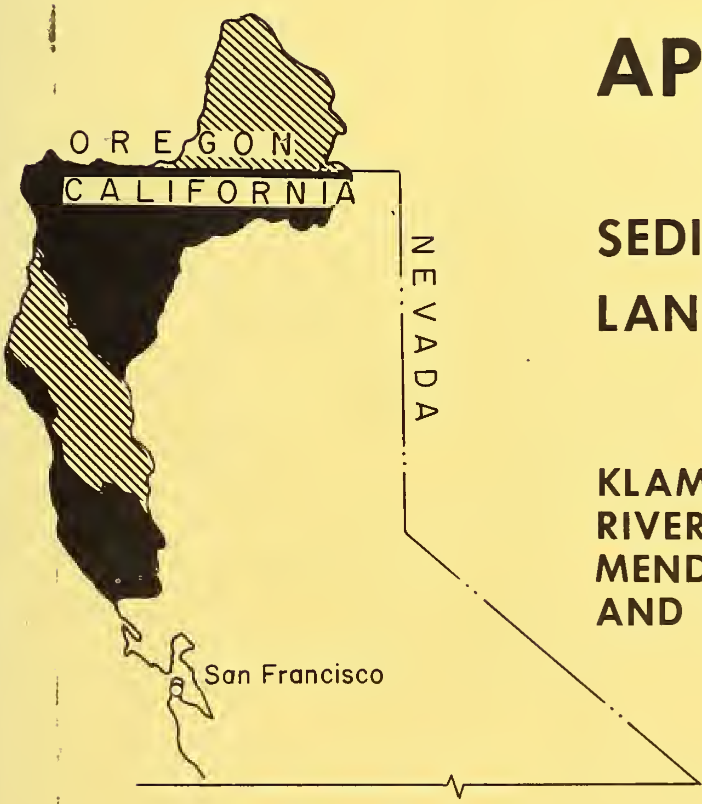
WATER, LAND, AND RELATED RESOURCES

NORTH COASTAL AREA of CALIFORNIA
and PORTIONS of SOUTHERN OREGON



APPENDIX NO. 2

SEDIMENT YIELD and LAND TREATMENT

KLAMATH, TRINITY, AND SMITH RIVER BASINS; RUSSIAN RIVER, MENDOCINO COASTAL, AND CLEAR LAKE BASINS

JUNE 1972

Prepared by the
UNITED STATES DEPARTMENT OF AGRICULTURE
RIVER BASIN PLANNING STAFF
SOIL CONSERVATION SERVICE FOREST SERVICE
ECONOMIC RESEARCH SERVICE
In cooperation with the
CALIFORNIA DEPARTMENT OF WATER RESOURCES

USDA-SCS-PORTLAND, OREGON 1972

WATER, LAND, AND RELATED RESOURCES

North Coastal Area of California
and Portions of Southern Oregon

APPENDIX NO. 2

Sediment Yield and Land Treatment

Klamath, Trinity, and Smith River Basins;
Russian River, Mendocino Coastal, and Clear Lake Basins

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June 1972

A C K N O W L E D G E M E N T S

During the course of the sediment studies, the following organizations provided valuable assistance or information:

FEDERAL AGENCIES

- U.S. Department of Defense
  - Corps of Engineers
- U.S. Department of Interior
  - Bureau of Reclamation
  - Geological Survey
- U.S. Department of Agriculture
  - Pacific Southwest Forest and Range Experiment Station (Forest Service)
  - Soil Conservation Service Areas I & II Area and Work Unit Staffs
  - Economic Research Service

COUNTY AGENCIES

- Mendocino County Engineer's Office
- Mendocino County Farm and Home Advisor's Office (Agricultural Extension Service)
- Humboldt County Farm and Home Advisor's Office (Agricultural Extension Service)

STATE AGENCIES

- California Department of Conservation
  - Division of Forestry
- Department of Water Resources
- Department of Fish and Game

OTHERS

- University of California
  - School of Forestry and Conservation
  - Hopland Field Station
- Numerous private industries and citizens

APPENDIX NO. 2

SEDIMENT YIELD AND LAND TREATMENT

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

T A B L E O F C O N T E N T S

M A P S

T A B L E   O F   C O N T E N T S

M A P S

Follows Page

T A B L E S

Page

TABLE OF CONTENTS

TABLES

Page

PHOTOGRAPHS

S U M M A R Y

The California Department of Water Resources requested a reconnaissance-level study of sources and causes of the high sediment yields in the North Coastal Area and an assessment of the ability of existing USDA programs to solve the problems identified by the study. This study[1/] is made in conjunction with water development studies of other federal and state agencies.

The study area is separated geographically by the Eel and Mad River Basins, and there are significant physiographic and climatic differences between the northern and southern portions; therefore, the two have been treated separately in much of this presentation. The Northern Basins include the Smith and Trinity River Basins and the California portion of the Klamath Basin, comprising some 10,795 square miles; the Southern Basins encompass the Mendocino Coastal Streams (several relatively short rivers that flow directly into the Pacific Ocean), the Russian River, and Clear Lake Basins, comprising some 4,041 square miles. With the exception of the Clear Lake Basin, where runoff flows into the Sacramento River, the rivers outlet directly into the Pacific Ocean.

Steep, mountainous terrain interspersed with narrow valleys typifies most of the area. The soils are generally characterized by their inherent high erodibility, and the parent rock by its weak, fractured nature and its susceptibility to landsliding. The major topographical exception is the relatively flat Modoc Plateau in the Upper Klamath Basin, where the soils are generally stable. Rainfall is heavy in the coastal regions and diminishes progressively from west to east, ranging from over 100 to about 10 inches per year.

This appendix presents the general physical characteristics and resources of the basins, such as topography, soil associations, geology, vegetal cover types, and land use and ownership. It describes the procedures used to investigate erosion, determine sediment yields, and formulate a land treatment program. Sediment rates are given for the various sources and causes, and possibilities for implementing the land treatment program are discussed.

[1/] This publication is the second of two appendices to the report, <u>Water, Land, and Related Resources--North Coastal Area of California and Portions of Southern Oregon.</u> The first covers the Eel and Mad River Basins; this one deals with the remaining river basins in the North Coastal Area and will be followed by the main report.

Sediment yields are summarized as follows:

Basins	Land Area (Square Miles)	Estimated Sediment Yield (Acre-Feet/Year)	Estimated Rate Of Sediment Yield (Acre-Feet/Sq.Mile/Year)
		Present	
Northern	10,795	5,940	0.6
Southern	4,041	4,950	1.2
Total	14,836	10,890	0.7
		Future Without Recommended Program	
Northern	10,795	6,520	0.6
Southern	4,041	6,090	1.5
Total	14,836	12,610	0.9
		Future With Recommended Program	
Northern	10,795	4,850	0.5
Southern	4,041	4,870	1.2
Total	14,836	9,720	0.7

Three sources of sediment -- streambank, landslide, and sheet and gully erosion -- were found to yield 46, 26, and 28 percent, respectively, of the total sediment. In the Northern Basins the percentages were 48, 31, and 21 and in the Southern Basins 45, 19, and 36, respectively. Natural causes are responsible for about 80 percent of sediment from streambanks, 75 percent of that from landslides, but only about 20 percent of that from sheet and gully erosion.

Two types of land treatment programs are recommended -- those designed mainly to reduce sediment yield and those designed primarily to increase production. Guidelines to improve land management and prevent future problems are also presented.

The following is a tabulation of the programs, their costs, and their effects in sediment reduction and/or production improvement.

Program	Installation Cost ($1,000)	Annual Sediment Reduction (Acre-Feet)	Annual Production Increases[1]
Private Lands			
Grassland			
Natural	10,509	190	424,000 AUM
Converted Timberland	3,150	110	9,000 AUM[2] 8 Mil.Cu.Ft.
Brushland Conversion To Timberland	9,232	20	14 Mil.Cu.Ft.
Public Lands			
Grassland Conversion To Timberland	1,792	-	5 Mil.Cu.Ft.
Brushland Conversion To Timberland	3,077	10	5 Mil.Cu.Ft.
Roads	62,349	480	-
Total	90,109	810[3]	433,000 AUM 32 Mil.Cu.Ft.

1/ Grass increases are shown as animal-unit-months of grazing, and timber increases are shown in millions of cubic feet.

2/ Part of the converted timberland will be reforested, and the rest will be managed as grassland.

3/ Adherence to the management guidelines would reduce sediment yield an additional 2,080 acre-feet.

Programs recommended include only those that were found to be economically feasible over large areas. Many remedial measures, such as streambank and landslide stabilization, were determined too costly for normal onsite benefits. However, many such measures may be economically feasible in localized areas where high values are involved.

Under present policy and funding, USDA programs could accomplish only about 16 percent of the land treatment program recommended in this appendix. If USDA programs were to be accelerated, about 24 percent could be realized. Such acceleration would require increased funds as well as intensified informational efforts to interest more landowners.

To accomplish the entire land treatment program, it will be necessary to modify USDA programs so that specific needs of the basins can be fully met. Some proposed modifications are presented in this appendix. For complete success, it is essential that the full capabilities of all USDA, state, and local agencies be utilized and that the local people, particularly the owners of grazing land, become deeply involved.

Alternative solutions are presented in the form of ideas for new programs and legislation that could successfully accomplish the program.

View of the Klamath River. USFS PHOTO

GLOSSARY

The following terms appear periodically in this appendix and are defined here to avoid repetition:

ANIMAL UNIT -- A measure of livestock numbers by which kinds, classes, sizes, and ages are converted to an approximate common standard in relation to feed and forage resources and is based on the equivalent of one mature cow (1,000 pounds, live weight).

ANIMAL UNIT MONTH (AUM) -- A measure of forage or feed requirement to maintain one animal unit for 30 days. See ANIMAL UNIT.

BEDLOAD -- The sediment that moves by sliding, rolling, or bouncing on or very near the streambed; sediment moved mainly by tractive or gravitational forces or both, but at a velocity less than that of the surrounding flow.

DEBRIS SLIDE -- Involves natural soil, unconsolidated sedimentary material, and weathered rock and is usually limited to material that overlies firm bedrock.

INFILTRATION -- The process whereby water passes through an interface, such as from air to soil or between two soil horizons.

PERCOLATION -- The movement of water within a porous medium such as soil.

PRESENT CONDITION -- The average condition for the 24-year study period (1941-1965). The 24-year period was selected because it was the longest interval between flights of the available sets of aerial photographs that could be compared.

SEDIMENT DISCHARGE -- The rate at which dry weight of sediment passes a section of a stream or is the quantity of sediment, as measured by dry weight or volume, that is discharged in a given time.

SEDIMENT YIELD -- The amount of sediment carried past a given point.

SHEET EROSION -- The removal of a fairly uniform layer of soil from the land surface by overland flow; includes rill networks up to six inches deep.

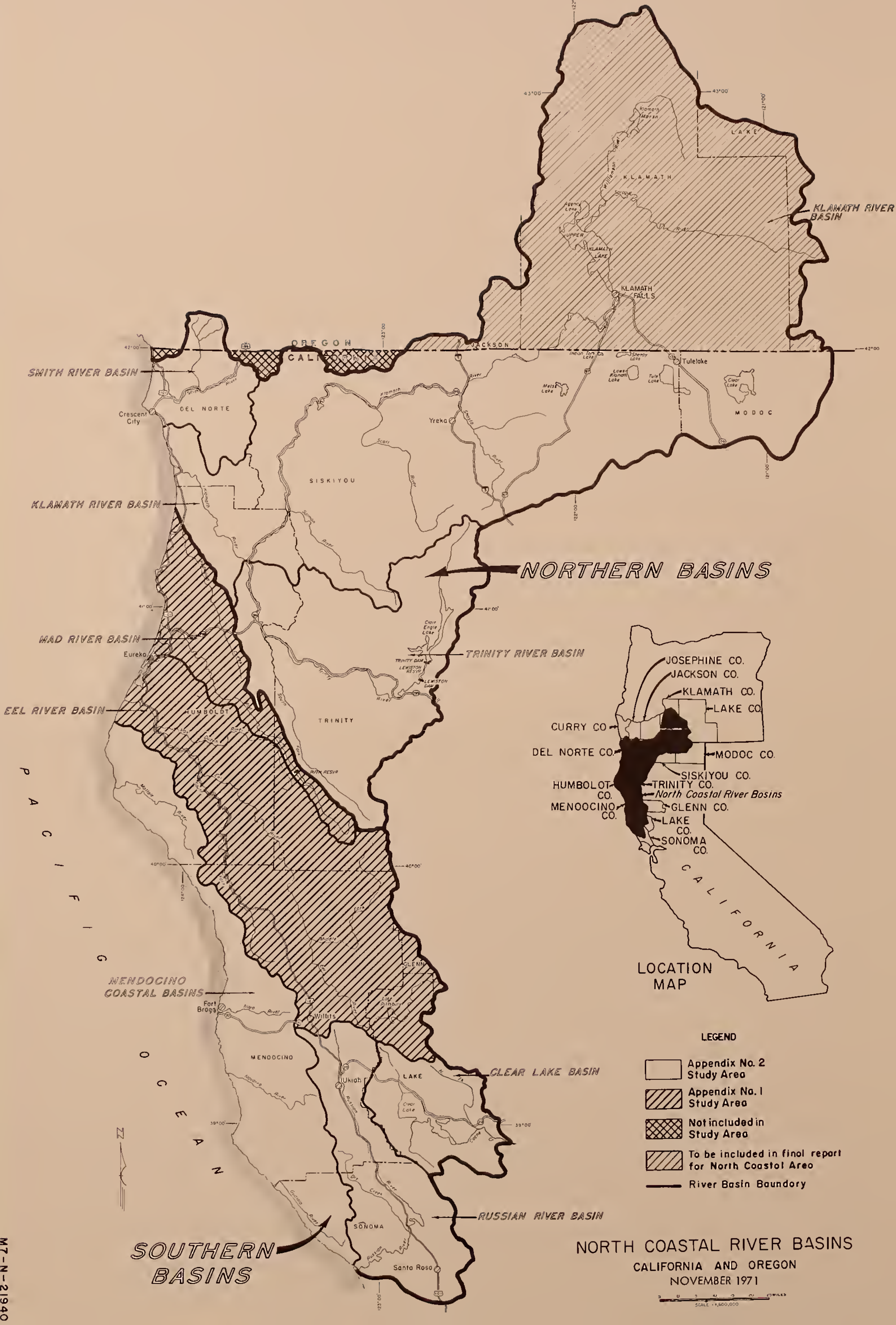
SUSPENDED SEDIMENT -- The sediment that at a given time is maintained in suspension by the upward components of turbulent currents or that exists in suspension as a colloid.

TRAP EFFICIENCY -- The ratio of the amount of sediment retained in a reservoir in respect to the total sediment yield brought into the reservoir.

WATERSHED -- All lands enclosed by a continuous hydrologic drainage divide above a specified point on a stream.

WATERSHED MANAGEMENT -- The inspection, analysis, protection, development, operation, or maintenance of the land, vegetation, fishery, and water resources of a drainage basin for the conservation of all its resources for the benefit of man. Watershed management for water production is concerned with the quality, quantity, and demand schedule of the water that is produced.

WATER TRANSMISSION -- The movement of water in the soil within and across soil horizons.


KLAMATH RIVER BASIN
OREGON
CALIFORNIA
SMITH RIVER BASIN
KLAMATH RIVER BASIN
NORTHERN BASINS
TRINITY RIVER BASIN
MAD RIVER BASIN
EEL RIVER BASIN
MENDOCINO COASTAL BASINS
CLEAR LAKE BASIN
RUSSIAN RIVER BASIN
SOUTHERN BASINS
PACIFIC OCEAN
DEL NORTE
SISKIYOU
MODOC
KLAMATH
LAKE
JACKSON
HUMBOLDT
TRINITY
GLENN
MENDOCINO
LAKE
SONOMA
Crescent City
Yreka
Tulelake
KLAMATH FALLS
UPPER KLAMATH LAKE
Eureka
Fort Bragg
Willits
Ukiah
Santa Rosa
Clear Lake
JOSEPHINE CO.
JACKSON CO.
KLAMATH CO.
LAKE CO.
CURRY CO.
DEL NORTE CO.
MODOC CO.
SISKIYOU CO.
HUMBOLDT CO.
TRINITY CO.
North Coastal River Basins
MENDOCINO CO.
GLENN CO.
LAKE CO.
SONOMA CO.
CALIFORNIA
LOCATION MAP
LEGEND
Appendix No. 2 Study Area
Appendix No. 1 Study Area
Not included in Study Area
To be included in final report for North Coastal Area
River Basin Boundary
NORTH COASTAL RIVER BASINS
CALIFORNIA AND OREGON
NOVEMBER 1971

I N T R O D U C T I O N

NEED FOR THE STUDY

An important mission of the California Resources Agency and its Department of Water Resources is the implementation of the State Water Project, a part of the California Water Plan currently financed to the extent of $1.75 billion as a result of the approval of the California Water Resources Bond Act by the voters in 1960. This Act included provisions for financing additional facilities to augment water supplies in the Sacramento-San Joaquin Delta. In 1957, the Department's Bulletin No. 3, "The California Water Plan," identified the North Coast as the principal remaining source of substantial surface water supplies to meet future needs of the State. In 1964, the Department's Bulletin No. 136, "North Coastal Area Investigations," concluded that the most favorable North Coastal project for augmenting State Water Project supplies in the Delta would involve a multiple-purpose reservoir on the Middle Fork Eel River. Bulletin 136 also recommended continuing reconnaissance studies of plans for later North Coastal projects. In cooperation with the Department and in coordination with the U.S. Department of Defense, Corps of Engineers, and the U.S. Department of the Interior, Bureau of Reclamation, the U.S. Department of Agriculture undertook an extensive study of the North Coastal Area within one of its particular areas of expertise -- namely the sources and causes of the high sediment yields and the ability of USDA programs to solve the problems identified.

Sediment yield is a major problem in the North Coastal Areas, as illustrated by the fact that the Eel River carried over 100 million tons (50,000 acre-feet) of sediment during the 1964 record flood.

Economic development of these basins has taken place slowly and has not reached a high level when compared to other parts of California; unemployment has been high in parts of the basins, and all nine counties in this area of California are designated as eligible for a full financial assistance program under the Economic Development Administration of the U.S. Department of Commerce. Inaccessibility and remoteness from markets have been the primary deterrents to economic growth. With construction of better highways, now underway, these impediments are lessening.

Both past and present land management practices have damaged the watershed to the detriment of the general economy. First, heavy use of grazing lands continues; second, indiscriminate skid logging and repeated accidental and prescribed burning dates from the early 1900's to the present; third, road construction and subsequent erosion and sediment yield continues; and fourth, sporadic dredge and devastating hydraulic placer mining for gold occurred from the mid to late 1800's.

This publication is the second of two appendices to the report <u>Water, Land, and Related Resources -- North Coastal Area of California and Portions of Southern Oregon</u>. Appendix No. 1 covers the Eel and Mad

River Basins in California and presents the findings of the sediment yield and land treatment studies. This appendix presents the same type of information on the remaining basins in the North Coastal Area. The portion of the Klamath River in Oregon is being studied by the USDA River Basin Staff in that state, and their report will be appended to the Main Report for the North Coastal Area.

The overall investigation includes all streams that flow into the Pacific Ocean from the Russian River in the south to the Smith River near the Oregon border. The portions of the Klamath and Smith River Basins in Oregon are included in the study area. The total area encompasses about 25,000 square miles, of which about 19,500 square miles are in California and 5,500 square miles are in Oregon.

AUTHORITY FOR THE STUDY AND PARTICIPATING USDA AGENCIES

On March 11, 1964, the California Department of Water Resources requested the U.S. Department of Agriculture to cooperate with other state and federal agencies in a study of the Eel River Basin. In the course of inter-agency deliberations, the Department of Water Resources extended its request to encompass the entire area of the North Coastal Basins. The Department of Agriculture agreed to participate in such a study under the authority of Section 6 of the Public Law 566, as amended. The Department of Agriculture agencies that participated in the study are the Economic Research Service, the Forest Service, and the Soil Conservation Service.

OBJECTIVES OF THE STUDY

The survey has five major objectives:

1. To estimate the sediment yield by sources and causes under present conditions.

2. To estimate the future sediment yield under the expected use and management.

3. To formulate a land treatment program that would reduce the sediment yield and to estimate the costs of remedial measures.

4. To evaluate the physical effects of the recommended program.

5. To evaluate the potential development that could be obtained through U.S. Department of Agriculture programs.

DESCRIPTION OF THE STUDY AREA

Results of studies made in the Russian River, Mendocino Coastal, and Clear Lake Basins in the southern portion of the North Coastal Area and in the Klamath, Trinity, and Smith River Basins to the north are reported in this appendix. Several small intervening coastal streams between the Klamath and Smith Rivers are included. This study area encompasses 14,904 square miles, of which 14,816 square miles are in California and 88 square miles of the Smith River drainage are in Oregon. Parts of Del Norte, Siskiyou, Modoc, Humboldt, Trinity, Mendocino, Sonoma, and Lake Counties in California and of Curry County in Oregon lie in the study area. A study of the 5,640 square miles in the Klamath River drainage in Oregon will be prepared by the USDA River Basin Staff in Oregon and will be presented in a separate report.

INTER-AGENCY COORDINATION

Coordination of the joint planning efforts in the North Coastal Area is provided by the California State-Federal Inter-Agency Group, which consists of the California Department of Water Resources, the Corps of Engineers, the Bureau of Reclamation, and the Soil Conservation Service. Other agencies are represented through their membership in the technical subgroups of the Inter-Agency Group. The objectives of the group are to facilitate coordination and cooperation among the various state and federal agencies and to eliminate duplication.

Primary study responsibilities were assigned to the four agencies according to their major interests. The Department of Water Resources was assigned the responsibility for determining the state water requirements and providing the overall coordination for the joint planning efforts, the Corps of Engineers for flood control in the main streams and the major tributaries, the Bureau of Reclamation for irrigation water development at major projects and the development of hydroelectric power for inclusion into federal power transmissions, and the Soil Conservation Service for watershed management studies and the investigation of flood control and irrigation projects in connection with U.S. Department of Agriculture programs.

The Inter-Agency Group will consider all agency study results in planning development of water and related land resources in the North Coastal area. The main objective of such planning is to improve living conditions of the people by enhancing the physical environment and improving the economic opportunities. Consideration for the complete development of water and related land resources will be given to flood control, local water supplies, water quality control, hydroelectric power, recreation development, sediment and erosion reduction, improved watershed management practices, enhanced fishing and hunting programs, and possible export of excess water to water deficient areas of California.

NATURE AND INTENSITY OF THE INVESTIGATIONS

Overall North Coastal Area investigations are being made at a reconnaissance level, with added emphasis placed on sediment yield problems. The intensity of the sediment yield studies was greater than that normally associated with a Type IV river basin survey. Watershed investigations were made to determine the opportunities for solving soil and water problems in the North Coastal Area through Public Law 566 projects. The full potential for development of these watersheds was the main consideration of the investigations, which were made only in sufficient detail to assure that a project is feasible.

Aerial view of Dry Creek Watershed, Russion river Basin. SCS PHOTO

LAND RESOURCES AND USE

Information regarding geology, soils, and vegetation is basic to studies of watershed management and serves as a guide in designing programs suited to the needs and limitations of the resource. After the inter-relationship of these factors is understood, interpretations regarding land use and management can be made. These include land capability classification for cropland, range, forest, and woodland production and the determination of suitability of sites for road location, recreation development, and the construction of buildings and other cultural features.

AVAILABLE DATA

Aerial photographs of the entire North Coastal Survey Area were taken in 1965 for this study and were used in combination with available older photographs. The oldest, taken in 1941, cover most of Mendocino County; 1942, 1944, 1947, 1948, or 1952 photographs cover the remainder of the basins.

The Santa Rosa, Ukiah, Redding, Weed, and Alturas sheets of the "Geologic Maps of California" published by the California Division of Mines and Geology[1/] were used to develop a generalized geologic map.

In compiling soils information, available data and maps were used extensively. The Soil-Vegetation Maps, prepared by the Pacific Southwest Forest and Range Experiment Station with funding by the California Division of Forestry[2/], cover the upland area outside the National

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1/ California Resources Agency, Department of Conservation, Division of Mines and Geology, Geologic Map of California; Ukiah Sheet. (San Francisco, 1960).
. . . Alturas Sheet. (1958).
. . . Redding Sheet. (1962).
. . . Santa Rosa Sheet. (1963).
. . . Weed Sheet. (1964)

2/ Cooperative Soil-Vegetation Survey Project: California Department of Natural Resources, Division of Forestry, in cooperation with the University of California and the USDA Forest Service California Forest and Range Experiment Station. Upland Soils [Map] of Lake County. (Sacramento; State Printing Division, Documents Section, 1955); Upland Soils [Map] of Mendocino County, (1951); Soil Vegetation Survey Maps. (San Francisco, USDA Forest Service, latest available editions).

Forests in Lake, Sonoma, Trinity, Mendocino, and Humboldt Counties and portions of the Mendocino National Forest in Lake County. The survey team prepared generalized soil association maps using both published and unpublished data.1/ through 5/

The most recent editions of U.S. Geologic Survey 15-minute topographic quadrangles were used to determine slope gradients when needed to supplement the Soil-Vegetation Maps.

The Vegetal Cover Types Maps for the basins were prepared from Timber Stand Maps of the Soil-Vegetation Survey when they were available. For areas not covered by Soil-Vegetation Survey Maps, National Forest Timber Stand Maps were used.6/ Information from the maps was supplemented with vegetal cover interpretations made from 1965 aerial photographs.

1/ Robert A. Gardner and others, Wildland Soils and Associated Vegetation of Mendocino County, California. (Sacramento; Resources Agency of California, Cooperative Soil-Vegetation Survey Project, 1964). 113 pp.

2/ James McLaughlin and Frank Harradine, Soils of Western Humboldt County, California. (Department of Soils and Plant Nutrition, University of California, Davis, in cooperation with the County of Humboldt, November 1965). 85 pp.

3/ USDA Soil Conservation Service, Report and General Soil Map; (for the following counties in California) Del Norte (12/67) 37 pp; Humboldt (4/67) 51 pp; Lake (4/67) 45 pp; Mendocino (2/67) 56 pp; Modoc (4/67) 49 pp; Siskiyou (3/67) 50 pp; Sonoma (1/67) 64 pp; Trinity (6/67) 30 pp. (Berkeley, California) Unpublished report.

4/ K.E. Lanspa and others, Siskiyou Study Area Soil Survey Report; Six Rivers-Klamath National Forests. (Unpublished Report) (San Francisco; USDA Forest Service, California Region; October 1968). 52 pp. plus maps.

5/ USDA Forest Service, California Region, Soil-Vegetation and Timber Stands Maps, Orleans Ranger District, Six Rivers National Forest. 1964. (Unpublished maps and legend)

6/ USDA Forest Service, Six Rivers National Forest, Timber Stand Maps. (San Francisco, 1967).

TOPOGRAPHY

SOUTHERN BASINS

The principal topographical features of Southern Basins -- the Russian, Mendocino Coastal, and Clear Lake Basins -- are the rugged northwest-southeast trending ridges and valleys. These reflect the geologic structural features of the basin, such as faults, folds, and contacts between formations, all of which have the same general alignment. The San Andreas Fault cuts through the western part of the basins and extends beneath the Pacific Ocean near Point Arena. This fault zone is characterized by a valley along most of its length. The Gualala and Garcia Rivers turn and follow the fault in their lower reaches.

As a consequence of the topography, the general trend of the main streams in the basin in northwest-southeast, and those streams crossing the structural grain of the basin usually do so at right angles, resulting in a rectilinear pattern known as trellis drainage.

Other important topographic features of these basins are the alluvial valleys, coastline, and a large lake. Most of the irrigable land occurs in the broad alluvial valleys scattered throughout the basin; the most prominent ones are Anderson, Potter, Redwood, and Ukiah Valleys, the flatlands around Clear Lake, and the alluvial plains around Santa Rosa and along the Russian River. The rugged coastline is noted for its spectacular and relatively unspoiled scenery. Clear Lake, located on the eastern side of the basins, is one of the largest natural fresh-water lakes in the State with a surface area of about 68 square miles. Lake Mendocino, a man-made lake in the Russian River Basin, is the only sizeable impoundment.

NORTHERN BASINS

The topography of Northern Basins -- the Klamath, Trinity, and Smith Basins -- is typified by rugged mountains and deep, narrow canyons in the western portion. The eastern portion consists of gently rolling to relatively flat plateau country dotted with many prominent volcanic cones. Mt. Shasta, with an elevation of 14,162 feet, one of the highest peaks in the United States, is the highest peak in the study area.

The drainage pattern of most of the Trinity, Smith, and western Klamath Basins is dendritic -- an irregular, branching pattern not controlled by underlying geologic structures. Some exceptions occur where streams flow parallel to the structural trend of the underlying rocks; examples are the South Fork Trinity River, and the lower reaches of the Klamath and Smith Rivers.

In the eastern Klamath Basin, an area underlain by volcanic rocks, much of the drainage is disjointed and irregular. The volcanic topography is relatively smooth over a large area, but individual cones or small areas may have steep relief. Consequently, much of the precipitation that falls on the area collects in small interior basins, where it evaporates or sinks into porous volcanic rock.

Most of the irrigable land is in broad alluvial valleys, such as Hayfork and Hyampom Valleys in the Trinity Basin, and Scott, Shasta, Butte, and Tule Lake Valleys in the upper part of the Klamath Basin. The flood plain near the mouth of the Smith River also supports some irrigated crops.

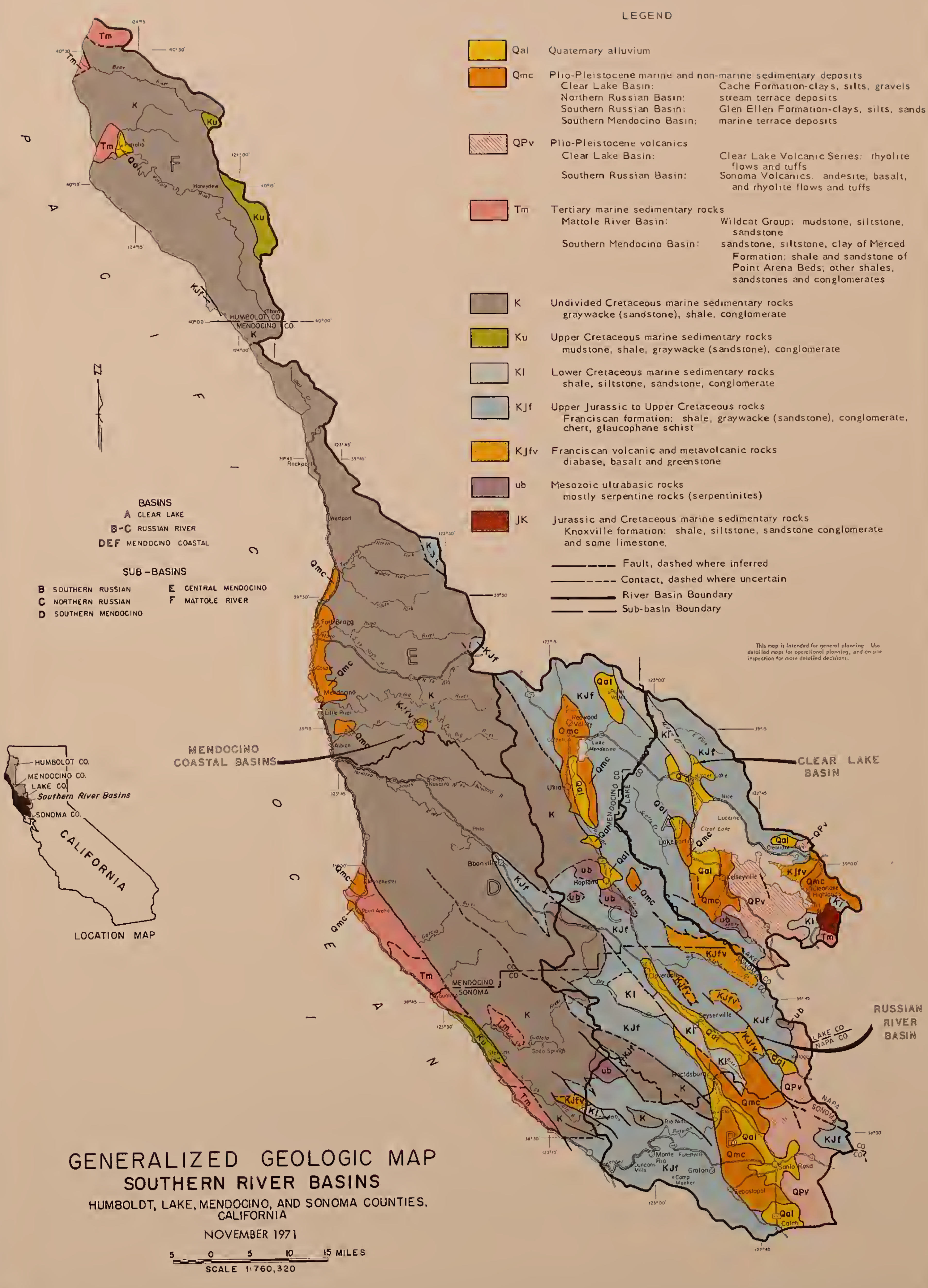
Spectacular scenery abounds in the basins. The area contains the Salmon-Trinity Alps Primitive Area, the Marble Mountain Wilderness, and part of the Yolla Bolly-Middle Eel Wilderness, totaling about 500,000 acres. These are particularly impressive for their remoteness and scenic beauty. Small mountain lakes formed by glacial action are abundant in some of the high mountain regions. Clair Engle Lake, on the Trinity River, is the largest manmade lake in the basins; others include Lewiston Reservoir on the Trinity River, Dwinnell Reservoir on the Shasta River, and Copco and Iron Gate Reservoirs on the Klamath River.

GEOLOGY

SOUTHERN BASINS

The basins contain rocks typically found in the Northern California Coast Ranges. The rocks range in age from Late Jurassic to Recent and are predominantly marine sediments. About 79 percent of the area is underlain by Franciscan rocks or rocks generally associated with the Franciscan. These rocks include the undivided Cretaceous marine sedimentary rocks or coastal belt rocks of the Franciscan formation (K), "typical" Franciscan rocks (KJf), Franciscan volcanic and metavolcanics (KJfv), and ultrabasic rocks, such as serpentinite (ub). The Great Valley sequence comprises about 3 percent of the rocks in the basins and is comprised of Upper (Ku) and Lower (Kl) Cretaceous marine sedimentary rocks. Tertiary marine (Tm) sediments comprise about 2 percent of the rocks; Pliocene and Pliestocene volcanic (QPv) and sedimentary (Qmc) rocks comprise 10 percent; and the remaining 6 percent of the basin is underlain by alluvium (Qal). The extent of these geologic assemblages in the various basins is shown on the Generalized Geologic Map and in the table "Area of Major Geologic Units" on the following pages.

The Franciscan formation is a heterogeneous mass of sedimentary, volcanic, and metamorphic rocks highly fractured and deformed by folding, faulting, and metamorphism. The formation has been intruded by basic and ultra-basic rocks that are predominantly serpentinized. The volcanic rocks, which are interbedded with marine sediments, are mostly submarine lava flows that are now largely altered to greenstone. By far the most prevalent rock type in the Franciscan formation is greywacke, a sandstone, which is commonly associated with minor amounts of shale. Chert is also common. The Great Valley sequence, although about the same age as the Franciscan formation, has less volcanic rock



USDA-SCS-PORTLAND, OREG. 1971

M7-N-21147

Area of Major Geologic Units--Southern Basins
(Square Miles)

Map Symbol	Geologic Assemblage	River Basin				Percent (Rounded)
		Russian	Mendocino Coastal	Clear Lake	Total	
Qal	Alluvium	130	24	85	239	6
Qmc	Plio-Pleistocene marine and nonmarine sediments	166	86	11	263	6
QPv	Plio-Pleistocene Volcanics	87	-	78	165	4
Tm	Tertiary marine sediments	-	78	5	83	2
K	Undivided Cretaceous marine sediments	189	1,787	-	1,976	49
Ku,Kl	Cretaceous marine sediments	56	34	30	120	3
KJf	Franciscan formation (marine sediments)	728	69	214	1,011	25
KJfv	Franciscan volcanics and metavolcanics	80	15	14	109	3
ub	Ultrabasic rocks (mostly serpentinite)	49	5	11	65	2
JK	Knoxville formation (marine sediments)	-	-	10	10	-
	TOTALS	1,485	2,098	458	4,041	100

and chert and many more fossils; it is also much less structurally deformed and much more regularly bedded.

Tertiary rocks outcrop in an area west of the San Andreas Fault and in small isolated areas near the coast. Generally, the Tertiary rocks are of marine origin and consist of sandstone, siltstone, and conglomerate. Sedimentary and volcanic rocks of younger age occur near Santa Rosa and around Clear Lake.

Erodibility of the various broad geologic formations or assemblages is variable and depends upon many factors such as mineralogy, degree of weathering, and structural history. Generally, the Franciscan formation is highly unstable, largely because of the presence of both small and very large faults and shear zones often hundreds of feet wide. The deeply weathered Franciscan formation contains shale interbedded with more massive rocks, and serpentinite is common. These inherently weak structural features, combined with high rainfall, prolonged storms, high peak flows, and rugged terrain, account for the widespread instability and erodibility of the Franciscan formation. Consequently, landslides, streambank erosion, and soil creep are common. In contrast, the volcanic rock in the Clear Lake and Russian River Basins is relatively stable and produces very little sediment from mass erosion processes, such as landslides and streambank erosion.

A commercial steam field is located within the Russian River Basin on the upper reaches of Big Sulphur Creek in an area known as The Geysers. This area remains an attraction as a spa. The Pacific Gas and Electric Company of San Francisco is developing the area and has been producing power from steam wells since 1960. The Geysers area is unique in that it is the only steam field outside of Italy which produces dry steam, and it is the only field in the United States sufficiently developed to produce electric power.

NORTHERN BASINS

The basins contain a complex array of rock types, including volcanics in the eastern part, older deformed and metamorphosed sedimentary and intrusive rocks in the central or mountainous part, and softer folded and faulted rocks of the Franciscan formation in the western coastal region. Ages range from Silurian or possibly older (300-400 million years) to recent sediments. About 20 percent, or 2,100 square miles, of the basin is underlain by intrusive rocks, such as granite, peridotite, and serpentinite. Young volcanic rocks cover another 25 percent, or 2,700 square miles, and about 37 percent, or 3,900 square miles, is underlain by older metamorphosed rocks. The Franciscan formation and unnamed Jurassic sediments and metasediments underlie about 12 percent of the basins. The remaining 6 percent is underlain by recent sediments, such as stream and lake deposits and Pleistocene terraces. The Generalized Geologic Map and the table "Area of Major Geologic Units" are shown on the following pages. The map shows the extent of these rock types, and the table shows a detailed breakdown of the various rock types shown on the map. Erodibility varies across the basin. The Franciscan formation, which outcrops in the western part of the basin, is easily eroded, LEGEND

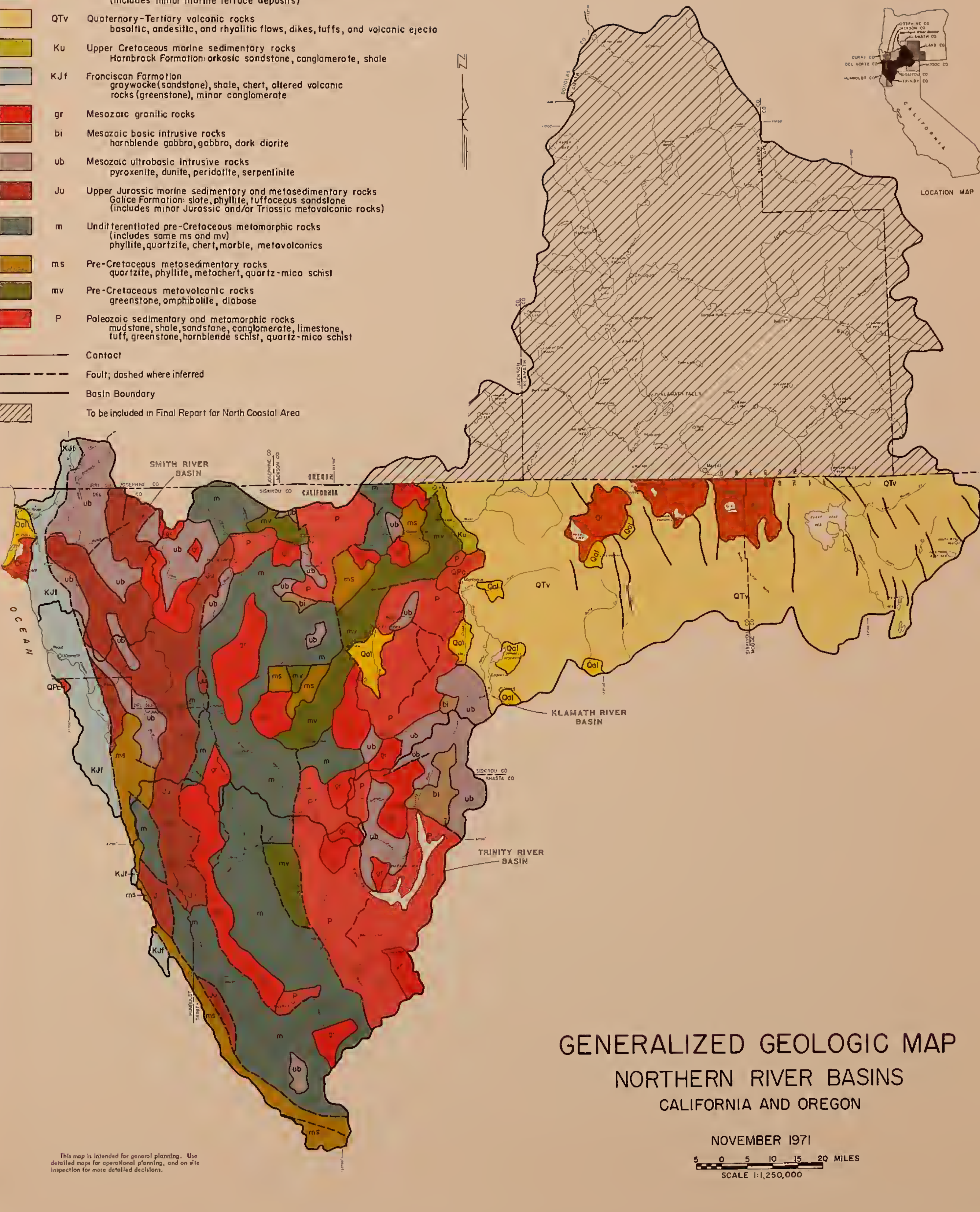
Qal	Quaternary alluvium and dune sand
Ql	Quaternary lake deposits clay, volcanic ash, diatomite, sand
QPc	Pliocene-Pleistocene non-marine sedimentary deposits clay, sand, gravel, sandstone, conglomerate (includes minor marine terrace deposits)
QTv	Quaternary-Tertiary volcanic rocks basaltic, andesitic, and rhyolitic flows, dikes, tuffs, and volcanic ejecta
Ku	Upper Cretaceous marine sedimentary rocks Hornbrook Formation: arkosic sandstone, conglomerate, shale
KJf	Franciscan Formation graywacke (sandstone), shale, chert, altered volcanic rocks (greenstone), minor conglomerate
gr	Mesozoic granitic rocks
bi	Mesozoic basic intrusive rocks hornblende gabbro, gabbro, dark diorite
ub	Mesozoic ultrabasic intrusive rocks pyroxenite, dunite, peridotite, serpentinite
Ju	Upper Jurassic marine sedimentary and metasedimentary rocks Galice Formation: slate, phyllite, tuffaceous sandstone (includes minor Jurassic and/or Triassic metavolcanic rocks)
m	Undifferentiated pre-Cretaceous metamorphic rocks (includes some ms and mv) phyllite, quartzite, chert, marble, metavolcanics
ms	Pre-Cretaceous metasedimentary rocks quartzite, phyllite, metachert, quartz-mica schist
mv	Pre-Cretaceous metavolcanic rocks greenstone, amphibolite, diabase
P	Paleozoic sedimentary and metamorphic rocks mudstone, shale, sandstone, conglomerate, limestone, tuff, greenstone, hornblende schist, quartz-mica schist

Contact

Fault; dashed where inferred

Basin Boundary

To be included in Final Report for North Coastal Area



GENERALIZED GEOLOGIC MAP
NORTHERN RIVER BASINS
CALIFORNIA AND OREGON

NOVEMBER 1971

5 0 5 10 15 20 MILES

SCALE 1:1,250,000

This map is intended for general planning. Use detailed maps for operational planning, and on site inspection for more detailed decisions.

