LAND PLANNING AND CLASSIFICATION REPORT

OF THE

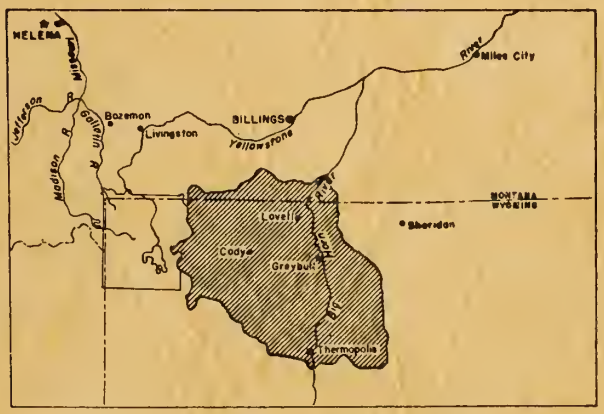
PUBLIC DOMAIN LANDS

IN THE

BIGHORN BASIN

AND PART OF

CLARK FORK OF THE YELLOWSTONE



MONTANA-WYOMING

A MISSOURI RIVER BASIN INVESTIGATION

(FOR ADMINISTRATIVE USE ONLY)

UNITED STATES DEPARTMENT OF THE INTERIOR

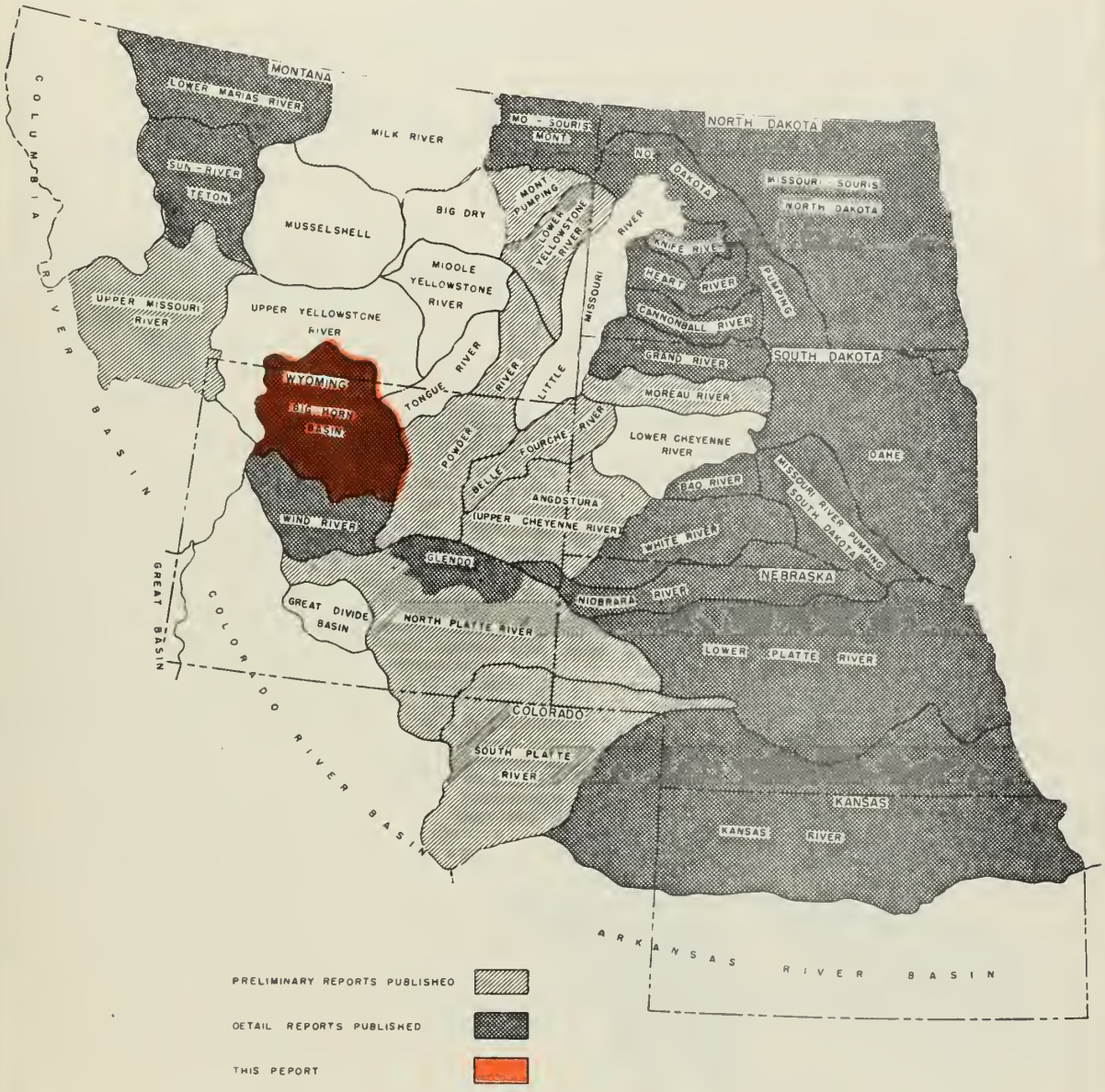
BUREAU OF LAND MANAGEMENT

REGION III

BILLINGS, MONTANA

MARCH 1953

PRESENT STATUS OF BUREAU OF LAND MANAGEMENT STUDIES IN THE MISSOURI RIVER BASIN (LAND CLASSIFICATION)



Land Planning and Classification Report of the Public Domain Lands

in the

BIGHORN BASIN

MONTANA AND WYOMING

A Missouri River Basin Investigation

For Administrative Use Only

Department of the Interior

Bureau of Land Management

Region III

Billings, Montana

March 1953

This report was compiled as a feature of the program of the Department of the Interior for the development of the resources of the Missouri River Basin

TRANSMITTAL AND ACKNOWLEDGMENT

Bighorn Basin presents the greatest challenge to American ingenuity and modern management methods of all the tributary basins within the Missouri River Basin. This challenge is made by the physical and economic conditions of the area. The Bureau of Land Management is particularly concerned because of the large area of land under its jurisdiction; largest in both area and portion of all the tributary basins. This report, along with the preliminary report of the area published by this Bureau in November 1950, presents the physical and economic conditions of the area. Problems, particularly as they concern the public domain of this desert basin, are outlined. Solutions are proposed for these problems in management methods and proposed improvements.

This Bureau has approached the study of the Bighorn Basin with due respect for the magnitude of the area and for the significance of its physical and economic aspects. Land management agencies have long been aware of the vital importance of the area and its problems to the Missouri River Basin and to the nation. The Bighorn Basin is so important to the Bureau of Land Management that it comprises an administrative area. This study, presented in five volumes, includes the largest area of public domain examined within any Missouri River tributary basin to date. Many features of this report have been made possible by the cooperation of the several government agencies concerned in the Bighorn Basin. County and State offices have provided records and data. Livestock operators and corporations within the basin have contributed time and information.

A pioneer member of the staff of this Bureau, Paul H. Crouter, died in the saddle while in charge of this study. Cecil L. Hase, Range Conservationist, has been in charge of the field studies and has prepared this report. C. R. Peteler, Range Conservationist, assisted in writing the report. The four volumes of maps were prepared under the supervision of William C. Anderson, Engineering Draftsman. The entire study was directed by Robert D. Nielson, Regional Chief of the Division of Lands. Valued assistance has been given by John Killough and James Andrews, present and former Managers of Wyoming Area 2, and by the members of their staff.

Albin D. Molohon
Regional Administrator, Region III
Billings, Montana

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INTRODUCTION

Bighorn Basin is an important segment of the Missouri River System as considered in any division of resources or problems. It is possibly the most important tributary basin in some respects. The physical conditions of location, soils and climate impose severe and definite economic and technical restrictions on the use and development of land and resources. It is the purpose of this study to inventory the lands and resources administered by the Bureau of Land Management within the Basin and those of adjacent associated lands. Problems and management of these lands and their resources are considered. This work was accomplished by field examination of the land and its resources within the area.

The results of the resource inventory and study are presented in five volumes. Volume I is a narrative consideration of resources, problems and proposals. The other four volumes are map supplements of land resources printed over a base showing landownership and culture. The maps are printed in four township sections for convenience in use. Map Supplement "A" is composed of the Vegetative Type Map, which includes recommended stocking rates shown in acres per animal unit month. The maps in Map Supplement "B" are titled Land Use Capability Map and include land resource condition. Map Supplement "C" contains the Erosion Condition Map. The Proposed Improvement Map makes up Map Supplement "D".

The preliminary report of the Bighorn Basin was published by this Bureau in November 1950, and it should be used in conjunction with this study. Included therein is a colored map of the entire study area showing landownership, land management areas, and culture, giving an over-all detailed picture of county, city, and road locations, as well as natural features. The preliminary report also presents a detailed description of physical and economic conditions and land management problems. Associated reports of this Bureau for the Upper Basin of the Bighorn River drainage are the preliminary Boysen Area, Wyoming, June 1947, and Wind River Basin, June 1949.

Bighorn Basin extends from Wind River Canyon to Bridger Pass in south central Montana. In order to include all public domain lands utilized in conjunction with the Bighorn Basin, a portion of the Upper Clarks Fork drainage in Montana and Wyoming has been included in this study. The gross area covers 13, 510 square

miles, or 8,646,555 acres. Included in the total area are 476,060 acres of Indian Reservation and 2,026,804 acres of National Forest lands located in the surrounding mountain areas as shown on the maps with the reports. The remaining area of the basin covers 6,143,691 acres of public domain, private, and state-owned lands. This lower portion is the area which has been examined and classified as described and mapped in the five volumes of this report.

The problems and problem areas outlined in the preliminary report have been considered in this study. The number one problem of watershed breakdown and consequent downstream sedimentation, especially as it would affect the proposed reservoir to be created in Bighorn Canyon, has been examined. This problem has been studied by division of the study area into nine subareas: Kirby Creek, Nowood-No Water, Shell-Kane, Bridger, Shoshone-Elk Basin, Oregon Basin-Dry Creek, Upper Greybull, Fifteen Mile, and Owl-Gooseberry.

Present land use has been determined and proposals have been made for adjustments and changes in use. Multiple and conflicting use problems of the public domain lands have been considered. Land tenure problems were investigated and solutions are proposed. Problems of the livestock industry and other land users are also presented in this work.

Proper range use by season and degree of utilization is the vital interest and responsibility of each and every operator, landowner, and management and development agency in the Bighorn Basin. The desert climate and soil conditions emphasize this responsibility for they make it difficult, if not impossible, to restore vegetal cover once it is seriously damaged or destroyed. These same conditions aggravate sediment production which involves an irretrievable resource and is an economic loss to the area Sediment becomes a physical and economic downstream liability. Minimization of runoff by maximized water absorption and storage on the area by means of vegetation development and structures are goals worthy of the efforts of all concerned.

GENERAL DESCRIPTION

Bighorn Basin is a resource-rich segment of the Missouri River System, replete with extensive irrigated areas of fertile cropland, desert grazing lands, cattle and sheep ranches, towering mountains, forests, oil and gas wells and refineries, eight thriving cities, a bustling tourist traffic, and deposits of bentonite, sulphur, gypsum, phosphate, and other minerals. The study area includes the drainage of the Bighorn River from Boysen Dam, at the head of Wind River Canyon in Wyoming, to the Yellowtail dam site, at the mouth of Bighorn Canyon in Montana. The upper portion of the drainage of the Clarks Fork of the Yellowstone located west of the Basin has been included in the area because it comprises a physical and economic land group. The area is 130 miles long by 153 miles in width, and covers 13,510 square miles.

The Custer National Forest is on the mountains in the northwestern and northeastern portion of the area in Montana. The Big Horn National Forest is on the eastern portion of the area and the Shoshone National Forest is on the west in Wyoming. Wind River Indian Reservation is in the southwestern part of the Basin and the Crow Reservation is in the Pryor Mountains on the northeast in Montana. The National Forests and Indian reservations are located on mountainous lands and were not examined. They cover an area of 2,502,864 acres. Gross size of the Basin area is 8,646,555 acres, with a net area of 6,143,691 acres, which has been examined as set forth in this report. This net area is private, state, and public domain land located outside the National Forests and Indian lands.

Political subdivisions included within the area are Big Horn, Hot Springs, Park, and Washakie Counties in Wyoming, and parts of Carbon, Big Horn, and Park Counties in Montana. Important cities are Basin, Cody, Greybull, Lovell, Powell, Thermopolis, and Worland, Wyoming, and Bridger, Montana. The Bureau of Reclamation units in the area include the pioneer Shoshone project with Buffalo Bill Dam and power plant, and the Shoshone extension unit.

The Bureau of Reclamation is conducting an active investigational program in the Basin to determine the most suitable sites for development so that the limited water supply may be most economically utilized. The total acreage under investigation approximates 300,000, of which 88,500 acres will probably be considered as possible new irrigated land, and 33,200 acres will probably be

proposed for supplementary supplies where water at present is insufficient for full use of the land.

Proposed projects under investigation include dams and reservoir sites to store irrigation water, produce power, and to control floods, and distribution systems and pump projects to supply bench and bottom lands. Seventeen units are being investigated by the Bureau of Reclamation for proposed development. These 17 units include 9 pump units with 16 pumping plants, 2 gravity units, 2 gravity units with 4 pumping plants serving parts of the two units and four reservoir-power plants. Twelve dams are proposed, seven for storage reservoirs and five diversion dams. One storage reservoir is proposed in the Oregon Basin, a natural depression, for which no dam is needed. Anchor Dam on Owl Creek is scheduled for construction. All of the proposed irrigation development is within the Bighorn Basin. The four reservoir-power units are located in the mountains on the Clarks Fork drainage.

Recently completed irrigation developments are the Heart Mountain division of the Shoshone project which was opened for settlement from 1946 to 1950. The Heart Mountain power plant went into production in December 1948. Boysen Dam power plant was completed in 1952.

Bighorn Basin is an elliptical lowland desert surrounded by high ranges of the Rocky Mountains located in north central Wyoming and south central Montana. The Beartooth and Absaroka ranges on the west are high and massive, extending above 13,000 feet and far west of the Continental Divide. On the south, the comparatively low and narrow Owl Creek and Bridger Mountains divide the Bighorn and Wind River Basins. The Bighorn and Pryor Mountains on the east and north are less massive than the western ranges, but are even higher, culminating in Cloud Peak with an elevation of 13,165 feet. The mountains are largely granite, with considerable limestone. Fronts of the mountains and foothills are frequently composed of red sandstones and shales of the Chugwater formation. Most of the mountains rise gradually from the Basin to the divides, but northeast of Worland the Bighorn Mountains rise sheer and bold for 6,000 feet. On the western edge of the "top" the visitor is presented a vivid panorama of the entire Basin, a view unusual in scope and beauty.

The floor of the Basin is rolling to steep, being largely the dissected remnants of terraces and benches of varying levels

combined with eroded clay and shale badlands and plains of the underlying Willwood formation. Lands sufficiently level for irrigation are confined to remnant portions of the benches and terraces and to the present stream valleys, as shown on the Land Use Capability Map in Map Supplement "B" of this report. Vegetal cover and the recommended stocking rate for the study area is presented on the Vegetative Type Map in Map Supplement "A". Degree of erosion is shown on the Erosion Map in Map Supplement "C", and proposed improvements are mapped in Map Supplement "D".

The Bighorn River enters the Basin through Wind River Canyon, 2,500 feet deep, flows along the eastern side of the Basin near the base of the Bighorn Mountains and leaves through spectacular, rugged, rocky Bighorn Canyon. Deep canyons have been cut through the mountain slopes and foothills by Shell Creek and Nowood River, the principal tributaries on the east side. These two tributaries have their headwaters high in the Bighorn Mountains. No Water and Kirby Creeks are less important, with their main headwaters on the Bridger Mountains. One of the principal drainages on the west is the Clarks Fork, which drains into the Yellowstone River. Western tributaries of the Bighorn River are the Shoshone and Greybull Rivers, and Gooseberry, Cottonwood, and Owl Creeks. These tributaries leave the Absaroka Mountains through deep canyons only slightly less spectacular than the Bighorn and Wind River Canyons.

Much of the Basin is underlaid with coal, gas, and oil. The world's largest hot springs are located at Thermopolis, and extinct geysers provide deposits of sulphur and calcite. Bentonite and gypsum are found in large deposits. "Thar's gold in them thar hills" too, but the developed mines have ceased operations. Irrigated lands dot the benches and line the river valleys. Livestock graze the grass and browse of the basin, foothills, and mountains. Prosperous cities thrive in the irrigated areas, with oil and gas development and processing contributing mightily to their progress.

Bighorn Basin offers beauty in its towering mountain borders, and wealth from oil, irrigated land, and year round grazing resources. Forests, snow fields, glaciers and crags ascending over 13,000 feet east and west of the Basin provide scenic grandeur, yield perennial water flow for thirsty basin lands, and furnish an abundance of fish and game. Oil and gas fields dot the Basin, providing material for local refineries and supplying pipelines to Billings, Montana, Casper, Wyoming, and to Wood

River, Illinois. Gas purifying plants extract essential sulphur, gasoline, and other products, and repressurize the oil fields with the expanded purified gas. Sheep and cattle graze on the basin lowlands in the winter, use the foothills in the spring and fall, and summer in the mountains.

Prehistoric people placed the Medicine Wheel high up on the Bighorns. Indians used the Basin as a hunting ground and valued Mammoth Hot Springs for their curative powers. Explorers passed this way. It is possible that the Verendrye expedition of 1742 discovered the Basin, but probably the first white man to see the Basin was John Coulter in 1806. He was followed by the Wilson, Price, and Hunt expedition of 1811. Captain Bonneville traversed the Basin in 1832.

Intrepid pioneers settled the land, diverted the streams, dug ditches, and began to raise hay for their stock. Virtually all farmlands in the Basin are irrigated because the limited rainfall precludes non-irrigated farming. Some grain is grown without irrigation on land near the top of the mountain in the vicinity of Bigtrails. Here rainfall becomes sufficient to produce non-irrigated grain. Hay, principally alfalfa, is the leading crop, occupying over forty percent of the irrigated lands. Grain and beans each utilize over twenty percent of the farmland. Beans are a specialty of the Basin with all types being produced: dry field beans, garden seed beans, and string beans for canning. Irrigated pastures are increasing in importance, now employing nearly ten percent of the farmlands. Sugar beets, a crop with large cash and feed values per acre, are found on about five percent of the cultivated area. Seed peas are grown in the northern portion of the Basin.

Tourists pass through the Basin in a steady stream every summer enroute to Yellowstone and Grand Teton National Parks on three transcontinental highway routes. Many pause to enjoy the Bighorn or the Absaroka Mountains or to view the Mammoth Hot Spring. The Basin is rich in history and romance. Cody is named for Colonel Buffalo Bill of wild west fame. Founder of the city, he was vitally interested in the development of the Bighorn Basin. He developed one of the first large scale irrigation projects in the Basin. The first National Forest in the land was the Shoshone on the west side of the Basin, established in 1891. Here too, is the first U. S. Ranger Station.

Climate

Climatic conditions present many problems in the Basin. The growing season is relatively short and precipitation is light, erratic, and undependable. Droughts have caused disastrous losses to the agricultural economy of the area. Floods have caused great damage by destroying homes, businesses, farmland, and other property. Blizzards have exacted their toll of animal and human lives. The basin floor has an arid climate with a desert type of vegetation. Production of cultivated crops is possible only with adequate irrigation. Approximately 70 percent of the annual precipitation falls from April to September, an excellent distribution for the production of cultivated crops if the amount were adequate.

Precipitation averages five inches at Basin, Powell, and Hyattville, the range being from three to twelve inches annually. The amount of rainfall and volume of forage produced increases with elevation. The stations at Buffalo Bill Dam and Thermopolis record approximately 12 inches per year. In the high mountain areas the precipitation averages approximately 30 inches annually. These are areas of heavy snowfall and supply the majority of the water for the irrigated agriculture of the Basin. Much of the precipitation in the lower elevations is in the form of torrential storms which result in flash floods and remove considerable soil from the area. Little penetration results from these storms.

Short but hot summers and comparatively long, cold winters are characteristic. Frost free periods average from 121 days at Hyattville and Thermopolis to 140 days at Worland. Extremes in temperature range from a high of 114 degrees to a low of 51 degrees below zero. Very hot or cold weather is infrequent and does not last long. The basin floor is seldom snowed in to such a depth to hinder livestock in their use of the area, and is valued for winter grazing by sheep and cattle. 1/

1/ A more complete description of climate with tables and precipitation map is presented in the preliminary report, Big Horn Basin, Bureau of Land Management, November 1950, pp. 2 to 9.

Geology and Soils

Exposed geological formations in the Basin range from pre-Cambrian to recent deposits. The Basin was formed by two large anticlinal folds, the Bighorn Mountains on the east and the Beartooth and Absaroka Mountains on the west. A low anticlinal fold from Heart Mountain to Pryor Mountains separates the Clarks Fork area from the main part of the Bighorn Basin. These folds expose the underlying layers of formations irregularly. This irregular exposure of formations, varying widely in composition and hardness, causes differences in erosion and results in widely varying soils and topography, often in limited areas. The folds and erosion have also permitted access to lower formations containing valued minerals.

Massive pre-Cambrian granites underlie the entire area and form the core of the mountain ranges surrounding the area. The tertiary uplift of the mountains caused an anticlinal uplift of Palezoic and Mesozoic formations which are several thousand feet thick. Deep erosion exposes the granites where the younger sedimentary rocks have been removed. The sedimentary rocks consist mainly of sandstone, limestone, shale, and alluvial gravels. Sheets of volcanic material have been deposited in the Beartooth and Absaroka ranges. Erosion in the soft shales, clays and siltstones of the Willwood formation has produced the badlands and adjoining clay soil areas of rough terrain which cover a considerable portion of the basin and lower foothills. The various formations in the basin and their thicknesses are given in table 1.

Rangeland within the area has been classified in the inventory study of the Bureau of Land Management. Land considered to be tillable if irrigation water becomes available was designated as class V, and cultivated land was delineated. No further attempt was made to classify potential irrigable lands. Such a classification is the responsibility of the Bureau of Reclamation and of other agencies. Rangeland was classified in land use capabilities V to VII, class VIII being wasteland unsuitable for livestock use. Soil, cover, and other site qualities are considered in this classification as explained in table 9. The condition of the site and its cover has also been considered in the inventory, being rated as good, fair, or poor, as explained in table 10. The results of this inventory of capability and condition classification are presented on the Land Use Capability Map in Map Supplement "B".

Table 1. - Geologic formations in Bighorn Basin, Wyoming 1/

System	Formation	Rocks	Thickness (feet)
	Alluvium	Sand, loam, and gravel	20-40
Quarternary	Hot Spring deposits	Light colored calcareous rock	20
	Later terrace gravels	Gravel and sand	20-30
	Early terrace gravels	Sand, gravel, and sandy clay	20-60
	Volcanic rocks	Volcanic breccia, basalt flows	--
Tertiary	Wasatch	Sand, clay, and conglomerate	2,000-3,000
	Laramie (Meeteetse	Sandstone and shale, some coal	5,000-7,000
	Pierre (Mesaverde	Sandy shale	1,000-2,000
	(Cody		
	(Niobrara		
	Colorado Group (Frontier	Shale with sandstone and clay	1,400-2,000
	(Mowry		
	(Thermopolis		
Cretaceous	Cloverly	Sandstone with red shales	200-300
	Morrison	Sandstone with shale	130-400
Jurassic	Sundance	Shale and sandstone with limestone	200-350
Triassic (?)	Chugwater	Red sandstone and shale with gypsum and limestone	600-800
	Embar	Gray limestone	80-200
Carboniferous	Tensleep	Gray sandstone	30-250
	Amsden	Red sandy shales and sandstone	100-200
	Madison	Gray massive limestone	700-1,000
Ordovician	Big Horn limestone	Siliceous gray limestone	200-300
Cambrian	Deadwood	Sandstone, shale, limestone conglomerate	700-1,500
Pre-Cambrian		Granite	--

1/ Bureau of Mines, Mineral Resources except Fuels, Bighorn River Basin, Preliminary Report, No. 58, p. 14; October 1951. The Geological Survey also refers to the Tatman and Willwood formations of the Eocene group in the Tertiary system.

Most of the Bighorn Basin, about 60 percent, consists of upland soils. These are nearly all shallow residual soils derived principally from shales. The parent material in some cases is sandstone or clay. The topography is gently to steeply rolling, there being relatively little level land. The soils are usually so shallow and the subsoil of parent material so impervious that they are unsuited to cultivation even if they are sufficiently level. The upland soils and sites are largely class VII land, varying toward VIII, with some VI. Some soil series represented are the Chipeta, Shoshone, Greybull, and Pierre. The Chipeta series generally is not shallow and may have possibilities of irrigation development. The Pierre alkali-saline clays and clay loams with a saltbush type of cover make up most of the upland soil site. Plant cover of upland soils is generally sparse, affording little protection against erosion on the typical slopes. Grass and sagebrush types are found on the loam and coarser soil types.

Mountain soils are found on 20 percent of the area at the higher elevations. They are residual soils derived principally from the igneous granites, gneiss and schists, and some from limestone and sandstone. Mountain soils are brown and black loams and sandy loams and are usually highly productive, supporting both grass and timber. They are shallow soils and are frequently stony. They support a good plant cover which protects them from erosion even on steep slopes. Most of these soils are in class VII because of slope of the site and shallow soils. There are some class VI sites.

Badlands make up over 10 percent of the area. They are raw clays and shales without any cover on steep slopes. They are totally unprotected from erosive action and present a serious erosion problem. They are the product of geologic erosion and are fully subject to continuance of that action. Badlands are all in class VIII land use capability.

Level stream terraces, bench and bottom lands, make up less than 10 percent of the area. Over 95 percent of the cultivated land in the Basin is on these sites, as shown on the maps in Map Supplements "A", "B", "C" and "D" of this report. Terrace, bench and bottom land soils are generally good alluvial soils, loams predominating in these sites. Wide variations occur in recent alluvial soils on the bottom lands and to a lesser extent on benches and terraces. Gravelly and sandy soils are found on these sites, and there are areas of heavy clay, some

of which are alkali-saline. Some of the farmlands near Lovell, now highly regarded, were once grease-wood flats. They were developed to their present stage of production by treatment, rotation, and working.

Some benchlands are gravelly and dry and unsuitable for farming. Drainage on these sites is generally good, with the exception of some low lands where the local water table interferes with drainage. Some benchlands drain so well that they are unsuitable for irrigation either because of their inability to retain sufficient moisture or because they would cause seepage into other lands. Subsoils vary, ranging from gravel and sand to stiff clay. Free lime is present at or near the surface in the higher bench and terrace soils. Native vegetation on these sites is sparse except where the soil is sub-irrigated. These soils are subject to both wind and water erosion because of this sparse cover and due to their considerable content of readily transportable fine material. Typical soil series in such sites are the Ralston, Gilcrest, Billings, and Meeteetse. Most of these soils are in land use capability classes I to V. Rangelands on terraces, bench, and bottom lands have been classified as V and VI lands.

Transportation and Roads

Rail transportation is furnished by the Chicago, Burlington and Quincy Railroad which follows the Bighorn River through Wind River Canyon and down the basin to Lovell, then turns slightly northwest to Bridger, Montana. A branch line from Deaver, Wyoming runs to Powell and Cody. A Northern Pacific branch line from Laurel ends at Bridger where the 20-mile long line of the Montana, Wyoming and Southern Railroad begins, serving the coal mines at Belfry and Bearcreek, Montana. In addition to the rail lines, four interstate common carriers and several interstate livestock carriers operate routes through the basin. Approximately 55 percent of the livestock are shipped by truck, including those going to different ranges and to market.

Good hard surfaced roads furnish through routes throughout the basin, while secondary roads make all but the most rugged portions of the basin accessible by automobile. United States Highway No. 20 enters the area from the south through the Wind River Canyon and goes north through Thermopolis and

Worland to Greybull, where it turns west to Cody and Yellowstone National Park. United States Highway No. 310 starts at Greybull and runs north through Lovell and Bridger to Laurel, Montana. United States Highway No. 16 enters the basin through Tensleep Canyon and connects with Highway No. 20 at Worland. Highway No. 14 enters the basin through Shell Creek Canyon, connects with No. 20 at Greybull, and follows it through Cody and into the Park. Wyoming State Highway No. 120 connects Thermopolis and Cody via Meeteetse. State Highway No. 14 serves Cody, Powell, Byron, and Lovell, and connects with United States Highway No. 14 high on the Bighorn Mountains.

Pipelines laid during the years of 1906 to 1915 connected the various oil fields in the basin with small refineries and natural gas lines reaching most of the towns in the basin. By 1944, known reserves were sufficient to justify the extension of pipelines to points outside of the basin. The first outside line connected the basin with refineries in Laurel and Billings, Montana. The second reached Casper, Wyoming. A third line completed in 1952 conveys oil to St. Louis, Missouri. The Casper line now delivers oil to Salt Lake City, Utah, Denver, Colorado, and Wood River, Illinois. A natural gas pipeline was laid in 1922 to carry gas to Bridger, Laurel, and Billings, Montana. A new gas line conveys Bighorn Basin gas eastward to Baker, Montana, where it connects with lines terminating at Malta, Montana, Bismarck and Williston, North Dakota, and Rapid City, South Dakota. Another line conveys gas to Columbus, Livingston, Bozeman, and Butte. A third line carries gas to the steam electric plant of the Montana Power Company in Billings, Montana.

LAND USE AND OWNERSHIP

Ninety-two and eight-tenths percent of the study area is principally used in the production of range livestock. The majority of this area is also important as wildlife habitat, there being very little of it which is not inhabited by some type of game. Fishing is an important sport in the mountain area and some choice locations are used as camp ground and picnic areas. The area is also important in the production of oil, coal, and other minerals. The majority of these uses do not conflict with the livestock industry. Approximately four-tenths of one percent of the area is taken up by townsites, reservoir sites, airports, and other miscellaneous uses. The remaining six and eight-tenths percent is used in the production of cultivated crops. Nearly all of this is under irrigation since the production of dry-land crops is not feasible in most of the basin. Land use is shown graphically in figure 1. Status of landownership within the study area by states is shown in the following tabulation and is displayed graphically in figure 2.

Status	Wyoming	Montana	Total	Percent
Vacant Public Domain	2,945,069	224,617	3,169,686	51.6
Stock Driveway W/D	116,015	122	116,137	1.9
Public Water Reserve	3,403	1,554	4,957	.1
Power Site	26,609	--	26,609	.4
Reclamation W/D admin. by BLM	56,289	--	56,289	.9
Other admin. by BLM	479	3,526	4,005	.1
Total admin. by BLM	3,147,864	229,819	3,377,683	55.0
Reclamation W/D	260,718	597	261,315	4.3
Reclamation W/D Cropland	19,177	110	19,287	.3
Other Federal	463	80	543	.1-
State	401,425	24,810	426,235	6.9
State Cropland	6,271	666	6,937	.1
Private Rangeland	1,418,638	220,665	1,639,303	26.6
Private Cropland	346,861	41,593	388,454	6.4
Other: Cities, Water Surface	22,653	1,281	23,934	.4
Total	5,624,070	519,621	6,143,691	100.0

This status was up-to-date as of January 1, 1952. Landownership status is subject to constant change. This tabulation agrees with the status shown on the maps in Map Supplements "A" to "D".

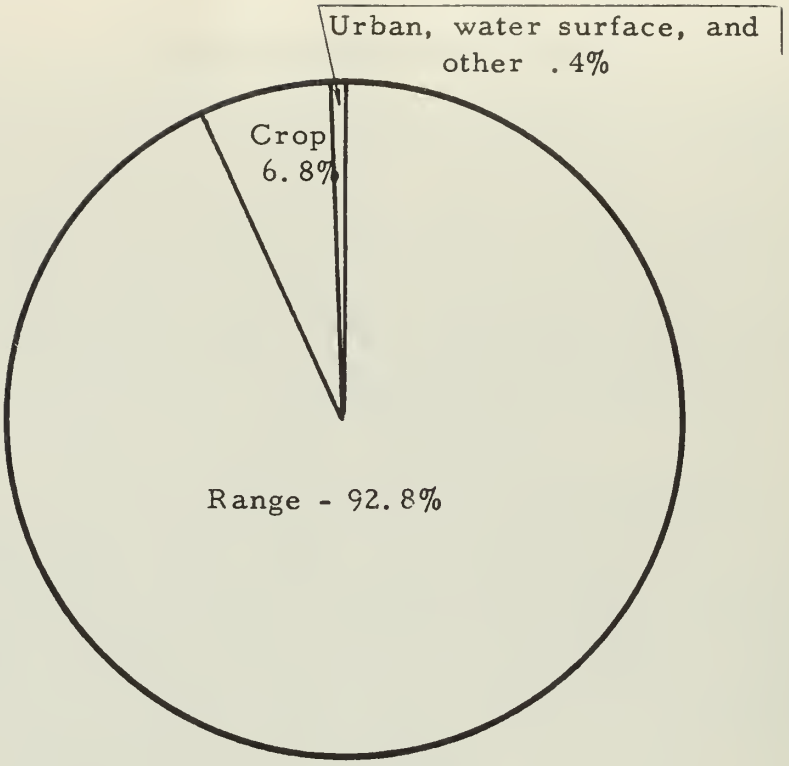


Figure 1. -Land Use, Bighorn Basin, Wyoming and Montana, 1950.

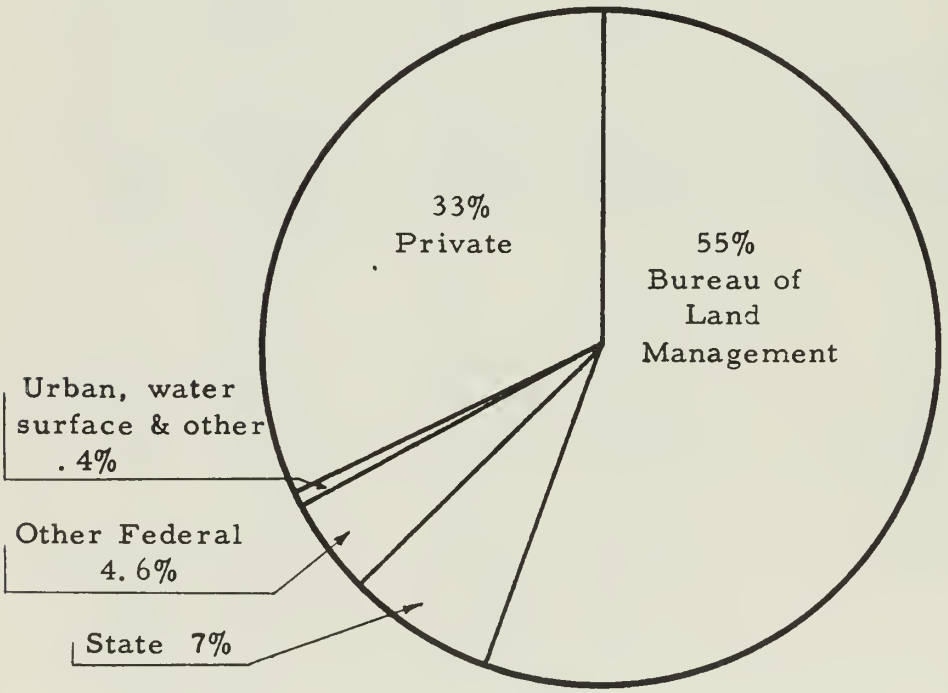


Figure 2. -Landownership within the Bighorn Basin in Montana and Wyoming, exclusive of National Forests and Indian Reservations.

