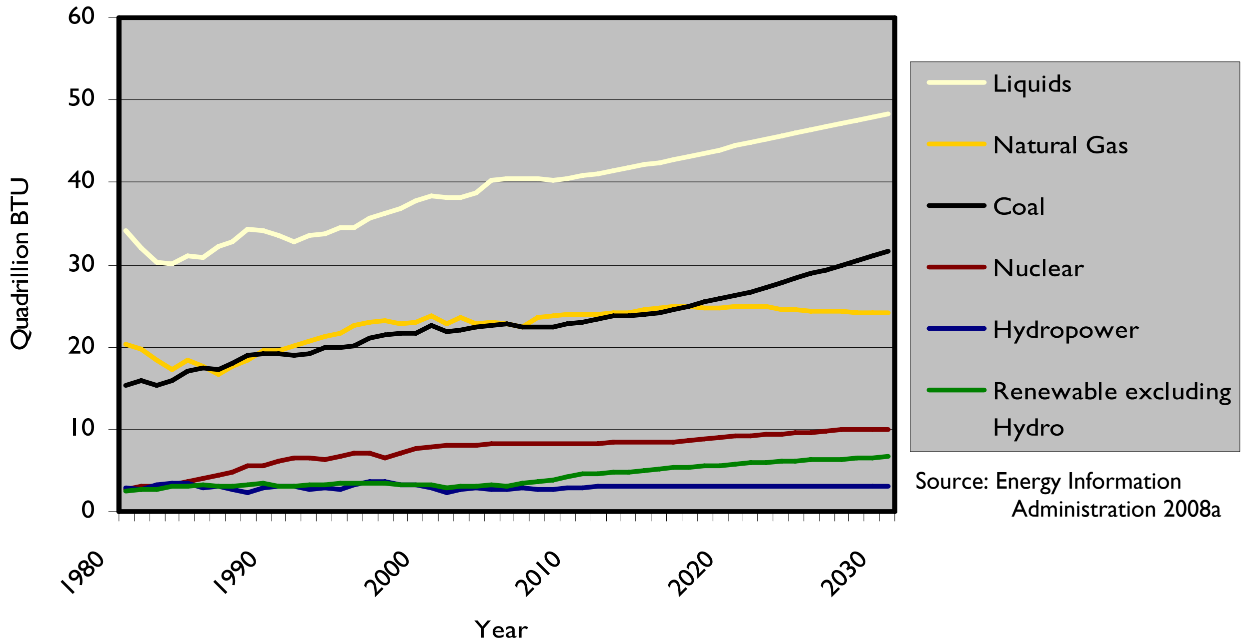
The time frame of the cumulative impact analysis incorporates the sum of the effects of anticipated future actions consistent with the implementation of Alternatives B and C in combination with other past, present, and future actions, because impacts may accumulate or develop over time. The future actions described in this analysis are those that are "reasonably foreseeable;" that is, they are ongoing (and will continue into the future), are funded for future implementation, or are included in firm near-term plans. The reasonably foreseeable time frame for future actions evaluated in this cumulative analysis is 20 years from the allocation of lands available for geothermal leasing and completion of land use plan amendments. While it is difficult to project reasonably foreseeable future actions (or trends) beyond a 20-year time frame, it is acknowledged that the effects identified in the cumulative impacts analysis will likely continue beyond the 20-year horizon.

5.2.4 What are the Reasonably Foreseeable Future Actions?

Reasonably foreseeable future actions include projects, activities, or trends that could impact human and environmental receptors within the defined regions of influence (Section 5.2.3) and within the defined time frame (Section 5.2.4). The reasonably foreseeable future actions in this section consider other uses on all lands in the 12-state project area regardless of land ownership. The data include public and NFS lands and do not specifically break out public and NFS lands.

Trends in energy supply and demand are affected by many factors that are difficult to predict, such as energy prices, US and worldwide economic growth, advances in technologies, and future public policy decision both in the US and in other countries (Energy Information Administration 2007b). Figure 5-1 depicts US energy consumption by fuel type from 1980 through present, and predicts future energy consumption trends through 2030.

Figure 5-1
US Energy Consumption by Fuel Type from 1980 – 2030
(Quadrillion Btu)



Source: Energy Information Administration 2008a

5.3 WHAT ARE THE TYPES OF MAJOR ACTIONS?

The following section provides a description of the types of major actions and trends occurring on federal and nonfederal lands in the project area.

5.3.1 Oil and Gas Exploration, Development, and Production

Oil and gas provides 62 percent of the nation's energy and almost 100 percent of its transportation fuels (BLM 2005c). The majority (over 60 percent) of oil and gas consumed in the US is imported.

Natural Gas

The US consumes approximately 21.6 billion cubic feet of natural gas annually, accounting for 22 percent of the nation's total energy consumption (Energy Information Administration 2008f). Of total US consumption, approximately 19 percent is imported (Energy Information Administration 2008f). Table 5-1 shows natural gas production in the project area between 2001 and 2006. During this period, gas production increased in half of the ten project area states with such production, and it decreased in the other half. This resulted in an overall increase in project area gas production by almost seven percent. This is higher than the US average, which decreased by about four percent during the same six-year period. Gas production increased significantly in Colorado (47.1 percent), Montana (39.4 percent), and Wyoming (29.2 percent) (Energy Information Administration 2008c).

Table 5-1
Annual Natural Gas Production in the Project Area, 2001–2006 (million cubic feet)

	Gas Production (mmcf)[1]						
State	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Percent Change**
US Total	**24,500,779**	**23,941,279**	**24,118,978**	**23,969,678**	**23,456,822**	**23,507,471**	**-4.1%**
Alaska	3,427,779	3,477,438	3,578,305	3,644,084	3,642,948	3,205,751	-6.5%
Arizona	307	301	443	331	233	611	99.0%
California	414,838	397,021	368,440	348,827	352,044	349,137	-15.8%
Colorado	825,378	945,659	1,021,294	1,089,622	1,143,985	1,214,396	47.1%
Idaho	0	0	0	0	0	0	0.0%
Montana	81,802	86,424	86,431	97,838	108,555	114,037	39.4%
Nevada	7	6	6	5	5	5	-28.6%
New Mexico	1,712,390	1,655,906	1,616,179	1,644,738	1,656,850	1,619,528	-5.4%
Oregon	1,112	837	731	467	454	621	-44.2%
Utah	301,422	293,063	284,359	290,586	311,994	356,038	18.1%
Washington	0	0	0	0	0	0	0.0%
Wyoming	1,634,987	1,747,476	1,836,115	1,929,040	2,003,826	2,111,766	29.2%
Project Area Total	**8,400,022**	**8,604,131**	**8,792,303**	**9,045,538**	**9,220,894**	**8,971,890**	**6.8%**

[1] MMCF = million cubic feet
Source: Energy Information Administration 2008b

Crude Oil

The US consumes almost 20.7 million barrels (707 million gallons) of crude oil per day, accounting for 40 percent of the nation's total energy consumption, the largest share of any fuel type (US Government Printing Office 2008, Energy Information Administration 2008f). Of the total US consumption, almost 60 percent is imported (Energy Information Administration 2008f). In 2006, the 12 western states that make up the project area accounted for approximately 37 percent of the crude oil supply produced in the US. Table 5-2 shows crude oil production in the project area between 2001 and 2006. During this period, crude oil production decreased in six of the nine project area states with such production, resulting in an overall decrease of oil production for the project area by almost 13 percent. This is slightly greater than the US average, which decreased by about 12 percent during the same six-year period. Oil production increased significantly in Colorado (41.6 percent), Montana (127.8 percent), and Utah (17.4 percent) (Energy Information Administration 2008c).

Table 5- 2
Annual Crude Oil Production in the Project Area, 2001–2006 (in thousand barrels)

	Oil Production (bbl)[1]						
State	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Percent Change**
US Total	2,117,511	2,097,124	2,073,453	1,983,302	1,890,106	1,862,259	-12.1%
Alaska	351,411	359,335	355,582	332,465	315,420	270,486	-23.0%
Arizona	59	63	47	52	50	55	-6.8%
California	260,663	258,010	250,000	240,206	230,294	223,449	-14.3%
Colorado	16,520	17,734	21,109	22,097	22,823	23,390	41.6%
Idaho	0	0	0	0	0	0	0.0%
Montana	15,920	16,855	19,320	24,724	32,855	36,262	127.8%
Nevada	572	553	493	463	447	426	-25.5%
New Mexico	68,001	67,041	66,130	64,236	60,660	59,818	-12.0%
Oregon	0	0	0	0	0	0	0.0%
Utah	15,252	13,676	13,096	14,629	16,651	17,910	17.4%
Washington	0	0	0	0	0	0	0.0%
Wyoming	57,433	54,717	52,407	51,619	51,626	52,904	-7.9%
Project Area Total	**785,831**	**787,984**	**778,184**	**750,491**	**730,826**	**684,700**	**-12.9%**

[1] (bbl) = Barrel: A unit of volume equal to 42 US gallons
Source: Energy Information Administration 2008c

Factors associated with oil and gas exploration that can produce impacts may include:

- Exploratory drilling;
- Construction of well pads;
- Well installation;
- Spills/releases;
- Pipeline and utility corridors;
- Access roads and helipads;
- Compressor stations; and
- Site reclamation and rehabilitation.

Factors associated with oil and gas production that can produce impacts may include:

- Production and processing plants;
- Refineries;

- Carrier pipelines;
- Spills/releases;
- Power plants; and
- Access roads.

Oil Shale

Oil shale is a sedimentary rock that releases petroleum-like liquid when heated. The mining and processing of oil shale is more complex and expensive than conventional oil recovery; however, increasing oil prices and advances in technology are making it a more feasible energy option (US DOE and BLM 2007). Over 50 percent of the world's oil shale resource estimate is from the US (BLM 2005c). The Green River Formation, a geologic unit that underlies portions of Colorado, Utah, and Wyoming in the project area, contains the largest oil shale deposits with an estimated 1.5 trillion barrels of oil (BLM 2005c). The federal government owns approximately 72 percent of the US acreage containing oil shale deposits (BLM 2005c). The BLM is currently preparing a PEIS analyzing the amendment of land use plans in Colorado, Utah, and Wyoming, to allow BLM to consider applications to lease oil shale and tar sands for development (BLM 2007m). Factors associated with oil shale mining and processing that can produce impacts may include:

- Surface mines;
- Underground mines;
- In situ retorting;
- Processing plants (rock crushing and retorting);
- Refineries;
- Solid waste (overburden, waste rock, spent shale, and tailings); and
- Site reclamation and rehabilitation.

In September 2008, the BLM published a Final PEIS for a commercial leasing program for oil shale and tar sands resources on public lands, with an emphasis on the most geologically prospective lands in Colorado, Utah, and Wyoming. The proposed land use plan amendments analyzed as the preferred alternative in the PEIS would make 1,991,222 acres of lands containing oil shale resources available for application for commercial leasing (Bureau of Land Management 2008k).

Tar Sand Deposits

Tar sand deposits comprise another oil-yielding resource under western federal land, primarily in eastern Utah. These deposits are a combination of clay, sand, water, and bitumen that can be mined and processed to produce oil (US DOE and BLM 2007). Deposits could yield 40 to 76 billion barrels of oil (BLM 2005c).

The BLM is currently preparing an PEIS analyzing the amendment of land use plans in Colorado, Utah, and Wyoming, to allow BLM to consider applications to lease oil shale and tar sands for development (BLM 2007m). Factors associated with tar sands mining and processing that can produce impacts may include:

- Surface mines;
- Underground mines;
- In situ recovery (e.g., steam injection);
- Extraction plants;
- Solid waste (overburden, waste sand, spend sand, tailings);
- Refineries; and
- Site reclamation and rehabilitation.

In September 2008, the BLM published a Final PEIS for a commercial leasing program for oil shale and tar sands resources on public lands, with an emphasis on the most geologically prospective lands in Colorado, Utah, and Wyoming. The proposed land use plan amendments analyzed as the preferred alternative in the PEIS would make 431,224 acres of lands containing tar sands resources available for application for commercial leasing (Bureau of Land Management 2008k).

5.3.2 Coal and Other Mineral Exploration, Development, and Production (Extraction)

Factors associated with coal and other mineral exploration and development that can produce impacts may include exploratory drilling and trenching and access road and helipad construction. Factors associated with coal and other mineral production (extraction) that can produce impacts may include:

- Surface mines;
- Underground mines;
- Access roads;
- Processing (beneficiation) plants;
- Transportation (e.g., railroads);
- Solid waste (overburden, waste rock, and tailings); and
- Site reclamation and rehabilitation.

Leasable Minerals, Including Coal

Leasable minerals include oil and gas; oil shale; geothermal resources; coal; potash; phosphate; sodium; native asphalt; gilsonite; sulfur in New Mexico; gold, silver, and quicksilver in certain private land claims; and silica deposits in certain parts of Nevada (BLM 2006c). They are leased on public lands under the Mineral Leasing Act of 1920. Leases to these resources on public lands are obtained through a competitive bidding process.

Coal

The US produces approximately 1.2 million short tons and consumes approximately 1.1 million short tons of coal annually, accounting for almost 23 percent of the nation's total energy consumption (Energy Information Administration 2008f). Wyoming is the largest coal-producing state. In the US, coal is used almost exclusively to generate electricity, and coal plants account for over 53 percent of all US electricity generation (BLM 2005c). Table 5-3 shows coal production in the project area in 2000 and 2006. During this period, coal production decreased in five of the eight project area states that produce coal. However, this was offset by substantial increases in Colorado (almost 25 percent) and Wyoming (almost 32 percent), resulting in an overall increase in coal production in the project area by almost 23 percent. This is four-fold greater than the US average, which increased by about eight percent during that same six-year period (Energy Information Administration 2008d, 2008e).

Table 5-3
Coal Production in the Project Area, 2000–2006 (million short tons)

State	**2000**	**2006**	**Percent Change**
US Total	**1,073.6**	**1,162.8**	**8.31%**
Alaska	1.6	1.4	-12.50%
Arizona	13.1	8.2	-37.40%
California	0	0	0.00%
Colorado	29.1	36.3	24.74%
Idaho	0	0	0.00%
Montana	38.4	41.8	8.85%
Nevada	0	0	0.00%
New Mexico	27.3	25.9	-5.13%
Oregon	0	0	0.00%
Utah	26.7	26.1	-2.25%
Washington	4.3	2.6	-39.53%
Wyoming	338.9	446.7	31.81%
Project Area Total	**479**	**589**	**22.86%**

Source: Energy Information Administration 2008d, 2008e

In the project area, there are seven states containing coal leases on public or NFS lands (Alaska, Colorado, Montana, New Mexico, Utah, Washington, and Wyoming). In these seven states, there are 269 coal leases covering 429,976 acres on public or NFS lands (BLM 2005c). Total short tons of coal produced from these lands totals 10.2 quadrillion Btus (BLM 2005c).

Locatable Minerals

The BLM administers mineral estate on almost 700 million acres of lands in the US, including its own lands, as well as other lands, such as NFS lands. Economic production of mineral resources on these lands includes locatable, leasable, and salable solid minerals.

Locatable minerals can be obtained by filing a mining claim and include both metallic minerals (e.g., gold, silver, lead) and nonmetallic minerals (e.g., fluorspar, asbestos, mica, gemstones). They are defined under the General Mining Law of 1872. Locatable minerals are those that are neither leasable minerals nor saleable mineral materials. Hardrock (locatable) minerals include, but are not limited to, copper, lead, zinc, magnesium, nickel, tungsten, gold, silver, bentonite, barite, feldspar, fluorspar, and uranium (BLM 2006c). In 2007, there were 341,012 active mining claims on file with the BLM, with the highest number (197,843) in Nevada (BLM 2006c). This represents a 70-percent increase from 2006 and a 50-percent increase from 2001 (US DOE and BLM 2007).

Saleable Mineral Materials

Saleable mineral materials include common varieties of sand, gravel, stone, pumice, pumicite, cinders, and ordinary clay. Use of salable minerals on public lands requires either a sales contract or a free use permit. The BLM may issue free use permits to a government agency or a nonprofit organization. The Forest Service administers the disposal of salable minerals from NFS lands.

5.3.3 Renewable Energy Development

Renewable energy resources are naturally replenished in a relatively short period of time and include geothermal energy, hydropower, solar energy, wind energy, and biomass. Renewable energy is used for electricity generation, heat in industrial processes, heating and cooling buildings, and transportation fuels. In 1850, about 90 percent of energy consumed in the US was from renewable energy resources. Now the US is heavily reliant on nonrenewable fossil fuels: coal, natural gas, and oil. In 2006, almost seven percent of all energy consumed, and about nine percent of total electricity production, was from renewable energy sources. In 2004, electricity generation accounted for about 70 percent of total renewable energy consumption. Industrial process heat and building space heating accounted for 25 percent of renewable energy use, and the remainder was used as vehicle fuels (Energy Information Administration 2008g, 2008i).