M7-S-21456-N

Area of Major Geologic Units--Northern Basins
(Square Miles)

Map Symbol	Geologic Assemblage	River Basin Klamath	Trinity	Smith	Total	Percent (Rounded)
Qal	Alluvium	166	-	29	195	2
Ql	Lake Deposits	318	-	-	318	3
QPc	Nonmarine sediments	41	-	20	61	1
QTv	Volcanic rocks	2,675	-	-	2,675	25
Ku	Marine sediments	42	-	-	42	1
KJf	Franciscan formation	246	24	160	430	4
gr	Granitic rocks	535	413	20	968	9
bi	Basic intrusives (gabbro)	24	72	-	96	1
ub	Ultra-basic intrusives (serpentinite, pyroxenite)	460	278	277	1,015	9
Ju	Older marine sediments	394	232	284	910	8
m	Undifferentiated metamorphics	982	999	-	1,981	18
ms	Metamorphosed sediments	250	201	-	451	4
mv	Metamorphosed volcanics	353	81	-	434	4
P	Oldest sediments and metamorphics	550	669	-	1,219	11
	TOTALS	7,036	2,969	790	10,795	100

and some metasedimentary rocks (m, ms on geologic map) are extremely erodible when disturbed. Important outcrops of these rocks are found in the South Fork, Lower Trinity, and Middle Klamath Subbasins. Volcanic rocks in the Butte Valley-Lost River and Shasta Valley Subbasins are very resistant to erosion.

Four episodes of glaciation have been recognized in the Trinity Alps. Evidence of past glaciation in the high mountainous areas includes U-shaped valleys, cirques, glacial lakes, and moraines. Glacial deposits along the valley sides (lateral moraines) are composed of sand, gravel, and boulders and are easily eroded. As a consequence, large quantities of boulders and gravel, derived from the moraines, have been eroded and redeposited downstream. Examples of such gravel deposits can be found along Swift Creek and Union Creek in the Trinity Alps and along Kidder and Canyon Creeks in the Marble Mountains.

SOILS

Information from soil surveys was utilized and supplemented by a generalized soil map of most national forest lands.

Several hundred phases of about 200 soil series and miscellaneous land types were combined into 92 soil associations for the river basin study of the North Coastal Area. Soil association names were derived from soil series names. The distribution of the soil associations is shown on the General Soil Maps and in the tables "Approximate Area of Soil Associations" on the following pages.

Detailed data on soils is presented in the Addendum to this appendix; included are the tables "Soil Characteristics, Qualities and Interpretive Groupings," interpretive maps, and definitions.

SOUTHERN BASINS

The dominant soils of these basins -- the Russian, Mendocino Coastal, and Clear Lake -- are in the Hugo and Josephine series, which comprise about 47 percent of the area. Both have loam or gravelly loam surface textures, but the Josephine soils have a higher clay content in the subsoils. They are from 30 to 60 inches or more in depth over fine-grained sandstone, and are used mainly for commercial timber production. Slope gradients range from 0 to 75 percent.

Laughlin soils cover 12 percent of the basins and occur on 30 to 50 percent slopes. They generally support grass, forbs, oak, and manzanita and are principally used for grazing. These soils have a loam surface and sandy clay loam subsoils underlain at depths of 20 to 40 inches by sandstone or shale.

The shallow Maymen and Henneke soils, which comprise about 12 percent of the Southern Basins, average 10 to 20 inches deep over parent material. Maymen soils are underlain by shattered hard sandstone, and Henneke soils by serpentine. Slopes range from 9 to 75 percent. Gravelly loam or gravelly sandy loam surface textures characterize these soils; the Henneke soils have a very gravelly clay subsoil. The vegetal cover consists of manzanita, chamise, oaks, and small shrubs, with an understory of grasses and forbs. The soils are located on 9 to 75 percent slopes and are mainly used for watershed and wildlife habitat.

Soils of the valleys and terraces make up about 20 percent of the basins. These soils are quite variable as to surface and subsoil texture, depth, drainage, and other properties. They usually occur on slopes of less than 9 percent and are mainly used for cropland and pasture. The remaining 9 percent of the soils are generally steeper than 30 percent and rocky. They are used mainly for woodland, wildlife, and watershed.

NORTHERN BASINS

About 60 percent of the basins consists of soils that normally support timber, such as Sheetiron, Masterson, Hugo, Josephine, Boomer, and Neuns series soils. Slopes range from 0 to 75 percent. All except Boomer and Neuns are formed from sandstone and shale and have gravelly loam surface soils, with bedrock at 30- to 60-inch depths. The Boomer and Neuns soils have gravelly, sandy loam surface soils over gravelly clay loam subsoils. Bedrock usually occurs between 40 and 60 inches deep.

About 20 percent of the area is made up of rock land or lava flows intermingled with very shallow to moderately deep members of the Yolla Bolly, Windy, Dubakella, and similar series. The vegetal cover is generally sparse, consisting of grasses and forbs, shrubs, oaks, and mixed conifer.

Cultivated areas near the coast, about 0.5 percent of the area, are confined mostly to the Ferndale and Timmons series. Both are used for pasture, and although both are highly suited for redwood growth, only the Timmons now has redwood stands. These soils are well drained, very deep, and have loam or silt loam textures.

The major portion of the soils used for cultivation and some pasture or grazing occur in the Klamath Basin. These soils comprise about 20 percent of the area. They are members of the Bieber, Modoc, Stoner, Greenhorn, and similar series. These soils have a variety of characteristics, ranging from gravelly sandy loam through loam to clay loam surface textures, with slopes mainly from 0 to 9 percent. Most are moderately deep to deep. Some, such as the Modoc, have hardpans that occur at about 3 feet; in the Bieber the hardpan occurs at about 2 feet. These soils are mostly used for irrigated or dry pasture, grain, and hay.

Approximate Area of Soil Associations--Southern Basins

Soil Association (Number)	Soil Associations (Name)	Area (Square Miles)				Percent of Total Area
		Russian Basin	Mendocino Coastal Basins	Clear Lake Basin	Total	
1	Mendocino - Caspar - Empire association, 0 to 30 percent slopes	-	95	-	95	2.4
2	Larabee - Mendocino - Caspar association, 30 to 50 percent slopes	-	20	-	20	0.5
3	Hugo - Josephine association, 0 to 30 percent slopes	30	85	-	115	2.8
4	Hugo - Josephine association, 30 to 50 percent slopes	120	645	55	820	20.5
5	Hugo - Josephine association, 50 to 75 percent slopes	145	800	-	945	23.6
8	Kneeland association, 9 to 50 percent slopes	-	35	-	35	0.9
9	Kneeland association, 50 to 75 percent slopes	-	20	-	20	0.5
10	Yorkville association, 15 to 50 percent slopes	50	55	-	105	2.6
11	Laughlin association, 0 to 30 percent slopes	40	10	40	90	2.2
12	Laughlin association, 30 to 50 percent slopes	230	75	-	305	7.5
13	Laughlin association, 50 to 75 percent slopes	50	25	-	75	1.8
15	Henneke association, 9 to 50 percent slopes	55	-	10	65	1.6
16	Maymen - Los Gatos association, 15 to 75 percent slopes	215	55	160	430	10.7
17	Boomer association, 30 to 50 percent slopes	15	-	-	15	0.4
18	Boomer association, 50 to 75 percent slopes	10	5	-	15	0.4
19	Colluvial land - Landslide association, 9 to 75 percent slopes	10	15	-	25	0.6
24	Wilder association, 15 to 50 percent slopes	-	10	-	10	0.2
26	Dune land - Coastal beaches association, 0 to 30 percent slopes	-	5	-	5	0.1
29	Yolo - Zamora association, 0 to 2 percent slopes	30	-	20	50	1.2
30	Ferndale - Russ association, 0 to 9 percent slopes	-	10	-	10	0.2
33	Carlotta - Ettersburg association, 0 to 5 percent slopes	-	10	-	10	0.2
34	Riverwash - Alluvial land association, 0 to 9 percent slopes	10	8	3	21	0.5
35	Cole - Clear Lake association, 0 to 2 percent slopes	-	-	25	25	0.6
36	Pinole - Talmage association, 0 to 9 percent slopes	45	5	-	50	1.2
37	Noyo - Blacklock assoication, 0 to 30 percent slopes	-	40	-	40	1.0
38	Maywood - Zamora association, 0 to 5 percent slopes	35	10	-	45	1.1
39	Arcata - Rohnerville association, 0 to 9 percent slopes	-	40	-	40	1.0
42	Pajaro association, 0 to 2 percent slopes	5	-	15	20	0.5
43	Goulding - Toomes association, 9 to 30 percent slopes	30	-	-	30	0.7
44	Forward - Kidd - Rock land association, 30 to 75 percent slopes	15	-	-	15	0.4
46	Spreckles - Felta association, 15 to 50 percent slopes	50	-	-	50	1.2
47	Goulding - Toomes association, 30 to 50 percent slopes	40	-	-	40	1.0
48	Cotati association, 2 to 9 percent slopes	10	-	-	10	0.2
49	Goldridge association, 2 to 15 percent slopes	40	15	-	55	1.4
51	Huichica - Wright association, 0 to 9 percent slopes	55	-	-	55	1.4
52	Clear Lake association, 0 to 2 percent slopes	25	-	-	25	0.6
53	Suther - Yorkville association, 15 to 50 percent slopes	40	5	5	50	1.2
55	Pinole - Manzanita association, 2 to 9 percent slopes	-	-	30	30	0.7
56	Yolo - Cortina - Pleasanton association, 0 to 2 percent slopes	85	-	-	85	2.1
57	Sobrante association, 15 to 50 percent slopes	-	-	10	10	0.2
58	Konokti - Pluth association, 30 to 75 percent slopes	-	-	35	35	0.9
59	Hesse - Glenview association, 15 to 50 percent slopes	-	-	10	10	0.2
60	Cohasset - Red Hill association, 0 to 30 percent slopes	-	-	35	35	0.9
62	Phipps - Soper association, 15 to 50 percent slopes	-	-	5	5	0.1
Total		1485	2098	458 1/	4041	100.0

1/ Does not include Clear Lake - 68 square miles.

GENERAL SOIL MAP
SOUTHERN RIVER BASINS

HUMBOLDT, LAKE, MENDOCINO, AND SONOMA COUNTIES, CALIFORNIA

NOVEMBER 1971

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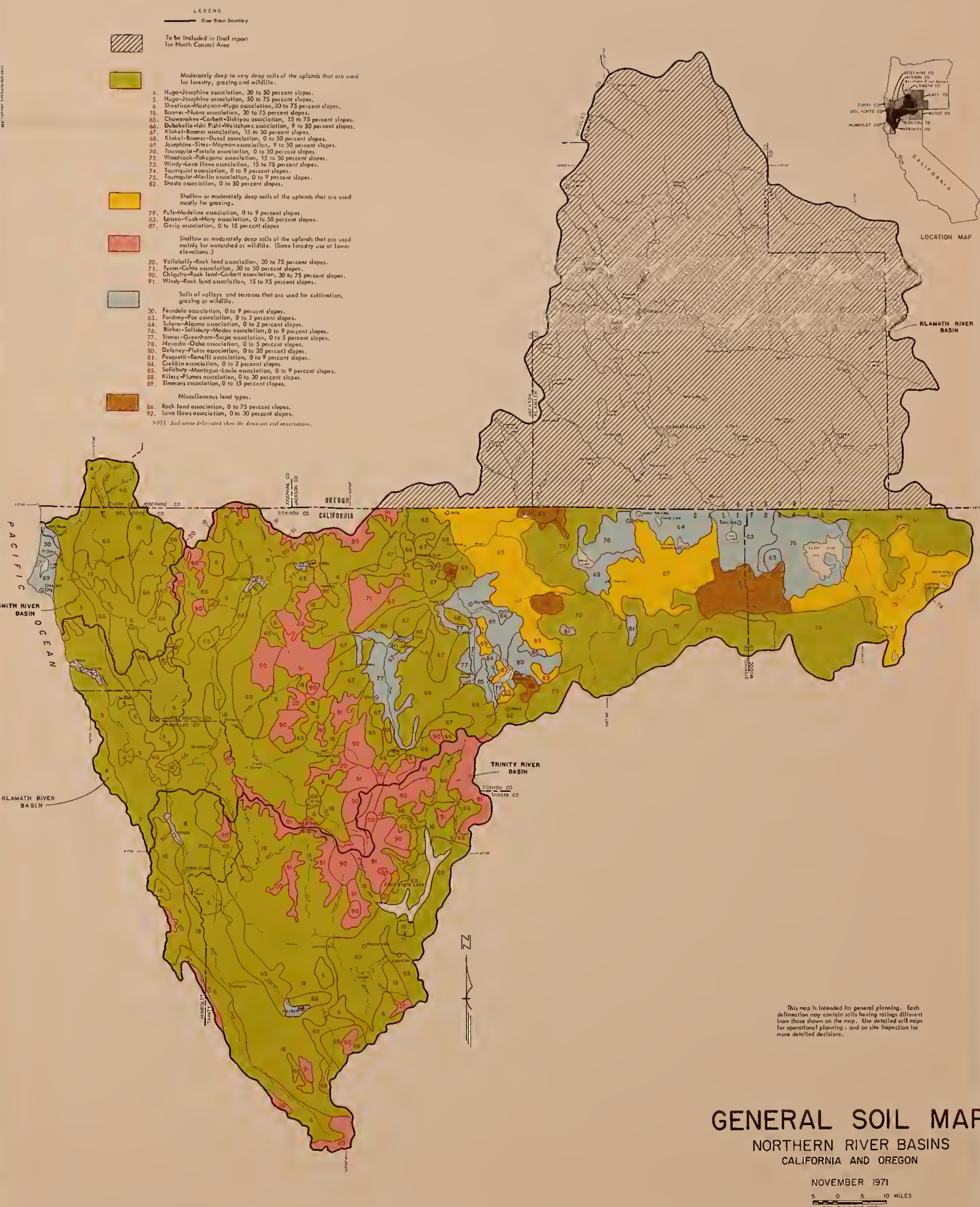

GENERAL SOIL MAP

NORTHERN RIVER BASINS

CALIFORNIA AND OREGON

NOVEMBER 1971

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SCALE 1:1,250,000

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Approximate Area of Soil Associations--Northern Basins

Soil Association (Number)	Soil Associations (Name)	Area (Square Miles)				Percent of Total Area
		Klamath Basin	Trinity Basin	Smith Basin	Total	
4	Hugo-Josephine association, 30 to 50 percent slopes	70	95	120	285	2.7
5	Hugo-Josephine association, 50 to 75 percent slopes	220	5	30	255	2.4
6	Sheetiron-Masterson-Hugo association, 30 to 75 percent slopes	700	370	250	1,320	12.[illegible]
18	Boomer-Nuens association, 30 to 75 percent slopes	600	1,120	65	1,785	16.5
20	Yollabolly-Rock land association, 30 to 75 percent slopes	140	85	-	225	2.1
[illegible]0	Ferndale association, 0 to 9 percent slopes	10	5	20	35	0.3
63	Fordney-Poe association, 0 to 2 percent slopes	140	-	-	140	1.3
64	Tulana-Algoma association, 0 to 2 percent slopes	100	-	-	100	0.9
65	Chawanakee-Corbett-Siskiyou association, 15 to 75 percent slopes	300	275	-	575	5.3
66	Dubakella-Ishi Pishi-Weitchpec association, 9 to 50 percent slopes	400	175	240	815	7.6
6	Kinkel-Boomer association, 15 to 50 percent slopes	300	-	-	300	2.8
68	Kinkel-Boomer-Duzel association, 0 to 50 percent slopes	400	-	-	400	3.7
69	Josephine-Sites-Maymen association, 9 to 50 percent slopes	-	390	-	390	3.6
70	Tournquist-Portola association, 0 to 50 percent slopes	350	-	-	350	3.3
71	Tyson-Cahto association, 30 to 50 percent slopes	80	-	-	80	[illegible].7
72	Woodstock-Pokegama association, 15 to 50 percent slopes	150	-	-	150	1.4
73	Windy-Lava flows association, 15 to 75 percent slopes	200	-	-	200	1.8
74	Tournquist association, 0 to 9 percent slopes	250	-	-	250	2.3
75	Tournquist-Merlin association, 0 to 9 percent slopes	200	-	-	200	1.8
76	Bieber-Salisbury-Modoc association, 0 to 9 percent slopes	180	-	-	180	1.7
77	Stoner-Greenhorn-Serpa association, 0 to 5 percent slopes	160	-	-	160	1.5
78	Nevador-Ocho association, 0 to 5 percent slopes	110	-	-	110	1.0
79	Pulls-Madeline association, 0 to 9 percent slopes	350	-	-	350	3.3
80	Delaney-Plutos association, 0 to 30 percent slopes	70	-	-	70	0.6
81	Pasquetti-Ramelli association, 0 to 9 percent slopes	10	-	-	10	0.[illegible]
82	Shasta association, 0 to 50 percent slopes	50	-	-	50	0.5
83	Lassen-Kuck-Mary association, 0 to 50 percent slopes	250	-	-	250	2.3
84	Crebbin association, 0 to 2 percent slopes	50	-	-	50	0.5
85	Salisbury-Montague-Louie Association, 0 to 9 percent slopes	120	-	-	120	1.[illegible]
86	Rock land association, 0 to 75 percent slopes	60	-	-	60	[illegible]
87	Gerig association, 0 to 15 percent slopes	250	-	-	250	[illegible].3
88	Kilarc-Plumas association, 0 to 30 percent slopes	-	25	-	25	0.2
89	Timmons association, 0 to 15 percent slopes	-	-	35	35	[illegible]
90	Chiquito-Rock land Corbett association, 30 to 75 percent slopes	210	125	30	365	[illegible]
91	Windy-Rock land association, 15 to 75 percent slopes	270	270	-	540	[illegible]
[illegible]	Lava flows association, 0 to 30 percent	155	-	-	155	1.4
Subtotal		6,905	2,940	790	10,635	98.5
Water		131	29	-	160	1.5
Total		7,036	2,969	790	10,795	100.0

VEGETAL COVER TYPES

The following tabulation summarizes the current areas of vegetal cover types and areas where original vegetal cover has been modified, such as cropland and urban and water development areas. The Vegetal Cover Types Maps for the basins appear on the following pages.

Current Land Cover	Area (Square Miles) Northern Basins	Southern Basins	Total	Percent Of Total Area
Conifer	4,460 1/	1,160	5,620	38
Woodland	2,100 1/	875	2,975	20
Grass	1,070	620	1,690	11
Woodland-Grass	520 2/	165	685	5
Brush (Shrub)	1,990	680	2,670	18
Cropland	390	360	750	5
Other (Barren, Water, Urban-Industrial, etc.)	265	249 3/	514	3
Total	10,795	4,109	14,904	100

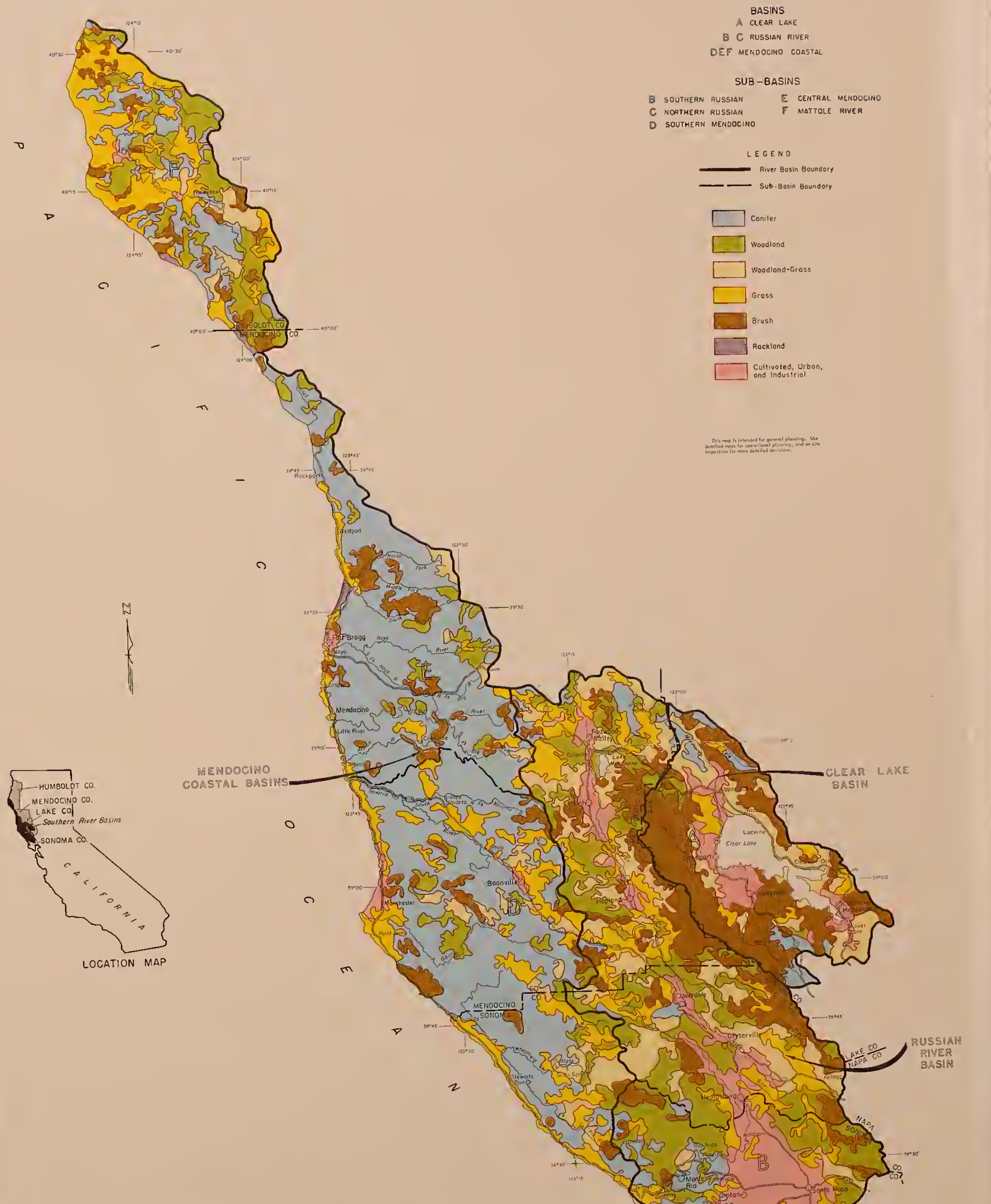
1/ Maps for this area were unavailable or insufficiently detailed to separate woodland from conifer; data represents an estimated proportion of 6,560 square miles of conifer-woodland.

2/ Data represents an estimated proportion of juniper-grassland among 1,590 square miles shown as grassland on the Vegetal Cover Types Map.

3/ Includes Clear Lake (68 square miles).

Coniferous forest is composed of several cover types, the most important of which are redwood, redwood--Douglas-fir, mixed conifer (mainly Douglas-fir, true firs, and sugar and ponderosa pine), and pure ponderosa pine. Respectively each lies further from the coast and each receives progressively less precipitation. Minor conifer species, such as Sitka spruce, various cypresses, Port Orford cedar, coast and mountain hemlock, lowland fir, incense cedar, canoe cedar, juniper, and Bishop and knobcone pine, are found in various locations, depending mostly upon soil-moisture relationships. Broadleaf trees, typical of which are tan oak, alder, madrone, and toyon, grow interspersed in patches throughout the conifer stands. Ferns, rhododendron, azalea, salal, thimbleberry, huckleberry, and other shrubs often form a rather luxuriant undergrowth in forests near the coast while, inland, both species and density of underbrush vary widely.

Woodland, as used here, is a collective term for broadleaf trees and includes both deciduous and evergreen species. California black oak, Oregon oak, alder, dogwood, Oregon ash, bigleaf maple, and buckeye are



VEGETAL COVER TYPES
SOUTHERN RIVER BASINS
HUMBOLDT, LAKE, MENDOCINO, AND SONOMA COUNTIES, CALIFORNIA

NOVEMBER 1971

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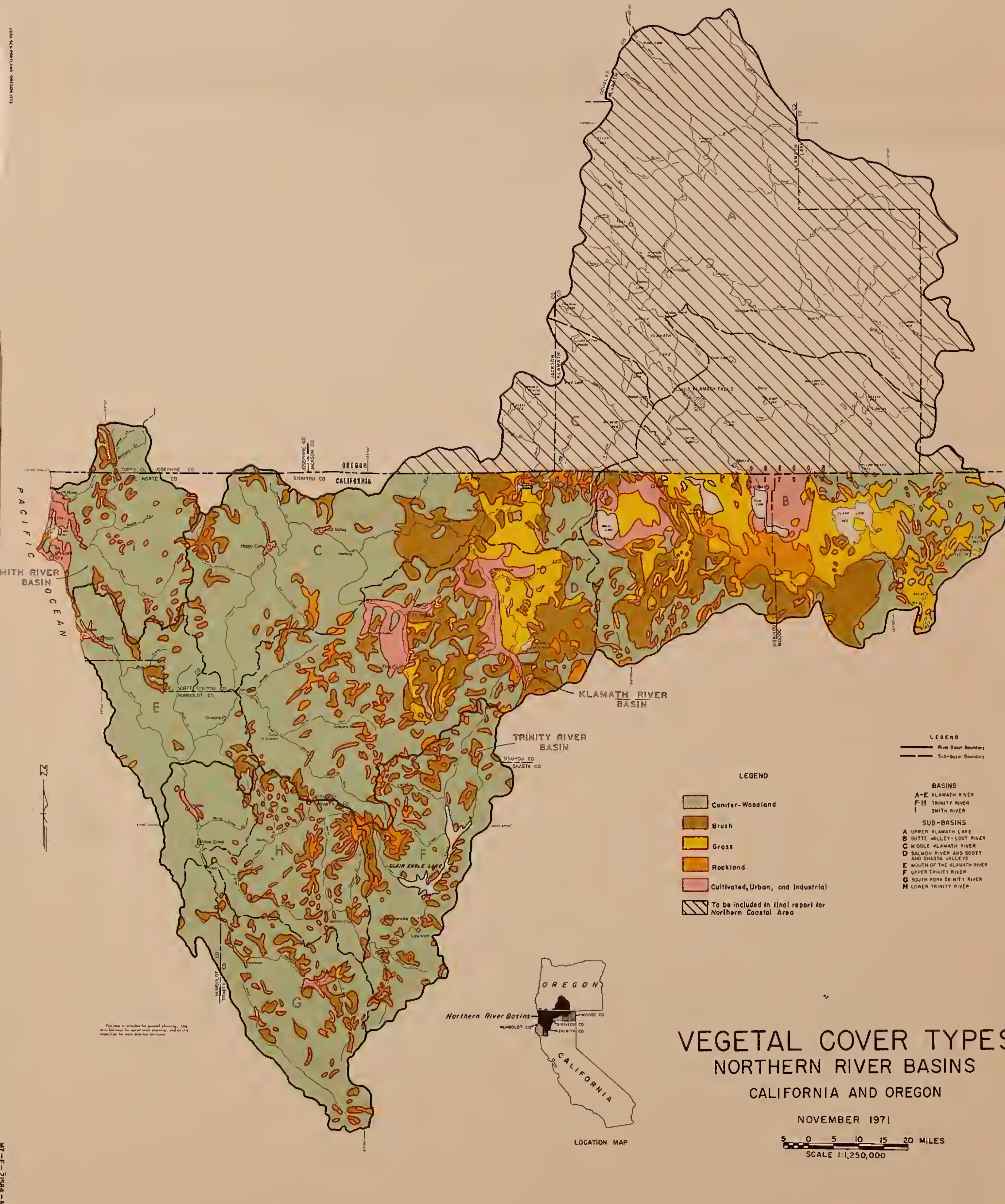
SCALE 1:760,320



VEGETAL COVER TYPES
NORTHERN RIVER BASINS
CALIFORNIA AND OREGON

NOVEMBER 1971

M7-E-21594-N

the most common of the deciduous species, while tan oak, live oak, madrone, bay, and toyon are the most representative of the evergreens. Typically, evergreens predominate near the coast, and in the inland mountainous zones deciduous trees are most prevalent. Poison oak, manzanita, various Ceanothus, scrub forms of various oaks, currant, raspberry, blackberry, annual grasses, and forbs form the understory.

The grass type is made up of a variety of herbaceous species, predominantly annuals. Typical herbaceous species are oat grasses, various bromes, wild barleys, fescues, wild oats, filaree, Medusahead, and burclover. The Modoc Plateau contains meadows that receive subterranean moisture where perennials, such as sedges and rushes, are found. In the uplands of the Modoc Plateau, low shrubs, such as rabbit brush, horsebrush, and sagebrush, are included.

The woodland-grass type is a combination of the two types described in the immediately preceding paragraphs. In parts of the study area, mostly in the Southern Basins, much of the landscape is savannah covered by low annuals with an occasional large single tree or scattered groups of trees. California black oak and live oak are the most common trees; vegetation in the open areas is grass and other herbaceous annuals.

The brush type, called chaparral, consists of species that range in height from three to twelve feet, generally with rigid branchlets and thorny projections. These often form dense thickets that are virtually impenetrable to all but birds and rodents. Along the coast, blueblossom Ceanothus, rhododendron, and azalea are the most common species and, in the spring, these present brilliant wildflower displays. Inland, chaparral usually occupies seasonally hot sites, and typical species are manzanita, various Ceanothus, chamise, scrub deciduous and live oaks, poison oak, baccharis, and Yerba Santa. On the more xeric timber sites, the shrub species tend to encroach on timber sites that have been burned or logged. Pure stands of a single species are common, and individual scattered digger pine occur in fringe areas that adjoin conifer or woodland types. On the Modoc Plateau, open stands of small juniper, bitterbrush, mountain mahogany, horsebrush, rabbit brush, sagebrush, and various forbs are the predominant species.

Cropland includes both irrigated and non-irrigated land and is located mostly in the river valleys scattered throughout the study area. The non-irrigated and much of the irrigated lands are generally used for hay production and pasture and are covered mainly by grasses. The other irrigated areas support orchards, vineyards, and grain and row crops.

The remaining land, shown in the "Other" category, is a combination of types that support little or no vegetal cover. Barren areas occur on mountain tops, rocky and sandy coastline, rock outcrops, and similar sites where soil and climate conditions limit vegetal growth. Some of the most spectacular scenery is in this category. Watersurface areas include lakes and reservoirs. Urban and industrial areas usually support considerable vegetation, but it is often different from the original natural cover.

LAND USE

Lands are often used for multiple purposes, but were categorized according to the principle use. The following tabulation shows the approximate present land use pattern.

Land Use	Area (Square Miles) Northern Basins	Southern Basins	Total	Percent Of Total Area
Timber Production	5,072	1,216	6,288	42
Grazing	2,093	1,666	3,759	25
Irrigated Cropland	273	240	513	3
Non-Irrigated Cropland	121	117	238	2
Urban and Industrial	8	43	51	<1
Designated Recreation	200	22	222	2
Designated Wilderness	726	0	726	5
Designated Fish and Wildlife	251	158	409	3
Miscellaneous Use	2,051	647	2,698	18
Total	10,795	4,109	14,904	100

The economy of the basins is tied directly to the productivity and utilization of the land resources. Timber, agriculture, and recreation rank in that order as the three most important segments of the economy; others include mining, manufacturing, power production and transmission, transportation, and services.

TIMBER PRODUCTION

The timber industry developed with the settlement of California's North Coast and quickly became the most important industry and accounts for most of the income and employment. The Northern Basins are almost 50 percent forested, while the Southern Basins are about 30 percent forested. In both cases, a large share of this land is dedicated to the production of timber. Most of the early timber harvest was simply an exploitation of the resource with little regard for the future, and much of the land in small ownerships continues to be managed that way. Recently, some private owners, particularly those holding large acreages, have shifted to sustained yield management, similar to a type of management long used on national forest timberlands.

About 3 percent of the commercial timberland acreage is logged each year, including the harvest of sawlogs and poles and products of thinning operations. Production per acre is generally superior to other timbered areas in the State.

About 200 square miles of timberland have been converted to grass for grazing. Recently, the number of new conversions has decreased, and some previously converted areas are being allowed to revert to timber.

A small net loss in timber producing lands is expected as recreation, urban, summer home, water development, roads, and other uses increase. Areas set aside for parks, wildernesses, or as part of a wild and scenic rivers program will also eliminate or modify the use of some areas for timber production.

CROPLAND

The major areas of irrigated cropland are widely scattered throughout the basins in the flood plains of the main rivers and along the Pacific Coast. These areas occur mainly around Tulelake and in the Shasta and Scott Valleys in the Northern Basins, and along the coast and inland near Santa Rosa and Clear Lake in the Southern Basins. Non-irrigated croplands generally occur in fringes around the irrigated lands.

Much of both the irrigated and non-irrigated cropland is used for pasture and the production of hay. In addition, other crops are produced as follows:

Coastal Zone - Nursery flower stock and bulbs.

Russian and Clear Lake Basins - Apples, pears, prunes, walnuts, and grapes.

Shasta and Scott Valleys - Grain crops and potatoes.

Butte and Tulelake Valleys – Potatoes and onions.

The area of irrigated cropland is expected to increase in the future despite a steady, but slow, encroachment by urban and other development. Non-irrigated cropland acreage will decrease because much of it will be irrigated as new sources of water are tapped and more intensive development occurs.

GRAZING

Grazing of cattle and sheep was one of the earliest land uses in the basins and is still economically important. In the Northern Basins, this consists of fall, winter, early spring, and late summer pasturing on valley ranches and late spring and early summer grazing on mountain sideslopes. Often the latter is by permit on public lands, mainly national forest.

In the Southern Basins, most private rangelands are grazed as soon and as long as forage is available. Much of the natural forage responds to winter rains and reaches its peak in late spring or early summer. After this period, stock on annual ranges must be moved to pastures, fed supplementally, or sold. Ranges near the coast are grazed yearlong because the cooler, more humid climate and the higher percentage of perennials tends to sustain forage growth. Other areas, such as the hills west of Santa Rosa, are also grazed yearlong where good management and a high percentage of perennials makes such use possible. The acreage of grazing land is expected to decrease as increased regional populations create demands for other land uses, such as recreation and summer home sites.

RECREATION

About 220 square miles in the basins are devoted to recreation uses, and these are becoming more important, both in economic impact and effect upon other land uses. Recreation development and use occurs on both public and private lands. General recreation use -- camping, fishing, hiking, and hunting, etc. -- is more prevalent on public lands, while specialized uses -- organization camps, summer homes, and hunting and fishing clubs, etc. -- are more common on private lands. Federal lands provide most of the recreation opportunities in the Northern Basins, while in the Southern Basins, private lands and state and municipal parks satisfy the bulk of the demand. The area has a tremendous recreation potential, and an increasing regional population, higher income levels, and increased leisure time are expected to contribute to a continued buildup in recreational activity.

WILDERNESS

About 726 square miles of wilderness-type areas are located in the Northern Basins, as shown in the following tabulation:

Area	Jurisdiction	Approximate Area (Square Miles)
Marble Mountains Wilderness 1/	Klamath NF	335
Yolla Bolly-Middle Eel Wilderness	Mendocino and Shasta-Trinity NF	12 2/
Salmon-Trinity Alps Primitive Areas 3/	Shasta-Trinity and Klamath NF	349 4/
Lava Bed National Monument	National Park Service	15 5/
Other	Mainly National Park Service	15
Total		726

1/Wildernesses are classified under the National Wilderness Preservation Act of 1964.

2/Area within the study basins only. Total wilderness is about 170 square miles.

3/Primitive Areas are under study for inclusion in the Wilderness System. Acreage eventually classified may vary somewhat.

4/Does not include 97 square miles of private land within the Primitive Area Boundary.

5/Estimated size of proposed wilderness type land within the Monument; remainder is counted as designated recreation.

Several other areas physically qualify for wilderness classification, nearly all on public lands, so the acreage classified could increase in the future.

FISH AND WILDLIFE

About 409 square miles of land scattered through the basins are dedicated to fish and wildlife uses of varying intensity. Some of these uses limit other uses, and some do not. Included in the former class are three National Wildlife Refuges (Lower Klamath, Tulelake, and Clear Lake) in northeastern Siskiyou and northwestern Modoc Counties, which cover about 155 square miles. These are managed mainly to protect and preserve waterfowl of the Pacific Flyway, but they also provide fisheries and other wildlife benefits. Several fish hatcheries located in the basins are exclusive-use areas that occupy very little land.

In national and state parks, fish are managed in conjunction with recreation use. All other animals are protected. State Game Refuges also protect game but allow some other uses. These are included as designated wildlife areas.

Not included as designated wildlife areas are the national forests and public domain lands, where the Forest Service and Bureau of Land Management, respectively, manage wildlife habitat as a part of their multiple use programs. In some cases, such as key deer winter ranges, special management programs are designed for the improvement of habitat. No privately owned lands are included as designated wildlife areas. However, many landowners restrict hunting and fishing by limiting access or by allowing use only by permit. Some landowners manage game habitat to enhance wildlife and construct fish ponds to make their lands attractive to hunters and fishermen.

It is not expected that the amount of land set aside for wildlife will increase greatly in the future.

MINING

Mining was one of the original industries in the Klamath and Trinity Basins and was responsible for the settlement of much of that area as well as the exploitation of many streamside zones. Extensive hydraulic mining and dredging and some tunnel mining were done for many years, but dredging and hydraulic mining are now restricted by sediment and debris protection limitations.

Chief minerals presently mined include gold, chromite, quicksilver, and asbestos, with limited amounts of perlite, diatomaceous earth, and decorative rock. Many temporary gravel quarries are established each year in channels away from streams throughout each basin.

Mining activity in the basins will probably maintain its present level except for an increase in gravel quarrying to satisfy building needs for increased populations. The latter will occur throughout the basins, while other types of mining will no doubt continue to be concentrated in the Klamath and Trinity Basins.

OTHER LAND USES

Development for urban and industrial uses has been slow, although it has accelerated considerably in the past few years around Santa Rosa; the largest and most industrialized city. Other population concentrations are Ukiah, Fort Bragg, and Lakeport in the Southern Basins and Yreka, Crescent City, Weaverville, and Tulelake in the Northern Basins. Scattered throughout the basins are several small towns, many of them relics of early mining and ranching activities. It is expected that population growth will result in more urban-industrial development, but most will occur near the present population centers. Vacation home and resort development will probably occur sporadically in the rural areas.

Powerlines and pipelines, which often limit other uses, span many miles. Power plants are located near many damsites, and a unique steam-electric plant is located near Cloverdale. Reservoirs preclude other land uses.

Major railroads serving the area are the Burlington Northern, Southern Pacific, and Western Pacific, but none extend into the Trinity, Middle and Lower Klamath, or the Smith Basins. The California Western Railroad, which runs between Willits and Fort Bragg, is operated for sightseeing tours.

Federal highways 101, 299, and Interstate 5 traverse the area and, with numerous state, county, national forest, and private roads, provide the transportation network.

The area used by roads and powerlines is expected to increase.

LAND OWNERSHIP AND ADMINISTRATION

Land ownership and administration for the Northern and Southern Basins is shown on the maps on the following pages and is summarized in the tabulation below.

	Area (Square Miles)		
	Northern Basins	Southern Basins	Total
Federal Land			
Forest Service	7,201	46	7,247
Bureau of Land Management	308	168	476
Bureau of Sports Fisheries and Wildlife	2	8	10
National Park Service	114	0	114
Bureau of Reclamation	30	1	31
Department of Defense	1	3	4
Subtotal (Federal Land)	7,656	226	7,882
State Land	80	94	174
Other Public Land[1]	56	0	56
Subtotal (Public Land)	7,792	320	8,112
Private Land			
Individual & Corporate Land	2,856	3,789[2]	6,645
Indian Land[3]	147	0	147
Subtotal (Private Land)	3,003	3,789	6,792
Total	10,795	4,109	14,904

[1] County, city, and special district land.

[2] Includes 68 square miles of Clear Lake.

[3] Includes private Indian holdings and tribal lands within the reservation boundaries.

About 72 percent of the land in the Northern Basins, but only 8 percent of that in the Southern Basins, is publicly owned. Virtually all of the public land in both basins is federally owned, with only a scattering of state and local ownerships.

In the Northern Basins, national forests comprise 92 percent of the public lands and 67 percent of all ownerships. In general, these are the mountainous areas that form fairly solid blocks of large holdings with scattered private ownerships within the national forest boundaries. However, in the upper Trinity and upper Klamath, east of longitude 123°, there is a checkerboard pattern of national forest alternating with other ownerships, mainly private. In the Southern Basins, only 20 percent of the public land is national forest, and that is confined to a narrow fringe on the northeast edge of the Clear Lake Basin.

Public domain, administered by the Bureau of Land Management, comprises about 3 percent of the land in the Northern Basins and 4 percent in the Southern Basins. These lands are generally consolidated blocks that occur in the Klamath, Trinity, and Clear Lake, and Mendocino Coastal Basins.

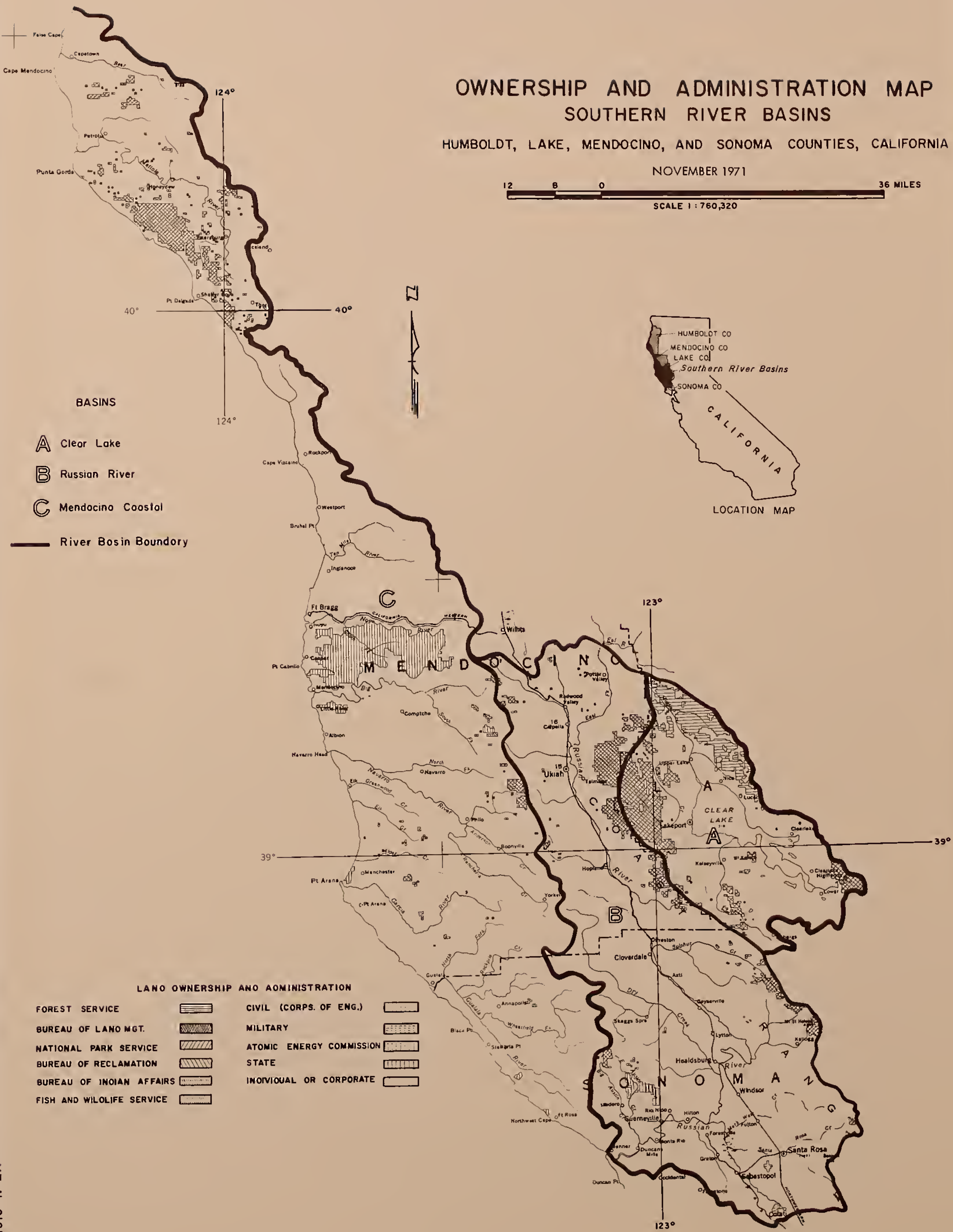
About 1 percent of the public land in the Northern Basins is administered by the National Park Service, this includes the Lava Beds National Monument in the Upper Klamath Basin and the portion of Redwoods National Park in the Smith and Klamath Basins. No national park land occurs in the Southern Basins. The bulk of the Bureau of Reclamation holdings are in the Upper Klamath Basin in the vicinity of Tulelake, Lower Klamath, and Clear Lake reservoirs. Parts of each of these reservoir areas are national wildlife reserves. The Bureau of Reclamation has other small scattered holdings, mainly in connection with water development projects.