AREA ECONOMY

In the space of 150 years, the economy of the Bighorn Basin has evolved from fur trading to a multi-million dollar agricultural and industrial economy based on the natural resources of the area. Little progress was made in settling the basin by the fur traders and gold seekers. In the early 1880's, people realized that the area was ideal for the raising of livestock and the first cattle ranches were established, although routes to market points were a handicap. In 1876, sheep were introduced into the basin.

The first important attempt at irrigation was near Worland in 1885, the Bighorn River being the source of water. From then until the present, the development of irrigated land has continued with several thousand acres scheduled for future development by the Bureau of Reclamation. Development of this cropland has had a stabilizing effect on the livestock industry of the area.

The presence of oil in the basin was first discovered about 1885 when settlers collected oil from seeps in the Bonanza area to burn in their lamps. The first well was drilled on this structure in 1888. Since that time, the basin has produced nearly 260 million barrels of crude oil and nearly 240 billion cubic feet of gas. 1/

The economic potential of the area is as follows:

1. Over 5,700,000 acres of rangeland capable of producing forage for approximately 120,000 animal units of livestock. This is the basis for an annual livestock production in excess of 14 million dollars.

2. Approximately 395,000 acres of irrigated cropland producing hay, grain, beans, sugar beets, and other crops valued at about eight million dollars in 1950.

3. Approximately $2,000,000 production of dairy and poultry products each year.

1/ For additional information on the economy of the area see the Preliminary Report, Big Horn Basin, Bureau of Land Management, November 1950, and Big Horn Basin, A Preliminary Business and Industrial Statement, Division of Economic Analysis, College of Commerce and Industry, University of Wyoming, Laramie, November 1951.

4. Fifty-eight oil fields with an estimated reserve of 455 million barrels of petroleum. Annual production has increased from 2,800,000 barrels in 1930 to 27,500,000 barrels in 1950. The 1950 production was valued at $55,000,000.

5. Twenty natural gas producing fields, some of which have been included in the oil fields classification. The estimated reserves of natural gas in the basin total 700 billion cubic feet, which at present rates of consumption are sufficient for thirty-three years. Annual production increased from 4.5 billion cubic feet in 1930 to 20.8 billion cubic feet in 1950. A valuation of ten cents per 1,000 cubic feet probably does not make full allowance for the value of sulphur and natural gasoline in the gas. This price would value the 1950 output at $2,080,000.

6. Coal reserves totaling approximately 600 million tons. Annual production of 408,200 tons in 1930 had dwindled to only 34,400 tons in 1950.

7. Important deposits of bentonite, clay, sulphur, limestone, gypsum, and other minerals.

8. Present hydroelectric production of 111.8 million kilowatt-hours annually from Buffalo Bill, Heart Mountain, and Boysen Dam power plants, with an installed capacity of 25,600 kilowatts. In addition, five plants are scheduled for construction to produce 1,511 million kilowatt-hours annually from an installed capacity of 322,000 kilowatts. Twenty sites have been proposed for investigation with a potential production of 472.9 million kilowatt-hours annually from a possible installed capacity of 109,000 kilowatts.

9. Timber reserves of approximately 3,754 million board feet, with an allowable yearly cut on a sustained yield basis of 20 million board feet.

10. Valuable mountain, stream, and lake recreational areas with fishing waters, big game, and cabin sites. The Mammoth Hot Springs at Thermopolis attract many tourists each year and tourism to Yellowstone National Park through the basin is an important economic feature.

11. Five oil refineries, with a total daily capacity of 17,100 barrels, and two plants producing sulphur by gas purification. Another sulphur-gas plant is being built and a fourth is planned.

Present daily production of the two plants is about 350 long tons. The annual sulphur production of 136,875 long tons was valued at $3,011,250 in 1950. Higher prices and increased production will greatly increase this annual value.

12. Other major industrial establishments include two sugar beet refineries, one at Lovell and one at Worland, a clay products plant at Lovell, and a vegetable cannery at Cowley.

13. Economic establishments within the area:

(a) Over 2,500 farms. More than 2,100 are provided with electricity and over 1,000 are equipped with telephones.

(b) Fifty-five manufacturing establishments.

(c) Fifty extractive industry firms.

(d) Sixty-two wholesale distributors of commodities.

(e) Six hundred retail stores of all types.

(f) Seven hundred service type establishments, including 25 grain and bean elevators.

14. Fiscal data:

(a) Bank and savings and loan deposits in excess of forty million dollars.

(b) "E" bond sales in excess of one and one half million dollars annually.

(c) Wages in excess of 25 million dollars annually.

(d) Retail sales in excess of 55 million dollars annually.

15. Population in excess of 43,000 of whom 63 percent live in cities or towns.

16. Certificates of necessity for critical construction in effect January 1, 1953:

Park County:	
Rayonier, Inc. Mining and Quarrying	$1,314,000
Seaboard Oil Co., Sulphur, natural gasoline and gas purification plant	1,120,000
Husky Oil Co., Petroleum refinery, Cody	1,807,000
Big Horn County:	
General Petroleum Corp., Sulphur, natural gasoline and gas purification plant at Manderson	4,220,000

Surface Resources

Range livestock production is practiced on 92.8 percent of the area. Supporting this industry is a wide variety of native vegetation on ranges varying from 3,600 to over 6,000 feet in altitude. Wide expanses of rangelands are useable only in the winter when snow supplies adequate livestock water. Nearly 83 percent of the basin area outside of National Forests and Indian reservations is below 6,000 feet in elevation. If the forests and reservations were included, 58 percent of the area would be in this category. Because of its vastness, winter feed, climate, irrigable areas, culture, and mineral resources this area is the most important in the basin.

Gardner saltbush (Atriplex gardneri) makes up the principal range type at 4,000 to 5,000 elevation range. Soils supporting this type are usually heavy, undeveloped clays derived from the Willwood shales. They support a very sparse vegetative cover because of poor soil texture and low permeability combined with low rainfall, and are highly vulnerable to erosion, especially water erosion. The sparse plant cover offers little protection against splash action, sheet erosion, or gully erosion during heavy flash floods. Large quantities of the relatively unstable soil are transported from the area by such storms. In general, the type receives from four to six inches of rainfall per year and much of this evaporates or runs off. Due to the fact that it is seldom snowed in, this type is used extensively as winter sheep range. The type is almost continuous throughout the width of the basin floor from Warren, Montana southward beyond Worland, Wyoming. Photograph 1 shows a typical saltbush type. Islands of sagebrush, grass, and greasewood types may break the type locally where better soil types or moisture conditions occur. Dominant plants in this association are Gardner saltbush (Atriplex gardneri) bluestem wheatgrass (Agropyron smithi) blue grama grass (Bouteloua gracilis) and various forbs. Halogeton (Halogeton glomeratus) a poisonous annual has invaded this type in the vicinity of Cowley and has spread over much of the basin floor.

Photograph 1. - A typical saltbush type in the Bighorn Basin. This one is on Little Dry Creek. Note the erosion, lack of grasses, and the scattered, low saltbush plants which have been overgrazed in the past. About 18,000 acres of the clay soil supporting this type in this vicinity is well adapted to waterspreading development.

Sagebrush of six species, principally big sagebrush (Artemisia tridentata) is quite widespread over the basin. With the exception of birdfoot sagebrush (A. pedatifida), it occupies a better and more developed soil than the saltbush type. Soils supporting sagebrush are usually more porous and much less subject to soil erosion than those with a saltbush cover, since there is generally enough vegetation to give some protection against splash action of falling rain. There is a fair understory of grasses through most of this type, so the soil is held more firmly against water movement. This type ranges in elevation from the basin floor up to 8,000 feet on the mountain slopes. It furnishes winter range at the lower elevations and spring-fall and early summer grazing at the higher elevations.

In general, there are three main areas in which sagebrush dominates the landscape. The first of these is a narrow belt along the eastern edge of the basin floor and extending up the mountain side. It is continuous from a point just below the Montana-Wyoming line south to a line due east of Thermopolis. The second broad expanse of this type is a narrow band following the Bighorn River from Thermopolis north to Greybull, then west up the Greybull River to Sunshine Reservoir. The other sagebrush area follows the Shoshone River as a rather wide band from Buffalo Bill Reservoir to Lovell. From this point it runs northwest to Bridger, Montana. Local areas of sagebrush occur in various places, but the three locations described above are the most important. Three species of sagebrush occur commonly in this area. They are big sagebrush (Artemisia tridentata), the most widely distributed; silver sagebrush (A. cana), occuring on flood plains and the more favorable locations; and black sage (A. nova) occurs on the most unfavorable sites such as dry rocky ridges with a thin top soil. Some bud sage (A. spinescens) is found in the basin. Other plants occurring commonly in the sagebrush type at the lower elevations are blue grama grass, bluestem wheatgrass, threadleaf sedge (Carex filifolia), needleandthread grass (Stipa comata), prairie Junegrass (Koeleria cristata), and other grasses and forbs. At higher elevations, bluebunch wheatgrass (A. spicatum), and Idaho fescue (Festuca idahoensis) replace the bluestem wheatgrass and blue grama grass of the lower elevations.

Grasslands generally occur around the outer edge of the basin in the foothills and mountain areas in the regions of higher precipitation. This type furnishes the best grazing of the entire basin. The largest part of the range in this type passed into private ownership at an early date. There is a considerable portion of National Forest lands in this type, principally as parks. Natural meadow lands, while accounting for less than one-tenth of one percent of the basin area, have the highest carrying capacity of any native vegetative type in the basin. Found mainly in the mountains, they furnish important amounts of summer grazing of good quality. They occur in wet areas along small streams and around seeps and springs. These areas support a wide variety of grasses, sedges, and forbs which are quite palatable to livestock and game. Use of these stringer areas of wet meadows has been so intense during many summers that the most palatable plants have been eliminated, leaving less desirable sedges as the bulk of the present cover.

Mountain brush types are generally found on the rocky slopes of the mountains. They are small in total area and generally support very little understory. They are excellent deer and elk forage but not too important for livestock. The most important mountain browse specie in the basin is mountain mahogany (Cercocarpus ledifolius), a shrub with evergreen leaves furnishing winter forage for game.

Greasewood (Sarcobatus vermiculatus) types are found on the valley floor, on flood plains, and on heavily alkali-saline sites. It usually has a sparse understory of alkali tolerant grasses and weeds. Greasewood, under certain conditions, will cause sheep losses by poisoning. Wise herding, combined with a sufficient supply of some good forage for sheep, is usually sufficient to prevent losses. Grasses of the understory are inland saltgrass (Distichlis stricta) and alkali sacaton (Sporobolus airoides).

Shale, clay, and rock outcropping account for large areas of waste land in the basin. Raw shale and clay areas support very little vegetation except in depressions where moisture and debris may accumulate to aid in the formation of some soil. Runoff and erosion are severe on these areas because of the rough topography, the unstable parent material and low permeability of the soil. A few of the larger and more spectacular areas of shale outcropping are the "honeycombs" between Worland and Tensleep, Potato Ridge and vicinity southwest of Shell, and the badlands in the vicinity of Tatman Mountain southwest of Otto. There are many other areas of badlands, but these three are the largest. The "honeycombs" are shown in photograph 2. The outcropping around Tatman Mountain appear to be rich in the fossil remains of many species of prehistoric animals. It is an area that would be very interesting to amateur paleontologists and probably to professionals as well.

The large areas of badlands in the basin show as class VIII land on the Land Use Capability Map in Map Supplement "B" of this report. The recommended stocking rate for these areas and of the adjacent clay soil areas is very low because of the scant cover and severe erosion hazard as shown on the Vegetative Type Map and Erosion Condition Map in Map Supplement "A" and "C" of this report. Table 11 shows the erosion condition classification system. Grazing in these areas should be eliminated or severely curtailed so as to reduce runoff and sedimentation. Catchment basins consisting of detention dams and vegetated waterspreader systems should be established in the drainages be-

low these areas to prevent downstream sedimentation. Suitable sites for such improvements have been selected and are shown on the Proposed Improvements Map in Map Supplement "D" of this report.

Photograph 2. -The "Honeycombs" badland area southeast of Worland, Wyoming.

Timber resources in the basin are largely under the administration of the Forest Service and the Bureau of Indian Affairs. These two services administer 97.8 percent of the forested area of the Bighorn Basin. Timber reserves total over 3,754 million board feet of which 1,717 million board feet are merchantable. Under present conditions, the annual cut on a sustained yield basis would be approximately 20 million board feet. Timber reserves on public domain lands outside of National Forests and Indian Reservations are as follows:

Species	Acres	Volume	Unit
Yellow Pine	15,680	44,160	M. B. F. Saw Timber
Spruce	1,920	5,760	M. B. F. Saw Timber
Douglas Fir	83,200	119,360	M. B. F. Saw Timber
Lodge Pole Pine	24,320	16,000	M. B. F. Saw Timber
Lodge Pole Pine		49,440,000	8' bolts
Juniper	49,240	81,220	Fence Posts

In addition to the above, there is a considerable volume of eastern poplar (cottonwood) along the streams of the lower basin. These stands have no commercial importance at the present time.

Mineral Resources

Since 1888, when the first oil well was drilled in the Bonanza field, the Bighorn Basin has yielded about 260 million barrels of oil and about 240 billion cubic feet of gas. Oil reserves for the basin are estimated to total 465 million barrels as of January 1, 1951. Of this, 190 million barrels was heavy, black, asphalt base oil difficult to refine into high grade fuels, the light high grade parafin base oil reserves being estimated at 275 million barrels. Gas reserves are estimated to be 700 billion cubic feet. Elk Basin is probably the most important field in the study area, having produced over six and one-half million barrels in 1950. Accumulative production through 1950 for all fields in the basin is shown in the following tabulation:

Field	Discovery Year	Crude Oil Barrels	Gas 1,000 cu. ft.	Estimated Life of Field
Badger Basin	1931	1,822,986	?	About 3 yrs.
Black Mountain	1923	679,248	--	10 - 15 yrs.
Bonanza	1888	--	--	No production until 1950
Byron	1918	23,823,926	5,101,751	At least 15 yrs.
Clarks Fork	1944	9,069	6,955	?
Corley	1946	37,996	--	Exhausted 1949
Crystal Creek	1919	76	--	Never operated
Dry Creek	1929	2,915,040	19,100,629	8 - 10 yrs.
Elk Basin	1915	54,345,678	46,228,394	About 30 yrs.
Enos Creek	1924	112,780	32,337	About 10 yrs.
Four Bear	1928	11,582	--	Shut in
Frannie	1928	19,109,849	--	More than 20 yrs.
Garland	1906	18,106,793	55,813,499	About 15 yrs.
Gebo	1916	3,032,668	--	15 yrs.
Golden Eagle	1918	253,627	2,773,016	12 - 15 yrs.
Gooseberry	1937	216,848	--	15 yrs.
Grass Creek	1914	40,335,143	5,221,872	15 yrs.
Greybull	1907	297,047	298,606	Stripper class
Halfmoon	1944	314,392	--	15 yrs.
Hamilton Dome	1918	19,743,314	112,180	20 yrs.
Heart Mountain	1948	--	--	Shut in
Hidden Dome	1932	623,547	22,246,759	15 yrs.
Kirby Creek	1918	234,282	--	5 yrs.
Lake Creek	1925	332,030	--	15 - 20 yrs.
Lamb	1913	96,569	1,819,211	10 - 15 yrs.
Little Buffalo Basin	1914	4,842,266	43,353,000	15 - 20 yrs.

(continued)

Accumulative Production, Bighorn Basin Fields, through 1950 (continued)

Field	Discovery Year	Crude Oil Barrels	Gas 1,000 cu. ft.	Estimated Life of Field
Little Grass Creek	1917	--	2,832,496	5 yrs.
Little Sand Draw	1949	372,203	--	At least 15 yrs.
Murphy Dome	1949	102,886	--	At least 15 yrs.
Neiber Dome	1947	841,725	469,016	18 yrs.
Northwest Elk Basin	1947	1,015,204	1,447,744	8 yrs.
North Danker	1948	--	--	Shut in
Nowood	1950	3,446	--	Stripper class
Oregon Basin	1912	50,150,043	10,023,212	20 - 25 yrs.
Pitchfork	1930	926,933	--	15 yrs.
Polecat	1916	--	6,883,634	5 yrs.
Red Springs	1919	13,898	--	Shut in since 1947
Sage Creek	1948	24,232	--	5 yrs.
Sand Creek	1947	782,612	162,265	?
Shoshone	1912	338,921	--	10 yrs.
Silver Tip	1948	829,360	2,187,020	At least 15 yrs.
Slick Creek	1950	25,410	--	?
South Byron	1950	9,496	--	About 8 yrs.
South Elk Basin	1945	1,786,602	6,970,958	15 yrs.
South Frisby	1949	9,573	--	--
South Fork	1947	224,001	--	At least 15 yrs.
South Shoshone	1948	2,525	--	Abandoned 1949
Spring Creek	1930	135,156	--	15 yrs.
Sunshine-North	1922	3,015	--	Shut in
Sunshine-South	1926	100,545	--	?
Spence Dome	1944	32,421	--	About 10 yrs.
Torchlight	1904	1,043,010	--	About 10 yrs.
Wagonhound	1944	283,536	--	5 - 10 yrs.
Warm Springs	1916	660,247	--	10 yrs.
Waugh	1934	483,900	--	5 yrs.
Wildhorse Butte	1919	3,503	--	?
Worland	1946	7,160,801	6,030,916	15 - 20 yrs.
Zimmerman Butte	1945	600,945	--	4 - 5 yrs.
Totals		259,262,905	239,115,470	

The above data were compiled from Preliminary Report #57 of the Bureau of Mines, September 1951, titled "Petroleum and Natural Gas Resources and Development in the Big Horn Basin".

Sulphur is produced by extraction from the hydrogen sulphide in natural gas. At present, only two extraction plants, one at Elk Basin and one in the Worland field, are engaged in the recovery of this vital mineral. The Seaborad Oil Company is constructing a plant near Powell to recover the sulphur from the gas produced at the Silver Tip Field. A fourth plant of the General Petroleum Corporation, to be located at Manderson, is in the planning stage at the present time. It is proposed to develop a utilized oil and gas field to supply this plant. The plant in Elk Basin recovers from 18 to 25 long tons of sulphur and approximately 56,200 gallons of gasoline and other products per day, while the one at Worland recovers from 300 to 350 long tons of sulphur and about 30,000 gallons of gasoline and other products per day. The new plant will have a capacity of about 100 long tons per day. This gas was originally flared but the sulphur dioxide formed was injurious to crops in the vicinity. It became necessary to purify the gas or cap the wells so a gas purification plant was constructed. An estimated reserve of five and one-half million long tons of sulphur could be recovered from the natural gas in the basin.

Natural deposits of sulphur are found near Cody, Thermopolis, and in Sunlight Basin. Sulphur content of the ore varies greatly and sulphur production would require selective mining of the ore. The ore averages about 25 percent sulphur. In 1950, only 725 tons of sulphur were recovered from these natural deposits. The impure material, mixed with calcite, is used as a soil conditioner. Mining and milling to produce sulphur are proposed for the deposits near Cody and in Sunlight Basin.

Bentonite deposits occur in a broad belt along the eastern part of the basin floor. At present, two companies, Magnet Cove Barium Corporation and Wyoming Sales Company, are producing bentonite for use in oil well drilling mud from the deposits. The former company produces 300 to 350 tons per day and the latter about 100 tons per day. The bentonite is generally under less than 30 feet of overburden and the beds dip from 0 degrees to 31 degrees. Thickness of the beds varies from a few inches up to 18 feet. At the present time, all of it is strip-mined.

Gypsum deposits are found along the southern and eastern edge of the basin from Thermopolis northward into Montana and in an area near Cody. It occurs in beds up to 42 feet thick in nearly pure form. The beds are of good quality and are all within reasonable hauling distance to the railroad, but distance from a suitable market does not warrant any substantial development at the present time. Some is mined in connection with

sulphur near Cody and marketed as a soil conditioner. Some is used to produce building blocks.

The U. S. Geological Survey estimates that the coal reserves in the Bighorn Basin total nearly 556 million tons. Nearly 50 percent of this could be mined, assuming that losses in mining would be equal to coal produced. Nearly 97 percent of the reserves are of sub-bituminous grade and the remainder is bituminous. Only two fields are actively mined at present. They are the Bearcreek field in Montana and the Gebo field in Wyoming. Coal production in the basin during the past 20 years has declined about 84 percent. This has been due to increased use of natural gas and fuel oil for industrial and domestic purposes, and the conversion to diesel-electric locomotives by the railroads. The development of low cost strip mines in eastern Montana provided coal formerly furnished by the underground mines, especially those at Bearcreek and Belfry. High freight rates also have an adverse effect on coal production in the basin. In the future these coal reserves may be of value for synthetic fuels or chemurgy.

Limestone in deposits up to 1,000 feet thick is found in the Pryor and Bighorn Mountains on the eastern side of the Basin. There is only one quarry in operation at the present time. It is located northeast of Warren, Montana, and nearly the entire output is used in the refining of sugar. This quarry not only supplies the two sugar refineries in the Basin but also those in Billings and Hardin, Montana, and some Colorado refineries. Limestone from this quarry is of good chemical quality, and, to date, cuts totaling 72 feet deep have been developed. These factors and the nearness to the railroad make this a highly desirable deposit. A by-product of this quarry is road ballast which is stock-piled for future use.

A large deposit of calcareous tufa occurs two and one-half miles northeast of Thermopolis. The deposit which covers about 130 acres is over 80 feet thick. In 1950, a company known as the Red Lane Sinter Company was organized to mine and market the mineral as a soil conditioner. Recently, the company was acquired by Jesperson, Inc. of Omaha, Nebraska, and the plant enlarged to produce about 40 tons of soil conditioner per day. It will be marketed under the trade name Calsintone.

Clay, sand, and gravel deposits are quite extensive in the eastern part of the Basin. The Lovell Clay Products Company of Lovell, Wyoming produces high quality soil and sewer pipe, septic tank tops, floor tile, and brick. The plant maintains nine gas-fired kilns and uses about 14,000 tons of material per year. Reserves are said to be sufficient for about 120 years at the present rate of consumption.

Commercial production of sand and gravel for construction purposes amounted to 200,000 tons in 1950. This production was in the Wyoming portion of the Basin. No commercial production was reported from the Montana portion of the Basin, but non-commercial production amounted to 177,000 tons.

Uranium deposits of low quality are found in various parts of the Basin. At present, there is no demand for this low quality ore. Deposits of phosphate, dolomite, and manganese also occur in the Basin but they have never been adequately explored because of the lack of a suitable market for the grades of ores available.

Wildlife and Recreation

Large numbers of deer, elk, and antelope find suitable habitat in this area. In addition to these animals, bear and mountain sheep can be found. Antelope are the only big game animals which inhabit the valley floor yearlong. Deer and elk are mainly on the forest during the summer. Elk generally winter at fairly high altitudes just below the forest, while deer migrate to the valley floor along streams. A few of them remain along the streams yearlong and do some damage to cultivated crops. An estimated 20,000 head of deer and 9,000 elk inhabit the Basin. Antelope probably number 3,500 head, mountain sheep 800, moose 260, and bear about 500. During the 1949 hunting season, 1,078 elk, 1,918 deer, 34 moose, 23 mountain sheep, and 9 bear were taken by hunters.

In addition to big game animals, there are numerous fur bearing animals to be found. These include beaver, fox, skunk, otter, mink, badger, marten, and muskrat. Little commercial trapping is conducted in the area at the present time. Livestock losses from predators such as coyote, bobcat, lynx, and mountain lion are small. Predator numbers are kept at a minimum by the control programs of the Fish and Wildlife Service.

Pheasants inhabit the areas around cultivated land and are quite numerous. They are the only resident game birds which are legally hunted in the basin. Sage hen, chuckar partridges, and a few quail inhabit the upland area. Franklins grouse can be seen in the mountains in limited numbers. Ducks, under favorable conditions, nest in the area. Both ducks and geese pass through the area on their spring and fall migrations to and from northern nesting grounds. Completion of the water developments and waterspreading projects proposed in this report will greatly benefit the waterfowl and upland game in the basin.

Trout fishing is excellent along the mountain streams and lakes and on the large reservoirs. The Wyoming Game and Fish Commission planted nearly one million fish in various waters in the basin during 1949. The best fishing waters are those hardest to reach. Since completion of Boysen Reservoir, fishing conditions in the Bighorn River have improved. Formerly, the river was so sediment laden and fluctuated so much that it furnished no fishing. The water is now clear between Boysen Dam and Thermopolis and the flow is suitable for the production of trout. Indications are that the Bighorn will become excellent fishing waters in a reach of the stream which previously furnished no fishing.

There are few desirable picnic and camp grounds outside of the National Forests which can be reached by automobile. Dude ranches and summer camps afford accommodations, but these are limited in number and are rather expensive. For the average individual there is little of this type of recreation available.

HISTORY OF RESOURCE USE

The fur trade was almost the sole commercial use of the vast natural resources in the Bighorn Basin during the period from 1806 to 1850. About 1880, it was realized that the Basin offered excellent ranching possibilities and within the next five years the Basin was completely stocked with cattle. The first sheep were brought into the Owl Creek area in 1876. In the fall of 1886, the first band of sheep was brought into the Worland area. From 1880 to 1934, a period of 54 years, cattle and sheep were grazed on the "free range" of the public domain without regard for proper grazing capacity and no payment was made for land use. While the majority of the ranchers filed homestead entries on lands adjoining streams for ranch headquarters, the so-called "tramp operator" was quite common. His headquarters was a sheep wagon, or chuck wagon, and he moved any time the forage was short. With the passage of the Taylor Act, this type of grazer was eliminated.

The severe winter of 1886-87 temporarily reduced the grazing load in the Basin by taking a heavy toll of livestock. The respite granted the range did not last long, for when one rancher lost all another was willing to take the gamble and the ranges were again overloaded with both sheep and cattle. The more progressive ranchers began to develop irrigated hay fields as insurance against hard winters. Their irrigation systems were generally small, simple stream diversions without storage facilities to provide water during periods of low stream flow. In spite of these short-comings, they were generally successful.

The severe overloading of the ranges on poor soils with low, undependable, erratic rainfall soon had an adverse effect on the native vegetation. The more palatable species soon disappeared from the plant associations and less desirable plants took their place. Continued overgrazing caused additional downward trends of the vegetation, until density was severely reduced and many of the most desirable species became extinct or nearly so. Thus, while the Bighorn Basin was supporting excessive numbers of sheep and cattle, it was actually producing less mutton, wool, and beef than it was capable of producing.

In addition to the above factors, the sub-climax species had a lower soil binding capacity which resulted in much of the thin layer of top soil going down the river with each rain. Accelerated erosion became severe and in many parts of the basin erosion is still classed as severe, as shown in the Erosion Condition Map in Map Supplement "C" of this report.

With controls established after the passage of the Taylor Act in 1934, much of the abuse of the range was eliminated. Severe damage had already occurred. Under this Act, the majority of the public domain land in the Basin was organized into two grazing districts. They were the Tensleep District in the Wyoming portion and the Bridger District in the Montana portion of the Basin. Under their administration, numbers of stock using the range were greatly reduced and the seasons of use controlled. Range improvement and soil and moisture conservation programs were initiated in an attempt to repair the damage caused by over 50 years of uncontrolled grazing. An example of erosion and sediment production in the form of headcuts on good rangeland is shown in photograph 3. In less than 20 years, much progress in improving the range has been accomplished. A titanic job of improvement remains. The Wyoming portion of the Basin today supports about ten percent of the stock cattle and about twelve percent of the range sheep in the State.

Photograph 3. - Headcuts like this one are spreading rapidly in the clay soil areas of the Bighorn Basin. They destroy rangeland, dry out their drainages, and contribute enormous amounts of sediment to the Bighorn River. Runoff waters entering these headcuts should be diverted and spread on adjacent flats.

A total of 542 operators now have permits for 113,657 animal units on the grazing district lands. A study of table 2 will show that nearly 37 percent of these operators run 50 or less animal units of livestock, while only 14 operators run over 1,000 animal units. In addition to the permits, there are 186 Section 15 grazing leases covering public domain outside of the grazing districts. Forty-nine of these lessees also have grazing permits.

In the year 1885, the first organized large scale irrigation system was initiated near Worland. This marked the beginning of actual commercial crop production, which has increased to such an extent that the Bighorn Basin is one of the important agricultural areas of the region. This transformation has been accomplished under several land laws and has required vast expenditures of money and labor.

Early development of cultivation in the basin was made under the Homestead Act of 1862 and the Desert Land Act of 1877. The latter Act was the first attempt of the Federal Government to aid and supervise irrigation development of arid lands. The Carey Act of 1894 was the basis for State development of irrigation. Unlike the first two Acts, where the burden of development fell upon the individual, the Carey Act provided for an organized effort under the supervision of the State. A total of 102,395 acres of land in the Wyoming portion of the Basin have been patented to settlers under this Act, as shown in table 3. These lands were located along streams and the first benches above the streams. This was the choice land of the basin and getting water to it was not difficult. There were no Carey Act developments in the Montana portion of the basin.

Under the Reclamation Act of 1902, the Federal Government undertook the complete development of irrigation systems, including storage facilities. The area to be developed is divided into units and then opened to homesteaders. Settlement of the Basin occurred largely in three phases, the pioneer phase based on cattle and sheep prior to 1894, the wave of land settlement beginning with projects developed under the Carey Act, and the final phase which began with large scale development by the Bureau of Reclamation under the Reclamation Act of 1902. In 1904, the Bureau of Reclamation started construction of Shoshone Project and the first water was delivered in 1908. Storage facilities are provided in the 456,000 acre-foot capacity Buffalo Bill Reservoir. More than 97,000 acres of

Table 2. - Size and Type of Livestock Operations by States in Wyoming Grazing District 1, 1952

Size Animal Units	Cattle		Sheep		Horses		Combination Operators		Total All Classes	
	Operators	Animal Units	Operators	Animal Units	Operators	Animal Units	Operators	Animal Units	Operators	Animal Units
WYOMING										
1 - 50	132	3,487	20	614	2	57	11	248	165	4,406
51 -100	56	4,427	12	958	--	--	2	170	70	5,555
101- 200	51	7,830	22	3,688	--	--	6	832	79	12,350
201- 500	52	15,489	26	8,897	--	--	10	3,535	88	27,921
501-1000	12	8,119	16	9,817	--	--	13	8,984	41	26,920
Over 1,000	4	6,530	2	3,783	--	--	8	13,843	14	24,156
Totals	307	45,882	98	27,757	2	57	50	27,612	457	101,308
MONTANA										
1 - 50	34	897	--	--	--	--	1	30	35	927
51 -100	13	1,010	1	80	--	--	--	--	14	1,090
101 -200	11	1,566	1	156	--	--	1	120	13	1,842
201 -500	10	3,019	6	1,750	--	--	5	2,171	21	6,940
501-1000	1	900	--	--	--	--	1	650	2	1,550
Over 1,000	--	--	--	--	--	--	--	--	--	--
Totals	69	7,392	8	1,986	--	--	8	2,971	85	12,349
Grand Total	376	53,274	106	29,743	2	57	58	30,583	542	113,657

Table 3. - Carey Act Lands in Bighorn Basin, Wyoming, 1952 (Acres) 1/

Canal or Project	List Number	County	Area Segregated	Net Area Segregated 2/	Area State Patent	Area Covered By Filings	Area Patented to Settlers
Bench	1-3-14	Big Horn	32,427.96	16,027.26	16,027.26	14,743.53	13,823.53
Sidon	11-12-18-19	Big Horn	20,559.56	19,307.08	19,307.08	18,727.92	18,478.76
Big Horn	21-31-45	Big Horn	20,411.12	19,468.23	19,468.23	18,940.82	18,919.78
Lovell	26	Big Horn	11,320.51	11,020.05	11,020.05	10,941.44	10,676.07
Agarian	109	Big Horn	896.90	896.90	896.90	896.90	--
Shell	44 - 61	Big Horn	15,088.14	6,888.30	6,888.30	3,351.03	3,069.70
		Totals	100,407.19	73,607.82	73,607.82	67,601.64	64,967.84
Elk	15 - 46	Park	77,447.50	2,480.21	2,480.21	2,277.41	2,257.46
Cody	6 - 9	Park	26,429.94	19,228.04	19,228.04	18,682.00	18,110.64
Sage Creek	17	Park	784.43	784.43	784.43	784.43	784.43
Lakeview	43-107	Park	10,107.98	9,272.46	9,272.46	8,835.69	7,991.27
		Totals	114,769.85	31,765.14	31,765.14	30,579.53	29,143.80
Hanover	28	Washakie	10,682.53	8,804.01	8,804.01	8,563.85	8,283.65
		Grand Total	225,859.57	114,176.97	114,176.97	106,745.02	102,395.29

1/ Twenty-third Biennial Report, Commissioner of Public Lands and Farm Loans, State of Wyoming.

2/ Area segregated after deducting relinquishments and cancellations.

land have been patented to settlers on this project, 3,000 acres are owned by the State of Wyoming, and about 13,000 acres are scheduled for future development.

The latest land Act to effect settlement of the Basin was the Stock-Raising Homestead Act of 1916. It provided for the settlement of non-tillable grazing land. Extensive areas in the mountains, where the best range lands are situated, went to patent under this Act.

The last large scale irrigation development in the Basin by private individuals took place in 1939 with the construction of Sunshine Dam. The reservoir has a storage capacity of 53,000 acre-feet and supplies supplemental water for lands along the Greybull River Valley and adjoining benches.

