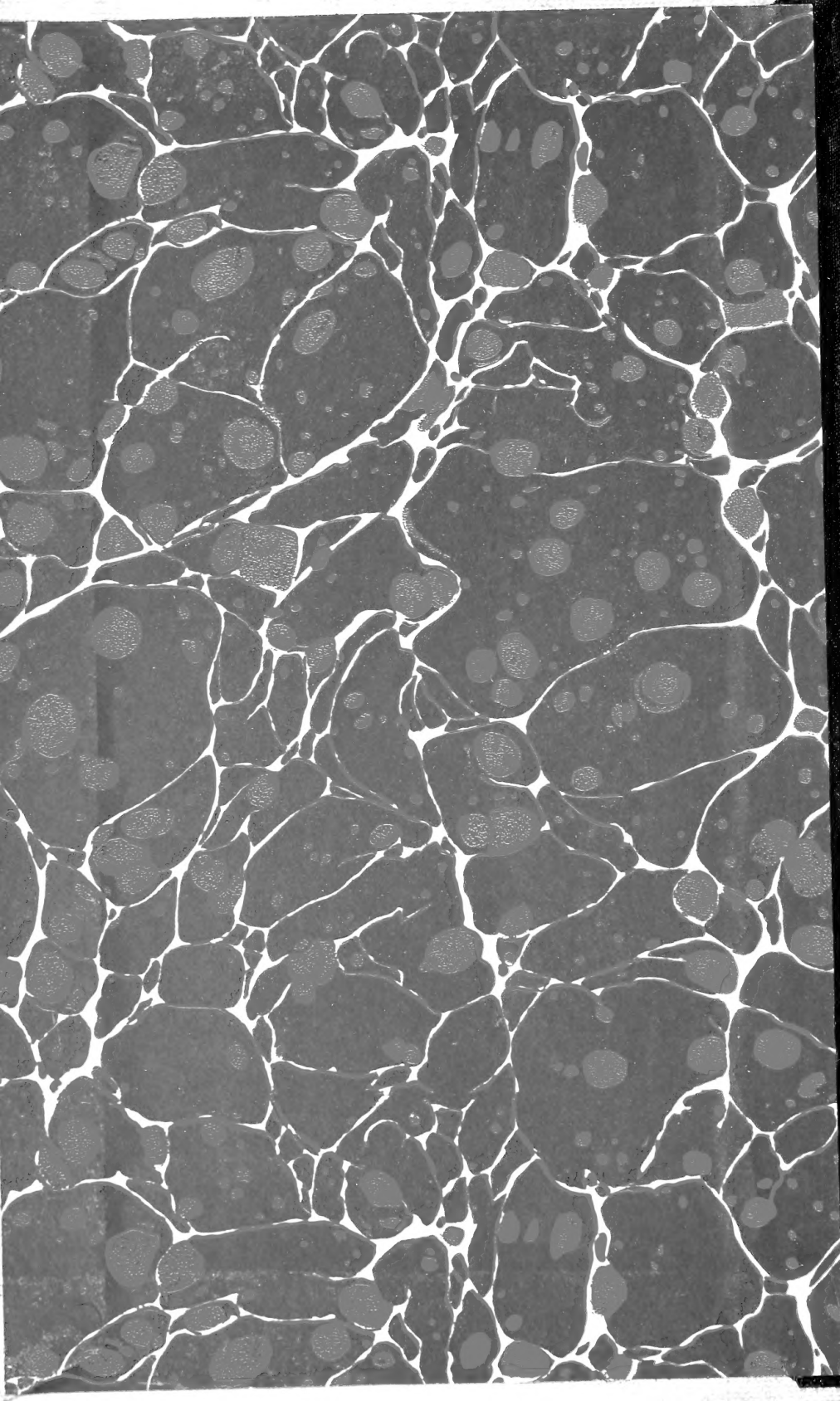

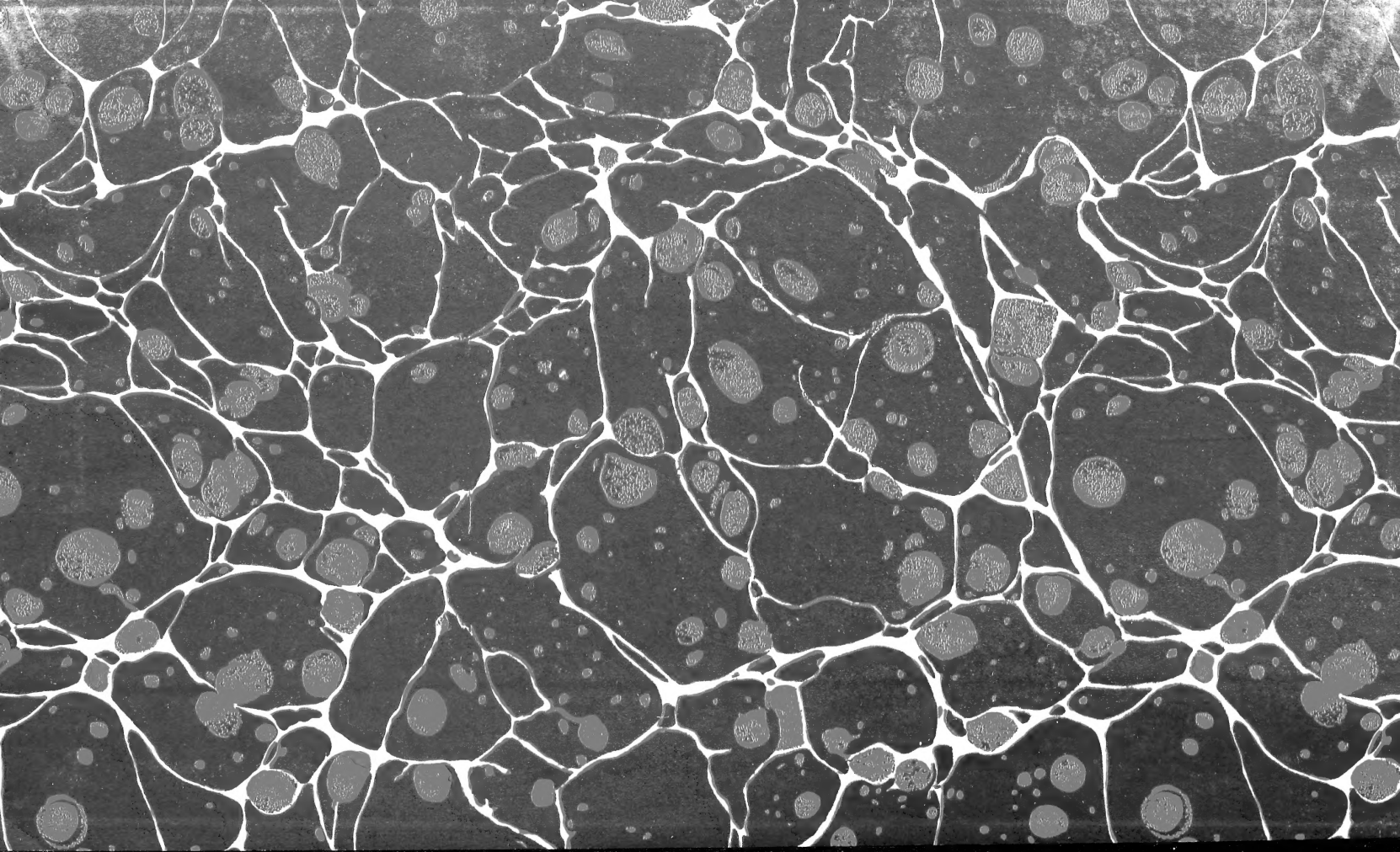

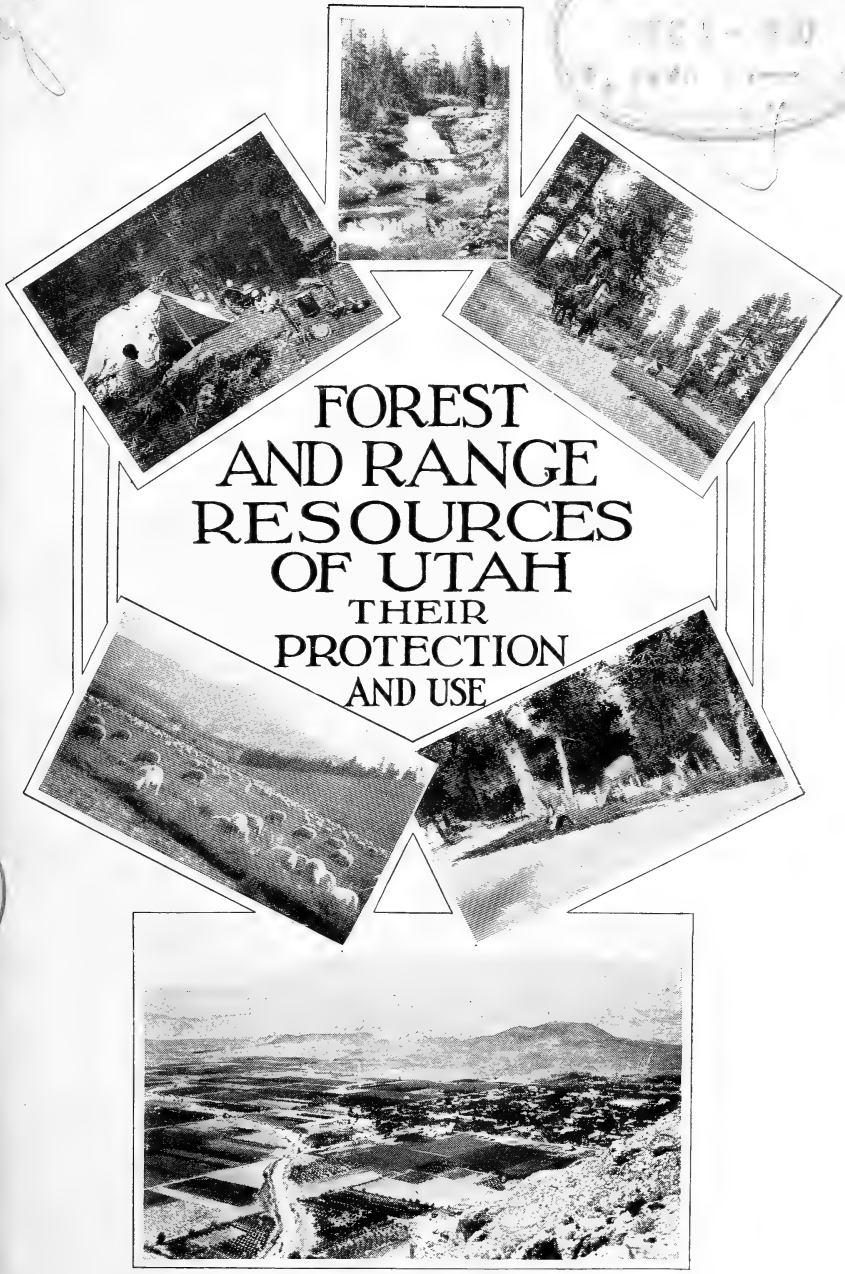

FOREST AND RANGE RESOURCES OF UTAH

THEIR PROTECTION AND USE

MISCELLANEOUS PUBLICATION NO. 90
UNITED STATES DEPARTMENT of AGRICULTURE

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FOREST AND RANGE RESOURCES OF UTAH: THEIR PROTECTION AND USE

Prepared by the *Forest Service Intermountain Region*,[1] in cooperation with *Utah Department of Public Instruction*

CONTENTS

INTRODUCTION

LAND IS primarily valuable to man for the products of the soil, such as cultivated crops, pasturage, and forests, for the water it supplies, and for the oil and minerals it contains. In the United States these resources were originally so extensive that until a comparatively few years ago little thought was given to the possibility of their exhaustion. As a result they have been seriously depleted, and the effects of their depletion are now being felt in Utah as well as in other parts of the country.

It is not possible to renew resources like oil and minerals. Conservation of these must consist chiefly in preventing waste of the available supply. It is different with the products grown from the soil. Such crops as grass and forests can be renewed, and the fertility