The Department of Defense has small, scattered holdings in connection with flood control projects. The Bureau of Sport Fisheries and Wildlife administers similar parcels for fish and wildlife purposes.

State and local ownerships make up the balance of the publicly owned lands. Most of the state lands are contained in state parks scattered through the area and in the Jackson State Forest near Fort Bragg. Local holdings are mainly municipal parks and special district lands.

In the Northern Basins, most of the private land is farm and ranch land, generally located in the valleys and foothills. The Simpson Timber Company and the Rellim Redwood Company own most of the coastal redwood land available for harvest, while most of the upland grazing and timber land is federally owned. In the Southern Basins, private ownership is predominant. The Boise Cascade, Georgia-Pacific, and Masonite Corporations and Mollala Forest Products, Inc. own large acreage of timberland, but considerable timberland is also contained in small ownerships. Farm and ranch lands account for most of the balance of the private lands. A relatively recent trend is the sale of small parcels, either in subdivisions or in individual plots, for construction of both vacation and permanent homes.

Included in the private holdings are 147 square miles of Indian trust land, located mainly in the Hoopa Reservation near the mouth of the Trinity River.



USDA-SCS-PORTLAND, OREG. 1971

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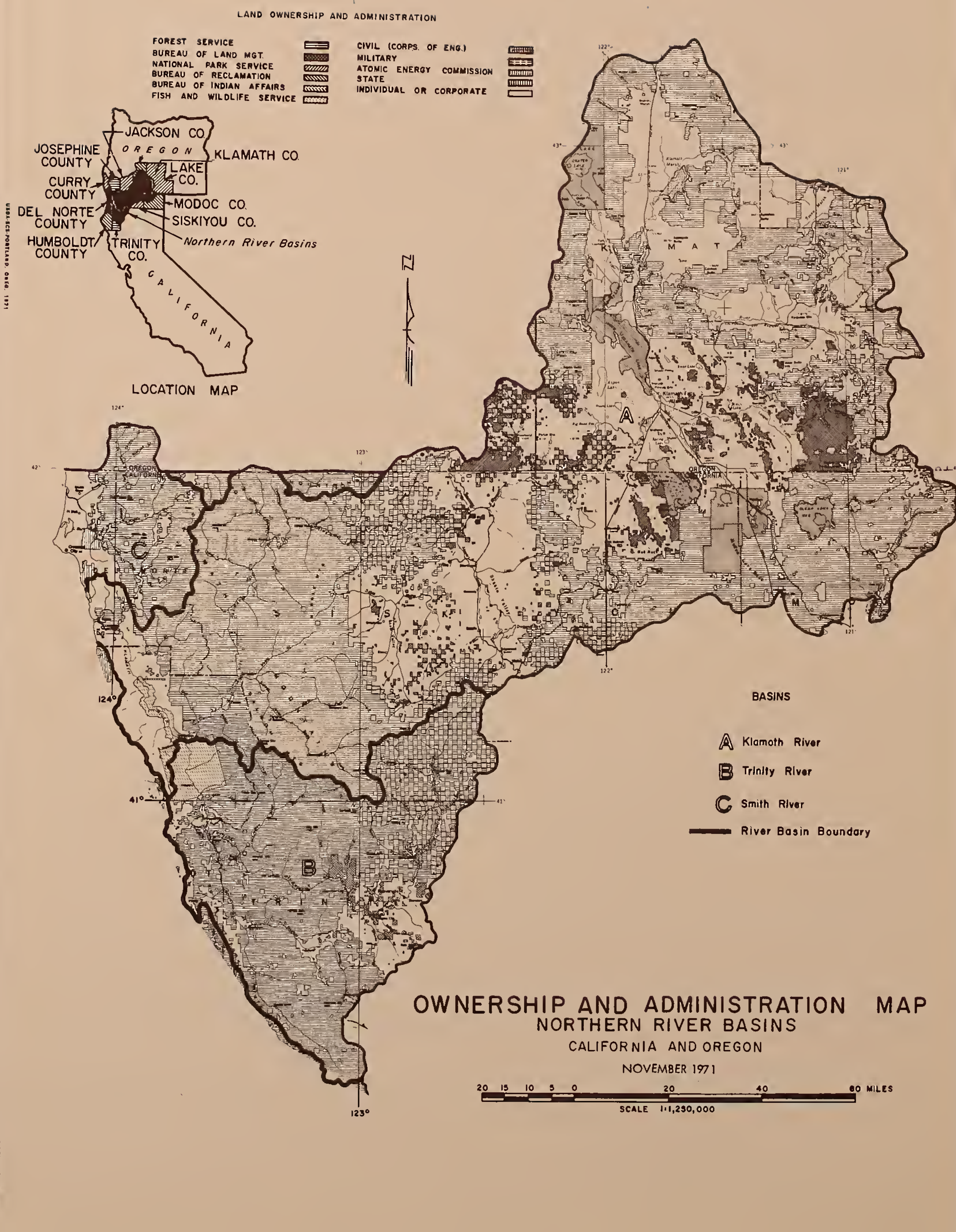
LAND OWNERSHIP AND ADMINISTRATION
FOREST SERVICE
BUREAU OF LAND MGT.
NATIONAL PARK SERVICE
BUREAU OF RECLAMATION
BUREAU OF INDIAN AFFAIRS
FISH AND WILDLIFE SERVICE
CIVIL (CORPS. OF ENG.)
MILITARY
ATOMIC ENERGY COMMISSION
STATE
INDIVIDUAL OR CORPORATE
JACKSON CO.
OREGON
JOSEPHINE COUNTY
KLAMATH CO.
LAKE CO.
CURRY COUNTY
MODOC CO.
DEL NORTE COUNTY
SISKIYOU CO.
Northern River Basins
HUMBOLDT COUNTY
TRINITY CO.
CALIFORNIA
LOCATION MAP
N
BASINS
A Klamath River
B Trinity River
C Smith River
River Basin Boundary
OWNERSHIP AND ADMINISTRATION MAP
NORTHERN RIVER BASINS
CALIFORNIA AND OREGON
NOVEMBER 1971
20 15 10 5 0 20 40 60 MILES
SCALE 1:1,250,000
124°
123°
122°
121°
42°
41°
43°
USDA-SCS-PORTLAND, OREG. 1971

PROBLEMS

Problems presented in this chapter are those connected with sediment yield and land treatment and are divided into two groups -- sediment and debris deposition and erosion. Sediment and debris deposition problems normally occur with each flood. In recent years, flooding has occurred every third or fourth year on the average; the two major floods of record took place in December 1955 and December 1964. Erosion problems occur each year, especially in the form of sheet and gully erosion and landslides, but the magnitude is greatly increased during the periods of major flooding.

Total damages resulting from the December 1964 flood were estimated at $63,500,000 by the Corps of Engineers for the Klamath, Trinity, and Smith River Basins,[1] with approximately $6,500,000 of this amount considered to be agricultural damage. Damages due to erosion and deposition were estimated by the Soil Conservation Service to be about 20 percent of the agricultural damages, or about $1,300,000. A portion of the remaining damages is also associated with erosion and deposition, but the amount was not estimated separately from floodwater damages.

SEDIMENT AND DEBRIS DEPOSITION

Sediment deposits usually consist of soil and weathered rock material with particle sizes ranging from clay to gravel. Debris deposits consist of non-mineral material, both natural and man-made, such as trees, brush, lumber, and fencing material.

DEPOSITION AREAS

The major deposition areas are located in deltas near the coast and on the flood plains and older terraces adjacent to the main rivers and tributaries in the valleys.

Agricultural

Damages from sediment and debris deposition occur over most of the areas that are flooded. Crops are frequently destroyed by these deposits and must be replanted. Sediment consisting of sand and gravel must be removed, and the fields must be reshaped before planting. Logs, trees, and other debris must be burned or removed. Irrigation pipelines must be cleaned, and pumps must be either overhauled or replaced. Farm equipment often must be dug out of debris and sediment and overhauled before it can be reused. Farm buildings not swept away by the floodwaters are

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[1] U.S. Department of the Army, Corps of Engineers, Report on Floods of December 1964 in Northern California Coastal Streams, San Francisco District, December 1965, Vol. I., pp. 25 & 28.

often damaged and require considerable cleanup and repair. About 12,000 acres of cropland, or 6 percent of the cropland in the basins, were damaged during the 1964 flood by sediment and debris deposition.[1]

Urban

A number of communities were damaged by sediment and debris deposition, and two towns, Klamath and Klamath Glen, were completely destroyed by floodwaters in December 1964. Others, including Happy Camp, Orleans, Willow Creek, and Hoopa, were severely damaged by floodwater, debris, and sediment, as were towns along the lower Russian River.

Roads

After floods, removal of sediment and debris is usually required on a number of roads in the valleys. Landslides are another major deposition problem on roads. Although they are not always a result of flooding, they frequently force the closure of roads. Road closures caused by sediment and debris deposition were extensive as a result of the 1964 flood, and replacement of washed out sections of roads and debris removal were major expenses after the flood.

CHANNEL DEPOSITION

At points along stream channels, aggradation decreases the channel capacity and increases the danger of flooding in adjacent areas. Trees, brush, rocks, and soil are deposited naturally into streams, but man adds to the problem by allowing waste materials from logging, road building, and agricultural and domestic activities to accumulate in or near channels. Debris jams sometimes form and block the channel, forcing the stream to overflow its banks. When these jams break up, the sudden rush of turbulent water accelerates the streambank erosion immediately downstream. Debris jams and floating debris have also damaged bridges, buildings, and other developments along the rivers.

As a result of the December 1964 storm, large quantities of sediment accumulated in many reaches of stream channels, and streambed elevations increased as much as 13 feet. The U.S. Geological Survey found that since the 1964 flood, channel aggradation occurred at most of their gaging stations in the basin, but a few stations showed degradation, as the table on the next page shows.[2] This aggradation problem appears

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[1] U.S. Department of Agriculture, Soil Conservation Service, Flood Damage Report December 1964 - January 1965, an unpublished report. (Berkeley, 1965).

[2] John J. Hickey, Variations in Low-Water Streambed Elevations at Selected Stream-Gaging Stations in Northwestern California, USDI Geological Survey Water Supply Paper 1879-E, (Washington, D.C., U.S. Government Printing Office, 1969). 33 pp.

Summary of Changes in Streambed Elevation

Number	Gaging Station Name[1]	Difference[2] in Streambed Elevation (Feet)
	Klamath River Basin	
11-4895	Antelope Creek near Tennant	0.1
-5166	Cottonwood Creek at Hornbrook	0.6
-5169	Little Shasta River near Montague	-
-5175	Shasta River near Yreka	0.2
-5178	Beaver Creek near Klamath River	-1.1
-5180.5	East Fork Scott River at Callahan	0.4
-5186	Moffett Creek near Fort Jones	-
-5195	Scott River near Fort Jones	-0.1
-5205	Klamath River near Seiad Valley	0.1
-5215	Indian Creek near Happy Camp	3.1
-5223	South Fork Salmon River near Forks of Salmon	2.5
-5225	Salmon River at Somesbar	-
-5230	Klamath River at Somesbar	3.0
-5232	Trinity River above Coffee Creek, near Trinity Center	-0.3
-5237	Coffee Creek near Trinity Center	1.4
-5258	Weaver Creek near Douglas City	-0.3
-5259	Browns Creek near Douglas City	-0.1
-5265	North Fork Trinity River at Helena	0.8
-5270	Trinity River near Burnt Ranch	0.6
-5274	New River at Denny	4.0
-5281	South Fork Trinity River at Forest Glen	2.2
-5284	Hayfork Creek near Hayfork	0.3
-5285	Hayfork Creek near Hyampom	0.6
-5290	South Fork Trinity River near Salyer	12.9
-5298	Willow Creek near Willow Creek	13.0
	Smith River Basin	
11-5310	Middle Fork Smith River at Gasquet	1.5
-5325	Smith River near Crescent City	-0.3

1/ No data is shown for gaging stations in the Russian, Clear Lake, or Coastal Basins.

2/ Difference in low-water streambed elevation between 1964 and 1965. John J. Hickey, in the paper previously cited, Table I, pg. E5.

to be temporary, and in time, degradation is expected to take place. Over a long period of time, the aggrading and degrading processes probably balance each other.

Potential Future Problems

The present unregulated flows have the capacity to transport sediment from the watershed to the ocean, but this beneficial flushing action could be upset if flow is regulated. A number of tributaries to the main rivers in the basins have high sediment yields. If a large reservoir were located upstream of tributaries having high sediment yields, the behavior of these typically fast-flowing mountain streams could change as follows:

1. Coarse material may be deposited at the confluence of tributaries with the main stem, and regulated flows might be insufficient to wash it downstream. Both the main channel and tributary could aggrade upstream from the confluence, reducing the stream gradient and sediment carrying capacity.

2. More fine material may be deposited in the reaches where the sediment carrying capacity of the stream is reduced or along the banks where velocities are slowed by friction. Such fines could promote growth of phreatophytes, such as willows and cattails, causing further deposition and growth to encroach upon the channel. This buildup could change the capacity, stability, ecology, and beauty of the stream.

3. In time, the deposition of this fine material on existing gravel beds could affect their suitability as spawning beds for anadromous fish. Reduction in spawning beds would in turn affect fishing in the problem area.

4. Regulated flows in the main stream may not possess sufficient momentum to counteract tributary flows entering at an angle, and both streams could be deflected against the opposite bank, causing erosion and instability.

This discussion of potential problems is based on examinations of existing problems below Lewiston Dam in the Trinity River. Sediment problems in the Trinity River near Lewiston have been studied in detail by the State Resources Agency.[1/] Although the hydrologic and sedimentation characteristics of other rivers may differ in scale, they have sufficient similarity to warrant caution.

During the planning stages of large reservoir projects, detailed studies should be made to predict the magnitude of potential sediment deposition

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[1/] State of California Resources Agency, Task Force Findings and Recommendations on Sediment Problems in the Trinity River near Lewiston, (Sacramento, January 1970). 32 pp.

problems in channel reaches with regulated flows and to formulate remedial measures that will minimize or eliminate the problems. These problems may require large reservoir releases and construction of debris dams on heavy sediment-carrying tributaries to preserve fish, wildlife, and natural beauty of rivers downstream of major dams. In the attempt to alleviate existing problems, caution must be exercised to avoid creating additional problems.

DESTRUCTION OF FISH AND WILDLIFE HABITAT

Heavy sediment deposition in bottoms of streams and rivers destroys the new crops of fish eggs and the natural fish and wildlife habitat. Deposition of fine material in these areas generally decreases the numbers of fish food organisms and degrades their use as future spawning areas for fish. Often, deposition fills holes in the river bed that are used by fish for resting areas in their journey upstream. Turbidity caused by high concentrations of sediment in waters can cause slower fish growth and, in extreme instances, death of fry and fingerlings.

PERIODIC EFFECT ON WATER QUALITY

During periods of high flow, usually during the months from December to March, considerable suspended sediment is present in many of the streams of the basin. Sometimes a landslide may slip into the stream and continue to feed sediment to the water until stable conditions are reached. During the investigation, several streams were noted to be exceptionally heavy sediment producers. Muddy sediment-laden water persisted much longer in those streams than in others nearby. Some of the notable examples of heavy sediment-producing streams are listed below.

<u>Klamath and Trinity River Basin</u>
Indian Creek near Happy Camp
Coffee Creek near Trinity Center
South Fork Trinity River
Pelletreau Creek near Hyampom
Willow Creek near Willow Creek

<u>Smith River Basin</u>
South Fork Smith River
Goose Creek (Tributary of South Fork Smith River)

<u>Russian River Basin</u>
Dry Creek near Geyserville
Big Sulphur Creek near Cloverdale

During the summer momths, the concentration of suspended sediment is very low. For example, the station "South Fork Trinity near Salyer," which is on one of the heaviest sediment yielding streams in the Klamath River Basin, has suspended load concentrations ranging from 1 to 10 ppm (parts per million) several days during the summer months. The maximum recorded concentration was 20,400 ppm on December 23, 1964.

Abnormally high suspended sediment loads affect municipal water supplies by adding to the cost of maintaining satisfactory drinking water. Suspended sediment also causes problems with mechanical equipment such as pump bearings, impellers, and filter beds. For example, such problems are causing considerable expense to the Humboldt Bay Municipal Utility District, which gets its water from the Mad River upstream of Arcata (in the Mad River Basin).

RESERVOIR SEDIMENTATION

Reservoir sedimentation causes a loss in storage capacity. Surveys were made on four reservoirs in the Russian Basin, and the results of these surveys are shown in the section "Special Sediment Studies" of the Addendum. The surveys showed that annual loss of original storage capacity ranged from 0.24 to 2.3 percent. Surveys have not been made on the existing larger reservoirs east of Interstate Highway 5 in the Klamath Basin because these have no history of high sedimentation.

Although no official surveys have been made, sediment deposition in Clair Engle Lake has been estimated. Suspended load data collected at the gage "Trinity River near Lewiston" prior to dam construction indicate a mean suspended sediment load of about 300 tons/square mile/ year.[1/] Ten percent was added for bedload, making the total load an estimated 330 tons/square mile/year. The drainage area above Trinity Reservoir is 688 square miles; therefore, the annual inflow of sediment is estimated to be about 227,000 tons per year. Assuming a density of 70 pounds per cubic foot (1,525 tons/acre-foot), about 150 acre-feet per year is being deposited in the lake. The original storage capacity was 2.5 million acre-feet, so the storage depletion is only about 0.006 percent per year.

Estimates of long term sediment yield for all suspended sediment gaging stations are presented in the section "Special Sediment Studies" at the end of this appendix. Sediment yields vary considerably from basin to basin and are a major factor to be considered in planning and designing reservoirs.

SOIL EROSION

Soil erosion problems were grouped into three main sources for study -- streambank, landslides, and sheet and gully erosion.

STREAMBANK EROSION

Terraces and alluvial fills are the major land forms subject to streambank erosion. These generally have steep banks which will slough when

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1/ See table "Mean Annual Sediment Discharge" in the Addendum.

Landslide damage to a seventy-foot high road fill.
SCS PHOTO 3-5735-6

Sediment deposition in a typical farm pond. SCS PHOTO 3-1234-9 undercut by streams. Terraces were formed by historic deposition and are usually located in wide canyon bottoms or valley floors. Alluvial fills are generally deposited along the inside of curves in streams or at the confluence of tributaries. Measured sediment rates per mile of channel are generally high in these terraced or alluvial areas, while the rates in narrow canyons with steep slopes and shallow soils are generally lower. Sloughing occurs as the toe of streambank or adjacent slope is undercut by streamflows.

Most streambank erosion appears to be a natural occurrence, but sometimes it is the result of man's activity upstream. Debris dams formed by such activity may suddenly collapse and release large quantities of water during a storm, causing a sudden acceleration of streambank erosion immediately downstream. Much of this type of streambank erosion occurred in the Klamath River during the December 1964 storm and had a heavy impact on roads and recreation sites.

LANDSLIDES

In much of the study area, topography is extremely rugged, rocks are relatively young and unstable, and annual rainfall is high and concentrated in the winter months. During the periods of high rainfall the rock formations which are often poorly consolidated, highly fractured, and structurally weak become saturated, as do the soils, and as a result landslides commonly occur.

Landslides are often triggered by stream action which removes the slope toe, especially in steep, narrow canyons. Man's activities, such as logging, vegetal cover conversion, and road construction, increase landslide incidence by decreasing slope stability in already unstable areas.

Once a slide has occurred, much of the surface area is left bare, and the surface soil material is generally loosened, increasing the hazard of sheet and gully erosion. The slide area usually remains unstable and is subject to future sliding, especially if the toe is again removed.

SHEET AND GULLY EROSION

Sheet and gully erosion is more often directly related to man's activity on the land than are streambank erosion and landslides. Historically those activities have included farming, livestock grazing, logging, road building, and most recently, recreation. Each of these activities has modified the land surface.

Logging

Logging affects soil erosion by temporarily removing vegetal cover and by disturbing soil during skidding and yarding operations and construction of logging roads. Even when using the most modern conservation techniques, some erosion is inevitable. Poor logging practices have caused serious soil disturbances in the form of excessive numbers of skid trails, stream crossings and landings; improperly located skid trails, landings, and spur roads; water pollution from debris entering stream channels; and the erosion of temporary road fills caused by inadequate culverts.

These practices are aggravated by inadequate post-harvest erosion control treatment. For example, skid trails and landings are too often not drained, spur roads not closed or drained, and temporary fills across intermittent stream channels not removed.

In the past fifteen years, logging practices have improved in national forests. Areas logged prior to 1955 often showed the shortcomings cited in the previous paragraph, and by the late fifties, the need for erosion control procedures became apparent. Areas were formerly logged using crawler type tractors, a method which caused excessive soil disturbance on steep slopes. Presently, tractor logging in national forests is limited to slopes of less than 35 percent, and steeper areas are logged by overhead cable systems, such as high lead or skyline. These logging methods cause less disturbance to land and reduce the resulting erosion. The three yarding systems now in use are discussed more thoroughly in the chapter "Land Treatment Programs." Most problems were associated with access roads and skid trails rather than the logging itself.

On very deep soils in the Mendocino Coastal vicinity, large private concerns still log slopes that have gradients of up to 60 percent by conventional skid-tractor logging methods. Though large volumes of soils are disturbed on the contour, little observable sedimentation results, and vegetal regrowth is rapid. Further inland, on deep soils, the same logging practices result in much soil loss. The apparent reason for this difference is that the very deep soils have the ability to infiltrate, percolate, and store large volumes of rain.

The present sediment rates from national forest areas logged ten or more years ago still reflect the poor practices used at that time. They still show the scars of logging, many of which are healing slowly, if at all. The sedimentation rates from these areas are higher than would be expected if they had been logged under the present standards.

Grazing

For more than a century, privately owned natural grassland and adjoining forest land converted to grass have been subjected to heavy grazing.[1] On much of the land, the more desirable grass species have been eliminated, and the poor quality of the replacement forage will no longer allow ranges to support the number of livestock for the length of season once possible. Perennial rangeland vegetation has generally been replaced by less adequate annual cover.

There is a general contrast between the soil erosion on grasslands in the Northern Basins and that in the Southern Basins. In the Northern Basins,

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[1] L.T. Burcham, California Range Land, An Historico-Ecological Study of the Range Resource of California, pp. 199-205 (Sacramento; California Department of Natural Resources, Division of Forestry, 1957).

Loamy range site. Both sides of fence are in poor condition, with cheatgrass and sagebrush cover. On right side of fence the range is severely over-utilized. SCS PHOTO 3-5463-4

the soil erosion problem is relatively small. In the Southern Basins, however, approximately one-third of the grassland has insufficient vegetal cover to protect the soil from sheet and gully erosion, and soil creep and slumps are prevalent. The situation is especially critical on private rangelands that are grazed throughout the year. Analyses of field data indicate that the percentage of bare ground is probably the most important factor related to sediment yield on grasslands.

In the Southern Basins, grasslands converted from timberlands have higher sediment yields per square mile than those from natural grasslands, especially on slopes steeper than 20 percent. Timber soils, being more acidic, tend to produce woody vegetation and poor quality grass cover causing the converted land to have more exposed ground. The number of gullies and small, shallow landslides per unit area is greater in converted areas than that on natural grasslands. This has been only a minor problem in the Northern Basins because very little timberland has been converted to grassland.

Prior to the establishment of national forests in the North Coastal Area, most of the rangeland in these areas was heavily grazed and some was destructively grazed. In some cases, this overgrazing continued into the early years of the national forests, and sheet and gully erosion increased as a result of the deterioration of the vegetal cover. Most national forest grazing land has now been placed in range allotments or closed to grazing because of high erosion hazard.

Deer

Although many wildlife species exist in the North Coastal Basins, only deer appreciably influence erosion or sediment yield. When deer populations are concentrated, their heavily travelled paths and browse areas expose bare soil to erosion, especially during the rainy season. As deer feed in brush or grassy openings, they tend to work around preferred browse plants, creating more trails and retarding vegetal growth.

Deer-caused erosion is considered a problem only in the Southern Basins. In most parts of the Northern Basins, only a small amount of such erosion was found.

Land use practices, such as type conversion or logging, modify vegetal cover over large areas, at least temporarily. The normal plant succession is first grasses, then shrubs, and finally trees. The new shoots of the shorter grasses and shrubs are favored deer feed, and stabilization of a disturbed area is often delayed because the herd continually browses the short, tender plants. The crown canopy of large shrubs and young trees, which succeed the grasses and small shrubs, must grow beyond the reach of browsing animals before the area will stabilize. Also, reforestation efforts are hampered by deer-browsing of seedling trees, often resulting in substantial financial loss to timberland owners. Until vegetal cover is established, soil is exposed to the weather and subject to sheet erosion and gullying. In the Southern Basins, field observations of widespread over-browsing of forage or severe trampling indicate that present deer populations exceed the carrying capacity of their range.

Burning

The climate of the basins in the study area is characterized by warm, dry summers where rain is minimal from June through October. This climate and the vast expanses of woody vegetal cover combine to create a high potential fire hazard. The severe erosion that often follows wildfire, particularly on steep slopes, is usually attributed to salvage logging.

Despite the high potential, wildfire has been insignificant as a cause of erosion in these basins because the average annual acreage burned by wildfire has been small. This record is attributable to the cooperative efforts of the fire protection agencies at all levels and a cooperative public that is becoming more aware of the problems coincident to burning.

Controlled burning, although used less in recent years, is still a land management tool in these basins. It has been used extensively in the Southern Basins to convert timber or brush covered lands to grass cover and to maintain the conversion. It is also an effective way to dispose of slash and debris from newly logged areas, for fire reduction, pest habitat elimination, and preparation of planting sites for reforestation of Douglas-fir or redwood. However, the ever-increasing demand for control of air pollution and concern for scenic beauty will probably preclude use of burning in the future.

Recreation

Although the overall sediment yield from recreation is not a problem at the present time, some recreation areas presently have high sediment rates and a serious problem could develop in the future. Recreation use is expected to expand significantly as more recreation sites are developed and new and improved highways make these facilities more accessible. Haul roads constructed for logging operations in national forests are opening up new areas that were previously considered inaccessible to most types of recreation. This is probably true of private timberlands also. Sheet and gully erosion will increase unless careful planning and good construction methods are used in the development of recreation facilities.

Croplands

Sheet and gully erosion is not a problem on most croplands because they are used for non-irrigated pasture or generally lie on gentle slopes. Erosion has been moderate or severe on some sloping cropland, such as vineyards. In time, additional grassland will probably be converted to cropland, and erosion potential will increase with the conversion.

Roads

In the North Coastal Basins, the road system acts as the arteries of the local economy. Because of the isolated nature of the towns and industries, disruption of any part of this system can immobilize communities in the affected area. Such occurrences were widespread as a result of the December 1964 storm. Tourism and recreation in the Redwood Region are sometimes hampered because of poor road conditions or delays during summer maintenance periods.

Road related erosion problems usually stem from poor location, design, construction, and maintenance. These often cause landslides, aggravate streambank erosion, disrupt drainage patterns, mar the beauty, and require costly maintenance or even costlier reconstruction.

Many examples of faulty road location were noted in all of the basins. Construction on lower slopes of steep-sided, narrow canyons, encroachment of roads upon streams, and alignment through obviously unstable areas were the major problems found. Roads located on the lower portions of slopes intercept more surface and ground water, thereby increasing surface erosion and landslide activity. Those encoraching upon streams constrict the channel, either resulting in undercutting of the road or forcing water against the opposite streambank and accelerating bank erosion. Roads in unstable areas pose a constant problem in that landslides and slips are common and maintenance costs are high. Misalignment of bridges and culverts in relation to stream channels causes turbulence and deflection of flows against erodible banks.

Major road design problems found in the basins are the steep, bare cuts and fills, many of which have long, uninterrupted slopes, and the inadequate drainage systems. The largest volumes of road-caused erosion and sediment yield comes from cuts and fills. Erosion on unsurfaced roadways is a minor problem. Erosion problems from construction occur mostly on minor roads, such as logging spurs, farm and ranch access roads, and some residential roads, where little or no design was made. These problems include inadequate erosion protection for borrow pits and waste fills; sidecast trees, rocks, and excess soil, and improper stream crossings.

Inadequate surface drainage design is compounded by the severance of continuous substrata layers, which disrupts the normal lateral water flows. When severed, these flow planes create supersaturated masses of soil materials in cut banks, which build up weight, lubricate weakened surfaces beyond shear limits, and slump. Other problems associated with the exposed road cross-sections are rain splash and rillwash of raw cut and fill slopes, downcutting along gutters and flushing of the dry-fall debris from these gutters, puddling along the road surfaces, uncontrolled spillway breaches, cutting action of runoff down rut tracks, erosion of fill materials by and around hanging culvert outlets, lack of energy dissipators at downspout ends, and runoff impact on channel banks from intercepted flows from adjacent hillsides.

Poor maintenance practices are another major cause of soil erosion and sediment yield from roads. The toe of cutbanks is removed by maintenance equipment, causing sloughing and sliding, and excess roadside surface material sometimes leaves a berm at the outside edge, permitting runoff to concentrate and cause erosion. Sometimes when road ditches are cleared the waste is dumped over the road bank, often directly into a stream. Using unsurfaced roads during the rainy season causes ruts that channel water and erode the surface. Sometimes plugged culverts are not cleaned out prior to the rainy season, and gullies are formed by the diverted flows. Too often, unsurfaced roads are not graded or maintained during the early spring months, when proper soil moisture is available to obtain the best results. Temporary roads are often used indefinitely even though they were originally designed for short term use. They usually receive little maintenance, resulting in additional erosion.

LIMITATION OF POTENTIAL LAND USE

SOUTHERN BASINS

Erosion reduces the maximum potential use of lands in the basins. Streambank, sheet, and gully erosion, along with floodwaters, prevent much of the cropland from being intensively farmed. As topsoil is removed by landslide, streambank, sheet, and gully erosion, the livestock carrying capacity of grassland is reduced, and in time, this erosion destroys its agricultural potential. Similar problems on timberland limit its potential for maximum production, and erosion of timberland converted to grassland may reduce its potential for reforestation. About 45 square miles of grassland and one square mile of converted timberland are in the severe erosion class and have lost most of their potential as productive lands. The best use of these lands is for watershed and wildlife areas.

NORTHERN BASINS

No survey of eroded land was made in the Northern Basins since severe erosion did not appear to be extensive.

ENDANGERED DEVELOPMENTS

Erosion of streambanks and gullies can cause the destruction of homes and buildings and endanger lives; damage or destruction of utilities could result in explosion, electrocution, or fire; interruption of water service may occur, which may increase disease hazard; and destruction of existing flood control facilities may occur.

INCREASED COSTS FOR LAND OPERATIONS

Erosion, particularly that connected with gullies and landslides, reduces the efficiency of land operations and increases operating costs. It causes delays, forcing operators to spend time and money on non-productive work. Gullies and landslides can interrupt livestock travel patterns, leading to uneven forage utilization and overgrazing of some areas. Logging may be hampered by blocked skid trails and spur roads, and the necessity of working around problem areas may force expensive changes in plans.

INCREASED RUNOFF RATES

Sheet and gully erosion causes an increase in runoff by removing topsoil and reducing the soil's capacity to grow good vegetal cover.

DESTRUCTION OF FISH AND WILDLIFE HABITAT

Several reaches of eroded channel bottoms were found, which indicates losses of fish habitat. Fish spawn in gravelly stream bottoms and feed on nearby aquatic life. Erosion of the gravel can destroy egg crops and reduce the food supply.

Many areas were found, especially in the Southern Basins, where erosion has reduced the capacity of the land to produce forage and cover for deer and other wildlife. This forces the animals to concentrate in other areas, causing additional overbrowsing problems. A related problem is caused when wildlife, particularly deer, find their normal ranges decimated and encroach upon croplands and areas where timber growers are attempting to reforest. The general health of deer herds is affected by lack of good habitat.

DESTRUCTION OF RECREATION POTENTIAL AND SCENIC BEAUTY

In many areas throughout the basins, scars from erosion detract from the natural beauty, lower land values, and reduce the recreation potential. This erosion has little effect on the total use of the area for recreation, home building, or tourism, but has a marked effect in those localities where it is excessive.

ADVERSE IMPACT ON LOCAL ECONOMY

When erosion reduces the productivity of the land, the economy of the North Coastal Area is adversely affected. Loss of production from timber, grazing, recreation, farming, fishing, and hunting directly affect the income of landowners. This, in turn, starts a chain reaction that has impacts upon all supporting businesses and upon employment in the area.

Landslide in road cut on State highway 299 along the Trinity River.

SCS PHOTO 3-5735-12

Sediment deposits in small reservoir. Tributary to Dry Creek, Russian River Basin. SCS PHOTO

Flood-borne sediment on a young orchard in Anderson Valley, Mendocino County, 1965. SCS PHOTO

In this chapter, sediment yield studies are described, present sediment data are shown, and predictions of future yields are presented. Future sediment yields that can be expected by the year 2020 were predicted assuming that a land treatment program is not installed. The total sediment yield was divided into three principal sources -- sheet and gully, streambank, and landslide erosion -- and each was studied separately. Sediment yield from roads is included under sheet and gully erosion, whereas in the Eel and Mad River Basins study reported in Appendix No. 1, roads were considered a separate source. The Northern Basins -- the Klamath, Trinity, and Smith -- and the Southern Basins -- the Russian, Mendocino Coastal, and Clear Lake -- were grouped and are discussed separately because of substantial differences in location, sediment yield characteristics, problems, and solutions. A more detailed survey entitled Reconnaissance Survey Report--Conservation Treatment of the Dry Creek Watershed, dated February 1966, is available for the Northern Russian River Basin.

The table on the next page, "Present Annual Sediment Yields by Source," presents the total sediment yields from each basin by source. Streambanks yield 47 percent of the total; sheet and gully erosion yield 28 percent; and landslides yield 25 percent.

The Northern Basins presently yield an estimated 5,940 acre-feet of sediment annually from 10,795 square miles of watershed, an average of about 0.55 acre-feet of sediment per square mile per year.

The Southern Basins presently yield an estimated 4,950 acre-feet of sediment annually from 4,041 square miles of watershed, an average of about 1.22 acre-feet of sediment per square mile per year.

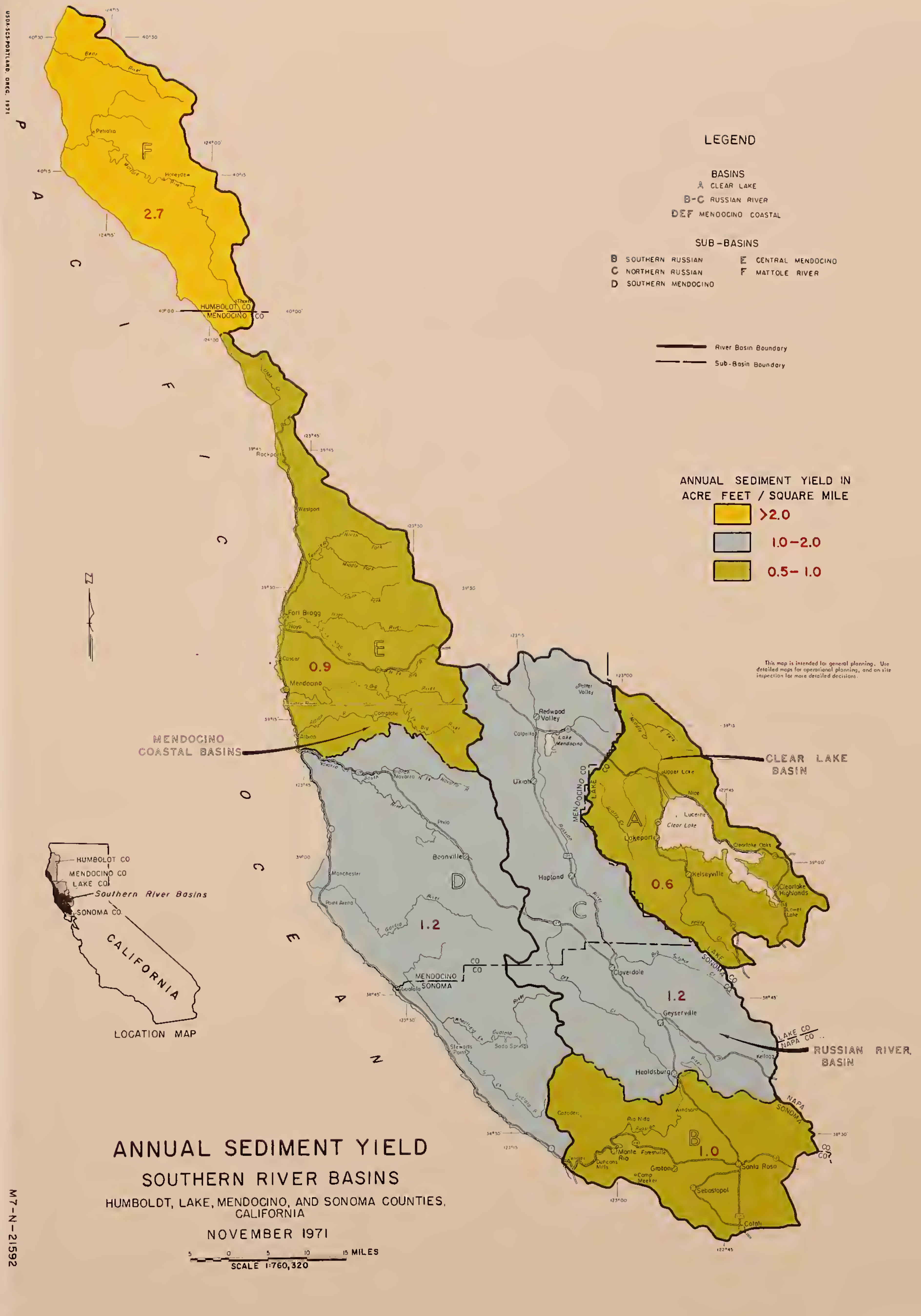
Caution should be used when interpreting the sediment yield rates presented in this chapter. These values imply greater accuracy than is warranted by the survey procedures used; however, they are useful in comparing the differences between sources and causes of sediment yield in the various basins and in evaluating the effects of land use practices and remedial programs. Also the sediment rates presented in this chapter are the estimated averages and, in any given year, may be several times more or less than these average rates.

It is estimated that total sediment yields in all basins will increase by 16 percent or 1,720 acre-feet per year if an effective land treatment program is not installed. These future yields are shown in the table "Future Annual Sediment Yields by Source." Reductions in yields that can be achieved with a program are discussed in the chapter "Recommended Land Treatment Program."

The maps "Annual Sediment Yield--Northern Basins" and "Annual Sediment Yield--Southern Basins" are presented on the following pages. Estimates of the rates in Oregon were prepared by the SCS State Office Staff in Oregon.

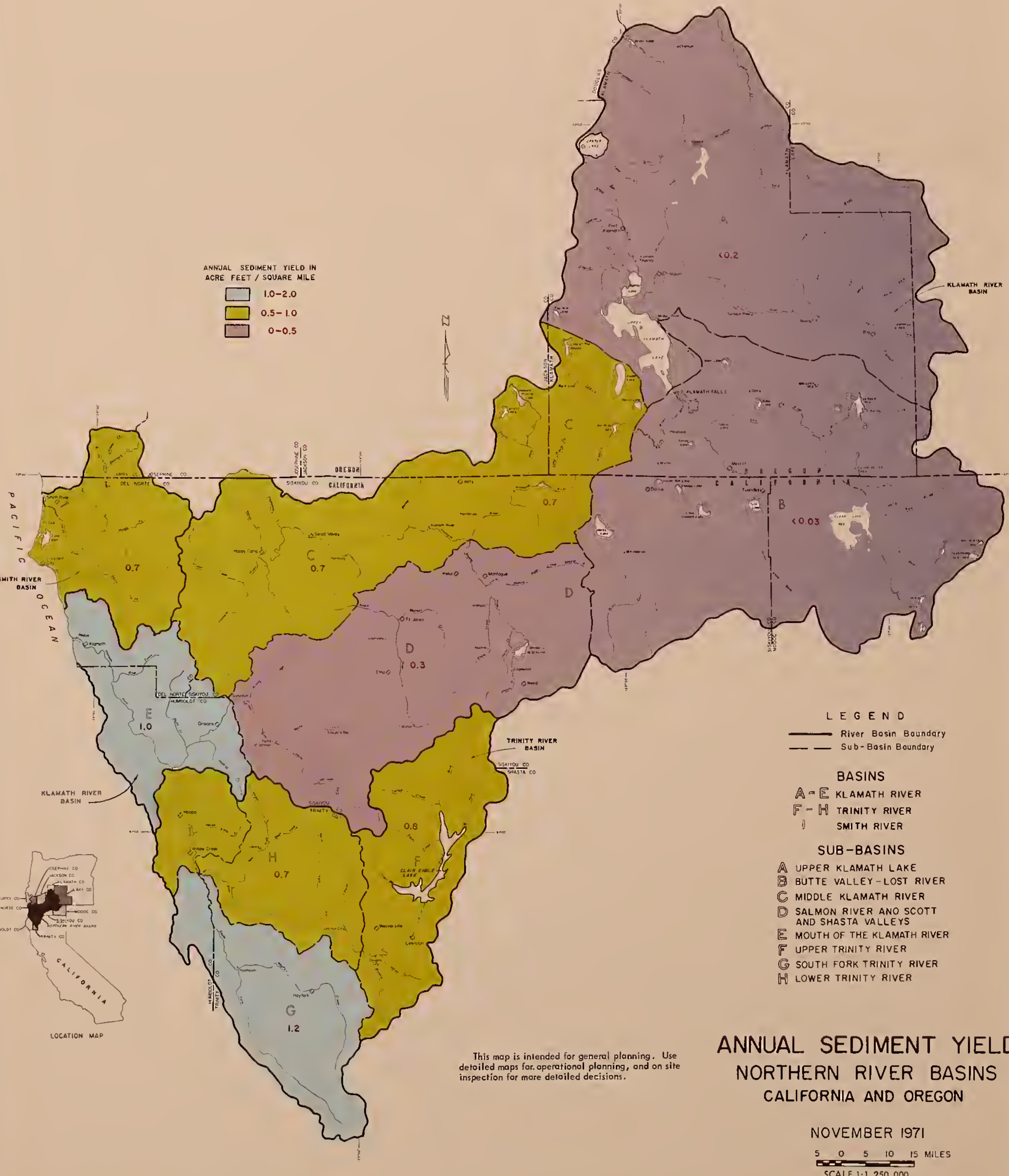
Present Annual Sediment Yields by Source

Basin and Subbasin	Area (Sq.Miles)	Stream-banks	Land slides	Sheet & Gully	Total
		Sediment Sources in Acre-Feet Per Year			
Northern Basins					
Klamath River					
Butte Valley-Lost River	2,309	10	T	50	60
Salmon-Scott-Shasta	2,199	440	180	100	720
Middle Klamath	1,756	430	580	180	1,190
Mouth of Klamath	772	450	160	160	770
Subtotal	7,036	1,330	920	490	2,740
Trinity River					
Upper Trinity	1,013	350	60	370	780
Lower Trinity	1,024	510	100	110	720
South Fork Trinity	932	380	570	190	1,140
Subtotal	2,969	1,240	730	670	2,640
Smith River	790	290	200	70	560
Total	10,795	2,860	1,850	1,230	5,940
Southern Basins					
Russian River					
Northern Russian	1,010	630	160	410	1,200
Southern Russian	475	270	20	170	460
Subtotal	1,485	900	180	580	1,660
Mendocino Coastal					
Mattole River	499	550	400	380	1,330
Central Mendocino	666	190	120	270	580
Southern Mendocino	933	470	230	400	1,100
Subtotal	2,098	1,210	750	1,050	3,010
Clear Lake	458	110	10	160	280
Total	4,041	2,220	940	1,790	4,950
Grand Total	14,836	5,080	2,790	3,020	10,890



ANNUAL SEDIMENT YIELD
SOUTHERN RIVER BASINS
HUMBOLDT, LAKE, MENDOCINO, AND SONOMA COUNTIES, CALIFORNIA

NOVEMBER 1971



This map is intended for general planning. Use detailed maps for operational planning, and on site inspection for more detailed decisions.