Cash crops grown in the Basin include dry beans, sugar beets, wheat, barley, oats, potatoes, and hay. Other crops of small acreage include radish seed, dry peas, rye, flax, alfalfa, and clover seed, and truck garden crops. Peas, beans, and sweet corn are grown for canning and quick freezing. Acreage and production for the principal crops grown in 1949 are as follows:

Crop	Acres Harvested	Average Yield	Production
Winter Wheat	1,257	23.8 bu.	29,900 bu.
Spring Wheat	8,500	27.3 bu.	27,300 bu.
Barley	28,000	31.3 bu.	876,400 bu.
Oats	22,900	38.5 bu.	881,650 bu.
Rye	93	11.8 bu.	1,097 bu.
Beans (dry)	44,000	13.5 bags	594,000 bags
Potatoes	1,000	234.1 bu.	234,100 bu.
Beets (sugar)	13,300	14.4 ton	191,520 ton
Tame hay	104,900	1.6 ton	167,840 ton
Alfalfa hay	71,300	2.1 ton	149,730 ton
Wild hay	3,800	1.2 ton	4,560 ton

In the early development of irrigated farms, the operator usually grows only cash crops. After five to six years, the farm is usually in full production and the operator has built up sufficient reserves and credits to start diversifying his operation. The usual trend then is for the operator to start contracting the feeding of livestock and later to purchase the stock and feed them on his own. A limited number branch into dairying, but a small market outlet for grade A milk limits this type of operation. High prices for

cash crops, beef, and sheep, combined with high labor costs of dairying, have discouraged the dairy enterprise.

The importance of feeding and fattening of livestock in the Basin is indicated by the following tabulation of livestock on feed:

Year	Big Horn County		Washakie County	
	Cattle	Sheep	Cattle	Sheep
1950	6,828	10,130	5,920	71,234
1949	5,906	15,531	3,626	70,520
1948	7,317	10,020	2,627	76,063
1947	9,454	20,579	3,742	111,870

No figures are available for the other counties in the Basin. As additional farms are brought into full production, the number of livestock fattened will probably increase.

The earliest attempts at exploiting the mineral resources of the Basin occurred shortly after the California gold rush. Although some gold and silver was found, mining of precious metals never played an important part in the economic development of the Basin except to contribute to settlement. Abandoned gold mining machinery in the Bighorn Canyon, and in various places in the mountains, bear mute testimony of the gold mining failures.

Coal mines were opened to supply local trade about 1880. By 1930, coal production reached a peak of over 400,000 tons annually. From that time on, coal production declined to a low of approximately 35,000 tons in 1950. Unless processing plants are established to convert coal to other fuels or chemurgic products, it is doubtful that production will increase in the future. On the local market, fuel oil and natural gas have replaced coal in domestic and industrial uses and adverse freight rates prevent it from going to markets outside the Basin.

The first use of the oil resources of the Basin was by settlers in the Bonanza area. They collected a low grade of kerosene from seeps in that area and burned it in their lamps. A shallow well drilled in 1888 found oil, but not in commercial quantities. In 1904, the Torchlight Field was discovered. Oil and gas production climbed steadily, and by 1950 had become the major industry in the Basin. At present rates of production, the known reserves of crude oil should be sufficient for about twenty years and the natural gas reserves for about thirty-three years. Towns

and cities in the Basin were the first in the State of Wyoming to use natural gas as a fuel for domestic heating.

Sulphur has been mined spasmodically from four deposits in the Basin, two near Cody and two near Thermopolis. but it was never important to the economy of the area until 1949 when sulphur was extracted from the natural gas produced in the Basin. Two plants are in operation, one at Elk Basin and the other at the Worland field. Details of their operations are presented in the mineral resources section of this report along with proposals for additional plants.

Mining of bentonite, now a major industry with two plants, began in 1918. The present clay products plant at Lovell was built in 1919. Gypsum has been used for making plaster and building blocks, but the plants are no longer active.

PROBLEMS OF THE BIGHORN BASIN AND PROPOSED ADJUSTMENTS

RANGE PROBLEMS

Range Protection Problems

1. Shortage of spring-fall range and overgrazing.

Seasonal ranges vary considerably in area, location and dates within the Bighorn Basin. Mild winters may permit grazing at relatively high elevations, especially on protected sites in the west part of the Basin. Usually only the area in the 5,500 to 7,000 foot zone can be counted on for reliable spring-fall range. Only five percent of the study area is in this zone as shown in figure 3 of this report and on the elevation map which is on page 3 of the preliminary Bighorn report. Under present operating conditions, ranges at lower elevations which are better suited to winter grazing are being used for spring-fall range. The relative amounts and usual elevation zones of seasonal range in the Basin are shown in figure 3. The type, availability and source of forage by seasons is presented in table 4. The amount of available natural forage within the study area distributed by types of landownership is shown in figure 4.

The practice of using ranges below 5,500 feet for spring-fall use reduces the quantity and quality of feed available for winter on the range which is best adapted for winter use. Present range use is largely dictated by feeding needs and desires and by cropland use. Grazing land use should be correctly scheduled according to optimum range use season and by the recommended stocking rate which would permit range improvement. Spring use prior to proper vegetative development results in reduced forage for the current season and range deterioration. This is particularly true on the heavy soils and low precipitation belt of the Basin floor. It is especially applicable to the great expanse of salt bush type which is not good spring range. Additional spring-fall feed should be developed and the present spring-fall range should be improved. Continuation of present practice should result in a severe cut-off in the allotted use to protect the range resource.

Grazing permits for the public domain in Bighorn Basin obligate 461,482 animal unit months of forage. Studies

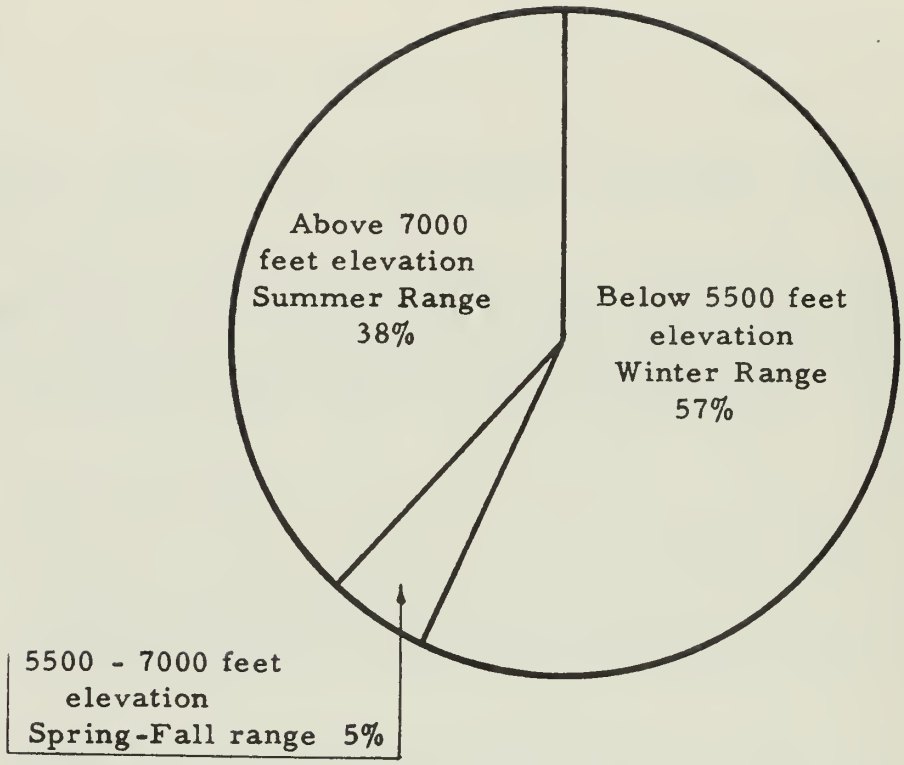


Figure 3. -Amounts of seasonal range, Bighorn Basin, Montana and Wyoming.

Table 4. - Type, source, and season of available livestock feed in the Bighorn Basin, Montana and Wyoming, 1952 (Animal Unit Months) 1/

Type and Source of Feed	Winter	Spring	Summer	Fall	Total Year Long	Percent of Total
Hay, concentrates and Aftermath - Private	166,148	83,074	--	185,777	434,999	31
Range - Private & State	98,531	59,118	177,356	59,118	394,123	29
Range - Public Domain	184,982	73,107	78,875	74,109	411,073	30
Range - National Forests	--	105	142,837	--	142,942	10
Total	449,661	215,404	399,068	319,004	1,383,137	100

1/ Compiled from field investigations, Bureau of Land Management, as shown on the Vegetative Type Map, Map Supplement "A" of this report; and from data supplied by the Extension Service, University of Wyoming, Forest Service, and by the Bureau of Reclamation.

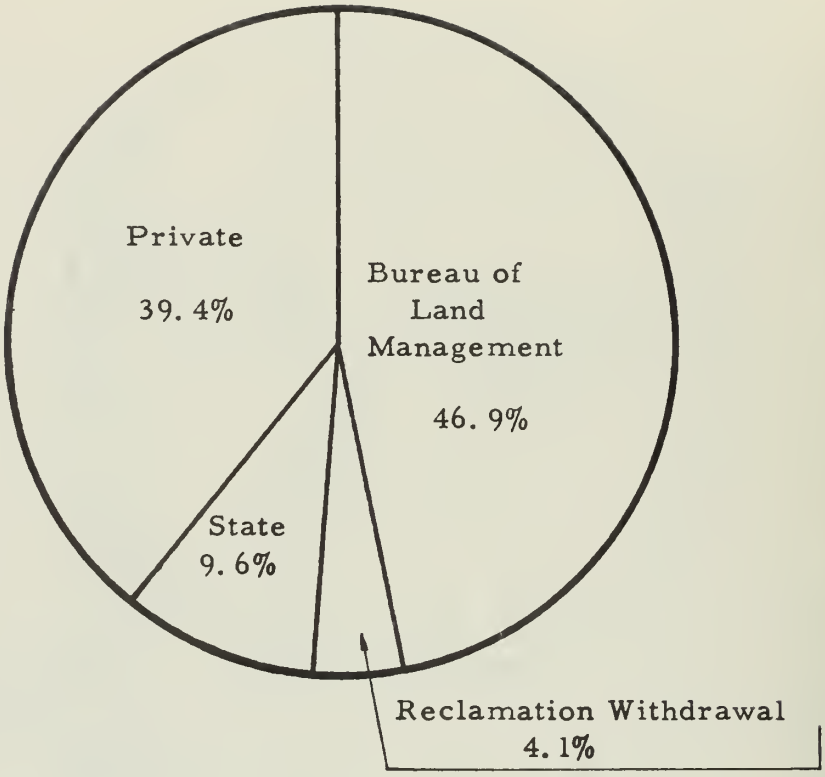


Figure 4. -Available natural forage by landownership status within the Bighorn Basin in Montana and Wyoming, 1952. This area excludes the National Forests and Indian reservations. Percentages shown are portions of the total amount of animal unit months available.

conducted for this report indicate that only 378,005 animal unit months of forage are available. This study is depicted on the Vegetative Type Map in Map Supplement "A". Comparison of these two figures shows a total of 83,477 animal unit months of forage which is over obligated. Fortunately, operators seldom stock or utilize up to the permitted rate, but this over allowance should be reduced to the recommended stocking rate to alleviate the possibility of allowable public domain over-use.

Spring-fall range is especially short on the east side of Bighorn Basin from Worland northward because the Bighorn Mountains rise abruptly from winter range to summer range levels. Most of the spring-fall range in the Basin is located on private land and so is not available for allotment to most operators. Some operators have ample spring-fall range, or even an excess, within the study area where this seasonal range is short. Other operators have none. Much of this problem must be worked out by individual operators as proposed later in this report. It will generally be advisable to reduce stocking until a good condition exists on the winter range of the Basin floor.

There are two solutions for the shortage of spring range. A reduction in livestock numbers is not considered to be desirable as it would disturb the livestock industry and would not make full use of the potential of the area. The development of pastures, irrigated where feasible, of cool season exotic grasses and legumes, is highly recommended as a partial solution to the problem. These pastures would furnish several weeks of early spring and late fall grazing, thus giving the native vegetation an opportunity to make sufficient growth to withstand later grazing. All sites suitable for pasture should be developed. Any waste water, or water which is surplus in early spring and fall, should be utilized to produce spring-fall pasture. Large areas in the vicinity of irrigation developments in the Basin can be employed for this use that are not suitable for crop production. These areas should be developed by individual operators and by groups or associations of operators on areas which are too large for individual development.

Early spring growth of perennial vegetation draws on the food reserves stored in the root system. If this first foliage is grazed off before the plant has the chance to restore the reserves, the root system is weakened and less able to withstand adverse climatic conditions. Exotic species, which

would start growth earlier in the spring could be utilized at an early date. These pastures would not be grazed all summer but by late fall could be utilized for a few weeks before stock went onto the winter range. The most suitable sites for these pastures are largely in private ownership so it is up to private individuals to carry out much of this phase of the program of range improvement. Good soils on bench and bottom lands, especially where flood or waste waters can be spread are excellent sites for pasture development. Land supporting good stands of big sagebrush will produce good tame pasture of adaptable exotics under proper development. Soils not suited to crop production, such as some in the vicinity of Frannie and Sheel Creek, should be used to produce spring-fall pasture on irrigated sites.

The second possibility of providing additional spring-fall range is to improve the existing range. This would be largely on public domain lands and would be carried out by the Bureau of Land Management. These improvements would be accomplished by reseeding depleted areas, waterspreading, water developments, and sagebrush eradication. 1/ Each of these will be discussed in later sections of this report, therefore are only mentioned here. It is estimated that the available spring-fall forage could be increased 75 percent by the above methods.

The amount of sagebrush on Bighorn rangeland and the value of burning as a means of control are well shown in photographs 4 and 5. Studies of four native ranges under different management located two to five miles south of Tensleep, Wyoming show that proper grazing management can enable climax grasses to largely displace big sagebrush without artificial aid. These studies also show that big sagebrush is a dominant species in the area largely as a result of past grazing practices. The Soil Conservation Service reported the results of these studies of four Bighorn ranges in Ecology, 2/ January 1953, Vol. 34, No. 1. Proper management permitting grass increase included conservative stocking and deferring. Under favorable weather and grazing conditions, climax grasses can displace big sagebrush on the study site within a decade or less.

1/ The total area proposed for sagebrush eradication makes up a small percent of the sagebrush of the basin, therefore the adverse effect on game will be negligible.
2/ Published by the Ecological Society of America and the Duke University Press.

Photograph 4. - Heavy to dense stands of sagebrush are typical in the foothill and mountain areas of the Bighorn Basin. Past overuse has increased the amount of sagebrush and has reduced or eliminated grass in the type. Sagebrush provides only limited grazing and very little erosion protection to the loam and clay loam soils supporting the type.

Photograph 5. -Controlled burning of the sagebrush shown in photograph 4 produced this effect. Sagebrush eradication combined with seeding of adapted grasses and legumes will provide many thousands of acres of sorely needed high quality spring-fall range.

An essential means of solving the spring range shortage problems, and all of the area problems, involves the individual operators and their use of the resources. Each operator should develop a proper use program for his area of use. An accurate and complete livestock and feed resource inventory should be prepared for each operator utilizing rangeland in the area. A livestock and land management program should then be developed for each operator, based on ample feed being available for all seasons.

Plans of ranch and farm operations would include proper use, conservation development, and improvement of the range and farm land used by each operator. All operators utilizing public domain range should be required to use their allotment only at proper rates and season as stipulated. They should be required to provide ample range, pasture, or supplementary feed for other seasons. Operators not in a position to do so should not be granted permits, licenses, or leases on the public domain.

Plans, programs, and improvements would be established by the operators and landowners in cooperation with the Bureau of Land Management, Soil Conservation Service, and other agencies. Improvement of the area in any specific location is dependent upon the proper use and development of that site by the user, and each acre affects the total. The low, erratic rainfall and heavy soil type over much of the basin make it important to maintain the plant cover in good condition. At some locations in the Bighorn Basin, rainfall has been less than five inches per year. All operators should cooperate to solve the land use problems of the area. To this end it may become advisable for the several Soil Conservation Districts to enact land use ordinances.

2. Poisonous and Noxious Plants

Halogeton, a poisonous annual weed, has invaded the Bighorn Basin. It is a prolific seed producer and has the ability to produce viable seed even under unfavorable climatic conditions. These characteristics make it a very serious threat to the operations of the livestock industry. It was first reported as a small infestation in the vicinity of Cowley in 1942. It had spread to infest 400,000 acres by 1950, with about 45,000 acres heavily infested. By 1952, it had spread to cover 500,000 acres, with over 90,000 acres heavily infested. The plant mainly invades overgrazed, disturbed or waste areas, as it cannot compete with healthy native vegetation. Halogeton distribution in the basin is shown in figure 5.

A halogeton control program was initiated in 1951 by the Bureau of Land Management. Although it was started late in the season, much valuable information was obtained. At first it was believed the plant could be controlled by the use of herbicides. This was found to be impractical, since the chemical killed nearly all the vegetation and the fast growing halogeton would reinfest the area with very little competition from the native vegetation. It has now been decided to use weed killers only in corrals, borrow pits, trails, and like areas. Waterspreading and reseeding of depleted areas to increase the native vegetation in order to control the weed by competition seems to be the best method.

Along stock trails where the heaviest halogeton losses occur, the development of sufficient water so that the animals can be watered every four hours is needed. It is also necessary to develop waterspreading areas to furnish sufficient poison-free forage as holding areas. These areas would have to be fenced to assure the reservation of this feed for trailing livestock. In general, the rancher must learn that ranges must not be overstocked, since an overgrazed range offers no competition to the invasion of the weed. The severity of halogeton infestation on bare land is shown in photograph 6. Removal of the native vegetation permits invasion of halogeton, as shown in photograph 7.

Other poisonous plants in the basin include death camas (Zygodenus spp.), larkspur (Delphinium spp.), lupine (Lupinus spp.), and others. These plants are found mainly in the higher elevations and are seldom in severe concentrations. Except in isolated areas, as shown on the Proposed Improvements Map, Map Supplement "D", no control measures, other than good

HALOGETON INFESTATION
Bighorn Basin
Montana - Wyoming

Explanation:

Edge of infestation =

Edge of concentration = 1951

Edge of concentration = 1952

Photograph 6. - Halogeton on an abandoned field between Deaver and Garland, Wyoming. The area to the right has been sprayed with a herbicide. The heavy stand of halogeton on the left shows the need for control measures.

Photograph 7. - "Halogeton Highway" along a recently constructed gas line north of Lovell. Note how the infested area coincides with the area disturbed by construction activities.

range management, are needed to prevent livestock losses.

Whitetop (Cardaria draba and Lepideum repens), Canada thistle (Cirsium arvense), Russian Centaurea or knapweed (Centaurea repens), field sawthistle (Sonchus arvensis), and bindweed (Convolvulus spp.) are root spreading perennials which cause considerable damage in cultivated areas. They compete severely with crops and thus cut down on yields, and no seed crops can be marketed from fields so infested. A control program with herbicides does much to keep them in check. Many farms are severely infested and additional control facilities are needed. Big sagebrush is a pest replacing better forage plants under overgrazing. Since it does provide some forage, it is not regarded as noxious.

3. Uncontrolled Livestock

The majority of the range in the Basin is unfenced. The control of livestock, especially cattle and horses, is impossible. Sheep are usually under control of a herder and are not a problem except in willful trespass. Cattle can be controlled to a certain extent by salt and water judiciously placed. Cattle and horses do not have the gregarious instincts of sheep and tend to stray. Ranchers are reluctant to place improvements on their unfenced range since they fear that others, by trespass, will use them and graze their range. The control of trespass and unclaimed horses is very difficult on an unfenced range. A total of 407 wild horses were rounded up and disposed of during February 1953 in the lower part of the Basin.

To insure the success of the improvement program proposed in this report, it is recommended that all range allotments be fenced at an early date. This would require the construction of approximately 1,500 miles of new fence. Fencing of the range would relieve the range manager and his staff of some of the policing duties now required and free them for other more constructive work. On a fenced range where predators are not a problem, sheep would not have to be herded thus cutting down on the operator's expense and increasing his profits. This Bureau realizes that there is considerable controversy over fencing on an antelope range where public lands are involved. Studies are being conducted in cooperation with the Fish and Wildlife Service at present to determine the effects of fencing on antelope migration, and no sheep tight fencing will be authorized until the results of this study are known.

4. Conversion from Sheep to Cattle

Due to the difficulty of obtaining reliable labor for sheep operations, many ranchers are converting to cattle. When the conversion is made, it is at the standard figure of one cow for five sheep. On range that is primarily suited to the grazing of sheep, this rate of conversion overloads the range and overgrazing results. In future changes of this type on a sheep range, the conversion factor should probably be eight or even ten sheep for one cow. This would protect the range from overloading by a class of stock that may be much less suited to that particular piece of range.

5. Rodents

Prairie dog infestations occur in several areas of the Basin, as shown on the Proposed Improvement Map in Map Supplement "D" of this report. Tests have shown that these animals compete directly with cattle in their food preference. They not only compete with cattle for forage, but they also cut down vegetation in their towns so that their line of vision will not be obstructed. It is estimated that sixteen prairie dogs require and consume enough forage to carry one sheep. It is apparent that prairie dogs add considerably to the grazing load. In view of the above facts, it is recommended that a rodent eradication program be initiated immediately on the 8,137 acres infested. It would be advisable to destroy even the small, insignificant infestations to prevent them from increasing or reinfesting other areas. Rock chucks (Marmots), field mice and ground squirrels consume considerable amounts of vegetation, especially in the foothills and mountains. It may be desirable to institute control measures for these rodents in some parts of the basin at times. Jack rabbits occasionally become a pest in local areas. Rodent control is a continuing program requiring periodic active control measures.

6. Insects

Insects cost the residents of the Basin large sums yearly either in crop and livestock profits or in expenditures for their control. Farmers must fight leaf hoppers and weevil on their croplands. Grasshoppers should be controlled on rangeland, for a heavy infestation can quickly destroy most of the range forage. Adequate control measures have been developed and can control infestations if applied. Severe infestations of grasshoppers have occurred in the Basin, particularly in the southern part.

Prairie Mound-Building Ants are an insect for which no practical control measures have been found. This insect inhabits about 1,000,000 acres of the Basin floor area in infestations sufficiently heavy to be a problem. In heavy concentrations, these insects will denude up to one-fourth of the total area they infest. Near Manderson, one of the heaviest infestations in the Basin, the ants average $32\frac{1}{2}$ colonies per acre, with a denuded area averaging twenty feet in diameter around each colony. Approximately 400,000 acres of the Basin have infestations of this magnitude, causing the range to be in poor condition with a very low forage yield. These ants forage for seeds, their main diet, over an area halfway to the next colony. Their seed gathering habits prevent the reseeding of the areas they infest by either natural or artificial means. The ants must be controlled before the sorely depleted range can be improved in condition. The magnitude of the problem is exemplified by the area depicted in photograph 8. Photograph 9 shows the amount of land denuded by a single colony. When this stripping of the surface is multiplied by the hundreds of thousands of colonies in the basin, one may realize the severity of the problem.

The Bureau of Land Management is experimenting on methods of controlling this insect, and as soon as a practical method of control is discovered a program of extermination and range restoration will be put in action. They are commonly called Red Harvester Ants, but entomologists report that these are a closely related species correctly called Prairie Mound Building Ants.

7. Distribution of Livestock Water

Due to insufficient stockwater facilities in the Basin, grazing is unevenly distributed. Areas in the vicinity of watering places must carry the grazing load, while areas remote from water are under utilized. This shortage is especially severe in the winter range area where snow is the major source of water. Under present operating conditions, the winter range is also used as early spring range after the snow is gone. Thus the concentration of stock in the vicinity of water holes is severe. Since early spring is probably the most critical period in the life cycle of range plants, this heavy concentration is especially damaging.

Photograph 8. - Ant infestations in the Torchlight Area. At this concentration, the insects cause a significant reduction of forage. Note the contour furrows in center of picture.

Photograph 9. - This circular bare area of 1,000 square feet has been made by a single colony of Prairie Mound Building Ants. These ants are a pest that creates a critical problem on thousands of acres of Bighorn Basin range.

Although there are many live streams in the mountains and foothills, topography many times limits the area which can be serviced from these streams. When stock have to travel excessive distances or ascend elevations to water, gains per animal are low, thereby decreasing the rancher's profit. In order to provide for the orderly and even utilization of the range resource, and to increase the gains per animal, a total of 1,350 stockwater developments are needed, as shown on the Proposed Improvements Map in Map Supplement "D" of this report. These reservoirs, while constructed for stockwater facilities, would serve the additional purposes of flood control and wildlife habitat.

Remote sections of the headwaters of Owl Creek are inaccessible except by horseback or on foot. It is recommended that about 25 miles of truck trails be constructed on the north and middle forks of Owl Creek. Roads in other areas will need maintenance and repair whenever storms cause damage. Construction of these roads would facilitate the management of livestock on these ranges, allow the transportation of the stock to and from the range, and would aid in fire control.

8. Range Rehabilitating Problems

Under the heavy use of the "free range" era, productive capacity of the range in terms of pounds of gain per animal was severely impaired. Climax forage species decreased in amount or disappeared entirely from the sagebrush and grassland types. On saltbush types, grasses became almost nonexistent and the saltbush plants severely weakened. Although some control was provided as a result of the passage of the Taylor Act in 1934, causing a reduction of the abuse, the productive capacity of the range had reached an alarmingly low point as the result of over fifty years of unregulated use. Under the Taylor Act, numbers and class of stock using the range were regulated. Seasons of use were not controlled because an extreme shortage of spring-fall range prevented correct adjustments in use. Total use has been reduced, and range allotments have been assigned, but use is still too greatly in accord with livestock needs and desires of the operators rather than being regulated to provide for range improvement.

Under protection established by the Taylor Act, the range began to improve. The mountain and foothill areas made a rapid recovery because of the high rainfall and a good soil. The basin floor, with a low rainfall and poor developed soil, has never completely recovered from the "free range" era. In order to insure the full potential of the area, it is recommended that approximately 179,000 acres of depleted range be reseeded.

9. Range Improvement

Sagebrush eradication is needed on 107,601 acres which now support so dense a stand of sage that the understory of grass has little forage value. Reseeding would not have to follow removal of sagebrush in most cases. Replacement of sage with grass would increase the grazing capacity of the treated areas by approximately fifty percent. Sagebrush produces a high percentage of unusable woody material, and the edible forage has a low palatability. It does not make as efficient use of available moisture and soil resources as grasses do. Grasses also afford a more protective soil cover. A considerable amount of sagebrush removal is proposed on the spring range area to improve a seasonal range which is critically short in the basin. The severity of the brush problem is well shown in photograph 10. The value of brush control is shown by the excellent stand of grass grown on this site, as shown in photograph 11. The location of areas proposed for sagebrush control is shown on the Proposed Improvements Map in Map Supplement "D".

Waterspreading projects have been proposed on approximately 79,000 acres, as shown on the Proposed Improvements Map in Map Supplement "D" of this report. Contour furrows have been proposed on 48,777 acres. This type of improvement can be used on slopes of 25 percent or less, while waterspreading is usually considered to be limited to areas under two percent slope. Some waterspreading areas have been developed in Montana on slopes much in excess of three percent. In waterspreading systems, water is taken from a channel supplied by a relatively large area and spread on a limited area. Contour furrows utilize only the amount of water falling on the immediate area. A good example of contour furrowing is shown in photograph 12. The purpose of these projects is to increase forage, conserve water and soil, reduce sediment production, and to aid in flood and halogeton control. It will be noted on the maps that some of these projects have been proposed on

Photograph 10. - Range improvement site along Fifteen Mile Creek before clearing a dense growth of sagebrush, rabbit brush and greasewood. This dense growth of woody shrubs provides very little forage.

Photograph 11. -Crested wheat grass growing on the site shown above taken the following spring. The brush was cleared with a heavy offset disk.

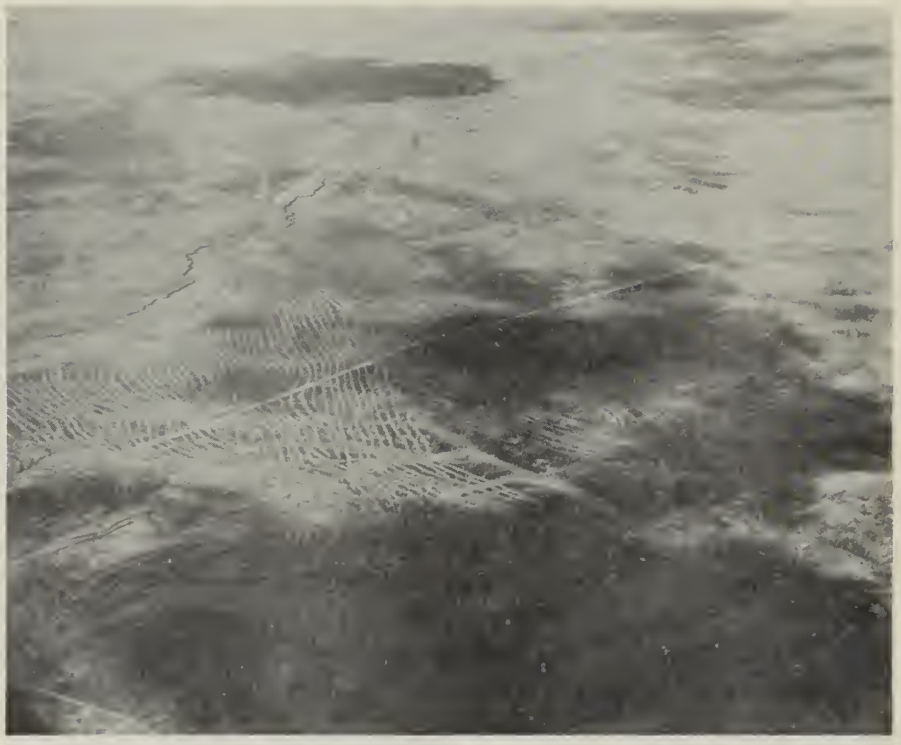
sites of relatively high grazing capacity. The majority though are on sites in a low condition class. The demand for forage in the basin is so great that the availability of sites and not merely the condition must be used as the determining factor in setting up the projects.

Range improvement is affected by the desert climate and heavy clay soils which are found on much of the basin floor below 5,000 feet in elevation. These soils have low permeability and much of the low annual rainfall runs off. If the native vegetation is reduced in condition, stocking must be greatly reduced to affect an improvement. If the vegetation is destroyed it is extremely difficult to establish a new cover of desirable species. The sudden, heavy summer storms which deliver most of the uncertain and limited precipitation further complicate the problem. In practice it is considered advisable to utilize reseeding only in conjunction with waterspreading, contour furrows or within areas where the soil has been disturbed in locations below 5,000 feet elevation in the basin.

The large area of class VIII badlands present a serious problem both in range improvement and good land management. It is not feasible at present to isolate these areas by fencing to prevent their use by livestock. Some of these areas have been utilized by livestock and problems have developed because of this use. Strictly suitable only for wildlife use, the use of such areas for livestock shelter, feeding and movement has disturbed or destroyed the very limited cover which should be maintained and has led to accelerated erosion.

10. Land Ownership Pattern

Sixty percent of the study area is in Federal ownership, 55 percent being public domain, and nearly 5 percent is reclamation withdrawal. This Federal land occupies the inferior sites and poorer soils with generally low quality vegetative cover. It occurs in large blocks, as shown on the Bighorn Basin Public Domain Map with the preliminary report and on the maps in Map Supplements "A" to "D" with this report. It is land which has been unsuitable for acquisition or settlement under any of the land laws because of its character. These Federal lands are not suitable for cultivation except for a relatively small portion which would be suitable if irrigation water can be supplied. Nearly all of these lands require careful management because of their inherent



Photograph 12. -A system of contour furrows in the Torchlight Area. Note how furrows start at the top of rolling slopes and keep water out of drainage ways.

qualities and due to past overuse. They have important positive and negative multiple use values for watershed, potential sediment production, wildlife grazing use, livestock grazing, minerals, and recreation. Under current tax policies it is doubtful that these lands could support taxation if placed under private ownership. Considering all of these factors, most of these Federal lands should remain in Federal ownership and be managed as proposed within this report. In some instances disposal has been proposed for isolated tracts of better grade public domain lands.

The pattern of landownership presents a problem generally restricted to the better lands, and to sites at the higher elevations and along the major streams of the basin. These areas are the choice lands of the basin and are most suitable for private use and ownership. The isolated tracts of public domain remaining within these areas of private ownership are the "tailings" left over after the better lands had been taken up by homesteaders. Their location is shown on the map supplements of this report. They were undesirable for private ownership because of rocks, steep topography, poor soil, climate, or other reasons. These lands in general have multiple values for wildlife habitat, watershed protection, grazing, and other uses, but due to their isolated nature do not fit well into any public land management program for managing such resources. No serious erosion problems exist on them and many of the small tracts are completely surrounded by private lands in one ownership. In view of the above facts, the multiple use values of these isolated tracts are not sufficiently important to justify their retention in government ownership. It is recommended that these isolated tracts be exchanged for either private or state lands in critical watershed areas. By blocking up Federal lands in critical areas, this Bureau would be in a better position to carry out its management and improvement programs. Tracts which could not be disposed of by exchange should be advertised and sold at public sale as provided by law.