[1] Acknowledgment is hereby made of cooperation and assistance in the preparation of this publication given by George Stewart, Utah Agricultural Experiment Station; W. P. Cottam, Brigham Young University; George Holman and R. Scott Zimmerman, Bureau of Biological Survey; C. N. Jensen, State Superintendent of Public Instruction; L. R. Humphreys and A. C. Matheson, of the Utah Department of Public Instruction; J. Cecil Alter, U. S. Weather Bureau; D. H. Madsen, Utah State Fish and Game Commission; C. L. Forsling and E. W. Nelson, of the Intermountain Forest and Range Experiment Station; R. E. Gery, C. B. Morse, S. B. Locke, A. R. Standing, J. W. Stokes, A. L. Taylor, U. S. Swartz, L. F. Watts, Ernest Winkler, C. N. Woods, and Dana Parkinson, of the Intermountain Region of the Forest Service.

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of the soil can be maintained, by proper management. The water supply can be conserved by the same measures which renew and perpetuate the forests and forage; for, by maintaining the plant cover on the watersheds, decreases in the amount of water available and increases in the damage to life and property by floods can largely be prevented. Wild life also is a natural resource of the forest and range which can be renewed.

Organized effort to conserve the natural resources of the United States began with the creation of the American Forestry Association in 1875. In 1891 Congress gave the President authority to set aside forest reserves, and President Cleveland took advantage of this authority to reserve extensive areas of forest from further entry. Among these areas was the Uinta Forest Reserve, established in 1897, covering the greater part of the Uinta range in Utah. In 1899 and 1901, President McKinley issued proclamations which marked the beginning of the Fishlake Forest and the Nebo division of the present Uinta Forest. Under President Roosevelt the proclamations became more frequent and included greater areas. In 1905 the forest reserves were transferred from the Department of the Interior to the Department of Agriculture by an act of Congress, and placed under the authority of the Forest Service; and in 1907 the name forest reserves was changed to the more appropriate name of national forests. By 1906 a nucleus had been established for each of the national forests now in the State. Since that time areas which have proved to be more valuable for agriculture than for forests have been eliminated. There have also been minor additions and some consolidations, and on June 30, 1929, there were 10 national forests in Utah with a total area of 7,475,762 acres.