ANNUAL SEDIMENT YIELD
NORTHERN RIVER BASINS
CALIFORNIA AND OREGON

NOVEMBER 1971

M7-E-21591-N

SHEET AND GULLY EROSION

Sheet and gully erosion presently contributes about 3,020 acre-feet per year, or nearly 28 percent of the total sediment yield of the basins. This yield is attributed to six principal causes -- logging, grazing, roads, cultivation, deer browsing, and natural causes.

If the land treatment program recommended in this appendix is not installed, future sediment yields from sheet and gully erosion are expected to increase 33 percent to 4,020 acre-feet per year.

SURVEY PROCEDURES

A basic category map was developed which showed specific combinations of mappable factors that were thought to affect soil erosion and sediment yield. The four major factors selected were soil-slope association, vegetal cover type, land use, and land ownership. These are further described in the chapter "Land Resources and Use." The map was based on the most recent U.S. Geologic Survey Topographic Quandrangles (15-minute) and on aerial photographs taken in 1965.

The map was used only as a working tool, and is not presented in this appendix. It showed the areas and distribution of each basic category and was used to apportion the number of field plots to the categories and to expand the sample data over the basins.

Seventy-eight soil-slope associations formed the basis for the category map, and the vegetal cover types delineated were conifer, woodland, conifer-woodland, woodland-grass, grass, brush, cropland, and barren. Land uses isolated were undisturbed, logged, logged and burned, type converted, type converted and burned, burned by wildfire, and cultivated. Grazing was considered as a land use but was not delineated on the category map because no source maps showing the area grazed were available. This area was determined by soil and vegetation acreage measurements from the category map. Two ownership classes, national forest and other, were also delineated. These factors were combined into the basic category map by the use of the MIADS2[1/] computer program.

Categories representing over one percent of the watershed area were selected for sampling; those comprising less than that were combined with similar categories unless they had a special significance. The number of plots located within a basic category varied according to its

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[1/] Elliot L. Amidon, MIADS2, An Alphanumeric Map Information Assembly and Display System for a Large Computer, U.S. Forest Service Research Paper PSW-38, (Berkeley, Pacific Southwest Forest and Range Experiment Station, 1966). 12 pp.

This Douglas Fir site cleared by girdling in 1918 is shown ten years later. Note serious gully erosion brought about by the land use conversion plus heavy grazing use. USFS PHOTO

Same site in 1953. Note increase in both size and extent of gullying, a result of continuing heavy grazing. SCS PHOTO 3-1559-9 size, homogeneity, and distribution. Sample plots were selected using aerial photographs; accessibility of a site was an important consideration in the selections.

Depth of erosion, period of occurrence, percentage of the eroded material that reached a stream, and the causes of erosion by percentage were estimated in the field for each plot. Other data, such as ground cover density, percent bare ground, and condition of the vegetal cover, and management recommendations were also recorded.

In the investigation of sediment yields caused by roads, those outside the national forests were classified in categories using the USGS Topographic Quadrangles, while those inside were classified using Forest Service Development Transportation Plan Maps, which showed more road detail. Only the roads shown on these maps were considered in this study, and sediment yield from other roads, such as logging spurs, was estimated as a part of the plots described in the previous paragraphs. A proportionate number of samples was taken in each of the road categories.

Two different sampling techniques were used during the course of the study, but results were similar. Some roads in the national forests were sampled with a plot system using 100- to 500-foot lengths of road. Measurements of grade and roadway and cut-fill widths were taken, and estimates of the amount of erosion and the percent delivered to the streams were made. On other roads, plot lengths were longer, up to several miles, and the measurements were estimated while driving slowly along the roads.

DATA ANALYSIS

Although there were slight variations in procedures, the same general analyses were used to determine the sediment yields in all basins. Using sample data from field plots, erosion rates were determined for each of the basic categories, and these rates were applied to the area of that category. In each basin, the total erosion volume was determined by summing the eroded volumes of each category. The average percent of eroded material reaching the streams was determined and was applied to the total erosion volume to arrive at the sediment yield for each basin. The percent of sediment yield assigned to each cause was determined by averaging the estimated percentages recorded in field samples for each basin.

Analysis of road-caused sediment yield followed the same general procedure except that road lengths rather than gross areas were used as the basis for calculations. From the sample data collected for each of the road classifications, the aggregate total of annual sediment rates and the lengths of sample reaches were determined. The weighted average annual sediment rate in acre-feet per year per mile of road was computed and was multiplied by the total length of roads in each basin to arrive at the annual sediment yield for each road classification and basin.

PRESENT SEDIMENT YIELD

The results of the sediment yield studies for the Northern and Southern Basins are discussed separately because the physiography and climate of the two areas are quite different.

Southern Basins

For the 4,041-square mile area of the Southern Basins, the average sediment rate from sheet and gully erosion is about 0.44 acre-feet per square mile per year, which accounts for approximately 36 percent of the total sediment yield from all sources. The Mendocino Coastal Basin has the highest sediment rates from sheet and gully erosion, with about 0.50 acre-feet per square mile per year, followed by the Russian River Basin, with about 0.39 acre-feet per square mile per year, and the Clear Lake Basin, with about 0.35 acre-feet per square mile per year. The percentage of sediment yield from sheet and gully erosion for each cause is as follows: logging - 28 percent, grazing - 26 percent, deer - 18 percent, natural erosion - 18 percent, roads - 7 percent, and cultivation - 3 percent.

The following table "Present Sediment Yields from Sheet and Gully Erosion in the Southern Basins" shows the annual sediment yields for each basin by cause. The accompanying table "Present Sediment Rates from Sheet and Gully Erosion in the Southern Basins" shows the annual rates per square mile for each cause.

The sediment rates from sheet and gully erosion are about the same for the three basins, but because of size and the large portion logged with tractors, the Mendocino Coastal Basin yields substantially more sediment than the other two. When considering sediment from sheet and rill erosion alone, the Clear Lake Basin has a considerably higher sediment rate. In this basin many hillsides with highly erodible soils are covered with chaparral. A considerable acreage of these soils is denuded each year. This causes a high sediment rate from sheet and rill erosion, although stream density in the basin is lower than that in the other two. The sediment rate for sheet erosion alone in the Russian Basin is higher than that in the Mendocino Coastal Basin probably because stream density is slightly higher.

Gully erosion accounts for most of the sediment yield in the Mendocino Coastal Basin. These gullies are usually associated with skid trails and rutted roads. A high proportion of sediment from gullies is delivered to streams, and stream density apparently has little effect on sediment yield.

Logging causes 28 percent of the sediment yield from sheet and gully erosion, about 500 acre-feet per year. Over 90 percent of the logging-caused sediment yield occurs in the Mendocino Coastal Basin, and a large proportion is attributed to gullying caused by poor logging and post-logging practices. Most of the timber land in this basin is privately owned, and logging is generally done by tractors, even on steep slopes. The Mattole River Subbasin has the most acreage logged and yields the most sediment.

Present Sediment Yields From Sheet and Gully
Erosion in the Southern Basins

Basin	Area (Sq.Miles)	Acre-Feet Per Year: Directly Influenced By Man: Logging	Grazing	Roads	Cultivation	Other: Deer	Natural	Total
Russian River	1,485	20	180	50	40	170	120	580
Mendocino Coastal	2,098	480	250	60	20	110	130	1,050
Clear Lake	458	Trace	30	10	Trace	40	80	160
Total	4,041	500	460	120	60	320	330	1,790

Present Sediment Rates From Sheet and Gully
Erosion in the Southern Basins

Cause of Sediment Yield	Sediment Yield (Acre-Feet/Year)	Percent Of Total	Area Affected (Square Miles)	Sediment Rate (Acre-Feet/Sq.Mile/Year)
Directly Influenced By Man				
Logging	500	28	729	0.69
Grazing	460	26	3,262	0.14
Roads	120	7	25	4.8 (0.03 Ac-Ft/Mi/Yr.)
Cultivation	60	3	534	0.11
Other				
Deer	320	18	2,972	0.11
Natural	330	18	4,041	0.08
Total	1,790	100		0.44 Avg.

The sediment yield caused by grazing is about 460 acre-feet per year, which is 26 percent of the total sediment from sheet and gully erosion in the Southern Basins. Although sediment yields from grazing and logging are similar, the sediment rate caused by grazing is only about one-fifth of that from logging. This rate is higher in the Mendocino Coastal Basin than in the other two. Grasslands in this basin are generally heavily grazed, especially in the Mattole Subbasin. The basin has large areas of unstable geology and soils, and the seasonal rainfall is higher than in the other two basins.

Deer use and natural causes contribute about the same amount of sediment yield, each accounting for about 18 percent of the volume from sheet and gully erosion. The sediment rate for deer use is a little higher than that attributed to natural causes since it occurs over a smaller area.

Roads in the Southern Basins are yielding only about 7 percent of the sediment from sheet and gully erosion. A higher proportion of roads are surfaced in the Southern Basins than in the Northern Basins; they have generally been established for a longer period and are usually located on flatter terrain.

Cultivation is a minor cause of sediment yield, accounting for about 60 acre-feet per year, which is about 3 percent of the total from sheet and gully erosion. Although the sediment rate from cultivation is about the same as some other causes, it occurs on a smaller area.

Northern Basins

For the 10,795-square mile area in the Northern Basins, the average sediment rate from sheet and gully erosion is 0.11 acre-feet per square mile per year, which accounts for 21 percent of the total sediment production from all sources. The Trinity Basin has the highest sediment rate from sheet and gully erosion, with 0.22 acre-feet per square mile per year, followed by the Smith Basin, with 0.09 acre-feet per square mile per year, and the Klamath Basin, with 0.07 acre-feet per square mile per year. The percentage of sediment yield from sheet and gully erosion for each cause is as follows: roads - 62 percent, natural erosion - 16 percent, logging - 14 percent, grazing - 6 percent, and deer - 2 percent.

The following table "Present Sediment Yields from Sheet and Gully Erosion in the Northern Basins" shows the annual sediment yields for each basin by cause. The accompanying table "Present Sediment Rates from Sheet and Gully Erosion in the Northern Basins" shows the annual rates per square mile for each cause.

The sediment rate per square mile of area disturbed by roads is considerably higher than that yielded by other causes of sheet and gully erosion. The average annual sediment rate from road prisms in the three basins is about 16.5 acre-feet per square mile (0.08 acre-feet per mile), which is about 13 percent of the total sediment yield from all sources and about 62 percent of that from sheet and gully erosion.

Present Sediment Yields From Sheet and Gully
Erosion in the Northern Basins

Basin	Area (Sq.Miles)	Acre-Feet Per Year: Directly Influenced By Man: Logging	Grazing	Roads	Cultivation	Other: Deer	Natural	Total
Klamath	7,036	70	40	250	Trace	10	120	490
Trinity	2,969	90	30	450	Trace	20	80	670
Smith	790	10	Trace	60	Trace	Trace	Trace	70
Total	10,795	170	70	760	Trace	30	200	1,230

Present Sediment Rates from Sheet and Gully
Erosion in the Northern Basins

Cause of Sediment Yield	Sediment Yield (Acre-Feet/Year)	Percent of Total	Area Affected (Square Miles)	Sediment Rate (Acre-Feet/Sq.Mile/Year)
Directly Influenced By Man				
Logging	170	14	1,020	0.17
Grazing	70	6	5,105	0.01
Roads	760	62	46	16.5 (0.08 Ac-Ft/Mi/Yr)
Cultivation	Trace	0	467	Trace
Other				
Deer	30	2	6,104	Trace
Natural	200	16	10,795	0.02
Total	1,230	100		0.11 Avg.

Land slippage and roadside erosion. SCS PHOTO 3-2220-10

Eroding roadside ditch causing slides on the roadcut.
SCS PHOTO 3-5735-14

The Trinity has the highest sediment yield caused by roads, followed by the Klamath and Smith Basins. Road and stream densities are greater in the Trinity Basin, which probably accounts for its higher yield. The Smith Basin yielded less total road-caused sediment, but has a sediment rate greater than the Klamath. Higher stream density and rainfall are probably responsible.

In the Trinity, Smith, and Klamath Basins, roads in the national forests accounted for 94, 85, and 76 percent, respectively, of the total road-caused sediment yield. The chief source of sediment is unstable cut banks, which are necessarily wide in steep terrain. Many national forest roads are new and have not had time to revegetate and otherwise stabilize. Terrain in the national forests is generally steeper and has more unstable rock and soil mantle than in the areas outside the boundaries. National forest road maintenance is often inadequate because funds for this purpose seldom keep pace with those for road construction. Most of these roads are unsurfaced, and surface erosion is an added minor problem.

An analysis of field data on roads within national forest boundaries was made to ascertain the effect of the nearness of roads to streams. One hundred feet was selected as the sample dividing point, and maps show that about one-third of the roads are within that distance. It was found that roads closer than 100 feet yielded about 2-1/2 times more sediment as those further away. This is attributed to erosion of fill materials during floods and surface erosion that directly enters stream channels.

Natural erosion is the second largest cause of sediment yield from sheet and gully ersoion. This is considered to be mostly a result of high rainfall and unstable soil and geological conditions.

Logging ranks third among the causes of sediment yield from sheet and gully erosion. Sediment rates from erosion caused by logging are slightly higher in the Trinity than in the Klamath and Smith Basins, which have about the same rate. Logging in the Klamath and Smith Basins is done primarily with high lead methods, while in the Trinity Basin, tractor logging is the most common system used. Tractor logging generally causes greater disturbance of the soils and requires more roads, many of which must be located on the lower slopes near streams.

Sediment yield caused by grazing is a minor problem in the Northern Basins. Total yield is only about 70 acre-feet, which is based upon a rate of 0.01 acre-feet per square mile per year for the area grazed. Virtually all of the yield is in the eastern part of the Klamath Basin; other grazed areas showed only a trace of erosion. The effect of deer use upon sediment yield is also very slight, with rates of only a trace basinwide. Cultivation occurs mainly on the nearly level valley soils, and sediment yields from this cause are too slight to measure.

FUTURE SEDIMENT YIELD

Sediment yields from sheet and gully erosion are expected to increase from 1,230 to 1,330 acre-feet per year in the Northern Basins and from

1,790 to 2,690 acre-feet per year in the Southern Basins during the next 50 years if the proposed land treatment program is not installed.

These estimates are projected from past sediment rate increases found in sample data and are modified according to some assumptions regarding the future use and management of the basins.

Since the Northern Basins have a high proportion of national forest land, the sediment rates will probably decrease because of continually improving management practices. At the same time, however, increased public use will tend to offset this decrease. For example, improvement in road design, construction, and maintenance may result in lower erosion rates, but the increasing public use will require more miles of road. Although sediment rates will decrease, the net sediment yield will not necessarily be reduced.

Management on private lands will also probably improve over the next 50 years as land becomes more valuable, more laws are passed controlling use, and traditional management practices that are often wasteful are changed by better informed managers. The public is becoming more cognizant of destructive management, and this attitude should result in more restrictions on private land use, especially where timber harvest is concerned. However, many areas, particularly in the Southern Basins, have been abused to the point where sediment yields will remain high for many years. This is especially true for heavily gullied areas, which are almost impossible to heal through rehabilitation programs and which heal very slowly under natural conditions.

Grazing use in national forests is decreasing, and this trend is expected to continue in the future. The Forest Service will limit grazing on most of the badly abused areas, and these will slowly rehabilitate themselves, with or without the application of special programs. In areas where grazing is to be continued in the national forests, livestock numbers are being brought into balance with the capacity of the resource. Sediment yield from all national forest grasslands should remain negligible.

On private lands, the grazing situation is quite different. Although some improvement in management is needed and expected, it is assumed that many areas will continue to be overgrazed, particularly in the Southern Basins. There are presently many grassland areas that have deteriorated through continued heavy use to the point that they cannot recover without remedial programs. Sediment yields on these areas are expected to increase at an accelerated rate unless remedial programs are installed.

Considering all these factors, it seems logical to predict that sediment yields from sheet and gully erosion will increase if remedial programs are not installed and management guidelines are not followed. This increase is projected to be about 100 acre-feet per year in the Northern Basins and about 900 acre-feet per year in the Southern Basins by the year 2020.

LANDSLIDE EROSION

Landslides are prominent features of the landscape in the basins and are one of the most visible sources of sediment yield. A prime example of their prominence can be seen along Highway 101 from Cloverdale to Hopland, which is repeatedly being repaired because of slide activity. Because of this prominence, slides are frequently cited as the major mode of landscape degradation as well as the major source of sediment in the basins. However, this study shows that landslides rank second as a source of sediment yield in the Northern Basins and rank third in the Southern Basins, contributing 31 and 19 percent, respectively, of the total sediment yield from all sources.

AVAILABLE DATA

The only specific data found on landslides in this area are contained in the Corps of Engineers report on landslides around the margin of Lake Sonoma behind the Warm Springs Dam in the Russian River Basin.[1/] Other sources of available data consisted of published reports on the geology of specific areas, ground water reports, and broad reconnaissance studies, in which landslides were briefly mentioned. General geology of the basins is shown on the Ukiah, Santa Rosa, Redding, Weed, and Alturas Sheets of the Geologic Map of California published by the State Division of Mines and Geology.

Aerial photographs taken in 1940, 1941, 1942, 1944, 1947, 1948, 1953, 1965, and 1968 and the latest editions of U.S. Geologic Survey Topographic Quadrangles were used extensively.

SURVEY PROCEDURES

Engineering and geological literature abounds with definitions of landslides, but the consensus seems to define a landslide as the downward movement of slope-forming movement of slope-forming materials, such as rock and soil. For this study, two criteria had to be met in order that a slide could be tabulated, (1) it had to be visible on a standard 1:20,000-scale aerial photograph and (2) it had to be actively producing sediment.

Many spectacular landslides can be seen from roads that traverse the basins, but many more occur in remote canyons, so it was necessary to use aerial photographs. Since it was impractical to examine all the photographs, a sampling technique was devised, by which about 10 percent of the area was examined on aerial photographs. In the Clear Lake Basin, about 40 percent of the area was examined to assure adequate coverage because few landslides were found. Landslide data measured or estimated from aerial photographs were checked in the field for accuracy when possible.

[1/] Corps of Engineers, Russian River Basin, Dry Creek; Warm Springs Dam and Lake Sonoma Project, Sonoma County, California, Design Memorandum No. 9, Geology, pp. 26-35. (San Francisco, August 1967.)

Large landslide in the Bear Creek Watershed, Humboldt County.
SCS PHOTO 3-5736-1

Active landslide causing road damage as well as sedimentation in Big Sulphur Creek, Sonoma County. SCS PHOTO 3-5138-11

Annual sediment yield for each sample was determined by dividing the volume of sediment lost during the time span between two aerial photograph flights by the number of years in that period. Photographs taken in 1965 were compared with those taken variously in 1940, '42, '44, '48, and '53. Consequently, the period between flights varied considerably over the study area. This could produce discrepancies in the results because differences in precipitation and runoff which affect sliding, occurred during the various periods. To counteract this potential bias, adjustments were made by correlating annual runoff data for the various time spans, using 1940-65 as the base period. No adjustments were needed for the Northern Basins, and only slight adjustments were made for the Southern Basins.

Other information recorded for each sample slide included interpretations of geology, probable causes of the slide, and possible remedial measures.

The smallest slide that could be adequately studied was found to be 200 feet in one dimension, which appears as a tenth of an inch on aerial photographs with a scale of 1:20,000. Slides smaller than 200 feet in one dimension were included in the studies of sheet and gully and streambank erosion.

DATA ANALYSIS

The volume of material yielded by slides was tabulated and the area covered by each photo was determined. The average annual sediment rate per square mile for the samples in each subbasin was determined, and the weighted average rate was applied to the entire subbasin area to obtain the average annual sediment yield for that subbasin.

FINDINGS

As shown in the following table, "Present Sediment Yields and Rates from Landslides," the sediment yield from the Northern Basins is nearly double that in the Southern Basins. However, the Southern Basins have a sediment rate about 25 percent higher than that in the Northern Basins. The Mattole River Subbasin of the Mendocino Coastal Basins has the highest rate, 0.80 acre-feet per square mile per year, followed by the South Fork Trinity Subbasin of the Trinity River Basin, with 0.61 acre-feet per square mile per year. The Clear Lake Basin showed the lowest rate, 0.02 acre-feet per square mile per year.

Southern Basins

The low yield for the Southern Russian Subbasin and Clear Lake Basin can probably be attributed to topographic and geologic factors. Much of the Southern Russian Subbasin is flat or gently rolling, and the mountains in the eastern part are underlain by the resistant Sonoma volcanics. To the west the terrain and geology are typical of the unstable conditions in the North Coastal Area, but the only major landslides observed were in the Austin Creek watershed north of Cazadero.

Present Sediment Yields and Rates From Landslides

Basin or Subbasin	Drainage Area (Sq.Miles)	Annual Sediment Yield (Acre-Feet)	Annual Sediment Rate (Ac.Ft./ Sq.Mile)
Southern Basins			
Russian River Basin			
Northern Russian	1,010	160	0.16
Southern Russina	475	20	0.04
Subtotal	1,485	180	0.12
Mendocino Coastal Basin			
Mattole	499	400	0.80
Central Mendocino	666	120	0.18
Southern Mendocino	933	230	0.25
Subtotal	2,098	750	0.36
Clear Lake Basin	458	10	0.02
Total	4,041	940	0.21 avg.
Northern Basins			
Klamath River Basin			
Butte Valley-Lost River	2,309	-	-
Salmon-Scott-Shasta	2,199	180	0.08
Middle Klamath	1,756	580	0.33
Mouth of Klamath	772	160	0.21
Subtotal	7,036	920	0.13
Trinity River Basin			
Upper Trinity	1,013	60	0.06
Lower Trinity	1,024	100	0.10
South Fork Trinity	932	570	0.61
Subtotal	2,969	730	0.25
Smith River Basin	790	200	0.25
Total	10,795	1,850	0.17 avg.

Nearly half of the Clear Lake Basin of the watershed is underlain by the erosion-resistant Clear Lake Volcanic Series, alluvium and other gently rolling or flat lands, and Clear Lake. Landslides in these areas are, for all practical purposes, non-existent, and nearly all the slides found were in the other half, the mountainous western and northern parts.

The major areas of landslide activity in the Northern Russian Subbasin are Dry Creek, Big Sulphur Creek, and stretches along Highway 101 north of Ukiah and between Cloverdale and Hopland. The Franciscan formation, noted for its inherent weakness and erodibility, underlies most of these areas. In Big Sulphur Creek, faults are common and geysers are present, indicating geologic instability.

Part of the variations in sediment yield among the subbasins is due to climatic differences. Mean annual rainfall in the Southern Russian Subbasin and Clear Lake Basin is a moderate 30-50 inches per year, whereas the range in the Mattole Subbasin is 50-120 inches per year. This high rainfall, combined with weak rocks and steep topography, creates an especially significant landslide hazard in the Mattole Subbasin.

Faulting is also a major cause of landslides, and many active slides are found along the San Andreas Fault in the Southern Mendocino Subbasin.

Northern Basins

As the table shows, some subbasins of the Klamath have very low sediment yields from landslides. For example, no slides were seen on any of the sample photos examined in the Butte Valley-Lost River Subbasin. Most of this subbasin is flat or gently rolling and is underlain by erosion-resistant lavas. This is an area of low precipitation, most of which falls as snow, and drainage of the subbasin is characterized by marshes, lakes, and sluggishly flowing streams.

The Salmon-Scott-Shasta, Upper Trinity, and Lower Trinity Subbasins also experience a relatively low frequency of slides. Although they have rugged topography, rock formations are generally resistant to sliding. Debris slides and avalanches in the glacially sculptured valleys of the Trinity Alps and Marble Mountains account for considerable sediment in some of the smaller glacial streams of these areas, but they are relatively unimportant in the Klamath Basin.

Landslide sediment yield in the South Fork Trinity Subbasin is the highest of any of the Northern Subbasins. It is estimated that landslides account for 570 acre-feet of sediment per year in this subbasin. Much of this area has steep terrain that was logged with little apparent regard for erosion control.

One of the most devastated areas in the entire basin is a tractor logged area of privately owned land around Pelletreau Creek, where large slides, bank erosion, and gullies are found. An extremely large debris fan has formed at the mouth of Pelletreau Creek. A similar situation exists on privately owned land that was tractor logged in the watershed of Goose

Creek, a tributary of the South Fork of the Smith River. However, no large fan was observed at the mouth of Goose Creek, probably because of the flushing action by the South Fork Smith River.

CAUSES OF LANDSLIDES

Landslides take place under the combined influence of land use practices and geologic, topographic, and climatic conditions. These conditions can lead to sliding either by contributing to high shear stress on the slope, such as that caused by the removal of the toe of a slope by stream or road undercutting, or contributing to low shear strength in the rock or soil mass, as in the examples of faults, joints, and high water content. Removal of the toe of a slope by stream erosion or road construction may appear to be the most evident cause of a particular landslide, but it may be only the last link in a chain of events leading to the failure of the slope.

From any land management point of view, the identification of landslides by probable cause is a useful and necessary assessment. Assuming that unstable slopes in the basins are now in a delicate state of equilibrium, any condition that causes the slope to fail can be considered the primary cause of a slide.

The apparent primary causes of landslides were determined from aerial photographs and were verified for those slides that were checked in the field. These causes can be grouped into two categories -- those associated with man's activities and those occurring under natural conditions. Roads and logging were the main activities of man that could be identified as influencing landslides, and the effect of these activities were easily detected on aerial photographs. The influence of grazing and man's other activities could not be easily identified from the photographs.

Most of the sediment yield from landslides is attributed to natural causes, the most common of which is undercutting by streams. Stream-caused sliding may be aided by other factors, such as spring seepage, location on a fault zone, and heavy precipitation. Slides not incident to streams can sometimes be attributed to gullying. In many cases, the primary cause of sliding is not evident from the aerial photographs.

In some areas, especially in the Klamath Basin, sliding may be attributable to unnaturally high stream flows indirectly caused by logging activities upstream. Stream courses in these areas are characterized by bare, raw channels where the natural streambank vegetation has been washed away. Landslides in these areas are caused by stream undercutting, but may be influenced by logging operations.

The percentage of man-caused landslide sediment yield varies widely among the basins, as shown in the following tabulation.

Basin	Annual Sediment Yield (Acre-Feet)	Directly Man-Caused (Percent)	Indirectly Man-Caused (Percent)	Natural Causes (Percent)
Klamath-Trinity-Smith	1,850	12	33	55
Russian	180	6	-	94
Mendocino Coastal	750	12	-	88
Clear Lake	10	1	10	89

FUTURE SEDIMENT YIELD

Unless effective land treatment programs are introduced, sediment yield from landslides will increase in the future because of construction and development brought on by the demands of an increased population. In the next 50 years, a sediment yield increase of 25 percent is estimated under these conditions.

STREAMBANK EROSION

Streambank erosion is defined as the removal of bank material by erosive stream action and includes small landslides that are less than 200 feet wide, measured along the stream. This sediment source yields about 5,080 acre-feet per year from the basins or about 47 percent of the total yield.

AVAILABLE DATA

The following material was available for use in determining the sediment yield from streambanks:

1. U.S. Geological Survey Topographic Quadrangles (scales 1:62,500 and 1:24,000).

2. Aerial photographs: 1940, 1941, 1942, 1944, 1946, 1948,1952, 1965, and 1968 flights (approximate scale 1:20,000).

SURVEY PROCEDURES

Because of the large number of streams and the variation in sizes, a sampling technique was used in selecting streams to be studied. Streams were classified by order, in accordance with Strahler's

Streambank erosion along the Trinity River. SCS PHOTO 3-5735-13

Streambank erosion along the Russian River. SCS PHOTO 3-5258-6 modification[1] of Horton's stream ordering system. A description of this system is presented in Appendix No. 1 for the Eel and Mad River Basins.

The number of samples for each stream order was determined in relation to its total length, and specific streams to be sampled were selected on topographic maps. These sample streams were studied under stereoscope on 1965 aerial photographs for all basins except Clear Lake, for which 1968 photographs were available. After viewing photographs of the sample streams, individual reaches to be studied were selected. A relatively unobstructed view of the sample site on the aerial photograph was an important consideration. Sample reaches averaging one mile in length were measured. The stream area in the bottom or at the top of eroded banks, whichever was most visible, was delineated on the aerial photograph and measured by planimeter. An Abrams height finder was used to determine the average height of some eroded banks, while others were estimated.

This process was repeated for the corresponding sample reaches on the oldest aerial photographs available. In the Northern Basins, 1944 photographs were available for 75 percent of the area, and 1942 and 1946 photographs were used for the remainder of these basins. In the Russian and Mendocino Basins, 1941 aerial photographs were available for about one-third of the area, and 1948 and 1952 photographs were used in the remaining area. In the Clear Lake Basin, 1940 aerial photographs were used. The streambank volume that eroded during the time between aerial flights is the difference in channel area times the average depth of the same reach. The average annual sediment yield was computed for each sample reach.

Of the 32,270 miles of stream in the six basins, about 602 miles or about 2 percent of the total were sampled. Most of the samples were checked in the field to assure that they were typical and that the measurements were reasonably accurate. Many other stream reaches were observed in the field for comparison with the sample reaches.

DATA ANALYSIS

Since there was a possibility that the average annual sediment yield could vary for the several time periods, 1941-1965, 1944-1965, 1946-1965, 1948-1965, and 1952-1965, it was necessary to make a comparison of suspended load and streamflow gage records to see if the estimated rates needed adjustment. The procedure used to make this comparison is described in the Appendix No. 1 for the Eel and Mad River Basins. Results of the comparison for the Northern Basins showed that the rates for the 1942-1965 and the 1946-1965 periods varied only slightly from that for the 1944-1965 period, so no adjustment was made for the other two periods. For the Russian and Mendocino Basins, the difference was significant, and the data for the 1948-1965 and 1952-1965 periods were adjusted to

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[1] Kenneth L. Bowden and James R. Wallis, "Effect of Stream-Ordering Technique on Horton's Laws of Drainage Composition." Geol. Society of America, Bulletin, Vol. 75, pp. 767-773 (1964).

correspond with that for 1941-1965. In the Clear Lake Basin, the 1940-1968 period was essentially the same as that for 1941-1965, so no adjustment was made.

For each stream order and subbasin, both the sample lengths, in miles, and the sediment rates of the samples, in acre-feet per year, were totaled. The aggregate sample of sediment yields was divided by the total sample length to arrive at an average sediment rate per mile for each order and subbasin. The average sediment rate per mile was multiplied by the total length of streams for that order and subbasin to obtain the final sediment rate in acre-feet per year.

PRESENT SEDIMENT YIELD

In general, streambanks in the Northern Basins are yielding less sediment per square mile than those in the Southern Basins. Except for the eastern side of the Klamath Basin, the Northern Basins are mainly comprised of steep mountainous terrain with shallower soils, are forested and brush covered, and have more stable geologic formations over a larger portion of the area. Heavily forested and brush covered areas generally provide better protection against streambank erosion. Although over half of the Southern Basins are forest and brushlands, the areas of grass and cropland are substantially larger than in most of the Northern Basins. Terrace material and alluvial valleys found in range and cropland areas have deeper soils, and streambanks located in these areas are more subject to erosion.

Although the erosion rates per mile for 2nd and 3rd order streams are much smaller than those for the higher order streams, their sediment yield is about half of the total from streambanks because of their greater lengths. These smaller streams represent about 70 percent of the total length of all streams.

In general, the sediment rates per square mile increase in the larger stream orders partially because they carry more flow, but also because stream channels generally become flatter and are located in succeedingly more terrace and alluvial fill material as they approach the mouth. These sources of erodible material appear to yield the greatest amount of sediment per mile. In a few cases, larger stream orders are yielding less sediment per mile than the smaller ones in the same basin, probably because the larger ones have low banks, rockbound reaches, or good vegetal protection.

Southern Basins

The results of the present sediment yield studies on streambanks in the Southern Basins are presented by stream order and subbasin in the tables "Present Annual Sediment Yield from Streambanks," "Length of Stream Channels," and "Annual Sediment Rate Per Mile of Stream," on the following pages. In these basins, streambank erosion yields about 40 to 54 percent of the total sediment.

Present Annual Sediment Yield From Streambanks
In The Southern Basins

Basin or Subbasin	Area (Sq.Miles)	Sediment Yield (Acre-Feet/Year) Stream Orders 2nd	3rd	4th	5th	6th	7th	8th	9th	Totals	Sediment Rate (Af/Sm/Yr.)
Russian River											
Northern Russian	1,010	190	140	80	60	90	70	-	-	630	0.62
Southern Russian	475	50	60	20	10	10	120	-	-	270	0.57
Subtotal	1,485	240	200	100	70	100	190	-	-	900	0.61
Mendocino Coastal											
Mattole	499	170	180	70	130	-	-	-	-	550	1.10
Central Mendocino	666	80	30	20	40	10	10	-	-	190	0.29
Southern Mendocino	933	120	90	120	80	60	-	-	-	470	0.50
Subtotal	2,098	370	300	210	250	70	10	-	-	1,210	0.58
Clear Lake	458	20	10	30	20	30	Tr	-	-	110	0.24
Total	4,041	630	510	340	340	200	200	-	-	2,220	0.55

Length of Stream Channels
In The Southern Basins

Basin or Subbasin	Area (Sq.Miles)	Stream Length (Miles) Stream Orders 2nd	3rd	4th	5th	6th	7th	8th	9th	Totals
Russian River										
Northern Russian	1,010	1,560	530	180	60	70	30	-	-	2,430
Southern Russian	475	690	200	70	40	10	60	-	-	1,070
Subtotal	1,485	2,250	730	250	100	80	90	-	-	3,500
Mendocino Coastal										
Mattole	499	670	200	70	50	-	-	-	-	990
Central Mendocino	666	980	380	90	80	30	30	-	-	1,590
Southern Mendocino	933	1,360	440	200	120	60	-	-	-	2,180
Subtotal	2,098	3,010	1,020	360	250	90	30	-	-	4,760
Clear Lake	458	430	150	90	30	20	Tr	-	-	720
Total	4,041	5,690	1,900	700	380	190	120	-	-	8,980

Annual Sediment Rate Per Mile of Stream
In The Southern Basins

Basin or Subbasin	Area (Sq.Miles)	Sediment Rate (Acre-Feet/Mile/Year) Stream Orders 2nd	3rd	4th	5th	6th	7th	8th	9th	Subbasin Average
Russian River										
Northern Russian	1,010	0.12	0.26	0.44	1.00	1.29	2.33	-	-	0.26
Southern Russian	475	0.07	0.30	0.29	0.25	1.00	2.00	-	-	0.25
Average	-	0.11	0.27	0.40	0.70	1.25	2.11	-	-	0.26
Mendocino Coastal										
Mattole	499	0.25	0.90	1.00	2.60	-	-	-	-	0.56
Central Mendocino	666	0.08	0.08	0.22	0.50	0.33	0.33	-	-	0.12
Southern Mendocino	933	0.09	0.20	0.60	0.67	1.00	-	-	-	0.22
Average	-	0.12	0.29	0.58	1.00	0.78	0.33	-	-	0.25
Clear Lake	458	0.05	0.07	0.33	0.50	1.50	Tr	-	-	0.15
Average For Basins	-	0.11	0.27	0.49	0.87	1.05	1.67	-	-	0.25

The Russian Basin has the highest sediment rate probably because it has a larger percentage of terrace material and flat alluvial valleys that are particularly subject to streambank erosion. The Northern Russian Subbasin has a slightly higher rate than the Southern Subbasin. Precipitation varies from about 30 to 60 inches over most of the basin, but this variation seems to be uniformly distributed in both subbasins.

The Mendocino Coastal Basin has the next highest sediment rate from streambanks, only slightly lower than that for the Russian Basin. Considerable variations in rates occur between the subbasins of the Mendocino Coastal Basin. Geologic conditions in the three areas are generally similar, but annual runoff varies considerably. There is significant correlation between total sediment yield and runoff, and this same relationship appears to be true for streambank erosion and runoff. The Mattole Subbasin has the highest sediment rate (1.10 acre-feet per square mile per year) and the most annual runoff, ranging from 30 to 90 inches. The Southern Mendocino Subbasin has the next highest sediment rate (0.50 acre-feet per square mile per year) and an annual runoff that varies from 15 to 40 inches. The Central Mendocino Subbasin has the lowest sediment rate (0.29 acre-feet per square mile per year) and the lowest annual runoff (15 to 30 inches).

Clear Lake Basin has the lowest sediment rate from streambanks, about 40 percent of that in the Russian Basin. Precipitation is much lower in this basin, varying from 22 to 40 inches per year.

Northern Basins

The results of the present sediment yield studies on streambanks in the Northern Basins are presented by stream order and subbasin in the tables "Present Annual Sediment Yield from Streambanks," "Length of Stream Channels," and "Annual Sediment Rate Per Mile of Stream" on the following pages. These yields account for about half of the total sediment in each basin.

In the Klamath Basin, both the number of streams and the sediment rate per square mile from streambanks decrease in a west-to-east direction. Rainfall decreases in the same direction -- from 130 inches near the mouth to 10 inches in the Butte Valley and Tulelake areas. Topography changes from steep mountainous terrain in the western portion to flat valleys and gently rolling to relatively flat plateaus in the east. The highest sediment yield from streambanks occurs in the mouth of the Klamath Subbasin, which has narrow alluvial valleys and unstable soil conditions on the highly erodible Franciscan formation. Much of this area has been tractor logged. Although the Middle Klamath and Salmon-Scott-Shasta Subbasins have mostly steep mountainous terrain, geologic formations in this area are generally more stable and resistant to erosion. Formations in the relatively level Butte Valley-Lost River Subbasin are mostly lava and other volcanic rocks that are highly resistant to erosion.

The sediment rate in the Trinity Basin is about double that for Klamath Basin, mainly because the Trinity Basin has a proportionately larger

Present Annual Sediment Yield From Streambanks
In The Northern Basins

Basin or Subbasin	Area Sq.Miles	Sediment Yield (Acre-Feet/Year) Stream Orders 2nd	3rd	4th	5th	6th	7th	8th	9th	Totals	Sediment Rate (AF/SM/Yr)
Klamath River											
Butte Valley-Lost River	2,309	Tr	Tr	10	Tr	Tr	-	-	-	10	0.00
Salmon-Scott-Shasta	2,199	130	110	90	30	60	20	-	-	440	0.20
Middle Klamath	1,756	100	90	100	30	60	50	-	-	430	0.24
Mouth of Klamath	772	170	80	60	40	-	-	30	70	450	0.58
Subtotal	7,036	400	280	260	100	120	70	30	70	1,330	0.19
Trinity River											
Upper Trinity	1,013	50	140	40	70	50	-	-	-	350	0.34
Lower Trinity	1,024	150	130	80	50	20	20	60	-	510	0.50
South Fork Trinity	932	150	50	30	40	70	40	-	-	380	0.41
Subtotal	2,969	350	320	150	160	140	60	60	-	1,240	0.42
Smith River	790	120	20	50	80	20	-	-	-	290	0.37
Total	10,795	870	620	460	340	280	130	90	70	2,860	0.26

Length of Stream Channels
In The Northern Basins

Basin or Subbasin	Area (Sq.Miles)	Stream Length (Miles) — Stream Orders: 2nd	3rd	4th	5th	6th	7th	8th	9th	Totals
Klamath River										
Butte-Valley-Lost River	2,309	1,160	330	120	40	20	-	-	-	1,670
Salmon-Scott-Shasta	2,199	2,730	1,220	220	60	80	20	-	-	4,330
Middle Klamath	1,756	3,290	880	180	50	90	80	-	-	4,570
Mouth of Klamath	772	1,500	540	150	60	-	-	20	40	2,310
Subtotal	7,036	8,680	2,970	670	210	190	100	20	40	12,880
Trinity River										
Upper Trinity	1,013	1,790	650	120	110	70	-	-	-	2,740
Lower Trinity	1,024	1,900	690	130	120	60	10	30	-	2,940
South Fork Trinity	932	1,580	570	110	100	50	30	-	-	2,440
Subtotal	2,969	5,270	1,910	360	330	180	40	30	-	8,120
Smith River	790	1,500	570	120	70	20	-	-	-	2,280
Total	10,795	15,450	5,450	1,150	610	390	140	50	40	23,280

Annual Sediment Rate Per Mile of Stream
In The Northern Basins

Basin or Subbasin	Area (Sq.Miles)	Sediment Rate (Acre-Feet/Mile/Year)								
		Stream Orders								Subbasin Average
		2nd	3rd	4th	5th	6th	7th	8th	9th	
Klamath River										
Butte Valley-Lost River	2,309	Tr	Tr	0.08	Tr	Tr	-	-	-	Tr
Salmon-Scott-Shasta	2,199	0.05	0.09	0.41	0.50	0.75	1.00	-	-	0.10
Middle Klamath	1,756	0.03	0.10	0.56	0.60	0.67	0.63	-	-	0.09
Mouth of Klamath	772	0.11	0.15	0.40	0.67	-	-	1.50	1.75	0.19
Average	-	0.05	0.09	0.39	0.48	0.63	0.70	1.50	1.75	0.10
Trinity River										
Upper Trinity	1,013	0.03	0.22	0.33	0.64	0.71	-	-	-	0.13
Lower Trinity	1,024	0.08	0.19	0.62	0.42	0.33	2.00	2.00	-	0.17
South Fork Trinity	932	0.09	0.09	0.27	0.40	1.40	1.33	-	-	0.16
Average	-	0.07	0.17	0.42	0.48	0.78	1.50	2.00	-	0.15
Smith River	790	0.08	0.04	0.42	1.14	1.00	-	-	-	0.13
Average For Basins	-	0.06	0.11	0.40	0.56	0.72	0.93	1.80	1.75	0.12

area of unstable geologic formations and more streams per square mile. Some private lands in the basin have been tractor logged.

The Lower and South Fork Subbasins of the Trinity Basin have higher sediment rates from streambanks than the Upper Trinity Subbasin. There is a 40- to 70-inch variation in rainfall, but the variation is somewhat uniform within each of the subbasins. Flatter gradient streams located in terrace material usually occur in the two lower subbasins, and probably account for this increase in sediment yield per square mile.

The Smith Basin also has a higher sediment rate than the Klamath Basin. As in the Trinity Basin, unstable geologic formations cover a large portion of the Smith Basin.

INFLUENCE OF MAN'S ACTIVITY

Most streambank erosion is caused by natural geologic and hydrologic conditions, but some was directly influenced by man's activities. The magnitude of this influence was estimated by analyzing the field data and studying aerial photographs. Watershed areas above the sampled streambank reaches were examined on aerial photographs for evidence of activities such as logging, roadbuilding, and grazing. Field samples were divided into two groups -- those with evidence of man's activities and those without -- and the average sediment yield was determined for each group and stream order. The average sediment rates from the undisturbed sample areas are assumed to be natural rates and, in all cases, are less than those associated with man's activities. The difference between these rates is the estimated influence of man on streambank erosion. Only the 2nd, 3rd, and 4th orders were analyzed because watershed areas above the larger stream order samples all contained some form of man's activities, and natural sediment rates could not be determined. Within the scope of this study, there is no effective way to analyze the influence of man's activity on streambank erosion in the larger stream orders, but it is considered to be less than that in the smaller stream orders.

The following tabulation presents the sediment yield from 2nd, 3rd, and 4th order streambanks directly influenced by man's activity for each of the basins:

Basin	Total Sediment Yield From All Streams (Acre-Feet/Year)	Sediment Yield Directly Influenced By Man From 2nd,3rd, & 4th Order (Acre-Feet/Year)	Percent Of Total
Klamath	1,330	310	23
Trinity	1,240	240	19
Smith	290	70	24
Russian	900	120	13
Mendocino Coastal	1,210	280	23
Clear Lake	110	30	27
Total	5,080	1,050	21 avg.