Geothermal Energy

Chapter 1 describes geothermal energy generation and use.

Hydroelectric Power

Hydropower is the largest renewable energy source used by the electric power sector. In 2006, the US consumed 2.9 quadrillion Btu of conventional hydroelectric power, approximately 42 percent of all renewable energy consumption (US Government Printing Office 2008). It is used almost exclusively to generate commercial electricity. Factors associated with hydropower energy development that can produce impacts may include dams and diversion structures and generating stations.

Solar

Solar energy can be converted into other forms of energy, such as heat and electricity. In 2004, about one percent of all renewable energy consumed in the US was from solar energy sources (Energy Information Administration 2008i). In 2004, over 90 percent of solar energy was consumed by the residential sector (Energy Information Administration 2008g). Factors associated with solar energy development that can produce impacts may include vegetation clearing, fencing around the solar collecting facilities, construction activity, access roads, and transmission lines.

The BLM is preparing a PEIS for solar energy development on BLM-administered lands in six western states (Arizona, California, Colorado, New Mexico, Nevada, and Utah). Similar to the geothermal PEIS, the solar energy PEIS supports the amendment of land use plans to designate lands that are available for solar development and lands that would be excluded from such development, and to adopt a comprehensive list of best management practices and procedures to serve as consistent guidance for future solar energy development. The solar PEIS will provide an RFD scenario to define the potential for future utility-scale solar energy development activities over a 20-year study period. The RFD scenario will include an estimate of the acres of disturbance associated with the likely development.

The Energy Information Administration estimates that solar electrical generation in the United States, not including off-grid photovoltaics, will increase from 0.05 gigawatts (GW) of capacity in 2008 to 0.30 GW of capacity by 2025 (Energy Information Administration 2008a). Assuming a land area requirement of 10 acres per MW for photovoltaics, this increase in capacity would cover a land area of 2,500 acres. The expansion of renewable energy projects in the US has been rapidly increasing in 2008, and it is therefore expected that the estimates given above are greatly understated. For example, in August 2008, the Pacific Gas and Electric Company in California agreed to purchase power from a new photovoltaic power project covering 8,000 acres and generating 800 MW (0.8 gigawatts) of capacity. This single project is greater than the Energy Information Administration's projected 2025 power generation capacity. With the recent rapid expansion of investment and interest in renewable energy, it is difficult to project what acreage will be devoted to solar development over the coming years.

Wind

Wind energy is mainly used to generate electricity. In 2004, just over two percent of all renewable energy consumed in the US was from wind energy sources (Energy Information Administration 2008i). In 2004, all wind energy was consumed by the electric power sector (Energy Information Administration 2008g). Factors associated with wind energy development that can produce impacts may include:

- Vegetation clearing and excavation;
- Construction of meteorological towers;
- Construction and operation of turbine towers;
- Access roads;
- Electrical substations and transformer pads; and
- Ancillary facilities (e.g., control building and sanitary facilities).

In 2005, the BLM published a PEIS supporting the establishment of a Wind Energy Development Program to support wind energy development on BLM-administered lands and to minimize potential environmental and sociocultural impacts associated with that development. The PEIS addressed 1) an assessment of wind energy development potential on BLM-administered lands through 2025 (a 20-year period); 2) policies regarding the processing of wind energy development right-of-way (ROW) authorization applications; 3) best management practices (BMPs) for mitigating the potential impacts of wind energy development on BLM-administered lands; and 4) amendments of specific BLM land use plans to address wind energy development. The wind PEIS covered BLM-administered lands in the 11 western states (the same project area as the geothermal PEIS, except for Alaska) and identified an estimated 160,100 acres of land that are economically developable (Bureau of Land Management 2005a).

Biomass

Biomass is organic material made from plants and animals and contains stored energy from the sun. Examples of biomass fuels are wood, crops, manure, and some garbage. When burned, the chemical energy in biomass is released as heat. In 2004, approximately 46 percent of all renewable energy consumed in the US was from biomass/waste energy sources (Energy Information Administration 2008i). In 2004, biomass/waste energy was consumed by several sectors, including electric power, industrial (electric and nonelectric), commercial, residential, and transportation (Energy Information Administration 2008g). Factors associated with biomass energy development that can produce impacts may include harvesting, access roads, transmission lines, and air pollution.

5.3.4 Nuclear Electric Power

A nuclear power plant operates by producing heat by fissioning or splitting uranium atoms. That heat boils water to make steam that turns a turbine-generator. Nuclear power accounts for approximately eight percent of the nation's total energy consumption (Energy Information Administration 2008f) and about 19 percent of the total electricity generated in the US (Energy Information Administration 2008j).

5.3.5 Transmission and Distribution Systems

Rights-of-way for electric, oil, and gas transmission, as well as roads, telephone/telegraph lines, water pipelines, and communication sites, cross multiple federal and nonfederal lands in the project area. Federal agencies authorized to grant rights-of-way for electric, oil, and gas transmission include the BLM, FS, National Park Service (electric only), USFWS, US Bureau of Reclamation, and US Bureau of Indian Affairs. About 90 percent of the oil and gas pipeline and electricity transmission rights-of-way in the western states cross federal lands, the majority of which are managed by the BLM or FS (National Energy Policy Development Group 2001). The demand for additional energy and electricity is projected to increase the number of rights-of-way across public and NFS lands in the years to come (National Energy Policy Development Group 2001). Factors associated with utility corridors that can produce impacts may include:

- Carrier pipelines;
- Oil and gas pipelines;
- Fuel transfer stations;
- Spills/releases;
- Transmission lines;
- Substations; and
- Access roads.

In 2007, the BLM and the Department of Energy released a Draft PEIS analyzing the designation of energy corridors on Federal land in the 11 western states (the same western states as examined in this geothermal PEIS, except for Alaska). The proposed corridors have a total surface area of about 2.9 million acres, and approximately 61 percent (3,713 miles) of the total miles (6,055 miles) of proposed corridors follow or incorporate existing transportation or utility ROWs (US DOE and BLM 2007).

5.3.6 Transportation

Transportation systems in the project area are extensive and include interstate and US highway system roads, county roads, bridges, tunnels, Indian reservation roads, defense access roads, federal lands roads, and public authority-owned roads serving federal lands. Railways also transport commodities such as coal. Factors associated with transportation facilities development that can produce impacts may include:

- Highways, roads, and parkways;
- Railroads (coal transport); and
- Hazardous material releases.

5.3.7 Major Uses of Federal and Nonfederal Land

Major uses of federal and nonfederal land that can include factors that may produce impacts include:

- Forest land;
- Grassland pasture and rangeland;
- Cropland;
- Special uses (parks and wildlife areas);
- Other uses (including commercial); and
- Urban land.

As shown in Table 5-4, the major uses of federal and nonfederal land in the US in 2002 were forest-use land, grassland pasture and rangeland, cropland, special uses (parks and wildlife areas), miscellaneous other uses, and urban land. Much of the land (32 percent) in the 12-state project area is used as grassland pasture and rangeland, followed by forest-use land (26 percent) and special uses (almost 21 percent) (USDA, Economic Research Service 2008).

Table 5-4
Major Land Uses by State in 2002 (in 1,000 acres)

State	Crop land[1]	Grassland pasture and range[2]	Forest-use land[3]	Special uses[4]	Urban	Other land[5]	Total land in 12-state project area[6]
Alaska	90	1,295	90,475	143,262	167	130,760	366,049
Arizona	1,235	40,533	17,608	11,373	1,080	897	72,726
California	10,655	21,729	33,780	21,558	5,095	6,997	99,814
Colorado	12,044	28,158	18,925	6,022	814	417	66,380
Idaho	6,408	20,984	16,824	6,175	263	2,305	52,958
Montana	18,118	46,361	19,184	6,863	168	2,458	93,153
Nevada	884	46,448	8,636	6,882	367	7,088	70,289
New Mexico	2,671	51,676	14,978	6,449	484	1,410	77,668
Oregon	5,311	23,239	27,169	3,946	662	1,112	61,438
Utah	2,044	24,339	14,905	4,958	444	5,882	52,572
Washington	7,983	7,369	17,347	6,839	1,367	1,682	42,588
Wyoming	2,860	44,323	5,739	6,416	109	2,697	62,144
Total	70,303	356,454	285,570	230,743	11,003	163,705	1,117,779
Percentage of Total Project Area	**6.29%**	**31.89%**	**25.55%**	**20.64%**	**0.98%**	**14.65%**	

Source: USDA, Economic Research Service 2008

[1] Total acreage in the crop rotation.

[2] Grassland and other nonforested pasture and range in farms excluding cropland used only for pasture, plus estimates of open or nonforested grazing land not in farms.

[3] Excludes an estimated 98 million forest acres in parks and other special uses of land.

[4] Transportation, recreation, and other special uses of land.

[5] Areas in miscellaneous uses not inventoried, and marshes, open swamps, bare rock areas, desert, tundra, and other land generally of low value for agricultural purposes.

[6] Approximate land area established by the Bureau of the Census in conjunction with the 2000 *Census of Population and Housing*.

5.3.8 Grazing and Rangeland Management

As shown in Table 5-5, grazing land is comprised of grassland pasture and rangeland, cropland, and forest land-grazed. In 2002, grazing land comprised about 43 percent of the 12-state project area's land (USDA, Economic Research Service 2008). Cropland pasture is the smallest, but generally the most productive, component of grazing acreage, accounting for less than one percent of the project area. New Mexico, Wyoming, and Nevada have the greatest percentage of grazing land. Factors associated with livestock grazing that can produce impacts may include resource conservation (during nonuse periods) and rangeland improvements (e.g., water pipelines, reservoirs, and fences).

Table 5-5
Grazing Land by State in 2002 (in 1,000 acres)

State	Cropland Pasture	Grassland and other pasture and range	Forest land grazed	Total Grazing Land	Percent of Total Land Area
Alaska	9	1,295	147	1451	0.40%
Arizona	214	40,533	11,709	52456	72.13%
California	1,345	21,729	12,070	35144	35.21%
Colorado	1,835	28,158	10,516	40509	61.03%
Idaho	770	20,984	4,432	26186	49.45%
Montana	1,726	46,361	6,620	54707	58.73%
Nevada	314	46,448	6,887	53649	76.33%
New Mexico	837	51,676	9,482	61995	79.82%
Oregon	1,003	23,239	11,558	35800	58.27%
Utah	602	24,339	9,596	34537	65.69%
Washington	499	7,369	3,879	11747	27.58%
Wyoming	913	44,323	3,543	48779	78.49%
Total	**10,067**	**356,454**	**90,439**	**456,960**	**43.29%**

Source: USDA, Economic Research Service 2008

5.3.9 Fire Management and Timber Production

Prescribed burns are used for fire management on federal and nonfederal lands in the project area. Factors associated with fire management that can produce impacts may include access roads and air pollution.

Forest lands are managed for commercial timber production and ecological stewardship. About 33 of the US is comprised of forest land (749 million acres); of this, about one-third (246 million acres) is owned by the federal government (US DOE and BLM 2007). As shown in Table 5-6, as of 2002, about 48 percent (358 million acres) of US forest land was located in the 12-state project area. About 27 percent (137 million acres) of US timber land was located in the project area, of which about 81 million acres are federally owned (USDA, Economic Research Service 2008).

Table 5-6
Forest Land by Major Class by State in 2002 (in 1,000 acres)

	Timberland			Reserved timber-land and other forest land[1]	Total forest land		
State	**Federal**	**Non-Federal**	**Total**		**Federal**	**Non-Federal**	**Total**
Alaska	4,750	7,114	11,865	115,004	63,423	63,446	126,869
Arizona	2,438	1,089	3,527	15,901	10,192	9,235	19,427
California	10,130	7,651	17,781	22,451	22,371	17,862	40,233
Colorado	8,020	3,587	11,607	10,030	15,075	6,562	21,637
Idaho	12,596	4,227	16,824	4,823	17,129	4,517	21,646
Montana	12,506	6,679	19,184	4,108	16,512	6,781	23,293
Nevada	265	99	363	9,841	9,608	596	10,204
New Mexico	2,829	1,530	4,359	12,323	9,522	7,159	16,682
Oregon	14,194	9,637	23,831	5,819	17,741	11,910	29,651
Utah	3,586	1,097	4,683	10,994	11,913	3,764	15,676
Washington	6,104	11,244	17,347	4,443	9,422	12,369	21,790
Wyoming	4,093	1,647	5,739	5,256	8,832	2,163	10,995
Project Area Subtotal	81,511	55,601	137,110	220,993	211,740	146,364	358,103
US	**109,717**	**393,823**	**503,540**	**245,388**	**246,425**	**502,497**	**748,922**

Source: USDA, Economic Research Service 2008

[1] Includes forest land in parks, wildlife areas, and other special uses.

Major timber products include roundwood, lumber (softwood and hardwood), plywood, turpentine, rosin, pulpwood, and paperboard. Factors associated with commercial timber production that can produce impacts may include timber and vegetation harvesting and access roads.

5.3.10 Recreation

In addition to recreation visits to public and NFS lands, the public also recreated on lands managed by the National Park Service, USFWS, state wildlife agencies, state parks, and other federal, state, and local agencies. Factors associated with recreation that can produce impacts may include:

- Visiting scenic and historic places;
- Cross-country and downhill skiing;
- Hunting and fishing;
- All-terrain vehicle use;
- Camping, hiking, and picnicking;

- Viewing wildlife; and
- Scenic driving.

5.3.11 Remediation

The US EPA includes on its National Priorities List the national priorities among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the US. These sites may present a significant risk to public health and/or the environment. The National Priorities List is intended primarily to guide the US EPA in determining which sites warrant further investigation. There are 235 National Priorities List sites in the project area, with an additional 15 proposed sites. These include sites in each project area state, as follows: Alaska (five); Arizona (eight with one additional site proposed); California (94, with an additional 2 proposed); Colorado (17 with an additional three proposed); Idaho (six with an additional three proposed); Montana (14 with an additional one proposed); Nevada (one); New Mexico (13 with an additional one proposed); Oregon (12); Utah (15 with an additional four proposed); Washington (48); and Wyoming (two) (US EPA 2008e). Abandoned mine lands and hazardous material sites are the main features in the planning area associated with remediation activities that can produce impacts.

5.3.12 Population Trends

As discussed in Section 3.18, Socioeconomics, the West is the fastest growing region in the US. Between 1990 and 2006, the project area's population grew at an average rate of 1.8 percent. The largest population growth occurred in Nevada with a 4.7-percent increase, while the lowest growth occurred in Montana, with a 0.7-percent increase. Relatively high growth rates in the remaining states were estimated for Arizona (3.3 percent), Utah (2.7 percent), Idaho (2.6 percent), and Colorado (2.4 percent). Close-to-average growth occurred in New Mexico (1.8 percent), Oregon (1.8 percent), and Washington (1.7 percent), with lower-than-average growth rates in the remaining states. Factors associated with population trends that can produce impacts may include:

- Agricultural, residential, and commercial property development adjacent to federal lands;
- Urbanization; and
- Resource use (e.g., water).

5.4 WHAT ARE THE CUMULATIVE IMPACTS?

Neither allocating lands open or closed to geothermal leasing nor amending land use plans, as identified under Alternatives B (Proposed Action) and C, would contribute to cumulative impacts on resources or resources uses in the project area. Likewise, issuing leases itself does not cause direct impacts (see discussion in Section 4.1.1). Issuing geothermal resource leases is, however, a conditional commitment of the resource for future exploration and utilization. Therefore, an analysis of these anticipated future actions (leasing and development) consistent with implementation of the alternatives discussed in Chapter 2 is provided to assess the incremental contribution of both the proposed actions (land use plan amendment and issuing of leases) as well as other anticipated future actions associated with development of geothermal resources, when added to impacts from past, present, and reasonably foreseeable future actions throughout the project area.

While the number, variety, and magnitude of actions on public and NFS lands considered in this analysis are great, information about how many future projects may actually be undertaken is lacking, and information about the likely locations of future development is unknown. As such, the cumulative effects discussed in this section are general in nature. The resource discussions below are intended, as is appropriate in a programmatic approach, to put potential future geothermal development into context with impacts of known ongoing and planned activities, and to highlight issues that will be considered in future, site-specific NEPA actions. Unless otherwise noted, the magnitude of difference in cumulative impacts between Alternatives B and C is negligible.

5.4.1 Land Use, Recreation, and Special Designations

The contribution to cumulative impacts of geothermal projects on public and NFS lands would be small or negligible unless a significant permanent, uncompensated loss of the current productive use of a site occurred, or if other future uses were precluded. Geothermal leasing and development requires a relatively small footprint and the land required is not completely occupied by the plant. As a point of reference, based on the upper range of the RFD for geothermal electrical generation, up to 89,548 acres could be disturbed for development compared to the 17 million areas of public land that have other commercial uses (this does not include NFS lands or livestock grazing or mining activities) (BLM 2005c).