The policy under which the national forests have always been administered was laid down at the outset by Secretary of Agriculture James Wilson, who directed that all their resources should be used, that this use should be for the benefit of the whole people and under such restrictions only as would insure the permanence of these resources, and that all questions of management of the forests should be decided from the standpoint of the greatest good to the greatest number in the long run.

On September 19, 1914, at the request of Salt Lake City, Congress reserved from all forms of entry and set aside as a municipal water-supply reserve for the use and benefit of the city of Salt Lake City, portions of City Creek, Red Butte, Emigration, and Parley's Canyons, to be administered by the Secretary of Agriculture in cooperation with and at the exclusive expense of the city for the purpose of storing, conserving, and protecting from pollution the said water supply, and preserving, improving, and increasing the timber growth on said lands to more fully accomplish such purposes. This reserve is within the Wasatch National Forest. Salt Lake City has also acquired lands of its own on its watersheds and administers them mainly for watershed protection.

The State of Utah has established game preserves and fish hatcheries; it has enacted fish and game laws; and it operates a fish and game department, all for the conservation of its natural resources.

It is evident that conservation of natural resources in Utah has already been recognized as a Federal, State, and municipal responsibility.

LAND USES AND CONTROL

LAND AND LAND USES

Utah, with a land area of 52,597,760 acres, is the eleventh largest State in the Union. It is rich in mineral resources, but these occupy only a small portion of the total area, and for the most part they are underground. The area adapted to farming is also small, chiefly because of low rainfall, rugged relief and limited supply of water for irrigation. According to the Utah Agricultural College, the land in cultivated crops in 1927 amounted to 1,871,000 acres, or only 3.6 per cent of the total land area. Because of the limited supply of water for irrigation, only approximately 2,500,000 acres, or about 5 per cent of the total, can ever be farmed successfully by agricultural methods now known. Land utilization in the State is about as shown in Table 1.

TABLE 1.—*Land utilization in Utah*

[Figures are only approximate]

Kind of land	Acres	Per cent of land surface
Irrigated land [1]	1,371,000	2.6
Dry farm land [1]	500,000	1.0
Timberland (4,748,000 acres within national forests, mostly used for grazing)	5,000,000	9.5
Other grazing land	39,000,000	74.1
Waste (desert, barren, rock) [1]	5,000,000	9.5
National monuments, national parks, cities, towns, and other uses	1,726,760	3.3
Total land surface [2]	52,597,760	100.0
Water surface [2]	1,795,840	
Grand total area of Utah	54,393,600	

[1] From Bulletin 204, Utah Agricultural Experiment Station (*2*).[2]
[2] From Annual Report of Commission of the General Land Office for Fiscal Year ended June 30, 1929.

It will be noted that over 83 per cent of the land surface is used for grazing. If the waste is excluded from the land surface, 90 per cent is used for grazing.

FACTORS INFLUENCING LAND USE

SURFACE RELIEF

Surface relief and precipitation are two factors which greatly influence present and future use and value of land in Utah. (Fig. 1.) Temperature, soil, transportation facilities, and general economic conditions also govern the use of land, but precipitation and relief have a greater effect. Relief will be discussed first because of its effect on precipitation.

Utah is characterized by mountain ranges or narrow high plateaus with valleys in between. In the main, the mountain ranges run in a general north and south direction. The Uinta Range in the northeastern part of the State and the mountains north of Price are important exceptions, both running practically east and west. The Uinta Mountains are the highest in the State, averaging well over 11,000 feet, and include Kings Peak with an elevation of 13,498 feet, the highest in Utah.

The principal mountain group is the Wasatch Range, which extends from the northern boundary of the State as far south as

[2] Italic numbers in parentheses refer to Literature Cited, p. 101.

Mount Nebo near Nephi. This range has an average elevation of about 10,000 feet above sea level, although several peaks are much higher. Chief among these are Mount Timpanogos with an elevation of 11,957 feet, and Mount Nebo with an elevation of 11,887 feet. From the end of the Wasatch Range, the Wasatch Plateau extends south for many miles and is joined by the Powell Plateau, which runs almost to the southern boundary of the State. Both plateaus are high and deeply dissected and have an elevation of approximately 10,000 feet. This chain of mountains and plateaus literally forms a backbone running the full length of the State.

The Pavant, Beaver, Cedar, and Pine Valley Mountains form an almost continuous range from the northeast corner of Millard County to near the center of Washington County in the southwest corner of the State. They parallel the main portion of the Wasatch and Powell Plateaus. In addition, there are many smaller mountain