The table shows that at least 21 percent, or 1,050 acre-feet per year, of sediment yield from streambanks is directly influenced by man. In the Northern Basins, essentially all of this influence came from tractor logging operations and associated spur roads. In the Southern Basins, about 80 percent of the sediment yield from this influence came from tractor logging operations; the rest was from grazing and other activities, as indicated in the following tabulation:

Sediment Yield Directly Influenced By Man
(Acre-Feet/Year)

Basin	Logging	Grazing and Other Activities	Total
Russian	84	36	120
Mendocino Coastal	240	40	280
Clear Lake	26	4	30
Total	350	80	430

FUTURE SEDIMENT YIELD

Unless an effective land treatment program is installed, the future sediment yield from streambanks is expected to continue at about the present rate of 5,080 acre-feet per year for the next 50 years. The present sediment yield for the 24-year study period is higher than the average for the last 50 years. One reason is that major storms, such as that of December 1964, leave most of the streambanks bare and subject to heavy erosion for many years. The subsequent regrowth of vegetation along the banks is sometimes retarded by the less intense storms.

L A N D   T R E A T M E N T   P R O G R A M S

Land treatment programs are presented in two phases -- measures to remedy sediment yield problems and increase productivity and management guidelines to prevent future problems. Costs, methods and problems of implementation, and effects of each program are discussed.

REMEDIAL AND PRODUCTION IMPROVEMENT PROGRAMS

The programs described in this section are recommended for basinwide installation because they either reduce sediment yield or increase productivity of the land. In many cases, they do both. Several other measures were investigated and were considered inadequate to meet those criteria, at least within practical economic limits. For example, basinwide installation of remedial measures that would reduce sediment yield from landslides and streambanks are not recommended because their high cost makes them impractical for general use. However, some may be feasible in local areas where high values are involved.

A simplified benefit-cost procedure was employed to determine the relative efficiency of the land treatment measures. The average annual land treatment costs were calculated for each range site after discounting for a 20-year installation period. The future annual increase in AUM's was calculated for each range site. The AUM's were multiplied by a value of $4 and discounted for lag in accrual. The benefits were then divided by the costs to determine the benefit-cost ratio. Those practices having a relatively low benefit-cost ratio were eliminated from consideration. No attempt was made to evaluate other benefits such as fish and wildlife benefits in this study. The cumulative environmental effects of these programs are described in the main report.

Total cost of the remedial and production improvement program is $90,109,000 over a 20-year installation period. Average annual maintenance costs are predicted to be $5,112,000, about 90 percent of which is for road maintenance.

PRIVATELY OWNED GRASSLAND

Privately owned grasslands encompass about 1,592 square miles. Because of the differences (mainly in productivity and climate) between the Northern and Southern Basins, separate programs were developed for natural grasslands in these areas. A third program was formulated to reforest suitable areas of grassland that had originally been converted from timberland. The total cost of these three programs is nearly $14 million.

Better grazing management will be essential to maintain the improved forage conditions and soil cover and to reduce sediment yield from all grazing lands regardless of erosion class or present condition. On-site investigations will be necessary to select the most effective treatment for each area. Technical services should be provided to assist landowners in making these decisions for each specific area.

Natural Grassland -- Southern Basins

The program for privately owned natural grasslands in Southern Basins covers about 462 square miles. It will provide the necessary increase in ground cover density and organic litter for sediment reduction and forage improvement.

Measures

Natural grasslands were grouped into three erosion classes -- slight, moderate, and severe -- that are discussed in the section "Soils Data" in the Addendum. Proposed treatment measures differ for each class.

Slight Erosion Class

This class comprises about 278 square miles of natural grassland and has slight sediment yields that average 80 acre-feet per year. On about 91 square miles, vegetal cover conditions are poor, and these areas should be reseeded and fertilized. Another 116 square miles have adequate natural seed and plants available, but should be fertilized to improve the composition and vigor of the stands. After good stands have been established in both areas, they should be fertilized about every third year to maintain maximum forage production. The remaining 71 square miles in this class produce adequate forage.

Moderate Erosion Class

About 139 square miles of natural grassland are in this class, which has moderate sediment yields that average 119 acre-feet per year. This land has been heavily grazed, leaving the ground cover in poor condition. About 4 square miles should be reseeded and fertilized to improve cover. Followup fertilizing will be needed about every third year to maintain the improved grass forage. Because of steep slopes and low potential for improvement, remedial measures are not considered practical on the remaining 135 square miles of land in this class.

Severe Erosion Class

This class comprises about 45 square miles of natural grassland and has high sediment yields that average 106 acre-feet per year. Because the ground cover is badly depleted, all of the existing vegetation is needed for soil erosion protection. The entire 45 square miles should be fertilized to improve the ground cover and should be fenced to exclude livestock grazing. Seeding to grasses would be desirable, but steep slopes and gullies make it impractical. Without proper seedbed preparations, seeding would be ineffective. In some areas, planting of suitable trees and shrubs may be feasible to reduce erosion and heal gullies. In general, it is impractical to construct debris dams or mechnically repair damaged lands because of the ruggedness of the terrain and the high erodibility of newly disturbed areas.

Cost

The table "Estimated Costs of the Private Natural Grassland Program in the Southern Basins" is presented on the following page. The total cost of installing the remedial measures is $5,404,000, averaging $292,000 per year for the 20-year installation period. After the installation period, an annual cost of $254,000 would be required for maintenance.

Natural Grassland -- Northern Basins

The Northern Basins encompass 916 square miles of privately owned natural grasslands. The entire estimated 15 square miles of grassland in the Trinity Basin and about 175 square miles of grassland in the Klamath are expected to be converted to more intensive use during the next 50 years. These areas need protection from erosion and improved management until conversion is accomplished. Treatment of these lands before conversion might avoid much disturbance during conversion. No appreciable acreage of grassland exists in the Smith Basin. This program covers the remaining 726 square miles of natural grassland in the Klamath Basin. Soil erosion is only a minor problem on most of these grasslands, but it is significant in places. Treatment measures are mainly designed to improve grass forage.

Measures

Since treatment measures vary, depending on the condition of plants, natural grasslands in this area are divided into two groups -- range sites in poor condition and those in fair condition. Range sites in good condition are almost non-existent in this area.

Range Sites in Poor Condition

This group comprises about 622 square miles of rangeland that is producing less than 25 percent of its forage potential. The number of existing grass plants is insufficient in some areas to produce the necessary seed to improve the stand naturally. Brush cover should be removed by mechanical means where needed on about 193 square miles, and the area should be reseeded to perennial grasses and legumes on a suitable seedbed. About 348 miles of fencing would be needed to protect these newly seeded areas. The remaining 429 square miles should not be seeded because they lie on steep slopes and rocky soils. An additional 274 miles of fence and 308 stockwater developments would make uniform distribution of grazing possible over the entire area, and proper livestock management would be essential to maintain good forage production.

Range Sites in Fair Condition

This group comprises about 104 square miles of natural grassland that is producing one-quarter to one-half of its potential. There is an adequate supply of natural perennial plants, but improved livestock management practices are needed to increase forage production. An estimated 61 miles of fence and 45 stockwater developments would allow better

Estimated Costs of the Private Natural Grassland Program in the Southern Basins

Item	Unit	Quantity	Total Cost ($)	Annual Maintenance[1/] Cost ($)
Slight Erosion Class (207 square miles)				
Seeding	Sq.Miles	91	900,000	
Fertilization	Sq.Miles	207	3,375,000	232,000
Subtotal			4,365,000	232,000
Moderate Erosion Class (4 square miles)				
Seeding	Sq.Miles	4	51,000	
Fertilization	Sq.Miles	4	66,000	4,000
Subtotal			117,000	4,000
Severe Erosion Class (45 square miles)				
Fertilization	Sq.Miles	45	302,000	
Permanent Fencing	Miles	100	200,000	8,000
Subtotal			502,000	8,000
Technical Services (462 square miles)			420,000	10,000
Total			5,404,000	254,000

1/ Annual maintenance cost after the 20-year installation period. During the 20-year installation period, annual maintenance costs will average one-half of this amount.

Grassland that has sufficient vegetal cover to prevent excessive erosion. This range site is in poor condition with a cover mainly of Medusa-head. SCS PHOTO 3-5538-2

A range site that has been seeded to perennial grass. SCS PHOTO 3-5538-6

A brush covered range site in fair condition. Mt. Shasta in the background. SCS PHOTO 3-5538-11 grazing management, and carefully controlled chemical spraying for brush control on about 54 square miles would allow grasses to grow more vigorously. About 5 square miles of meadow area should be reseeded to more desirable grasses; although these meadows could be improved by better grazing management, improvement would be faster with reseeding.

Cost

The table "Estimated Costs of the Private Natural Grassland Program in the Northern Basins" is on the following page. The total cost of installing the remedial measures is $5,105,000, averaging $275,900 per year for the 20-year installation period. After the installation period, an annual maintenance cost of $275,000 would be required.

Converted Timberland

Essentially all of the grassland converted from timberland occurs in the Russian and Mendocino Coastal Basins and comprises about 214 square miles, which is about 13 percent of the privately owned grassland. Treatment measures for these lands are designed to improve the vegetal cover, increase production, and reduce sediment yield.

Measures

Because of the difference in treatment measures for these lands, they are divided into three areas -- those that should be reforested, those that should remain in grass for grazing, and those that are so severely eroded that they must be permanently excluded from uses that cause further erosion.

Area to be Reforested

About 57 square miles of converted timberland are classified as high or very high quality sites for Douglas-fir forests. These lands should be reforested since timber soils usually are strongly acid and have a relatively low fertility level for grasses.[1/] On these lands, much effort is required to prevent regrowth of woody vegetation, and good quality timberland will yield greater returns over a long period of time.[2/] These newly forested lands should be fenced for 3 or 4 years to exclude grazing.

1/ Robert A. Gardner and others, Wildland Soils and Associated Vegetation of Mendocino County, California, p. 19ff. (Sacramento: Resources Agency of California, Cooperative Soil-Vegetation Survey Project 1964).

2/ Adon Poli and E.V. Roberts, Economics of the Utilization of Commercial Timberland on Livestock Ranches in Northwestern California, Miscellaneous Paper No. 25, p. 36ff. (Berkeley, USDA Forest Service California Forest and Range Experiment Station, April 1958).

Estimated Costs of the Private Natural Grassland Program in the Northern Basins

Item	Unit	Quantity	Total Cost ($)	Annual Maintenance Cost 1/ ($)
Range Sites in Poor Condition (622 square miles)				
Seeding (Brush control where needed)	Sq.Miles	193	3,088,000	174,000
Fencing	Miles	622	732,000	45,000
Stock Water Development	Number	308	308,000	15,000
Subtotal			4,128,000	234,000
Range Sites in Fair Condition (104 square miles)				
Brush Control (Spraying)	Sq.Miles	54	173,000	14,000
Seeding	Sq.Miles	5	80,000	5,000
Fencing	Miles	61	79,000	5,000
Stock Water Development	Number	45	45,000	2,000
Subtotal			377,000	26,000
Technical Services (726 square miles)			600,000	15,000
Total			5,105,000	275,000

1/ Annual maintenance cost after the 20-year installation period. During the 20-year installation period, annual maintenance costs will average one-half of this amount.

Area to Remain in Grass

About 147 square miles of converted timberland is classified as medium to low quality for Douglas-fir forests. These lands are not considered feasible for reforestation and probably should remain in grass cover. About 10 square miles are suitable for good grass forage production and should be seeded and fertilized, with followup fertilization every third year to assure maximum forage production. The remaining 137 square miles in this group has little potential for forage improvement, and no additional treatment measures are recommended.

Severely Eroded Area

This area contains about 10 square miles and has ground cover that is badly depleted. These lands should be fertilized to improve the vegetal cover for protection against erosion and should be fenced to exclude livestock grazing. In some areas, planting of trees and shrubs may be practical to reduce erosion and heal gullies.

Cost

The table "Estimated Costs of the Private Converted Timberland Program in the Southern Basins" is on the following page. The total cost of installing the remedial measures is $3,150,000, averaging $170,200 per year for the 20-year installation period. After the installation period, an annual cost of $20,000 would be required for maintenance.

Effects of the Program

Sediment Yield

The land treatment programs for privately owned grassland would reduce the sediment yield by about 300 acre-feet per year in the Southern Basins. The program for privately owned grassland in the Northern Basins would improve forage production and maintain a good surface cover, but would have only a minor effect on sediment yield. The following table presents the estimated area and sediment yield for privately owned grasslands in the Southern Basins, with and without the installation of the land treatment program.

Production

The private grassland program would increase the future forage production by about 433,000 animal-unit-months, which represents an increase of 250 percent over the expected production without the program. This increase is based on the assumptions of constant price levels and the installation of the complete land treatment program. Since reforestation areas will be fenced to exclude livestock grazing, forage production in these areas will be zero. The table "Grass Forage Production on Privately Owned Grassland" gives a breakdown of the production by classes or areas of land.

Estimated Costs of the Private Converted Timberland Program in the Southern Basins

Item	Unit	Quantity	Total Cost ($)	Annual Maintenance[1] Cost ($)
Reforestation Area (57 square miles)				
Tree Planting	Sq.Miles	57	2,554,000	
Temporary Fencing	Miles	23	30,000	2,000
Subtotal			2,584,000	2,000
Grassland Area (10 square miles)				
Seeding	Sq.Miles	10	109,000	
Fertilization	Sq.Miles	10	160,000	11,000
Subtotal			269,000	11,000
Severely Eroded Area (10 square miles)				
Fertilization	Sq.Miles	10	67,000	
Permanent Fencing	Miles	25	50,000	2,000
Subtotal			117,000	2,000
Technical Services (214 square miles)			180,000	5,000
Total			3,150,000	20,000

1/ Annual maintenance cost after the 20-year installation period. During the 20-year installation period, annual maintenance costs will average one-half of this amount.

Effects of the Privately Owned Grassland Programs
in the Southern Basins

Erosion Class	With Remedial Measures		Without Remedial Measures	
	Area (Sq.Miles)	Annual Sediment Yield (Acre-Feet/Year)	Area (Sq.Miles)	Annual Sediment Yield (Acre-Feet/Year)
Natural Grassland				
Slight	278	80	180	50
Moderate	139	60	226	190
Severe	45	40	56	130
Subtotal	462	180	462	370
Converted Timberland				
Reforestation	57	Tr	55	30
Grassland	147	70	126	80
Severely Eroded	10	10	33	80
Subtotal	214	80	214	190
Total	676	260	676	560

Grass Forage Production on Privately Owned Grassland
(Animal-Unit-Months)

Class or Area	Present Condition	Future Without Program	Future With Program
Natural Grassland (Southern Basins)			
Slight	117,000	64,000	298,000
Moderate	60,000	104,000	62,000
Severe[1]	0	0	0
Subtotal	177,000	168,000	360,000
Natural Grassland (Northern Basins)			
Range Sites in Poor Condition	73,000	45,000	248,000
Range Sites in Fair Condition	43,000	30,000	59,000
Subtotal	116,000	75,000	307,000
Converted Timberland			
Reforestation	13,000	11,000	0[2]
Grassland	41,000	36,000	56,000
Severely Eroded[1]	0	0	0
Subtotal	54,000	47,000	56,000
Total	347,000	290,000	723,000

[1] Current forage production is essentially zero, and the recommended treatment for these lands is to exclude grazing.

[2] Under the recommended program, grazing will be excluded from reforestation areas.

Timber production from reforestation of converted timberland would increase timber production by 8 million cubic feet per year. The optimum harvest period would be 60 years for saw logs, but two thinning cycles would be required during this period. Trees removed by thinning could be used for pulpwood, Christmas trees, or fuelwood.

PUBLICLY OWNED GRASSLAND

There are about 963 square miles of public grass and herb covered land. Of this, about 246 square miles are capable of producing timber of commercial quality and volume. However, only 40 square miles are considered to be highly productive and economically feasible to reforest under present price structures and interest rates. The other 206 square miles, although not now feasible to reforest, should be left in their present condition. They can be used for grazing but will no doubt reforest naturally at a very slow rate. If prices rise as demand for lumber increases, it may become economically feasible and desirable to intensify management for timber production on some of these areas.

About 701 square miles of the grass and herb covered lands have natural grassland soils and are capable of producing at least 0.3 animal-unit-months of forage per acre per year. This land is well suited to grazing, and it is recommended that such use be continued. Another 16 square miles are judged to be suitable for open space uses, such as dispersed recreation and wildlife habitat, but intensive uses should not be permitted.

Measures

The reforestation program consists of mechanically removing existing grass and herbaceous vegetation and planting trees. Weeding is essential during the first five years to free young trees from competition. On gentle slopes, weeding can be accomplished by machine, while on steeper slopes, a combination of hand weeding and spot applications of herbicides may be used. Where feasible, carefully controlled aerial spraying would reduce costs 30 to 60 percent; however, since the effects of herbicides upon the environment are not fully known, and such a program requires extreme care and a detailed study of the long-range ecological effects, it was not included.

The 206 square miles of forest soils not now feasible to reforest and the 701 square miles recommended to remain in grass should be managed for grazing. The public agencies that have jurisdiction over these lands generally have programs that are designed to achieve proper management and development of the grazing resource. Therefore, no further program recommendations are made here.

The 16 square miles that are suitable only for open space management may require some fencing, although it is probable that proper management will achieve the desired results.

Cost

The following tabulation shows a breakdown of the total cost for the 40-square-mile area to be reforested over a 20-year period.

Item	Cost Per Acre ($)	Total Cost ($)
Site Preparation	20	512,000
Tree Planting	20	512,000
Weeding	30	768,000
Total	70	1,792,000

After the initial installation is accomplished, the only additional costs would be for general land management and administration.

Effects of the Program

Sediment Yield

Sediment yield would not be appreciably affected by this program.

Production

The program, when fully installed, would produce about 5 million cubic feet of wood annually based on the maximum average net growth. About 20 percent of this volume would result from thinning that would start when the trees are between 20 and 30 years old. The feasibility of this program is based upon thinnings and final harvest of timber products, although Christmas trees may be harvested, enhancing the benefits. Approximately 7,600 AUM's of annual forage production will be lost as a result of the program.

BRUSHLAND

About 2,666 square miles of land, approximately half of which is privately owned, is presently covered with brush and chaparral, including about 1,366 square miles that is suitable for producing commercial timber. Only 139 square miles is considered productive enough to make a reforestation program feasible under the present price and interest rate structure. The recommended program covers only that acreage.

Another 277 square miles have been recently logged and will probably reforest naturally in time. Therefore, no reforestation program is proposed for those lands; it is recommended, however, that they be managed for timber production. The remaining 950 square miles, although suitable for timber production, are not considered potentially productive enough to support a reforestation program with the present price and interest rate situation. A change in either of these or a less expensive reforestation procedure could result in making many more acres feasible for reforestation. These 950 square miles and the 1,300 square miles of brushland that is incapable of producing timber crops should be left in their present condition, in which they will continue to provide wildlife habitat, watershed protection values, dispersed recreation, and a small amount of grazing. In the future, economic conditions may make it feasible to convert some of these lands to grass.

Measures

Brush should be removed by mechanical means and, if possible, chipped and spread over the area. After the trees are planted, at least one weeding is essential during the first five years to keep the young trees free from competition. Where conditions are suitable, weeding can be accomplished mechanically, but a combination of hand weeding and spot applications or herbicides may be necessary in some cases. Weeding must be done carefully to avoid erosion. About 75 percent of the program would take place on private land where technical services would be needed for assistance to landowners.

The use of herbicides for brush removal would lower costs by 30 to 60 percent and would make the reforestation of considerably more land feasible; however, because of the uncertainty regarding herbicides, their use was not included.

Cost

The following tabulation shows a breakdown of the total program costs over a 20-year period for the 139 square mile area to be treated.

On privately owned land, the recommended program would probably require a cost-sharing arrangement between the government and the landowner.

Estimated Cost Of
Reforestation Program
On Brush Covered Lands

Item	Cost Per Acre ($)	Total Cost ($)
Site Preparation	100	8,896,000
Tree Planting	20	1,779,000
Weeding	15	1,334,000
Technical Services	-	300,000
Total	135	12,309,000

Effects of the Program

The program, when fully installed, would produce about 19 million cubic feet of wood annually based on a high average net growth. About 20 percent of this volume would result from thinnings that would start when the trees are between 20 and 30 years old. The feasibility of this program is based upon thinnings and final harvest of timber products, but Christmas tree harvests may enhance the benefits. Sediment yield would be reduced by about 30 acre-feet per year after the program is installed.

ROADS

There are approximately 14,500 miles of roads in the study area, responsibility for which is distributed as follows:

Federal	State	County	Private	Total (Miles)
8,078	1,226	4,783	368	14,455

Of the roads maintained by the federal government, 7,925 miles are under the direct care of the Forest Service, and the proposed program covers only these roads. The following tabulation summarizes the mileage of these roads by status:

Description of Road	Length (Miles)
Paved Permanent	
Near Stream1/	540
Away From Stream	836
Subtotal	1,376
Unpaved Permanent	
Near Stream1/	1,041
Away From Stream	3,318
Subtotal	4,359
Unpaved Temporary2/	2,190
Total	7,925

1/ "Near stream" means that the road centerline is within 100 feet of a stream.

2/ Proximity to stream was not ascertained.

Measures and Costs

The table on the next page presents types of measures to be installed over a 20-year period and the estimated costs for installation. The 1,376 miles of permanent paved roads are not included in the program because sediment yield from these is low. Some unpaved permanent roads are little used and should be closed to all traffic, while some unpaved temporary roads receive considerable use and should be upgraded into the permanent status.

Estimated Measures and Costs for National Forest Roads in the Northern Basins

Measure	Length (Miles)	Construction Cost ($1,000)	Annual Maintenance Cost ($1,000)
Unpaved Permanent Roads			
Near Streams			
Paving	300	22,255	1,688
Improved Drainage	550	7,755	433
Relocation	86	2,580	196
Road Closure	105	21	0
Subtotal	1,041	32,611	2,317
Away From Streams			
Paving	166	12,314	934
Outsloping	2,820	564	45
Road Closure	332	66	0
Subtotal	3,318	12,944	979
Unpaved Temporary Roads			
Paving	219	16,246	1,232
Outsloping	1,533	460	35
Road Closure	438	88	0
Subtotal	2,190	16,794	1,267
Total	6,549	62,349	4,563

Road paving consists of all types, such as asphalt, chip seal, and gravel, and includes the necessary drainage facilities. Drainage improvement is considered primarily for unpaved roads and includes insloping of road surfaces and installing of paved gutters, culverts, energy dissipaters, crossdrains, concrete fords, and bridges. Road relocation is recommended on some reaches in unstable areas where maintenance problems are extensive. Road closure costs include installation of barriers to stop traffic, removal of temporary bridges and culverts, installation of water barriers on road surfaces, outsloping, and seeding. Outsloping consists of grading unpaved roads so that they slope toward the downhill side and removing berms along the outside edges.

Effects of the Program

The road program is expected to reduce sediment yield on the area treated by about 75 percent, a reduction of about 480 acre-feet per year, or 55 percent of the total volume of sediment from all roads. This program will result in a better road system that will provide more dependable year-round service to the public.

MANAGEMENT GUIDELINES

The following management guidelines are recommended to improve existing situations and to prevent future problems. In some cases, they must be used in conjunction with remedial measures to achieve full rehabilitation of deteriorated sites. However, proper land management, by itself, usually has beneficial effects and can often be practiced without great cost to the landowners. Stabilization of the local economy and greater long-range returns to the landowner will usually result.

SHEET AND GULLY EROSION

Logging Guidelines

1. Logging operations should be planned well in advance, as is now done by the U.S. Forest Service, the California Division of Forestry, and large timber companies with forestry staffs. Owners of small timber tracts should obtain the assistance of foresters to arrive at the best plan for specific areas.

2. A system is needed for judging the potential soil erosion from lands where timber is to be harvested. An example of this type of system is the Erosion Hazard Rating System used by the Forest Service, in which weighted values are assigned to the individual characteristics of soil, slope, climate, and cover. The result is a numerical rating that indicates erosion hazard and the methods to be used when harvesting timber for each particular hazard area. It also indicates precautions that should be taken during logging and provides a guide to the type of postlogging treatment needed.

3. Logging systems that minimize soil distrubance should be used. Cable logging or skyline systems are preferred for erosion control and are the only methods recommended for areas of high erosion hazard. Tractor logging is acceptable in areas of low erosion hazard. Where it is used, the number of skid trails should be minimized, and they should be constructed as nearly parallel to the contour as possible and provided with crossdrains after use. Long, continuous downslope skid trails should be avoided because they tend to channel the runoff and form gullies.

4. Timber harvest should be deferred on extremely unstable soils where logging by present methods is likely to cause landslides. New methods, which are now being developed, will probably make it feasible to harvest such timber in the future.

5. Landings, roads, and skid trails should be located away from creekbeds or washes. Landings should be located on benches away from channels, and stream crossings should be avoided wherever possible.

6. Steep slopes or shallow soil areas should not be logged where sediment will enter directly into streams.

7. Temporary bridges or culverts should be installed at all watercourses to be crossed by trucks and tractors. During winter shutdown or immediately after logging is completed on a given area, the culverts and all fill material should be removed with a minimum of disturbance to the stream channel.

8. Crossdrains (also referred to as waterbars, water breaks, or dips) should be constructed in all temporary roads and skid trails immediately after logging is completed on a given area and should be maintained as necessary. They should completely cross the course's width, have proper outlets, and be deep enough to withstand abuse, including travel over them by tractors or 4-wheel-drive equipment. Recommended spacing for crossdrains on national forest land is determined by the Erosion Hazard Rating. Where the Erosion Hazard Rating is not used, the following spacings are recommended as a guide:

Percent Gradient	Spacing Between Crossdrains(Feet)
1- 3	250
4- 8	150
9-13	100
14-22	70
23-40	40
Over 40	25

Private logging area that has not been reseeded. - Roads and skid trails also were not properly cared for. SCS PHOTO 3-5736-3

Timber harvested in clear cut blocks. High lead system of logging was used to remove timber on Six Rivers National Forest. Cut blocks are shaped to fit contours. USFS PHOTO

The above spacings are to be measured on the slope. The water should be dissipated onto stable areas well protected by rocky ground, slash, or vegetal cover. Crossdrains should be located to promptly intercept runoff from lateral skid trails or other features that may concentrate runoff.

As an alternative to crossdrain installation, all temporary roads could be outsloped 3 percent after logging is completed.

9. Immediately after logging is completed, and cross drains are installed, landings, skid trails, and spur roads should be seeded or planted with appropriate species, depending upon the erosion hazard.

10. In all areas where an inadequate seed source remains after logging, tree species should be seeded or planted to encourage immediate and complete reforestation.

11. Standards that minimize the length and width of entry roads into logging areas should be set and followed.

12. Gradients of logging roads should not exceed 10 percent.

13. Where soil disturbance is unavoidable, it should be confined to the contour as much as possible. Practices that lead to downhill convergence of skid trails and that concentrate runoff volumes should be avoided.

14. Soil disturbance within streamside zones (within 50 feet of a stream) should be restricted to that necessary for removal of insect or disease infested and decadent trees. Cable lift systems of logging are preferable, and use of ground disturbing, heavy equipment for tree removal should generally be excluded. When logging near streams, trees should be felled uphill away from channels, and slash debris should be kept out of watercourses. Any debris inadvertently deposited in channels should be removed immediately, with the least possible disturbance to streambeds and streambanks.

15. Prescribed burning should be minimized because it destroys both litter accumulations and plant canopy vital to soil protection and also creates large volumes of air pollutants. Slash or other unwanted plant materials should either be chipped and spread as protective cover or marketed for fiber.

16. In areas devastated by wildfire, loss of litter and vegetal canopy exposes the soil to erosive forces. Salvage of merchantable timber should be permitted only where little further disturbance to the surface soils results.

17. Restrict the size, shape, and location of clear-cut blocks. The cut blocks should probably be limited in size to about 20 acres and should conform to the lines of the terrain.

adjacent hillsides should have at least pole-sized stands. Cut blocks can extend across ridge tops, but not across channel ways. Roads should not be allowed within the bounds of a cut block, except along ridge lines.

Converted timberland that is severly eroded. Hardwoods have started to take over the area. SCS PHOTO 3-5736-6

Grazing Guidelines

1. Management plans that consider differences in forage, cover, topography, and other physiographic features should be formulated for all grazing areas. These should specify kind and number of livestock, system of grazing, length of season, improvement potentials, and other details pertinent to full utilization of the range consistent with adequate protection of the soils.

2. Stocking rates should be adjusted yearly to a level that will maintain the best possible vegetal cover for soil protection and grazing. The grazing season should be adjusted to avoid excessive damage to soils and vegetal cover that occurs when grazing takes place on wet soils.

3. In the Northern Basin, systems that defer grazing during the growing season at least every third year are recommended. This will enable the perennial grasses, desirable forbs, and brush species to replenish the plant food reserves and should result in healthier plants, more vigorous growth, more total forage, and greater amounts of viable seed.

4. To avoid cover deterioration in small areas, livestock use should be distributed evenly over large areas. Good distribution can be aided by use of measures such as properly located stockwater facilities, fences, and salt licks.

5. Grazing should be excluded on land in the severe erosion class because all the vegetal cover is needed for protection of the soil. After the land has healed, extreme caution should be used in further grazing. Land in this class was found mostly in the Southern Basins.

6. Conversion of cutover timberland to grass should be limited to soils suitable for forage production. Such conversions require careful planning and sensible range management to prevent sediment and erosion damage to the land.

7. On land in the slight erosion class, livestock numbers should be reduced slightly, or the season of use should be shortened. Seed is plentiful and ground cover is generally adequate, but composition and vigor of stands should be improved through lighter use. In the long run, this will protect the soil and increase economic returns.

8. On land in the moderate erosion class, strong steps should be taken to bring livestock numbers into balance with the forage supply. These lands are frequently overstocked, and the reduction of livestock will increase forage and provide greater protection for the soil resource.

Deer Guidelines

1. Deer populations should be kept to a level commensurate with the carrying capacity of the wildlife habitat. This will maintain a healthier herd, protect the soil resource, and probably sustain a greater animal harvest.

2. Deer hunting effort should be spread more evenly to better utilize and manage the resource. Much of the private land, especially in the Southern Basins, is closed to public hunting, and although most of it is hunted to some extent by private clubs or friends of the landowners, this tends to concentrate hunters on national forest and other public lands.

3. Legislation should be provided and game management programs adjusted and coordinated to encourage private landowners and hunters to harvest deer under realistic management plans. These plans would enable them to remove deer of both sexes, to stimulate more efficient management of deer on private land, to improve deer habitat, and to realize reasonable monetary returns.

4. On some cattle and sheep ranges, competition for feed between domestic livestock and deer has a detrimental effect upon the

land. In these cases, until a sound deer management program is adopted, numbers of domestic livestock must be reduced to achieve a balance between grazing use and available forage.

Wildfire Guidelines

The following guidelines are designed mainly to recognize and plan for the impacts that are anticipated as the basins become developed:

1. Coordination between fire control, planning, fire prevention efforts, and pre-attack construction must continue and should be intensified by cooperating fire suppression agencies as watersheds are subjected to more intensive use and increased valuation.

2. Fire control and burned area rehabilitation practices that afford maximum protection to soil resources should be employed. Regardless of the level of fire protection, fires will occasionally occur. To minimize soil damage and to rehabilitate these areas as quickly as possible, the following should be considered:

   a. Expediency often dictates fire fighting tactics that disturb large areas of soil. The firefighting team should consider the resource values involved and choose the tactics that are least likely to cause soil erosion. The installation of erosion control measures on all areas disburbed by fire fighting activities, presently standard practice with the Forest Service and California Division of Forestry, should be continued and improved wherever possible.

   b. Salvage logging or any other activity within the burned area should be undertaken with the guidance of the Erosion Hazard Rating System or similar systems. In many cases, the potential financial gain from these activities may not be worth the risks of increased erosion and loss of future productivity.

   c. The area should be seeded promptly to restore vegetal cover, and other emergency measures should be used to provide initial protection to the soil. Specialists should be consulted to formulate the best total rehabilitation plan to eventually restore full productivity to all lands within the burned area.

3. Fuel breaks should have sufficient crossdrains for water dispersion, as described under item 8 of the "Logging Guidelines" section in this chapter. These should be annually inspected for maintenance needs.

Type Conversion Guidelines

1. The decision to type convert should hinge not only upon the production potential of the soils present, but upon the

inherent soil erodibility and steepness of terrain. Where conversion is desired on the more erodible soils and steep slopes, those practices that create the least soil disturbance or tend to disperse rather than concentrate expected runoff should be employed. A few examples are contour ripping, brush crushing, and the limited application of herbicides.

2. Detailed studies should be made to assure that the conversion will effectively meet the proposed objectives and that the economic returns will be satisfactory. For example, sites on timber soils should not normally be converted to grass and vice versa. Such conversions are generally ineffective, expensive to maintain, and do not usually result in high financial returns.

3. A combination of mechanical clearing or crushing and control burning should be given preference over the use of fire alone. However, controlled burns may be the only practical method for initial brush removal, especially in dense fields with heavy cover. Herbicides have proven very effective in both initial clearing and maintenance of conversions, but their effects upon the environment are questionable so they should be used carefully.

4. A specific seeding and fertilization prescription for each area to be converted to grass should be obtained from range management and soils specialists.

5. For conversions to grass, livestock grazing should be restricted and sometimes excluded until the grass cover is established and the seedlings have attained sufficient vigor to sustain themselves. Grass cover and plant vigor should be maintained at a satisfactory level through proper grazing management. For conversions to timber, livestock grazing should be excluded entirely.

6. If control burning is done, to help prevent escape of fire, burns should be kept relatively small, probably 200 acres or less, depending upon terrain and vegetal conditions. Burns should be well planned to take advantage of weather conditions that will allow a successful conversion, to assure full control at all times, and to provide for adequate post-fire treatment.

Recreation Guidelines

1. Guidelines for road design, construction, and maintenance are presented in the "Road Guidelines" section of this chapter, and these should be followed during the installation of recreation roads. However, special care is needed because recreation roads are often built along streams and reservoirs, and road density is usually high. The construction of vista points or observation sites where large fills are usually

required, often on steep slopes, present especially critical erosion control problems.

2. Recreation development sites along streambanks and lakeshores -- such as beaches, campgrounds, picnic areas, and boat launch facilities -- should be carefully selected, designed, developed, and operated to minimize streambank erosion. Locations that are particularly susceptible to damage, such as the outside curves of streams, flood plains, and areas with unstable soils should be avoided for development. Recreation development should be guided by professional recreation planners and designers.

3. Foot and horse trails should be located, constructed, and maintained so as to keep soil loss to a minimum; adequate drainage is the most important consideration. Barriers should be used to restrict vehicles to established roadway or parking surfaces, and foot travel should be confined to desired routes to reduce destruction of vegetal cover by trampling and to minimize soil compaction and erosion. To avoid permanent damage, trails and unsurfaced roads should be closed to use during wet seasons. Trails and roads that must be used during wet weather should be paved and drained. Camp and picnic sites and other areas where people congregate should be closed when use exceeds that which the soil can withstand.

Cropland Guidelines

1. On-site investigations and detailed soil surveys should be used to determine management practices and remedial measures that are compatible with the great variety of soils and climates in the areas where these croplands are found.

2. The various educational, financial, and technical assistance programs of federal, state, and county agencies should be used to increase productivity and protect the soil resource.[1/]

3. Farm management practices that retard runoff and reduce the sediment yield should be used; a suggested list is presented in the table "Guidelines for Land Use and Minimum Conservation Treatment of Land Suited for Cultivation" on the following pages.

Road Guidelines

1. Soil and geologic conditions should be investigated so that road locations can be planned to avoid steep slopes and areas of unstable soil and rock. In potential problem areas,

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[1/] See the chapter "Opportunities for Development through USDA Programs."

excavation and soil disturbance should be minimized even though the best alignment may sometimes be sacrificed.

2. Roads should be constructed during the dry season. Full inspection during all construction phases is essential.

3. Except in very steep terrain, cutbank slopes should be no steeper than 1-1/2 to 1, and fill slopes no steeper than 2 to 1. Slopes should be interrupted by intermediate terraces at 20-foot vertical intervals. Adequate surface and subsurface drainage should be provided for all slopes and terraces.

4. All cut and fill slopes that will support vegetation should be protected from erosion by seeding grasses, planting shrubs or trees, and applying mulch and fertilizer.

5. Excess material should be end-hauled to safe disposal sites where it will not erode into streams.

6. All fills should be sufficiently compacted during construction, and decomposable material should be eliminated from fill slopes.

7. When it is absolutely necessary to construct roads in unstable soil and landslide areas, particular attention should be given to surface and subsurface drainage.

8. Roads should be located so that fills will not encroach upon streams during peak flows. Riprap and retaining walls should be provided to protect fills when it is necessary to locate them within high-water elevations at culvert or bridge crossings.

9. Fording of live streams with construction equipment should be avoided.

10. The location of stream crossing points should be selected to minimize the disturbance to streambanks and streamflow. The natural stream channel gradients should not be altered. Bridges or culverts should be provided at all watercourses for both temporary and permanent roads. Bridge piers and abutments should be aligned to minimize deflection of current. Culverts should be designed to permit the free movement of fish.

11. Adequate surface drainage facilities should be installed. Downdrains and energy dissipators should be installed at outlets of drainage ditches and culverts to prevent outflow water from being discharged directly onto unprotected slopes. Whenever possible, culvert outlets should be located in existing waterways or in rocky areas. In erodible channels, energy dissipators should be provided at culvert outlets. Surfaced dips or outsloping should be considered for lower-standard roads to prevent accumulation of drainage flows. Road grades should be limited to six percent.

Guidelines for Land Use and Minimum Conservation
Treatment of Land Suited for Cultivation
(By Land Capability Class and Subclass - L.C.S.)

(Southern Basins)

L.C.S.	Area (Sq.Mi.)	Land Management Problems	Suitable Alternate Agricultural Land Uses 1/	Minimum Conservation Treatment 2/ - 3/
I	25	No permanent problems.	Irrigated Cropland Row Crops Field Crops	Conservation Cropping System Irrigation Water Management
			Orchard Vineyard Small Fruits	Cover and Green Manure Crop, or Minimum Tillage Irrigation Water Management
			Pastureland (and Hayland)	Irrigation Water Management Pasture Proper Use
			Non-Irrigated Cropland Row Crops Field Crops	Conservation Cropping System
			Orchard Vineyard Small Fruits	Cover and Green Manure Crop, or Minimum Tillage
IIe	100	Erosion hazard due to sloping land. Some soils are gravelly and have lower available water capacity.	Irrigated Cropland Row Crops Field Crops	Conservation Cropping System Irrigation Water Management
			Orchard Vineyard Small Fruits	Cover and Green Manure Crop, or Minimum Tillage Irrigation Water Management
			Pastureland (and Hayland)	Pasture Proper Use Irrigation Water Management
			Non-Irrigated Cropland Row Crops Field Crops	Conservation Cropping System Minimum Tillage
			Orchard Vineyard Small Fruits	Cover and Green Manure Crop, or Minimum Tillage
IIw	145	Overflow.	Irrigated Cropland Row Crops Field Crops	Conservation Cropping System Irrigation Water Management
			Orchard Vineyard Small Fruits	Cover and Green Manure Crop, or Minimum Tillage Irrigation Water Management
			Pastureland (and Hayland)	Irrigation Water Management Pasture Proper Use
			Non-irrigated Cropland Row Crops Field Crops	Conservation Cropping System
			Orchard Vineyard Small Fruits	Cover and Green Manure Crop, Minimum Tillage
		Somewhat poor drainage; maintenance of drainage system.	Irrigated Cropland Row Crops Field Crops	Conservation Cropping System Irrigation Water Management (drainage)
			Orchard (pears) Vineyard Small Fruits	Irrigation Water Management Minimum Tillage, or Cover and Green Manure Crop (drainage)
			Pastureland (and Hayland)	Irrigation Water Management Pasture Proper Use
			Non-irrigated Cropland Row Crops Field Crops	Conservation Cropping System Minimum Tillage (drainage)
			Orchards (pears) Vineyard Small Fruits	Minimum Tillage, or Cover and Green Manure Crop (drainage)

Guidelines for Land Use and Minimum Conservation Treatment of Land Suited for Cultivation (By Land Capability Class and Subclass - L.C.S.)

(Southern Basins)

L.C.S.	Area (Sq.Mi.)	Land Management Problems	Suitable Alternate Agricultural Land Uses 1/	Minimum Conservation Treatment 2/ - 3/
IIs	25	Fine texture, slow permeability.	Irrigated Cropland Row Crops Field Crops	Conservation Cropping System Irrigation Water Management Minimum Tillage (drainage)
			Orchard (Cherries not adapted)	Cover and Green Manure Crop, or Minimum Tillage Irrigation Water Management
			Pastureland (and Hayland)	Irrigation Water Management Pasture Proper Use
			Non-irrigated Cropland Field Crops	Conservation Cropping System Minimum Tillage
IIIe	65	Erosion hazard due to sloping land. Some soils are very gravelly and have low available water capacity.	Irrigated Cropland Row Crops Field Crops	Conservation Cropping System Crop Residue Use Irrigation Water Management Minimum Tillage
			Orchard Vineyard Small Fruits	Cover and Green Manure Crop, or Mulching Irrigation Water Management Minimum Tillage
			Pastureland (and Hayland)	Irrigation Water Management Pasture Proper Use
			Non-irrigated Cropland Field Crops	Conservation Cropping System Crop Residue Use Minimum Tillage
			Orchard Vineyard Small Fruits	Cover and Green Manure Crop, or Mulching Minimum Tillage
		Erosion hazard due to sloping land. Restricted rooting. Slow subsoil permeability.	Irrigated Cropland Row Crops Field Crops	Conservation Cropping System Crop Residue Use Irrigation Water Management Minimum Tillage
			Orchard(marginal) Vineyard Small Fruits	Cover and Green Manure Crop, or Mulching Irrigation Water Management Minimum Tillage
			Pastureland (and Hayland)	Irrigation Water Management Pasture Proper Use
			Non-irrigated Cropland Field Crops	Conservation Cropping System Crop Residue Use Minimum Tillage
			Vineyard	Cover and Green Manure Crop, or Mulching Minimum Tillage
IIIw	80	Wetness, poor drainage, may have some salts	Irrigated Cropland Row Crops Field Crops	Conservation Cropping System Irrigation Water Management Minimum Tillage (drainage)
			Pastureland (and Hayland)	Irrigation Water Management Pasture Proper Use (drainage)
			Non-irrigated Cropland Field Crops	Conservation Cropping System Minimum Tillage (drainage)

Guidelines for Land Use and Minimum Conservation Treatment of Land Suited for Cultivation (By Land Capability Class and Subclass - L.C.S.) (Southern Basins)

L.C.S.	Area (Sq.Mi.)	Land Management Problems	Suitable Alternate Agricultural Land Uses 1/	Minimum Conservation Treatment 2/--3/
IVe	315	Erosion hazard due to sloping land. Soil depth. Acidity for some crops.	Irrigated Cropland Field Crops (Hay)	Conservation Cropping System Crop Residue Use Irrigation Water Management Minimum Tillage Sprinkler Irrigation System
			Orchard(except Pears - other orchards are marginal in some areas) Vineyard Small Fruits	Cover and Green Manure Crop, or Mulching Crop Residue Use Sprinkler Irrigation System Irrigation Water Management Minimum Tillage
			Pastureland (and Hayland)	Sprinkler Irrigation System Irrigation Water Management Pasture Proper Use
			Non-irrigated Cropland Field Crops	Conservation Cropping System Crop Residue Use Minimum Tillage
			Orchard (marginal in some areas) Vineyard (marginal in some areas)	Cover and Green Manure Crop, or Mulching Crop Residue Use Minimum Tillage
		Erosion hazard due to sloping land. Soil depth. Slow subsoil permeability. Acidity for some crops.	Irrigated Pastureland (and Hayland)	Sprinkler Irrigation System Irrigation Water Management Pasture Proper Use
			Non-irrigated Cropland Field Crops (not well adapted)	Conservation Cropping System Crop Residue Use Minimum Tillage
			Orchard(existing) Vineyard (existing)	Cover and Green Manure Crop, or Mulching Crop Residue Use Minimum Tillage
IVs	15	Low available water capacity. Low Fertility. Erosion hazard. Deposition. Vary gravelly.	Irrigated Cropland Field Crops	Conservation Cropping System Crop Residue Use Irrigation Water Management Minimum Tillage
			Vineyard	Cover and Green Manure Crop, or Mulching Crop Residue Use Irrigation Water Management Minimum Tillage
			Pastureland	Pasture Proper Use Irrigation Water Management

1/ Other suitable alternate agricultural land uses for each of the Land Capability Classes and Subclasses are:
Non-irrigated Pastureland
Recreation Land and/or Wildlife Land
Some soils in Classes IIe, IIw, IIIe, and IVe are suited to Woodland.
Land uses not shown indicate their general unsuitability.