Adjustments in stock driveways are needed from Cody south to the entrances to the Shoshone National Forest. There is no usable and continuous trail between these points, yet more than 33,000 acres have been withdrawn for that purpose in the area. Most of the withdrawal is in large blocks of land which, due to topography, cannot be used for trailing livestock. Adjustments to provide a continuous and usable trail will include the withdrawal of approximately 880 acres of public domain lands and the acquisition of about 1,000 acres of private

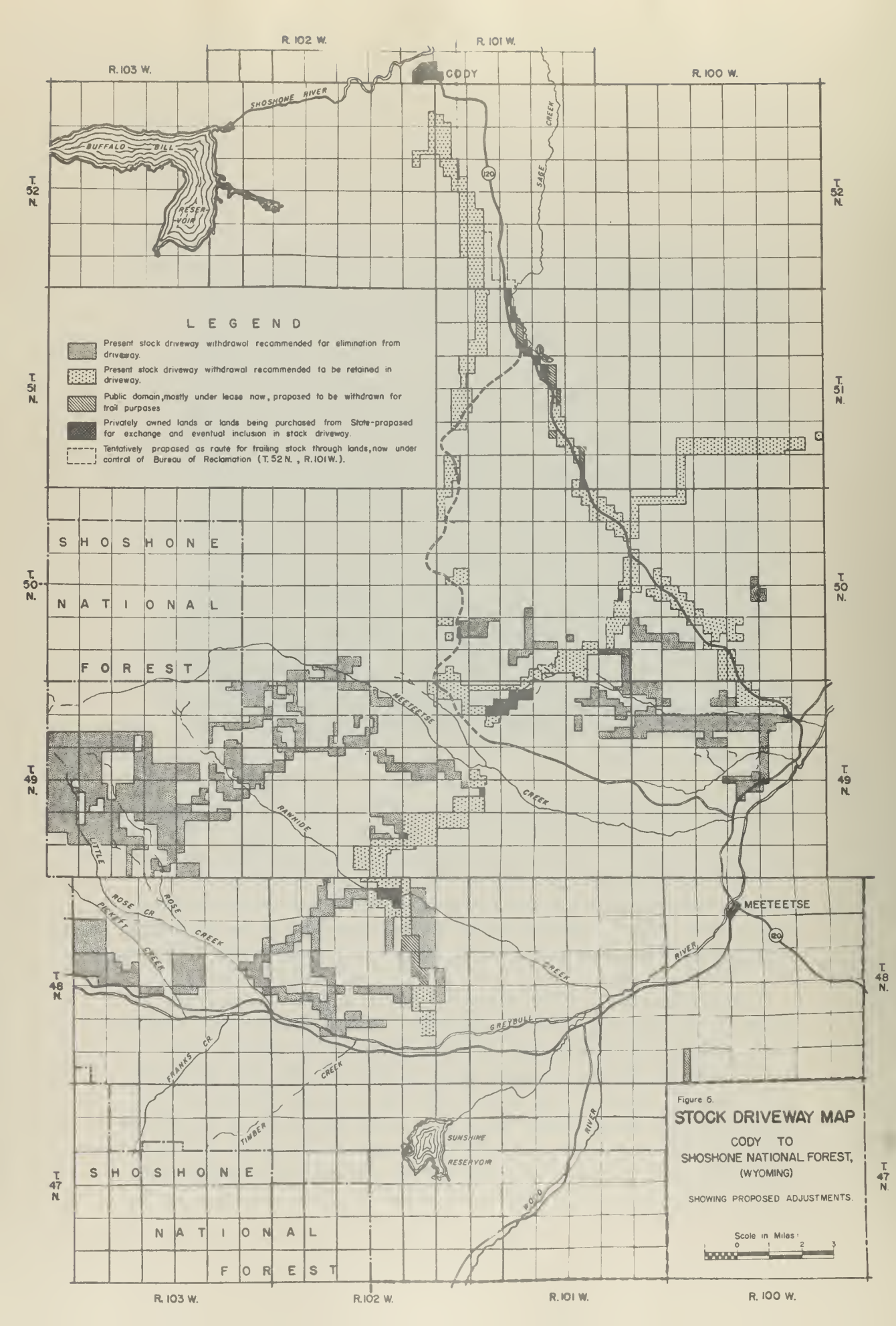


Figure 6.

STOCK DRIVEWAY MAP

CODY TO
SHOSHONE NATIONAL FOREST,
(WYOMING)

SHOWING PROPOSED ADJUSTMENTS.

Scale in Miles
0 1 2 3

and state lands. All stock driveway withdrawals not needed in the proposed trail, as shown on the small scale map in figure 6, should be revoked. The value and need for this driveway under present conditions is being investigated by the area staff of this Bureau. The recommendation may be made to abandon the driveway.

The following is a list of lands now vacant and under Section 15 lease which should be withdrawn for stock driveway purposes:

T. 48N., R. 102 W. - $SW\frac{1}{4}$ sec. 11, $E\frac{1}{2}NW\frac{1}{4}$, $NW\frac{1}{4}SW\frac{1}{4}$, $W\frac{1}{2}SE\frac{1}{4}$ sec. 14
T. 49N., R. 102 W. - $N\frac{1}{2}NW\frac{1}{4}$ sec. 36
T. 51N., R. 101 W. - $W\frac{1}{2}NE\frac{1}{4}$, $NW\frac{1}{4}SE\frac{1}{4}$ sec. 9, $SW\frac{1}{4}NE\frac{1}{4}$, $W\frac{1}{2}SE\frac{1}{4}$ sec. 15, $E\frac{1}{2}NE\frac{1}{4}$ sec. 22, $SW\frac{1}{4}SE\frac{1}{4}$ sec. 26, $SW\frac{1}{4}NE\frac{1}{4}$ sec. 27, $NW\frac{1}{4}NE\frac{1}{4}$ sec. 35

Private or state lands needed for trailing purposes which should be acquired by exchange under Section 8 of the Taylor Act are as follows:

T. 48N., R. 102 W. - $S\frac{1}{2}NE\frac{1}{4}$, $SE\frac{1}{4}NW\frac{1}{4}$, $NW\frac{1}{4}SE\frac{1}{4}$ sec. 3
T. 49N., R. 101 W. - $S\frac{1}{2}NE\frac{1}{4}$, $SE\frac{1}{4}NW\frac{1}{4}$, $N\frac{1}{2}SW\frac{1}{4}$, $SW\frac{1}{4}SW\frac{1}{4}$ sec. 4, $NW\frac{1}{4}SE\frac{1}{4}$, $S\frac{1}{2}SE\frac{1}{4}$ sec. 5, $SE\frac{1}{4}NW\frac{1}{4}$ sec. 20
T. 49N., R. 102 W. - $SW\frac{1}{4}SW\frac{1}{4}$ sec. 25, $SE\frac{1}{4}SE\frac{1}{4}$ sec. 26
T. 50N., R. 101 W. - Section 24, $NW\frac{1}{4}NW\frac{1}{4}$ sec. 36
T. 51N., R. 101 W. - $W\frac{1}{2}E\frac{1}{2}NW\frac{1}{4}$, $W\frac{1}{2}W\frac{1}{2}SW\frac{1}{4}$ sec. 4, $NW\frac{1}{4}NW\frac{1}{4}$, $SE\frac{1}{4}NW\frac{1}{4}$, $NW\frac{1}{4}SW\frac{1}{4}$ sec. 15, $SE\frac{1}{4}SE\frac{1}{4}$ sec. 19, $SW\frac{1}{4}NE\frac{1}{4}$, $W\frac{1}{2}SE\frac{1}{4}$ sec. 35

Lands now designated as stock driveway should be retained for that use in T. 52N., R. 102 W., and in T. 51N., R. 100 and 101 W.

The following lands should be retained in driveway withdrawal status and other lands in the townships so designated should be eliminated:

T. 49N., R. 100 W. - $N\frac{1}{2}S\frac{1}{2}$, $SE\frac{1}{4}SE\frac{1}{4}$ sec. 2, Lots 2, 3, $S\frac{1}{2}NE\frac{1}{4}$, $SE\frac{1}{4}NW\frac{1}{4}$, $NE\frac{1}{4}SW\frac{1}{4}$, $N\frac{1}{2}SE\frac{1}{4}$ sec. 3, $NE\frac{1}{4}NE\frac{1}{4}$ sec. 11, Lot 1 sec. 12, $SW\frac{1}{4}SW\frac{1}{4}$ sec. 14, $SE\frac{1}{4}SE\frac{1}{4}$ sec. 15, Lots 1, 3, 4, 5, 6, $N\frac{1}{2}NE\frac{1}{4}$ sec. 22, Lot 1 sec. 23

(continued)

(continued)

T. 49N., R. 101 W. - Lots 1, 2, 3, 4, SW¼NW¼, W½SW¼ sec. 4, Lots 1, 2, 3, 4, S½NE¼, S½SW¼, W½SE¼ sec. 5, Lots 1, 2, 3, 4, S½N½, E½SE¼ sec. 6, sec. 7, Lots 1, 2, 3, 4, 79A, 79B, 79C sec. 8, Lots 7, 8 sec. 17, sec. 18, SE¼ sec. 19, Lots 2, 4, 5, NW¼NW¼, W½SW¼ sec. 20, N½ sec. 30

T. 50N., R. 100 W. - Lot 2, SW¼NE¼, S½NW¼ sec. 5, Lots 5, 6, 7, S½NE¼, SE¼NW¼ sec. 6, Lots 1, 2, 6 sec. 7, SE¼SE¼ sec. 15, Lot 4, NE¼SW¼, SE¼, that part of Lot 38 in SW¼SW¼ sec. 17, Lots 1, 2, 3, 6, 47C, SE¼SE¼ sec. 18, Lot 47J, 47C, E½NE¼ sec. 19, Lots 1, 2, SW¼NE¼, E½NW¼, W½NW¼ sec. 20, SW¼SW¼ sec. 21, E½NE¼ sec. 22, Lot 2, SW¼NW¼ sec. 23, NW¼NE¼, N½NW¼, SW¼NW¼ sec. 27, NE¼, N½NW¼, SE¼NW¼, SW¼SE¼ sec. 28

T. 50N., R. 101 W. - SW¼NW¼, SW¼, SW¼SE¼ sec. 1, Lots 1, 2, 3, S½NE¼, E½SE¼ sec. 2, Lots 3, 4, 5, 6, 7 sec. 6, Lot 1, NE¼, NE¼NW¼ sec. 12, Lots 1, 6, SE¼NE¼, NE¼SE¼, Lots 47D, 47E sec. 13, SE¼SW¼, SE¼ sec. 18, Lots 1, 2, SE¼, Lots 47D, 47E sec. 24, N½NE¼, SW¼NE¼, E½W½, NW¼SW¼, sec. 25, S½ sec. 26, Lots 1, 3, NE¼NW¼, NE¼SW¼ sec. 30, Lots 6, 7, E½SW¼ sec. 31, Lot 8 sec. 33, Lots 4, 5, 6, E½NE¼, NE¼SW¼, SW¼SW¼, N½SE¼ sec. 34, Lots 1, 2, 3, 4, 5, NW¼, N½SW¼, SE¼SW¼ sec. 35, Lots 1, 2, 4, 5, 6, NE¼NE¼ sec. 36

All stock driveway withdrawals in T. 48, 49, and 50N., and R. 100W. to the National Forest, which are not listed for retention, should be revoked. These restored lands, with the exception of those in T. 48 and 49N., R. 103 and 104W., where all public land should be retained for future winter game range, should be exchanged for lands in critical watershed areas.

Bureau of Reclamation withdrawals cover extensive areas in the Shoshone and Greybull River drainages. Many of the withdrawals have been developed or are being developed at present, and future development is scheduled on additional acreages. There remain, however, large areas under Reclamation withdrawal which, because of soil type, topography, or inadequate drainage, are not suited to the production of cultivated crops. Grazing on approximately 185,000 acres of these lands is administered by the Bureau of Land Management and the remainder is managed by the Bureau of Reclamation. This arrangement creates problems for both the Area Manager and the livestock operator. The Area Manager must issue separate permits and leases on these lands, thus increasing his work load, while an operator may need three different permits for his federal range. By law, the Area Manager cannot place any improvements on the lands and many times the withdrawn lands are critical erosion areas. It would, therefore, be advisable for the Bureau of Reclamation to re-examine all of their withdrawals in the basin and revoke those which it is not advisable to develop.

11. Unleased Section 15 Lands

On July 1, 1952 there were 23,554 acres of unleased public domain lands outside of the two grazing districts which are subject to lease under Section 15 of the Taylor Act. Approximately 3,000 acres of this land was worthless, barren land of no use to ranchers. This leaves a total of 20,554 acres of grazing land which could be leased to stockmen. Since these lands are undoubtedly used by ranchers illegally, the Area Manager should make every effort to bring them under lease. At present, there are 186 Section 15 leases in the study area. The number of leases could be cut considerably by combining the leases for one operator into one lease. Several of these operators will have as many as five or six leases. Consolidation of these leases would increase efficiency.

FOREST PROBLEMS

Access is poor to much of the public domain timber. Present value of much of the stand is so low that it is difficult to justify suitable access roads. Much of the timber is mature or over-mature and should be harvested. The market for saw timber is quite limited and is virtually lacking for other classes of forest material. There are only a few small mills in the basin with little of the lumber being finished. Freight rates virtually preclude marketing lumber outside of the immediate area. This Bureau is short of man power for proper forest administration. An accurate and intensive inventory of the forest resources on public domain lands within the basin is needed. Fire control is a problem on both timber and grass lands at the higher elevations, particularly on the west side of the basin. Equipment, detection, presuppression programs, and suppression are all fire control problems on the public domain at the higher elevations.

LAND USE PROBLEMS

Cadastral Surveys

Legal land boundaries are very inadequately identified in 71 townships of the basin. Many of these townships were surveyed before 1911 and have never been resurveyed. The original monuments were of stone with the identifying marks chiseled in. By weathering, most of these marks have become illegible and in many cases the monument has been destroyed. Identification of land in such cases is very difficult except by someone familiar with landownership and operating units in the area. To facilitate the administration of the land, it is recommended that the following lands be resurveyed at an early date: T. 40N., R. 87, 88, 89, 93, and 94; T. 41N., R. 93 and 94; T. 42N., R. 93 and 94; T. 43N., R. 93, 94, 95, 96, 97, 98, 99, 100, 101 and 103; T. 44N., R. 93, 94, 95, 96, 98, 100 and 102; T. 45N., R. 85; T. 46N., R. 85 and 86; T. 47N., R. 86; T. 48N., R. 103; T. 49N., R. 86; T. 50N., R. 105; T. 51N., R. 100 and 102; T. 52N., R. 105; T. 53N., R. 91 and 92; T. 54N., R. 92; T. 57N.,

R. 93, 94, 95, 100, 101, 102 and 103; T. 58N., R. 94, 95, 96, 97, 98, 101, 102 and 103, all west of the 6th Principal Meridian, Wyoming; T. 6S., R. 22, 23 and 24; T. 7S., R. 22, 23, 24 and 25; T. 8S. and 9S., R. 22, 23, 24 and 25, all east of the Montana Principal Meridian.

Small Tracts and Special Land Use

Approximately 92 acres of land in the basin have been classified as valuable for home and business sites. This land is in two parcels, one near Greybull contains about 52 acres and the other containing 40 acres is near Worland. These lots do not exceed five acres in size. Lots for homesites are leased for three years with an option to purchase after one year. Business sites are leased for a five year period with the same option to purchase as in the homesite leases. Sites for cabins and summer homes on basin public domain lands are generally of poor quality. The most desirable sites of this type are located on the National Forest lands in the mountainous areas of the basin. However, sites for two cabins near Cody in Section 24, T. 53N., R. 103W., seem to be desirable and of good quality.

A parcel of land near Powell is used as a soap box derby race track under special land use, as shown in photograph 13. In addition, there are two areas which should be set aside for public recreation. Both of them border on National Forest lands. The first of these sites should include the $E\frac{1}{2}$ of sec. 25, T. 56N., R. 93W and all of sec. 30, T. 56N., R. 92W. This area includes several springs, a creek, a waterfall about 40 feet high, and timber. The Service Clubs of Lovell have indicated their willingness to develop and maintain the recreational facilities of the site, thus relieving the Bureau of Land Management of this expense. At present, the State of Wyoming uses about five acres adjoining the highway in section 25 as a gravel dump. A new site for this dump could be found a short distance to the west which would adequately serve their purpose. Section 30 is designated as a stock driveway and is used for access to the forest. Recreational use would not interfere with the legitimate trailing of livestock.

The second recreational site is on the Clarks Fork River. Here good fishing waters are found, excellent camping grounds are common, and big game animals abound. The area is accessible by a fair county road which could be readily improved. All public domain lands which should be withdrawn are in sections 5, 6, 7, 8, 17 and 18, T. 56N., R. 103W. This land would be

especially valuable when the four dams proposed by the Bureau of Reclamation are completed on the Clarks Fork River above these lands.

Construction of the proposed Yellowtail Dam will increase the accessibility of the scenic and semi-wilderness area in the vicinity of the reservoir. A view of spectacular Bighorn Canyon, third deepest in the United States, is shown in photograph 14. The National Park Service makes the following proposals for the preservation and use of the scenic and recreational resources of the proposed Yellowtail Reservoir:

1. Protection of a strip of land one-half mile wide along the entire west rim of the canyon from unnecessary development or unsightly structures. About one-third of this area is within the Crow Indian Reservation in Big Horn County, Montana. It is Indian tribal land. The balance is vacant public domain land.

2. Acquisition of all non-federal lands in this strip, about 1,300 acres of private land and 640 acres of state-owned land.

3. Development of camping and vacation facilities, including cabins, lodges, and boat docks, at the upper and lower ends of the reservoir.

4. Construction of a good all weather road along the western rim of the canyon to replace the trail now used.

At the time of field examination it did not appear necessary to reserve any additional lands for cabins, homesites, recreation or industrial development.

Photograph 13. -One example of recreational land use in the basin. This soap box derby race track is located on public domain land near Powell, Wyoming. Photo by Robert S. Hede, Powell, Wyoming.

Photograph 14. -Bighorn Canyon, third deepest in the United States, affords thrilling scenery. It is about 3,000 feet deep here at Devils Canyon Junction in Wyoming. When filled with water after Yellowtail Dam is built, a lake of magnificent beauty will be created between the canyon walls.

Water Rights and Appropriations

With the exception of the Shoshone River, which has irrigation water storage facilities, water in all the streams of the basin has been over appropriated. These streams either flow through or near far more irrigable land than can be irrigated from the natural flow of the streams. Water shortages generally occur during the summer season, the most critical period in the production of irrigated crops. To correct this situation, the Bureau of Reclamation has proposed four storage reservoirs in the basin with an aggregate capacity of 195,000 acre feet. In addition, 14 pumping projects have been proposed along the Bighorn River. When completed, these projects will bring approximately 114,020 acres of new land under irrigation and supply supplemental water for about 31,688 acres. An adequate water supply for the Bighorn Pumping Projects is assured by storage within the reservoir created by Boysen Dam, with a capacity of 970,000 acre feet.

Drainage and Excess Water

Subsurface drainage is inadequate on many irrigated fields. The topography of the underlying formations makes it difficult and very expensive to construct adequate drainage systems in some locations. Some farms on some of the older projects have been abandoned due to a water-logged soil. Other farms which are becoming waterlogged are requiring large sums of money to provide drainage systems. Some soils and sites do not have internal drainage. Proper and judicial use of water would decrease the necessity for many of these drainage systems. The Bureau of Reclamation provides drainage systems on project lands while the Soil Conservation Service does the engineering work for drainage on privately developed projects. Proper use of water and proper disposition of excess water are needed to reduce sedimentation and soil loss. Present practices present a serious problem.

Submarginal Lands

There are a considerable number of abandoned and submarginal farms in the basin. Most of these are on heavy soil types in the vicinity of Frannie and Shell Creek. Parts of other farms contain land unsuited to cultivation. These lands are far better suited to the production of perennial vegetation than to the production of cultivated crops due to heavy clay soils and poor drainage. This type of land offers a prime opportunity for the ranchers to increase the spring, fall, and summer forage by developing pastures of exotic species to round out their livestock operations. No attempt has been made to reclaim many of these abandoned farms, but attempts are still made to produce cash crops on many submarginal farms. Land use should be adapted to land capability. If these submarginal sites were planted with adapted species for use as irrigated pasture and hay land, and are properly managed, they can be profitable enterprises. This is an action problem for the landowner and operator.

Integration of Cultivated and Range Land Uses

Five types of cultivated and range land use integration are practiced in Bighorn Basin:

1. The range livestock operator purchases all needed hay, grain, and crop by-products from local farmers.

2. The farm operator contracts or purchases range feeder stock as a means of marketing all or part of his crops.

3. A single operator operates both irrigated farmland and rangeland as a unit.

4. Both operations under the same ownership operated as separate units by lease or management.

5. Feed lot operation in which the operator purchases both feed and livestock.

Expansion of these types of integration, as new land is brought under irrigation, will have a stabilizing effect on the agricultural economy of the area. Development of

irrigated pastures for spring, fall, and summer use by both farmers and ranchers will probably increase and become important as a type of land use integration. It is possible that some operators will develop irrigated pastures in units sufficiently large so that they can take in range livestock on a custom feeding basis. This type of enterprise has been practiced in Idaho for many years.

Increased freight rates and lower crop prices will make it more favorable economically to produce feed crops, livestock, and livestock products rather than cash crops on Bighorn Basin farmland. Range operators will probably develop more irrigated land use or utilize more of the products of irrigated land in the future as it becomes increasingly more advisable for them to do so. This is true from an economic-returns standpoint, as well as for good management and proper land use. In addition, education and regulation will stimulate range operators to utilize more irrigated land and its products. As additional lands are brought under irrigation and to full production, a more stable agricultural economy will be possible. Although the two types of agriculture, grazing of livestock and cultivation, are frequently under different ownership, generally the integration between the two types of operation will increase. At present, about 98 percent of the hay produced in the basin is consumed there. Approximately 120 carloads of concentrates are shipped into the basin yearly and while importation of protein supplements will be necessary, the basin should be able to produce considerably more of the feed needed.

Oil Exploration and Development

Some petroleum exploration groups have conducted their activities without regard for the preservation of the surface resources. Temporary roads are made with a bulldozer without any thought of topography or drainage. The denuded portion of these trails furnish excellent invasion routes for noxious plants of all types. During periods of heavy runoff, gullies are formed by the uncontrolled water concentrating in them. Oil well development companies may do considerable damage to surface resources by their activities. Sludge pools may become death traps for livestock and overflow from the pools often ruins water developments farther downstream. Once a producing well is brought in, pipelines are constructed for the transportation

of the oil or gas. The denuded area left by this construction becomes a potential Halogeton highway, as shown in photograph 7. No provisions are made for erosion control and gullies will form along the route.

These problems have been considered by the corporations engaged in the petroleum industry, and a Code of Ethics has been established. This Code should be enforced. If the Code cannot be enforced, it is recommended that all petroleum exploration and development activities be placed under strict surveillance. The bulldozing of trails is for the most part unnecessary and should be stopped. All future right-of-way permits for pipeline construction should contain stipulations for the reseeding of the denuded area and for the prevention of erosion. Examples of the problem and of the damage done are exhibited in photographs 15 and 16.

Photograph 15. -Seismograph "roads" built with a bulldozer averaging from six to eighteen inches deep. In this area it would have been necessary only to remove the sagebrush.

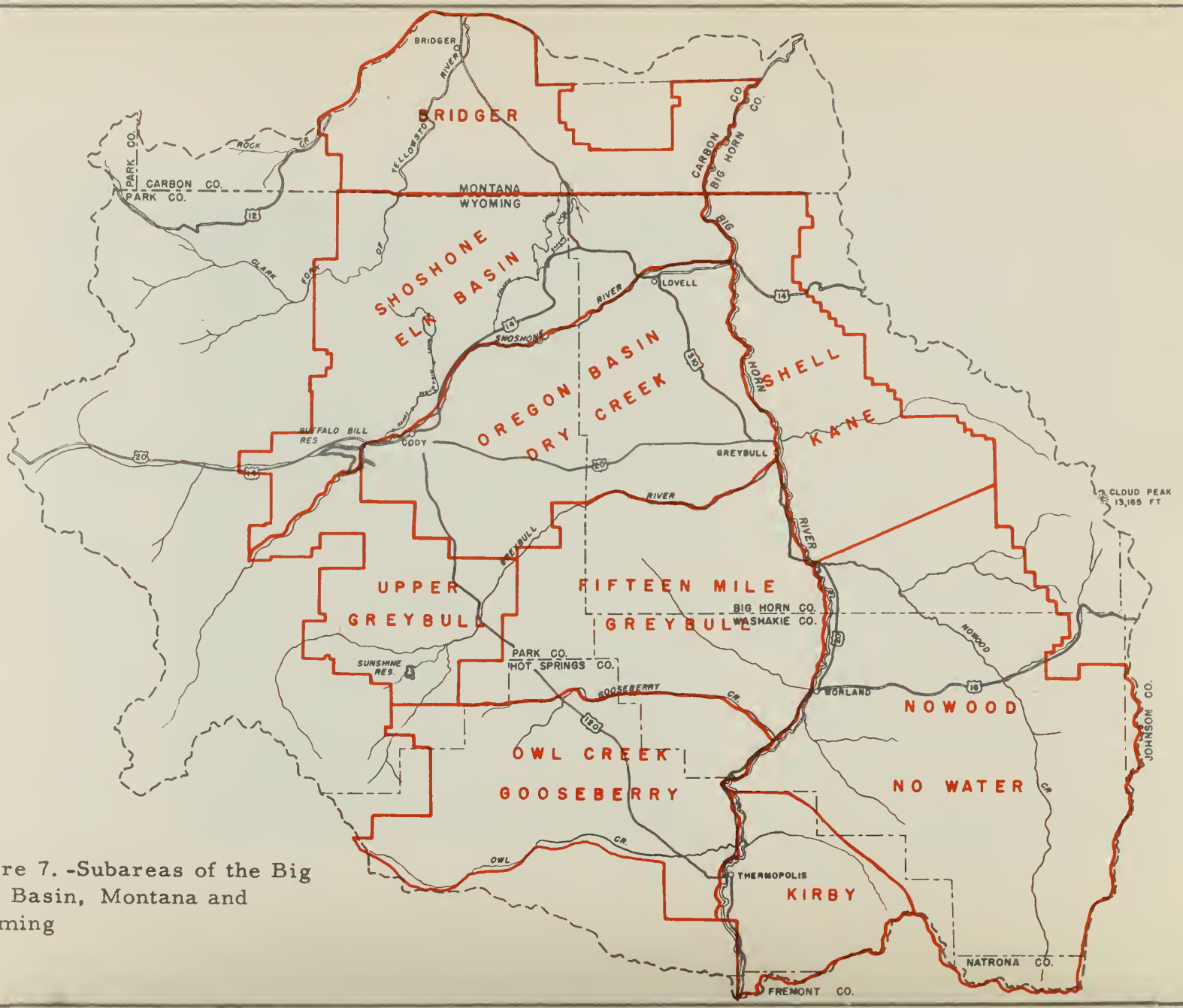


Figure 7. -Subareas of the Big horn Basin, Montana and Wyoming

WATERSHED PROBLEMS BY SUBAREAS

The preliminary report of the Bighorn Basin delineated the study area into nine subareas for detailed study and investigation. These subareas are: Kirby Creek, Nowood-No Water, Shell-Kane, Bridger, Shoshone-Elk Basin, Oregon Basin-Dry Creek, Fifteen Mile-Greybull, Upper Greybull, and Owl Creek-Gooseberry. The name and boundaries of each of these areas are shown in figure 7.

General information, resource inventory data, and problems applicable to the entire study area have been presented in the preceding portion of this report. The balance of this report is devoted to a presentation of the specific watershed problems of the nine subareas, and the costs and benefits of the improvements proposed to treat these watershed problems. In addition to the watershed problems of each subarea, a brief description and use history is presented. The status of landownership, the surface water supply, and surface resources are also given. The costs and benefits of the proposed improvements for all of the subareas are presented in a section following the subareas. The location and type of proposed improvements are shown on the Proposed Improvements Map, Map Supplement "D" of this report.

The areas of poor soils, high erosion, sparse vegetative cover and high rate of sediment production generally coincide. Subareas with large areas of badlands and heavy clay soils are the Shell-Kane, Fifteen Mile-Greybull, Oregon Basin-Dry Creek, and Nowood-No Water. These subareas are mostly within the low rainfall area of relatively low elevation and are largely a winter range area. The saltbush type covers most of these clay soil areas where the precipitation averages less than eight inches per year. The location of vegetative types is described for each subarea and is shown on the Vegetative Type Map in Map Supplement "A".

The size of each subarea, the types of land uses by the several landownerships, and the recommended stocking rate for rangelands by the several ownerships are presented in table 5. This table not only gives information regarding the relative land uses of the subareas but also presents part of the surface resource background of the economy for the subareas and for the report area.

Additional comparison between the subareas is furnished in tables 6 and 7. Table 6 shows the type of land use by ownerships as percentages of the total area of each of the nine subareas and for the entire study area. Table 7 shows the relative quality of the range in different ownerships. It also presents a qualitative comparison of the nine subareas. This comparison is shown by means of the number of surface acres required to furnish one animal unit month of forage on an average basis. The figure for smaller range areas is shown by types on the Vegetative Type Map in Map Supplement "A".

Photograph 16. -A close-up of a seismograph bulldozer trail showing how water has already started to gully.

Table 5.-Distribution of Land Areas by Types of Ownership, Land Uses, and the Recommended Stocking Rate for Rangelands for the Nine Subareas Within the Bighorn Basin in Montana and Wyoming, 1952 1/

Subareas	Public Domain Rangeland		Withdrawn Rangeland		Total Rangeland Administered by Bureau of Land Management		Reclamation Withdrawal 2/			Total Federal			State			Private			Other Lands	Total			
							Range		Crop	Range		Area	Range		Crop	Range		Crop		Range		Crop	Area
	Acres	AUMs	Acres	AUMs	Acres	AUMs.	Acres	AUMs.	Acres	Acres	AUMs.	Acres	Acres	AUMs.	Acres	Acres	AUMs.	Acres	Acres 3/	Acres	AUMs	Acres	Acres
1	114,558	17,130	3,591	486	118,149	17,566				118,149	17,566	118,149	28,717	5,660	355	120,773	24,169	4,365	360	267,639	47,395	4,720	272,719
2	873,354	102,612	53,175	7,809	926,529	110,421	4,722	767	5	931,251	111,188	931,256	103,050	16,976	726	345,787	82,672	51,902	1,358	1,380,088	210,836	52,633	1,434,079
3	331,007	18,556	24,387	935	355,394	19,491				355,394	19,491	355,394	22,426	1,905	95	81,708	8,905	17,619	4,238	459,528	30,301	17,714	481,480
4	224,617	18,589	5,202	516	229,819	19,105	677	36	110	230,496	19,141	230,606	24,810	2,529	666	220,665	32,875	41,593	1,281	475,971	54,545	42,369	519,621
5	244,173	22,840	12,070	2,147	256,243	24,987	130,575	19,012	15,587	386,818	43,999	402,405	47,768	8,851	1,199	251,382	41,417	102,523	9,217	685,968	94,267	119,309	814,494
6	411,269	34,646	71,826	11,226	483,095	45,872	121,127	12,918	2,844	604,222	58,790	607,066	40,674	4,178	1,783	88,076	12,223	93,513	4,447	732,972	75,191	98,140	835,559
7	554,735	55,754	918	125	555,653	55,879	4,469	331		560,122	56,210	560,122	30,653	3,483	804	99,085	16,253	31,164	1,257	689,860	75,946	31,968	723,085
8	27,358	5,439	33,685	8,725	61,043	14,164	208	25	741	61,251	14,189	61,992	75,980	21,951	488	214,056	50,832	21,553	1,281	351,287	86,972	22,782	375.350
9	388,615	70,170	3,143	350	391,758	70,520	80	9		391,838	70,529	391,838	52,157	11,456	821	217,771	47,791	24,222	495	661,766	129,776	25,043	687,304
	3,169,686	345,636	207,997	32,319	3,377,683	378,005	261,858	33,098	19,287	3,639,541	411,103	3,658,828	426,235	76,989	6,937	1,639,303	317,137	388,454	23,934	5,705,079	805,229	414,678	6,143,691

1/ Compiled from the field investigations made by the Bureau of Land Management for this study. Landownership records of this Bureau, and those of the counties and states were utilized. Subareas are as follows: No. 1, Kirby subarea; No. 2, Nowood No Water subarea; No. 3, Shell-Kane subarea; No. 4, Bridger subarea; No. 5, Shoshone-Elk Basin subarea; No. 6, Oregon Basin-Dry Creek subarea; No. 7, Fifteen Mile-Greybull subarea; No. 8, Upper Greybull subarea; and No. 9, Owl Creek-Gooseberry Creek subarea. AUM is an abbreviation for animal unit months. One animal unit of forage is sufficient for one cow, one horse, or five sheep for a month.

2/ Includes minor areas of other Federal lands as follows: Owl Creek-Gooseberry subarea, 40 acres with 3 AUMs; Upper Greybull subarea, 52 acres with 6 AUMs; Oregon Basin-Dry Creek subarea, 208 acres with 5 AUMs; Shoshone-Elk Basin subarea, 163 acres with 16 AUMs; Bridger subarea, 80 acres with 0 AUMs. The total of other Federal lands is 543 acres with 30 AUMs. of forage.

3/ Other lands are principally water surface areas and townsites.

Table 6. -Type of Land Use by Ownerships as percentages of total area by subareas in the Bighorn Basin, Montana and Wyoming, 1952 1/

Subarea	Administered by B. L. M.	Reclamation Withdrawal 2/		Total Federal		State		Private		Totals		Other Lands 3
	Range	Range	Crop	Range	Crop	Range	Crop	Range	Crop	Range	Crop	
1	43.3	--	--	43.3	--	10.6	.1	44.3	1.6	98.2	1.7	.1
2	64.6	.3	.0003	64.9	.0003	7.18	.05	24.1	3.7	96.2	3.7	.1
3	73.8	--	--	73.8	--	4.68	.02	16.9	3.7	95.4	3.7	.9
4	44.2	.1	.02	44.3	.02	4.8	.1	42.5	8.0	91.6	8.1	.3
5	31.5	16.0	1.9	47.5	1.9	5.9	.1	30.9	12.6	84.2	14.7	1.1
6	57.8	14.5	.3	72.3	.3	4.9	.2	10.5	11.2	87.7	11.8	.5
7	76.8	.6	--	77.4	--	4.2	.1	13.7	4.3	95.4	4.4	.2
8	16.3	.05	.2	16.3	.2	20.3	.1	57.0	5.8	93.6	6.1	.3
9	57.0	.01	--	57.01	--	7.6	.1	31.7	3.5	96.3	3.6	.1
Total	55.0	4.3	.3	59.3	.3	6.9	.1	26.7	6.3	92.9	6.7	.4

1/ Compiled from records of field surveys and investigations made by the Bureau of Land Management. No. 1, Kirby subarea; No. 2, Nowood-No Water subarea; No. 3, Shell-Kane subarea; No. 4, Bridger subarea; No. 5, Shoshone-Elk Basin subarea; No. 6, Oregon Basin subarea; No. 7, Fifteen Mile-Greybull subarea; No. 8, Upper Greybull subarea; and No. 9, Owl Creek-Gooseberry subarea.

2/ Includes minor areas of other Federal lands as follows: Owl Creek-Gooseberry subarea 40 acres with 3 AUMs;Upper Greybull subarea 52 acres with 6 AUMs; Oregon Basin-Dry Creek subarea 208 acres with 5 AUMs; Shoshone-Elk Basin subarea 163 acres with 16 AUMs; Bridger subarea 80 acres with 0 AUMs; the total of other Federal lands is 543 acres with 30 AUMs of forage.

3/ Other lands are principally water surface areas and townsites.