Given the small footprint, geothermal development (direct and indirect uses) is generally compatible with many other land uses, including livestock grazing; some forms of recreation; wildlife habitat conservation; and oil, gas, and wind generation. The small number of workers at a geothermal power plant (e.g., about 155 people/year during the peak construction period for a 50 MW plant, and about 20 workers during operations) would not likely add to cumulative impacts on land use or land disturbance that are occurring or have occurred from ongoing and past activities.

While geothermal is compatible with some other land uses and not all geothermal development would occur on Federal lands, it is undeniable that any power generation facility constructed where none previously existed would alter local visual and aural (auditory/sound) conditions (i.e., recreation setting), and thereby affect the recreation experience. However, given the relatively small area needed to develop geothermal operations, impacts on the recreation setting and experienced by recreation users would be minimal.

As outlined in Alternatives B and C, geothermal leasing would not be allowed for many specially designated areas, including wilderness (see Chapter 2). Some areas, such as ACECs could allow geothermal leasing. These areas have been determined to have special resource values that are compatible with controlled mineral development; hence most of these areas are also open to other fluid mineral activities. Stipulations, conditions of approval, and BMPs would minimize any impacts in these areas. Management of special designation areas is governed by site-specific management direction to protect the special resource values. This gives local authorized officers the information and discretion on how to manage leases to minimize local and cumulative impacts. Cumulative impacts would be expected in areas of high mixed mineral development (e.g., oil/gas and geothermal development); however, the collocation of these mineral sources is rare.

5.4.2 Geological Resources and Seismic Setting

Cumulative impacts on geologic resources or seismic characteristics from geothermal exploration, drilling and development are expected to be minor. Alternatives B and C include many BMPs to mitigate impacts from future drilling and earthmoving activities. Any impacts from development that might occur would be minimal and largely limited to the project site. The construction of new access roads, improvements to existing roads and bridges, and installation of wells and facilities would involve cut and fill operations. If large amounts of fill material would be necessary, increased demands on off-site supplies of sand, gravel, and crushed rock could occur. If multiple construction projects were developed within a single area, local supplies of required fill material, particularly gravel or crushed rock, could be reduced to the point of impacting the needs of roadways and other construction projects. Local changes in topography could be caused by construction of roads, well pads, pipelines, and the power plants. Cumulatively, up to 89,548 acres of land could be disturbed by geothermal development in the planning area for the next 30 years. Seismic events related to geothermal reservoir injection could cumulatively contribute to seismic events triggered by oil and gas production.

5.4.3 Energy and Minerals

An increase in development of geothermal resources would have a cumulative impact of contributing to the domestic energy supplies of the United States and of possibly reducing the demand for nonrenewable energy, such as oil, gas, and coal. According to the RFD, there is the potential to triple the megawatts produced with geothermal resources. Geothermal development could cumulatively result in competition for water rights and energy developments at the local and regional level.

5.4.4 Paleontological Resources

Disturbances from geothermal drilling and utilization, combined with other surface-disturbing development activities, could uncover or destroy paleontological resources. However, the proposed stipulations and BMPs addressing cultural resources and the proposed exclusion of many NLCS lands would limit the potential impacts. Likewise, monitoring by a qualified paleontologist would also be a site-specific requirement in areas where any excavation would occur in formations of moderate to high resource potential and would reduce any cumulative impacts.

5.4.5 Soils

Geothermal energy exploration, development, and utilization would have a minor cumulative impact on soil compaction and erosion when combined with other development projects and land uses such as livestock grazing across the Planning Area.

In total, up to 89,548 acres of land could be disturbed by geothermal development within the 12 western states over the next 30 years. Stipulations that limit siting projects in steeply sloped areas and BMPs that address stormwater runoff and fugitive dust would limit erosion-related impacts.

5.4.6 Water Resources

Drilling, well testing, construction, and geothermal production would require the consumption of water. Any additional consumption of water would have a cumulative impact when joined with other water use projects, such as agriculture, municipal wells, other energy projects, and water transfers. The actual consumption of water by energy facilities can be somewhat mitigated through water efficiency and reuse measures. There is a potential for energy facilities to concentrate in areas abundant with the particular energy resource, be it oil, gas, solar, or geothermal. In such areas, there is a greater potential to contribute to cumulative depletion of water resources. Groundwater depletion is not one of the issues addressed in the proposed lease stipulations, except indirectly through the requirement for compliance with applicable laws and regulations. The state engineer is responsible for assigning water rights and managing groundwater resources. Any added use of groundwater in areas where demand for water is nearing the available sustainable supply would contribute to cumulative impacts on groundwater. Use of closed system geothermal facilities (e.g., binary plant) with air cooling, as opposed to water cooling, would minimize any depletion as no water is directly consumed during operation.

5.4.7 Air Quality and Atmospheric Values

While geothermal energy generates minimal emissions compared to fossil fuels, the exploration, development, and operation of this renewable resource would be responsible for minor amounts of air pollutants. Most of the emissions associated with geothermal development would be during exploration, drilling, and construction activities and include particulate material (dust) and emissions from vehicles and equipment. When combined with other projects near geothermal developments, there would be a minor localized increase in emissions; however, over the long-term and across the Planning Area, geothermal electrical generation may have a beneficial cumulative impact on air quality and atmospheric values by offsetting the need for energy production that results in higher levels of emissions, such as coal, oil, and natural gas.

5.4.8 Vegetation

There would be a minor cumulative impact on vegetation from geothermal development. As a result of exploration, drilling, and utilization disturbance (including roads, transmission lines, and pipelines), there is the potential for nonnative and invasive species to colonize and dominate sites. For example, cheatgrass is a concern in much of the areas that have a high potential for geothermal development, especially in the Great Basin. The facilitation of seed dispersal could result from construction equipment transporting invasive species from the construction areas to adjacent lands along access roads and main roads. Soil compaction from machinery, vehicles, and laydown areas can limit the ability of plants to re-establish in these areas if reclamation is not conducted appropriately. In addition, exploratory drilling or uncontrolled releases, spills, seepages, or well blowouts could result in the addition of toxic, mineralized, or saline geothermal waters to the soil, streams, ponds, or wetlands. This contamination could adversely impact vegetation growth and distribution, particularly for sensitive riparian and wetland vegetation. There could be the long-term conversion of habitat types, such as from sagebrush to grassland. Many of these impacts would be minor on a site-by-site basis, but if geothermal development is consolidated with other developments that have similar effects, the cumulative impact could affect the functioning of local ecosystems.

5.4.9 Fish and Wildlife

The potential cumulative effects on vegetation would impact native fish and wildlife as habitats are fragmented, degraded, or destroyed from development. Industrial activities such as geothermal development can substantially modify or eliminate habitat within and near the development footprint, although not all species are harmed by conversion of land to more intensive uses. While the footprints of geothermal developments are relatively small, if geothermal development is consolidated with other developments that have similar effects (e.g., oil wells, wind farms, solar installations, etc.), there would be a cumulative effect via habitat fragmentation. The creation of new access roads, pipelines and transmission lines would also contribute to fragmentation and serve as a vector for invasive species. Conditions of approval and BMPs are applied at the permitting phases of geothermal development to minimize these impacts; however, fragmentation is unavoidable.

5.4.10 Threatened and Endangered Species and Special Status Species

Loss of habitat is also an important factor contributing to the increase in the number of species listed as threatened or endangered in recent years. Stipulations and permitting requirements including appropriate compliance with Section 7 of the ESA, would minimize the risk of directly taking listed species, but there could be a cumulative effect from removal of small patches of habitat that can add up to a notable acreage. Sage grouse is one special status species that could be negatively affected by extensive development due to the potential cumulative loss of habitat. Stipulations and permitting requirements would minimize this impact, but because much of the higher temperature resources are located in the Great Basin, there is likely to be some loss to sagebrush habitat.

5.4.11 Wild Horses and Burros

Cumulative impacts on wild horses and burros would occur when geothermal development projects occur along with other projects in Herd Management Areas and when both types of projects result in loss of vegetation, water supplies, Herd Management Area capacity, and the disruption of wild horses and burros practices. Geothermal developments tend to congregate in areas where there is a viable geothermal resource present. Should such conditions be discovered within Herd Management Areas, wild horses and burros could be displaced. This cumulative effect would only be realized where there is a high potential for geothermal development and there are larger populations of wild horses and burros, such as in northern Nevada.

5.4.12 Livestock Grazing

Cumulative impacts on livestock grazing would occur from the loss of forage for grazing, loss of AUM capacity, and the disruption of livestock grazing practices where geothermal development and other projects overlay grazing allotments. Geothermal developments would remove some forage, and could lower the AUM capacity in areas with livestock operations.

5.4.13 Cultural Resources

Disturbances from geothermal drilling and utilization, combined with other surface-disturbing development activities, could uncover or destroy cultural resources. However, the proposed stipulations and BMPs addressing cultural resources and the proposed exclusion of many NLCS lands would limit the potential impacts.

5.4.14 Historic and Scenic Trails

Historic and scenic trails on Federal lands are generally managed as a special designation. The proposed closure of trails to leasing and the inclusion of additional stipulations for leases near historic or scenic trails would reduce impacts on the setting of the trail system. Geothermal developments that are visible from trail sections would result in cumulative impacts when combined with other projects being developed across the Planning Area that are also visible from portions of the trail system.

5.4.15 Visual Resources

Development of geothermal resources could result in cumulative impacts on visual resources across the Planning Area when combined with other projects. The heights, type, and color of drilling equipment and power plants, together with their placement with respect to local topography (i.e., on valley floor or open basin), are factors that would contribute to determining the extent of visual intrusion on the landscape. Also, the development of transmission lines to connect new electrical production facilities to the regional power grid could contribute to cumulative impacts. Flexibility in locating power plants and other large structures to avoid cumulative impacts on important (e.g., VRM Class I or II) viewsheds should be considered during the permitting process.

5.4.16 Socioeconomic and Environmental Justice

Geothermal development projects could cumulatively contribute to beneficial socioeconomic effects across the Planning Area when combined with other projects that are also creating jobs and generating tax and royalty revenues for local, state, and Federal government.

Geothermal development projects could cumulatively contribute to adverse environmental justice effects when sited along with other industrial projects in close proximity to low-income or minority populations. Noise and air emissions (from flow testing, well venting, and blowouts) from geothermal facilities could result in health effects on nearby residents.

5.4.17 Noise

Geothermal projects are typically developed at remote locations that are away from other noise sources, where noise generated by power generation, substations, transmission lines, and maintenance activities generally approach typical background levels for rural areas at distances of 2,000 ft (600 m) or less. Therefore, the sphere of noise impact is limited in scope and would not be expected to combine with other projects and result in cumulative impacts on local residents.

5.4.18 Health and Safety

The combination of hazardous materials and other health and safety risks associated with the development and operation of geothermal energy facilities in conjunction with similar health and safety concerns for other reasonably foreseeable projects across the Planning Area is expected to be negligible. All projects would have to comply with state and federal requirements pertaining to worker safety and the use, storage, transport, and disposal of debris and hazardous materials and wastes,- thereby minimizing cumulative impacts. The potential for hazardous waste spills (fuel, drilling muds, etc.) would be minimized through the application of BMPs included in lease terms and would not be at a large enough scale to cumulatively affect human health and safety either at the local level when combined with other local projects, or across the Planning Area when combined with all other projects with similar individual effects.

5.5 What Unavoidable Adverse Impacts might be Caused by Designating Lands for Geothermal Leasing Potential and Amending Land Use Plans?

Designating lands for geothermal leasing potential, amending land use plans, and issuing leases would not result in any unavoidable adverse impacts. Subsequent development and operation of geothermal facilities could have such impacts. These impacts would be assessed during the permitting process and on a site-specific basis. If geothermal leases were developed, the following general adverse impacts would be expected:

- Long-term loss of vegetation, habitat, soil, and soil quality. The BMPs and stipulations in the PEIS would reduce some of these effects.
- Short-term and intermittent noise impacts from construction and maintenance activities. Operations would have minimal noise impacts.
- Possible loss of some recreational opportunities from energy infrastructure, although new roads could provide access for additional recreational opportunities.
- Long-term visual impact from power plants and infrastructure.
- Short-term impact on groundwater during drilling and before well casing, if drilling promotes a pathway between separate (e.g., deep and shallow) aquifers.

5.6 The Relationship Between Local Short-Term Uses of the Environment and Long-Term Productivity

This section discusses the relationship within each action alternative (Alternatives B and C) between the anticipated short-term use of the environment and the maintenance and enhancement of long-term productivity. For this PEIS, short term refers to the steps needed to develop a geothermal resource (exploration, drilling, testing, and construction). Generally it is during this time that the most extensive environmental impacts would occur. Long term refers primarily to the 20-30 year time frame considered within this PEIS. This time frame includes the production and utilization phase of a geothermal project.

The exploration and testing phase of a geothermal project is designed to determine the nature and extent of the geothermal resources. Generally, the active portion of this phase is of short duration (less than two years). Where such exploration proves unsuccessful, these lands would not be used for subsequent development and production. Instead, these lands would be restored as much as possible to their original condition upon completion of exploration and testing activities.

If geothermal activities progress beyond the exploration and testing phase into long-term productivity, the lands could be affected to a greater extent. This would depend on the degree of development (i.e., surface disturbance) and the geothermal resource potential. The short-term uses of the environment associated with anticipated future actions (i.e. exploration, drilling, land clearing, plant construction, etc.) consistent with implementation of the action alternatives are described in Chapter 2 (under Section 2.5.1 for indirect use and Section 2.5.2 for direct use) include effects on the natural environment, cultural resources, recreation, and socioeconomic resources. These short-term effects can be compared to the long-term benefits associated with the proposed action, such as clean, renewable energy production for a growing regional population and economy.

Over the long-term, while geothermal plants are in production, these new plants would be producing a low-cost, clean source of renewable energy for use in the project area and other western states. While in production, each plant would provide employment opportunities for citizens of surrounding communities. The sale of this new energy would be a new source of revenue for the counties within which the projects are located. In addition, geothermal energy development offsets the use of irretrievable resources such as coal and oil, which would result in less pollution, fewer greenhouse gas emissions, less dependence on foreign oil and gas, and a possible reduction in the trade deficit.

5.7 What Irreversible and Irretrievable Commitment of Resources would be Involved with Implementation of the Alternatives?

This section describes the irreversible and irretrievable commitments of resources associated with implementing the action alternatives (Alternatives B or C). Resources irreversibly or irretrievably committed by a proposed action are those utilized on a long-term or permanent basis. Irreversible resource commitments occur when there is unavoidable destruction of natural resources that could limit the range of potential uses of that particular environment. Irreversible commitments apply primarily to nonrenewable resources, such as cultural resources, and also to those resources that are renewable only over long periods of time, such as soil productivity or forest health.

Irretrievable resource commitments occur when an action causes the use or consumption of a resource that is neither renewable nor recoverable for future use. Irretrievable commitments apply to loss of production, harvest, or use of natural resources. These include the use of nonrenewable resources such as metal, fuel, and other natural or cultural resources considered non-retrievable, in that they would be used for the proposed action when they could have been conserved or used for other purposes.

No irreversible commitments of resources would result from amendment of land use plans or from allocating lands as open or closed to geothermal leasing. However, anticipated future development actions that may follow leasing consistent with implementation of any of the alternatives discussed in Chapter 2 could result in a variety of irreversible and irretrievable commitments of resources, as follows:

- **Hydrology and Water Quality.** Because of the large volume and long duration of geothermal fluid production, the production stage of resource development is likely to have to the greatest potential for impact on hydrologic resources. These impacts could occur in terms of changes to the hydraulics of the geothermal and groundwater reservoirs and spent geothermal fluid disposal. Hydraulic head pressures in the geothermal and adjacent groundwater reservoirs could change during production. The result could include reduction in spring discharge rates and lowering of water levels in wells. Disposal of spent fluids by injection could also affect hydraulic heads and could introduce low-quality fluids to groundwater pathways that discharge at springs or wells. This could also affect the quality of available water. Surface disposal of spent fluids could create large pools of low-quality water. Changes in spring flow and development of spent fluid-holding ponds could induce changes to wetlands-supported ecosystems and habitats. As a result, hydrologic impacts associated with geothermal development could have secondary impacts in the plant and animal community supported by natural or created wetlands.
- **Noxious Weeds.** Introduction of noxious weeds by construction and support vehicles into previously clean areas would be probable during all phases of geothermal development. The drilling and utilization phases would present the greatest opportunity for noxious weed introduction and proliferation. Once introduced, control or eradication of noxious weeds could be difficult.
- **Visual Resources.** Any changes in the characteristic landscape of the affected areas due to geothermal energy development could be visible for many years. Succession (change in habitat type over time, including the return of an area to its pre-development state after site reclamation/rehabilitation) in the Basin and Range geomorphic province is very slow due to the lack of rainfall. Rehabilitation techniques could use non-indigenous plant species, thus changing the character of the area. The degree of contrast between a reclaimed project site and its untouched surroundings would vary by area, rehabilitation techniques, and the success of those techniques. All landscapes are unique in their own right, and any change or loss of scenic values is irretrievable. Those losses become more significant in areas of unique or outstanding scenic quality.