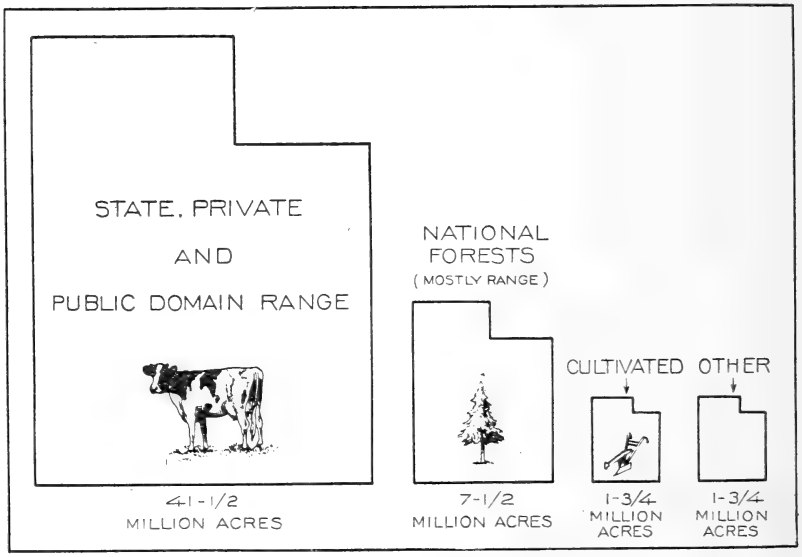

FIGURE 1.—Land utilization in Utah

ranges mostly with a lower altitude, although the La Sal and Blue Mountains in the east-central portion of the State reach up well over 10,000 feet.

The valleys between the various mountain ranges are mostly between 4,000 and 6,000 feet above sea level. The lowest place in the State has an elevation of about 2,000 feet above sea level. This is in Washington County, where the Beaver Dam wash leaves Utah and enters Arizona.

Even though other conditions were favorable, the steepness of the mountains and the narrowness of the canyon bottoms would limit farming largely to the intermountain valleys. In some places, such as the Great Salt Lake Desert, the Sevier Desert, areas immediately adjoining Salt Lake, and some of the bottom land along the rivers, the land is not usable because of a highly saline soil.

PRECIPITATION

The annual precipitation in Utah varies from less than 5 inches at the western border of the State on the Great Salt Lake Desert to 30 or 35 inches near the tops of the Wasatch Mountains and Plateau. The State average is about 13 inches. (Fig. 2.) Areas with less

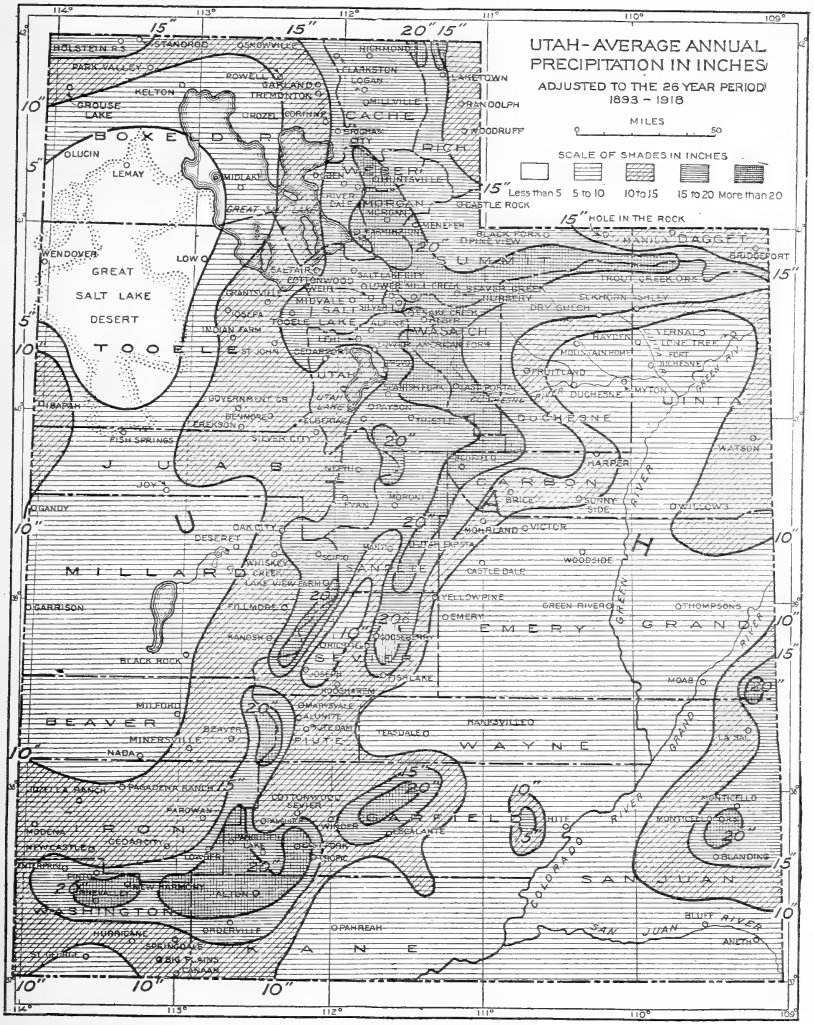

FIGURE 2.—Average annual precipitation in inches

than 13 to 15 inches of precipitation are unsuitable for farming without irrigation. The amount of land with 15 inches or more of rainfall, suitable relief, and a satisfactory growing season is limited. Rainfall in excess of 15 inches occurs mostly in the mountains where the land is too rough or the growing seasons too short for farming. The prevailing winds of Utah are out of the west, and precipitation takes place generally on the west side and in the tops of the mountains. The only areas suitable for the production of ordinary farm

crops without irrigation are narrow strips at the foot of the west slope of the higher mountain ranges. Although only a little of the foothill and valley land is capable of being farmed, it all receives sufficient rainfall to support a vegetative cover that is of considerable economic value. As the air rises and strikes the mountains it cools, and the cooling condenses much of the vapor, causing it to be precipitated. As the air descends on the other side of the moun-