2/ Pasture Proper Use and Woodland Proper Use are the minimum conservation treatments for Non-irrigated Pastureland and Woodland respectively.
No specific practices are indicated as minimum conservation treatment for Recreation Land and/or Wildlife Land because of the wide variety of activities that might occur under these land uses. Applicable conservation treatment should assure maintenance of land and water resources.

There are many structural and other conservation practices that are supplemental to the minimum conservation treatment practices such as grassed waterways and outlets, streambank protection, and diversion terraces.

3/ Definitions of minimum conservation treatment practices:

Conservation Cropping System - Growing crops in combination with needed cultural and management measures. Cropping systems include the use of rotations that contain grasses and legumes, as well as sequences in which the desired benefits are achieved without the use of such crops.

Cover and Green Manure Crop - A crop of close-growing grasses, legumes, or small grain used primarily for seasonal protection and for soil improvement. It usually occupies the land for a period of one year or less, except where there is permanent cover as in orchards.

Crop Residue Use - Utilizing plant residues left in cultivated fields to prevent erosion and improve the soil.

Irrigation Water Management - The use and management of irrigation water, where the quantity of water used for each irrigation is determined by the moisture-holding capacity of the soil and the need of the crop, where the water is applied at a rate and in such a manner that the crops can use it efficiently and significant erosion does not occur. (Includes the timing of irrigations to meet crop needs, the control and adjustment of stream sizes to prevent erosion, and the control of lengths of "set" to reduce water losses.)

Minimum Tillage - Limiting the number of cultural operations to those that are properly timed and essential to produce a crop and prevent soil damage.

Mulching - Applying plant residues or other suitable materials, not produced on the site, to the surface of the soil.

Pasture Proper Use - Grazing at an intensity which will maintain adequate cover for soil protection and maintain or improve the quantity and the quality of desirable vegetation.

Woodland Proper Use - Treating woodlands in a manner which will maintain adequate cover for soil and water conservation, and maintain or improve the quantity and quality of desirable wood crops, by the application of one or more woodland protection and/or woodland conservation practices.

Guidelines for Land Use and Minimum Conservation
Treatment of Land Suited for Cultivation
(By Land Capability Class and Subclass - L.C.S.)
(Northern Basins)

L.C.S.	Area (Sq.Mi.)	Land Management Problems	Suitable Alternate Agricultural Land Uses 1/	Minimum Conservation Treatment 2/ - 3/
IIe	90	Erosion hazard due to sloping land. Some soils are gravelly and have lower available water capacity.	Irrigated Cropland Row Crops Field Crops	Irrigation Water Management Crop Residue Use (only in Siskiyou County) Minimum Tillage (only in Siskiyou County) Conservation Cropping System
			Orchard (only in Del Norte County) Vineyard (only in Del Narte County)	Cover and Green Manure Crop, or Minimum Tillage Irrigation Water Management
			Pastureland (and Hayland)	Irrigation Water Management Pasture Proper Use
			Non-irrigated Cropland Field Crops	Conservation Cropping System Crop Residue Use (only in Siskiyou County) Minimum Tillage (only in Siskiyou County)
			Orchard (only in Del Norte County) Vineyard (only in Del Norte County)	Cover and Green Manure Crop, or Minimum Tillage
IIw	40	Overflow	Irrigated Cropland Row Crops Field Crops	Conservation Cropping System Irrigation Water Management
			Pastureland	Irrigation Water Management Pasture Proper Use
			Non-irrigated Cropland Field Crops	Conservation Cropping System
IIIe	255	Erosion hazard due to sloping land. Some soils are gravelly or sandy and have low available water capacity.	Irrigated Cropland Field Crops	Conservation Cropping System Crop Residue Use Minimum Tillage Irrigation Water Management
			Orchard (only in Del Norte County) Vineyard (only in Del Norte County)	Cover and Green Manure Crop, or Minimum Tillage Irrigation Water Management Sprinkler Irrigation System
			Pastureland (and Hayland)	Irrigation Water Management Pasture Proper Use
			Non-irrigated Cropland Field Crops	Conservation Cropping System Crop Residue Use Minimum Tillage
		Erosion hazard due to sloping land. Restricted rooting. Slow subsoil permeability.	Irrigated Cropland Field Crops	Conservation Cropping System Crop Residue Use Minimum Tillage Irrigation Water Management
			Pastureland (and Hayland)	Irrigation Water Management Pasture Proper Use
			Non-irrigated Cropland Field Crops	Conservation Cropping System Crop Residue Use Minimum Tillage
IIIw	150	Wetness, poor drainage Some soils have clayey texture. Some soils have slight or moderate alkali.	Irrigated Cropland Field Crops	Conservation Cropping System Crop Residue Use (Drainage) Irrigation Water Management Minimum Tillage Toxic Salt Reduction (in soils that have moderate alkali)
			Pastureland (and Hayland)	(Drainage) Irrigation Water Management Pasture Proper Use Toxic Salt Reduction (in soils that have moderate alkali)
			Non-irrigated Cropland Field Crops	Conservation Cropping System Crop Residue Use Minimum Tillage

Guidelines for Land Use and Minimum Conservation Treatment of Land Suited for Cultivation (By Land Capability Class and Subclass - L.C.S.)

(Northern Basins)

L.C.S.	Area (Sq.Mi.)	Land Management Problems	Suitable Alternate Agricultural Land Uses 1/	Minimum Conservation Treatment 2/ - 3/
IIIs	140	Soils are sandy or gravelly and have low available water capacity. Wind erosion hazard. Soils have low fertility	<u>Irrigated</u> Cropland Field Crops Row Crops	Conservation Cropping System Crop Residue Use Irrigation Water Management Sprinkler Irrigation System
			Pastureland (and Hayland)	Pasture Proper Use Sprinkler Irrigation System Irrigation Water Management
			<u>Non-irrigated</u> Cropland Field Crops	Conservation Cropping System Crop Residue Use Minimum Tillage
IVe	130	Erosion hazard due to sloping land. Soil depth. Slow subsoil permeability.	<u>Irrigated</u> Pastureland (and Hayland)	Irrigation Water Management Pasture Proper Use Sprinkler Irrigation
			<u>Non-irrigated</u> Cropland Field Crops	Conservation Cropping System Contour Farming Crop Residue Use Minimum Tillage
IVw	100	Wetness, somewhat poor drainage, and strong alkali.	<u>Irrigated (Sub)</u> Pastureland (and Hayland)	Irrigation Water Management Pasture Proper Use Toxic Salt Reduction
			<u>Non-irrigated</u> Pastureland (and Hayland)	Pasture Proper Use
IVs	370	Soils are coarse-textured, very gravelly, or stony and have lower available water capacity.	<u>Non-irrigated</u> Pastureland (and Hayland)	Pasture Proper Use

1/ Other suitable alternate agricultural land uses for each of the Land Capability Classes and Subclasses are:
Non-irrigated Pastureland
Recreation Land and/or Wildlife Land
Some soils in Classes IIe, IIw, IIIe, and IVe are suited to Woodland.
Land uses not shown indicate their general unsuitability.

2/ Pasture Proper Use and Woodland Proper Use are the minimum conservation treatments for Non-irrigated Pastureland and Woodland respectively.
No specific practices are indicated as minimum conservation treatment for Recreation Land and/or Wildlife Land because of the wide variety of activities that might occur under these land uses. Applicable conservation treatment should assure maintenance of land and water resources.

There are many structural and other conservation practices that are supplemental to the minimum conservation treatment practices such as grassed waterways and outlets, streambank protection, and diversion terraces.

3/ Definitions of minimum conservation treatment practices:

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Cover and Green Manure Crop - A crop of close-growing grasses, legumes, or small grain used primarily for seasonal protection and for soil improvement. It usually occupies the land for a period of one year or less, except where there is permanent cover as in orchards.

Crop Residue Use - Utilizing plant residues left in cultivated fields to prevent erosion and improve the soil.

Irrigation Water Management - The use and management of irrigation water, where the quantity of water used for each irrigation is determined by the moisture-holding capacity of the soil and the need of the crop, where the water is applied at a rate and in such a manner that the crops can use it efficiently and significant erosion does not occur. (Includes the timing of irrigations to meet crop needs, the control and adjustment of stream sizes to prevent erosion, and the control of lengths of "set" to reduce water losses.)

Minimum Tillage - Limiting the number of cultural operations to those that are properly timed and essential to produce a crop and prevent soil damage.

Mulching - Applying plant residues or other suitable materials, not produced on the site, to the surface of the soil.

Pasture Proper Use - Grazing at an intensity which will maintain adequate cover for soil protection and maintain or improve the quantity and the quality of desirable vegetation.

Woodland Proper Use - Treating woodlands in a manner which will maintain adequate cover for soil and water conservation, and maintain or improve the quantity and quality of desirable wood crops, by the application of one or more woodland protection and/or woodland conservation practices.

Road culvert outletting above ground on unstable soil causing erosion. Landslide on far hillside. SCS PHOTO 3-5736-2

Confluence of three large, deep gullies caused by three small cross-drains on road with improper outlet conditions. SCS PHOTO 3-5735-16

12. All roads that will be used during the wet months should be paved, and unpaved roads should be closed during this period.

13. All drainage ditches, dips, and culverts should be inspected each year and repaired and cleaned out prior to the rainy season. Maintenance operations should not remove the toe of cutbanks, and the excess material should not be sidecast or deposited on streambanks.

14. All roads should be inspected periodically for possible maintenance needs.

This road was constructed across an oxbow and is encroaching upon the stream. SCS PHOTO 3-5735-7

Mining Guidelines

1. Channel systems formerly used in hydraulic mining operations, old tailing piles, and dredging should be restored to their natural state. This is needed to prevent further erosion and sedimentation and to enhance scenic beauty. Land leveling, bank sloping, installing gully plugs, and, in some instances, channel diversion are recommended to shape the terrain for planting.

2. Specific regulations should be developed to require mining operators to use proper restoration measures for controlling erosion and sediment and for re-establishing adequate vegetal cover.

3. A monitoring system should be developed to enforce water quality standards for mining effluent where it is discharged into rivers.

Gold dredge tailings in the Trinity River at the upper end of Trinity Lake. SCS PHOTO 3-5735-10

Old hydraulic mine with severely eroded mine tailings in foreground and severely eroded mining escarpment face in background. SCS PHOTO 3-5735-2

STREAMBANKS

The application of management guidelines will help to reduce the sediment yield influenced by man's activities, especially in 2nd and 3rd order channels.

1. Clearing and snagging: Snags, drifts, sand bars, or other obstructions to channel flow should be removed to increase the channel capacity, to prevent bank erosion by eddies, to prevent the formation of sand bars, to minimize the occurrence of debris jams, and to eliminate the diversion of flows directly into erodible streambanks.

    a. All trees, stumps, and brush within the channel should be cut as low as possible.

    b. Large, bulky, and top-heavy trees that are undercut by streamflows and might topple over should be removed to avoid causing debris jams and deflection of streams.

    c. Trees selected should be felled so as to avoid damage to other trees and the channel.

    d. Trees, logs, and all other non-salvageable combustible material resulting from clearing and snagging operations should be removed from the channel area.

    e. Where sand bars have built up, especially after heavy flooding, and have caused the channel to meander and expose raw banks, removal of material to redirect flows away from the raw banks is sometimes necessary. These raw banks should then be shaped to a stable slope and planted with suitable vegetation to help reduce further bank erosion.

    f. Where removal will result in channel erosion, either the clearing and snagging should not be done, or other practices, such as riprap or other revetment, should be installed concurrently.

    g. Removal of vegetation on the toe of landslides should be done selectively and with good judgement.

2. Trash, debris, slash, or other materials should not be dumped into stream channels or left where it could reach channel flows.

3. Surface waters should not be discharged directly over the edges of the streambanks. Diverted flows from farm drainage ditches and road gutters should be provided with adequate outlets.

4. Vegetal cover along streambanks should be encouraged as long as it does not restrict channel capabilities.

5. Temporary earth fills that may impede high flows should be removed prior to the rainy season.

6. Strong action should be taken to control activities in and adjacent to stream channels and unstable areas. Regulations such as the state water quality standards, building codes, and regulations of planning commissions, fish and game commissions, road commissions, and other responsible bodies should be enforced to reduce sediment and alleviate debris problems. The general public should be informed of the problems and the consequences associated with streambank erosion. More stringent controls should be enacted when needed.

7. The management guidelines for logging and road building activities (discussed elsewhere in this section) should be applied where appropriate since they are interrelated with those for streambanks.

8. Other considerations, such as the effect on wildlife habitat and scenic beauty, should be taken into account when any management guideline is contemplated.

LANDSLIDES

The following are guidelines for prevention and reduction of sediment yield from man-caused landslides:

1. Soils and geologic information should be used to map potential problem areas and the maps made available to interested parties, such as construction engineers and foresters, to enable them to plan their operations accordingly.

2. Landslide areas supporting timber should not be logged.

3. Roads, skid trails, and landings should not be built in geologically unstable areas.

4. Grazing should be eliminated during periods when the soils are appreciably moist in areas experiencing rapid soil creep (areas of rumpled topography and minor sliding).

5. Conversion of timberland to grassland should not be made in geologically unstable areas.

6. Where life or economic interests are endangered by landslides, it may be desirable to stabilize a slide area such as by end-hauling deposits to the toe of a slide.

<u>Other Studies on Landslide Problems</u>

The first management guideline for landslides suggests mapping potential problem areas before proceeding with planned developments. Landslide studies, such as the following made by various agencies or professional societies, will guide planners in designing programs for mapping landslides and unstable terrain.

1. The Association of Engineering Geologists has assembled a map showing the distribution of known landslides that are over 100 feet in width or height of Ventura, Los Angeles, and San Diego Counties.[1]

2. The California Department of Water Resources, Corps of Engineers, and Bureau of Reclamation are making detailed studies around proposed reservoir sites.

3. The U.S. Forest Service Pacific Southwest Forest and Range Experiment Station is studying mass erosion processes in the North Coastal Area. Station personnel have also mapped landslides and potentially unstable areas in Nicasio Valley in Marin County to provide the Planning Commission with information about the distribution of landslide zones and other geologic hazards.

4. Other studies by the U.S. Geological Survey and the State Division of Mines and Geology are in progress or are being published.

Landslide badly gullied from poor drainage conditions. Drainage pipe on the slide ends 25 feet above road and is causing gully. SCS PHOTO 3-5736-8

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[1] F.B. Leighton, "Preliminary Map Showing Landslide Locations in a Portion of Southern California," in Engineering Geology in Southern California, Richard Lung and Richard Proctor, eds., pp. 194-207, (Los Angeles, Association of Engineering Geologists, 1966).

Landslide at toe of Trinity Dam on the east abutment. Treatment measures on slide include benching at intervals and a system of drain lines and collector pipes. SCS PHOTO 3-5735-5

EFFECTS OF THE MANAGEMENT GUIDELINES

If the proposed management guidelines are implemented, annual sediment volume from sheet and gully erosion, streambank erosion, and landslides will be reduced 2,080 acre-feet. This reduction amounts to more than sixty percent of the sediment now attributed to man's activities. Sheet and gully erosion can be reduced by 390 acre-feet per year with the largest reductions resulting from improved road construction and logging methods. Streambank erosion can be reduced 810 acre-feet per year with the guidelines. The largest reduction would be that from the landslides, which would be about 880 acre-feet per year. If the guidelines are not followed, sediment yields will increase with man's increasing activities. Natural erosion will not be greatly affected by the guidelines.

SUMMARY OF THE EFFECTS OF THE LAND TREATMENT PROGRAM

The physical, biological, and social effects of the land treatment program are summarized in this section. The effects of the program on fish and wildlife, scenic beauty, recreation, and the economy were not evaluated in monetary terms.

SEDIMENT YIELD

The land treatment program would reduce sediment yield in the next 50 years by an estimated 2,890 acre-feet per year.

All remedial and production improvement programs will reduce sediment yield except that on public grassland; the reduction in this case was considered negligible because existing sediment from this source is minor. The following tabulation summarizes the sediment reduction that can be expected from the various programs.

Annual Sediment Yield
(Acre-Feet)

Item	Streambank	Landslides	Sheet & Gully	Total
PRESENT CONDITIONS				
Northern Basins	2,860	1,850	1,230	5,940
Southern Basins	2,220	940	1,790	4,950
Total	5,080	2,790	3,020	10,890
FUTURE WITHOUT PROGRAMS				
Northern Basins	2,860	2,330	1,330	6,520
Southern Basins	2,220	1,180	2,690	6,090
Total	5,080	3,510	4,020	12,610
FUTURE WITH PROGRAMS1/				
Northern Basins	2,400	1,745	705	4,850
Southern Basins	1,870	885	2,115	4,870
Total	4,270	2,630	2,820	9,720

Reduction in Sediment Yield
(Acre-Feet)

Item	Streambank	Landslides	Sheet & Gully	Total
REMEDIAL PROGRAM	0	0	810	810
MANAGEMENT GUIDELINES	810	880	390	2,080
Total	810	880	1,200	2,890

1/ Includes effects of remedial program and management guidelines.

PRODUCTION

Remedial and production improvement programs would provide an overall increase in forage and timber production. In the case of type conversion programs, some forage production would be shifted to production of timber; however, the net result is an overall increase in both types of production. The road program would have very little direct effect on production. The following tabulation summarizes the increases or decreases in forage and timber production that could be expected if the programs were installed:

Program	Annual Forage Production (Animal-Unit-Months)	Annual Timber Production (1,000 Cubic Feet)
Private Grassland	+433,000	+ 8,000
Public Grassland	- 8,000	+ 5,000
Brushland	0	+19,000
Roads	-	-
Total	+425,000	+32,000

WATER QUANTITY AND QUALITY

Hydrologic studies in the Eel and Mad River Basins, presented in Appendix No. 1, indicate that the land treatment program would reduce runoff from 2-year recurrence interval storms of up to 10-day duration. The amount of reduction that could be realized from the various remedial programs varied from about 5 to 30 percent in the area to be treated. Use of the management guidelines would also reduce runoff, but probably by a lower percentage. In most cases, the reductions would be more noticeable in the smaller upstream creeks than in the larger downstream ones. The percent reduction in runoff would be less during the larger storms than it would be for the smaller ones.

The temporary sedimentation that occurs during the rainy season would be reduced by about 23 percent from the application of the land treatment program. This reduction would also be more noticeable in the smaller creeks. The chemical characteristics of the water should remain unchanged except for a possible minor increase in nitrogen caused by fertilization from the private grassland program; this slight increase would have little effect on water quality.

FISH AND WILDLIFE

With the reduction in sediment yield from installation of the land treatment program, fewer fish eggs would be lost from sediment deposition in streams, spawning beds and aquatic food production would be improved, and the population of anadromous fish would be increased. These changes would occur mostly in the smaller upstream creeks. The resulting improvement in vegetal cover along streambanks would improve the natural habitat for both fish and wildlife.

As the vegetal cover is improved, wildlife food and cover protection will be enhanced and game populations will increase. Programs that convert grass or brush to timber generally reduce habitat for deer, but may enhance that for other species of wildlife.

SCENIC BEAUTY AND RECREATION

Reduction in eroded areas and improved vegetal cover would enhance the natural beauty of the area, especially in reforested areas and along streambanks.

As wildlife habitat and scenic beauty are improved, recreation opportunities will increase. Increased populations of fish and game will provide more hunting and fishing, and more people should engage in tourism, camping, and other forms of recreation.

MONETARY AND SOCIAL BENEFITS

Incomes should be increased through improved productivity on grass and timber land if the land treatment program is installed, and enterprises should be placed on a firmer financial basis. This increase in primary income would enhance profits of supporting industries and local business, and the existing unemployment and underemployment would be reduced. The overall living conditions in the basins should improve.

Adherence to management guidelines for future road construction will reduce operation and maintenance costs, and roads will be safer and more useful during and after intense storms. There will be less likelihood of travelers being stranded and communities being isolated during major storms.

Recreation is the third largest land use in the basins and is an important source of local income. With the predicted increase in recreation activity from installation of the program, the income from this source will increase accordingly.

Improvements in productivity, recreation, and scenic beauty will increase the value of the land.

IMPLEMENTATION

A large land treatment program has certain implementation problems and needs that must be overcome before a basinwide installation can be successful. This section presents major problems and needs that may be encountered in installing the program.

PROBLEMS

Implementing programs on privately owned lands is often considerably more difficult than it is on publicly owned lands. The Southern Basins are essentially privately owned and, therefore, present a greater problem than the Northern Basins. Generally, the agencies with jurisdiction over public lands have the authority, policy direction, and technical expertise to implement needed programs. Quite often, however, funding is the limiting factor.

In the case of privately owned lands, the success of the program depends entirely on the voluntary participation of the landowners and operators. Many of the agricultural enterprises in the basins are marginal operations, and landowners show little apparent interest in spending money for improvements. The entire North Coastal Area is considered an economically depressed area by the Economic Development Administration, and all counties in the study area are eligible for full financial assistance.

Although the proposed remedial measures provide both monetary and non-monetary benefits, the returns are sometimes not realized for long periods. In the case of reforestation measures, it will be many years before any income is received from the sale of thinnings and at least 60 years before the major income from sawtimber harvests can be realized. Even grazing benefits may not be realized for the first year or two until the grassland is rehabilitated.

Land in the severe erosion class will be excluded from livestock grazing, and, therefore, will yield little or no income. Much of this area would be suitable for wildlife production after planned treatment that emphasized planting woody vegetation. Landowners will probably still have to pay property taxes based on grazing use, and this may discourage landowners from participating in the program.

Many landowners do not live on their property and are often not aware of the erosion problems that can be created by unconcerned operators or leasees. Some people buy land mainly for speculation of future sale profits, and these owners are seldom interested in spending money for improvement, especially when the benefits are long term.

Under the Rural Environmental Assistance Program, administered by the USDA Agricultural Stabilization and Conservation Service, federal funds are available on a cost-sharing basis to install remedial practices for soil and water conservation problems. For many of these practices, the federal contribution is too small to encourage landowners to make the large investments necessary to install the recommended program.

NEEDS

Before programs are installed, detailed surveys of soils, vegetal cover conditions, and needs should be made. A plan listing specific treatments for each problem area should be developed with each landowner. Detailed economic studies are needed to evaluate all on-site and downstream benefits that will accrue from installing both the remedial measures and the management guidelines, especially those that affect the general public. These benefits may include improved water quality, reduced sediment yield, improved fish and wildlife habitat, increased recreational value, increased land value, reduced road maintenance, increased scenic beauty, and conservation of vegetal resources for future use. Any adverse affects, such as decreased water quality caused by fertilization or lower prices caused by increased production, also need to be studied.

A special study should be made on cost sharing to arrive at an equitable distribution of program installation costs between public and private interests.

An effective educational and informational program is essential to the success of the program. Landowners, local officials, and the general public should be made aware of the need for a land treatment program and the benefits that can be derived from its installation. Local officials and landowners should recognize the erosion problems that may result from improperly planned and installed construction projects, and they should be informed of the technical consulting services and financial assistance programs available to them through federal and state agencies.

Property tax assessments on land to be excluded from livestock grazing should be studied in detail to determine an equitable method of compensating the landowner for this financial loss. Tax relief could be accomplished locally by removing these lands from the tax rolls or reducing the taxes to a minimum, or compensation could be made by state or federal funds that would spread the costs over a larger tax base.

The possibility of establishing land preserves for severely eroded lands similar to agricultural preserves under the California Land Conservation Act of 1965 should be investigated.

It would be desirable to make studies regarding the capability of specific areas to provide light recreation use, such as hunting. The income from such enterprises may be sufficient to pay the property taxes and relieve the public of this burden. The initial installation of such a program may require cost sharing from public funds.

Additional basic data is needed on landslides and their movement, streambank erosion, erosion effects on productive capabilities of forest soils, the relation between sediment and streamflow to salmon and steelhead populations, and other factors that affect land use and management. Research efforts should be expanded and coordinated so that land managers can be furnished firm guides that will enable them to avoid some of the mistakes of the past and to achieve greater productivity.

OPPORTUNITIES FOR DEVELOPMENT THROUGH USDA PROGRAMS

The U.S. Department of Agriculture has the authority and responsibility, under various laws, to promote wise use of land and water resources through land treatment and construction programs. The following sections summarize those development programs that are considered applicable under the limited assumptions in this study. A more detailed description of these programs is included in the main report.

WATERSHED PROTECTION AND FLOOD PREVENTION PROJECTS (PUBLIC LAW 566)

The Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 1954, as amended) authorizes the expenditure of federal funds through USDA to plan and carry out a program for the development, use, and conservation of the Nation's soil and water resources. The primary purpose of potential projects must be watershed projection, flood prevention, irrigation, or drainage; other purposes such as recreation, fishery enhancement, municipal and industrial water supply, and other water management measures may also be included. SCS provides administrative leadership for cooperative federal assistance to local organizations in planning and implementing projects for small watersheds (up to 250,000 acres). Technical assistance, cost-sharing, and long-term credit are the main contributions provided by USDA in the development of PL 566 projects.

Nineteen potential watersheds have been identified by watershed investigation or preliminary investigation reports as being feasible projects for an early action program. These are described in the main report of this study. The watershed projects will reduce sediment and erosion with land treatment and structural measures. The land treatment measures required in these projects will have similar effects to those already described in this appendix. The structural measures will trap 11,990 acre-feet of sediment, retard 15,700 acre-feet of floodwater, store 15,100 acre-feet of recreation water, provide 82,794 acre-feet of irrigation supply, and furnish 25,760 acre-feet of municipal water supply.

As a part of the total project cost, additional funds could be made available for technical services to accelerate installation of that portion of the land treatment program within the watershed boundary. The amount of acceleration funds needed would depend on the size of the current resource conservation district program in the watershed; this district program is described in the following section.

RESOURCE CONSERVATION DISTRICT PROGRAMS

Resource conservation districts are legally constituted units of state government that administer soil and water conservation work within their boundaries. Each district is governed by an elected board of local people, usually resident landowners or operators, and has the authority to enter into working agreements with other government agencies and with private interests.

The following conservation districts cover about 87 percent of the study area:

Resource Conservation District	County	SCS Work Unit Office
Gold Ridge	Sonoma	Santa Rosa
Santa Rosa	Sonoma	Santa Rosa
Sotoyome	Sonoma	Santa Rosa
Mendocino County	Mendocino	Ukiah
Westlake	Lake	Lakeport
East Lake	Lake	Lakeport
Napa County	Napa & Sonoma	Napa
Trinity County	Trinity	Redding
Siskiyou	Siskiyou	Yreka
Shasta Valley	Siskiyou	Yreka
Butte Valley	Siskiyou	Tulelake
Lava Beds	Siskiyou & Modoc	Tulelake
Central Modoc	Modoc & Lassen	Alturas

There are no resource conservation districts in Humboldt and Del Norte Counties.

The Soil Conservation Service has working agreements to provide assistance to these districts. District programs, which are carried out through cooperative agreements with individuals or groups, include:

1. the treatment and use of cropland, rangeland, woodland, and forest, including the problems incident to their conversion to urban uses;

2. the improvement and protection of stream channels; and

3. the development of water for irrigation, livestock, and recreation.

Increasing emphasis is being given to the management and protection of the steep eroding mountain slopes.

About 90 percent of the privately owned grassland in the basins is within one of the thirteen resource conservation districts. Each district is in a position to take leadership in implementing the land treatment program within its district boundary.

Modern cabins overlooking enclosed, stocked fish pond built with SCS assistance. SCS PHOTO ORC 82-13

Woodland soil site correlation in Douglas-fir and Ponderosa pine area. SCS PHOTO 3-3179-6

CONSERVATION OPERATIONS (PUBLIC LAW 46)

Public Law 46, enacted by the 74th Congress, established a national soil and water conservation policy and created the Soil Conservation Service (SCS). The law directed the SCS to develop a program to control and prevent soil and water losses and to reduce flooding and sediment hazards.

The SCS has no enforcement powers, but carries out its responsibilities largely through working agreements with organized soil and water conservation districts. Technical services are available to districts and their cooperators to assist in planning, designing, and applying conservation practices. These services include soil surveys to help determine the capability and best use of land; planning to help determine needed conservation measures and programs; and engineering and geologic services to investigate, design, and assist in the installation of structural measures. Technical services dealing with agronomy, biology, range management, and recreation are also available; however, according to the law, no funds are provided for installation of programs.

The proposed technical services needed to install the remedial measures could be supplied by the SCS under the Conservation Operations Program, especially those in the grazing portion of the program. Technical services for the grazing program were estimated to be about $51,000 a year during the 20-year installation period and $25,000 a year thereafter.

RURAL ENVIRONMENTAL ASSISTANCE PROGRAM

The Agricultural Stabilization and Conservation Service (ASCS) administers the Rural Environmental Assistance Program (REAP; formerly the Agricultural Conservation Program -- ACP), through which they share with private landowners and operators the cost of installing conservation measures. This allows the installation of measures that are too expensive for private landowners, but that have long term benefits to soil and water resources.

The ASCS State Committee determines measures eligible for cost sharing in the state and sets the maximum allowable payment rate. A 5-member County Committee is elected annually by the farmers in each county and, assisted by a local office manager and staff, administers the program locally. After considering the most urgent conservation needs of the county, the Committee determines which of the eligible measures will be offered and establishes the local cost-sharing rates. Generally, the rates do not exceed 50 percent of the cost, but for erosion control practices they may be as high as 80 percent.

All of the proposed remedial measures in the recommended land treatment programs for private grassland and timberland are eligible for federal cost-sharing under the REAP. Federal cost-sharing averages about 50 percent for practices on grasslands and varies from 50 to 70 percent for practices on timberland. REAP payments for practices in the eight counties of the basins totaled $450,000 in 1971.

A special REAP project could be formulated to install the land treatment program in the study area, and additional funds would be allotted for this purpose. The maximum amount of money that would probably be available under this type of project is about $100,000 a year for the 20-year installation period.

FARM AND HOME ADMINISTRATION LOAN PROGRAMS

The Farmers Home Administration (FHA) provides loan programs and financial and advisory assistance for:

1. Farmers to purchase and improve real estate; to buy livestock, equipment, and other essentials; and to finance forestry and recreational enterprises.

2. Farmers and rural residents to construct, purchase, or improve homes, farm service buildings, housing for domestic labor, and rental housing.

3. Groups of farmers and rural residents to develop and improve rural water supply systems, waste disposal systems, rural outdoor recreational facilities, and livestock grazing land. In addition, loans can be made to organizations to finance the local share of the cost of installing watershed protection (Public Law 566) works of improvement.

4. Low-income rural families, on an individual family or cooperative group basis, to enable them to increase their incomes and make a modest improvement in their standards of living through loans for both agricultural and business enterprises.

In addition, FHA provides assistance to rural communities for planning, financing, and executing complete programs of economic development, including assistance in locating and using services of non-USDA programs to solve problems. The loan programs do not compete with those of other lenders, and financial management assistance accompanies each loan. Landowners who qualify for loans through private lending organizations are not eligible for loans under the FHA programs. The maximum loan available to each landowner is $60,000.

FHA could loan money to qualified private landowners to pay their cost-share of installing the land treatment program. In 1969, FHA had about $1 million available for this type of loan for the entire state, but to date, no loans for grazing improvements have been made in California.

AGRICULTURAL EXTENSION SERVICE

The Agricultural Extension Service (AES) provides educational and informational services to landowners and operators, and maintains an office in each county in the basins. University of California farm advisors help the agricultural interests to keep up-to-date on the latest agricultural advances and to improve farming operations. Livestock improvement and field trials on crops and fertilizers are part of AES activities.

The farm advisors' offices and areas they serve are listed below:

Farm Advisory Location	Area Served
Santa Rosa	Sonoma County
Kelseyville	Lake County
Ukiah	Mendocino County
Eureka	Humboldt and Del Norte Counties
Weaverville	Trinity County
Yreka	Siskiyou County
Alturas	Modoc County

AES will provide leadership in an educational and informational program to make landowners and the general public aware of the need for the land treatment program and the benefits that can be derived from its installation. Their technical advice on fertilization, seeding, and livestock management will be of valuable assistance in applying the grazing portion of the land treatment program.

RESOURCE CONSERVATION AND DEVELOPMENT PROJECTS

The U.S. Department of Agriculture, by authority of Public Law 87-703, the Food and Agriculture Act of 1962, gives technical and financial help to local groups in conserving and developing natural resources. Also, it helps project sponsors seek funds and services from other federal agencies and from state and local sources. The Soil Conservation Service has leadership for the USDA in this program.

Resource Conservation and Development (RC&D) projects usually include more than one county. Each area should be large enough to include the resource developments needed to meet project objectives but small enough for effective local leadership to prepare and carry out a project plan. Local people initiate and run them. Applications for a project are sent to the USDA through one or more legal sponsors -- a qualified local group such as a conservation district, a county governing body, a town, a local or state agency, or a public development corporation.

Each resource conservation and development project has its own unique goals, but typically they attempt to:

1. Develop land and water resources for agricultural, municipal, or industrial use and for recreation and wildlife.

2. Provide soil and water resource information for a variety of land and water uses including farming, ranching, recreation, housing, industry, and transportation.

3. Provide conservation measures for watershed protection and flood prevention.

4. Accelerate the soil survey where it complements project measures.

5. Reduce pollution of air and water.

6. Speedup conservation work on individual farms, ranches, and other private holdings and on public land.

7. Improve and expand recreation facilities; promote historical and scenic attractions.

8. Encourage existing industries to expand and new ones to locate in the area and thus create jobs; encourage industries to process products of the area.

9. Improve markets for crop, livestock, and forest products.

Through a resource conservation and development project, technical services and funds could be made available to plan and install the remedial measures and to provide information services necessary for implementing the management guidelines. With the large area involved, at least two RC&D projects would probably be formed -- one covering the three Northern Basins and the other for the three Southern Basins.

COOPERATIVE STATE AND FEDERAL FORESTRY PROGRAMS

The cooperative state and federal forestry programs are designed to promote sound forest management, protection, and use on private forest land. They also help improve the quality of life in rural areas. The programs require a close federal-state relationship that allows the state complete administrative authority while assuring the proper expenditure of federal funds.

The Cooperative Fire Control Program allows the Forest Service to assist the state with funding and technical guidance to hold fire occurrence and damage to a low level.

The total cost of this program in California in Fiscal Year 1971 was over $27,457,000 for the entire state; federal funds amounted to

$1,118,648 of this total. In the past several years the federal contribution has been about five percent of the total expenditure.

Presently the program emphasizes increasing the effectiveness of fire control by strengthening coordinated air attack operations and dispatch, command, and control systems.

The Cooperative Tree Nursery Program encourages private landowners to keep their forest land productive by providing forest tree seeds and seedlings at a reasonable cost. The seedlings are raised at three state nurseries. This program, authorized by Section 4 of the Clarke-McNary Act, allows the federal government to contribute up to 50 percent of the net operational cost. In fiscal year 1971, the cost of operating these nurseries were shared as follows:

Federal contribution	$12,000
State contribution	71,000
Sales to private landowners	92,000

Under the Cooperative Forest Management Act, Service Foresters, employed by the California Division of Forestry and partially financed from federal funds on a matching basis, are assigned to advise and assist small private timberland owners to help increase returns from timber resources and recreation development by applying multiple-use concepts. The local headquarters of the Service Foresters and the North Coastal Area served are as follows:

Office	Area Covered
Santa Rosa	Sonoma and Lake Counties
Willits	Mendocino County
Fortuna	Del Norte, Humboldt, and Western Trinity Counties.
Redding	Modoc, Shasta, Siskiyou, and Eastern Trinity Counties

This program has been highly successful, but there is a need for considerably more services and program development than these four offices can provide.

No statistics are available specifically for the study area, but for the entire State of California in fiscal year 1971, the federal share for the Cooperative Forest Management Program amounted to $86,208, while almost $148,000 was contributed by the state. About one-fourth of the private timberland in the state is within the study area. The area presently is served by the equivalent of two Service Foresters and has a need for three times as many. Service Foresters would be instrumental in accomplishing the forestry portions of the land treatment program on private lands.

Under the General Forestry Assistance Program, the Forest Service provides direct technical assistance to industrial foresters, forestry consultants, landowners holding over 5,000 timbered acres, other federal agencies, and participating states. Through this program, the Forest Service provides technical forestry services that are unavailable from other state-federal cooperative programs. The assistance is directed toward developing, managing, and utilizing forest resources under multiple use principles so as to contribute to the Nation's economy, natural beauty, and resource wealth. Another objective is to correlate and interpret forest research findings for application of forested land.

The Forest Pest Control Program is directed toward reducing insect and disease infestation on forest lands. The federal government may contribute up to 50 percent of the funds needed to stop infestations on non-federal lands. The program also maintains surveillance of the forest pest and disease problems on all lands. The following table shows how some of this money is spent throughout California:

	Federal Funds	State Funds	Total
Blister Rust Control	$20,000	$20,000	$40,000
Other Pest Control Programs	$15,000	$20,500	$35,500

Timber production on non-federal commercial forest land can be aided by Title IV of the Agriculture Act (1956). Under this program, the Forest Service assists the State Forester in producing, distributing, and planting forest trees. Four seed orchards have been established in the state under this program. One of these, a Douglas-fir seed orchard, is located on the Jackson State Forest, near Fort Bragg.

The Pacific Southwest Forest and Range Experiment Station of the U.S. Forest Service seeks solutions for full development, use, and protection problems on forested lands and works closely with the State Forester and other agencies interested in forest management.

The Forest Service also assists the states by providing specialized training and by helping to secure federal surplus equipment.

NATIONAL FOREST DEVELOPMENT AND MULTIPLE USE PROGRAMS

Approximately 7,247 square miles of this study area are within six national forests, and all but 46 square miles of this area is in the Northern Basins.

Prior to the passage of the Multiple Use--Sustained Yield Act on June 2, 1960, national forests were managed under several federal statutes, the principal of which was the Organic Act of June 4, 1897, as amended. The various statutes were implemented or supported by regulations and policies promulgated by the Secretary of Agriculture and the Forest Service.

Although the principles and concepts of multiple-use management were developed before the passage of the Multiple Use--Sustained Yield Act, it provided a congressional mandate for this type of management. Under this law, the Forest Service is directed to administer the national forests for outdoor recreation, range, timber, watershed, and wildlife and fish purposes. Multiple-use management guides have been prepared by each Forest Service Region and Subregion. In the guide for the Northern California Subregion, six broad management zones -- the Crest, Front, General Forest, Travel Influence, Water Influence, and Special Zones -- are delineated, and general management directions are provided for each.

Using the principles outlined in these guides, multiple-use plans that provide broad management direction have been developed for each Ranger District. Within the framework of the multiple-use plans, functional plans are written to cover the development and use of each resource and to provide day-to-day management guidance.

The following is an assessment of the ability of Forest Service to accomplish that portion of the recommended land treatment program that involves the national forests. The Forest Service has adequate legal authority and technical expertise to install the programs within the framework of its regular management and development. Generally, the only real lack is funding and, in some cases, setting of priorities.

About 42 percent of the program for converting grassland to timber and about 25 percent of the one for converting brushland to timber is designed for national forest land. These involve about 40 and 35 square miles, respectively. Reforestation of this type, in the past few years, has totalled about six square miles per year on national forests. At that rate, it would take about 13 years to complete the recommended program.

All of the recommended remedial road program involves national forest roads. Rehabilitation of these roads is estimated to cost over $62 million, with an additional annual maintenance cost of $4.5 million. Funds presently allotted in the four national forests allow for little or no rehabilitation. Maintenance allocations average about $130.00 per mile of road, while the program calls for a maintenance expenditure of about $700 per mile.

It is difficult to ascertain precise deficits in the funds allocated to do an adequate road rehabilitation and maintenance job. Final decisions must be made based upon a detailed study of the individual roads involved. However, it seems certain that present funds are inadequate and that these Forest Service roads will continue to yield sediment for many years to come if funding is not increased.

Many of the management guidelines for logging, grazing, wildfire, recreation, game habitat management, and road construction are standard procedure in national forests. When failures in accomplishment occur, they are often tied to lack of funding or staffing, unforeseen events, pressures from outside groups, or lack of control of the resources.

OTHER ACTIONS NEEDED

The total cost of the proposed remedial measures is about $90,109,000 and would amount to $4,869,500 annually for the 20-year installation period. The previous chapter "Opportunities for Development Through USDA Programs" indicates that these programs, under present policy, could probably provide about $743,000 annually, which is about 16 percent of the amount needed to install the recommended remedial measures. Under accelerated conditions, about $1,063,000 could possible be furnished, which is about 24 percent of the amount needed. New legislation and programs or changes in present programs will be required to complete the full land treatment program.

CHANGES NEEDED IN USDA PROGRAMS

Most of the recommended land treatment program could be accomplished with the following changes in USDA programs:

1. The land treatment program on federal lands can be accelerated by increasing the appropriations to the administering agencies; on privately owned lands, the programs could also be accelerated by providing adequate funds to each agency involved to cover the federal cost-share. To assure continued acceleration, appropriations should be specifically designated for the land treatment program in these basins.

2. To coordinate the USDA programs on privately owned lands, the Secretary of Agriculture should designate an individual or agency to provide leadership at the local level. This would accomplish the program in an efficient manner and prevent duplication of effort by the several agencies administering the USDA programs.

3. The federal cost-share for installing the proposed remedial measures on privately owned grasslands should be increased from the present 50 percent to 80 or 90 percent. It should be raised to 100 percent for those measures to be applied on severely eroded grasslands since livestock would be excluded and the land would yield little or no future income. The increased cost-sharing for the proposed measures would increase federal costs about $3,000,000. These increases would provide a greater incentive for landowners and operators to participate. The federal cost-share should be increased on these lands because overgrazing has occurred for more than a century and often is not primarily the fault of the present landowners, and it is in the national interest to protect the scenic beauty and natural resources of this area. The present federal cost-share for remedial measures on other privately owned lands is probably adequate because the major benefits accrue to the landowner in the form of increased production. Interest-free loans,

deferred payment of loans, and safeguards for continued maintenance or retirement should also be considered.

4. A local association, such as a range improvement district or an association of resource conservation districts, should be formed to represent the landowners and provide the overall leadership for the land treatment program on private lands. Direct local participation would provide better opportunities for cooperation between federal agencies and landowners and for successful completion of the land treatment program. In any association formed, ranchers should be well represented since their interests are most deeply involved.

5. Landowners of severely eroded private grasslands should be compensated for excluding livestock from these areas. If they are remunerated for property taxes, more landowners would participate in this portion of the program. Once the treatment programs are installed, the stabilizing effects should not be allowed to degrade by a return of improper use. Adequate maintenance and usage must be assured by long-term agreement.

NEW PROGRAMS OR LEGISLATION NEEDED

New USDA programs or legislation would be another way to accomplish more of the land treatment program on privately owned lands. The following ideas might provide a framework for developing a new USDA program:

1. Formulate a regional program to develop and protect large regions, such as the North Coastal Area of California. Problems in flood control, fish and wildlife, recreation, and urban development would be considered in addition to those of agriculture and forestry. A regional agency under state and local leadership would be established to develop and coordinate the activities of the local people and the cooperating state and federal agencies. This agency and its cooperators would formulate a coordinated plan to develop and protect the resources of the area, making use of private resources and existing state and federal programs. Congress would appropriate the necessary federal money, and the state would contribute funds to cover its share. Each of the cooperating agencies would be assigned responsibility for certain functions of the plan and would be given funds by the regional agency to implement their responsibilities. Prior to starting work, detailed work plans would have to be prepared for each function or phase of work.

2. Form a council of USDA agencies to provide the overall leadership and to coordinate the activities of its agricultural and forestry programs. The council would cooperate with local associations or agencies to establish the policies and goals

of the land treatment program on private lands. It would assign the responsibilities for various functions to the appropriate USDA agency and would allocate the necessary funds to carry out these functions.

3. Provide a specifically funded program similar to that for the Great Plains Area that would provide for federal-local sharing of the land treatment program costs on private lands in the North Coastal Area. A local association cooperating with the USDA agency designated to administer the program would establish the policy and goals. A treatment plan with specific time limits would be developed for each property by the owner and the two groups. Prior to starting the work, a contract between the owner, the local association, and the USDA agencies would be signed, assuring that the necessary amount of federal funds would be made available to landowners during the agreement period.

The present USDA programs with proposed changes or the recommended and new programs could accomplish most of the land treatment program. Since there are always a few individuals that will not participate, voluntary programs like these cannot be entirely successful, regardless of the incentives provided. To fully accomplish the objectives of the land treatment program, restrictive legislation would be necessary, although this approach may be politically unacceptable. Some possible actions would be to:

1. Enact state or local laws requiring landowners to protect the soil and vegetal resources on their land, with stiff penalities for failure to comply with the laws.