- **Threatened, Endangered, and Special Status Species.** Loss of any species is irretrievable. Protection of threatened, endangered, and special status species is governed by federal and state statute. To minimize the effects on threatened, endangered, and special status species, the lessee would be required to complete a site-specific NEPA analysis outlining their proposed action and alternatives, and the direct and indirect impacts of their proposed action, on any threatened, endangered, and special status species prior to any occupancy and surface disturbance. Site-specific compliance with the ESA would occur at the time of development as well.
- **Geology and Minerals.** The principle commitment of resources in implementing the proposed action would be the depletion of thermal energy and water from the geothermal reservoirs tapped for energy use. To minimize this effect, the super-hot water extracted from the subterranean geothermal reservoirs through production wells is injected back into the reservoir for reheating and reuse. Over time, these resources (heat and water) could be depleted to the point that the power generating plant would no longer be economically productive.
- **Cultural Resources.** Destruction and/or loss of cultural resources are irretrievable. Federal and state statutes govern the protection of cultural resources. To minimize the effects on cultural resources, the lessee would be required to complete a site-specific NEPA analysis outlining their proposed action and alternatives, and the direct and indirect impacts of their proposed action on the cultural resources within the lease area, prior to any occupancy and surface disturbance beyond minor exploration activities.
- **Hazardous Materials/Waste and Solid Waste.** If handled improperly, hazardous materials/waste and solid waste have the potential to create irretrievable consequences. The transportation, storage, use, and disposal of hazardous materials/waste and solid waste are governed by Federal and state statute. To minimize the effects of hazardous materials/waste and solid waste, the lessee would be required to complete a site-specific NEPA analysis outlining their proposed action and alternatives, and the direct and indirect impacts of hazardous materials/waste and solid waste associated with their proposed action, prior to any occupancy and surface disturbance beyond minor exploration activities.

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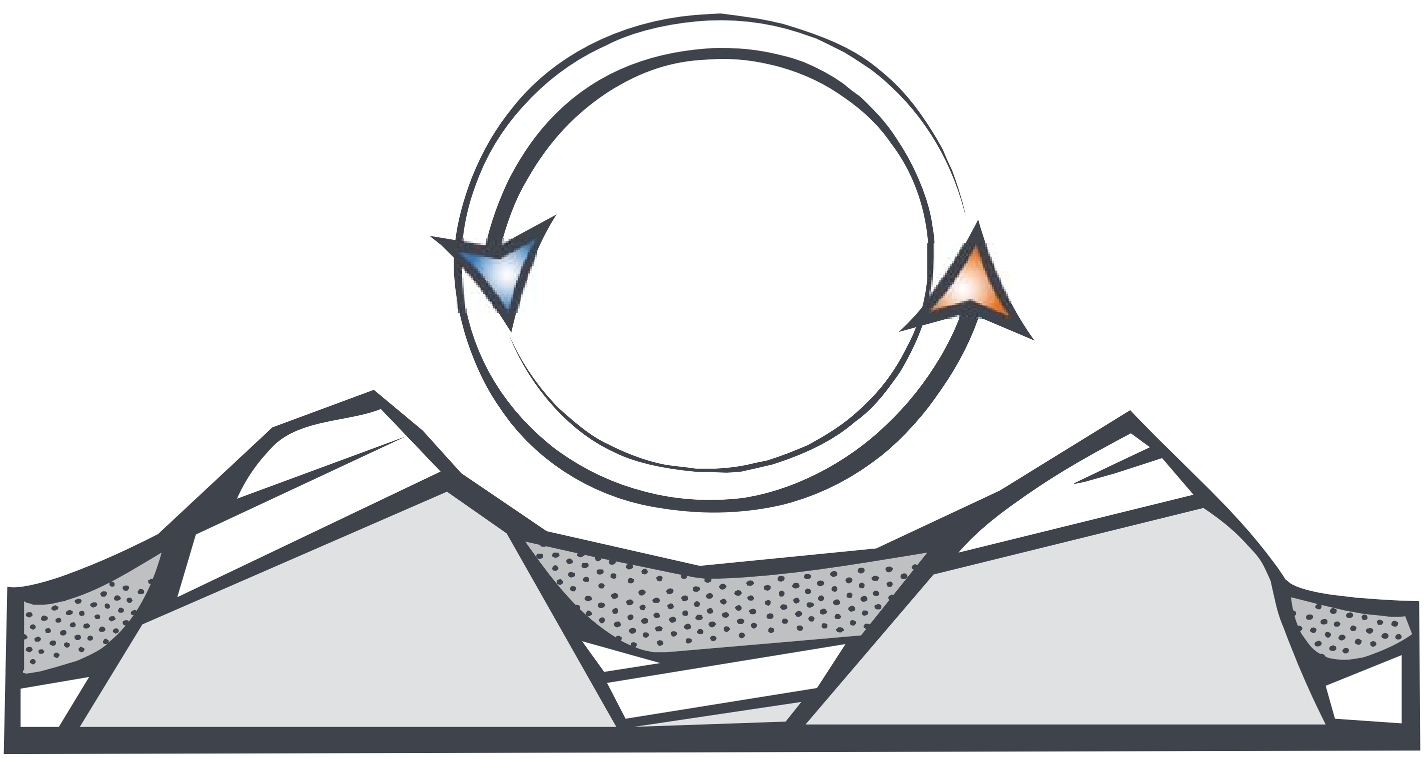

Chapter 6

Consultation and Coordination

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CHAPTER 6
CONSULTATION AND COORDINATION

6.1 PUBLIC SCOPING

The BLM published the Notice of Intent (NOI) to prepare a PEIS to evaluate geothermal leasing in the 12 western states, including Alaska, on lands administered by the BLM and the FS in the *Federal Register* (72 FR 113) on June 13, 2007. The NOI initiated the public scoping process and invited public comments on the content and issues that should be addressed in the PEIS. The BLM and the FS conducted scoping from June 13, 2007 through August 13, 2007. During that period, the BLM and the FS invited the public and interested groups to provide information and guidance, suggest issues that should be examined, and express their concerns and opinions on geothermal leasing in eleven western states and Alaska on public lands administered by the BLM and the FS. During the scoping process, the public was given four means of submitting comments to the BLM and the FS:

1. Traditional mail;
2. Toll-free facsimile transmission; and
3. Electronic mail.
4. This variety of ways to communicate issues and submit comments was provided so as to encourage maximum participation. All comments, regardless of how they were submitted, received equal consideration.

Public meetings, which were held in ten cities in July 2007: Anchorage, Alaska; Boise, Idaho; Denver, Colorado; Missoula, Montana; Phoenix, Arizona; Portland, Oregon; Reno, Nevada; Sacramento, California; Salt Lake City, Utah; and Santa Fe, New Mexico.

The scoping meetings were advertised through the following means: newspaper notices (ten newspapers); the project website; a project newsletter that was sent to approximately 1,600 recipients; electronic mail messages; newspaper articles and trade publications.

Approximately 175 people attended the scoping meetings and 101 verbal comments were identified and cataloged from these meetings. A total of 79 written comments were received in the form of comment cards submitted at the public meetings (2); letters by US Mail or by hand delivery (16); and by electronic mail (63).

The following agencies, organizations, and industries provided comments, as well as private individuals.

- California Wilderness Coalition
- Calpine Corporation
- Earth Systems Southwest
- Greater Yellowstone Coalition
- Idaho Conservation League
- New Mexico Department of Fish and Game
- Ormat, Inc.
- Save Medicine Lake Coalition
- Sierra Club, Oregon Chapter
- Skamania County Public Utility District No. 1
- Utah Environmental Congress
- Utah Office of the Governor, Utah Geological Survey
- United States Environmental Protection Agency
- Western Resource Advocates
- The Wilderness Society and Western Resource Advocates
- Wyoming Game and Fish Department
- Wyoming Outdoor Council

The BLM and FS published a scoping report on the project web site that summarized and categorized the major themes, issues, concerns, and comments expressed by private citizens, government agencies, private firms, and nongovernmental organizations. The BLM and FS considered the comments in developing the alternatives and analytical issues that are contained in this PEIS. Summaries of the individual letters, facsimiles, and electronic comments received during scoping are available within the scoping report (www.blm.gov/geothermal_eis).

6.2 PUBLIC COMMENT ON THE DRAFT PEIS

The United States Environmental Protection Agency published a Notice of Availability (NOA) of the Draft Programmatic Environmental Impact Statement for geothermal leasing in the 12 western states on June 20, 2008. The NOA initiated the 90-day public comment period provided for planning actions.

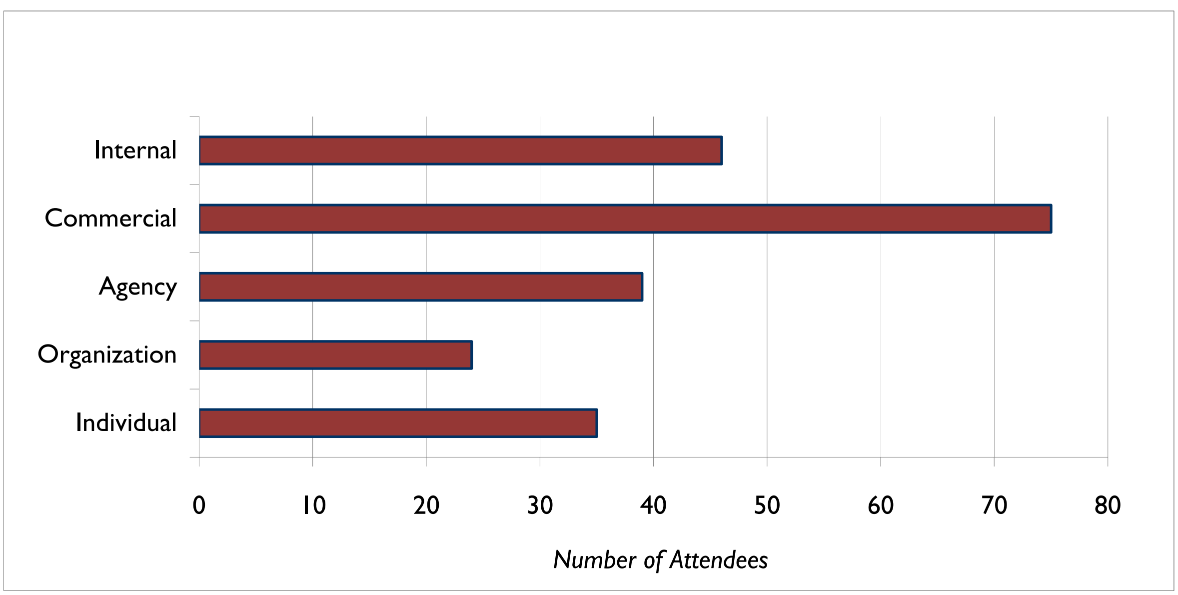
The BLM Project Web site contained the PEIS in its entirety for download. Copies of the document were sent to a mailing list of over 1,000 recipients. In addition, over 100 copies of the CD-ROM or hardcopies of the document were mailed in response to document requests. In preparing the Final PEIS, the BLM and FS considered all comments received or postmarked during the public comment period.

6.2.1 Public Meetings and Public Notification

The BLM and FS held 13 public meetings in the 12 western state project area in July 2008. Meeting locations included Albuquerque, New Mexico; Anchorage, Alaska; Boise, Idaho; Denver, Colorado; Fairbanks, Alaska; Helena, Montana; Portland, Oregon; Reno, Nevada; Sacramento, California; Salt Lake City, Utah; Seattle, Washington; and Tucson, Arizona.

Over 200 people attended the public meetings. The largest number of attendees were from the commercial/industrial sector, followed by government agencies, non-profit organizations, and non-affiliated individuals. Breakdown of attendance is presented in Figure 6-1, Public Meeting Attendees.

Figure 6-1
Public Meeting Attendees



Internal-FS and BLM staff, Commercial-Industry and commercial organizations, Agency-government agencies and tribal organizations, Organization- non-profit organization, Individual- no affiliation provided.

The PEIS newsletter, which provided the locations and times for the public hearings and instructions for comment submittal, was sent to those on the project mailing list and was posted on the project Web site. Public hearing times and locations were also posted directly on the Web site and were printed in local newspapers for each city where a meeting was held.

In addition, notices were published to inform the public about the analysis of pending lease applications on FS lands. Notices were published in August 2008 in the following papers, identified as the Newspapers of Record for the affected FS offices:

- Modoc NF: Modoc County Record, Alturas, California
- Mt Hood NF: The Oregonian, Portland, Oregon
- Willamette National Forest: Register-Guard, Eugene, Oregon
- Mt. Baker-Snoqualmie National Forest: Seattle Post-Intelligencer, Seattle, Washington
- Humboldt-Toiyabe NF: Reno Gazette-Journal, Reno, Nevada
- Tongass National Forest: Ketchikan Daily News, Ketchikan, Alaska

6.2.2 Summary of Comments

The comment period closed on September 19, 2008. All written comments sent prior to midnight (12:00 AM on September 20, 2008) were accepted as official comments. Methods of submitting comments included letters, facsimiles, and electronic mail messages. All comments, regardless of how they were submitted, received equal consideration.

Over 70 organizations, government agencies, industry representatives, and individuals responded during the comment period. Most of the written submissions contained multiple comments on different topics, and over 500 unique comments were made. All information received through these comments has been evaluated, verified, and incorporated into the Final PEIS, as appropriate. Copies of all accepted written submissions are provided in Appendix L, and the BLM and FS response to each separate comment follows the comment letter.

Comments on the PEIS pertained to a number of issues, including but not limited to scope of the document, identification of lands available for leasing, and incorporation of site-specific stipulations and BMPs. In addition, comments were received for the following resources and resource uses: air quality, cultural resources, fish and wildlife, geologic resources and seismic setting, livestock grazing, land use and special designations, minerals and energy, noise, national scenic and historic trails, recreation, socioeconomics and environmental justice, special status species, tribal interests, vegetation, visual resources, and water resources.

6.3 Government-to-Government Consultation

The BLM and the FS are working on a government-to-government basis with Native American tribes. As a part of the government's treaty and trust responsibilities, the government to government relationship was formally recognized by the federal government on November 6, 2000, with E.O. 13175, "Consultation and Coordination with Indian Tribal Governments," (U.S. President 2000).

The BLM and FS coordinate and consult with tribal governments, Native communities, and tribal individuals whose interests might be directly and substantially affected by activities on BLM- and FS-administered lands. These agencies strive to provide the tribal entities sufficient opportunities for productive participation in BLM and FS planning and resource management decision making.

The BLM and FS developed a process to offer specific consultation opportunities to "directly and substantially affected" tribal entities, as required under the provisions of E.O. 13175. Letters were mailed in September 2007 to each tribal executive official of over 400 tribes and pueblos in the western US and Alaska from the Deputy Director of the BLM and Deputy Chief of National Forest Systems of the FS (Table 6-1). The letters documented the PEIS process and detailed the pending lease applications that are being assessed in the PEIS, and invited them to participate in the consultation process. Seven tribes provided a response letter. One letter noted that no lease applications were in their area of interest, four letters requested consultation if any lease applications would fall in their areas of interest, and two letters requested consultation and to help participate in the PEIS process.

The Draft PEIS was sent to an updated list of over 400 tribes and pueblos in the western US and Alaska. Follow-up contacts were made with the two tribes that had requested consultation on the PEIS, along with another tribe with interests in multiple states. Of these, one tribe was not interested in direct government-to-government consultation at this time; one tribe is considering requesting a meeting; and the third tribe is working with the BLM and FS to schedule a formal government-to-government consultation meeting. Local BLM and FS officials are coordinating ongoing government-to-government consultation for the pending leases, as described in Volume II.

6.4 Coordination of BLM and FS Offices

This PEIS was prepared by the BLM and the FS to evaluate a program that will have BLM- and FS-wide impacts. Weekly conference calls were held to brief BLM and FS staff and to enhance coordination among the project team, the BLM State and District offices, and the FS offices. In addition, the project team presented in-person briefings to both regional and headquarters' staff as requested. Coordination with State Office and Field Office staff will continue on issues related to geothermal leasing on BLM- and FS-administered lands through the completion of the project.