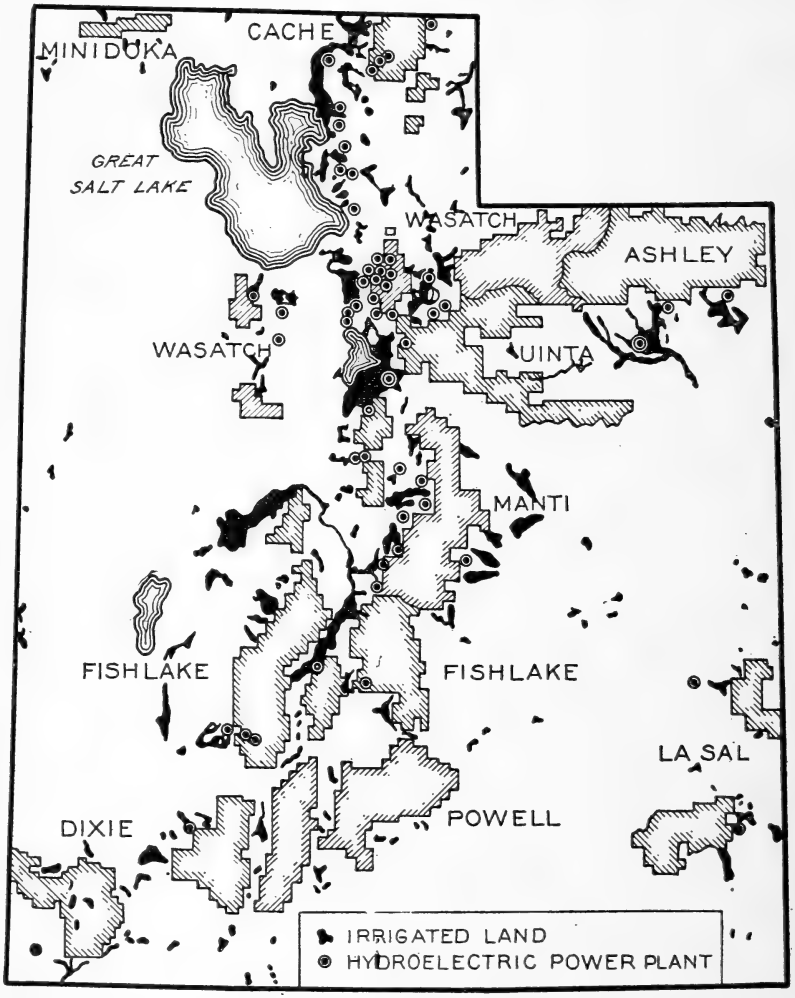

FIGURE 3.—Map showing irrigation and hydroelectric plants and national forests

tains it tends to take up rather than to lose moisture, so that the lowlands in Utah are very dry. Were it not for the high mountains running from the north to the south end of the State, Utah would all be semidesert.

WATER FOR IRRIGATION

In spite of the limited area suitable for farming, the production of farm crops holds high rank among the State's industries. This

is made possible by the water that is available for irrigation. The first settlers who came to Utah established their homes and began to till the soil in the valleys at the foot of the higher mountain ranges near the mouths of the canyon streams where water from the mountains was readily available for their crops. The population has continued to cling to these places. Over 1,000,000 acres of highly productive farming land is now irrigated with water derived from high mountain watersheds. (Fig. 3.)

LAND OWNERSHIP AND CONTROL

At the time of admission to the Union, Utah, along with a few other Western States, was granted four sections out of each township as school lands. When Utah was admitted many of the sections that would have been school lands were already patented. In lieu of these the Federal Government allowed land to be taken from remaining public lands. The best land was thereby lost to the State; but it was possible, by consolidating the lieu lands, to obtain the State land in large blocks instead of in isolated sections.

Land and script granted to Utah has totaled over 7,000,000 acres, as shown below. The Morrill Act allowed land for agricultural colleges and gave the Utah Agricultural College 200,000 acres. The University of Utah was allowed 110,000 acres, and additional grants of 100,000 acres each were made for the school of mines and the normal school. Smaller additional grants to the university included the campus.