2. Purchase the land or property rights from the present owners, under condemnation proceedings if necessary, and resell or lease them with appropriate controls on their development and use.

ADDENDUM

SPECIAL SEDIMENT STUDIES

Two special sediment studies were made to check the soundness of field estimates of sediment yield. One consisted of measuring sediment deposition in eight reservoirs in the Southern Basins, and the other consisted of analyzing and interpreting suspended sediment data from seven gaging stations in the Russian River Basin and 11 in the Klamath River Basin. The results of these two studies serve as checks on the field estimates of sediment yield.

RESERVOIR SEDIMENT SURVEYS

In the Southern Basins, sediment surveys were made on eight reservoirs -- McGuire, Lazy Creek, M.S. Wilson, Ridgewood (Walker Ranch), Wood, Frediani, Hill, and Trentadue. The surveys were made between 1965 and 1967, and the pertinent data are shown in the table on the next page. A map showing the location of the reservoirs and suspended sediment gaging stations is on the page following the table.

Procedures

The reservoirs were surveyed by the range method, which consists of laying out a system of representative cross sections and determining water and sediment depths at regular intervals along them. Water depths were measured with a lead weight and surveyor's tape, and the thickness of sediment deposits were measured with a sampling spud.

Sediment samples were collected in six reservoirs, and the dry unit weights were determined. The average dry unit weight for each reservoir was weighted according to the volume of sediment represented by each sample. In the other two reservoirs, the dry unit weight was estimated by comparison with the sampled reservoirs.

Trap efficiencies of the reservoirs were obtained from a graph developed by Brune.[1/] In this graph, trap efficiency is plotted against a ratio of reservoir capacity to average annual inflow, and the results are shown in the table as Item 7. These efficiencies were used to determine the total sediment yielded by the watershed (Item 9).

Field estimates of sediment yield by sources were made in the watersheds above the lake using the procedures described in the chapter "Sediment Yield Studies and Survey Procedures." Comparisons of the results of the reservoir surveys and the field estimates are shown in Item 13 in the table.

[1/] Gunner H. Brune, "Trap Efficiency of Reservoirs." American Geophysical Union Transactions, Vol. 34, No. 3, pp. 407-418. (1964).

Reservoir Sedimentation Summary

		Unit	Reservoir							
			Ridgewood	McGuire	Lazy Creek	Wilson	Wood	Frediani	Hill	Trentadue
1.	Year constructed	-	1930	1954	1955	1952	1959	1961	1961	1962
2.	Year surveyed	-	1966[1/]	1967	1967	1967	1965	1965	1965	1965
3.	Age (last survey)	Years	36	13	12	15	6	4	4	3
4.	Capacity (last survey)	Acre-Ft.	216	7.07	19.50	13.02	46.76	4.61	21.04	9.86
5.	Drainage area	Sq. Miles	5.7	0.08	0.67	0.17	1.69	0.59	0.18	0.04
6.	Dry unit weight of sediment	Lb./Cu./Ft. (Tons/Acre-Ft.)	78 (1,699)	60[2/] (1,307)	67 (1,459)	60[2/] (1,307)	79 1,721	87 1,895	65 1,416	66 1,437
7.	Trap efficiency[3/]	Percent	74	87	65	75	65	51	87	93
8.	Annual sediment accumulation in reservoir	Acre-Ft./Yr.	3.6	0.018	0.62	0.07	1.15	0.43	0.10	0.12
9.	Annual sediment yield per watershed (Item 8 ÷ 7)	Acre-Ft./Yr.	4.9	0.021	0.95	0.09	1.77	0.84	0.11	0.13
10.	Annual sediment yield per unit of area (Item 9 ÷ 5)	Acre-Ft./Sq. Mile	0.86	0.26	1.42	0.32	1.05	1.42	0.61	3.16
11.	Annual sediment yield per unit of area (Item 10 X 6)	Tons/Sq. Mile	1,461	340	2,072	418	1,807	2,691	864	4,541
12.	Annual sediment yield per watershed (field estimate)	Acre-Ft./Yr.	4.0	0.02	0.68	0.062	2.60	0.55	0.13	0.11
13.	Comparison check (Item 12 ÷ Item 9)	Ratio	0.82	0.95	0.72	0.69	1.47	0.65	1.18	0.85

1/ Also surveyed in 1949 by the SCS.

2/ Estimated.

3/ Gunner H. Brune, "Trap Efficiency of Reservoirs", American Geophysical Union Transactions, Vol. 34, No. 3, pp. 407-418, (1964).

Survey crew conducting a sediment survey of Walker Lake, Mendocino County. SCS PHOTO

Findings

The results of these studies indicate that the field procedures used to estimate sediment yield are reasonable. In four of the reservoirs, the results varied by less than 20 percent, and in three others the difference was within 35 percent.

SUSPENDED SEDIMENT DATA

AVAILABLE DATA

Suspended sediment data is published annually by the U.S. Geological Survey[1] for 18 stations in the basins. The maps on the following pages show the location of these suspended sediment gaging stations some of which began operating in October 1956. Streamflow

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1/ USDI Geological Survey, Quality of Surface Waters of the United States, Parts 9-14, Water Supply Paper 1945. (Washington, D.C., U.S. Government Printing Office, annually from 1957-1962).

Water Resources Data for California, Part 2. Water Quality Records. (Menlo Park, California, annually since 1963).

data, published annually by USGS[1] and flow duration data for California streams,[2] available through 1959, were used extensively in the analyses.

PROCEDURES

Suspended sediment samples are taken periodically at 16 stations in the basins, and daily at two stations -- South Fork Trinity at Salyer and Trinity at Hoopa. Periodic sediment sample data were converted to mean annual sediment yields, using flow duration curves and other methods described by Searcy[3] and Miller.[4] The table "Mean Annual Sediment Discharge for the Period 1940-1965" on the next page presents the results of this study.

To determine the total sediment load at each gaging station, bedload, estimated to be 10 percent of the suspended sediment, was added to the suspended sediment, using methods described by Sheppard (1963).[5]

The volumes in the last two columns in the table were computed using two different unit weights. The next to the last column shows the total volume of sediment that is eroded from the watershed each year, assuming an average in-place soil density of 92 pounds per cubic foot.

1/ USDI Geological Survey, Quality of Surface Waters of the United States, Parts 9-14, Water Supply Paper 1945. (Washington, D.C., U.S. Government Printing Office, annually from 1957-1962).

Water Resources Data for California, Part 2. Water Quality Records. (Menlo Park, California, annually since 1963).

2/ Winchell Smith and Charles F. Hains, Flow-Duration and High- and Low-Flow Tables for California Streams, Open File Report (Menlo Park, California, USDI Geological Survey, 1961). 600 pp.

3/ James K. Searcy, Manual of Hydrology: Part 2. Low-Flow Techniques, Flow Duration Curves, U.S. Geological Survey Water Supply Paper 1542-A. (Washington, D.C., U.S. Government Printing Office, 1960). 33 pp.

4/ Carl R. Miller, Analysis of Flow-Duration, Sediment-Rating Curve Method of Computing Sediment Yield. (Denver, Colorado, USDI Bureau of Reclamation Hydrology Branch, April 1951). 55 pp.

5/ John R. Sheppard, "Methods and Their Suitability for Determining Total Sediment Quantities." Proceedings of the Federal Inter-Agency Sedimentation Conference, 1963, USDA Miscellaneous Publication No. 970, pp. 272-287. (Washington, D.C., U.S. Government Printing Office, June 1965).

SUSPENDED SEDIMENT GAGING STATIONS and RESERVOIR SEDIMENTATION SURVEYS

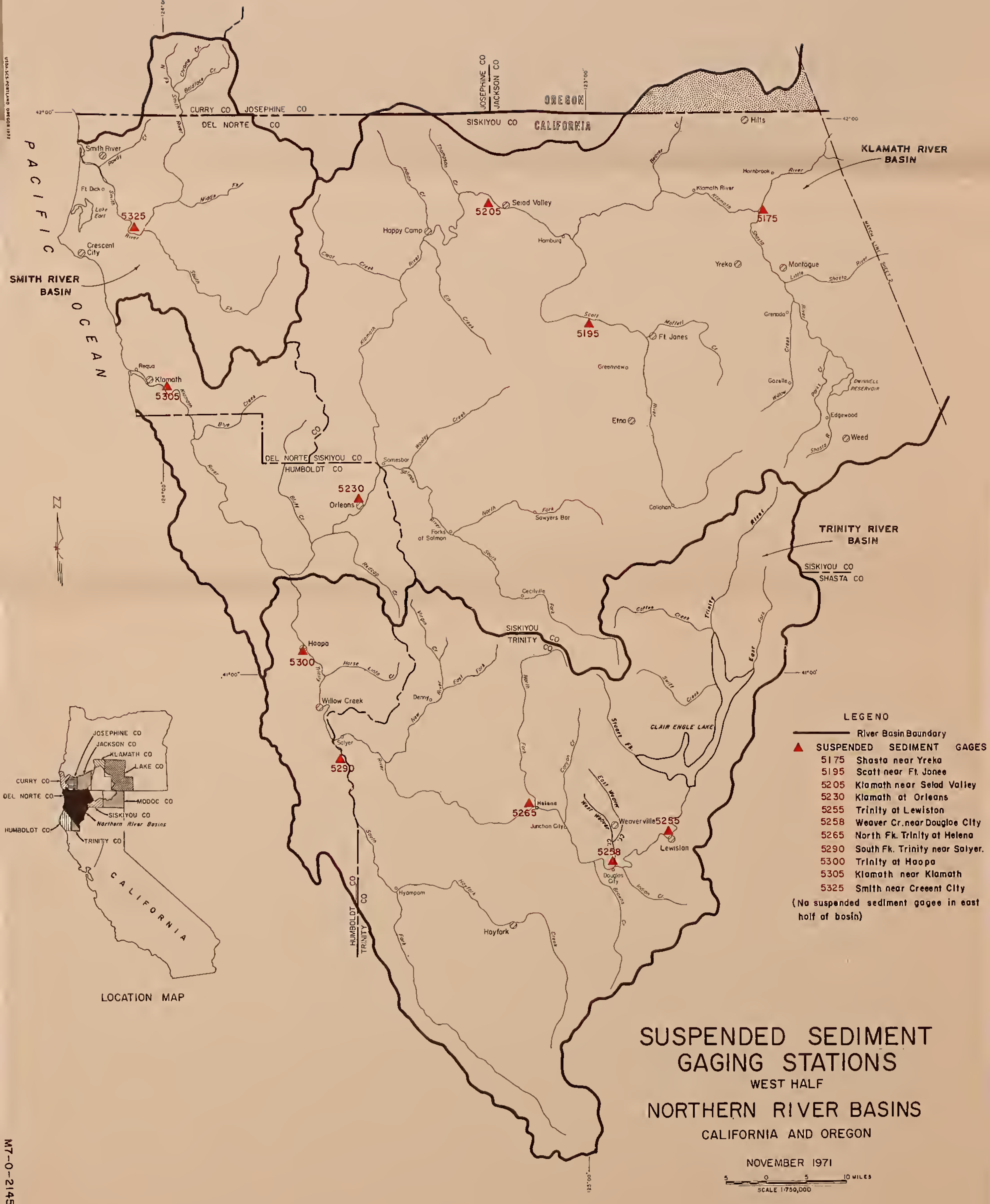
SOUTHERN RIVER BASINS

HUMBOLDT, LAKE, MENDOCINO, AND SONOMA COUNTIES, CALIFORNIA

NOVEMBER 1971

USDA-SCS-PORTLAND, OREG. 1971

M7-N-21148



SUSPENDED SEDIMENT GAGING STATIONS
WEST HALF
NORTHERN RIVER BASINS
CALIFORNIA AND OREGON

NOVEMBER 1971

USDA-SCS-PORTLAND OREGON 1972

M7-O-21451-N

Mean Annual Sediment Discharge
for the Period 1940-65

Station (Number)	Period of Record by Water Years1/ Water	Sediment	Drainage Area (Sq.Miles)	Suspended Sediment Per Sq.Mile (Tons/Yr.)	Total (Tons/Yr.)	With Bedload est. at 10% (Tons/Yr.)	Volume in Ac-Ft/Yr. Lost from Watershed	Deposits in Reservoir
				Russian River Basin				
Russian near Ukiah (4610)	1953-65	1964-65	99.7	1600	160,000	176,000	90	110
E.Fork Russian nr.Calpella (4615)	1942-65	1964-65	93	800	73,800 3/	81,000	40	50
Russian nr.Cloverdale (4630)	1952-65	1964-65	502	1300	653,000	718,000	360	450
Big Sulphur Cr. nr.Cloverdale(4632)	1958-65	1964-65	82.3	2800	230,000	253,000	125	160
Maacama Cr. nr. Kellogg (4639)	1961-66	1964-65	43.2	600	26,000	27,000	15	17
Dry Cr.nr.Geyserville (4652)	1960-65	1964-65	162	4300	697,000	767,000	380	480
Potter Valley Tailrace nr Potter V.(4710)	1909-65	1964-65	4/	-	3,200	3,200	-	-
				Klamath, Trinity, Smith River Basins				
Shasta nr.Yreka (5175)	1946-65	1956 1959-62	796	25	20,000	22,000	11	14
Scott nr.Fort Jones (5195)	1942-65	1956 6/	653	800	-	-	-	-
Klamath nr.Seiad V. (5205)	1960-65	1956 6/	6,980	40	-	-	-	-
Klamath nr.Somesbar (5230)	1942-65	1956 6/	8,500	200	-	-	-	-
Trinity nr.Lewiston (5255)	1940-60 5/	1956-60	728	300	218,000	240,000	120	151
Weaver Cr.nr.Douglas City(5258)	1959-65	1963-65	48	500	24,000	26,000	13	16
N.Fk.Trinity nr. Helena (5265)	1958-65	1963-65	151	200	30,000	33,000	16	21
S.Fk.Trinity nr Salyer (5290)	1951-65	1956 1958-65	898	1,500	1,347,000	1,482,000	740	930
Trinity nr.Hoopa (5300)	1940-65	1957-65	2,865	1,700	4,870,500	5,358,000	2,680	3,370
Klamath nr.Klamath (5305)	1951-65	1956 6/	12,100	1,000	-	-	-	-
Smith nr.Crescent City (5325)	1940-65	1956 6/	609	300	-	-	-	-

1/ A water year is the 12-month period October 1 through September 30. The year is designated by the calendar year in which it ends and includes the first nine months of that year.

2/ Volumes are based on estimated dry unit weight (bulk density) of 2000 Tons/Acre-Ft.(92 lbs./cu.ft.) for soil in place. The estimated weight of 1590 Tons/Acre-Ft.(73 lbs./cu.ft.) reflects the effect of bulking such as would be expected if the sediment were deposited in a storage reservoir.

3/ Rate is net for watershed after subtracting 3200 Tons per year estimated to be contributed by Eel River water diverted through the Potter Valley tailrace.

4/ Water is diverted from Eel River above Van Arsdale Dam. After passing through powerhouse, part of it is used for irrigation in Potter Valley and remainder flows into East Fork Russian River. Sediment is essentially all suspended.

5/ Unregulated flows prior to construction of Lewiston Dam.

6/ One year of sediment record. Record is very scanty and computed yields should be considered only as estimates for the one year of record shown.

This density is a weighted average of soil samples taken by Gardner (1963)[1] and by McLaughlin and Harradine (1965).[2] Field estimates of sediment yield from all sources can be compared with the figures shown in this column.

The last column presents the annual sediment rate that could be expected if a reservoir were constructed in the vicinity of a particular gaging station. The figure reflects the effect of bulking, which is the tendency of sediment to occupy more space in a reservoir than it does in-place on the watershed. Sediment deposition in reservoirs would probably have characteristics similar to those found in a survey of Lake Pillsbury in 1959. The U.S. Geological Survey found that the average dry density of sediment was 1,590 tons per acre-foot (73 pounds per cubic foot),[3] which represents a bulking increase of 26 percent.

SOILS DATA

Soil characteristics and interpretations presented in this section are based on information taken from published surveys, except in national forests, where only limited standard surveys have been made. A generalized soil map was developed for the national forest lands, using aerial photos, geology maps, and other available data. About 200 soil series, each with several phases, were combined into 92 soil associations for this study.

The table "Soil Characteristics, Qualities, and Interpretive Groupings" appears on the following pages and shows the main components of the soil associations and some of their features. An estimate of the areal proportion of the major soils and of the others included in each association

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[1] Robert A. Gardner and others, Wildland Soils and Associated Vegetation of Mendocino County, California. (Sacramento; Resources Agency of California, Cooperative Soil-Vegetation Survey Project, 1964). 113 pp.

[2] James McLaughlin and Frank Harradine, Soils of Western Humboldt County, California. (Department of Soils and Plant Nutrition, University of California, Davis, in cooperation with the County of Humboldt, November 1965). 85 pp.

[3] G. Porterfield and C.A. Dunnam, Sedimentation of Lake Pillsbury; Lake County, California, U.S. Geological Survey Water-Supply Paper 1619-EE. (Washington, D.C., U.S. Government Printing Office, 1964). 46 pp.

SOIL CHARACTERISTICS, QUALITIES, AND INTERPRETIVE GROUPINGS

SOUTHERN BASINS

SOIL MAP SYMBOL	SOIL ASSOCIATIONS AND MAJOR COMPONENTS	PERCENT OF ASSOCIATION 1/	LAND CAPABILITY SUBCLASS		LAND RESOURCE AREA	SOIL PROFILE					DRAINAGE CLASS	SUBSOIL PERMEABILITY	EROSION HAZARD	EFFECTIVE DEPTH (INCHES)	AVAILABLE WATER CAPACITY (INCHES)	HYDROLOGIC SOIL GROUP	UNIFIED SOIL CLASS. (SUBSOIL)
						SURFACE LAYER		SUBSOIL		SUBSTRATUM OR PARENT MATERIAL							
			IRRIGATED	DRY		TEXTURE	REACTION(pH)	TEXTURE	REACTION(pH)								
1	Mendocino-Gaspar-Empire Association, 0 to 30 percent slopes																
	Mendocino	40		IVe	4	Loam	Medium acid	Clay	Medium acid	Soft sedimentary rocks	Moderately well	Moderately slow	Moderate	36 to 60	7 to 10	B 2/	GL
	Gaspar	30		IVe	4	Sandy loam	Strongly acid	Sandy clay loam	Very strongly acid	Soft sedimentary rocks	Moderately well	Moderately slow	Moderate	36 to 60	7 to 9	B	GL or SG
	Empire	20 (10)		VIe	4	Sandy loam	Medium acid	Clay loam	Strongly acid	Soft sedimentary rocks	Well	Moderately slow	Moderate	36 to 60	4 to 11	C	CL
2	Larabee-Mendicino-Gaspar Association, 30 to 50 percent slopes																
	Larabee	30		VIIe	4	Loam	Slightly acid	Clay loam	Strongly acid	Soft sedimentary rocks	Well	Moderate or moderately slow	High	36 to 60+	5 to 11	B	GL or SG
	Mendocino	30		VIIe	4	Loam	Medium acid	Clay	Medium acid	Soft sedimentary rocks	Moderately well	Moderately slow	High	36 to 60	7 to 10	B	GL
	Caspar	20 (20)		VIIe	4	Sandy loam	Strongly acid	Sandy clay loam	Very strongly acid	Soft sedimentary rocks	Moderately well	Moderately slow	High	36 to 60	7 to 9	B	GL
3	Hugo-Josephine Association, 0 to 30 percent slopes																
	Hugo	50		IVe	4, 15	Loam	Medium acid	Loam	Strongly acid	Sandstone (Graywacke)	Well	Moderate	Moderate	30 to 60	4 to 11	B	ML or CL
	Josephine	30 (20)		IVe	4, 15	Loam	Medium acid	Clay loam	Strongly acid	Sandstone (Graywacke)	Well	Moderate or moderately slow	Moderate	30 to 60+	4 to 11	B	ML or CL
4	Hugo-Josephine Association, 30 to 50 percent slopes																
	Hugo	60		VIe	4, 15	Loam	Medium acid	Loam	Strongly acid	Sandstone (Graywacke)	Well	Moderate	High	30 to 60	4 to 11	B	ML or CL
	Josephine	30 (10)		VIe	4, 15	Loam	Medium acid	Clay loam	Strongly acid	Sandstone (Graywacke)	Well	Moderate or moderately slow	High	30 to 60+	4 to 11	B	GL or ML
5	Hugo-Josephine Association, 50 to 75 percent slopes																
	Hugo	70		VIIe	4, 15	Loam	Medium acid	Loam	Strongly acid	Sandstone (Graywacke)	Well	Moderate	Very high	30 to 60	4 to 11	B	ML or CL
	Josephine	20 (10)		VIIe	4, 15	Loam	Medium acid	Clay loam	Strongly acid	Sandstone (Graywacke)	Well	Moderate or moderately slow	Very high	30 to 60+	4 to 11	B	GL or ML
8	Kneeland Association, 9 to 50 percent slopes																
	Kneeland	80 (20)		VIe	4	Clay loam	Medium Acid	Clay loam	Medium Acid	Sandstone (Graywacke)	Well	Slow	High	20 to 36	4 to 6	C	CL
9	Kneeland Association, 50 to 75 percent slopes																
	Kneeland	80 (20)		VIIe	4	Clay loam	Medium Acid	Clay loam	Medium Acid	Sandstone (Graywacke)	Well	Slow	Very High	20 to 36	4 to 6	C	GL

1/ PERCENT IN (___) GIVES EXTENT OF OTHER SOILS IN THE ASSOCIATIONS

2/ Indicates rating used on Hydrologic Soil Groups Map

SOIL CHARACTERISTICS, QUALITIES, AND INTERPRETIVE GROUPINGS

SOUTHERN BASINS

SOIL MAP SYMBOL	SOIL ASSOCIATIONS AND MAJOR COMPONENTS	PERCENT[1] OF ASSOCIATION	LAND CAPABILITY SUBCLASS		LAND RESOURCE AREA	SOIL PROFILE					DRAINAGE CLASS	SUBSOIL PERMEABILITY	EROSION HAZARD	EFFECTIVE DEPTH (INCHES)	AVAILABLE WATER CAPACITY (INCHES)	HYDROLOGIC SOIL GROUP	UNIFIED SOIL CLASS. (SUBSOIL)
						SURFACE LAYER		SUBSOIL		SUBSTRATUM OR PARENT MATERIAL							
			IRRIGATED	DRY		TEXTURE	REACTION (pH)	TEXTURE	REACTION (pH)								
10	Yorkville Association, 15 to 50 percent slopes																
	Yorkville	70 (30)		VIe	4, 15	Clay loam	Neutral	Clay	Mildly alkaline	Metamorphosed basic rocks	Moderately well or somewhat poorly	Slow	Very high	20 to 40	4 to 9	D	CH
11	Laughlin Association, 0 to 30 percent slopes																
	Laughlin	80 (20)	IVe		4, 15	Loam	Medium acid	Loam	Medium acid	Sandstone (Graywacke)	Well	Moderately rapid	Moderate	20 to 40	2 to 5	B	ML
12	Laughlin Association, 30 to 50 percent slopes																
	Laughlin	80 (20)		VIe	4, 15	Loam	Medium acid	Loam	Medium acid	Sandstone (Graywacke)	Well	Moderately rapid	High	20 to 40	2 to 5	B	ML
13	Laughlin Association, 50 to 75 percent slopes																
	Laughlin	80 (20)		VIIe	4, 15	Loam	Medium acid	Loam	Medium acid	Sandstone (Graywacke)	Well	Moderately rapid	Very high	20 to 40	2 to 5	B	ML
15	Henneke Association, 9 to 50 percent slopes																
	Henneke	70 (30)		VIIs	15	Very gravelly loam	Slightly acid	Very gravelly clay loam	Neutral	Serpentine	Well	Moderately slow	High	5 to 20	1 to 3	D	SC or GC
16	Maymen-Los Gatos Association, 15 to 75 percent slopes																
	Maymen	50		VIIIe[2]	4, 15	Gravelly loam	Medium acid	Gravelly loam	Strongly acid	Sandstone (Graywacke)	Somewhat excessively	Moderately rapid	Very high	5 to 20	1 to 3	D[2]	SM
	Los Gatos	40 (10)		VIIe	4, 15	Gravelly loam	Slightly acid	Gravelly clay loam	Medium acid	Sandstone (Graywacke)	Well	Moderately slow	Very high	16 to 30	2 to 5	C	SC or CL
17	Boomer Association, 30 to 50 precent slopes																
	Boomer	70 (30)		VIe	15	Gravelly loam	Medium acid	Gravelly clay loam	Medium acid	Metamorphosed basic igneous rocks	Well	Moderately slow	High	30 to 60	3 to 9	B	SC or CL
18	Boomer Association, 50 to 75 precent slopes																
	Boomer	70 (30)		VIIe	15	Gravelly loam	Medium acid	Gravelly clay loam	Medium acid	Metamorphosed basic igneoua rocks	Well	Moderately slow	Very high	30 to 60	3 to 9	B	SC or CL
19	Colluvial land-Landslide Association, 9 to 75 percent slopes																
	Colluvial land	60		VIIIs	—	Mixed deposits of soil materials and rock fragments					—	—	Very high	—	—	—	—
	Landslide	20 (20)		VIIIs	—	Mixed deposits of soil materials and rock fragments and exposed surfaces resulting from loss of material					—	—	Very high	—	—	—	—
									(2)								

1/ PERCENT IN (___) GIVES EXTENT OF OTHER SOILS IN THE ASSOCIATIONS

2/ Indicates rating used on General Land Capability Map, Or Hydrologic Soil Groups Map.

SOIL CHARACTERISTICS, QUALITIES, AND INTERPRETIVE GROUPINGS

SOUTHERN BASINS

SOIL MAP SYMBOL	SOIL ASSOCIATIONS AND MAJOR COMPONENTS	PERCENT OF ASSOCIATION 1/	LAND CAPABILITY SUBCLASS		LAND RESOURCE AREA	SOIL PROFILE					DRAINAGE CLASS	SUBSOIL PERMEABILITY	EROSION HAZARD	EFFECTIVE DEPTH (INCHES)	AVAILABLE WATER CAPACITY (INCHES)	HYDROLOGIC SOIL GROUP	UNIFIED SOIL CLASS. (SUBSOIL)
						SURFACE LAYER		SUBSOIL		SUBSTRATUM OR PARENT MATERIAL							
			IRRIGATED	DRY		TEXTURE	REACTION(pH)	TEXTURE	REACTION(pH)								
24	Wilder Association, 15 to 50 percent slopes																
	Wilder	70 (30)		VIe	4	Sandy loam	Strongly acid	Gravelly sandy loam	Very strongly acid	Sandstone	Well	Moderately rapid	High	24 to 48	3 to 5	B	SM
26	Dune land-Coastal beaches Association, 0 to 30 percent slopes																
	Dune land	50		2/ VIIIe	14	Coastal sand dunes consisting of medium and coarse sand					Excessively	Very rapid	Moderate	60+	2 to 3	A 2/	SW or SP
	Coastal beaches	50		VIIIw	4	Sandy and rocky beaches subject to frequent wave action					—	—	—	—	—	—	SP
29	Yolo-Zamora Association, 0 to 2 percent slopes																
	Yolo, overflow	50	2/ IIw		14	Loam	Neutral	Stratified fine sandy loam & silt loam	Neutral	Alluvium from sedimentary rocks	Well	Moderate	Low	60+	B to 11	B	ML
	Zamora	40 (1[illegible])	I		14	Silty clay loam	Neutral	Silty clay loam	Neutral	Alluvium from sedimentary rocks	Well or moderately well	Moderate or moderately slow	Low	60+	10 to 13	B	CL
30	Ferndale-Russ Association, 0 to 9 percent slopes																
	Ferndale	60	IIw		4	Silt loam	Neutral	Loam	Neutral	Stratified sand, loam and gravel	Well	Moderate	Low	60+	10 to 12	B	ML
	Russ	20 (20)	IIw		4	Loam	Slightly acid	Loam	Medium acid	Loam	Moderately well or somewhat poorly	Moderate or moderately slow	Low	60+	10 to 12	B	ML
33	Carlotta-Ettersburg Association, 0 to 5 percent slopes																
	Carlotta	40	IIe		4	Loam	Slightly acid	Loam	Strongly acid	Stratified loam and gravel	Moderately well	Moderate or moderately slow	Low	40 to 60	6 to 11	B	ML
	Ettersburg	40 (20)	IIe		4	Loam	Very strongly acid	Loam	Very strongly acid	Gravel	Well	Moderate	Low	40 to 60	6 to 10	B	ML
34	Riverwash-Alluvial land Association, 0 to 9 percent slopes																
	Riverwash	40		2/ VIIIw	—	Sandy, gravelly, and cobbly materials along stream channels					—	—	Very high	—	—	A	GP, GW, SP or SW
	Alluvial land	40 (20)		VIIw	14, 15	Alluvial deposits varying widely in texture and subject to frequent changes through stream overflow					—	—	Very high	10 to 60	—	A	—
35	Cole-Clear Lake Association, 0 to 2 percent slopes																
	Cole	50	IIIw		14	Loam	Medium acid	Sandy clay	Medium acid	Sandy clay	Somewhat poorly	Moderate to slow	Low	60	7 to 9	C 2/	CL or CH
	Clear Lake	40 (10)	IIIw		14	Clay	Slightly acid	Clay	Moderately alkaline	Clay	Poorly	Slow or very slow	Low	60	8 to 10	0	CH

(3)

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SOIL CHARACTERISTICS, QUALITIES, AND INTERPRETIVE GROUPINGS

SOUTHERN BASINS

SOIL MAP SYMBOL	SOIL ASSOCIATIONS AND MAJOR COMPONENTS	PERCENT 1/ OF ASSOCIATION	LAND CAPABILITY SUBCLASS		LAND RESOURCE AREA	SOIL PROFILE					DRAINAGE CLASS	SUBSOIL PERMEABILITY	EROSION HAZARD	EFFECTIVE DEPTH (INCHES)	AVAILABLE WATER CAPACITY (INCHES)	HYDROLOGIC SOIL GROUP	UNIFIED SOIL CLASS. (SUBSOIL)
						SURFACE LAYER		SUBSOIL		SUBSTRATUM OR PARENT MATERIAL							
			IRRIGATED	DRY		TEXTURE	REACTION(pH)	TEXTURE	REACTION(pH)								
36	Pinole-Talmage Association, 0 to 9 percent slopes																
	Pinole	60	IIe 2/		14	Gravelly loam	Strongly acid	Clay loam	Medium acid	Very gravelly sandy loam	Well	Moderate or moderately rapid	Low	40 to 60	5 to 10	B 2/	ML or CL
	Talmage	30 (10)	IIIs		14	Gravelly sandy loam	Slightly acid	Very gravelly sandy loam	Slightly acid	Gravelly coarse loamy sand	Somewhat excessively	Rapid	Low	20 to 40	2 to 4	A	GM
37	Noyo-Blacklock Association, 0 to 30 percent slopes																
	Noyo	50	IVe 2/		4	Sandy loam	Very strongly acid	Sandy clay loam	Strongly acid	Sandstone	Somewhat poorly	Slow	Moderate	20 to 40	2 to 6	C 2/	CL or SC
	Blacklock	30 (20)		VIIIw	4	Sandy loam	Extremely acid	Cemented sandy hardpan	Strongly acid	Alluvium	Poorly	Slow	High	4 to 12	1 to 2	D	SM
38	Maywood-Zamora Association, 0 to 5 percent slopes																
	Maywood	60	IIw 2/		14	Very fine sandy loam	Medium acid	Very fine sandy loam	Medium acid	Silt loam	Well	Moderately rapid	Low	60+	8 to 12	B	ML
	Zamora	30 (10)	IIe		14	Silt loam	Medium acid	Silt loam	Slightly acid	Silty clay loam	Well or moderately well	Moderate or moderately slow	Low	60+	7 to 11	B	ML or CL
39	Arcata-Rohnerville Association 0 to 9 percent slopes																
	Arcata	50	IIe 2/		4	Loam	Medium acid	Clay loam	Strongly acid	Gravelly sandy loam	Well	Moderately rapid to moderate	Moderate	40 to 60	6 to 9	B	CL
	Rohnerville	20 (30)	IIIe		4	Loam	Medium acid	Sandy Clay	Medium acid	Clay	Moderately well to well	Slow	Moderate	40 to 60	4 to 9	B	CL or SC
42	Pajaro Association, 0 to 2 percent slopes																
	Pajaro	70 (30)	IIw		14	Loam	Slightly acid	Loam	Slightly acid	Stratified sandy loam and clay loam	Somewhat poorly	Moderately slow	Low	30 to 50	9 to 10	C	ML or CL
43	Goulding-Toomes Association, 9 to 30 percent slopes																
	Goulding	70		VIs 2/	15	Cobbly Clay Loam	Slightly acid	Cobbly Clay Loam	Slightly acid	Fractured Basalt	Well	Moderate	Moderate	20 to 24	3 to 5	D	ML or CL
	Toomes	20 (10)		VIIe	15	Rocky loam	Medium acid	Clay loam	Slightly acid	Weathered basic Igneous rock	Well	Moderate	Moderate	8 to 15	1 to 2	D	CL
44	Forward-Kidd-Rock land Association, 30 to 75 percent slopes																
	Forward	50		VIIe 2/	15	Gravelly loam	Slightly acid	Sandy clay loam	Medium acid	Weathered rhyolite	Well	Rapid	Very high	15 to 25	3 to 5	C 2/	SC or CL
	Kidd	20		VIIe	15	Gravelly loam	Slightly acid	Gravelly loam	Medium acid	Shattered rhyolite	Well	Rapid	Very high	10 to 20	2 to 4	D	SM or GM
	Rock land	20 (10)		VIIIs		Very shallow soil materials and rock outcrops.					—	—	—	—	—	D	--

(4)

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SOIL CHARACTERISTICS, QUALITIES, AND INTERPRETIVE GROUPINGS

SOUTHERN BASINS

SOIL MAP SYMBOL	SOIL ASSOCIATIONS AND MAJOR COMPONENTS	PERCENT 1/ OF ASSOCIATION	LAND CAPABILITY SUBCLASS		LAND RESOURCE AREA	SOIL PROFILE					DRAINAGE CLASS	SUBSOIL PERMEABILITY	EROSION HAZARD	EFFECTIVE DEPTH (INCHES)	AVAILABLE WATER CAPACITY (INCHES)	HYDROLOGIC SOIL GROUP	UNIFIED SOIL CLASS. (SUBSOIL)
						SURFACE LAYER		SUBSOIL		SUBSTRATUM OR PARENT MATERIAL							
			IRRIGATED	DRY		TEXTURE	REACTION(pH)	TEXTURE	REACTION(pH)								
46	Spreckles-Felta Association, 15 to 50 percent slopes																
	Spreckles	50		VIIe 2/	15	Loam	Slightly acid	Clay	Strongly acid	Basic rock fragments and volcanic ash	Well	Moderately slow	Very high	22 to 26	4 to 6	C	CH
	Felta	40 (10)		VIIs	15	Very gravelly loam	Slightly acid	Clay loam	Slightly acid	Gravelly alluvium	Well	Moderate	High	14 to 18	3 to 4	C	CL
47	Coulding-Toomes Association, 30 to 50 percent slopes																
	Coulding	80		VIIs 2/	15	Cobbly Clay Loam	Slightly acid	Cobbly Clay Loam	Slightly acid	Fractured basalt	Well	Moderate	High	20 to 24	3 to 5	D	ML or CL
	Toomes	10 (10)		VIIe	15	Rocky loam	Medium acid	Clay loam	Slightly acid	Weathered basic Igneous rock	Well	Moderate	High	8 to 15	1 to 2	D	CL
48	Cotati Association, 2 to 9 percent slopes																
	Cotati	90 (10)	IIIe		14	Fine sandy loam	Strongly acid	Clay	Strongly acid	Clay	Somewhat poorly	Slow	Moderate	24 to 36	4 to 6	D	CH
49	Coldridge Association, 2 to 15 percent slopes																
	Coldridge	80 (20)	IVe		4	Fine sandy loam	Strongly acid	Sandy clay	Strongly acid	Soft sandstone	Moderately well	Moderately slpw	Moderate	40 to 60	5 to 8	B	CL or SC
51	Huichica-Wright Association, 0 to 9 percent slopes																
	Huichica	40	IIIe		14	Loam	Strongly acid	Clay	Medium acid	Weakly cemented alluvium	Somewhat poorly	Very slow	Low	20 to 24	3 to 4	D	CL or CH
	Wright	40 (20)	IIIe		14	Loam	Strongly acid	Clay	Medium acid	Clay loam or clay	Somewhat poorly	Very slow	Low	24 to 36	8 to 10	C	CL or CH
52	Clear Lake Association, 0 to 2 percent slopes																
	Clear Lake	90 (10)	IIs		14	Clay	Medium acid	Clay	Moderately alkaline	Gravelly sand	Moderately well	Slow or very slow	Low	60	8 to 10	D	CH
53	Suther -Yorkville Association, 15 to 50 percent slopes																
	Suther -	40		VIIe	15	Loam	Medium acid	Gravelly clay	Strongly acid	Weathered sandstone	Well	Moderately slow	High	20 to 40	5 to 6	C 2/	CL or CH
	Yorkville	40 (20)		VIe	15	Clay loam	Slightly acid	Clay	Mildly alkaline	Metamorphosed basic rocks	Moderately well or somewhat poorly	Slow	Very high	20 to 40	4 to 9	D	CH
55	Pinole-Manzanita Association, 2 to 9 percent slopes																
	Pinole	40	IIIe 2/		14	Gravelly loam	Medium acid	Clay loam	Medium acid	Gravelly sandy loam	Well	Moderate	Low	40 to 60	5 to 10	B 2/	CL or ML
	Manzanita	40 (20)	IIe		14	Clay loam	Medium acid	Clay loam	Medium acid	Clay loam	Well	Moderate	Low	60+	7 to 10	C	CL

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SOIL CHARACTERISTICS, QUALITIES, AND INTERPRETIVE GROUPINGS

SOUTHERN BASINS

SOIL MAP SYMBOL	SOIL ASSOCIATIONS AND MAJOR COMPONENTS	PERCENT OF ASSOCIATION [1]	LAND CAPABILITY SUBCLASS		LAND RESOURCE AREA	SOIL PROFILE					DRAINAGE CLASS	SUBSOIL PERMEABILITY	EROSION HAZARD	EFFECTIVE DEPTH (INCHES)	AVAILABLE WATER CAPACITY (INCHES)	HYDROLOGIC SOIL GROUP	UNIFIED SOIL CLASS. [illegible]
						SURFACE LAYER		SUBSOIL		SUBSTRATUM OR PARENT MATERIAL							
			IRRIGATED	DRY		TEXTURE	REACTION (pH)	TEXTURE	REACTION (pH)								
56	Yolo-Cortina-Pleasanton Association, 0 to 2 percent slopes																
	Yolo; overflow	50	IIw [2]		14	Loam	Neutral	Clay loam	Neutral	Loam	Moderately well	Moderate	Low	60+	B to 11	B [2]	ML or CL
	Cortina	20	IVs		14	Very gravelly sandy loam	Strongly acid	Very gravelly sandy loam	Strongly acid	Gravelly sand	Excessively	Very rapid	Low	20 to 40	3 to 6	A	GM
	Pleasanton	20 (10)	IIs		14	Gravelly loam	Strongly acid	Gravelly clay loam	Medium acid	Gravelly sandy clay loam	Well	Moderate	Low	60+	9 to 10	B	ML or GL
57	Sobrante Association, 15 to 50 percent slopes																
	Sobrante	90 (10)		VIe	15	Clay loam	Slightly acid	Glay loam	Neutral	Fractured basic volcanic materials	Well	Moderate	High	20 to 40	4 to 6	C	CL
5B	Konokti-Pluth Association, 30 to 75 percent slopes																
	Konokti	80		VIIe	15	Gravelly rocky loam	Slightly acid	Gravelly clay loam	Slightly acid	Weathered basic volcanic materials	Somewhat excessively	Moderately rapid	Very high	10 to 30	2 to 4	C [2]	GM or ML
	Pluth	10 (10)		VIIs	15	Gravelly loam	Slightly acid	Very gravelly loam	Slightly acid	Loose porous volcanic cinders	Somewhat excessively	Moderately rapid	Very high	12 to 36	2 to 5	B	GM or SM
59	Hesse-Glenview Association, 15 to 50 percent slopes																
	Hesse	70		VIIs [2]		Gravelly clay loam	Slightly acid	Gravelly clay loam	Slightly acid	Fractured volcanic rock, chiefly obsidian	Well	Moderate	High	18 to 36	4 to 6	C	GM or ML
	Glenview	20 (10)		VIe	15	Gravelly loam	Slightly acid	Gravelly clay loam	Medium acid	Fractured volcanic rock, chiefly obsidian	Well	Moderate	High	30 to 50	5 to 7	B	GM or ML
60	Cohasset-Red Hill Association 0 to 30 percent slopes																
	Cohasset	60	IVe		15	Gravelly loam	Medium acid	Glay loam	Strongly acid	Weathered basic volcanic materials	Well	Moderate	Moderate	30 to 40	5 to 6	B [2]	CL or ML
	Red Hill	30 (10)	IVe		15	Loam	Slightly acid	Loam	Strongly acid	Weathered basic volcanic materials	Well	Moderately slow	Moderate	4B to 60+	7 to 9	C	ML
62	Phipps-Soper Association, 15 to 50 percent slopes																
	Phipps	60		VIe [2]	15	Gravelly loam	Slightly acid	Clay loam	Slightly acid	Conglomerate	Well	Moderately slow	High	20 to 40	3 to 6	C	CL or ML
	Soper	20 (20)		VIIe	15	Gravelly loam	Neutral	Gravelly sandy clay loam	Midly alkaline	Conglomerate	Well	Moderately slow	High	20 to 40	3 to 6	B	GC or SG
									(6)								

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SOIL CHARACTERISTICS, QUALITIES, AND INTERPRETIVE GROUPINGS

NORTHERN BASINS

SOIL MAP SYMBOL	SOIL ASSOCIATIONS AND MAJOR COMPONENTS	PERCENT [1] OF ASSOCIATION	LAND CAPABILITY SUBCLASS		LAND RESOURCE AREA	SOIL PROFILE					DRAINAGE CLASS	SUBSOIL PERMEABILITY	EROSION HAZARD	EFFECTIVE DEPTH (INCHES)	AVAILABLE WATER CAPACITY (INCHES)	HYDROLOGIC SOIL GROUP	UNIFIED SOIL CLASS. (SUBSOIL)
						SURFACE LAYER		SUBSOIL		SUBSTRATUM OR PARENT MATERIAL							
			IRRIGATED	DRY		TEXTURE	REACTION(pH)	TEXTURE	REACTION(pH)								
4	Hugo-Josephine association, 30 to 50 percent slopes																
	Hugo	65		VIe	4,5	Loam	Medium acid	Gravelly loam	Strongly acid	Sandstone	Well	Moderate or Moderately rapid	High	30 to 60	4 to 10	B	ML or GM
	Josephine	20 (15)		VIe	4,5	Loam	Medium acid	Clay loam	Strongly acid	Sandstone	Well	Moderate or Moderately slow	High	30 to 60+	5 to 11	B	CL or ML
5	Hugo-Josephine association, 50 to 75 percent slopes																
	Hugo	75		VIIe	4,5	Loam	Medium acid	Gravelly loam	Strongly acid	Sandstone	Well	Moderate or Moderately rapid	Very High	30 to 60	4 to 10	B	ML or GM
	Josephine	10 (15)		VIIe	4,5	Loam	Medium acid	Clay loam	Strongly acid	Sandstone	Well	Moderate or Moderately slow	Very High	30 to 60+	5 to 11	B	CL or ML
6	Sheetiron-Masterson-Hugo association, 30 to 75 percent slopes																
	Sheetiron	40		VIIe [2]	5	Gravelly loam	Medium acid	Gravelly loam	Strongly acid	Metamorphosed sedimentary rocks	Somewhat excessively	Moderate	Very High	20 to 40	2 to 6	B	GM, SM, or ML
	Masterson	20		VIIe	5	Gravelly loam	Medium acid	Gravelly loam	Strongly acid	Metamorphosed sedimentary rocks	Well	Moderately rapid	Very High	20 to 40	2 to 6	B	GM, SM, or ML
	Hugo	20 (20)		VIIe	5	Loam	Medium acid	Gravelly loam	Strongly acid	Sandstone	Well	Moderate or Moderately rapid	Very High	30 to 60	4 to 10	B	ML, CL
18	Boomer-Neuns association, 30 to 75 percent slopes																
	Boomer	50		VIIe [2]	5	Gravelly loam	Medium acid	Gravelly clay loam	Medium acid	Metamorphosed basic igneous rocks	Well	Moderately slow	Very High	30 to 60	5 to 10	B	ML or CL
	Neuns	30 (20)		VIIs	5	Gravelly sandy loam	Medium acid	Very gravelly clay loam	Medium acid	Metamorphosed basic igneous rocks	Somewhat excessively	Moderate	Very High	24 to 48	3 to 7	B	GM or GC
20	Yollabolly-Rock land association, 30 to 75 percent slopes																
	Yollabolly	60		VIIs [2]	5	Gravelly loam	Strongly acid	Stony very gravelly loam	Strongly acid	Metamorphosed sedimentary rocks	Excessively	Rapid	Very High	5 to 20	1 to 3	0	
	Rock land	25 (15)		VIIIs	5	Very shallow soil materials and rock outcrops					----	--	--	--	--	D	--
30	Ferndale association, 0 to 9 percent slopes																
	Ferndale	50 (50)	IIw		4	Silt loam	Neutral	Silt loam	Neutral	Loamy fine sand	Well	Moderate	Low	60+	8 to 10	B	ML
63	Fordney-Poe association 0 to 2 percent slopes																
	Fordney	40	IIIs		21	Loamy fine sand	Neutral	Loamy sand	Neutral	Sand	Excessively	Rapid	Low (High) [3]	40 to 60+	3 to 8	A [2]	SM
	Poe	40 (20)	IIIs		21	Loamy fine sand	Moderately alkaline	Loamy fine sand	Moderately alkaline	Cemented loamy sand	Somewhat poorly	Rapid	Low (High) [3]	20 to 40	2 to 5	C	SM

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3/ Wind erosion hazard.