6.5 AGENCY COOPERATION, CONSULTATION, AND COORDINATION

From the start of this PEIS process, the BLM and the FS consulted with several federal agencies regarding the purpose and need for the proposed action and the scope of the analysis. The US Department of Energy participated on the project core team. The US Geological Survey also worked closely with the core team to provide technical guidance in defining areas of geothermal development potential for electrical generation. The BLM and FS are also coordinating with the US Environmental Protection Agency regarding air quality, wetlands, and other natural resources.

The BLM and FS are coordinating with and soliciting input from the State Historic Preservation Offices and the Advisory Council on Historic Preservation in accordance with the National Historic Preservation Act. This PEIS provides for a phased consultation process related to historic, traditional, and cultural resources.

Dialogues have been initiated with key state agencies involved in the promotion, analysis, and permitting of geothermal development projects including state geological surveys, state energy offices, and state energy regulatory bodies. Coordination with research institutes, universities, and stakeholders groups, including business and geothermal industry groups is ongoing.

In addition, the BLM initiated activities to coordinate and consult with the governors of each of the 12 states and with state agencies. Prior to the issuance of the ROD and the approval of proposed plan amendments, the governor of each state will be given the opportunity to identify any inconsistencies between the proposed plan amendments and state or local plans and to provide recommendations in writing.

6.6 ENDANGERED SPECIES ACT - SECTION 7

6.6.1 Section 7 Requirements

Section 7 of the Endangered Species Act (ESA) directs each Federal agency, in consultation with the Secretary of the Interior and the Secretary of Commerce, as appropriate, to ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any listed threatened or endangered species or result in the destruction or adverse modification of critical habitat[1].

[1] See ESA § 7; 16 USC 1536. The standard for determining when Federal agencies must consult under the ESA is different from the standard for determining when Federal agencies must prepare an Environmental Impact Statement under the National Environmental Policy Act.

Under Section 7 of the ESA, those agencies that authorize, fund, or carry out a Federal action are commonly known as "action agencies." If an action agency determines that its Federal action "may affect" listed species or critical habitat, it must consult with the USFWS of the DOI or the National Marine Fisheries Service (NMFS) of the Department of Commerce (DOC) (collectively known as the "Services") or both, whichever has jurisdiction over the species or habitat that may be affected[2].

If an action agency determines that the Federal action will not cause any effects on listed species or critical habitat, the action agency does not initiate consultation with the Services, and its obligations under Section 7 are complete. In order to make this determination, an action agency must consider the effects of the action at issue. Regulations implementing NEPA and ESA each use the terms "direct effect," "indirect effect," and "cumulative effect," but the definitions of these terms are not identical under the statutes. Regulations at 40 CFR 1508.8 and 50 CFR 402.02 highlight these differences. Under NEPA, and as demonstrated in this PEIS, an agency will examine the direct, indirect, and cumulative impacts of a proposed action. Indirect effects are those caused by the action, later in time, and *reasonably foreseeable*. Under the ESA, however, the effects of an action are evaluated by a stricter standard. Regulations implementing the ESA define the term "effects of an action" at 50 CFR 402.02 to include direct and indirect effects (and the effects of interrelated or interdependent activities), but limit indirect effects to those that are caused by the action, later in time, and *reasonably certain* to occur. In addition, ESA regulations limit the term "cumulative effects" to those effects of future state or private activities; NEPA regulations are not so limited.

The "reasonably certain to occur" standard used in the ESA regulations is more demanding than the "reasonably foreseeable" standard used in the NEPA regulations (see 40 CFR 1508.8). Thus, it is possible that a proposed action may have "no effect" under the ESA standard but will have multiple effects under NEPA. The ESA standard has been part of interagency regulations at 50 CFR Part 402 since 1986 and is the subject of proposed rules recently promulgated by FWS and NMFS[3].

6.6.2 Agency Status under ESA Section 7

The DOI (BLM) and USDA (Forest Service) have concluded that they are action agencies for ESA purposes because each manages Federal land where leasing and development of geothermal resources may take place. In particular, the BLM is an action agency for purposes of the land use plan amendments to allocate land as available for leasing, as analyzed in this PEIS; decisions to be made regarding pending lease applications, as analyzed in Volume II of this PEIS; and future lease

[2] See 50 CFR 402.02, 402.13-14.

[3] Interagency Cooperation Under the Endangered Species Act, 73 Fed. Reg. 47868 (Aug. 15, 2008) (to be codified at 50 CFR pt. 402).

applications that may be submitted. As the FS will be making decisions appropriate to their respective management authority regarding these pending lease applications, the FS, too, is an action agency for ESA purposes.

6.6.3 "No Effect" Determination under Section 7

In complying with their duties under Section 7 of the ESA, the action agencies have examined the effects on listed species and critical habitat both of allocating land as available for leasing of geothermal resources through land use plan amendments, and of issuing leases for these resources. As a result of this examination, the action agencies have determined that neither of these actions (amending land use plans; issuing geothermal leases) would cause any effect on a listed species or on critical habitat. This determination is based on the following.

Allocation Decisions Do Not Cause Effects on Species or Habitats

The first proposed action, allocation of BLM-administered lands with geothermal resource potential as closed, open, or open with major or moderate constraints to geothermal leasing, through amendment of land use plans, fulfills BLM's obligations under FLPMA and would not cause any impact, direct or indirect, as cognizable under the ESA, to listed species or critical habitat. The land use plan amendments identify and allocate such areas, adopt RFDs, and adopt a list of stipulations, best management practices, and procedures to be applied for the protection of resources.

This proposed action does not establish a precedent or create any legal right that would allow ground-disturbing activities within any of these areas allocated for geothermal leasing. Following lease issuance, when an application to conduct activities involving surface disturbance is submitted that could affect a listed species or critical habitat at a particular location within one of these areas, it would be subject to full policy and legal review at the time it is filed. This includes review and coordination under the ESA and other applicable statutes of the applicability of the stipulations, best management practices, and procedures for the protection of other resources.

Similarly, providing suitability information to facilitate the FS' subsequent consent decision to the BLM for leasing on NFS lands to the FS, to the extent this providing of information could be construed to be an action under ESA, is an administrative task that would not cause any impact, direct or indirect, as cognizable under the ESA, to listed species or critical habitat.

Lease Issuance Does Not Cause Effects on Species or Habitats

The decision to issue a lease is a separate and discretionary decision from the allocation decision made through land use plan amendment. With respect to the pending lease applications analyzed in Volume II, BLM has determined that the issuing of a geothermal lease similarly does not cause any effect on listed species or critical habitat under the ESA. Moreover, there is no guarantee that any particular authorization or lease will be granted, or, even if granted, as explained below, that any development will ever take place on such lease.

This second proposed action, therefore, to complete processing of active pending lease applications and nominations by deciding whether, and under what stipulations, to issue geothermal leases on NFS and public lands, is an action that, in itself, and on the condition that the stipulation addressing ESA matters is incorporated in any lease issued, would not cause any impact, direct or indirect, as cognizable under the ESA, to listed species or critical habitat. Lease rights are always limited by the requirements of other laws, as illustrated in the geothermal regulations at 43 CFR 3200.4.

As explained in Section 2.2.2 of the PEIS, in accordance with BLM Instruction Memorandum No. 2002-174, the BLM will apply the following ESA-related stipulation on any leases where threatened, endangered, or other special status species or critical habitat is known or strongly suspected:

> "The lease area may now or hereafter contain plants, animals, or their habitats determined to be threatened, endangered, or other special status species. BLM may recommend modifications to exploration and development proposals to further its conservation and management objective to avoid BLM-approved activity that will contribute to a need to list such a species or their habitat. BLM may require modifications to the lease terms or disapprove proposed activity that is likely to result in jeopardy to the continued existence of a proposed or listed threatened or endangered species or result in the destruction or adverse modification of a designated or proposed critical habitat. BLM will not approve any ground-disturbing activity that may affect any such species or critical habitat until it completes its obligations under applicable requirements of the Endangered Species Act as amended, 16 USC 1531 et seq., including completion of any required procedure for conference or consultation."

Additionally, the BLM will provide a separate notification through a lease notice to prospective lessees identifying the particular special status species that are present on the lease parcel offered. For agency-designated sensitive species (e.g., sage grouse), a lease stipulation (NSO, CSU, or TL) would be imposed for those portions of high value/key/crucial species habitat where other existing measures are inadequate to meet agency management objectives.

Moreover, even without the ESA-related stipulation, lease issuance, by itself, does not afford lessees the right to engage in any ground-disturbing activity. Under the regulations applicable to geothermal development, permits, with associated environmental reviews and coordination, are required at every stage of exploration, drilling, and utilization before the applicant may proceed. Even before lease issuance, pre-leasing exploration cannot take place without approval, which may include protective "Conditions of Approval" (43 CFR 3251.10). The geothermal regulations include prohibitions such as "Do not start activities that will result in surface disturbance until we approve your drilling permit and Sundry Notice" (43 CFR 3261.14). Similar language appears in relation to the regulations that correspond to each stage of geothermal development, including the sections related to drilling (43 CFR 3261.11(b)), utilization, and site licenses: "Do not begin site investigations…" (43 CFR 3271.12(b)); "Do not start construction of pipelines…" (43 CFR 3271.13); "Do not start delivery of geothermal resources to a facility…" (43 CFR 3271.14(b)); "Do not start building or testing your facility…" Each of these stages provides the BLM with opportunities to decide whether the next stage should be approved, denied, or approved with conditions such as protective measures. See, for example, 43 CFR 3273.12 (e). Each subpart also contains general standards and environmental requirements. See, for example, 43 CFR 3260.11 and 3272.12. Moreover, the agencies must verify that leasing on the applicant's parcel has been adequately addressed in a NEPA document. Using the ESA stipulation above, as well as the many distinct decision points described in the geothermal development regulations, the agencies have retained the authority post-lease issuance to condition, and even to deny, the use of the leased property if required by the ESA. Therefore, even the decision to lease does not result in any effect on listed species or critical habitat. For this reason, the agencies have made a "no effect" determination for the proposed allocation decisions in the land use plan amendments, as well as for the decision to issue leases.

It is important to note that the effects of any future development-stage activities that might occur subsequent to the issuance of a lease would be allowed only following additional site-specific compliance with ESA and other applicable laws, and are not included in the scope of this action. Thus, the effects of development-stage activities are not to be considered effects, direct or indirect, caused by the proposed action (lease issuance) at issue here. The regulations governing geothermal leasing and development provide for several decision stages prior to any ground-disturbing activities taking place and contemplate further compliance with applicable authorities during these decision stages. Therefore, both under the regulatory scheme, and as a practical matter, until BLM receives an application for a permit to drill, or other authorization, which includes specific information about particular projects (i.e., location, scale, technology, etc.), and adjudicates it, it is impossible to determine what effects on listed species or critical habitat might be "reasonably certain to occur" (see 50 CFR Part 402). It is at that time that consultation under Section 7 with NOAA or the FWS may be appropriate and useful.

For the above reasons, the action agencies have determined that amending land use plans to allocate areas as available for geothermal leasing, providing information for later FS decision-making, and issuing geothermal leases would have no effect on listed threatened or endangered species or critical habitat.

The action agencies reach their "no effect" determination not because listed species and critical habitat are unlikely to be present. To the contrary, Appendix H of the PEIS identifies numerous listed species that occur in the 12 western states where land use plans will be amended, and leases may be issued. Areas that may eventually be leased would likely include areas occupied by listed species or within critical habitat.

The action agencies considered preparing a biological assessment and initiating consultation with USFWS and NMFS under Section 7(a)(2). After discussing various approaches, the action agencies determined that the administrative actions of allocating lands as available for leasing of geothermal resources and issuing leases for these resources would have no effect on listed species or critical habitat. Preparing a biological assessment before a site-specific application for permit to drill has been filed with BLM would be based largely on conjecture and speculation. There would be no way to know before such a site-specific proposal is made whether the impacts to be assessed would be from one or another specific type of geothermal plant or facility, or associated transmission line, etc., or some combination of uses. Further, without knowing the specifics of when and where a project would occur, it would be impossible to know what species, if any, would be affected by these future projects. The agencies considered whether it made sense to make assumptions for the purposes of a biological assessment, but were left with no credible basis on which to make such assumptions. The agencies determined such assumptions would be speculative and not linked to the Federal action of allocating lands as available for geothermal leasing through land use plan amendments, or even issuing such leases. Any biological assessment would be a speculative assessment of effects from future site-specific projects, not of the proposed actions addressed in this PEIS as a whole.

This is not to say that there would be no Section 7 consultations (including preparation of biological assessments or biological opinions where appropriate) on future actions that may affect listed species or critical habitat. On the contrary, as explained above, the action agencies fully expect that Section 7 compliance, including consultations if necessary, will be appropriate as applications for permits to drill on particular leaseholds are submitted for decision-making by the BLM, with FS concurrence, as necessary. That is, if an application for a permit, or other authorization is received by an action agency for lands allocated as open for leasing, further compliance with Section 7 of the ESA would be initiated at that time.[4] This may take the form of preparation of a biological assessment by the action agencies and issuance of a biological opinion by USFWS and/or NMFS; a "may affect, not likely to adversely affect" determination by the action agencies with Service concurrence; or a "no effect"

[4] Further, if a future, site-specific proposal may adversely affect essential fish habitat (EFH), the action agencies would consult with NMFS, as required by the Magnuson Stevens Fishery Conservation and Management Act, 16 USC l855(b)(2), prior to approval.

determination by the action agencies. At such time, any biological assessment, biological opinion, concurrence, or "no effect" determination would be based on a detailed application describing the project, site, and method of construction – all features lacking at the present time.

In reaching their "no effect" determination, the action agencies found no causal connection, whether direct or indirect, between the mere allocation of areas as available for geothermal leasing (through land use plan amendment), or issuance of such leases, and any effect on a listed species or critical habitat. Allocation of areas as available for leasing of geothermal resources neither guarantees that a lease within such an area will be granted, nor, even if a lease is granted (assuming that the ESA stipulation is incorporated in such lease) that an application for a permit to drill will be granted. Any effects to a listed species or critical habitat that might occur in any of the areas allocated through this planning action or lease issuance in the future are simply unknown at this time and, in any event, would be caused by the grant of a permit, or other site-specific authorization, following full policy and legal review, including compliance (and consultation if appropriate) under Section 7 of the ESA.

6.7 Potential Adoption of the PEIS by Other Organizations

The PEIS provides an analysis of the positive and negative environmental, social, and economic impacts associated with geothermal leasing on BLM-administered and NFS lands in the western United States and Alaska. It identifies potential measures that may be undertaken to avoid, mitigate, or minimize potential impacts and proposes specific policies and BMPs to govern geothermal leasing. The information contained in the PEIS and the decisions represented in the proposed policies and BMPs may be relevant to geothermal leasing on other lands, including other Federal, private, state-owned, and tribal lands. They may also be relevant to decisions regarding other related activities, including development of new transmission lines, substations, and other facilities.

Other agencies may elect to adopt this PEIS, or a portion of this PEIS, at some time in the future. The CEQ regulations provide specific guidance on the process by which one agency can adopt another agency's final environmental document even though it did not participate as a cooperating agency (40 CFR 1506.3). According to the CEQ in its March 23, 1981 "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," Question 30, "If the proposed action for which the EIS was prepared is substantially the same as the proposed action of the adopting agency, the EIS may be adopted as long as it is recirculated as a final EIS and the agency announces what it is doing. This would be followed by the 30-day review period and issuance of a Record of Decision by the adopting agency. If the proposed action by the adopting agency is not substantially the same as that in [46 FR 18036] the EIS (i.e., if an EIS on one action is being adapted for use in a decision on another action), the EIS would be treated as a draft and circulated for the normal public comment period and other procedures" (46 FR 55, 18026-18038).

Individual organizations should consider their own NEPA implementing regulations or comparable programmatic requirements to evaluate the potential benefits associated with implementation of all or portions of the PEIS.