Table 7. -Surface acres of rangeland per animal unit month by types of ownership by subareas within the Bighorn Basin, Montana and Wyoming, 1952 1/

Subarea	Administered by B. L. M.	Reclamation Withdrawal	Total Federal	State	Private	Totals
1	6.726	--	6.726	5.074	4.997	5.647
2	8.391	6.156	8.375	6.070	4.182	6.546
3	18.233	--	18.234	11.772	9.175	15.165
4	12.029	18.805	12.042	9.810	6.710	8.726
5	10.255	6.868	8.791	5.396	6.069	7.276
6	10.531	9.377	10.277	9.735	7.206	9.748
7	9.944	13.501	9.965	8.801	6.096	9.083
8	4.310	8.320	4.317	3.461	4.211	4.039
9	5.555	8.888	5.555	4.553	4.557	5.099
Total	8.935	7.911	8.853	5.536	5.169	7.085

1/ Compiled from field inventory made by the Bureau of Land Management. This table shows the relative quality of lands in different ownerships and of the nine subareas. Subareas are as follows: No. 1, Kirby subarea; No. 2, Nowood-No Water subarea; No. 3, Shell-Kane subarea; No. 4, Bridger subarea; No. 5, Shoshone-Elk Basin subarea; No. 6, Oregon Basin-Dry Creek subarea; No. 7, Fifteen Mile-Greybull subarea; No. 8, Upper Greybull subarea; and No. 9, Owl Creek-Gooseberry subarea. Variations for smaller areas and specific sites are shown on the Vegetative Type Map, Map Supplement "A" of this report.

KIRBY CREEK SUBAREA

Description

This subarea is located in Hot Springs County east of Thermopolis and east of the Bighorn River. The boundaries and location of the Kirby Creek and of the other subareas within the Bighorn Basin are shown on the map of the subareas, figure 7. Important drainages of the area are Kirby Creek and its tributaries in the northern part, Warm Springs Creek, a small drainage area in the central part, and Buffalo Creek in the southern portion. The southern boundary of Wyoming Grazing District No. 1 divides the area into nearly equal north and south portions. The subarea includes 427 square miles of hilly to mountainous terrain, the only level land of any extent being along the Bighorn River and lower Kirby Creek. Kirby Creek is an important watershed area because of the readily erodible clay soils and rolling to steep topography. The southern drainages are generally located on more stable soils supporting a more protective vegetative cover. Elevations range from about 4,200 feet at the river to about 8,500 feet on Copper Mountain. All social, commercial, and service facilities center at Thermopolis.

Land Use and Ownership

Ninety-eight and three-tenths percent of this subarea is used as grazing land and the remaining one and seven-tenths percent is under cultivation. The majority of the cultivated land is along the Bighorn River. The narrow creek valleys afford little level land for crop production. This use closely follows the land use capability of the area, as shown on the Land Use Capability Map in Map Supplement "C" of this report. Other uses and potential uses of the area are watershed, oil production, coal, and other minerals, and as a wildlife habitat. The area is now serving most of these important multiple purposes. Some of the potential uses may become more significant in the future. Federal ownership of the area amounts to 43.3 percent, the majority of which is located on the Kirby Creek drainage area, as shown on the maps with this report. Private ownership is concentrated along Kirby Creek and throughout the Warm Springs and Buffalo Creeks drainage areas and accounts for 45.9 percent of the land in the subarea. The remaining 10.7 percent is in state ownership and is distributed throughout the subarea. Distribution of land use by ownerships is presented in table 5. The location of the several ownerships is shown on the maps with this report and on the map with the Preliminary report.

SURFACE RESOURCES

Rangeland

The subarea generally supports a sagebrush-grass association, with a few isolated stands of unmerchantable limber pine and juniper in the higher elevations. The more dense stands of sagebrush are located south of the Kirby Creek Divide. Location of these types and carrying capacities of each are shown on the Vegetative Type Map in Map Supplement "A" of this report. Species of sagebrush dominating this association are: Big sagebrush, silver sagebrush, fringed sagebrush, and black sagebrush. The grass dominants are: Prairie junegrass, bluestem wheatgrass, bluebunch wheatgrass, sandberg bluegrass, needleandthread, green needlegrass, blue grama, cheatgrass, and Japanese bromegrass. In some localities the sagebrush is absent, forming a grassland type with the same dominants as those in the understory of the sagebrush type.

The valley floor of Kirby Creek is occupied by a black greasewood type with an understory dominated by annual grasses and weeds. This type is a prime example of range deterioration and of departure from the climax species due to over use in the past. Dominant grasses in this type now are: cheatgrass, Japanese bromegrass, bluestem wheatgrass, blue grama grass, prairie junegrass, and sandberg bluegrass.

The area and recommended stocking rates of grazing lands in different ownerships within the subarea are given in the following tabulation:

Ownership	Acres	Animal Unit Months	Acres Per Animal Unit Month
Federal lands administered by Bureau of Land Management	118,149	17,566	6.7
State	28,717	5,660	5.1
Private	120,773	24,169	5.0
Total	267,639	47,395	5.6

Water Supply

Kirby Creek is the only stream in the subarea for which water discharge records are available. These records cover the period from June 13, 1941 to September 30, 1945. The gaging station was located in section 33, township 44 North, range 94 West and measured the runoff from 240 square miles of drainage area. The four and one-half years of records indicate an average annual runoff of 12,242 acre feet. The majority of the runoff occurs from March through June, although in January 1943 a total of 1,290 acre feet of runoff was recorded. This was only 410 acre feet below that of March of the same year. Variation in flow ranges from a maximum of 570 second feet down to no flow at times in August and during freezing weather. There are no published water supply records for the remaining 190 square miles of the subarea. This part of the subarea is higher in elevation and in amount of precipitation than the Kirby Creek drainage so it may produce more runoff per acre.

PROBLEMS AND PROPOSED ADJUSTMENTS

Land Use History

According to reports of early residents of the area, Kirby Creek was once a live meandering stream with flood plains supporting an excellent cover of desirable grasses. Early cattlemen used the Kirby Creek valley as a holding ground while making up their trail herds. The use during such periods was concentrated due to the necessity of restricting the movements of the cattle. A few cattlemen also used the valley as a winter range. In spring and summer the cattle ranged in the higher elevations from Buffalo Creek south to the Wind River Divide.

Watershed Breakdown and Erosion

The heavy grazing use of the Kirby Creek flood plains caused a breakdown of the vegetation and the displacement of the climax vegetation by inferior species. These inferior subclimax species with lower soil binding properties and probably a lowered density permitted the unstable soils in the main channel to start eroding. No corrective measures were taken at that time and the erosion of the channel continued. The drought of the early thirties added

to the problem by further weakening the vegetation. Lower Kirby Creek is now a gully 15 to 20 feet deep and 40 to 50 feet wide for the last 14 miles of its course. This gully has caused a serious lowering of the water table in the valley floor and additional deterioration of the vegetative cover. The creek has ceased to flow permanently in the gully and black greasewood has dominated the valley floor.

Except for smaller numbers of stock, cessation of trail use, and the lack of hay meadows along Kirby Creek, the use of the area remains about the same as in the past. The main drainage area of Kirby Creek is used as winter range by the large operators and as summer range by a few of the smaller operators. These small operators have an allotment on the north side of Kirby Creek known as the Lucerne group allotment. This group runs cattle on the allotment during the spring, summer, and fall. This allotment receives very heavy use under present permits which also allow winter sheep use. A reduction of about 25 percent in stocking rate is needed on this allotment. Additional management practices are needed to distribute the livestock over the allotment and to prevent their concentration on the better areas. During the winter their stock are held in feed lots in the cultivated areas where forage crops are fed.

The large operators use the south side of Kirby Creek as winter sheep range and feed forage crops grown on cultivated land only as forced to do so by the elements. Several of these operators also run cattle on these same allotments during spring, summer, and fall. These large operators move their sheep south of the Kirby Creek drainage to the Buffalo Creek drainage area, where the land is predominately privately owned, for spring, summer, and fall grazing. This range is outside of the grazing district and the public domain lands there are leased under Section 15 of the Taylor Act. Dual use by cattle and sheep is prevalent on these lands.

The northern portion of the subarea is largely below 5,000 feet elevation with a desert climate. The irregular undependable precipitation largely occurs as sudden severe summer storms. This rain cannot be absorbed by the heavy clay soils of low permeability which are common in that portion of the subarea. These conditions call for careful management of limited grazing to maintain a vegetative cover in good condition.

Erosion and Sedimentation Control

There are no records available to indicate the amount of sediment contributed to the Bighorn River by Kirby Creek, but the total is evidently very large. The tributaries are beginning to cut gullies across the valley floor to further complicate the problem. The upper reaches of Kirby Creek are not a serious erosion problem except for the water transported to the gully below. Some sheet erosion is taking place here, although it is not serious. Degrees of erosion in the subarea are shown on the Erosion Map in Map Supplement "C". The Proposed Improvements Map, Map Supplement "D" of this report, shows improvements planned to control erosion.

To be successful, any erosion control program or watershed treatment must be fitted to the physical land characteristics irrespective of ownership. When needed structures are proposed on private or state lands, it is recognized that the Bureau of Land Management cannot construct them. It would be possible to cooperate with individuals and other governmental agencies by furnishing technical advice. It is recommended that three large detention dams be constructed on the Kirby Creek gully in the approximate locations shown on the Proposed Improvements Map. Purpose of these dams is to retain sediment, to control flood flows, and to divert flood flows to waterspreading systems. These dams would also provide for erosion control and stock water. Smaller dams would be needed on the side drainages in addition to those on the main draw. Excess water from these reservoirs would be utilized in waterspreading systems to irrigate the adjacent flood plains.

This gully is influencing use and grazing pressure on the public domain lands in the drainage area, so it is actually a problem of the whole drainage area. Water from the public domain watershed must leave the area through the gully on privately owned land, and the feed formerly furnished by the meadows is now demanded from the public domain range or purchased if necessary. The gully will gradually work back onto the public domain, decreasing its value and increasing the erosion and utilization problems there. To prevent this it is important that the gully be controlled at its present site and rehabilitation of the devastated area be undertaken.

In addition to the structures on the main gully, the flood waters from Upper Kirby Creek should be controlled. Eight large detention dams are proposed on the main creek and on the large tributaries above the main gully. The primary purpose of these dams would be to lower the flood crests and to allow the discharge to be spread over a longer period of time. Overflow from the spillways would be utilized in waterspreading systems where feasible. Proposed waterspreading areas total 455 acres in the subarea, all being within the Kirby Creek drainage. If the above practices are carried out it would not be necessary to reseed the flood plains. It would be advisable to eradicate the greasewood to allow the grasses to make a more rapid recovery.

This program, when completed, would have both on-site and off-site benefits. The on-site benefits would be the returning of the valley floor to its former productive state and the termination of erosion damage. The off-site benefits would be the virtual elimination of sediment contributions from Kirby Creek to the Bighorn River and to downstream works. Most of the area south of the Kirby Creek drainage presents no serious erosion problems. Minor areas need erosion control structures, as shown on the Proposed Improvements Map in Map Supplement "D". Most of this portion of the subarea is in good condition and the majority of the gullies are healing over.

Proposed Improvements

A summary of the improvements proposed on both private and Federal lands in the Kirby Creek subarea is as follows:

	Federal	Private	Total
Stockwater Reservoirs (Number)	51	36	87
Spring Developments (Number)	2	7	9
Reseeding (Acres)	--	1,876	1,876
Brush eradication (Acres)	4,873	9,247	14,120
Waterspreading (Acres)	--	455	455
Check dams (Number)	2	--	2
Insect control (Acres)	25,000	3,000	28,000
Rodent control (Acres)	40	765	805
Large dams (Number)	7	4	11

The location of these improvements is shown on the Proposed Improvements Map, Map Supplement "D" of this report. Their benefits and costs are considered in the last section of this report.

Landownership Pattern

The pattern of landownership is a problem in the southern portion of the subarea located between the Wind River Divide and the grazing district boundary. The majority of this land, as shown on the maps, is in private ownership with many small isolated tracts of public domain. There are fairly large blocks of public domain lands in township 42 North, ranges 91, 92, and 93 West. These large blocks of land, due to unstable soil types, sparse vegetation, and rough topography, constitute a critical watershed problem. In addition to the watershed use, which demands careful management and control, these large blocks of land serve other uses for grazing, wildlife habitat, and oil production. Due to their coal and other mineral reserves, these critical areas may become even more important in the future development of the basin. Because of these multiple uses and the watershed problems, these lands should be retained in government ownership.

All public domain lands outside the grazing district are leased under Section 15 of the Taylor Act. Due to their generally poor quality, these lands were unsuited for acquisition under any of the land laws. The isolated nature of the small tracts of public domain lands south of the grazing district creates problems of administration. The proper development of a comprehensive improvement program would call for the cooperation of many individuals if it is to be successful. This cooperation is difficult and many times impossible to obtain in an area of varying and complicated ownership. These isolated tracts are not in an area of critical watershed problems. Due to the small percentage of Federal lands, any contribution made by the Bureau of Land Management toward improving this area would be insignificant. Any improvements needed could be carried out by private owners with the aid of local Soil Conservation Districts.

Private lands along the main stem of Kirby Creek prevent the Bureau of Land Management from doing any actual erosion control work on the main gully. However, this agency should cooperate with the Soil Conservation District and the ranchers involved in rehabilitating the entire area. A land exchange program should be initiated to dispose of Bureau of Land Management lands in the subarea which present no serious problems and which do not provide significant multiple land uses. The isolated tracts of public domain south of the grazing district

boundary are in this category. Such lands would be exchanged to consolidate multiple use problem areas administered by the Bureau. These exchanges would endeavor to consolidate the critical watershed problem areas within the subarea first, but if such arrangements were not feasible, the exchanges would be used to consolidate the Bureau's multiple use administrative areas elsewhere. This program, when completed, would greatly simplify administration of the area. This is especially true when proposals for range improvements and watershed management are considered.

The stock driveway withdrawal in sections 18 and 19, township 42 North, range 93 West is not used for driveway purposes. It is not on any route used in the movement of livestock and is so isolated from such a route that it cannot be used as a stock rest. At present, it is allotted to qualified applicants. The withdrawal should be revoked and the lands restored to public domain status. The remaining stock driveway is used in trailing stock from the winter range in the Kirby Creek drainage to the spring and summer range in the Buffalo Creek drainage. Consideration should be given to the advisability of extending the grazing district boundary southward so as to include the large blocks of public domain lands consisting of critical watershed areas located in township 42 North. Under district management, more stringent controls over numbers and classes of stock and seasons of use could be exercised.

NOWOOD - NO WATER SUBAREA

Description

This subarea covers all of the land east of the Bighorn River between the northern divide of Kirby Creek to the southern divide of Shell Creek, as shown on the map of the subareas, figure 7. From the Bighorn River on the west, the area extends eastward across the rough badlands and terraces to the Bighorn Mountains. The mountains rise steeply in the northern portion of the area to high snow-covered peaks. In the southern portion, the mountains rise more gradually to a rounded grass and brush-covered range. The northern portion of the mountains is within the Bighorn National Forest. The principal drainages of the area are the Nowood River and No Water Creek and their tributaries. Headwaters of these streams are in the high mountain areas where snow is the principal source of water. The Nowood River is a live stream while No Water Creek is a live stream only in the upper reaches of its course.

The subarea includes 2,235 square miles. Elevations range from 3,700 feet at the river to 13,186 feet on Cloud Peak, the highest point on the Bighorn Basin divide. Geological formations vary from the highly erodible and unstable Willwood clays, sandstone and shales and the Cody shales of the lower elevations to the massive limestone and Pre-Cambrian rocks of the higher mountain areas. Soils are as varied as the parent materials from which they have been developed. The unstable Willwood and Cody shales have eroded into fantastic badlands which support only scant vegetation, as shown in photograph 17.

The Chicago, Burlington and Quincy Railroad and U. S. Highway No. 20 provide north and south routes along the western edge of the subarea. East-west routes are furnished by U. S. Highway No. 16 from Worland through Tensleep and across the divide to Buffalo, and a state secondary highway from Manderson to Hyattville. Earth roads and trails lead from these main roads throughout the area making nearly any point in the area fairly accessible by automobile. Worland and Tensleep are the important trade and social centers of the subarea.

Photograph 17. -Badlands typical of a wide belt just east of the Bighorn River. This picture was taken near Worland along Highway No. 16.

Land Use and Ownership

Approximately 96 percent of this subarea is used as grazing land and the remainder is cultivated. Oil and gas are produced in the subarea and bentonite and other minerals occur. The majority of this land, approximately 65 percent, is in Federal ownership. Lands in private ownership account for 28 percent of the total. State-owned lands account for the remaining seven percent of the subarea. Some of the private lands are located in narrow bands along the creek bottoms and adjacent to the Bighorn River. These private lands are used chiefly in the production of irrigated crops. The majority of the private land is summer range located in the higher elevations along the Bighorn-Powder River divide south of the National Forest. A small area of this land is dry-farmed. The private lands along the Bighorn and Nowood Rivers were patented under the 160-acre Homestead Law, while those in the higher elevations were patented under the Stock-Raising Homestead Law. Location of the lands by types of ownership are shown on the maps in Map Supplements "A", "B", "C", and "D" with this report. Total acreage in the various classes of ownership and use is shown in table 5.

Rangeland

This subarea supports a wide variety of vegetative types, the most extensive being the sagebrush type, as shown on the Vegetative Type Map in Map Supplement "A" of this report. This type extends over all of the area except the northwest part where a saltbush type occupies a heavy clay soil. Throughout the remainder of the area, it is broken locally by associations of black greasewood, saltbush, waste, juniper, grass, and open pine. Important species found throughout the sagebrush type in the lower elevations are: Bluestem wheatgrass, blue grama grass, prairie junegrass, big sagebrush, fringed sagebrush, and several annual grasses and weeds of no importance except as indicators of overgrazing. In the mountain areas, bluebunch wheatgrass and Idaho fescue replace the bluestem wheatgrass and blue grama grass of the basin areas. The majority of this type at the lower elevations is in fair condition, with a few localities in good condition. Land use capability and condition for the subarea is shown on the Land Use Capabilities and Condition Class Map in Map Supplement "B" of this report. The mountain sites of this type are generally in good condition. Erosion on this type is classed as moderate to severe in the basin floor area, with local areas classed as severe to critical. The mountain areas which have a better vegetative cover have only slight to moderate erosion. Erosion conditions of the subarea are shown on the Erosion Condition Map in Map Supplement "C" of this report.

The majority of the saltbush type is located adjacent to the Nowood River, with smaller areas scattered throughout the lower elevations. This type supplies a very sparse ground cover and, as a rule, 80 to 90 percent of the vegetation is saltbush. Condition of the saltbush types was generally fair, although a large amount was classed as being in poor condition. Due to the sparse vegetative cover and the unstable soil types, erosion is rated as severe over most of the area. On many of the waste areas interspersed in this type, the erosion was classed as totally destructive. Species other than saltbush found in this type are: Bluestem wheatgrass, blue grama, squirrel tail, and several annuals. The northern edge of this area is being invaded by the poisonous annual weed, Halogeton. Black greasewood, as a type, occupies the smallest area of any plant association in the subarea. This type is found

in a narrow stringer along the East Fork of No Water Creek. Alkali sacaton, bluestem wheatgrass, and blue grama grass make up the understory of this type.

The grassland type is scattered throughout the subarea. This type was probably more extensive at one time, but due to overuse sagebrush has invaded much of the area. Dominants of this type in the lower elevations are: Bluestem wheatgrass, blue grama grass, prairie junegrass, threadleaf sedge and sandberg bluegrass. Bluestem wheatgrass and blue grama grass are displaced by bluebunch wheatgrass and Idaho fescue in the higher elevations.

A few open pine types are found adjacent to the Big Horn National Forest. The area covered by this type is small in extent with an understory composed of the same grasses found in the grassland type at the same elevation. Juniper types are generally found on the rocky ridges. This type supports a sparse understory of forage plants, hence the carrying capacity is low.

Waste range makes up the final type in this subarea. Badlands in the lower elevations make up the majority of this type. These are areas of raw outcrops of the Willwood and Cody shales which support very little vegetation, as shown on the Vegetative Type and Capability Maps in Map Supplements "A" and "B". An outstanding example of this type is the area known as the "Honeycombs" between Worland and Tensleep. Waste range in the mountains is found in dense timber of little grazing value, in areas of very steep topography and in inaccessible canyons.

Woodland types occur at the higher elevations. Species are Douglas fir and Ponderosa pine, with some limber pine, Engelmann spruce, alpine fir, and lodgepole pine. A considerable amount of this timber is inaccessible and is chiefly valuable for watershed protection and wildlife habitat. Accessible portions of the type are mainly valuable for rough lumber, posts, poles, and pulpwood. Timber sales in 1950 and 1951 were 3,000 M. B. F. of saw timber and 1,200 posts.

Proper stocking rate of the subarea varies widely from the lower elevations to the mountain ranges, as shown on the Vegetative Type Map in Map Supplement "A". The area and recommended stocking rates of grazing lands in different ownerships within the subarea are as follows:

Ownership	Acres	Animal Unit Months	Acres Per Animal Unit Month
Federal lands administered by Bureau of Land Management	926,529	110,421	8.391
Other Federal Lands	4,722	767	6.156
State	103,050	16,976	6.070
Private	345,787	82,672	4.182
Total	1,380,088	210,836	6.546

Water Supply

Records of runoff are available for approximately one-half of the subarea. These records are not continuous and must be considered only as giving an indication of the amount of water the area will supply. The following is a list of the gaging stations, the area covered by the gage and the average annual runoff in acre-feet for the years of record.

No Water Creek	300 sq. mi.	1941-1944	6,660 acre feet
Nowood River	805 sq. mi.	1938-1943	77,623 acre feet
Canyon Creek	66 sq. mi.	1939-1944	25,270 acre feet
Paintrock Creek	164 sq. mi.	1920-1927 1941-1949	92,807 acre feet

Canyon Creek and Paintrock Creek are tributaries of the Nowood River. The gage on the Nowood is located above the mouth of these two tributaries. Since these stations gage the runoff for the snowy mountainous regions, it can be assumed that the remainder of the area produces considerably less water. The period of high runoff generally occurs from May through July, although the records show that in March and April of 1943 an extremely heavy runoff occurred. While a large amount of water is diverted for irrigation, there appears to be no shortage except in unusually dry years.

Land Use History

Until the passage of the Taylor Act in 1934 there was no control over the use made of the public domain lands. Prior to that time excessive numbers of stock were run on the basin floor during winter, and the higher elevations were utilized just as heavily during spring and summer. Heavy overgrazing and consequent depletion of the vegetative cover resulted. Depletion of the vegetative cover was followed by accelerated erosion which took much of the thin layer of top soil from the area. Overstocking continued even though it was obvious that the surface resources were being ruined. Later, homesteaders filed on the land adjoining the Bighorn River and larger streams. Still later, the majority of the better land on the mountains was filed on under the Stock-Raising Homestead Law. Status of the lands is shown on the maps in Map Supplements "A", "B", "C", and "D" of this report. These homesteaders also had livestock which ran on the public domain, thus adding to the grazing load on the "free range". With the passage of the Taylor Act, the use of the range was brought under a degree of control. The tramp operator was ruled from the range, numbers of legitimate stock were reduced and class of stock and seasons of use were regulated.

Present use of the area is fairly well regulated as to season of use, numbers and class of stock. That portion of the subarea north of the Nowood River up to the base of the mountain is used as winter sheep range. Most of the western one-third of the area south of the Nowood River is also used as winter sheep range. Part of this area southeast of Worland has a small amount of summer cattle use in addition to the winter sheep use. These cattle belong to small operators who depend largely on cultivated crops for their income. They winter their stock in feed lots and cultivated pastures on private lands. East of range 90 West to the base of the mountains is a winter range chiefly used by cattle. Forage crops grown on private land are used to supplement the native range during the winter months. The majority of the mountainous range is used as late spring and summer range by cattle. Sheep are mainly on the National Forest during the summer.

Approximately 75 percent of the operators along the Nowood River between Bonanza and Manderson have no grazing rights on the public range. These farmers grow cash crops of small grain and beans, and the few head of stock which they

own never use the public range except in trespass. Those who have range allotments grow about half cash crops and half forage crops to supplement the forage obtained from the native range. The cultivated area adjoining the Bighorn River is used mostly in the production of cash crops of sugar beets and field beans. Some small grains and forage crops are also grown. The remainder of the cultivated land in the subarea is used to grow forage crops as a supplement to the range lands. A small portion of this is in the higher elevations where forage crops are grown by dry farming practices.

There are two sawmills operating in the subarea; a small one at Tensleep and a relatively large one at Hyattville. Timber is purchased from lands in all types of ownership, largely from the Big Horn National Forest. The small mill produces only rough lumber, while the one at Hyattville produces finished lumber at a planing mill in Worland. Posts and poles are produced by both companies to supply local demand.

PROBLEMS AND PROPOSED ADJUSTMENTS

Watershed Breakdown and Erosion

During the period of unrestricted free-use before the passage of the Taylor Act, stock was run on the range without regard to actual carrying capacity or proper land use. This practice, in combination with an unfavorable climate and unstable soils, led to depletion of the vegetation. The most desirable species were replaced by plants of inferior quality which were also lower in soil binding properties. Accelerated erosion was a natural sequence to the breakdown of the vegetation. Much of the thin layer of top soil went "down the river". With the operation of control provided for by the Taylor Act, much of the abuse was eliminated. The damage, however, had already occurred and erosion continued at a rapid rate because of the low quality and quantity of the vegetation. Most of the subarea is below 5,000 feet in elevation. This lower portion has a desert climate with many unfavorable conditions for plant growth. In this part the soils are principally heavy clays of low permeability causing a heavy runoff from the sudden summer storms which furnish most of the limited precipitation. These

conditions call for careful management of the grazing resource and make it difficult to establish a new plant cover.

Erosion and Sedimentation Control

Under the administration of the Bureau of Land Management, there has been considerable recovery of native vegetation, but substantially more improvement is both feasible and desirable. Many depleted areas would reestablish the climax vegetation if the grazing load were lessened. Other areas have been more severely depleted and will require reseeding or other rehabilitation measures to improve the forage production. Reseeding has been proposed on 10,063 acres of the subarea, as shown on the Proposed Improvements Map in Map Supplement "D".

Areas of dense sagebrush furnish a low quality forage and produce less pounds of gain per animal than grass does. It also makes inefficient use of soil and moisture by producing a high percentage of woody material instead of usable forage. Once the competition for water and light between the sagebrush and grasses is removed, the sites will produce an additional amount of grass thereby increasing the recommended stocking rate. Sagebrush areas which support a sparse understory of desirable grasses have been recommended as reseeding sites when the sagebrush is removed. Removal of sagebrush is recommended on approximately 25,800 acres of the subarea. Areas requiring sagebrush removal have been delineated on the Proposed Improvements Map in Map Supplement "D".

Erosion control in the form of contour furrows, waterspreaders and detention dams will prevent further loss of top soil and aid in the production of additional forage. The crests of flash floods and their velocities would be lowered and their most damaging power curtailed. These projects would also store the sediment on the site and not in the expensive reservoirs on the main streams. A total of 130 detention dams, ranging in size from about 6,000 cubic yards to about 40,000 cubic yards have been proposed for the subarea. These dams, in addition to flood control and sediment storage, would also supply badly needed stockwater for the area. Drawdown tubes to allow the reservoirs to drain slowly would be installed in each of them. This feature would generally empty the reservoir before the

next flood and make a semi-permanent stream of what are now dry gullies. Bank sloughing would be greatly reduced and under the increased moisture vegetation would become established in the channel, further stabilizing the banks. In addition to erosion control, these structures would furnish needed water for livestock.

Proposed Improvements

Improvements proposed on Federal and other lands in the Nowood-No Water subarea are as follows:

	Federal	Other	Total
Stockwater reservoirs (number)	499	138	637
Reseeding (acres)	8,511	1,552	10,063
Brush eradication (acres)	12,545	13,353	25,898
Waterspreading (acres)	8,411	2,030	10,441
Contour furrows (acres)	1,850	1,042	2,892
Check dams (number)	784	41	825
Insect control (acres)	75,000	10,000	85,000
Rodent control (acres)	2,380	915	3,295
Poison weed control (acres)	1,000	500	1,500
Large dams (number)	119	21	140

The location of these improvements is shown on the Proposed Improvements Map, Map Supplement "D" of this report.

SHELL-KANE SUBAREA

Description

This subarea encompasses all of the land outside of the Big Horn National Forest and east of the Bighorn River from the Montana-Wyoming line south to the southern divide of Shell Creek, as shown on the map of the subareas, figure 7. Shell Creek, including its tributaries, is the largest and most important drainage system in the subarea. Trout, Deer, and Porcupine Creeks drain the northeast corner of the area. Headwaters of these creeks are on the Big Horn National Forest and their confluence with the Bighorn River is on the Crow Indian Reservation. Other drainages of the area are Cottonwood, Five Springs, Crystal, and Bear Creeks.

The subarea covers 753 square miles of rough broken land and mountains. Cultivated lands are virtually restricted to bottom lands along the Bighorn River and Shell Creek. Elevations vary from below 4,000 feet along the river to over 10,000 feet on the mountains in the National Forest east of the area. Here the mountains rise steep and sheer from the basin floor. The highway from the Bighorn Divide to Kane winds down the precipitous mountain face like a cobweb suspended from the mantel to the floor. Highway No. 14 connects Greybull and Shell and extends up scenic Shell Canyon over Granite Pass eastward to Sheridan. The view of the basin from the mountains is extensive and impressive. The Medicine Wheel and the Dinosaur Beds are in this subarea.

Land Use and Ownership

Grazing is the principal land use of the subarea, employing 95 percent of the surface. Cultivation utilizes four percent and one percent is water surface and urban area. Oil and gas production is important in the subarea. Bentonite is mined and processed and other minerals are found in the subarea. Federal ownership makes up 74 percent of the subarea, private ownership is 21 percent and state land is 5 percent. Location of the lands in different ownerships is shown on the maps with this report and on the map with the preliminary report. The areas in classes of ownerships and uses are shown in table 5. The private land is principally located along Shell Creek and at the higher elevations providing summer range adjacent to the National Forest in the northeast and

southeast parts of the subarea. Minor areas of private land are along the Bighorn River and creeks.

NATURAL RESOURCES

Rangeland

Present land use of 96.3 percent of this subarea is for grazing. The remaining 3.7 percent is used in the production of cultivated crops. Of the total 481,480 acres in the subarea, 73.8 percent is in Federal ownership. State ownership accounts for 4.7 percent of the total and the remaining 21.5 percent is in private ownership. The bulk of the private land lies adjacent to Shell Creek and its main tributary, Beaver Creek, and a small amount borders the Bighorn River. A relatively large block of private land is located in township 57N., R. 93W., and another in township 52N., R. 89W. The cultivated land along the Bighorn River and along Shell Creek is all under irrigation, while private lands in the higher elevations are used as grazing lands. The maps give the location of other small tracts of private land throughout the area.

There is a wide variation in carrying capacity from the lower elevations to the mountains. The better grazing lands are located at the higher elevations. The area and recommended stocking rates of grazing lands in different ownerships within the subarea are given in the following tabulation:

Ownership	Acres	Animal Unit Months	Acres per Animal Unit Month
Federal lands administered by Bureau of Land Management	355,394	19,491	18.233
State	22,426	1,905	11.772
Private	81,708	8,905	9.175
Total	459,528	30,301	15.165

Saltbush and sagebrush are the two most extensive vegetative types of the subarea. Saltbush generally occupies the area between the Bighorn River and the base of the mountains from Crystal Creek south to the southern boundary of the subarea. This type is broken locally by waste range and sagebrush types, as shown on the Vegetative Type Map in Map Supplement "A". Important species found in this type are bluestem wheatgrass, sandberg bluegrass, blue grama grass, and also several annuals.

The sagebrush type is quite extensive, being found on the better soils of the basin floor and extending up the mountains to the Big Horn National Forest. In the mountains, this expanse is broken by timber, grass, and waste types. Dominants of the sagebrush type in the lower elevations are: blue grama grass, bluestem wheatgrass, prairie junegrass, threadleaf sedge, sandberg bluegrass, and both big and black sagebrush.

Budsage is the dominant plant found in an area of several sections in T. 56N., R. 94W. This is in an area of shallow, rocky soils which supports few plants other than budsage. In the higher elevations, bluebunch wheatgrass and Idaho fescue replace the bluestem wheatgrass and blue grama grass as the grass dominants in the sagebrush type.

A narrow stringer of Juniper is found along the base of the mountain. It extends from Shell Creek north to the Montana state line. Dominants of the sparse understory are black sagebrush and bluebunch wheatgrass. Rocky, shallow soils are characteristic throughout this type. Timber in this type is valuable only for fence posts. There is no commercial demand for the product. Ranchers cut some posts from the type. Timber types of pine and Douglas fir are found along the forest boundary and in several of the canyon areas.

Waste land in the lower elevations is usually due to bentonite and shale outcroppings. These areas support very little vegetation and generally present high erosion problems. Areas of very steep topography, inaccessible canyons, and dense timber in the mountains are also classed as waste.

Water Supply

Water discharge records covering a nine-year period are available for Shell Creek. The station was established in October 1940 and was still operating in 1951. However, records have been published only through 1949. The gaging station is located five miles east of Shell and records the runoff from 148 square miles of mountainous range. The average annual runoff during the nine years of published records is 89,095 acre feet. Much of this water is diverted for irrigation purposes before it reaches the Bighorn River. The remaining creeks of the subarea are either intermittent or flow through deep canyons, and their flow is not used for irrigation purposes in this subarea. Although no records are available for these creeks, it seems reasonable that Porcupine and Deer Creeks would produce proportionately as much water as Shell Creek. The other creeks would produce considerably less due to the lower elevations of their headwaters and because they are intermittent streams.

History of Use

The earliest grazing use made of this area was by ranchers in the vicinity of Lovell. These ranchers were from high rainfall belts of Texas where forage production was excellent. They attempted to stock the range at the same rate as the Texas range. Under arid climatic conditions this proved to be severe overuse. Ranchers coming on the scene at later dates merely added their stock to the already overloaded range. There was no authority to force an adjustment of numbers so the range potential was severely impaired by overgrazing.

Homesteaders were attracted to the area under the 160-Acre Homestead Act. They filed on the land adjoining the Bighorn River and Shell Creek and its tributary, Beaver Creek. Most of this land was placed under cultivation. These ventures were successful when the soil and drainage were suitable for irrigation. Abandoned fields show that all land in the area was not suitable for crop production. Each of these homesteaders had a few head of livestock which they added to public range. The private lands in the mountains passed into private ownership under the Stock-Raising Homestead Act. Here again, the stock on the "free" range was increased. Although this abuse of the range was stopped with the administration of use provided for by the Taylor Act, the damage had already occurred.