NORTHERN BASINS

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						SURFACE LAYER		SUBSOIL		SUBSTRATUM OR PARENT MATERIAL							
			IRRIGATED	DRY		TEXTURE	REACTION(pH)	TEXTURE	REACTION(pH)								
64	Tulana-Algoma association 0 to 2 percent slopes																
	Tulana	40	IIIw[2]		21	Silt loam	Neutral	Silt	Moderately alkaline	Stratified diatomaccous earth, peat, and muck	Poorly or very poorly	Moderately slow	Low (Moderate)[3]	40 to 60+	8 to 12	D	ML
	Algoma	35 (25)	IVw		21	Silt loam	Strongly alkaline	Silt loam	Moderately alkaline	Sand	Poorly or very poorly	Moderately slow	Low (Moderate)[3]	20 to 40	4 to 8	D	ML
65	Chawanakee-Corbett-Siskiyou association, 15 to 75 percent slopes																
	Chawanakee	30		VIIe[2]	5	Coarse sandy loam	Medium acid	Coarse sandy loam	Medium acid	Weathered granitic rock	Somewhat excessively	Moderately rapid	Very high	20 to 40	2 to 6	B	SM
	Corbett	30		VIIs	5	Loamy coarse sand	Strongly acid	Loamy coarse sand	Medium acid	Weathered granitic rock	Somewhat excessively	Rapid	Very high	24 to 48	2 to 5	B	SM
	Siskiyou	10 (30)		VIIe	5	Gravelly sandy loam	Medium acid	Gravelly sandy loam	Medium acid	Weathered granitic rocks	Excessively	Moderately rapid	Very high	15 to 30	2 to 4	B	SM or GM
66	Dubakella-Ishi Pishi-Weitchpec association, 9 to 50 percent slopes																
	Dubakella	35		VIs	5	Stony clay loam	Slightly acid	Stony silty clay loam	Neutral	Serpentine	Well	Moderate	High	20 to 40	3 to 6	C[2]	CL or ML
	Ishi Pishi	30		VIe[2]	5	Gravelly loam	Medium acid	Gravelly clay	Slightly acid	Serpentine	Well	Slow	High	30 to 60	4 to 9	C	CH or CL
	Weitchpec	20 (15)		VIe	5	Very gravelly loam	Medium acid	Gravelly loam	Slightly acid	Serpentine	Well	Moderate	High	20 to 40	3 to 6	B	ML or CL
67	Kinkel-Boomer association, 15 to 50 percent slopes																
	Kinkel	40		VIs[2]	21	Gravelly loam	Medium acid	Very gravelly clay loam	Medium acid	Metamorphosed sedimentary and igneous rocks	Well	Moderately slow	High	40 to 60	5 to 8	B	GC
	Boomer	30 (30)		VIe	21	Gravelly loam	Medium acid	Gravelly clay loam	Medium acid	Metamorphosed sedimentary and igneous rocks	Well	Moderately slow	High	30 to 60	5 to 10	B	ML or CL
68	Kinkel-Boomer-Duzel association, 0 to 50 percent slopes																
	Kinkel	35		VIs	21	Gravelly loam	Medium acid	Very gravelly clay loam	Medium acid	Metamorphosed sedimentary and igneous rocks	Well	Moderately slow	High	40 to 60	5 to 8	B	GC
	Boomer	20		VIe[2]	21	Gravelly loam	Medium acid	Gravelly Clay loam	Medium acid	Metamorphosed sedimentary and igneous rocks	Well	Moderately alow	High	30 to 60	5 to 10	B	ML or CL
	Duzel	25 (20)		VIe	21	Gravelly loam	Neutral	Gravelly clay loam	Neutral	Metamorphosed sedimentary and igneous rocks	Well	Moderately slow	High	20 to 48	4 to 7	B	CL
69	Josephine-Sites-Maymen association, 9 to 50 percent slopes																
	Josephine	30		VIe[2]	5	Gravelly loam	Medium acid	Clay loam	Strongly acid	Sandstone, shale, or schist	Well	Moderate or moderately slow	High	30 to 60+	5 to 11	B[3]	CL or ML
	Sites	30		VIe	5	Loam	Slightly acid	Clay	Strongly acid	Schist or shale	Well	Slow	High	30 to 60+	5 to 11	C	CL

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SOIL CHARACTERISTICS, QUALITIES, AND INTERPRETIVE GROUPINGS

NORTHERN BASINS

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						SURFACE LAYER		SUBSOIL		SUBSTRATUM OR PARENT MATERIAL							
			IRRIGATED	DRY		TEXTURE	REACTION(pH)	TEXTURE	REACTION(pH)								
69 cont.	Maymen	20 (20)		VIIIs[2]	4, 15	Gravelly loam	Medium acid	Gravelly loam	Strongly acid	Sandstone (Graywacke)	Somewhat excessively	Moderately rapid	Very high	5 to 20	1 to 3	D	SM
70	Tournquist-Portola association, 0 to 50 percent slopes																
	Tournquist	30		VIs	21	Stony loam	Slightly acid	Gravelly clay loam	Slightly acid	Basalt, andesite or tuff	Well	Moderate	High	30 to 60	4 to 9	B[2]	ML or CL
	Portola	30 (40)		VIs	21	Stony sandy loam	Medium acid	Very stony sandy loam	Medium acid	Volcanic materials	Somewhat excessively	Moderately rapid	High	20 to 40	3 to 6	C	SM
71	Tyson-Cahto association 30 to 50 percent slopes																
	Tyson	55		VIIs	5	Gravelly loam	Slightly acid	Very gravelly clay loam	Medium acid	Shale	Well	Moderately slow	High	20 to 40	3 to 7	C	GC or GM
	Cahto	35 (15)		VIIs	5	Gravelly loam	Slightly acid	Very gravelly silty clay loam	Medium acid	Shale	Well	Moderate	High	20 to 40	3 to 7	C	GM ro CG
72	Woodcock-Pokegema association, 15 to 50 percent slopes																
	Woodcock	40		VII[3]	21	Stony loam	Slightly acid	Very stony clay loam	Medium acid	Very atony colluvium	Well	Moderate	High	40 to 60	4 to 6	B	SC or CL
	Pokegema	35 (25)		VIe	21	Loam	Slightly acid	Clay loam	Medium acid	Cobbly and stony mud flows	Well	Moderately slow	High	40 to 60	6 to 10	B	ML or CL
73	Windy-Lava flows association, 15 to 75 percent slopes																
	Windy	40		VII[3]	21,22	Very stony sandy loam	Medium acid	Very stony sandy loam	Strongly acid	Volcanic materials	Somewhat excessively	Moderately rapid	Very high	20 to 40	2 to 4	C[2]	GW or GP
	Lava flows	30 (30)		VIIIs	21,22	Highly fractured lava rock.					--	--	--	0	0	A	--
74	Tournquist association 0 to 9 percent slopes																
	Tournquist	85 (15)		IVs	21	Stony loam	Slightly acid	Gravelly clay loam	Neutral	Basalt, andesite or tuff	Well	Moderate	Low	30 to 60	4 to 10	B	SM or ML
75	Tournquist-Merlin association 0 to 9 percent slopes																
	Tournquist	60		IVs[2]	21	Stony loam	Slightly acid	Gravelly clay loam	Neutral	Basalt, andesite or tuff	Well	Moderate	Low	30 to 60	4 to 10	B[2]	SM or ML
	Merlin	30 (10)		VIIs	21	Extremely stony loam	Neutral	Clay	Neutral	Tuff	Well	Slow	Low	10 to 20	2 to 4	D	CH
76	Bieber-Salisbury-Modoc association, 0 to 9 percent slopes																
	Bieber	35		VIe	21	Gravelly loam	Neutral	Clay	Neutral	Hardpan	Well	Slow	Moderate	10 to 20	2 to 4	D	CH
	Salisbury	30	IVe		21	Gravelly loam	Neutral	Clay	Neutral	Hardpan	Well	Slow	Low	20 to 40	3 to 7	C[2]	CH

1/ PERCENT IN (—) GIVES EXTENT OF OTHER SOILS IN THE ASSOCIATIONS.

2/ Indicates rating used on Hydrologic Soil Groups Map or General Land Capability Map.

3/ Wind erosion hazard.

SOIL CHARACTERISTICS, QUALITIES, AND INTERPRETIVE GROUPINGS

NORTHERN BASINS

SOIL MAP SYMBOL	SOIL ASSOCIATIONS AND MAJOR COMPONENTS	PERCENT[1] OF ASSOCIATION	LAND CAPABILITY SUBCLASS		LAND RESOURCE AREA	SOIL PROFILE					DRAINAGE CLASS	SUBSOIL PERMEABILITY	EROSION HAZARD	EFFECTIVE DEPTH (INCHES)	AVAILABLE WATER CAPACITY (INCHES)	HYDROLOGIC SOIL GROUP	UNIFIED SOIL CLASS. (SUBSOIL)
						SURFACE LAYER		SUBSOIL		SUBSTRATUM OR PARENT MATERIAL							
			IRRIGATED	DRY		TEXTURE	REACTION(pH)	TEXTURE	REACTION(pH)								
76 cont.	Modoc	15 (15)		IVe	21	Sandy loam	Slightly acid	Sandy clay loam	Neutral	Strongly cemented loam	Well	Moderately slow	Moderate	20 to 40	3 to 8	C	CL or SC
77	Stoner-Greenhorn-Serpa association, 0 to 5 percent slopes																
	Stoner	40	IIe[2]		21	Gravelly Loam	Slightly acid	Gravelly loam	Medium acid	Stratified silty, sandy, or clayey sediments	Well	Moderate	Low	60+	8 to 10	B[2]	ML or CL
	Greenhorn	20	IIIw		21	Loam	Slightly acid	Stratified loam and clay loam	Neutral	Stratified sandy and gravelly sediments	Somewhat poorly or poorly	Moderate or moderately slow	Low	40 to 60	6 to 10	D	ML or CL
	Serpa	20 (20)	IIIw		21	Silty clay loam	Moderately alkaline	Silty clay	Moderately alkaline	Stratified clayey and gravelly sediments	Poorly	Slow	Low	60+	10 to 13	D	CL or CH
78	Nevador-Ocho association 0 to 5 percent slopes																
	Nevador	45	IIIe[2]		21	Loam	Mildly alkaline	Sandy clay loam	Moderately alkaline	Hardpan	Moderately well	Moderately slow	Low (Moderate)[3]	20 to 40	3 to 8	C[2]	CL
	Ocho	35 (20)		VIs	21	Sandy loam	Strongly alkaline	Sandy clay	Strongly alkaline	Hardpan	Somewhat poorly	Very slow	Low (Moderate)[3]	15 to 40	2 to 3	D	CL or CH
79	Puls-Madeline association, 0 to 9 percent slopes																
	Puls	55		VIIs	21	Very stony loam	Slightly acid	Clay	Neutral	Hardpan	Well	Slow	Low	10 to 20	1 to 3	D	CH
	Madeline	25 (20)		VIIs	21	Stony loam	Slightly acid	Stony clay	Neutral	Fractured basalt	Well	Slow	Low	10 to 20	1 to 3	D	CH
80	Delaney-Plutos association, 0 to 30 percent slopes																
	Delaney	35	IIIe[2]		21	Sand	Slightly acid	Sand	Neutral	Bedrock or stratified sandy or gravelly sediments	Somewhat excessively	Rapid	Moderate (High)[3]	40 to 60	3 to 6	A[2]	SP-SM
	Plutos	35 (30)		VIIs	21	Very rocky sand	Neutral	Stony sand	Neutral	Basalt	Excessively	Rapid	Moderate (High)[3]	20 to 30	1 to 3	C	SM or SP
81	Pasquetti-Ramelli association 0 to 9 percent slopes																
	Pasquetti	40	IIIw		21	Silty clay loam	Neutral	Silt loam	Mildly alkaline	Stratified silty and sandy sediments	Poorly	Slow	Low	60+	8 to 12	D[2]	ML
	Ramelli	40 (20)	IIIw		21	Silty clay loam	Slightly acid	Silty clay	Moderately alkaline	Coarse sand or silty sediments	Poorly	Slow	Low	40 to 60+	10 to 13	C	CH
82	Shasta association, 0 to 50 percent slopes																
	Shasta	50 (50)		VIs	21	Loamy sand	Medium acid	Loamy sand	Strongly acid	Stratified sandy and gravelly sediments	Somewhat excessively	Moderately rapid	High (High)[3]	40 to 60+	4 to 7	A	SM
83	Lassen-Kuck-Mary association 0 to 50 percent slopes																
	Lassen	30		VIs	21	Stony clay	Neutral	Stony clay	Moderately alkaline	Shattered volcanic rocks	Well	Slow	High	20 to 40	3 to 6	D	CH

1/ PERCENT IN (—) GIVES EXTENT OF OTHER SOILS IN THE ASSOCIATIONS.

2/ Indicates rating used on General Land Capability or Hydrologic Soil Groups Map.

3/ Wind erosion hazard.

SOIL CHARACTERISTICS, QUALITIES, AND INTERPRETIVE GROUPINGS

NORTHERN BASINS

SOIL MAP SYMBOL	SOIL ASSOCIATIONS AND MAJOR COMPONENTS	PERCENT[1] OF ASSOCIATION	LAND CAPABILITY SUBCLASS		LAND RESOURCE AREA	SOIL PROFILE					DRAINAGE CLASS	SUBSOIL PERMEABILITY	EROSION HAZARD	EFFECTIVE DEPTH (INCHES)	AVAILABLE WATER CAPACITY (INCHES)	HYDROLOGIC SOIL GROUP	UNIFIED SOIL CLASS. (SUBSOIL)
						SURFACE LAYER		SUBSOIL		SUBSTRATUM OR PARENT MATERIAL							
			IRRIGATED	DRY		TEXTURE	REACTION(pH)	TEXTURE	REACTION(pH)								
	Kuck	30		VIs	21	Stony silty clay loam	Neutral	Stony clay	Mildly alkaline	Fractured andesitic rocks	Well	Slow	High	20 to 40	3 to 7	C[2]	CH
	Mary	20 (20)		VIs	21	Very stony loam	Neutral	Clay loam	Mildly alkaline	Andesitic tuff	Well	Moderately slow	High	20 to 48	3 to 8	C	CL
84	Crebbin association, 0 to 2 percent slopes																
	Crebbin	65 (35)	IVw		21	Loam	Strongly alkaline	Sandy loam	Strongly alkaline	Hardpan	Poorly or very poorly	Moderate	Low	20 to 40	3 to 7	C	SM
85	Salisbury-Montague-Louie Association, 0 to 9 percent slopes																
	Salisbury	30	IVe		21	Gravelly loam	Neutral	Clay	Neutral	Hardpan	Well	Slow	Low	20 to 40	3 to 7	C[3]	CH
	Montague	25	IIIe		21	Clay	Neutral	Clay	Moderately alkaline	Hardpan	Well	Slow	Low	20 to 40	3 to 8	D	CH
	Louie	25 (20)	IIIe		21	Sandy loam	Neutral	Clay loam	Mildly alkaline	Hardpan	Well	Moderately slow	Moderate (Moderate)[3]	20 to 40	3 to 8	C	CL
86	Rock land association, 0 to 75 percent slopes																
	Rock land	60 (40)		VIIIs	21,22	Very shallow soil materials and rock outcrops.					--	--	--	--	--	D	--
87	Gerig association, 0 to 15 percent slopes																
	Gerig	60 (40)		VIe	21	Stony loam	Slightly acid	Clay loam	Neutral	Tuff	Well	Moderately slow	Moderate	20 to 40	3 to 7	8	CL
88	Kilarc-Plumas association, 0 to 30 percent slopes																
	Kilarc	50	IVe[2]		5	Sandy clay loam	Slightly acid	Clay	Extremely acid	Sandstone, shale or conglomerate	Moderately well	Slow	Moderate	24 to 48	3 to 6	D[2]	CL or CH
	Plumas	30 (20)	IIe		5	Gravelly loam	Medium acid	Gravelly loam	Slightly acid	Stratified sand and gravel	Well	Moderately rapid	Low	20 to 60	5 to 9	B	ML or CL
89	Timmons Association 0 to 15 percent slopes																
	Timmons	60		IIIe	4	Clay loam	Medium acid	Clay loam	Strongly acid	Sandy loam	Well	Moderate or Moderately slow	Moderate	60+	9 to 11	B	CL
90	Chiquito-Rock land-Corbett association, 30 to 75 percent slopes																
	Chiquito	30		VIIs[2]	5	Loamy very coarse sand	Very strongly acid	Very coarse sandy loam	Strongly acid	Slightly weathered granitic rock	Excessively	Rapid	Very high	12 to 36	1 to 3	D[2]	SM
	Rock land	30		VIIIs	5	Very shallow soil materials and rock outcrops.					--	--	--	--	--	D	--

1/ PERCENT IN (—) GIVES EXTENT OF OTHER SOILS IN THE ASSOCIATIONS.

2/ Indicates rating used on General Land Capability Map or Hydrologic Soil Groups Map.

3/ Wind erosion hazard.

NORTHERN BASINS

SOIL MAP SYMBOL	SOIL ASSOCIATIONS AND MAJOR COMPONENTS	PERCENT[1] OF ASSOCIATION	LAND CAPABILITY SUBCLASS		LAND RESOURCE AREA	SOIL PROFILE					DRAINAGE CLASS	SUBSOIL PERMEABILITY	EROSION HAZARD	EFFECTIVE DEPTH (INCHES)	AVAILABLE WATER CAPACITY (INCHES)	HYDROLOGIC SOIL GROUP	UNIFIED SOIL CLASS. (SUBSOIL)
						SURFACE LAYER		SUBSOIL		SUBSTRATUM OR PARENT MATERIAL							
			IRRIGATED	DRY		TEXTURE	REACTION(pH)	TEXTURE	REACTION(pH)								
90 cont.	Corbett	20		VIIs	5	Loamy coarse sand	Strongly acid	Loamy coarse sand	Medium acid	Weathered granitic rocks	Excessively	Rapid	Very high	24 to 48	2 to 5	B	SM
91	Windy-Rock land association, 15 to 75 percent slopes																
	Windy	40		VIIs[2]	5	Very stony sandy loam	Medium acid	Very stony sandy loam	Strongly acid	Volcanic materials	Somewhat excessively	Moderately rapid	Very high	20 to 40	2 to 4	C[3]	SM or GM
	Rock land	40 (20)		VIIIs	5	Very shallow soil materials and rock outcrops.					--	--	--	--	--	D	--
92	Lava flows association, 0 to 30 percent slopes																
	Lava flows	80 (20)		VIIIs	21, 22	Highly fractured lava rock.					--	--	--	--	--	A	--

[1] PERCENT IN (—) GIVES EXTENT OF OTHER SOILS IN THE ASSOCIATIONS.

[2] Indicates rating used on General Land Capability Map or Hydrologic Soil Groups Map.

[3] Wind erosion hazard.

is given in percentages. The most prevalent feature of the soils within each association determined the classification or grouping used in tables or on maps. For example, soils in the Mendocino-Caspar-Empire association (0-30 percent slopes) were delineated as group B rather than C on the Hydrologic Soil Group Maps because 70 percent of the soil area belongs in that category.

Land capability is a classification[1/] of soils made primarily for agricultural purposes and is not designed to classify timber and range production potentials. Soils and climate are considered together as they influence use, management, and production. The classification has two general divisions: (1) land suited for cultivation and other uses; and (2) land limited in use and generally not suited for cultivation. Both divisions have four classes, each designated by a roman numeral that indicates increasing hazards and limitations in land use. The following are descriptions of the classes:

Land Suited for Cultivation and Other Uses

Class I — Soils in Class I have few or no limitations or hazards. They may be used safely for cultivated crops, pasture, grazing, production of forest products, recreation, or wildlife.

Class II — Soils in Class II have few limitations or hazards. Simple conservation practices are needed when cultivated. They are suited to cultivated crops, pasture, grazing, production of forest products, recreation, or wildlife.

Class III — Soils in Class III have more limitations and hazards than those in Class II and require more difficult or complex conservation practices when cultivated. They are suited to cultivated crops, pasture, grazing, production of forest products, recreation, or wildlife.

Class IV — Soils in Class IV have greater limitations and hazards than Class III, and still more difficult or complex measures are needed when cultivated. They are suited to cultivated crops, pasture, grazing, production of forest products, recreation, or wildlife.

[1/] USDA Soil Conservation Service, Land-Capability Classification, Agriculture Handbook No. 210. (Washington, U.S. Government Printing Office, September 1961). 21 pp.

Land Limited in Use; Generally Not Suited For Cultivation

Class V	Soils in Class V have little or no erosion hazard but have other limitations that prevent normal tillage for cultivation crops. They are suited to pasture, production of forest products, grazing, recreation, or wildlife.
Class VI	Soils in Class VI have severe limitations or hazards that make them generally unsuited for cultivation. They are suited largely to pasture, grazing, production of forest products, recreation, or wildlife.
Class VII	Soils in Class VII have very severe limitations or hazards that make them generally unsuited for cultivation. They are suited to grazing, production of forest products, recreation, or wildlife.
Class VIII	Soils and land forms in Class VIII have limitations and hazards that prevent their use for cultivated crops, pasture, grazing, or the production of forest products. They may be used for recreation, wildlife, or water supply.

Capability classes are further divided into subclasses that reflect the principal kinds of limitations: "e" for erosion, "w" for wetness, "s" for soil, and "c" for climate. The distribution of classes and subclasses is shown in the table "Distribution of Land Capability Classes in the Northern and Southern Basins" and on the General Land Capability Maps on the following pages.

Land Resource Areas (LRA's) are geographic divisions that have particular patterns of soil, climate, water resources, topography, and land use. There are portions of six major land resource areas in the basins: LRA 4 -- the California Coastal Redwood Belt, LRA 5 -- the Siskiyou-Trinity Area, LRA 14 -- the Central California Coastal Valleys, LRA 15 -- the Central California Coast Range, LRA 21 -- the Klamath and Shasta Valleys and Basins, and LRA 22 -- the Sierra Nevada Range. These comprise, respectively, 16, 48, 3, 9, 22, and 2 percent of the study area.

Erosion hazard describes the susceptibility of the soil to erosion by water or wind under specified conditions. Generally the risk of erosion depends upon the slope, texture, and structure of the soil. In this study, erosion hazard is an estimate of water erosion that can be expected if vegetal cover is removed.

Slope is a dominant factor and determines the hazard class, as shown in the following tabulation:

Low hazard	0-9	percent slope
Moderate hazard	9-30	percent slope
High hazard	30-50	percent slope
Very high hazard	over 50	percent slope

Distribution of Land Capability Classes

Land Capability Class and Subclass	Area (Square Miles)			Percent Of Total Area
	Northern Basins	Southern Basins	Total	
I	-	25	25	0.2
II e	90	100	190	1.3
II w	40	145	185	1.3
II s	-	25	25	0.2
III e	255	65	320	2.2
III w	150	80	230	1.6
III s	140	-	140	0.9
IV e	130	315	445	3.0
IV w	100	-	100	0.7
IV s	370	15	385	2.6
VI e	1,780	1,395	3,175	21.6
VI s	1,350	55	1,405	9.6
VII e	2,855	1,420	4,275	29.1
VII w	-	10	10	0.1
VII s	2,630	105	2,735	18.6
VIII w	-	36	36	0.2
VIII s	745	250	995	6.8
Subtotal	10,635	4,041	14,676	100.0
Water	160	68	228	
Total	10,795	4,109	14,904	

Distribution of the classes is shown in the following tabulation:

Erosion Hazard Class	Area (Square Miles) Northern Basins	Southern Basins	Total
Low	1,680	431	2,111
Moderate	560	485	1,045
High	3,070	1,395	4,465
Very High	5,325	1,730	7,055
Subtotal	10,635	4,041	14,676
Water Area	160	68	228
Total	10,795	4,109	14,904

Effective depth is the depth of soil to claypan, bedrock, or other layer that stops or hinders penetration by plant roots. Available waterholding capacity refers to the total amount of water available to plants within the effective depth (maximum of 5 feet) when the soil is at field-moisture capacity. This moisture content is approximately that of a well-drained soil two or three days after wetting.

Hydrologic soil groups are used to estimate runoff potential of soils, assuming wet soil conditions with no vegetal cover. Soils are divided into the following four groups, according to their influence on runoff:

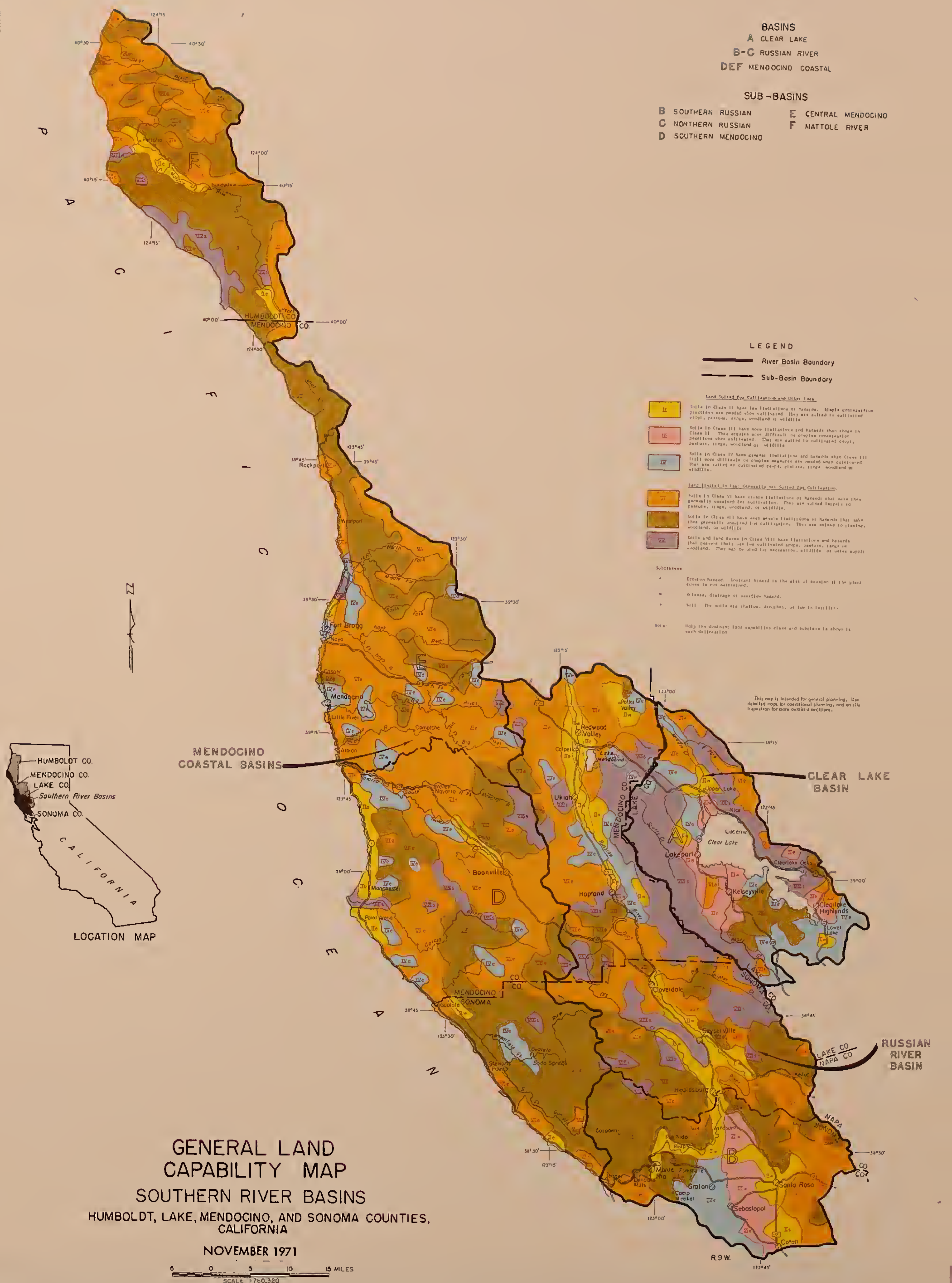
Group A - (Low runoff potential) Consists of deep, well-drained sands or gravels with high infiltration and transmission rates.

Group B - (Moderately low runoff potential) Consists of moderately deep to deep, moderately well- to well-drained soils with moderately fine to coarse texture, moderately slow to rapid permeability, and a moderate rate of water transmission.

Group C - (Moderately high runoff potential) Consists of moderately deep, moderately well-drained soils with moderately fine to fine texture, slowly to very slowly permeable layers at moderate depths (hardpan, bedrock), moderate depth water tables, and slow infiltration and transmission rates.

Group D - (High runoff potential) Consists of shallow, poorly drained soils with a claypan or clay layer that is nearly impervious, high water table, and very slow infiltration and transmission rates.

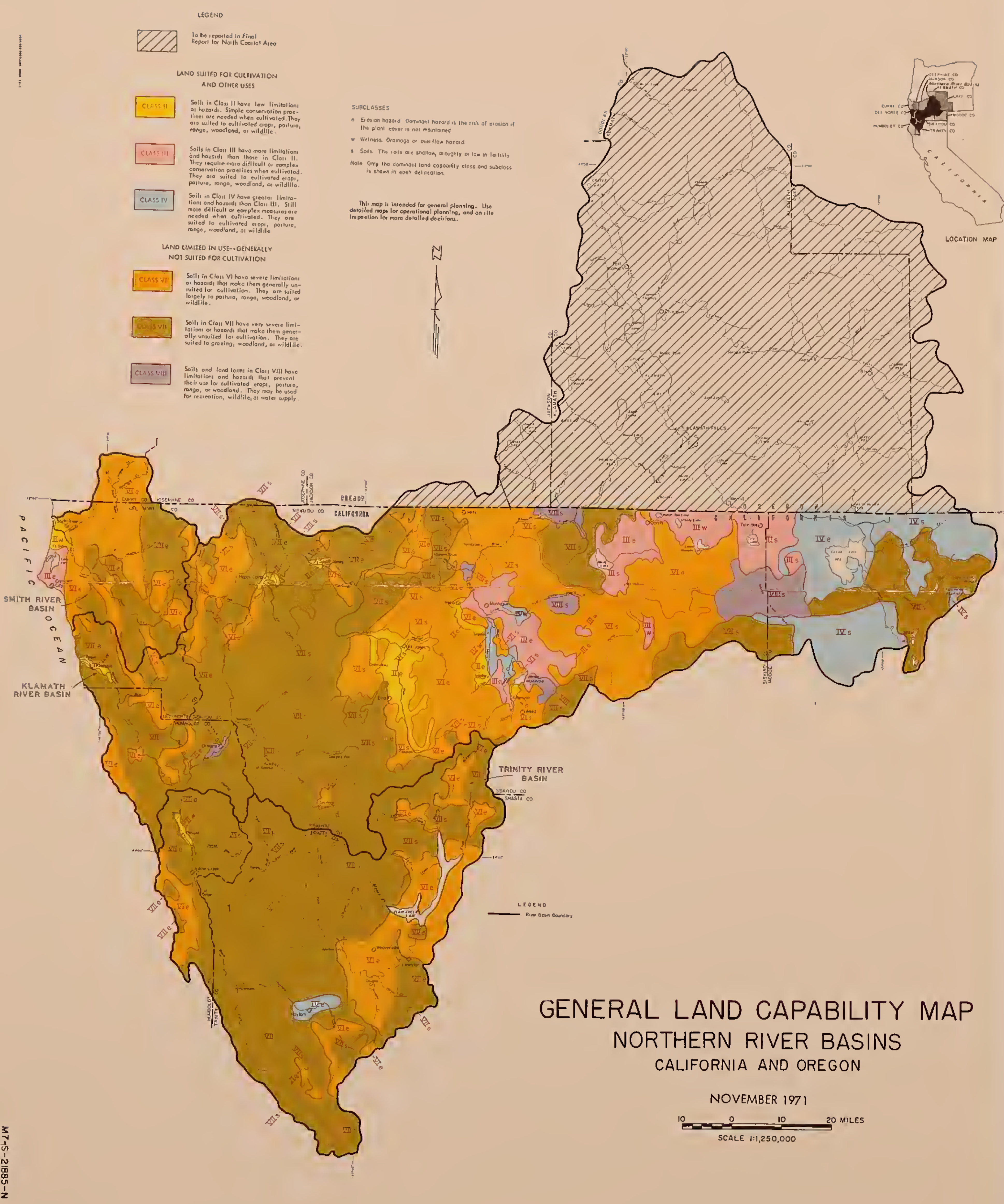
Distribution of Hydrologic Soil Groups is as follows:



GENERAL LAND CAPABILITY MAP
SOUTHERN RIVER BASINS
HUMBOLDT, LAKE, MENDOCINO, AND SONOMA COUNTIES, CALIFORNIA

NOVEMBER 1971

5 0 5 10 15 MILES
SCALE 1:760,320


LEGEND
To be reported in Final Report for North Coastal Area
LAND SUITED FOR CULTIVATION AND OTHER USES
CLASS II
Soils in Class II have few limitations or hazards. Simple conservation practices are needed when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife.
CLASS III
Soils in Class III have more limitations and hazards than those in Class II. They require more difficult or complex conservation practices when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife.
CLASS IV
Soils in Class IV have greater limitations and hazards than Class III. Still more difficult or complex measures are needed when cultivated. They are suited to cultivated crops, pasture, range, woodland, or wildlife
LAND LIMITED IN USE--GENERALLY NOT SUITED FOR CULTIVATION
CLASS VI
Soils in Class VI have severe limitations or hazards that make them generally unsuited for cultivation. They are suited largely to pasture, range, woodland, or wildlife.
CLASS VII
Soils in Class VII have very severe limitations or hazards that make them generally unsuited for cultivation. They are suited to grazing, woodland, or wildlife.
CLASS VIII
Soils and land forms in Class VIII have limitations and hazards that prevent their use for cultivated crops, pasture, range, or woodland. They may be used for recreation, wildlife, or water supply.
SUBCLASSES
e Erosion hazard. Dominant hazard is the risk of erosion if the plant cover is not maintained
w Wetness. Drainage or overflow hazard
s Soils. The soils are shallow, droughty or low in fertility
Note Only the dominant land capability class and subclass is shown in each delineation.
This map is intended for general planning. Use detailed maps for operational planning, and on site inspection for more detailed decisions.
N
LOCATION MAP
CALIFORNIA
OREGON
PACIFIC OCEAN
SMITH RIVER BASIN
KLAMATH RIVER BASIN
TRINITY RIVER BASIN
KLAMATH FALLS
LEGEND
River Basin Boundary
GENERAL LAND CAPABILITY MAP
NORTHERN RIVER BASINS
CALIFORNIA AND OREGON
NOVEMBER 1971
10 0 10 20 MILES
SCALE 1:1,250,000

M7-S-21885-N

Hydrologic Soil Group	Area (Square Miles) Northern Basins	Southern Basins	Total
A	410	61	471
B	6,520	2,880	9,400
C	1,965	470	2,435
D	1,740	630	2,370
Subtotal	10,635	4,041	14,676
Water Surface	160	68	228
Total	10,795	4,109	14,904

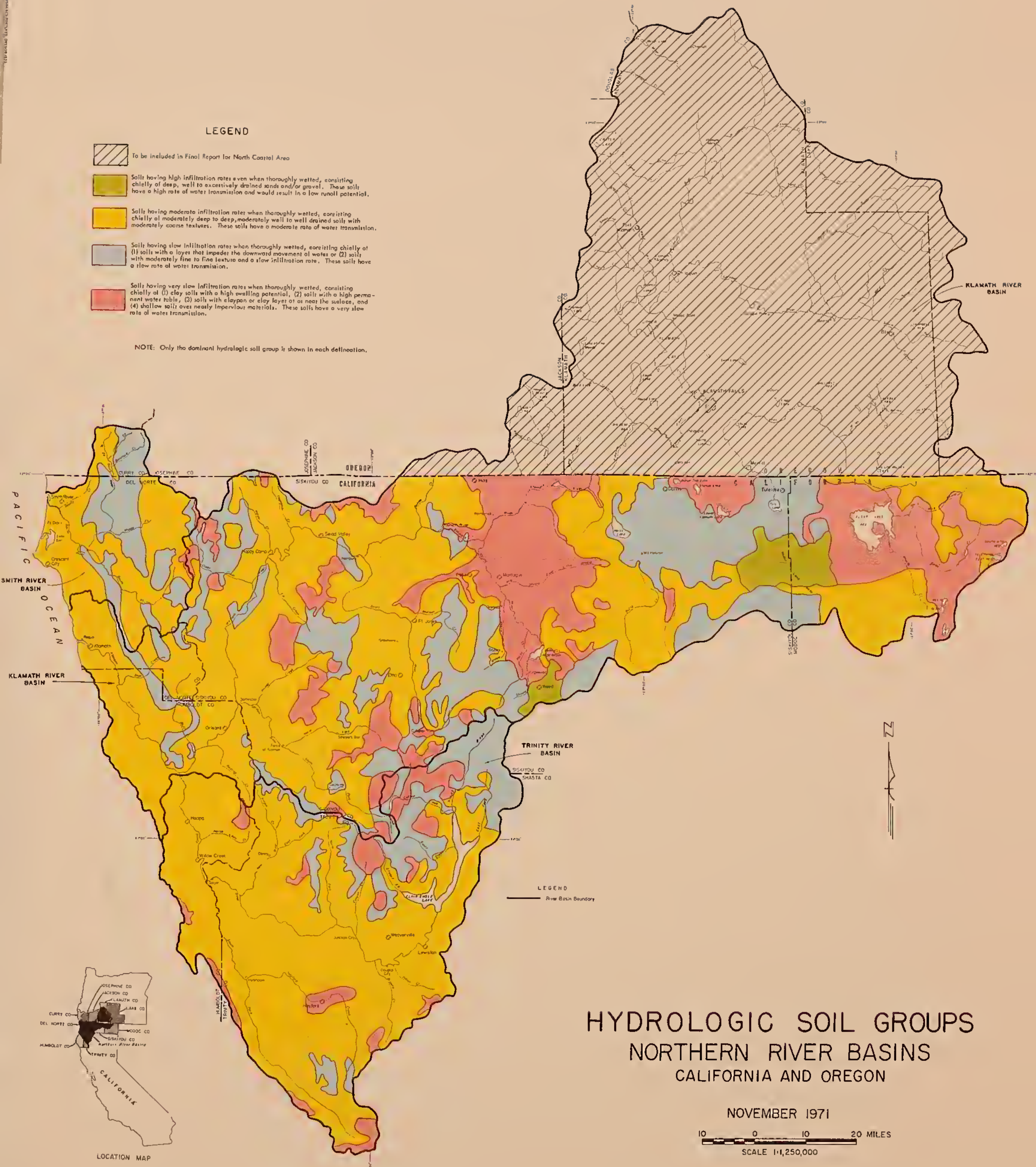
The Hydrologic Soil Groups Maps on the following pages show the location and distribution of these soil groups. Soils and subsoils were grouped into the Unified Soil Classification System, using the procedures shown in the PCA Soil Primer by the Portland Cement Association (Chicago, 1962, 52 pp.).

SOIL EROSION CLASSES

In the Southern Basins, severity of existing sheet and gully erosion was estimated by examining aerial photographs for selected sample areas and by field checking. Areas that had visible sheet and gully erosion were delineated on the photographs and were categorized into moderate or severe erosion classes. The remainder of the areas was assumed to be slightly eroded. Since sheet and gully erosion from watershed slopes was not a major problem in the Northern Basins, this type of study was not made in that area.

The area of each erosion class was estimated by statistical methods, using eroded areas of samples. About 320 square miles are in the moderate erosion class, usually with 5 to 10 linear miles of gullies per square mile; and about 80 square miles are in the severe erosion class, which commonly has 10 to 20 linear miles of gullies per square mile. Approximately 50 percent of the Yorkville soils, 15 percent of the Maymen-Los Gatos Soils, and 30 percent of the Laughlin soils are moderately or severely eroded. Although these soils differ in erosion hazard, variations in the percentages are mainly attributable to differences in use and management, as reflected by vegetal cover density.

HYDROLOGIC SOIL GROUPS
SOUTHERN RIVER BASINS
HUMBOLDT, LAKE, MENDOCINO, AND SONOMA COUNTIES, CALIFORNIA
NOVEMBER 1971
SCALE 1:760,320
5 0 5 10 15 MILES
BASINS
A CLEAR LAKE
B C RUSSIAN RIVER
DEF MENDOCINO COASTAL
SUB-BASINS
B SOUTHERN RUSSIAN
C NORTHERN RUSSIAN
D SOUTHERN MENDOCINO
E CENTRAL MENDOCINO
F MATTOLE RIVER
LEGEND
River Basin Boundary
Sub-Basin Boundary
A Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of deep, well to excessively drained sands and/or gravel. These soils have a high rate of water transmission and would result in a low runoff potential.
B Soils having moderate infiltration rates when thoroughly wetted, consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately coarse textures. These soils have a moderate rate of water transmission.
C Soils having slow infiltration rates when thoroughly wetted, consisting chiefly of (1) soils with a layer that impedes the downward movement of water or (2) soils with moderately fine to fine texture and a slow infiltration rate. These soils have a slow rate of water transmission.
D Soils having very slow infiltration rates when thoroughly wetted, consisting chiefly of (1) clay soils with a high swelling potential, (2) soils with a high permanent water table, (3) soils with claypan or clay layer at or near the surface, and (4) shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission.
NOTE: Only the dominant hydrologic soil group is shown in each delineation.
This map is intended for general planning. Use detailed maps for operational planning, and on site inspection for more detailed decisions.
PACIFIC OCEAN
MENDOCINO COASTAL BASINS
CLEAR LAKE BASIN
RUSSIAN RIVER BASIN
LOCATION MAP
HUMBOLDT CO.
MENDOCINO CO.
LAKE CO.
Southern River Basins
SONOMA CO.
CALIFORNIA
HUMBOLDT CO
MENDOCINO CO
MENDOCINO
SONOMA
LAKE CO
NAPA CO
NAPA
SONOMA
Petrolia
Honeydew
Rockport
Westport
Fort Bragg
Noyo
Caspar
Mendocino
Little River
Albion
Comptche
Redwood Valley
Potter Valley
Ukiah
Calpella
Philo
Boonville
Manchester
Point Arena
Gualala
Hopland
Cloverdale
Geyserville
Healdsburg
Windsor
Santa Rosa
Sebastopol
Cotati
Graton
Forestville
Monte Rio
Rio Nido
Duncans Mills
Camp Meeker
Cazadero
Stewarts Point
Sode Springs
Upper Lake
Nice
Lucerne
Clear Lake
Lakeport
Kelseyville
Clearlake Highlands
Lower Lake
Kellogg



This map is intended for general planning. Each delineation may contain soils having ratings different from those shown on the map. Use detailed soil maps for operational planning, and on site inspection for more detailed decisions.