Table 6-1
Consultation Invitation Letter Mailing List

Agdaagux Tribe of King Cove
Agua Caliente Band of Cahuilla Indians
Ak Chin Indian Community Council
Akiachak Native Community (IRA)
Akiak Native Community (IRA)
Alatna Village
Aleut Community of St. Paul Island
Algaaciq Native Village
Allakaket Village
Alturas Rancheria
Angoon Community Association (IRA)
Anvik Village
Arapaho Business Committee
Arctic Village Council
Asa'carsarmiut Tribe
Atqasuk Village
Augustine Band of Mission Indians
Barona Band of Mission Indians
Battle Mountain Band Council
Bear River Band of Rohnerville Rancheria
Beaver Village Council
Benton Paiute Reservation
Berry Creek Rancheria
Big Lagoon Rancheria
Big Pine Paiute Tribe of the Owens Valley
Big Sandy Rancheria
Big Valley Rancheria
Birch Creek Tribal Council
Bishop Paiute Tribe
Blackfeet Tribal Business Council
Blue Lake Rancheria
Bridgeport Indian Colony
Buena Vista Rancheria
Burns Paiute Tribe, General Council
Cabazon Tribal Business Committee
Cahto Tribal Executive Committee
Cahuilla Band of Mission Indians
California Valley Miwok Tribe
Campo Band of Mission Indians
Carson Community Council
Cedarville Rancheria
Central Council Tlingit & Haida Indian Tribes of Alaska
Chalkyitsik Village Council
Cheesh-Na Tribal Council
Chemehuevi Tribal Council
Chenega IRA Council
Chevak Native Village
Chickaloon Native Village
Chicken Ranch Rancheria
Chignik Lagoon Council
Chignik Lake Village Council
Chilkat Indian Village (Klukwan) (IRA)
Chilkoot Indian Association (IRA)
Chinik Eskimo Community
Chippewa Cree Business Committee
Chitina Traditional Indian Village Council
Chuloonawick Native Village
Circle Native Community (IRA)
Cloverdale Rancheria
Cocopah Tribal Council
Coeur d'Alene Tribal Council
Cold Springs Rancheria
Colorado River Tribal Council
Colusa Rancheria
Colville Business Council
Confederated Salish & Kootenai Tribes, Tribal Council
Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians
Confederated Tribes of the Chehalis Reservation
Confederated Tribes of the Grand Ronde Community of Oregon
Confederated Tribes of the Umatilla Indian Reservation
Confederated Tribes of the Warm Springs Reservation, Tribal Council
Coquille Indian Tribe
Cortina Rancheria

Cow Creek Government Offices
Cowlitz Indian Tribe
Coyote Valley Reservation
Craig Community Association (IRA)
Crow Tribal Council
Curyung Tribal Council
Douglas Indian Association (IRA)
Dresslerville Community Council
Dry Creek Rancheria
Duckwater Tribal Council
Egegik Village
Eklutna Native Village
Ekwok Village
Elem Indian Colony
Elim IRA Council
Elk Valley Rancheria
Elko Band Council
Ely Shoshone Tribal Council
Emmonak Village
Enterprise Rancheria
Evansville Village
Ewiiaapaayp Band of Kumeyaay Indians
Fallon Paiute Shoshone Tribal Business Council
Federated Indians of Graton Rancheria
Fort Belknap Community Council
Fort Bidwell Reservation
Fort Hall Business Council
Fort Independence Reservation
Fort McDermitt Tribal Council
Fort McDowell Yavapai Tribal Council
Fort Mojave Tribal Council
Fort Peck Tribal Executive Board
Gambell IRA Council
Gila River Indian Community Council
Goshute Business Council
Greenville Rancheria
Grindstone Rancheria
Guidiville Rancheria
Gulkana Village
Habematolel Pomo of Upper Lake
Havasupai Tribal Council
Healy Lake Village
Hoh Tribal Business Committee
Holy Cross Village
Hoonah Indian Association (IRA)
Hoopa Valley Tribal Council
Hopi Tribal Council
Hopland Reservation
Hualapai Tribal Council
Hughes Village
Huslia Village Council
Hydaburg Cooperative Assn. (IRA)
Igiugig Village
Inaja-Cosmit Reservation
Inupiat Community of Arctic Slope (IRA)
Ione Band of Miwok Indians
Iqurmiut Traditonal Council
Ivanoff Bay Village Council
Jackson Rancheria
Jamestown S'Klallam Tribal Council
Jamul Indian Village
Jicarilla Apache Nation
Kaguyak Village
Kaibab Paiute Tribal Council
Kaktovik Village
Kalispel Business Committee
Kaltag Tribal Council
Karuk Tribe of California
Kenaitze Indian Tribe (IRA)
Ketchikan Indian Community Tribal Council
King Island Native Community (IRA)
King Salmon Tribe
Klamath General Council
Klawock Cooperative Association
Knik Village
Kobuk Traditional Council
Kokhanok Village
Kongiganak Traditional Council
Kootenai Tribal Council
Koyukuk Native Village
La Jolla Band of Luiseno Indians
La Posta Band of Mission Indians
Larsen Bay Tribal Council
Las Vegas Tribal Council
Lesnoi Village, Woody Island Tribal Council
Levelock Village
Lime Village Traditional Council
Lone Pine Paiute Shoshone Reservation
Los Coyotes Band of Cahuilla & Cupeno Indians
Louden Tribal Council
Lovelock Tribal Council
Lower Elwha Tribal Council
Lower Lake Rancheria
Lummi Indian Business Council
Lytton Rancheria
Makah Indian Tribal Council
Manchester - Point Arena Band of Pomo Indians
Manley Hot Springs Village
Manokotak Village
Manzanita Band of Mission Indians

Mary's Igloo Traditional Council
McGrath Native Village Council
Mechoopda Indian Tribe of the Chico Rancheria
Mentasta Lake Tribal Council
Mesa Grande Band of Mission Indians
Mescalero Apache Tribe
Metlakatla Indian Community
Middletown Rancheria
Moapa Business Council
Mooretown Rancheria
Morongo Band of Mission Indians
Muckleshoot Tribal Council
Naknek Native Village
Native Village of Afognak
Native Village of Akhiok
Native Village of Akutan
Native Village of Aleknagik
Native Village of Ambler
Native Village of Atka
Native Village of Barrow Inupiat Traditional Government
Native Village of Belkofski
Native Village of Bill Moore's Slough
Native Village of Brevig Mission
Native Village of Buckland (IRA)
Native Village of Cantwell
Native Village of Chignik
Native Village of Chuathbaluk
Native Village of Council
Native Village of Crooked Creek
Native Village of Deering (IRA)
Native Village of Diomede (IRA) (aka Inalik)
Native Village of Eagle (IRA)
Native Village of Eek
Native Village of Ekuk
Native Village of Eyak
Native Village of False Pass
Native Village of Fort Yukon (IRA)
Native Village of Gakona
Native Village of Georgetown
Native Village of Goodnews Bay
Native Village of Hamilton
Native Village of Hooper Bay
Native Village of Kanatak (IRA)
Native Village of Karluk (IRA)
Native Village of Kasigluk
Native Village of Kiana
Native Village of Kipnuk
Native Village of Kivalina (IRA)
Native Village of Kluti-Kaah (aka Copper Center)
Native Village of Kotzebue (IRA)
Native Village of Koyuk (IRA)
Native Village of Kwigillingok
Native Village of Kwinhagak (IRA)
Native Village of Marshall
Native Village of Mekoryuk (IRA)
Native Village of Minto (IRA)
Native Village of Nanwalek (aka English Bay)
Native Village of Napaimute
Native Village of Napakiak (IRA)
Native Village of Napaskiak
Native Village of Nikolski (IRA)
Native Village of Noatak (IRA)
Native Village of Nuiqsut
Native Village of Nunam Iqua
Native Village of Nunapitchuk (IRA)
Native Village of Ouzinkie
Native Village of Paimiut
Native Village of Perryville Tribal Council
Native Village of Pitka's Point
Native Village of Point Hope (IRA)
Native Village of Point Lay (IRA)
Native Village of Port Heiden
Native Village of Savoonga (IRA)
Native Village of Shaktoolik (IRA)
Native Village of Shishmaref (IRA)
Native Village of Shungnak (IRA)
Native Village of South Naknek
Native Village of St. Michael (IRA)
Native Village of Stevens (IRA)
Native Village of Tanana (IRA)
Native Village of Tatitlek (IRA)
Native Village of Tazlina
Native Village of Tetlin (IRA)
Native Village of Tyonek (IRA)
Native Village of Unalakleet (IRA)
Native Village of Venetie Tribal Government (IRA)
Native Village of Wales (IRA)
Native Village of White Mountain (IRA)
Navajo Nation
Nelson Lagoon Tribal Council
Nenana Native Association
New Koliganek Village Council
New Stuyahok Village
Newhalen Village
Newtok Traditional Council
Nez Perce Tribal Executive Committee

Nightmute Traditional Council
Nikolai Village
Ninilchik Traditional Council
Nisqually Indian Community Council
Nome Eskimo Community
Nondalton Village
Nooksack Indian Tribal Council
Noorvik Native Community (IRA)
North Fork Rancheria
Northern Cheyenne Tribal Council
Northway Village
Northwestern Band of Shoshone Nation
Nulato Tribal Council
Nunakauyarmiut Tribe
Ohkay Owingeh
Ohogamuit Traditional Council
Organized Village of Grayling (IRA)
Organized Village of Kake (IRA)
Organized Village of Kasaan (IRA)
Organized Village of Kwethluk (IRA)
Organized Village of Saxman (IRA)
Orutsararmuit Native Council
Oscarville Tribal Council
Paiute Indian Tribe of Utah Tribal Council
Pala Band of Mission Indians
Pascua Yaqui Tribal Council
Paskenta Band of Nomlaki Indians
Pauloff Harbor Village
Pauma/Yuima Band of Mission Indians
Pechanga Band of Mission Indians
Pedro Bay Village Council
Petersburg Indian Association (IRA)
Picayune Rancheria of Chukchansi Indians
Pilot Point Tribal Council
Pilot Station Traditional Village
Pinoleville Reservation
Pit River Tribal Council
Platinum Traditional Village Council
Port Gamble S'Klallam Tribe
Port Graham Village Council
Port Lions Traditional Tribal Council
Portage Creek Village Council
Potter Valley Tribe
Pueblo of Acoma
Pueblo of Cochiti
Pueblo of Isleta
Pueblo of Jemez
Pueblo of Laguna
Pueblo of Nambe
Pueblo of Picuris
Pueblo of Pojoaque
Pueblo of San Felipe
Pueblo of San Ildefonso
Pueblo of Sandia
Pueblo of Santa Ana
Pueblo of Santa Clara
Pueblo of Santo Domingo
Pueblo of Taos
Pueblo of Tesuque
Pueblo of Zia
Pueblo of Zuni
Puyallup Tribal Council
Pyramid Lake Paiute Tribal Council
Qagan Tayagungin Tribe of Sand Point Village
Qawalangin Tribe of Unalaska
Quartz Valley Reservation
Quechan Tribal Council
Quileute Tribal Council
Quinault Indian Nation - Business Committee
Ramah Navajo Chapter
Ramona Band of Mission Indians
Rampart Village
Redding Rancheria
Redwood Valley Reservation
Reno-Sparks Tribal Council
Resighini Rancheria
Rincon Band of Mission Indians
Robinson Rancheria
Round Valley Reservation
Ruby Tribal Council
Rumsey Rancheria
Salt River Pima-Maricopa Indian Community Council
Samish Indian Nation
San Carlos Tribal Council
San Juan Southern Paiute Council
San Manuel Band of Mission Indians
San Pasqual Band of Diegueno Indians
Santa Rosa Band of Cahuilla Indians
Santa Rosa Rancheria
Santa Ynez Band of Mission Indians
Santa Ysabel Band of Mission Indians
Sauk-Suiattle Tribal Council
Scammon Bay Traditional Council
Scotts Valley Rancheria
Selawik IRA Council
Seldovia Village Tribe (IRA)
Shageluk Native Village (IRA)
Sherwood Valley Rancheria
Shingle Springs Rancheria

Shoalwater Bay Tribal Council
Shoshone Business Committee
Shoshone-Paiute Business Council
Siletz Tribal Council
Sitka Tribe of Alaska (IRA)
Skagway Village
Skokomish Tribal Council
Skull Valley Band of Goshute Indians General Coucnil
Sleetmute Traditional Council
Smith River Rancheria
Snoqualmie Tribal Organization
Soboba Band of Luiseno Indians
Solomon Traditional Council
South Fork Band Council
Southern Ute Tribe
Spokane Business Council
Squaxin Island Tribal Council
St. George Traditional Council
Stebbins Community Association (IRA)
Stewart Community Council
Stewarts Point Rancheria
Stillaguamish Board of Directors
Summit Lake Paiute Tribal Council
Sun'aq Tribe of Kodiak
Suquamish Tribal Council
Susanville Indian Rancheria
Swinomish Indian Tribal Community
Sycuan Band of the Kumeyaay Nation
Table Mountain Rancheria
Takotna Village
Tanacross Village Council
Telida Village
Teller Traditional Council
Te-Moak Tribe of Western Shoshone Tribal Council
Timbi-sha Shoshone Tribe
Tohono O'odham Nation
Tonto Apache Tribal Council
Torres-Martinez Desert Cahuilla Indians
Traditional Village of Togiak
Trinidad Rancheria
Tulalip Board of Directors
Tule River Reservation
Tuluksak Native Community (IRA)
Tuntutuliak Traditional Council
Tununak IRA Council
Tuolumne Rancheria
Twenty-Nine Palms Band of Mission Indians
Twin Hills Village Council
Ugashik Traditional Village Council
Umkumiut Native Village
Unga Tribal Council
United Auburn Indian Community
Upper Skagit Tribal Council
Ute Business Committee
Ute Mountain Ute Tribe
Venetie Village Council
Viejas Band of Mission Indians
Village of Alakanuk
Village of Anaktuvuk Pass
Village of Aniak
Village of Atmautluak
Village of Chefornak
Village of Clarks Point
Village of Dot Lake
Village of Iliamna
Village of Kalskag
Village of Kotlik
Village of Lower Kalskag
Village of Old Harbor
Village of Red Devil
Village of Salamatoff
Village of Stony River
Village of Wainwright
Walker River Paiute Tribal Council
Washoe Tribal Council
Wells Indian Colony Band Council
White Mountain Apache Tribe
Winnemucca Tribal Council
Wiyot Tribe
Woodfords Community Council
Wrangell Cooperative Assn. (IRA)
Yakama Nation
Yakutat Tlingit Tribe
Yavapai-Apache Community Council
Yavapai-Prescott Board of Directors
Yerington Paiute Tribe
Yomba Tribal Council
Yupiit of Andreafski
Yurok Tribe

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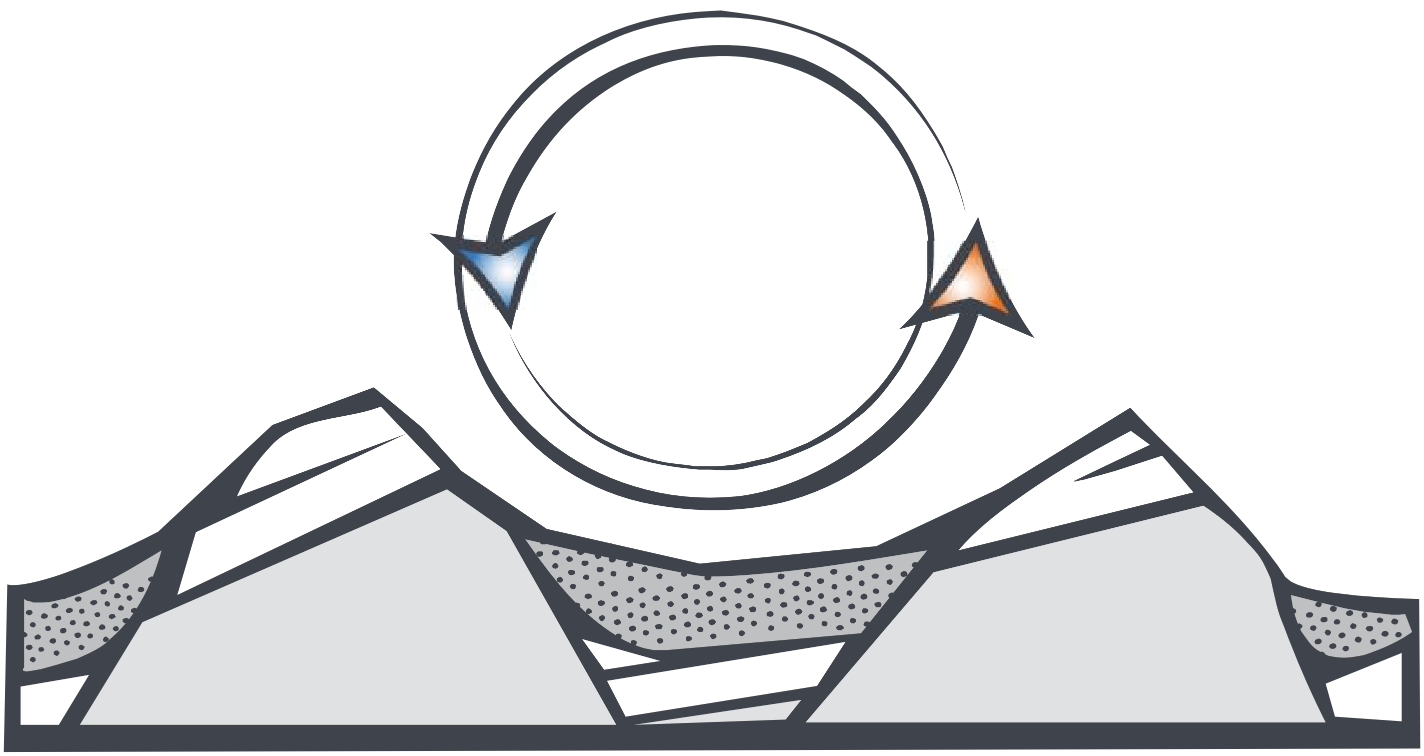