Except for smaller numbers of stock and elimination of the tramp operator, the area is used much the same as in the past. The area between the Bighorn River and the base of the mountain from Crystal Creek south to the southern boundary of the subarea is used as winter sheep range. The land to the north of Crystal Creek is used as spring, fall and winter cattle range. South of Shell Creek, the higher elevations are used as spring and summer range by both cattle and sheep. The majority of both sheep and cattle are run on the Big Horn National Forest during the summer months. The area of spring-fall range is very limited in this subarea because the mountains rise abruptly, causing a transition almost directly from winter range to summer range.

PROBLEMS AND PROPOSED ADJUSTMENTS

Shortage of Spring-Fall Range

This typical problem of the basin is acentuated in this subarea because of the steep western face of the Big Horn Mountains which rises directly from the sparse winter range of the desert basin floor to the summer range on the mountains. Both foothills and spring-fall range are virtually lacking in this subarea. This unfortunate natural condition is to no small extent responsible for the poor condition of the basin range in the subarea. It is necessary to provide spring-fall feed on tame pastures and to properly utilize the basin winter range so that it may recover to good condition. All lands which can advantageously produce spring or spring-fall feed by planting rye, crested wheat grass or other adapted plants should be developed. All areas of lower grade irrigable land which are not suitable for row crops should be developed for mixed pasture to alleviate the shortage of spring-fall range in this subarea. This problem calls for the individual study of each operators resources and work program, and a corresponding intensive action program. This program will probably include some major realignments of land use and will call for considerable intensive development.

Watershed Breakdown and Erosion

The heavy use given the area by the early settlers and an unfavorable climate led to severe depletion of the vegetation. Under these conditions, the most desirable species were soon displaced by less palatable plants. Thus, an area that once supported a grassland type was soon taken over by big sagebrush or other less productive plants. Areas of poorer soil which supported saltbush did not change in aspect as the grassland type did. Saltbush continued as the dominant species; however, the density and vigor of the plants were reduced and associated grass species virtually disappeared. Sagebrush is now so vigorous and dense on some areas that use of the understory of grasses is denied livestock grazing the area.

With this deterioration in vegetation came an increase in erosion. The subclimax vegetation was lacking in the soil binding properties of the climax. A considerable amount of soil was transported from the area. Under control established as a result of the Taylor Act, the mountainous portions of the area made a good recovery. This is probably due to the higher rainfall and better soil. Sagebrush is dense on the mountains, but a good understory of grasses with high soil binding qualities is also usually present. A study of the Erosion Maps in Map Supplement "C" of this report will show the various areas of critical erosion.

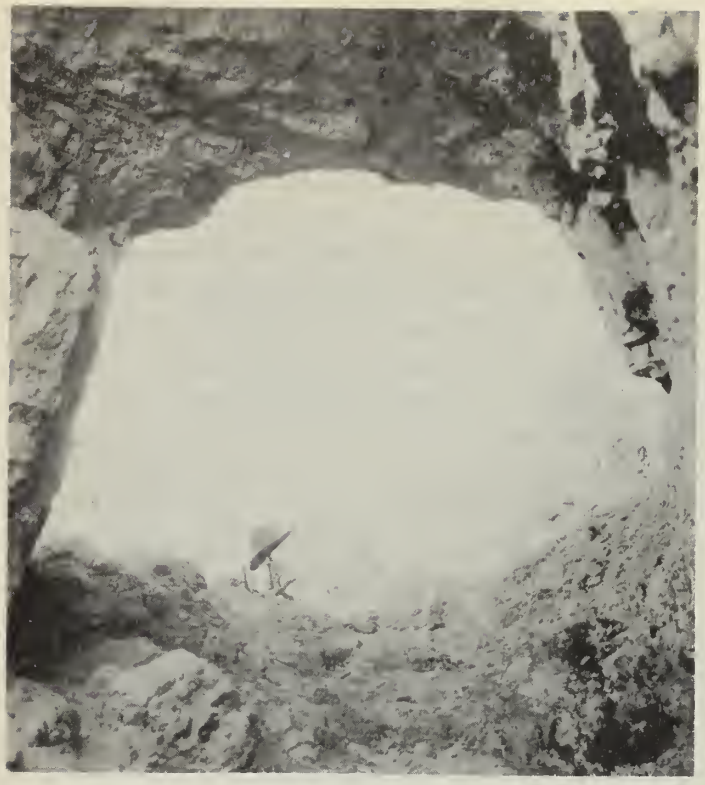
Much of the subarea is below 5,000 feet in elevation with limited rainfall from sudden summer storms. Most of this portion has heavy clay soils with low permeability and consequent heavy runoff. This part requires careful management of limited grazing to preserve the vegetative cover in good condition. Once the cover is damaged, it is very difficult to reestablish desirable species because of the desert climate.

The heavy clay soils of the saltbush areas present the most critical erosion problem of the subarea. The sparse vegetative cover of this type offers no protection against splash erosion from raindrops. During rainstorms the clay soil quickly seals over because of its poor permeability, causing an excessive amount of runoff. Runoff water has virtually nothing to retard its flow on this type of soil, and carries an extremely heavy load of sediment with it.

A soil and moisture conservation program is now in the construction phase on much of this subarea. When it is completed, much of the water and sediment which was formerly carried from the subarea will be held there.

Runoff waters concentrate in channels where they cause more erosion by channel degradation and bank sloughing, as shown in photographs 18 and 19. In addition to erosion and sediment production, further damage results from gullies because of the drainage and drying out of the adjacent soil area, reducing the potential of the range site.

Photograph 18. -Wildhorse Draw near Basin, Wyoming. Recent gully erosion has formed the 40-foot vertical clay banks with a bottom 200 feet wide. This and countless smaller gullies contribute enormous amounts of sediment to the Bighorn River by bank erosion and degrading.



Photograph 19. -Caves, arches and tunnels in the clay banks of draws are common in the Bighorn Basin. This one is on Wildhorse Draw. They are caused by water acting on unstable soils.

Erosion and Sedimentation Control

Erosion conditions are critical in the Torchlight area which extends from Shell Creek to the southern boundary of the subarea. This condition is being brought under control by an active resource development program of the Bureau of Land Management. Completion of the program at an early date is anticipated. When completed, this development should control the movement of water and sediment from the area. An aerial view of a waterspreading system is shown in photograph 20. Photograph 21 shows a diversion dam and ditch in this vicinity.

The area between Crystal Creek and Shell Creek, especially in the lower elevations, presents a critical erosion problem. Extremely heavy use has severely depleted the vegetation and the heavy clay soil type is very susceptible to water erosion. Waterspreading and contour furrowing are needed on 16,862 acres of this area. These improvements will not only improve the vegetative cover, but will retard the flow of water and sediment. When it is impossible to control sediment by the above methods, large sediment detention structures are recommended on the main channels. Construction of these dams should be followed

immediately by tree and shrub plantings in the channels below. Location of these structures should be the best sites available irrespective of landownership. Locations of these recommended practices are outlined on the Proposed Improvements Map in Map Supplement "D" of this report. From Crystal Creek north to the Montana state line, erosion conditions are not so critical as on the above mentioned areas. Local areas of critical erosion occur, although the major portion is not an erosion problem. Waterspreading, mainly to improve the vegetation, has been recommended.

Photograph 20. -Diversion dam and waterspreading system near Greybull, Wyoming. Some of the small dikes are still full of water from melting snow.

Submarginal Cultivated Lands

Several tracts of land which are now cultivated in T. 52N., R. 92 and 93W., have a very poor soil and inadequate drainage for the production of cultivated crops. Due to these factors, a number of other tracts, formerly under cultivation, have now been abandoned. In addition to the soil and drainage factors, the maintenance of the excessively long irrigation canal serving these lands is an economic burden. It is doubtful that these submarginal farms will ever carry their share of this expense. Observations indicate that several tracts of cultivated land south of Shell Creek could be put to more efficient use in the production of tame pastures instead of cultivated crops. This would aid in reducing the load carried

by the range. These are private lands, so it will be up to the individual owner to carry out these proposals.

Proposed Improvements

The following is a tabulation of improvements proposed on Federal and other lands within the Shell-Kane subarea.

	Federal	Other	Total
Stockwater reservoirs(number)	193	35	228
Reseeding (acres)	8,452	2,705	11,157
Brush eradication (acres)	5,342	2,873	8,215
Waterspreading (acres)	2,690	1,495	4,185
Contour furrows (acres)	9,322	3,355	12,677
Check dams (number)	19	--	19
Rodent control (acres)	490	150	640
Large dams (number)	46	5	51
Poison plant eradication (acres)	310	120	430
Insect control (acres)	3,687	1,575	5,262

Location of these improvements is shown on the Proposed Improvements Map, Map Supplement "D" with this report.

Photograph 21. -View of a diversion ditch to pick up runoff waters and carry it to a dry lake bed. The dry lake is just to the right of the area shown.

BRIDGER SUBAREA

Description

The Bridger subarea includes the Montana portion of the study area. It is located in southeast Carbon County extending northward from the Montana-Wyoming state line to the township line between townships 5 and 6, as shown on the map of the subareas, figure 7. It is bounded on the west by the Custer National Forest, on the northwest by the Rock Creek-Clarks Fork Divide, and on the northeast and east by the Crow Indian Reservation and the Custer National Forest boundaries. This subarea is largely west of the lower portion of the Bighorn Basin as extended down to the Yellowtail Dam site, and is principally within the Clarks Fork drainage. The subarea is within the boundaries of Montana Grazing District No. 4.

The subarea covers 813 square miles of valley, bench and mountain land exclusive of Indian reservation and National Forest lands. Public domain and withdrawn lands in the area total 359 square miles. The Clarks Fork Valley varies from one to nine miles in width with foothills and mountains on the east and west. East of this drainage the area includes bench land and the foothills of the Pryor Mountains to the deep, rocky gorge of the Bighorn River Canyon. The Pryor Mountains are located on the Custer National Forest and on the Crow Indian Reservation in the eastern part of the area. Poverty Flats and the north end of Pole Cat Bench are an extensive area of level bench land at the base of the Pryor Mountains extending southward from Bowler to the Wyoming line.

Land Use and Ownership

Ninety-two percent of the subarea is used for grazing and eight percent is cultivated. The cultivated land is nearly all irrigated. A small amount in the north central part is dry-farmed with grain. Nearly all of the irrigated land is along the Clarks Fork River and its tributaries. The subarea is also utilized for oil, gas, coal, limestone, wildlife, and watershed. This subarea has the second largest portion of privately owned land, 51 percent. Federal land is 44 percent and State is 5 percent. The location of the land in different ownerships and uses is shown on the maps with this report. Distribution of the ownerships and uses is shown in table 5.

Rangeland

Grazing, the principal use of the land, is practiced on 91.8 percent of the total area of 519,621 acres. The remaining 8.2 percent is devoted to the production of cultivated crops, most of which are under irrigation. Federal ownership accounts for 44.3 percent of the subarea, state ownership 4.9 percent, and private ownership 50.8 percent. The major portion of the private land was acquired under the 160-Acre Homestead Law, Stock-Raising Homestead Law, and Desert Land Act. Land grants to railroads account for other portions of private land. Homesteads in this area were located on the best land available. Many are small irrigated farms on which cash crops of small grain, beets and beans are grown. Others serve a dual purpose of producing some cash crops as well as providing winter feed and pasture for livestock which are grazed on the public domain for the balance of the year.

The vegetative cover of the rangeland is divided roughly into four major types: sagebrush, grassland, saltbush, and waste range. Small areas adjacent to the National Forests support timber stands of poor quality. The sagebrush type is located in a wide belt through the center of the subarea and approximately 90 percent of the vegetative cover is made up of this type. Throughout this general sagebrush type many minor variations or subtypes exist. The main components of the sage association are big sagebrush, bluebunch wheatgrass, sandberg bluegrass and threadleaf sedge. The grassland types are small and are found along the outer fringes of the subarea. These types, like the sage type, have several variations, but the main associates are bluebunch wheatgrass, needleandthread, blue grama, prairie junegrass, and threadleaf sedge. The saltbush type occurs in scattered segments in the southern portion of the subarea, the largest of which forms a fingerlike projection north into the area along U. S. Highway No. 310 and the Chicago, Burlington and Quincy Railroad.

Small areas of waste range are found throughout the subarea. These small areas are due to outcrops of raw shale, rock bluffs and areas of such low density that little or no forage may be obtained by a domestic grazing animal. One particularly large area of waste range in the southeast corner

of the subarea was classified as such due to the roughness of the topography, the rocky shallow soil and the resultant sparse vegetative cover. Other areas of waste adjacent to the National Forests are due to dense stands of timber which afford little or no understory of grazing value, or are caused by sheer rock cliffs.

The area and recommended stocking rates of grazing lands in different ownerships within the subarea are as follows:

Ownership	Acres	Animal Unit Months	Acres per Animal Unit Month
Federal lands administered by Bureau of Land Management	229,819	19,105	12.0
Other Federal Lands	677	36	18.8
State	24,810	2,529	9.8
Private	220,665	32,875	6.7
Total	475,971	54,545	8.7

Water Supply

Water yield records are available for the Clarks Fork drainage of the subarea. These records are from two stations, one located one-half mile north of the Montana-Wyoming state line, and the other located a few miles north of the subarea at Edgar, Montana. This data covers a period of 28 years and indicates an average annual runoff of 706,915 acre feet at Edgar, while the station at Chance, Montana reports an annual runoff of 653,474 acre feet. The headwaters of the Clarks Fork River are high on the Shoshone National Forest. Further water yield information is not available.

Several areas of aesthetic interest are found within the subarea, but are seldom seen by the average citizen. Spectacular Bighorn Canyon, third deepest in the United States, is practically inaccessible. Mystic Cave offers a potential development similar to Lewis and Clark Cavern in western Montana. These areas could be developed into important recreation areas.

PROBLEMS AND PROPOSED ADJUSTMENTS

Land Use History; Watershed Breakdown and Erosion

The past history of this area follows much the same pattern exhibited by other areas similar in character. Prior to the advent of the white man, game roamed the prairies and mountains freely, held in check only by the biological balance of nature. With the great movement west, the potentialities of the range resources were realized and exploited by the large cattle companies. Horse outfits flourished by supplying horses to the army posts. Homesteaders migrated to the area to avail themselves of the "free" land under the 160-Acre Homestead Act. Later, additional inducements in the form of the enlarged Homestead Act and the Stock-Raising Homestead Act attracted many more. All brought livestock with them, and these were turned on the "free" range. This range belonged to the public and all had an equal right. Carrying capacity was unheard of as was proper range management. The once serene range, now teeming with livestock, began to come apart at the seams. The vegetative cover, sorely depleted by overuse, deteriorated and in some cases became almost nonexistent. Small waterways became gullies and many tons of soil were removed by more subtle sheet erosion.

Most of this subarea is below 5,000 feet in elevation. In the southern part this lower elevation land has a typical desert climate with very limited rainfall. The lower elevation soils are largely heavy clays of low permeability and high runoff which need careful management to preserve their limited cover. If the native vegetation is lost or damaged it is very difficult to establish new plants of desirable species. There are large areas of class VIII land in the subarea which scarcely have any feed and which should be used only for wildlife. These areas have been used for grazing and have been damaged.

The first step toward management came with controls established after the passage of the Taylor Act. Range administration under this Act placed a check on excessive use and marked beginning of the modern concept of proper use. The manner of grazing land use today is much different than in the past. The grazing load has been greatly reduced by the Bureau of Land Management and many ranchers have

followed suit on their private lands. The problem is still not solved, however, as indiciated on the Vegetative Type Map in Map Supplement "A". Many areas need specific attention, as indicated on the Proposed Improvements Map in Map Supplement "D".

Erosion and Sedimentation Control

Ranchers of the "free use" era overstocked the range. This heavy use caused a shift in composition of the native vegetation. The climax species decreased in extent and other less desirable plants increased. In places where the use was extremely heavy, the sub-climax species were decreased and invaders began to occupy the area. A reduction in productive capacity in terms of pounds of animal gain followed. In order to speed the recovery of the vegetation to its former productive capacity, reseeding is recommended on about 4,400 acres of the subarea. Areas proposed as reseeding sites have been shown on the Proposed Improvements Map in Map Supplement "D".

Sub-climax species which displaced climax plants in the native range had lower soil binding characteristics, so an increase in erosion followed. In order to prevent the movement of this sediment from the area and to conserve water, the following practices are recommended: (1) contour furrows on about 4,600 acres of land. Besides slowing down runoff it would increase the carrying capacity of the range. (2) thirty-one large detention dams with drawdown tubes are needed on the dry washes. The main purposes of these would be to take the crest from floods and allow a longer period of flow. This long period of flow would aid in the establishment of vegetation for stream bank stabilization.

Shortage of Stock Water

Lack of stock water in many areas results in uneven utilization of the range. Areas around existing waterholes are generally severely used, while those remote from water are lightly used. Consequently, lower gains per animal are realized under these conditions. In order to provide for the orderly and even utilization of the range resources, it is recommended that a program for the development of stock water be instituted. Locations for 105 stock water dams are shown on the Proposed Improvements Map in Map Supplement "D" of this report.

Proposed Improvements

All conservation and range improvement practices and structures proposed on Federal and other lands for the Bridger subarea are summarized as follows:

	Federal	Other	Total
Stockwater reservoirs (number)	52	53	105
Spring developments (number)	5	--	5
Reseeding (acres)	1,750	2,710	4,460
Brush eradication (acres)	3,127	2,101	5,228
Contour furrows (acres)	3,375	1,265	4,640
Rodent control (acres)	--	145	145
Poison weed control (acres)	160	430	590
Large dams (number)	15	16	31

The Proposed Improvements Map, Map Supplement "D" shows the location of these improvements.

Administrative Adjustments

Natural barriers create an administrative and access problem in connection with a portion of the Crow Indian Reservation boundary in the subarea. The Bureau of Land Management controls trespass and fire on Indian lands south of Porcupine and Trout Creeks because they are inaccessible from the reservation. Exchange of use has been proposed for that area with public domain lands north of Dry Creek.

SHOSHONE-ELK BASIN SUBAREA

Description

All of the lands north of the Shoshone River to the Montana-Wyoming state line west of the Bighorn River to the Shoshone National Forest are included in this subarea, as shown on the map of the subareas, figure 7. The Wyoming portion of the Clarks Fork River drainage outside the Shoshone National Forest is included. Shoshone project of the Bureau of Reclamation is mostly within this subarea. Buffalo Bill Reservoir and power plant, and the Heart Mountain power plant are here. Additional areas of bench lands are being considered for reclamation developments. Powell, Garland, and Byron are leading towns of the subarea, all on State Highway No. 14. Cowley, Deaver, and Frannie are on U. S. Highway No. 310. In addition to these communities, Cody and Lovell, on the south boundary, also serve the area. Thousands of tourists pass through the subarea on U. S. Highway's 14 and 20 en-route to Yellowstone National Park.

The subarea includes 1,274 square miles, exclusive of the National Forest. Nearly one-third of this area, 400 square miles, is public land. Elevations range from 3,800 feet to over 10,000 feet in the Absaroka Mountains within the National Forest west of the area. The Shoshone River is the largest stream tributary to the Bighorn River in the study area, and supplies the largest area of irrigated land. The Shoshone is supplied by a large area of high mountain watershed. The Clarks Fork is probably the largest tributary of the Yellowstone River, and also is provided by a large area of high mountain watershed in the Absaroka and Beartooth Mountains.

Land Use and Ownership

This subarea leads in the amount of cultivated land, 15 percent being devoted to this use. Eighty-four percent is used for grazing and one percent is water surface and cities. Oil, gas, sulphur, and bentonite production are important. Recreation and wildlife are important uses of the area. Private land is an important portion of the area, 44 percent being in that ownership. Federal land is 49 percent of the subarea, state land makes up 6 percent, and 1 percent is water surface and urban areas. Location

of landownership and uses is shown on the maps with this report, and their distribution is presented in table 5.

SURFACE RESOURCES

Rangeland

Grazing is the principal land use of this area at the present time, 84 percent of the total area of 814,494 acres being so used. Cultivation is practiced on the remaining 16 percent, the majority of such land being irrigated. Federal ownership accounts for 49.4 percent of the subarea. State lands cover 6 percent of the area, and water surface and townsites account for 1.1 percent. Private ownership accounts for 43.5 percent of the land. This land has passed into private control under several of the land laws. Railroad land grants accounts for the "checkerboard" land pattern in the northwest corner of the subarea. Other tracts were patented under the Carey Act, the 160-Acre Homestead Law, the Stock-Raising Homestead Law, the Desert Land Act, and under the Reclamation Homestead Act. Approximately 30,000 acres of Reclamation land is now in the process of passing into private ownership, while other tracts are scheduled for future development. The base of all the maps in Map Supplements "A", "B", "C", and "D" show the pattern of landownership in the area.

The recommended stocking rate of all lands in the subarea which are used for grazing averages 7.3 acres per animal unit month. The area and recommended stocking rates of grazing lands in different ownerships within the subarea are shown below:

Ownership	Acres	Animal Unit Months	Acres per Animal Unit Month
Federal lands administered by Bureau of Land Management	256,243	24,987	10.2
Other Federal Lands	130,575	19,012	6.8
State	47,768	8,851	5.3
Private	251,382	41,417	6.0
Total	685,968	94,267	7.3

There is a wide variety of vegetative types in this subarea, as shown on the Vegetative Type Map in Map Supplement "A". Sagebrush is the most extensive type. Grass, waste, saltbush and open pine types are interspersed throughout the subarea. Dominants of the sagebrush type are big sagebrush, bluestem wheatgrass, sandberg bluegrass, threadleaf sedge, prairie junegrass and blue grama grass. This type and the grass type are generally found on the better soils of the subarea.

Grass types are found chiefly in the western portion of the subarea. Important components of this type in the lower elevations are the same as the grasses of the sagebrush type. In the mountainous portions, bluebunch wheatgrass and Idaho fescue replace the bluestem wheatgrass and blue grama grass.

Open pine types are located in the higher elevations near the Shoshone National Forest. Components of the understory are the same as those in the grass type at the same elevations. Grazing capacity is comparable to that of the grass type.

Waste range due to dense timber is located in the area adjoining the forest. This type supports such a dense stand of timber that the understory is nearly valueless for grazing. Waste range at the lower elevations is generally the result of shale outcrops. Erosion is usually critical on these shale outcrop areas, as shown on the Erosion Condition Map in Map Supplement "C".

Water Supply

Water yield records are available for the Clarks Fork and the Shoshone Rivers. The headwaters of both of these streams are in the high mountains on the Shoshone National Forest. Nearly all of the water carried by these rivers is from the forest lands. Water from the Shoshone River is used to irrigate nearly all of the cultivated land in the subarea. Water for irrigating the Shoshone project is taken from the river at Buffalo Bill Dam, seven miles west of Cody, and at Corbett Dam, about the same distance. Other smaller diversions are located at various places along the river.

There are two gaging stations on the Shoshone River, one just below Buffalo Bill Reservoir and the other at Byron. The records for the gaging station below Buffalo Bill Dam cover a period of 30 years and indicate an average annual runoff of 721,416 acre feet. The station at Byron shows an average discharge of 674,811 acre feet for a period of 22 years. This would indicate that 46,605 acre feet were diverted annually for irrigation purposes.

Only minor diversions for irrigation are made from the Clarks Fork River. The 28 years of record of the Clarks Fork River indicate an average annual runoff of 653,474 acre feet. The gaging station on the Clarks Fork is located one-half mile north of the Wyoming-Montana state line and covers the period from 1921 to 1949.

History of Use

This subarea was settled early in the history of the basin. Ranchers were attracted to the area because the basin floor was an excellent wintering area. It was seldom "snowed in" and also produced good forage. Before the Taylor Act, ranchers wintered in the area irrespective of the carrying capacity. The area was also attractive to homesteaders and many tracts were filed on under the 160-Acre Homestead Act. When settlement began to slack off, additional inducements were offered. These were the enlarged Homestead Act, the Stock-Raising Homestead Act, and the Carey Act. Each of these homesteaders had a few head of stock which were added to those already on the public domain. Shortly after the turn of the century, the Bureau of Reclamation started development work in the area. This opened up many more areas to settlement and provided a sufficient supply of water to those areas already under cultivation. Future development of considerable acreages of the subarea is scheduled by the Bureau of Reclamation.

Present use of the area is chiefly grazing as it was in the past. With land use regulation established under the Taylor Act, there has been a drastic reduction in numbers of stock grazed on the area. In the beginning, the reduction was not great enough and certain areas continued to be overgrazed. Within the past few years the Bureau of Land Management has further reduced the grazing load. Ranchers concerned recognized the problem and made an additional cut voluntarily.

The northeast corner of the subarea is used as spring-fall cattle range. Northwest of Byron the public land is used as winter sheep range, with a small amount of use as spring sheep range. The area from Gypsum Creek west along the state line over to the Clarks Fork River is used as winter sheep range. West of the Clarks Fork River the area is used as spring-fall cattle and sheep range. The high range south along the Shoshone National Forest to the south border of the subarea is used as summer range. This includes the area around Heart Mountain. Seasonal use at the higher elevations varies with climatic conditions each year.

The majority of the irrigation farmers in the area depend on cash crops of beans, sugar beets, and small grain for their income. Some of the farmers are also stockmen and grow forage crops to carry their stock during the time they are not on native range or during storms. Other farmers are buying stock and feeding crops grown on irrigated lands. This feed lot practice is increasing in popularity. The aftermath of sugar beets and field beans are generally pastured off by sheep or cattle on the animal unit month basis of payment if sold.

PROBLEMS AND PROPOSED ADJUSTMENTS

Watershed Breakdown and Erosion

Heavy use under the "free range" concept of the early days of settlement led to severe depletion of the vegetative cover. Climax species were displaced by less productive plants of lower palatability. By this means the actual production of the range in pounds of meat and wool was impaired. The subclimax species had lower soil binding properties, thus increasing the vulnerability to erosion. As the heavy use continued even the subclimax species produced less than they were capable of producing. The vegetation thus weakened was unable to prevent severe soil erosion. Gullies were the first visible signs of erosion, although the more insidious sheet erosion had already removed much of the top soil.

The eastern part of the subarea and land adjacent to the rivers in the western part are below 5,000 feet in elevation with a desert climate and limited vegetative cover. Much of the soil in this portion is poorly developed clay with low permeability and considerable runoff from the small amount of precipitation. These sites should be carefully managed to protect the soil and to preserve the grazing resource. If the natural cover is damaged it is necessary to drastically reduce stocking to effect slow recovery. It is very difficult to establish a new cover of desirable plants if the original cover is destroyed.

Although regulated land use established after passage of the Taylor Act halted the majority of the abuse on the range, the damage had already occurred. Once the use of the range had been brought under control, the vegetation slowly began to recover. The recovery in the mountainous portions was more rapid due to more favorable soil and climatic conditions. The Land Use Capability Map, Map Supplement "B", indicates the condition of the range as it was at the time of the survey. Local areas of sandy soil around Clarks Fork River are susceptible to wind erosion. Once the vegetative cover had been broken in such areas, small sand dunes soon developed. Local areas of severe sheet and gully erosion occur in this same vicinity. The remainder of the subarea outside the Clarks Fork drainage is not so susceptible to wind erosion. Local areas of severe sheet and gully erosion do occur. Areas in the vicinity of watering places are generally affected by these forms of erosion. The exact location of varying erosion conditions are shown on the Erosion Condition Map in Map Supplement "C".

Erosion and Sedimentation Control

As a whole, this area will not require much reseeding. A few small areas where reseeding is needed to speed recovery of the range have been delineated on the Proposed Improvements Map, Map Supplement "D". Adjustments in season of use and reduction in numbers in some locations will be sufficient to restore the range vegetation.

Wind erosion is a problem in a part of the Clarks Fork drainage area. Reestablishment of the original vegetation on these sandy areas is probably the most effective control measure that can be used. Dams, contour furrows and waterspreaders will be required in the limited areas where sheet and gully erosion are active. Location of these proposed structures are shown on the Proposed Improvements Map, Map Supplement "D". Excess water from the spillway of all dams should be utilized in waterspreading systems whenever feasible. The Shoshone River drainage of the subarea is not subject to severe wind erosion. Sheet and gully erosion are severe in some places.

Proposed Improvements

The following conservation and range improvement practices and structures have been proposed within the Shoshone-Elk Basin subarea on Federal and other lands:

	Federal	Other	Total
Stockwater reservoirs (number)	48	21	69
Reseeding (acres)	16,996	15,047	32,043
Brush eradication (acres)	2,405	13,556	15,961
Waterspreading (acres)	4,418	390	4,808
Contour furrows (acres)	10,793	3,810	14,603
Check dams (number)	6	--	6
Poison weed control (acres)	5,000	8,000	13,000
Large dams (number)	21	3	24
Ant eradication (acres)	1,195	25	1,220

The specific location of these improvements is shown on the Proposed Improvements Map, Map Supplement "D".

OREGON BASIN-DRY CREEK SUBAREA

Description

This subarea is bounded by the Shoshone River on the north, by the Bighorn River on the east, and by the Greybull River on the south. The western boundary is a line starting at Buffalo Bill Dam and running south and east on township and range lines to the center of the township line between T. 49N. and T. 50N., R. 99W., as shown on the small scale map showing the subareas of the basin, figure 7. There has been considerable reclamation development in this subarea. Other large tracts are proposed for future development. This entire subarea is used as winter range as it is relatively low in elevation.

Drainage of the area is made up of tributaries of the boundary rivers, nearly all being intermittent streams in clay-shale areas with eroding channels. The more important tributaries are Dry Creek and Whistle Creek. McCullough Peaks, northwest of Cody, are high, rough, extensive badlands. Little Sheep Mountain and the surrounding badlands along the Bighorn River in the eastern part of the area are a large expanse of rough, poor lands with sparse cover. The rest of the area is largely clay and shale creek valleys and hills, with a considerable area of bench lands, some of which are quite level and extensive, and bottom lands along the rivers. Oregon Basin is a large depression south of McCullough Peaks in the western part of the area.

The subarea is well provided with roads and communities. Highway No. 20 extends across the area from Greybull to Cody. U. S. Highway No. 310 connects Greybull and Lovell. A part of the Shoshone project is along the Shoshone River. Important irrigated areas have been developed downstream, largely under the Carey Act, especially around Byron and Lovell. An extensive area of bench lands has been developed around Cody, Emblem, Burlington, and Otto. Bottom lands along the Greybull are served by a number of large and small ditches. This subarea includes 1,306 square miles, of which 755 square miles are administered by the Bureau of Land Management. Elevations vary from 3,600 feet on the Bighorn River to over 6,000 feet on McCullough Peaks.

Land Use and Ownership

This subarea is second in cropland, 12 percent being so used. Grazing use accounts for the remaining 88 percent. Important oil and gas fields and other mineral deposits are located within the subarea. Clay products are manufactured from local deposits at Lovell. Antelope, pheasants and some deer utilize the subarea. Seventy-three percent of the subarea is in Federal ownership, five percent is state owned, and twenty-two percent is privately owned. The private land is nearly all on bench and bottom lands adjacent to the Greybull and Shoshone Rivers, as shown on the maps with this report. Distribution of land uses and ownerships within the subarea is shown in table 5.

SURFACE RESOURCES

Rangeland

This subarea is generally used as grazing land, 87.7 percent of the total being devoted to that use. Cultivation is practiced on the remaining 12.3 percent. Land pattern of the area is characterized by large blocks of vacant land interspersed with state lands. Federal ownership accounts for 72.6 percent of lands in this subarea. Private lands account for 21.7 percent. State lands make up 5.7 percent of the area. The percentage of private lands in the area will go up as additional reclamation lands are developed and patented. Very few of these lands passed into private ownership by the Stock-Raising Homestead Act. They generally went to patent under the 160-Acre Homestead Act, the Carey Act, or under reclamation homestead developments.

Carrying capacity varies throughout the subarea, with an average of 9.7 acres per animal unit month for all rangelands. The area and recommended stocking rates of grazing lands in different ownerships within the subarea are presented in the list below:

Ownerships	Acres	Animal Unit Months	Acres per Animal Unit Month
Federal lands administered by Bureau of Land Management	483,095	45,872	10.5
Other Federal Lands	121,127	12,918	9.4
State	40,674	4,178	9.7
Private	88,076	12,223	7.2
Total	732,972	75,191	9.7

Saltbush occupies the majority of the rangeland in this subarea. It is characterized by a sparse vegetative cover, about 85 percent of which is saltbush. The other 15 percent of the cover is made up of bluestem wheatgrass, blue grama grass, sandberg bluegrass and several forbs. Soils are a heavy clay and are very susceptible to erosion. Carrying capacity is low but because of its extent saltbush is the most important vegetative type in the subarea. A few grass types occur in the western half of the subarea. These types are limited in extent but have good carrying capacities. Species occurring in the grassland type are: Blue grama, bluestem wheatgrass, sandberg bluegrass, threadleaf sedge and needleandthread. Rangeland typical of the Lower Greybull River is shown in photograph 22.

Sagebrush types occur mostly in the western half of the subarea. Soils supporting this type are better than those of the saltbush areas and are not so susceptible to erosion. Dominants of the type are: Big sagebrush, fringed sagebrush, blue grama grass, sandberg bluegrass, threadleaf sedge, needleandthread and several annuals, grasses, and weeds. Waste range is the result of shale outcropping. These areas support very little vegetation of any type. A large area of waste range occurs in the vicinity of McCullough Peaks, as shown on the Vegetative Type Map in Map Supplement "A".

Photograph 22. -Sheep utilizing typical Lower Greybull River range. Note good dispersion of the flock.

Water Supply

Rivers form the three boundaries of this subarea and it lies entirely in relatively low country. No water supply records are available for any of the streams other than the rivers bordering the subarea. Flash floods of short duration and high intensity are characteristic of the area. It is seldom snowed in during the winter, and so is considered good winter range. Runoff records of the Shoshone River have been discussed in the Shoshone Elk Basin. The records of the gaging station near Basin, on the Greybull River, cover a period of 21 years and indicates an average annual runoff of 135,291 acre feet. The majority of this water was produced in the higher elevations in the Absaroka Mountains west of this subarea.

History of Use

Early settlers in the basin used the subarea as winter range. Elevations are low and the country was seldom snowed in. Under these conditions, very little supplemental feed was needed and losses due to the elements were minor. Since it was a good wintering area, large numbers of stock were concentrated on the range irrespective of carrying capacity. As land along the Greybull and Shoshone Rivers was filed on, the homesteaders added their few head of stock to the vast numbers already grazing the public domain. Unfortunately, the homesteaders held their stock in the area for the entire year. Lands around Otto, Burlington, and Emblem were filed on under the 160-Acre Homestead Act and the Carey Act. There are several diversions of irrigation water from the Greybull River in this vicinity. Lands on the Shoshone River in the vicinity of Cody, Byron, and Lovell were settled under the same conditions.