The Union Pacific Railroad was allowed alternate sections for 20 miles on each side of its right of way with the privilege of choosing other lands in lieu of any of these alternate sections already entered. Large areas of good land were thus made available in solid blocks, as lieu lands could be chosen at will on public lands. Mineral lands were excluded from this grant, but timberlands were not.

The following tabulation gives the most important alienations from the Federal lands of Utah, together with withdrawn and reserve lands, up to June 30, 1929.

1. Land and script granted to Utah for educational and other purposes:[3]

	Acres
University	156,080
Agricultural college	200,000
Public buildings	64,000
Insane asylum	100,000
Deaf and dumb asylum	100,000
Reform school	100,000
School of mines	100,000
Normal school	100,000
Blind asylum	100,000
Reservoirs	500,000
Miners' hospital	50,000
Common schools (sec. 2, 16, 32, 36)	5,844,196
Miners' hospital (act Feb. 20, 1929)	50,000
Total[4]	7,464,276

	Acres
2. Patented under enlarged homestead act[5]	930,548
3. Patented under all homestead entries, both final and commuted entries (except enlarged homesteads[5]	2,907,868

[3] Annual Report of Commissioner of the General Land Office, Fiscal Year, 1929.
[4] Area belonging to State (192) is about 2,800,000 acres.
[5] At close of June 30, 1929.

	Acres	Acres
4. Timber and stone entries[3]	3,196	
5. Desert land entries[3]	454,562	
6. Stock grazing homestead[3]	2,005,807	
7. Coal-land entries[3]	75,828	
8. Railroad grants (approximate)[6]	2,500,000	
Total of items 1 to 8		16,342,085
9. National monuments:[5]		
Timpanogas Cave 250 acres (included within national forests)—		
Arches	4,520	
Dinosaur	80	
Hovenweep (125.8 in Colo.) in Utah	160	
Natural bridges	2,740	
Rainbow bridge	160	
Total outside national forests		7,660
11. National parks:[5 7]		
10. National forests (net)[5]		7,475,762
Bryce Canyon[5]	14,480	
Zion	76,800	
Total		91,280

12. Indian reservations:[5]	Acres allotted	Acres unallotted	
Goshate		34,500	
Pauite		10,240	
Shivwitz		26,880	
Koosharen		120	
Kanosh		920	
Skull Valley		18,640	
Uinta Valley	111,947	249,340	
Ute (school site)		40,	
Total	111 947	340,680	452,627

13. Unappropriated and unreserved:[5]	Acres	
Surveyed	13,192,133	
Unsurveyed	11,955,734	
Total		25,147,867
14. Unperfected entries[3]		1,362,097
15. Withdrawals:		
a. Stock driveways[3]	1,224,222	
b. Coal[3]	3,636,541	
c. Helium[3]	12,255	
d. Oil[3]	1,341,264	
e. Oil shale[3]	91,464	
f. Phosphate[3]	277,344	
g. Power site classification[5]	175,574	
h. Power site reserves[5]	441,592	
i. Federal power projects[5] (largely included in *g* and *h*)	34,155	
j. Public water[3]	37,941	
k. Reservoir sites[3]	26,040	
l. Miscellaneous reservations[3]	2,320	

[3] Annual Report of Commissioner of the General Land Office, Fiscal Year, 1929.
[5] At close of June 30, 1929.
[6] Obtained by multiplying length of Union Pacific Railroad across Utah in miles by 12,800 acres (20 sections per mile).
[7] During the fiscal year 1930, additions to Bryce Canyon and Zion National Parks increased their areas to 14,720 acres and 94,720 acres, respectively, a total of 109,440 acres.

15. Withdrawals—Continued.	Acres	Acres	Acres
First and second form	1,002,400		
m. Reclamation [5]—			
Additional area under act of June 25, 1910	24,960		
		1,027,360	
Total withdrawals		8,328,072	
Less conflicts		6,609,690	
Total withdrawals (net)			1,718,382
Total land surface			52,597,760
Water surface			1,795,840
Total area			54,393,600

Ninety-five per cent of the land area of the State is not suitable for cultivated crops. About 83 per cent, however, has the capacity to produce native crops. It devolves upon the respective owners to develop this capacity to the limit; otherwise the State as a whole suffers economically. The capacity of the national forests to produce is being energetically capitalized although the ideal has not been reached. On private lands the administration of native crops naturally depends upon the inclination of the owner and upon his knowledge of forest, range, and watershed management. On State lands a permanent forest and range policy is needed; these lands are now subject to the varying policies of changing State administrations. On the unappropriated and unreserved public domain there is no management of range and forest resources; consequently the range in many places is used before the plants are ready, fences are lacking, much-needed watering places are undeveloped, stock is poorly distributed, and the range is often overstocked.

USE AND MANAGEMENT OF FORAGE RESOURCES

RANGE HISTORY

Some years previous to the landing of the first English settlers at Jamestown, another group of Europeans had gained foothold in the extreme southwestern part of the continent and were grazing large numbers of livestock. There are records of large numbers of horses, mules, cattle, sheep, and hogs raised and moved from place to place by Spanish adventurers in Mexico. This livestock industry seems to have prospered amazingly, the grassy plains adjacent to the coast furnishing almost unlimited range, in a mild, even climate.