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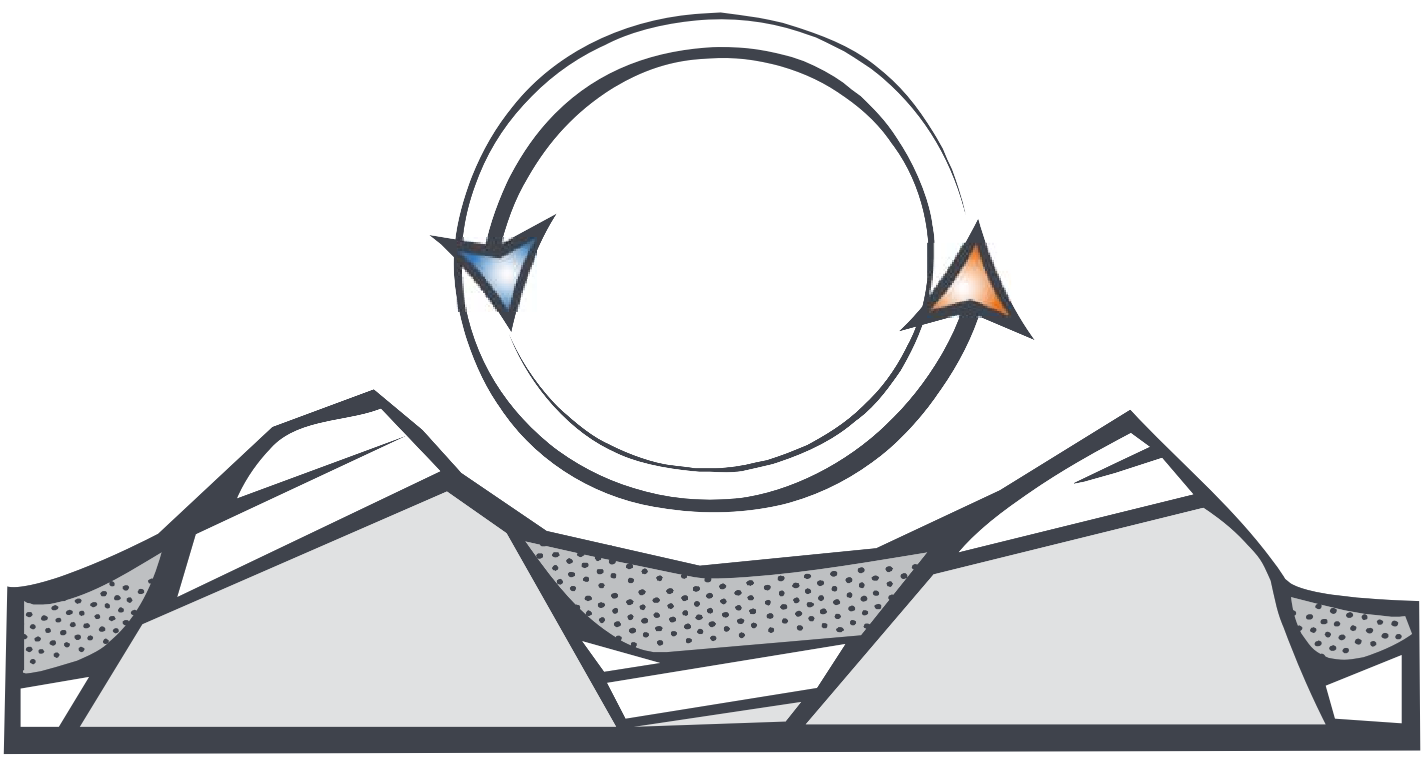

Chapter 8

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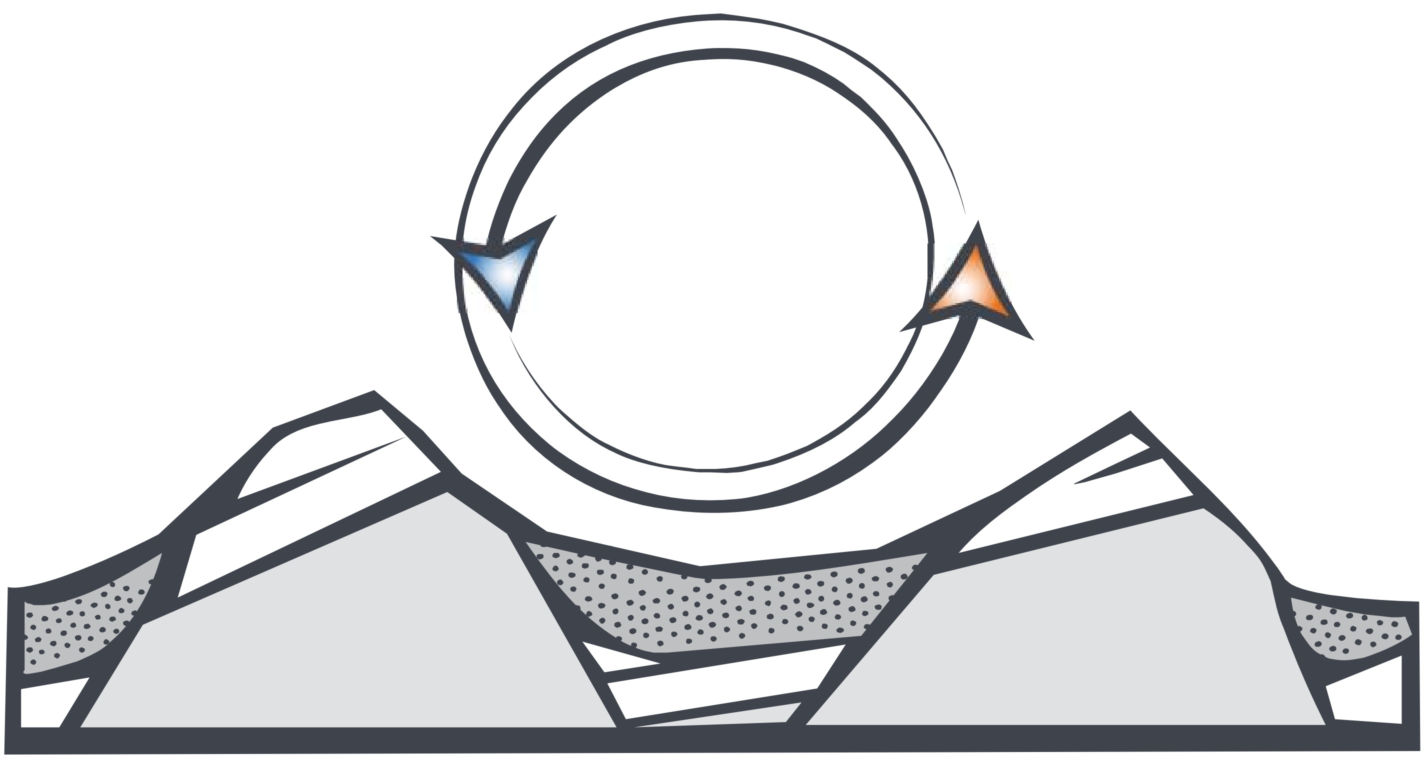

Chapter 9
Glossary

CHAPTER 9
GLOSSARY

Aquaculture: Farming of organisms that live in water, such as fish, shellfish, and algae.

Allotment: An area of land where one or more operators graze their livestock. It generally consists of public lands but may include parcels of private or state-owned lands. The number of livestock and period of use are stipulated for each allotment.

Amendment: The process for considering or making changes in the terms, conditions, and decisions of approved RMPs using the prescribed provisions for resource management planning appropriate to the proposed action or circumstances. Usually only one or two issues are considered that involve only a portion of the planning area.

Animal Unit Month (AUM): The amount of forage necessary for the sustenance of one cow or its equivalent for a period of one month (approximately 800 pounds of air-dried material per AUM). A full AUM's fee is charged for each month of grazing by adult animals if the grazing animal: 1) is weaned, 2) is six months or older when entering public land, or 3) will become 12 months old during the period of use. For fee purposes, an AUM is the amount of forage used by five weaned or adult sheep or goats or one cow, bull, steer, heifer, horse, or mule. The term AUM is commonly used in three ways: 1) stocking rate, as in X acres per AUM, 2) forage allocation, as in X AUMs in allotment A, and 3) utilization, as in X AUMs consumed from Unit B.

Area of Critical Environmental Concern (ACEC): Special Area designation established through the Bureau's land use planning process (43 CFR 1610.7-2) where special management attention is needed to protect and prevent irreparable damage to important historical, cultural, or scenic values, fish and wildlife resources, or other natural systems or processes, or to protect life and safety from natural hazards. The level of allowable use within an ACEC is established through the collaborative planning process. Designation of an ACEC allows for resource use limitations in order to protect identified resources or values.

Assessment: The act of evaluating and interpreting data and information for a defined purpose.

Best Management Practices (BMP): A suite of techniques that guide, or may be applied to, management actions to aid in achieving desired outcomes. Best management practices are often developed in conjunction with land use plans, but they are not considered a land use plan decision unless the land use plan specifies that they are mandatory. They may be updated or modified without a plan amendment if they are not mandatory.

Biochronology: The relative dating of geologic events based on fossil evidence.

Biostratigraphy: The science of dating rocks by using the fossils contained within them. Usually the aim is correlation, that is, demonstrating that a particular horizon in one geological section represents the same period of time as another horizon at some other section. The fossils are useful because sediments of the same age can look completely different because of local variations in the sedimentary environment.

Casual use: Activities on public lands that have negligible disturbance. No notification to or approval by the authorized officer is required for casual use operations. However, casual use operations are subject to monitoring by the authorized officer to ensure that unnecessary or undue degradation of Federal lands will not occur. (43 CFR 3809)

Categorical Exclusion (CE): A category of actions (identified in agency guidance) that do not individually or cumulatively have a significant effect on the human environment, and for which neither an environmental assessment nor an EIS is required (40 CFR 1508.4)

Citizen wilderness proposal: Areas that have been inventoried and proposed for Wilderness designation by citizens.

Closed: Generally denotes that an area is not available for a particular use or uses; refer to specific definitions found in law, regulations, or policy guidance for application to individual programs. For example, 43 CFR 8340.0-5 sets forth the specific meaning of "closed" as it relates to OHV use, and 43 CFR 8364 defines "closed" as it relates to closure and restriction orders.

Collaboration: A cooperative process in which interested parties, often with widely varied interests, work together to seek solutions with broad support for managing public and other lands. This may or may not involve an agency as a cooperating agency.

Collaborative partnerships and collaborative stewardship: Refers to people working together, sharing knowledge and resources, to achieve desired outcomes for public lands and communities within statutory and regulatory frameworks.

Conformance: Means that a proposed action shall be specifically provided for in the land use plan or, if not specifically mentioned, shall be clearly consistent with the goals, objectives, or standards of the approved land use plan.

Conservation agreement: A formal signed agreement between the U.S. Fish and Wildlife Service or National Marine Fisheries Service and other parties that implements specific actions, activities, or programs designed to eliminate or reduce threats or otherwise improve the status of a species. CAs can be developed at a State, regional, or national level and generally includes multiple agencies at the State and Federal level, as well as tribes. Depending on the types of commitments the BLM makes in a CA and the level of signatory authority, plan revisions or amendments may be required prior to signing the CA, or subsequently in order to implement the CA.

Conservation strategy: A strategy outlining current activities or threats that are contributing to the decline of a species, along with the actions or strategies needed to reverse or eliminate such a decline or threats. Conservation strategies are generally developed for species of plants and animals that are designated as BLM Sensitive species or that have been determined by the Fish and Wildlife Service or National Marine Fisheries Service to be Federal candidates under the Endangered Species Act.

Consistency: Proposed land use plan does not conflict with officially approved plans, programs, and policies of tribes, other Federal agencies, and State and local governments to the extent practical within Federal law, regulation, and policy.

Controlled Surface Use (CSU) The CSU stipulation is intended for application where standard lease terms and permit-level decisions are deemed insufficient to achieve the level of resource protection necessary to protect the public interest, but where an NSO is deemed overly restrictive. A CSU stipulation allows BLM to require that a proposed facility or activity be relocated by more than 200 meters from the proposed location if necessary to achieve the desired level of protection. A CSU is not required if relocating a proposed facility or activity by up to 200 meters would be sufficient for protection of the specified resources.

Cooperating agency: Assists the lead Federal agency in developing an EA or EIS. The Council on Environmental Quality regulations implementing NEPA defines a cooperating agency as any agency that has jurisdiction by law or special expertise for proposals covered by NEPA (40 CFR 1501.6). Any tribe or Federal, State, or local government jurisdiction with such qualifications may become a cooperating agency by agreement with the lead agency

Condition of Approval (COA): A site-specific and enforceable requirement included in an approved Application for Permit to Drill (APD) or Sundry Notice that may limit or amend the specific actions proposed by the operator. Conditions of Approval minimize, mitigate, or prevent impacts to resource values or other uses of public lands.

Designated right-of-way corridor: A parcel of land, usually linear in shape, that is identified through Secretarial Order in a land use plan or by other management decision as a preferred location for existing and future rights-of-way grants.

Directional drilling: The intentional deviation of a well bore from a vertical position to reach subsurface areas off to one side from the drilling site.

Endangered species: As defined in the Federal Endangered Species Act, any species which is in danger of extinction throughout all or a significant portion of its range. For terrestrial species, the USFWS determines endangered status.

Environmental Assessment (EA): A public document for which a federal agency is responsible that serves to; (a) briefly provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement or a finding of no significant impact; (b) aid an agency's compliance with the National Environmental Policy Act (NEPA) when no Environmental Impact Statement is necessary; (c) Facilitate the preparation of a statement when one is necessary. An EA includes brief discussions of the need for the proposal and of the environmental impacts of the proposed action and other alternatives.

Environmental Impact Statement (EIS): A written analysis of the impacts on the natural, social, and economic environment of a proposed project or resource management plan.

Evaluation (plan evaluation): The process of reviewing the land use plan and the periodic plan monitoring reports to determine whether the land use plan decisions and NEPA analysis are still valid and whether the plan is being implemented.

Evolution: The sequence of events involved in the evolutionary development of a species or taxonomic group of organisms. In the context of the life sciences, evolution is change in the genetic makeup of a group—a population of interbreeding individuals within a species. Such a population shares a common gene pool and members exhibit a degree of genetic relatedness.

Exception: is a one-time exemption for a particular site within the leasehold; exceptions are determined on a case-by-case basis; the stipulation continues to apply to all other sites within the leasehold. An exception is a limited type of waiver.

Extinction: The disappearance of a species or group of species. The moment of extinction is generally considered to be the death of the last individual of that species.

Federal land: Land owned by the United States , without reference to how the land was acquired or which Federal Agency administers the land, including mineral and coal estates underlying private surface.

Federal Land Policy and Management Act of 1976 (FLPMA): Public Law 94-579, which gives the BLM legal authority to establish public land policy, to establish guidelines for administering such policy and to provide for management, protection, development and enhancement of the public land.

Fishery management plan: A plan developed by a Regional Fishery Management Council and the Secretary of the Department of Commerce to manage a fishery resource pursuant to the Magnuson Fishery Conservation and Management Act of 1976.

Fluvial: Pertaining to rivers, streams, and floodplains.

Fossiliferous: Fossil containing rocks.

Geographic Information System (GIS): A computer system capable of storing, analyzing, and displaying data and describing places on the earth's surface.

Geophysical exploration: Efforts to locate deposits of oil and gas resources and to better define the sub-surface.

Geothermal potential area: any area that may contain underground reservoirs of hot water or steam created by heat from the earth, or that have subsurface areas of dry hot rock.

Geothermal energy: Natural heat from within the Earth, captured for production of electric power, space heating or industrial steam.

Geothermal heat pumps: Devices that take advantage of the relatively constant temperature of the Earth's interior, using it as a source and sink of heat for both heating and cooling. When cooling, heat is extracted from the space and dissipated into the Earth; when heating, heat is extracted from the Earth and pumped into the space.

Geothermal plant: A plant in which the prime mover is a steam turbine. The turbine is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the Earth. The energy is extracted by drilling and/or pumping.