Present use of the area is much the same as in the past, except that under controls established by provisions of the Taylor Act, the grazing load is now nearer to the actual carrying capacity of the range. Small farmers, for the most part, confine their stock to their private lands. The majority of the farmers depend on cash crops of small grain, sugar beets and field beans for their income. Crop residues of their sugar beet and field bean crops are sold to livestock operators. The ranchers run their stock on the fields for about a month in the fall, which usually cleans up all the tops and straw. Ranchers also purchase forage crops grown on the irrigated lands to use as supplemental feed during inclement weather.

Additional lands will be brought under cultivation by development of reclamation lands in the subarea. Farming practices on these lands will probably follow the pattern set by the established farms. Use of irrigated pastures should be developed to supplement spring-fall range and as a major source of income.

PROBLEMS AND PROPOSED ADJUSTMENTS

Range Depletion

Due to past heavy use, many of the climax species have been replaced by inferior plants. In the saltbush type the grass species of the climax have been reduced or have disappeared. In the areas outside of saltbush types, this displacement usually was in the form of an increase in sagebrush and a decrease in bluestem wheatgrass and needleandthread. In other areas, the short grasses increased while the midgrasses decreased. Further depletion caused an invasion of annuals and such undesirable perennial plants as snakeweed and rabbitbrush.

Most of the eastern part of the area and along the rivers in the western portion are below 5,000 feet in elevation with a desert climate and a low precipitation with low efficiency. Clay soils and badlands of class VIII land are common in the area and are a major management and erosion problem. The class VIII lands should not be grazed but it is not feasible to fence them out of the better lands. In some cases sheep have been winter fed in class VIII areas, causing severe depletion of the cover and stimulating erosion. The clay soils have low permeability and much of the small precipitation runs off, especially if the limited cover is depleted. It is difficult to improve or replace range cover on such sites. This makes good management necessary for protection of the resources.

Land use controls provided by passage of the Taylor Act halted the severeoveruse of the range, but recovery of the natural vegetation has been slow due to soil, climate and the persistence of invading species. In order to speed the reestablishment of climax vegetation, it is recommended that brush removal be carried out on 2,650 acres. In general, it will not be necessary to reseed areas after the sagebrush has been removed. Grassland types now dominated by annuals should be reseeded. Areas needing reseeding total about 35,000 acres.

Erosion and Sedimentation Control

Saltbush areas, due to their sparse cover and heavy clay soils, are very susceptible to water erosion. In order to prevent loss of soil from some of these areas, a system of waterspreaders is recommended. Carrying capacities of such areas, which are now low, would also be increased. Areas recommended for waterspreading are shown on the Proposed Improvements Map in Map Supplement "D". In areas where waterspreading is not feasible, other means such as large detention dams and small check dams will have to be used. Wherever possible, excess water from the spillway of these structures should be utilized in waterspreading systems in order to obtain additional benefits.

Proposed Improvements

Proposed improvements on Federal and other lands in the subarea are as follows:

	Federal	Other	Total
Stockwater reservoirs (number)	110	4	114
Reseeding (acres)	32,534	3,467	36,001
Brush removal (acres)	2,650	--	2,650
Waterspreading (acres)	34,831	2,060	36,891
Contour furrows (acres)	12,502	2,625	15,127
Rodent control (acres)	1,120	222	1,342
Large dams (number)	27	--	27

The location of these improvements is shown on the Proposed Improvements Map in Map Supplement "D".

Pattern of Landownership

A large block of reclamation withdrawal in the Little Dry Creek drainage area will probably never be developed. This is an area of heavy soil with inadequate drainage considered to be unsuitable for crop production. The Bureau of Land Management is reluctant to initiate an improvement program on lands under reclamation withdrawal. It is recommended that this withdrawal be revoked in order to allow the land to be improved. A few small isolated tracts south of Cody could be managed to a higher degree under private ownership. These tracts should be disposed of either by exchange or public sale. It would be more desirable to exchange these lands for either state or private lands and block up other areas of public domain.

FIFTEEN MILE-GREYBULL SUBAREA

Description

The Bighorn River forms the eastern boundary of this subarea and the northern boundary is the Greybull River. The western boundary coincides with that of the grazing district, and Gooseberry Creek forms the southern boundary, as shown on the map of the subarea, figure 7. This area is all relatively low in elevation and is used almost entirely as winter range. There are no reclamation developments within the subarea, all irrigation developments having been accomplished by private individuals under various land laws. The bulk of the private land borders the Bighorn and Greybull Rivers, with tracts scattered throughout the western half of the subarea. North and south transportation is by way of U. S. Highway No. 20 and the Chicago, Burlington and Quincy Railroad along the Bighorn River. U. S. Highway No. 120 crosses the southeast corner of the subarea. Earth roads follow the Greybull River and Gooseberry Creek, and fair roads form a network to permit access to most of the area by car. Excellent social, trade and service facilities are available in Worland, Greybull and Basin, with limited facilities available in Manderson. These centers are all on the Bighorn River. The western edge of the subarea is serviced by Meeteetsee in the Upper Greybull subarea.

This subarea covers 1,131 square miles, of which 868 square miles are administered by the Bureau of Land Management. Surface of the subarea is mostly rolling with a considerable area of badlands and near badlands in the upper portions of Fifteen Mile Creek. Bench land areas are not extensive. Clay and shale soils predominate in the eastern portion. Lighter clay loams and loams make up the western portion of the area. Elevations vary within a relatively narrow range from 3,800 feet on the Bighorn River to 6,000 feet on the western edge of the area.

Land Use and Ownership

Approximately 95 percent of the subarea is used as rangeland. The remaining 5 percent is used in the production of cultivated crops, mostly on private land, although a small amount of state land is cultivated. Oil and gas are produced in the subarea. It is an important antelope range and is of negative watershed value because of its high sediment production. Of the total 723,085 acres in the subarea, Federal ownership accounts for 78 percent. The State of Wyoming controls 4 percent, while private individuals own 18 percent. The percentage of Federal lands and of those lands administered by the Bureau of Land Management is the largest of all the subareas. The percentile of both private and state land is the lowest of all the subareas. Location of lands in the several ownerships and uses is shown on the maps with this report and their distribution is presented in table 5.

SURFACE RESOURCES

Rangeland

Most of the area supports a saltbush type with a relatively low carrying capacity, as shown on the Vegetative Type Map in Map Supplement "A". Soils supporting this type are of heavy clay which is highly erodible. Saltbush types characteristically have a sparse ground cover and, therefore, offer little protection against splash erosion. Approximately 70 percent of the vegetation in this type is saltbush, and the remaining 30 percent is made up of sandberg bluegrass, bluestem wheatgrass, blue grama grass and various forbs. Sagebrush occurs mainly in the western part of the subarea and in the southeastern corner. This type occupies a better soil than the saltbush type and, in general, is not so susceptible to erosion. Dominants of the understory of the sagebrush type are: blue grama grass, bluestem wheatgrass, sandberg bluegrass, threadleaf sedge and various forbs. A relatively small area in the Cottonwood Creek drainage is occupied by a grass type. Dominants in this type are blue grama grass,

bluestem wheatgrass, threadleaf sedge, sandberg bluegrass and several annuals. The location of the several types are shown on the Vegetative Type Map in Map Supplement "A".

The area and recommended stocking rates of grazing lands in different ownerships within the subarea are shown below:

Ownership	Acres	Animal Unit Months	Acres per Animal Unit Months
Federal lands administered by Bureau of Land Management	555,653	55,879	9.9
Other Federal Lands	4,469	331	13.5
State	30,653	3,483	8.8
Private	99,085	16,253	6.1
Total	689,860	75,946	9.1

Waste range in this area is generally the result of outcrops of raw shale. These badlands have developed under geologic erosion over the centuries. Tatman Mountain is an erosional remnant of a plain that was quite extensive at one time. The area now supports very little in the way of vegetative cover; in fact, large areas are completely barren. Parent material of these badlands is the highly erodible sandstone, clay and shales of the Willwood formation. The recommended stocking rate of the entire area averages nine and one-half acres per animal unit month. There are 75,946 animal unit months of forage available.

Water Supply

Runoff records for the Greybull River have been discussed in the Oregon Basin-Dry Creek section of this report. Gooseberry Creek on the southern border of the subarea is the only other stream for which runoff records are available. The station is located at Pulliam, one mile above the mouth. These records cover a period of nine years from 1940-1950, except for the year 1946-1947, and indicate an average annual runoff of 12,871 acre feet. The headwaters of the stream are on the Shoshone National Forest so these figures do not represent actual water production of the subarea. Some water is also diverted for

irrigation above the station. This area is entirely low country and is seldom snowed in. It is, however, subject to flash storms of high intensity and short duration. During such storms, the dry streams become raging torrents which carry heavy concentrations of sediment from the area.

History of Use

Early ranchers of the Bighorn Basin used this subarea as winter range. It was seldom snowed in and livestock losses due to the elements were very light. Due to the fact that climatic conditions were favorable for wintering livestock, excessive numbers were run on this range. Later, homesteaders filed on the land along the rivers and they turned additional stock onto the same range. Their stock was run on the area for the entire year. The majority of the vegetation was actually better suited to withstand winter grazing and this yearlong use deteriorated the vegetation. Until the passage of the Taylor Act, there was no authority by which numbers and classes of livestock could be controlled. It was "free range" and could be stocked without regard to the proper grazing capacity. In saltbush areas, this heavy over utilization caused depletion of the vegetative cover. The majority of the grasses in the type disappeared and the density and volume of the saltbush were greatly reduced.

There was a considerable change in the sagebrush types under heavy overuse. The climax grasses began to disappear and the sagebrush increased. The subclimax species did not have the soil binding abilities of the climax plants, nor could they produce as large a gain per animal. Present use of the area is much the same as in the past. It is almost entirely winter range for sheep. Some cattle use the area spring, summer, and fall.

Cultivated lands along the rivers are used chiefly for production of cash crops of sugar beets, field beans and small grains. Some forage crops are grown to carry the farmers' cattle through the winter and also for sale to ranchers in the area. Aftermath of sugar beet and field bean crops are sold to livestock operators who use them by turning their stock into the fields. A few farmers buy stock or contract to feed them on the forage grown on the farms. These farmlands went to patent under the 160-Acre Homestead Act, the Desert Land Act, and later under the Carey Act.

PROBLEMS AND PROPOSED ADJUSTMENTS

Range Depletion

Under the heavy use of the "free range" era, productive capacity in terms of pounds of gain per animal was severely impaired. Climax species decreased in amount or disappeared entirely on the sagebrush and grassland types. On saltbush types, grasses became almost nonexistent and the saltbush plants became weakened and decreased in amount. Although control established under the Taylor Act halted much of the abuse, productive capacity of the area had reached an alarmingly low point. Under arid conditions, such as exist in the basin as a whole, natural recovery of the vegetation was slow. In order to speed recovery of the area, reseeding is definitely needed on about 28,500 acres. Additional livestock reductions are needed to allow other areas to return to the original productive capacity of the area.

Most of the eastern part of the subarea is below 5,000 feet in elevation with a desert climate. Badlands of class VIII land are common throughout the subarea. They are a problem in proper range management. Sheep wintering in the subarea have frequently overgrazed the limited forage available on the VIII lands which is insufficient for grazing use. The heavy clay soils common in the area are of low permeability and lose much of the limited rainfall by runoff. Vegetation on these sites is limited, difficult to impossible to replace, and requires careful use under proper management in order to maintain a good condition.

Erosion and Sedimentation Control

Depletion of the climax vegetative cover caused an increase in inferior species with lower soil binding characteristics. Erosion under these conditions soon became severe. Flash floods of short duration and high intensity transport heavy loads of sediment from the area. Stream channels are degrading and headcutting. Stream banks are sloughing and eroding. Fifteen Mile Creek and its tributaries are critical in this respect, as shown in photograph 23. In order to cope with this situation and also increase the ground cover, it is recommended that

waterspreading be developed on 18,400 acres and that contour furrows be constructed on 9,500 acres. These practices would hold back a considerable amount of water and also greatly increase the vegetative cover. In addition to the above structures, 43 large detention dams and 90 check dams are needed. The detention dams should be built with drawdown tubes to allow them to drain between storms and also furnish a reasonable flow of water for a longer period of time. Forty-seven miles of tree and brush plantings are recommended for bank and channel stabilization below these detention dams.

Photograph 23. -Fifteen Mile Creek, usually a dry stream, frequently changes its course. The bank shown here has cut back 40 feet in 8 months.

Proposed Improvements

To control erosion and facilitate rangeland use, the following improvements have been proposed for the Fifteen Mile-Greybull subarea:

	Federal	Other	Total
Stockwater reservoirs (number	34	1	35
Reseeding (acres)	25,796	2,751	28,547
Brush eradication (acres)	3,742	1,750	5,492
Rodent control (acres)	320	135	455
Large dams (number)	37	6	43
Waterspreading (acres)	15,154	3,271	18,425
Contour furrows (acres)	8,790	765	9,555
Check dams (number)	85	5	90

The location of these improvements is shown on the Proposed Improvements Map, Map Supplement "D".

UPPER GREYBULL SUBAREA

Description

The western boundary of this subarea is formed by the Shoshone National Forest and the Shoshone River. From Buffalo Bill Reservoir the boundary runs south and east by township lines until it meets the grazing district boundary between townships 49 and 50 North. From this point the boundary follows the district boundary south and west until it joins the Shoshone National Forest. The boundaries are shown on the small scale map, figure 7, of this report. Sunshine Reservoir is located in the southern part of the subarea, and Buffalo Bill Reservoir is on the northern edge. Sunshine Reservoir is located on a tributary of the Greybull River and supplies irrigation water for lands along that river. U. S. Highway No. 120 from Thermopolis to Cody furnishes north and south transportation through the subarea. Good county roads service the area. There are no railroads in this subarea. All trade, social, and service facilities center in Cody with limited facilities available at Meeteetsee.

This subarea is 587 square miles in area, next to the smallest. It contains 95 square miles of land administered by the Bureau of Land Management, the least of all of the subareas. The area is made up of foothills of the Absaroka Mountains and sloping lands below them. The Greybull River system drains about two-thirds of the area. Shoshone River tributaries drain about one-third. Elevations vary from 5,600 feet to 7,800 feet at the National Forest boundary, and exceed 12,000 feet in the mountains west of the subarea.

Land Use and Ownership

Grazing is the principal land use of the area and accounts for 94 percent of the total. The remaining six percent is used for the production of cultivated crops. The grazing land has significant multiple use values: oil and gas production, watershed, fish and wildlife, and recreation. The subarea has the largest percentage of state and private land and the lowest percentage of public domain of the subareas. The Federal Government owns 16.8 percent of the land in the subarea. This compares with the average of 59.3 percent Federal ownership and the extreme of 77.4 percent in the Fifteen Mile-Greybull subarea. State ownership accounts

for 20.4 percent, while private ownership amounts to 62.8 percent. Much of the grazing land is of high quality and is privately owned. Location of lands in the several uses and ownerships are shown on the maps with this report. They are distributed by ownerships and uses in table 5.

SURFACE RESOURCES

Rangeland

The area generally supports a grassland vegetative type although sagebrush, mountain brush, saltbush, and timber types are interspersed through the area. Principal plants of the grassland type are bluestem wheatgrass, prairie junegrass, and blue grama grass. On intermediate bench lands and gravelly or sandy soils there is a considerable amount of needleandthread in the type. At higher elevations bluebunch wheatgrass, threadleaf sedge, and Idaho fescue are components of the type along with diminishing amounts of other species. Green needlegrass also occurs in the type.

Sagebrush types are found mostly in the area southeast of Buffalo Bill Reservoir. It occupies a poorer soil than the grassland type and is not in as high a rainfall belt as the grassland types. Dominants of this association are bluestem wheatgrass, blue grama grass, threadleaf sedge, sandberg bluegrass, and big sagebrush. Mountain brush occupies high rocky slopes adjoining the Shoshone National Forest. It is chiefly wildlife habitat, the forage being utilized mainly by deer. The principal brush is mountain mahogany. It supports a sparse understory of bluebunch wheatgrass, black sagebrush and several species of weeds. The saltbush type is found on the eastern edge of the subarea where it generally occurs as small areas. Dominants in this type are Gardner saltbush, blue grama grass, sandberg bluegrass, bluestem wheatgrass, and weeds. Location of the types are shown on the Vegetative Type Map in Map Supplement "A".

Grazing capacity of these lands varies widely but averages four acres per animal unit month with a total of 86,972 animal unit months of forage available. There are large areas of good grassland. One large type has a recommended stocking rate of 2.6 acres per animal unit month. It is composed of threadleaf

sedge, needleandthread, and bluestem wheatgrass. The area and recommended stocking rates of grazing lands in different ownerships within the subarea are as follows:

Ownership	Acres	Animal Unit Months	Acres per Animal Unit Month
Federal lands administered by Bureau of Land Management	61,043	14,164	4.3
Other Federal Lands	208	25	8.3
State	75,980	21,951	3.5
Private	214,056	50,832	4.2
Total	351,287	86,972	4.0

Water Supply

Water discharge records are available on the Greybull River from a gaging station at Meeteetse and on the Wood River from a station about one mile above its confluence with the Greybull River. Water records of the Shoshone River on the northern edge of the area are presented in the Shoshone-Elk Basin subarea. The station on the Greybull River covers the period from 1920 to 1950 and records the runoff from 690 square miles. The flow is partly regulated by Sunshine Reservoir. The 31 years of record indicate an average annual runoff of 237,813 acre feet. The station on the Wood River records the flow from 218 square miles of drainage area. Records have been continuous from April 1930 to 1950 and indicate an average annual runoff of 237,813 acre feet. The station on the Wood River records the flow from 218 square miles of drainage area. Records of the Geological Survey have been continuous from April 1930 to 1950 and indicate an average annual runoff of 85,492 acre feet.

History of Use

The majority of this land went to patent early in the settlement history of the Bighorn Basin. Early patents were issued under the 160-Acre Homestead Act and the enlarged Homestead Act. Most of these lands were placed under cultivation. Additional inducements to settlement were offered by the Carey Act, the irrigation development law under which a small part of the land went to patent. Later settlement was under the Stock-Raising Homestead Act and was strictly on the grazing lands unsuited for cultivation. This land was highly valuable as grazing land because of a desirable soil and a high rainfall compared with the rest of the basin. The combination of the two factors produce an excellent grassland range. Even though it was badly overgrazed at first, the climatic and soil factors were such that the vegetation made a rapid recovery. At present the western two-thirds of the area is used as late spring and summer range, mostly for sheep. The eastern one-third of the area is used as winter range by both sheep and cattle. Over 50 percent of the Federal lands are designated as stock driveway. The Federal lands are leased under Section 15 of the Taylor Act.

The cultivated lands along the Wood River are used in connection with livestock operations. Main crops are hay and some grain which the operator uses to carry his stock through the winter. Most of the other cultivated land in the subarea is used chiefly for the production of cash grain crops.

PROBLEMS AND PROPOSED ADJUSTMENTS

Range Depletion and Erosion

All of this subarea is well above 5,000 feet in elevation, so it is not subject to the desert conditions found in most of the other subareas. The area of class VIII lands is also much less than in the other subareas. Clay soils of low permeability also cover less of this subarea. Management and range rehabilitation problems are relatively minor in comparison with those existing in the other subareas. In general, the quality of the soil and range is so good that the subarea has largely passed into private ownership. More of the Federal land would have been taken up if it had not been withdrawn as stock driveway.

Except for local areas of abuse, the range in this area is in good condition. Reseeding could be used to good advantage on about 490 acres of private range, as shown on the Proposed Improvements Map in Map Supplement "D". Erosion over the area is moderate and not a serious problem. Two large detention dams have been proposed mainly for flood protection in other subareas. Waterspreading and contour furrow proposals total about 2,700 acres, all but 30 acres of which is on private land. Erosion and vegetative conditions in this subarea are good and the percentage of Federal lands is low, so improvement proposals in this subarea should have the lowest priority of any in the entire Bighorn Basin.

Proposed Improvements

Improvements proposed to control erosion and facilitate range use within the Upper Greybull subarea are as follows:

	Federal	Other	Total
Stockwater reservoirs (number)	4	23	27
Reseeding (acres)	--	490	490
Large dams (number)	2	--	2
Waterspreading (acres)	30	1,170	1,200
Contour furrows (acres)	--	1,583	1,583
Check dams (number)	10	7	17
Rodent control (acres)	--	655	655

Specific sites of the proposed improvements are shown on the Proposed Improvements Map in Map Supplement "D".

OWL CREEK-GOOSEBERRY CREEK SUBAREA

Description

The Owl Creek-Gooseberry Creek subarea extends from the Bighorn River on the east to the Shoshone National Forest and the Bighorn Basin Divide on the west. It is bounded on the north by Gooseberry Creek and on the south by the Wind River Indian Reservation. Exact location of these boundaries is shown on figure 7, the small scale map of the basin subareas. The upper portion of the subarea consists of the rough and mountainous foothills of the Absaroka and Owl Creek Mountains. The lower, or eastern, portion varies from nearly level valley lands to rolling and rough hills, chiefly valuable for grazing. Elevations vary from 4,200 feet to over 12,000 feet on the mountains just west of the area. Major drainages in addition to Owl and Gooseberry Creeks, are Grass Creek, Cottonwood Creek, and Coal Draw, all of which are perennial streams. Red Canyon Creek makes an interesting formation in the southeastern part of the area.

Hard surfaced highways, U. S. No. 20 and Wyoming No. 120, serve the area. A hard surfaced highway also extends up Owl Creek to Hamilton Dome. County roads service the majority of the area. The Chicago, Burlington and Quincy Railroad is in the Bighorn River Valley on the eastern border of the area. Commercial and social activities center at Thermopolis. The subarea includes 1,074 square miles, of which 612 square miles are public domain. The subarea is second in average quality and total grazing capacity. Most of the area has good vegetative cover on fairly good soils. The soils and cover are of lower quality in the eastern part of the subarea where the Chugwater and Willwood formations have produced readily erodible clays.

Land Use and Ownership

Fifty-seven percent of the land in the subarea is in Federal ownership, 35.3 percent is privately owned, and 7.7 percent is owned by the State. The majority of the private land lies along the bottoms of Owl Creek, Gooseberry Creek, Cottonwood Creek, and the Bighorn River. Large amounts of private land are located in the western part of the subarea, interspersed with isolated tracts of public domain. Most of the remainder of the subarea consists of

nearly solid blocks of vacant public domain interspersed with state lands.

This subarea is primarily used for grazing land which accounts for 96.4 percent of the total acreage. The remaining 3.6 percent is devoted to the production of cultivated crops. Other land uses are watershed, wildlife, timber, and mineral production. Minerals include oil, gas, coal and sulphur. Distribution of lands in the several ownerships by uses is presented in table 5. Location of lands by ownerships is shown on the maps with this report and on the preliminary report map.

SURFACE RESOURCES

Rangeland

The principal surface resource of the subarea is the rangeland which furnishes forage for domestic livestock and wildlife. Major vegetative types are grass, sagebrush and sagebrush-grass on the greater portion of the area, with small local areas of saltbush on the lower elevations, greasewood on the alkaline flats, and conifers on rock ridges and some of the higher slopes. Dominant species of the sagebrush type on the lower elevations are big sagebrush, blue grama grass, bluestem wheatgrass, bluebunch wheatgrass, prairie junegrass, and needleandthread grass. At higher elevations in favorable locations the sage decreases until little or none is present. In other areas there is an increase in shrubs including wild currant and chokecherry. In sites which have undergone vegetative deterioration, an increase in cheat grass, mustard, and broomweed is evident.

Principal plants of the saltbush type are gardner saltbush, shadscale, greasewood, Indian rice grass, birdsfoot sagebrush, and squirrel tail grass. Portions of the coniferous type in which juniper predominates are of low grazing value for livestock, being chiefly valuable for wildlife habitat and as watershed. Areas in which other conifers are found usually support an understory of grasses, forbs, and shrubs of high value for summer grazing.

Carrying capacity varies from high in the upper elevations to relatively low in the lower sagebrush and saltbush types. The subarea is second in quality and quantity of range resource as measured by acres per animal unit month and by the number of animal unit months available on both Bureau of Land Management lands and the total area. This position compares with its fifth in size and fourth in area of Bureau of Land Management lands among the subareas. The area and recommended stocking rates of grazing lands in different ownerships within the subarea are presented in the list below:

Ownership	Acres	Animal Unit Months	Acres per Animal Unit Month
Federal lands administered by Bureau of Land Management	391,758	70,520	5.6
Other Federal Lands	80	9	8.9
State	52,157	11,456	4.6
Private	217,771	47,791	4.6
Total	661,766	129,776	5.1

Water Supply

Water discharge records are available for both Owl Creek and Gooseberry Creek. Average annual runoff of Owl Creek at the station located six miles northwest of Thermopolis during the 13 years for which records are available is 17,838 acre feet. This station records the discharge from 484 square miles drainage area. Another gaging station is located one mile upstream from the mouth of Gooseberry Creek one mile north of Pulliam, recording the discharge from 371 square miles. Published records for nine years show an average annual runoff of 12,871 acre feet. Much of the water from both drainages is diverted for irrigation purposes. In the best rainfall years, Owl Creek furnishes a full water supply to irrigate 25,000 acres, but ordinarily there is a lack of irrigation water. This condition would be corrected by the construction of Anchor Dam and reservoir on the South Fork of Owl Creek as proposed by the Bureau of Reclamation. This reservoir will furnish a supplemental water supply to 14,400 acres of land now irrigated but in need of additional water for late season irrigation.

History of Use

The first cattle to enter the subarea were brought in by Captain Robert Torrey of Fort Washakie in 1881. The first sheep in the Bighorn Basin were those brought to Owl Creek from Oregon by J. D. Woodruff about 1871. The major use of the subarea is now, as it was in the past, seasonal range for livestock. The lower rolling eastern portion is used primarily as spring-fall range for cattle and as spring-fall and winter range for sheep. The higher slopes in the extreme western portion are used as summer range for both sheep and cattle. Most livestock operators control land in other parts of the Bighorn Basin to round out their operations. Because of the high grazing value of the high altitude summer range in the western part of the subarea, most of it has gone into private ownership under the terms of the Stock-Raising Homestead Act. Most of the remaining private land, which largely lies along the live streams, was patented under the 160-Acre Homestead Law.

Croplands in the subarea total 25,043 acres and are used mainly for feed production, although some cash crops are grown. The principal crop is hay, both grasses, legumes, and wild hay. Other feed crops include wheat, barley, and oats, while grains and a few sugar beets are grown as cash crops.

PROBLEMS AND PROPOSED ADJUSTMENTS

Range Depletion

Severe overuse was practiced on the subarea prior to control established under the Taylor Act, so much of this range was severely depleted. With the controls imposed by the Taylor Act, the native vegetation began to reestablish itself on the greater portion of the range. Further improvement is both advisable and feasible. Approximately 22, 700 acres have been severely depleted and are in need of reseeding. The areas needing reseeding are shown on the Proposed Improvements Map in Map Supplement "D". Other localities will improve and will reestablish the climax vegetation if the grazing load is lessened. More stringent controls over numbers and classes of stock and seasons of use are recommended in accord with the range condition, as shown on the Land Use Capability Map in Map Supplement "B". Sheep bed grounds should not be used for more than two or three nights each season.

Only the extreme eastern portion of this subarea is below 5, 000 feet in elevation, so relatively little of this subarea is subject to the desert climate which accounts for its better quality of range cover. The amount of badlands is also relatively small in comparison with other areas. The area of clay soil type of low permeability is considerable, but much less than in the other subareas with the exception of Upper Greybull. The extremely critical areas for management, condition maintenance, range resource, recovery and reestablishment are less in extent than on the other subareas with the exception of Upper Greybull.

Proposed Improvements

In order to control erosion, reduce sediment production, and to facilitate range utilization, the following improvements are proposed for the Owl Creek-Gooseberry subarea:

	Federal	Other	Total
Stockwater reservoirs (number)	47	2	49
Springs (number)	5	1	6
Reseeding (acres)	20,843	1,876	22,719
Brush eradication (acres)	1,855	30	1,885
Rodent control (acres)	780	20	800
Large dams (number)	26	4	30
Waterspreading (acres)	1,735	1,625	3,360
Contour furrows (acres)	2,145	150	2,295
Check dams (number)	20	--	20

The location of these improvements is shown on the Proposed Improvements Map, Map Supplement "D".

Inadequate Supply of Irrigation Water

Approximately 4,500 acres of cultivated land has been abandoned in the Owl Creek drainage due to the lack of a stable water supply. The acreage remaining in cultivation cannot be sufficiently irrigated in years of normal water supply. There appears to be a sufficient supply if water were stored. Without storage facilities, the supply is not sufficient during period of low flow and crops suffer from lack of water at critical times. To correct this situation, the Bureau of Reclamation proposes to build Anchor Reservoir on the South Fork of Owl Creek. It will have an operating capacity of 14,500 acre feet and will regulate the natural flow of the South Fork of Owl Creek. Approximately 10,000 acres will be irrigated from gravity canals from Owl Creek and 4,300 acres will be under a pumping system provided from Bighorn River and protected by storage in Boysen Dam.

BENEFITS AND COSTS OF IMPROVEMENTS

Benefits and costs of improvements proposed within the basin and benefits to be derived therefrom are summarized in table 8 of this report. This tabulation lists the improvements by location on lands of two different types of ownership, Federal, and private and state. The total of the two types of ownership, including all proposed improvements, is also presented. Federal lands are nearly all public domain, with small amounts of stock driveway and reclamation withdrawal lands. Construction, maintenance, interest and depreciation are continuing annual costs. The cost of these improvements would be liquidated in approximately 17 years from on-site benefits only if no charge were made for interest. If both on-site and off-site benefits are considered, costs would be repaid in 12 years, all charges being allowed for.

Benefits have been figured on a long term average, for they will increase to the maximum until the projects become established. Stockwater reservoirs will be usable as soon as they have filled after construction, while reseeding, waterspreading and contour furrowing may take from two to five years to become established. After this time there should be a gradual increase in effectiveness until the maximum productivity is realized. On-site tangible benefits for waterspreading, sagebrush removal, reseeding and other revegetative practices have been calculated on the basis of the increase in forage which can reasonably be expected as a result of the improvement. Stockwater development benefits have been computed on the probable animal gain basis to be realized from the utilization of an adequately watered range over those to be realized from an inadequately watered range.

Improvements proposed for On-Site Benefits

Stockwater reservoirs are proposed where possible to cut down the distance stock must travel to water. If the distance between water holes is too great, stock will "trail" to water instead of grazing from one watering place to the next. Trailing cuts down on the pounds of gain an animal may make per day. Studies of additional gains per animal on native range through the addition of more frequent water supplies, indicate an additional gain of 1/4 pounds or more

per animal per day. In calculating benefits for the stockwater developments described in this report, the conservative figure of 1/4 pound of additional gain per animal per day was used. Estimating that 25 cows would use each reservoir for a period of 90 days, the increased gains would be 562 pounds per reservoir. Recent economic studies generally consider $16.50 per 100 pounds as the long term average price of beef. Using this price, each reservoir would return a gross profit of $92.81 annually. On this basis, the annual gross profit on the 1,038 reservoirs proposed on lands administered by the Bureau of Land Management for the basin would be $96,336. In addition to weight gains, the reservoirs will aid in flood control, reduce sediment production and protect downstream structures, property and water use. Trailing and other abuse of the range would be eliminated or greatly reduced, and it would become possible to practice improved land management. Annual costs have been calculated for reservoir maintenance, interest, and depreciation. Yearly maintenance is allowed at one percent of the construction cost. Interest is figured at $2\frac{1}{2}$ percent, a standard rate for Federal projects. Depreciation is on the basis of a life expectancy of 15 years. These charges total $75,894. This amount deducted from the benefits allowed for weight gains only shows an annual net benefit of $20,442. The benefit cost ratio on this basis is 1.45 to 1.

Waterspreading has been proposed on 67,269 acres of Federal land administered by the Bureau of Land Management in the basin. These projects have a high rate of forage production due to the flood irrigation effects. In addition to the greater amount of forage produced, the feed remains green and succulent over a longer period of time, increasing its quality and nutritive values. Waterspreading structures have increased forage production in certain locations in the Wind River Basin to more than one animal unit month per acre and on better sites production increased over three animal unit months per acre. Records of the Alzada waterspreading project in Montana show an increase in forage production of more than 250 percent while the Hale project in the same state shows an increase of over 500 percent.

It appears safe to assume that grazing capacity on completed and fully established waterspreading projects in the Bighorn Basin will average approximately two acres per animal unit month. Under rainfall conditions in the basin,

Table 8.-Summary of Proposed Conservation Improvements in the Bighorn Basin, Montana and Wyoming, 1952 1/

Type of Improvement	Number of Units	COSTS					ESTIMATED BENEFITS								Benefit Cost Ratio
			ANNUAL								ANNUAL				
		Construction	Maintenance	Interest 2/	Depreciation	Total	Estimated Life	Increased Grazing Capacity	Annual Sediment Storage	Water Storage Capacity	Gross On-Site	Gross Off-Site	Gross Total	Net	
A. On Federal Lands		dollars	dollars	dollars	dollars	dollars	years	AUMs.	acre feet	acre feet	dollars	dollars	dollars	dollars	
Stockwater Reservoirs (each)	1,038	746,500	7,465	18,663	49,766	75,894	15	--	277	4,152	96,336	13,706	110,042	34,138	1.45 - 1
Spring Developments (each)	12	9,250	92	231	--	323	--	--	--	--	1,113	--	1.113	790	3.44 - 1
Wells (each)	1	3,200	32	80	--	112	--	--	--	--	92	--	92	-20	.82 - 1
Fencing (miles)	1,125	675,000	6,750	16,875	45,000	68,625	15	--	--	--	99,000	--	99,000	30,375	1.44 - 1
Reseeding (acres)	148,820	744,100	--	18,603	--	18,603	--	22,332	--	--	44,664	--	44,664	26,061	2.40 - 1
Brush Eradication (acres)	64,691	219,234	--	5,481	--	5,481	--	12,331	--	--	24,662	--	24,662	19,181	4.49 - 1
Waterspreading (acres)	67,269	739,959	7,400	18,499	--	25,899	--	24,027	5,605	33,634	48,054	277,335	325,389	299,490	12.56 - 1
Contour Furrows (acres)	48,777	292,062	2,920	7,302	--	10,222	--	9,292	4,065	16,259	18,584	201,136	219,720	209,498	21.49 - 1
Check Dams (each)	926	115,750	1,158	2,894	11,575	15,627	10	--	46	--	--	2,276	2,276	-13,351	.15 - 1
Ant Control (acres)	350,000	400,000	--	10,000	--	10,000	--	5,000	--	--	10,000	--	10,000	--	1.00 - 1
Rodent Control (acres)	5,130	2,567	--	64	--	64	--	477	--	--	954	--	954	890	14.91 - 1
Poison Weed Control (acres)	36,000	2,000	2,000	50	--	2,050	--	--	--	--	--	--	--	- 2,050	Net Cost
Large Dams (each)	300	3,000,000	30,000	75,000	100,000	205,000	30	--	5,700	171,000	27,843	282,036	309,879	104,879	1.51 - 1
Tree Planting (miles)	49	37,125	--	928	--	928	--	--	17	--	--	841	841	- 87	.91 - 1
Sub Total		6,986,747	57,817	174,670	206,341	438,828		73,459	15,710	225,045	371,302	777,330	1,148,632	709,804	2.62 - 1
B. Private & State-owned lands															
Stockwater Reservoirs (each)	312	224,328	2,243	8,973	14,955	26,171	15	--	104	1,560	28,956	5,146	34,102	7,931	1.30 - 1
Spring Developments (each)	8	6,160	61	246	--	307	--	--	--	--	742	--	742	435	2.42 - 1
Wells (each)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Fencing (miles)	375	225,000	2,250	9,000	15,000	26,250	15	--	--	--	33,000	--	33,000	6,750	1.26 - 1
Reseeding (acres)	30,598	152,975	--	6,119	--	6,119	--	4,590	--	--	9,180	--	9,180	3,061	1.50 - 1
Brush Eradication (acres)	42,910	145,894	--	5,835	--	5,835	--	8,173	--	--	16,346	--	16,346	10,511	2.80 - 1
Waterspreading (acres)	12,496	137,456	1,375	5,498	--	6,873	--	4,463	1,041	2,083	8,926	51,509	60,435	53,562	8.79 - 1
Contour Furrows (acres)	14,595	87,570	876	3,503	--	4,379	--	2,780	1,216	4,865	5,560	60,168	65,728	61,349	15.00 - 1
Check Dams (each)	53	6,625	66	265	663	994	10	--	3	--	--	148	148	- 846	.15 - 1
Ant Control (acres)	50,000	57,000	--	2,280	--	2,280	--	1,431	--	--	2,862	--	2,862	582	1.26 - 1
Rodent Control (acres)	3,007	1,504	--	60	--	60	--	280	--	--	560	--	560	500	9.33 - 1
Poison Weed Control (acres)	54,000	10,000	--	400	--	400	--	--	--	--	--	--	--	- 400	Net cost
Large Dams (each)	59	590,000	5,900	23,600	19,666	49,166	30	--	1,121	33,630	5,476	55,467	60,943	11,777	1.24 - 1
Tree Planting (miles)	7	5,250	--	210	--	210	--	--	3	--	--	148	148	- 62	.70 - 1
Sub Total		1,649,762	12,771	65,989	50,284	129,044	--	21,717	3,488	42,138	111,608	172,586	284,194	155,150	2.20 - 1
C. Total All Ownerships															
Stockwater Reservoirs (each)	1,350	970,828	9,708	27,636	64,721	102,065	15	--	381	5,712	125,292	18,852	144,144	42,079	1.41 - 1
Spring Developments (each)	20	15,410	153	477	--	630	--	--	--	--	1,855	--	1,855	1,225	2.94 --1
Wells (each)	1	3,200	32	80	--	112	--	--	--	--	92	--	92	- 20	.82 - 1
Fencing (miles)	1,500	900,000	9,000	25,875	60,000	94,875	15	--	--	--	132,000	--	132,000	37,125	1.39 - 1
Reseeding (acres)	179,418	897,075	--	24,722	--	24,722	--	26,922	--	--	53,844	--	53,844	29,122	2.18 - 1
Brush Eradication (acres)	107,601	365,128	--	11,316	--	11,316	--	20,504	--	--	41,008	--	41,008	29,692	3.62 - 1
Waterspreading (acres)	79,765	877,415	8,775	23,997	--	32,772	--	28,490	6,646	35,717	56,980	328,844	385,824	353,052	1.18 - 1
Contour Furrows (acres)	63,372	379,632	3,796	10,805	--	14,601	--	12,072	5,281	21,124	24,144	261,304	285,448	270,847	19.55 - 1
Check Dams (each)	978	122,375	1,224	3,159	12,238	16,621	10	--	49	--	--	2,424	2,424	-14,197	.15 - 1
Ant Control (acres)	400,000	457,000	--	12,280	--	12,280	--	6,431	--	--	12,862	--	12,862	582	1.05 - 1
Rodent Control (acres)	8,137	4,071	--	124	--	124	--	757	--	--	1,514	--	1,514	1,390	12.21 - 1
Poison Weed Control (acres)	90,000	12,000	2,000	450	--	2,450	--	--	--	--	--	--	--	- 2,450	Net Cost
Large Dams (each)	359	3,590,000	35,900	98,600	119,666	254,166	30	--	6,821	204,630	33,319	337,503	370,822	116,656	1.46 - 1
Tree Planting (miles)	56	42,375	--	1,138	--	1,138	--	--	20	--	--	989	989	- 149	.87 - 1
Grand Total		8,636,509	70,588	240,659	256,625	567,872		95,176	19,198	267,183	482,910	949,916	1,432,826	864,954	2.52 - 1

1/ Determined by field investigation, Bureau of Land Management, 1946 - 52. Location of the proposed improvements is shown in the Proposed Improvements Map, Map Supplement "D" of this report. Federal land is nearly all public domain with minor areas of stock driveway and reclamation withdrawals, all under the administration of the Bureau of Land Management. A small acreage of land under other Federal administration is included.

2/ Interest is calculated at 2½ percent for improvements on Federal land and at 4 percent on state and private land.

a waterspreading system may not be flooded each year, and all parts of a system may not be flooded with each storm. Two acres per animal unit month averages the good years with the poor years. Figuring this increased forage at $2.00 per animal unit month, the commercial rate in the basin in 1952, the increase would be worth $48,054 (24027 x $2.00). After deducting $25,899 for the annual costs of maintenance and interest on the investment, a net benefit of $22,155 would be realized. The benefit-cost ratio would be 12.56 to 1 after allowing off-site benefits of $277,148. Flood and sediment control are the principal off-site benefits to be derived from waterspreading structures. These controls contribute to the protection of downstream structures, property and water uses. Off-site benefits have been calculated on the basis of $4.12 per acre annual benefit over the area on which water is spread for flood control and reduction of sediment. This figure is based on sediment retention alone, calculated on the basis of one inch annual retention per acre valued at $49.48 per acre foot. This valuation is based on value of sediment space in downstream reservoirs. It does not include flood control and other benefits.

Contour furrows, while increasing production, would not do so to the same extent as waterspreaders, as they utilize only the water falling on the treated area. Waterspreading systems spread water from detention or diversion dams. A series of dykes spreads the water which has originated on a large watershed area. Contour furrows hold and concentrate the water and provide for more percolation and storage of water in the soil than would occur on untreated areas. Contour furrows can be used on slopes up to 25 percent while waterspreaders are usually limited to slopes of two percent or less. An average grazing capacity of three acres per animal unit month is anticipated for contour furrowed areas in the Bighorn Basin. Contour furrowing, proposed on 48,777 acres of public domain land in the basin, is estimated to provide an increase of 9,292 animal unit months of forage valued at $18,584 based on 1952 rates in the basin. After paying annual maintenance costs and interest a net benefit of $8,362 would be realized.

Eradication of rodents on the 5,130 acres so infested would increase the grazing capacity of the basin by 477 animal unit months. This forage would be valued at $954.00. Interest

at $2\frac{1}{2}$ percent would amount to $64.00, leaving a net benefit of $890.00.

The eradication of the prairie mound-building ant on the 350,000 acres of public domain severely infested with this insect is a serious problem. No economically feasible method of control is known at present. Present control methods would cost about $9.00 per acre per treatment. Tests conducted to date indicate that a minimum of two treatments are needed. Experimentation should be continued until an economical method of control is discovered and then a program of control can be initiated. These costs should not exceed 15 cents per acre. Ant control for purposes of this report was figured at $1.14 per acre. Interest on the investment would amount to $10,000 and gross benefits would amount to at least $10,000 on the basis of increased forage production. Additional benefits would accrue from reduced runoff and erosion.

Halogeton infests about 400,000 acres of which 90,000 acres are very heavily infested. Eradication of this weed now appears to be impossible. It is probable that good range management and agricultural practices will considerably reduce the hazard to livestock. Abandoned fields must be returned to grass to prevent Halogeton from taking over, as shown in photograph 6. Fence lines, ditch banks and roadways should be kept clear of this weed. These structures are usually on private or state land, so the state or private individuals should control the pest in these locations. This can probably be done by the use of herbicides at a cost of about $10,000 dollars per year. Where rangeland is affected, an effort must be made to increase native forage production, thus controlling the weed by competition. In addition to the range improvements already discussed, the Bureau of Land Management will have to spend about $2,000 annually to spray Halogeton in corrals and along trails. The other control methods have been charged to range improvements. This would leave the cost of spraying as a net cost to be carried by other improvements.

Fencing of the allotments will provide several types of benefits, thus making it difficult to assign a monetary value to each. These benefits are considered to be: better range management and protection, increased calf crop by about

10 percent, prevention of trespass, no loss from straying, and less handling costs for the operator.

Assuming a conservative figure of 30,000 breeding cows in the basin, and if 50 percent of these were effected by fencing, an increased calf crop of 1,500 might reasonably be expected. At $16.50 per hundred pounds, a 400 pound calf would be worth approximately $66.00. The gross value of this increase would be $99,000. A net benefit of $30,375 would result after subtracting the yearly maintenance, interest and depreciation costs for the fence of $68,625.

Off-Site Benefits

Most of the proposed improvements will have off-site, as well as on-site benefits. Significant off-site benefits will be realized as flood control and sediment reduction. The values of off-site and on-site benefits are shown in table 8. Stockwater reservoirs, range reseeding, waterspreading, and contour furrowing are proposed principally for their on-site benefits. On-site benefits from these improvements will equal the costs or nearly so. Off-site benefits of stockwater reservoirs are over one-half of the amount allowed for on-site benefits. Range reseeding off-site benefits are nearly equal to the on-site benefits. The flood and sediment control off-site values of waterspreading greatly exceed the on-site benefits. The off-site benefit value of contour furrows is twice that of the on-site benefit value.

Large silt retention reservoirs were proposed primarily to produce off-site benefits. Their value in furnishing stockwater must not be overlooked. On-site benefits were figured on the same basis as stockwater developments. Off-site benefits have been figured on the basis of silt retention and flood control which are their fundamental purposes. Interest, maintenance and depreciation will total $254,166 annually while gross benefits from sediment storage alone amount to $337,503. The value of an acre foot of sediment kept out of the proposed Yellowtail Reservoir is considered to be $49.48.

Tree plantings for the stabilization of stream banks will have both off-site and on-site values. Primarily, the benefits will be off-site in that sediment will be held in place instead of going down the river. It is estimated that each mile of

tree planting will collect 1/10 acre foot of sediment per year and that each mile would also prevent 1/4 acre foot of bank sloughing. Thus, with an acre foot of sediment storage valued at $49.48, the 56 miles of tree planting would be worth $989.00 in off-site values. There would be no maintenance or depreciation charges, but interest would be $1138.00, resulting in a charge of $149.00 for the benefits.

Benefits from improvements suggested on private and state lands, as tabulated in table 8, were computed on the same basis as those on public domain lands, except that the interest was calculated at 4 percent annually.

Summary of Benefits and Costs of Proposed Improvements

A very favorable benefit-cost ratio of 2.35 to 1 has been computed for the improvements on Federal land. The direct benefits of all improvements will keep the projects in a continuing state of effective operation and the total benefits will completely liquidate the cost in twelve years after the projects have become established. Only four types of proposed improvements will not produce sufficient estimated annual benefits to equal their annual estimated costs. Check dams are negative with a charge of $14,197; Poison weed control shows an annual estimated loss of $2,450; Tree planting costs do not equal benefits by $149.00; and the one well proposed will cost $20.00 per year in excess of estimated benefits. It is believed to be advisable to put in these improvements and spread their costs over the entire program.

A summary of benefits and costs for the area on a per acre and gross basis for the lands in different types of ownership is presented in the following tabulation:

BENEFITS

Type of Land Ownership	Area (acres)	Gross Annual		Net Annual	
		Total (dollars)	Per Acre (dollars)	Total (dollars)	Per Acre (dollars)
Federal	3,639,541	1,148,632	.32	709,804	.20
Private and State	2,065,538	284,194	.14	155,150	.08
Total	5,705,079	1,432,826	.25	864,954	.15

COSTS

Type of Land Ownership	Area (acres)	Construction		Annual	
		Total (dollars)	Per Acre (dollars)	Total (dollars)	Per Acre (dollars)
Federal	3,639,541	6,986,747	1.92	438,828	.12
Private and State	2,065,538	1,649,762	.80	129,044	.06
Total	5,705,079	8,636,509	1.51	567,872	.10

In the above tabulation Federal lands are principally public domain with minor amounts of stock driveway and reclamation withdrawal lands, all under the administration of the Bureau of Land Management. A small area in other types of Federal administration is included. The area of water surface and cities, 23,934 acres, and of cropland, 414,678 acres, is not included, so the total above does not equal the study area total of 6,143,691 acres. The total tabulated is the total area of rangeland.

Benefits to be derived from improvements are closely associated with good land management. They are largely dependent upon the quality of the management of the land and of its surface resources. This proper management is a never ending daily responsibility of the users of each acre of the surface of the basin. True benefits will accrue only as the users accept their trust and responsibility with good technical guidance. Each livestock operator in the basin should formulate and follow a program which would properly provide ample feed

for his livestock for each day of the year. This program would allow for reasonable range use at the proper season and would be sufficiently flexible so that the range cover could be protected in periods of drought or of other emergency. Each operator should accept the responsibility for the proper and full development of all of his land resources and should then utilize these resources, whether they are owned or leased, in accord with the best conservation practices.

Table 9 Description and definitions of land-use capability classes 1/

Class	Suitable for	Topography		Characteristic Native Vegetation	Soil Characteristics						Vulnerability to Erosion	Requisite Special Practices
		Slope (percent)	Character of Surface		Texture	Depth	Relative Salinity	Fertility	Productivity	Drainage		
I	Best type of farming land	0 to 2	Level or nearly level	Tall and mid-grasses, thrifty sagebrush, deciduous trees	Medium; Friable	12" or more; subsoil 36" or more	Negligible	High	Good to High	Good to Excellent	Low	None to minor
II	Farming with simple conservation practices	0 to 10	Irregular	Tall, mid, and short grasses; big sagebrush, deciduous trees	Light to Heavy; Friable	8" or more; subsoil 36" or more	Negligible to slight	Good to High	Moderate to High	Good	Slight to moderate	Minor to simple practices
III	Farming with complex conservation practices	0 to 10	Irregular	Tall, mid, and short grasses; big sagebrush, rabbitbrush, greasewood, coniferous, and deciduous trees	Light to Heavy; Friable	6" or more; subsoil 24" or more	Slight to moderate	Fair to Good	Moderate to High with management	Often poor; may be needed	Moderate to High	Complex practices essential
IV	Limited or occasional cultivation; best for permanent hay or pasture	0 to 15	Irregular or stony	Tall, mid, and short grasses; big sagebrush, rabbitbrush, greasewood, coniferous, deciduous trees, saltbush, winterfat	Sandy to Clay; porous or tight	6" or more; may have shallow hardpan	Negligible to critical	Poor to Good	Poor for row crops; best for hay and pasture	Not justifiable if needed	Moderate to High	Complex and intensive practices with good management
V	Range or woodland; farming only if irrigation water becomes available	0 to 5	Smooth to irregular; may be stony	Tall, mid, and short grasses; big sagebrush, rabbitbrush, greasewood, coniferous, and deciduous trees Density .3 or more	Light to Heavy; Friable	Good permeability to 24" depth	Negligible to moderate	Good to High	Moderate to High; not over three acres per A. U. M.	Usually not a problem	Low	None to minor
VI	Range and woodland only	0 to 20 (greater only on good soils)	Irregular to rough or rocky	Tall, mid, and short grasses; big sagebrush, rabbitbrush, greasewood, coniferous, deciduous trees, saltbush, winterfat Density .3 or more	Very Light to Heavy	Shallow to moderate; permeability excessive to poor	Negligible to moderate	Fair to Good	Light to Moderate; 3-10 acres per A.U.M.	Not practicable if a problem	Moderate	Proper management with simple restrictions
VII	Range and woodland with severe restrictions	0 to 100	Rough, rocky, or eroded	Tall, mid, and short grasses; big sagebrush, rabbitbrush, greasewood, coniferous, deciduous trees, saltbush, winterfat, mountain browse and annuals Density under .3	Any: May be tight clay or open sand or gravel	Often shallow, poorly developed	Negligible to critical	May be Poor	Poor to Light; over 10 acres per A.U.M.	Seldom a problem or not practicable	High	Proper management with complex restrictions and intensive practices
VIII	Watershed, wildlife and recreation	Generally steep	Extremely rough, barren or inaccessible	Often only annuals or scanty perennials; may be dense coniferous timber	Usually poorly developed	Very shallow or nil	May be excessive for plant growth	Usually very low	Usually very low or nil	Often poor; not justifiable if a problem	High (unless a swamp)	Complete protection

1/ Adapted from Soil Conservation Service Standards, U. S. Department of Agriculture. Any one of the factors listed may classify a soil, factors determining classification singly, not necessarily in combination.

Table 10 - Description and definitions of Land Resource Condition Classes 1/

Condition Class and Map Symbol	Principal Characteristics Affecting Condition of Range Resource				
	Soils		Vegetation		
	Fertility	Erosion	Presence or absence of inferior species	Vigor	Relative Productivity
Excellent "E"	Good soil, limited by climatic conditions.	No apparent accelerated soil erosion by wind or water and no recent accumulation of silt or debris.	An absence of "invader" species of inferior utility.	Vigorous condition and good reproduction of the more valuable native vegetation.	Maximum (optimum) or near maximum production of high quality vegetation during normal years.
Good "G"	Slightly reduced soil fertility and loss of organic matter and tilth.	Only very minor accelerated sheet and shoe-string erosion or possibly some blowing and minor accumulations.	Slightly increased abundance of inferior species and "invader" plants.	Slightly reduced vigor and reproduction of desirable native vegetation; decreased density of vegetative cover.	Reduced production to between 75 and 90 percent of optimum.
Fair "F"	Moderately to severely depleted soil fertility; poor tilth.	Advanced accelerated erosion evidenced by some gullies, moderate sheet erosion and topsoil loss.	Predominance of less desirable plants. Decided increase of "invader" species.	Moderately reduced vigor and abundance and little or no reproduction of more desirable native vegetation; generally decreased density of perennial cover.	Reduced productivity to between 50 and 75 percent of optimum.
Poor "P"	Severely depleted soil fertility, poor tilth.	Excessive rapid runoff with heavy silt loam, greatly accelerated soil erosion evidenced gullying; topsoil may be lost, subsoil exposed.	Predominance of inferior perennial species or annual vegetation.	Greatly reduced vigor and density of perennial vegetation; most desirable native species may be absent or have high mortality; reproduction absent.	Productivity reduced below 50 percent of optimum.

1/ Under proper range management a high good condition would be the maximum condition attained. Excellent condition is limited to undergrazed, inaccessible and relict areas.

Table 11 Description and definitions of soil erosion condition classes

Erosion Class	Description of degree of erosion	Sheet Erosion 1/	Wind Erosion 1/	Gully Erosion 1/
1	None to Slight	0-10 percent of topsoil removed. Little apparent evidence of surface erosion and then only localized areas too small to delineate into Class 2. Vegetation often climax type. Generally smooth to gently undulating plains and forested lands; dominantly 0-3 percent slopes.	None to only local evidence of slight soil drift or surface soil removal. 0-10 percent of topsoil removed. Soil usually well protected by sod or plant litter.	No evidence of active gullying. All waterways well established.
2	Slight to Moderate	10-25 percent of topsoil removed, but with little evidence of vegetation breaking up. Slopes generally moderate; characterized by climax type of vegetation with few annual weeds and of usually lower density than vegetation in Class 1 above.	Local evidence of slight to moderate soil drifting and surface soil removal and/or accumulation. Most soil types, particularly the silty and fine sandy textured soils under certain conditions of culture and drought combined with high winds, are subject to this form of soil deterioration.	Occasional active gullies which are usually shallow, occuring primarily along main watercourses at intervals of more than 100 feet. In open areas and where slopes permit, little difficulty in traversing the area in a car.
3	Moderate to Severe	25-50 percent of topsoil removed. "Cat steps" and terraces noticeable on slopes which may be moderate to steep. Bare spots are quite common. Undesirable weeds and plants are beginning to dominate the vegetation with climax types more often scattered than dominant. Perennial woody plants frequently pedestalled. Subsoil rarely exposed except in localized areas.	Bare spots common and areas generally more consistently subject to damage by soil blowing. Soils often removed to depths of 1 to 4 inches and drift accumulations and hummocks noticeable. Sod grass deterioration and plant pedestals in evidence and plant cover is insufficient for soil protection. Subsoil occasionally exposed and soils containing gravel show pavement appearance.	Occasional gullies shallow or deep occuring at intervals of more than 100 feet apart. Concentration of run-off and drainage channeling generally due to steepness of slope. Main water courses deeply channeled, generally U-shaped with tributaries usually V-shaped. Moderate difficulty in traversing area in car, ordinarily having to "head" gully in crossing. Generally associated with extensive shoe-string or rill gullying.
4	Severe to Critical	50-100 percent of topsoil removed and subsoil may be exposed in many places and is being removed to varying depths. Bare spots and trampled out areas common and plant pedestalling and erosion pavement highly evidenced. Loss of surface soil may be complete, associated with active gullying and high mortality of climax species of vegetation. Annual and perennial invaders may dominate the vegetation.	Majority of topsoil may be removed; usually accompanied by destructive accumulations in form of hummocks and dunes particularly along such obstructions as fences and edges of drainageways. Perennial vegetation often scanty and extensively pedestalled.	Frequent, usually shallow, gullies occuring at intervals of less than 100 feet apart. Main waterways deeply channeled and undergoing active gullying, usually U-shaped. Areas often incised by shoestring gullies and rills but are not generally so numerous or deep as to destroy the land completely but dissection permits rapid drainage of surface water. Corduroyed surface makes car travel impossible.
5	Critical to Extreme	Usually all the surface soil has been removed and utility and productivity of land has been largely destroyed by advanced stages of gully erosion which usually continues and retirement from use is, therefore, mandatory. Barren wastelands are often in this class. Desirable perennials never have occupied the area or have been practically obliterated and low density of annuals usually predominates.	Represents a condition of soil deterioration amounting to essential destruction. Retirement from further use is mandatory and artificial treatment is often essential to soil stabilization. Constantly shifting dunes are common. Deep fine sandy soils usually predominate in areas so classified.	Frequent and deep gullies. Generally represents maximum destruction by erosion. Complete and rapid drainage of surface water and soil moisture effected through intricate dissection of soil by gullies. Deeply channeled waterways with edges broken and caved in. Gully banks, slopes and bottoms in active erosion stage.

1/ The erosion condition and proposed improvement map utilizes three numbers in series to show the degree of erosion in each of the three types of erosion in this order; sheet, wind, gully. An example would be 3 - 2 - 1.

Table 12. -Plants of the Bighorn Basin, their Scientific and Common Names and their Symbols as appearing on the Vegetation Map, Map Supplement "A", Bighorn Basin, Montana and Wyoming, 1953.

The symbols are listed with the scientific and common names of the plants they represent. The symbols of the three principal plants in each vegetative type appear on the quadrangle maps following the type number on the Vegetation Map. The proper stocking rate in surface acres per animal unit month is in figures following the three symbols on the Vegetation Map in Map Supplement "A".

Symbol	Technical Name		Common Name
	Grass		
Ada	Agropyron	dasystachyum	thickspike wheatgrass
Ain		inerme	beardless bluebunch wheatgrass
Apa		pauciflorum	slender wheatgrass
Are		repens	quackgrass
Asm		smithi	bluestem wheatgrass
Asp		spicatum	bearded bluebunch wheatgrass
Aal	Agrostis	alba	red top
Asc	Andropogon	scoparius	little bluestem
Afe	Aristida	fedleriana	Fendler threeawn
Alo		longiseta	red threeawn
Bgr	Bouteloua	gracilis	blue grama
Bca	Bromus	carinatus	mountain brome
Bja		japonicus	Japanese brome
Bte		tectorum	cheatgrass brome
Clo	Calamovilfa	longifolia	prairie sandreedgrass
Dun	Danthonia	unispicata	onespike danthonia
Dca	Deschampsia	caespitosa	tufted hairgrass
Dst	Distichlis	stricta	inland saltgrass
Eca	Elymus	canadensis	Canada wildrye
Eco		condensatus	giant wildrye
Fid	Festuca	idahoensis	Idaho fescue
Foc		octoflora	sixweeks fescue
Hki	Hesperochlea	kingi	spikefescue
Hju	Hordeum	jubatum	foxtail barley
Hno		nodosum	meadow barley
Kcr	Koeleria	cristata	prairie junegrass
Mbu	Melica	bulbosa	oniongrass
Msq	Munroa	squarrosa	false buffalograss
Pal	Phleum	alpinum	alpine timothy
Ppr		pratense	timothy

Symbol	Technical Name		Common Name
	Grass		
Pco	Phragmites	communis	common reed
Pap	Poa	alpina	alpine bluegrass
Pfe		fendleriana	mutton bluegrass
Ppa		pratensis	Kentucky bluegrass
Pse		secunda	Sandberg bluegrass
Shy	Sitanion	hystrix	bottlebrush squirrel-tail
Spe	Spartina	pectinata	prairie cordgrass
Sai	Sporobolus	airoides	alkali sacaton
Scr		cryptandrus	sand dropseed
Sco	Stipa	comata	needleandthread
Svi	Stipa	viridula	green needlegrass
	Grass-like plants		
Cfi	Carex	filifolia	threadleaf sedge
Cge		geyeri	elk sedge
Jba	Juncus	balticus	baltic rush
	Forbs		
Ala	Achillea	lanulosa	western yarrow
Ata	agoseris	taraxacifolia	dandelion agoseris
ALL	Allium	(spp)	onion
Alu	Anemone	ludoviciana	American pasque-flower
Aro	Antennaria	rosea	rose pussytoes
Aco	Arnica	cordifolia	heartleaf arnica
AST	Aster	(spp)	aster
Bsa	Balsamorhiza	sagittata	arrowleaf balsamroot
BID	Bidens	(spp)	beggarticks
Cnu	Calochortus	nuttalli	segolily mariposa
Cco	Castilleja	coccinea	Indian paintbrush
Cal	Chenopodium	album	lambsquarters goosefoot
Car	Cirsium	arvense	Canada thistle
Cun		undulatum	wavyleaf thistle
CLA	Claytonia	(spp)	springbeauty
CLE	Clematis	(spp)	clematis
Cvi	Chrysopsis	villosa	hairy goldaster
DOD	Dodecantheon	(spp)	shootingstar
Ean	Epilobium	angustifolium	fireweed
ERI	Erigeron	(spp)	fleabane
ERI	Eriogonum	(spp)	eriogonum
Gvi	Geranium	viscosissimum	sticky geranium
Gle	Glycyrrhiza	lepidota	American licorice

Symbol	Technical Name		Common Name
	Forbs		
Gsq	Grindelia	squarrosa	curlycup gumweed
Han	Heliathus	annuus	common sunflower
Imi	Iris	missouriensis	Rocky Mountain iris
Iam	Iva	axillaris	poverty sumpweed
Ixa	Iva	xanthifolia	rag sumpweed
Kam	Kochia	americana	greenmolly summer-cypress
LAC	Lactuca	(spp)	lettuce
LEP	Lepidium	(spp)	pepper weed
Lle	Linum	lewsi	lewis flax
LOM	Lomatium	(spp)	lomatium
Lju	Lygodesmia	juncea	rush skeletonplant
Mal	Melilotus	alba	white sweetclover
Mof		officinalis	yellow sweetclover
Mci	Mortensia	ciliata	mountain bluebells
PEN	Penstemon	(spp)	penstemon
PHL	Phlox	(spp)	phlox
Ppu	Plantago	purshi	wooly Indianwheat
Roc	Rudbeckia	occidentalis	niggerhead
RUM	Rumex	(spp)	dock
Ste	Salsola	tenuifolia	tumbling Russian-thistle
SED	Sedum	(spp)	stonecrop
SCA	Senecio	canus	woolly groundsel
Sci	Sieversia	ciliata	prairiesmoke sieversia
SOL	Solidago	(spp)	goldenrod
SON	Sonchus	(spp)	sowthistle
Tof	Taraxacum	officinale	common dandelion
Tpr	Tragopogon	pratensis	meadow salsify
URT	Urtica	(spp)	nettle
VIO	Viola	(spp)	violet
XAN	Xanthium	(spp)	cocklebur
	Poisonous Plants		
Axy	Aster	xylorrhiza	common woody aster
AST	Astragalus	(spp)	loco
CIC	Cicuta	(spp)	waterhemlock
Dbi	Delphinium	bicolor	little larkspur
EQU	Equisetum	(spp)	horsetail
Hgl	Halogeton	glomerata	halogeton
LUP	Lupinus	(spp)	lupine
OXY	Oxytropis	(spp)	crazy weed
Tma	Triglochin	maritima	shore podgrass
Zve	Zigadenus	venenosus	meadow deathcamas

Symbol	Technical Name		Common Name
	Shrubs		
Acx	Artemisia	cana	silver sagebrush
Adr		dracunculoides	falsetarragon sagebrush
Afi		filifolia	sand sagebrush
Afr		frigida	fringed sagebrush
Agn		gnaphalodes	cudweed sagebrush
Ano		nova	black sagebrush
Ape		Pedatifida	birdfoot sagebrush
Asp		spinescens	bud sagebrush
Atr		tridentata	big sagebrush
Ati		tripartita	threetip sagebrush
Aca	Atriplex	canescens	fourwing saltbush
Aco		confertifolia	shadscale saltbush
Anu		gardneri	gardner saltbush
Cve	Ceanothus	velutinus	snowbrush ceanothus
Cle	Cercocarpus	ledifolius	curlleaf mountain-mahogany
Cla	Chrysothamnus	lanceolatus	lanceleaf rabbitbrush
Cna		nauseosus	rubber rabbitbrush
Cst	Cornus	stolonifera	redosier dogwood
Ela	Eurotia	lanata	common winterfat
Gsp	Grayia	spinosa	spiny hopsage
Gsa	Gutierrezea	sarothrae	broom snakeweed
Opo	Opuntia	polyacantha	plains pricklypear
Pfr	Potentilla	fruiticosa	bush cinquefoil
Rtr	Rhus	trilobata	skunkbush sumac
Ram	Ribes	americanum	American black currant
Rse		setosum	Redshoot gooseberry
Rwo	Rosa	woodsi	woods rose
Sve	Sarcobatus	vermiculatus	black greasewood
Sal	Symphoricarpos	albus	common snowberry
Tsp	Tetradymia	spinosa	cottonhorn horsebrush
Ygl	Yucca	glauca	small soapweed
	Trees		
Ala	Abies	lasiocarpa	alpine fir
Ane	Acer	negundo	boxelder
Aal	Amelanchier	alnifolia	Saskatoon serviceberry
Bfo	Betula	fontinalis	water birch
CRA	Crataegus	(spp)	hawthorn
Jco	Juniperus	communis	common juniper

Symbol	Technical Name		Common Name
	Trees		
Jsc		scopulorum	Rocky Mountain juniper
Jut		utahensis	Utah juniper
Pen	Picea	englemanni	Englemann spruce
Pco	Pinus	latifolia	lodgepole pine
Pfl		flexilis	limber pine
Ppo		ponderosa	ponderosa pine
Pan	Populus	angustifolia	narrowleaf cottonwood
Pde		deltoides	river cottonwood (eastern poplar)
Ptr		tremuloides	quaking aspen
Pvi	Prunus	virginiana	common chokecherry
Pta	Pseudotsuga	taxifolia	common Douglas-fir
QUE	Quercus	(spp)	oak
SAL	Salix	(spp)	willow
Sca	Sheperdia	canadensis	russet buffaloberry
Sam	Sorbus	americana	American mountain ash

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2. Hydrogen Sulfide from Oil and Gas Produced in Wyoming, June 1949.
3. Variable Characteristics of the Oil in the Tensleep Sandstone Reservoir, Elk Basin Field, Wyoming and Montana, April 1951.
4. A Study of Coal Mines, Resources, and Power Requirements in the Big Horn River Basin, Wyoming, and Carbon County, Montana August 1951.

Bureau of Reclamation:

1. A Preliminary Business and Industrial Statement - Prepared for the Bureau of Reclamation by University of Wyoming, November 1951.
2. Power Resources, Requirements, and Supply, Missouri River Basin, July 1951.
3. Definite Plan Report, Yellowtail Unit, Montana, Lower Bighorn Division, Missouri River Basin, January 1950.

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1. Coal Resources of Wyoming, Circular 81, September 1951.
2. Ground-Water Resources of the Paintrock Irrigation Project, Wyoming, May 1951.
3. Gaging-Station Records in the Missouri River Basin - Water Supply Paper 1077, December 1948.
4. Progress Report, Sedimentation and Chemical Quality of Water in the Bighorn Drainage Basin, Wyoming and Montana (no date).

Fish and Wildlife Service:

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1. Clarks Fork Division, Montana and Wyoming, December 1952.
2. Bluff Unit, Wyoming, October 1951.

National Park Service:

1. Supplemental Report to the Preliminary Report of Recreational Use and Development, Yellowtail Reservoir, Big Horn River, Wyoming and Montana, October 1948.
2. Recreational Reconnaissance Report on the Buffalo Bill Reservoir, Wyoming, January 1951.
3. Evaluation of the Effects of the Paintrock Project on the Recreational and Scenic Values of Lake Solitude and Cloud Peak Primitive Area, Big Horn National Forest-Wyoming, December 1948.
4. Reconnaissance Report on Recreational Potentialities of the Anchor Reservoir, South Fork Owl Creek, Hot Springs County, Wyoming, April 1948.
5. Preliminary Report of Recreational Use and Development, Oregon Basin Reservoir Site (offstream) Shoshone River, Wyoming, June 1947.