Guzzler: General term covering guzzler, wildlife drinker, or tenaja. A natural or artificially constructed structure or device to capture and hold rain water, and make it accessible to small and/or large animals. Most guzzlers involve above or below ground piping, storage tanks, and valves. Tenajas are natural depressions in rock, which trap and hold water. To some tenajas, steps are sometimes added to improve access and reduce mortality from drowning.

Heat pump: A heat and cooling source. Heat pumps extract heat from either the air or ground and transfer that heat by circulating a refrigerant through a cycle of alternating evaporation and condensation. The cycle can be reversed for cooling. The efficiency of an air source heat pump varies tremendously with climate while ground source heat pumps take advantage of stable ground temperatures to deliver consistent performance.

Historic resources: material remains and the landscape alterations that have occurred since the arrival of Euro-Americans.

Holotype: A holotype (sometimes simply *type*) is the single physical example or illustration of an organism that defines the characteristics of the whole species. It is the definitive member of that species. Other specimens can be compared with the holotype to determine whether they are actually a member of that species.

Implementation decisions: Decisions that take action to implement land use plan decisions. They are generally appealable to IBLA under 43 CFR 4.40.

Implementation plan: A site-specific plan written to implement decisions made in a land use plan. An implementation plans usually selects and applies best management practices to meet land use plan objectives. Implementation plans are synonymous with "activity" plans. Examples of implementation plans include interdisciplinary management plans, habitat management plans, and allotment management plans.

Indian Trust Assets (ITA): Legal interests in assets held in trust by the Federal Government for federally recognized Indian tribes or nations or for individual Indians.

Invertebrate: Animals without vertebrae (back bones) or notochord.

Isotherm: a line connecting locations with equal temperature. Isotherm maps show where temperatures are relatively high and low, and also where temperature changes are gradual or dramatic over a distance.

Known Geothermal Resource Area (KGRA): A region identified by the U.S. Geological Survey as containing geothermal resources. New leasing regulations no longer use KGRAs as a basis for the leasing process.

Lease stipulation: A condition of lease issuance that provides a level of protection for other resource values or land uses by restricting lease operations during certain times or locations or to avoid unacceptable impacts, to an extent greater than standard lease terms or regulations. A stipulation is an enforceable term of the lease contract, supersedes any inconsistent provisions of the standard lease form, and is attached to and made a part of the lease. Lease stipulations further implement the Bureau of Land Management's (BLM) regulatory authority to protect resources or resource values. Lease stipulations are developed through the land use planning process.

Land use allocation: The identification in a land use plan or land use plan amendment of the activities and foreseeable development that are allowed, restricted, or excluded for all or part of the planning area, based on desired future conditions.

Land use plan: A set of decisions that establish management direction for land within an administrative area for the BLM and FS. BLM plans are commonly called Resource Management Plans (RMPs), although older plans are called Management Framework Plan (MFP) or Management Plan. The FS has Forest Plans at the forest level.

Land use plan decision: Establishes desired outcomes and actions needed to achieve them. Decisions are reached using the planning process in 43 CFR 1600. When they are presented to the public as proposed decisions, they can be protested to the BLM Director. They are not appealable to IBLA.

Leasable minerals: Minerals such as coal, oil shale, oil and gas, phosphate, potash, sodium, geothermal resources, and all other minerals that may be acquired under the Mineral Leasing Act of 1920, as amended.

Locatable minerals: A mineral subject to location under the 1872 mining laws. Examples of such minerals would be gold, silver, copper, and lead as compared to oil and natural gas, which are leasable minerals.

Magnuson-Stevens Fishery Conservation and Management Act: This Act governs the conservation and management of ocean fishing. It establishes exclusive US management authority over all fishing within the exclusive economic zone, all anadromous fish throughout their migratory range (except when in a foreign nation's waters), and all fish on the Continental Shelf. The Act also establishes eight Regional Fishery Management Councils responsible for the preparation of fishery management plans to achieve the optimum yield from US fisheries in their regions. Congress amended the Act extensively when it passed the Sustainable Fisheries Act in 1996, which also changed the name of the Act from The Magnuson Fishery Conservation Management Act to the Magnuson-Stevens Fishery Conservation and Management Act.

Management decision: A decision made by the BLM to manage public lands. Management decisions include both land use plan decisions and implementation decisions.

Mineralized: The process where a substance (in this case, the buried remains of plants or animals) is converted from an organic substance to an inorganic substance, thereby becoming mineralized.

Modification: A change to the provisions of a lease stipulation, either temporarily or for the term of the lease. Depending on the specific modification, the stipulation may or may not apply to all sites within the leasehold to which the restrictive criteria are applied.

Monitoring (plan monitoring): The process of tracking the implementation of land use plan decisions.

Multi-jurisdictional planning: Collaborative planning in which the purpose is to address land use planning issues for an area, such as an entire watershed or other landscape unit, in which there is a mix of public and/or private land ownership and adjoining or overlapping tribal, State, local government, or other Federal agency authorities.

National Environmental Policy Act (NEPA) of 1969: A law enacted on January 1, 1970 that established a national policy to maintain conditions under which man and nature can exist in productive harmony and fulfill the social, economic, and other requirements of present and future generations of Americans. It established the Council on Environmental Quality for coordinating environmental matters at the federal level and to serve as the advisor to the President on such matters. The law made all federal actions and proposals that could have significant impact on the environment subject to review by federal, state, and local environmental authorities.

Native (indigenous) species: A species of plant or animal that naturally occurs in an area and that was not introduced by humans.

National Forest System (NFS) lands: Forests and grasslands that the Forest Service (FS) manages. Includes both lands reserved from the federal estate and acquired lands.

National forest visit: the entry of one person upon a national forest to participate in recreation activities for an unspecified period of time.

No Surface Occupancy (NSO): A fluid minerals leasing constraint that prohibits occupancy or disturbance on all or part of the lease surface to protect special values or uses. Lessees may exploit the fluid mineral resources under the leases restricted by this constraint through use of directional drilling from sites outside the NSO area.

Objective: A description of a desired condition for a resource. Objectives can be quantified and measured and, where possible, have established time frames for achievement.

Open: Generally denotes that an area is available for a particular use or uses. Refer to specific program definitions found in law, regulations, or policy guidance for application to individual programs. For example, 43 CFR 8340.0-5 defines the specific meaning of "open" as it relates to OHV use.

Orogeny: The process of forming mountains

Petroglyph: A form of rock art created by incising, scratching or pecking designs into rock surfaces.

Pictograph: A form of rock art created by applying mineral based or organic paint to rock surfaces.

Paleobiogeography: The study of the geographic distribution of ancient biodiversity.

Paleoecology: The study of the interactions between fossil organisms and their environments, including their life cycle, their interactions, their natural environment, their manner of death and burial. Paleoecology's aim is to build the most detailed model possible of the life environment of those organisms we find today as fossils.

Paleoenvironments: Ancient environments.

Permitted use: The forage allocated by, or under the guidance of, an applicable land use plan for livestock grazing in an allotment under a permit or lease; expressed in Animal Unit Months (AUMs) (43 CFR 4100.0-5).

Permittee: A person or company permitted to graze livestock on public land.

Phanerozoic: The period of geologic time that is the most recent eon; defined to include all of geologic history characterized by conspicuous animal life. Includes the Paleozoic, Mesozoic, and Cenozoic, and extends from the present to 600 million years ago.

Phylum (*Plural*, Phyla): A taxonomic rank at the level below kingdom and above class.

Physiography: terrain texture, rock types, and geologic structure and history

Planning area: Geothermal potential area; includes all lands regardless of ownership or administration.

Planning analysis: A process using appropriate resource data and NEPA analysis to provide a basis for decisions in areas not yet covered by an RMP.

Planning criteria: The standards, rules, and other factors developed by managers and interdisciplinary teams for their use in forming judgments about decision making, analysis, and data collection during planning. Planning criteria streamlines and simplifies the resource management planning actions.

Prehistoric resources: refer to any material remains, structures, and items used or modified by people before Euro-Americans established a presence in the region.

Project area: Lands within the 12 western states, including Alaska; includes all lands regardless of ownership or administration.

Public lands: Surface acres managed by the Bureau of Land Management (BLM). Includes both lands reserved from the federal estate and acquired lands.

Regression: Fall of sea level relative to the shore with the resulting movement of the sea off the land.

Renewable energy: Resources that constantly renew themselves or that are regarded as practically inexhaustible. These include solar, wind, geothermal, hydro and wood. Although particular geothermal formations can be depleted, the natural heat in the Earth is a virtually inexhaustible reserve of potential energy. Renewable resources also include some experimental or less-developed sources such as tidal power, sea currents and ocean thermal gradients.

Research and Natural Area (RNA): Research Natural Areas (RNAs) are areas that contain important ecological and scientific values and are managed for minimum human disturbance. RNAs are primarily used for non-manipulative research and baseline data gathering on relatively unaltered community types. Since natural processes are allowed to dominate, RNAs also make excellent controls for similar communities that are being actively managed. In addition, RNAs provide an essential network of diverse habitat types that will be preserved in their natural state for future generations.

Resource Advisory Council (RAC): A council established by the Secretary of the Interior to provide advice or recommendations to BLM management. In some states, Provincial Advisory Councils (PACs) are functional equivalents of RACs.

Resource Management Plan (RMP): The BLM considers resource management plans to be synonymous with land use plans so the terms may be used interchangeably. Land use plan decisions made in RMPs establish goals and objectives for resource management (such as desired future conditions), the measures needed to achieve these goals and objectives, and parameters for using public lands. Land use planning decisions are usually made on broad scale and customarily guide subsequent site-specific implementation decisions.

Resource use level: the level of use allowed within an area. It is based on the desired outcomes and land use allocations in the land use plan. Targets or goals for resource use levels are established on an area-wide or broad watershed level in the land use plan. Site-specific resource use levels are normally determined at the implementation level, based on site-specific resource conditions and needs as determined through resource monitoring and assessments.

Revision: The process of completely rewriting the land use plan due to changes in the planning area affecting major portions of the plan or the entire plan.

Right-of-Way (ROW): An easement or permit, which authorizes public land to be used for a specified purpose that generally requires a long narrow strip of land. Examples are roads, power-lines, pipelines, etc.

Seismic exploration: Seismic exploration remains the most common way to locate sub-surface resources. The process involves sending sound waves into the earth at one point and recording them at others after having passed through differing geological strata. There are two common methods utilized today. One method involves the detonation of small explosive charges. The other method consists of a truck that drops a huge weight at various intervals. The data collected is used to show probable sub-surface resource deposits.

Site visit: The entry of one person upon a national forest site or area to participate in recreation activities for an unspecified period of time.

Sole source aquifer: Defined by the US EPA as an aquifer supplying at least 50 percent of the drinking water consumed in the area overlying the aquifer, where the surrounding area has no alternative drinking water source(s) that could physically, legally, and economically supply all those who depend upon the aquifer for drinking water.

Special status species: Includes proposed species, listed species, and candidate species under the ESA; State-listed species; and BLM State Director-designated sensitive species (see BLM Manual 6840 - Special Status Species Policy).

Speciation: The process leading to the creation of new species. It is one form of biological evolution. Speciation occurs when a parent species splits into two (or more) reproductively-isolated populations, each of which then accumulates changes from sexual reproduction and/or random mutation until the populations are no longer capable of interbreeding.

Standard lease terms and conditions: Areas may be open to leasing with no specific management decisions defined in a Resource Management Plan; however, these areas are subject to lease terms and conditions as defined on the lease form (Form 3100-11, Offer to Lease and Lease for Oil and Gas; and Form 3200-24, Offer to Lease and Lease for Geothermal Resources).

State Implementation Plan (SIP): A strategic document, prepared by a State (or other authorized air quality regulatory agency) and approved by the U.S. Environmental Protection Agency, which thoroughly describes how requirements of the Clean Air Act will be implemented (including standards to be achieved, control measures to be applied, enforcement actions in case of violation, etc.).

Stipulation: A condition of lease issuance that provides protection for other resource values or land uses by establishing authority for substantial delay or site changes or the denial of operations within the terms of the lease contract.

Stipulation Standards: the physical and temporal conditions, resources or resource values that must be present and met for application of a specific stipulation to a specific lease

Strategic Plan (BLM Strategic Plan): A plan that establishes the overall direction for the BLM. This plan is guided by the requirements of the Government Performance and Results Act of 1993, covers a 5-year period, and is updated every 3 years. It is consistent with FLPMA and other laws affecting the public lands.

Stromatolite: Stromatolites are commonly thought to have been formed by the trapping, binding, and cementation of sedimentary grains by microorganisms, especially blue-green algae (cyanobacteria).

Subduction: Relates to plate tectonics in which the margin of one plate is subducted (descends) below an adjacent plate.

Subsidence: The lowering of the soil level caused by the shrinkage of organic layers.

Surficial: Pertaining to or lying in or on the surface. Sediments covering bedrock.

Taphonomy: The study of what happens to an organism's remains from the time of death until discovery by a paleontologist in an attempt to better interpret the fossil record and conditions responsible for fossil preservation. It includes processes such as scavenging, weathering, transport, and diagenesis.

Temporal: Refers to geologic time for the purposes of this report.

Tectonic: Tectonics is a field of study within geology concerned generally with the structure of the crust of the Earth and particularly with the forces and movements that have operated in a region to create geomorphic features.

Terranes: A crustal block or fragment that preserves a distinctive geologic history that is different from the surrounding areas and that is usually bounded by faults

Timing Limitation (TL): This stipulation limits activity during a specified period of the year. A TL stipulation is intended for application where standard lease terms are deemed insufficient to achieve the level of resource protection necessary to protect the public interest, but where an NSO is deemed overly restrictive. The scope of the TL stipulation goes beyond ground-disturbing activities to encompass any source of protracted or high-intensity disturbance that could interfere with normal wildlife behavior and adversely affect habitat use. The limitation is applied annually for a specified period lasting more than 60 days. Under the Proposed Plan, TLs may also be applied to land uses and activities other than oil and gas development.

Transmission: The movement or transfer of electric energy over an interconnected group of lines and associated equipment between points of supply and points at which it is transformed for delivery to consumers, or is delivered to other electric systems. Transmission is considered to end when the energy is transformed for distribution to the consumer.

Threatened species: 1) Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, and 2) as further defined by the Endangered Species Act of 1973.

Transgression: Rise of sea level relative to the shore with resulting encroachment of the sea onto the land.

Tribal interests: Native American or Native Alaskan economic rights such as Indian trust assets, resource uses and access guaranteed by treaty rights, and subsistence uses.

Traditional cultural resources or properties: Areas of cultural importance to contemporary communities, such as sacred sites or resource gathering areas.

Utility: A regulated entity which exhibits the characteristics of a natural monopoly. For the purposes of electric industry restructuring, "utility" refers to the regulated, vertically-integrated electric company. "Transmission utility" refers to the regulated owner/operator of the transmission system only. "Distribution utility" refers to the regulated owner/operator of the distribution system which serves retail customers.

Vapor-dominated: A geothermal reservoir system in which subsurface pressures are controlled by vapor rather than by liquid. Sometimes referred to as a dry-steam reservoir.

Visual resource protection program: A program to establish the criteria and methodologies to manage visual resource protection measures throughout the life of a project (from design, construction, and operation of the project through reclamation).

Vertebrate: Animals with vertebrae (back bones), including fish, amphibians, reptiles, birds and mammals.

Waiver: A permanent exemption from a lease stipulation. The stipulation no longer applies anywhere within the leasehold.

Watt: The electrical unit of power. The rate of energy transfer equivalent to 1 ampere flowing under a pressure of 1 volt at unity power factor.

Watt-hour (Wh): An electrical energy unit of measure equal to 1 watt of power supplied to, or taken from, an electric circuit steadily for 1 hour.

Wilderness area: An area of public land designated by an Act of Congress to be protected in its natural condition according to the requirements of the Wilderness Act of 1964.

Wilderness characteristics: Identified by congress in the 1964 wilderness act; namely size, naturalness, outstanding opportunities for solitude or a primitive and unconfined type of recreation, and supplemental values such as geological, archeological, historical, ecological, scenic, or other features. It is required that the area possess at least 5,000 acres or more of contiguous or be of a size to make practical its preservation and use in an unimpaired condition; be substantially natural or generally appear to have been primarily by the forces of nature, with the imprint of man being substantially unnoticeable; and have either outstanding opportunities for solitude or a primitive and unconfined type of recreation.

Wilderness inventory areas : These areas are found in Utah that were not made into WSAs but citizens inventoried and found wilderness characteristics. During the Clinton Administration, the BLM re-inventoried these lands, completed in 1999, and found Wilderness characteristics on these lands.

Wilderness Study Area (WSA): Created by the BLM through the inventory process of the Federal Land Policy and Management Act (FLPMA), which required the BLM to inventory lands under its management authority for wilderness quality and protect those lands until Congress decides whether or not to designate the land as Wilderness.