When Coronado, in 1540, started from northeastern New Mexico, on his march across the prairies of the Colorado and Kansas of today, he took with him, according to historical records, 1,000 horses and 500 cows and more than 5,000 rams and ewes. From Mexico, the line of settlement spread in two directions, north along the Pacific coast, and northeast up along the Rio Grande into what is now New Mexico and Arizona. Another stream of exploration took the Spanish along the Gulf coast up into the rich coastal plains of Texas. From these various settlements of the Spanish, the livestock industry of the Southwest spread gradually until it finally met and merged with the livestock movement from the East.

[5] At close of June 30, 1929.

In the nineteenth century in the latter part of the seventies, the West awoke to the opportunities offered for raising cattle and sheep upon the open ranges (fig. 4) that lay west of the Missouri River from the Mexican to the Canadian line. Great cattle companies were formed in the East and in Europe, the promoters of which went into Texas and bought thousands of long-horned cattle and moved them north on to the unoccupied ranges. Those were the great years of the Texas trails, during which that State disgorged hundreds of thousands of her surplus cattle into the new unstocked ranges to the north.

In consequence of overgrazing, disaster befell the livestock industry again and again. The longhorns of the West and the better breeds from the East spread out over the entire region. By 1895 no open range remained unstocked. Ranges that, for permanent and regular use, would have been fully stocked with a cow to every

FIGURE 4.—Types of western range land: A, cattle range; B, sheep range

40 acres, were loaded until they were carrying one to every 10 acres. Into western Kansas, Nebraska, eastern Colorado, out into the Red Desert country of Wyoming and Utah, up across Montana and the two Dakotas, clear to the Canadian line, they pressed in their search for grass. Final readjustment was brought about, but the business of raising cattle upon the open ranges has always been a fluctuating one.

Along in the early nineties, the sheep industry came into active competition with the cattle industry. The sheepman was much better able to cope with conditions than was the cattleman, and many of the latter, in sheer self-defense, joined the ranks of the woolgrowers and gave up the cattle industry. However, with the swelling tide of settlement overflowing the western prairies, under the homestead and other land laws, competition for the ranges became more and more fierce, and this competition developed into the range wars which were checked only with the placing under Federal regulation in national forests during the first decade of the present

century of millions of acres of public lands, which, for 50 years had been used by western stockmen without let or hindrance.

At first many of the stockmen did not take kindly to this new scheme of supervision. Gradually, however, they saw the benefits possible from such a system and rendered splendid cooperation in aiding the Government officials to work out the difficult problems that naturally arose. Gradually a system of range use has been evolved on the national forests that has improved the ranges and at the same time has secured full utilization of the forage crop.

LIVESTOCK ON UTAH RANGES

The livestock industry is among the largest in Utah. In 1929 there were 363,000 beef cattle, 100,000 horses, and 2,866,000 sheep in the State. (Fig. 5.) The sale of livestock and livestock products brings in about 43 per cent of the gross farm income. More stockmen than in any other State, 6,300 in all, have permits to graze livestock on the national forests, and in 1929 the forests furnished summer grazing for nearly 31 per cent of the beef cattle and 26 per cent of the sheep.

The cattle and sheep in the State obtain 77 per cent of their feed by grazing. Of this 14 per cent comes from farm pasture and controlled range, 18 per cent from national forests, and 68 per cent from the open public domain and other ranges.

Unscientific use has reduced the productivity of much of the unregulated public range and some of the State and private range until it now yields less than one-half as much forage as it did originally. Since to feed an animal harvested crops costs from four to eight times as much as to graze it, and since 83 per cent[8] of the State is range land, it is of the utmost importance to Utah that the depleted areas be restored, the remainder protected, and the whole made as productive as possible through the practical application of scientific methods. Proper management of the ranges is also essential to watershed protection, timber reproduction, wild life, and recreation.

PLACE OF CATTLE RAISING ON FARMS

Cattle raising fits in very well with other farm activities in the State. The practice of crop rotation on farms is well established as a means of building up or maintaining soil fertility. This calls for a diversity of crops, among which alfalfa, clover, and other forage crops have prominent places. The success of the diversified-crop plan depends upon livestock to utilize the forage. This does not mean that the man who raises the crops must own the livestock, but somewhere within a reasonable marketing distance must be stockmen who need to buy forage.

Some parts of Utah, as the vast Uinta Basin and many of the southern communities, are long distances from the railroads. The production of such crops as beets, fruits, potatoes, and the like, means many long trips by truck or wagon to market the product. Many people in these communities have solved the problem by raising forage crops which they feed to livestock. The stock can be driven to the railroads, thus furnishing their own transportation to market.

[8] Includes 5,000,000 acres of timberland mostly used for grazing.

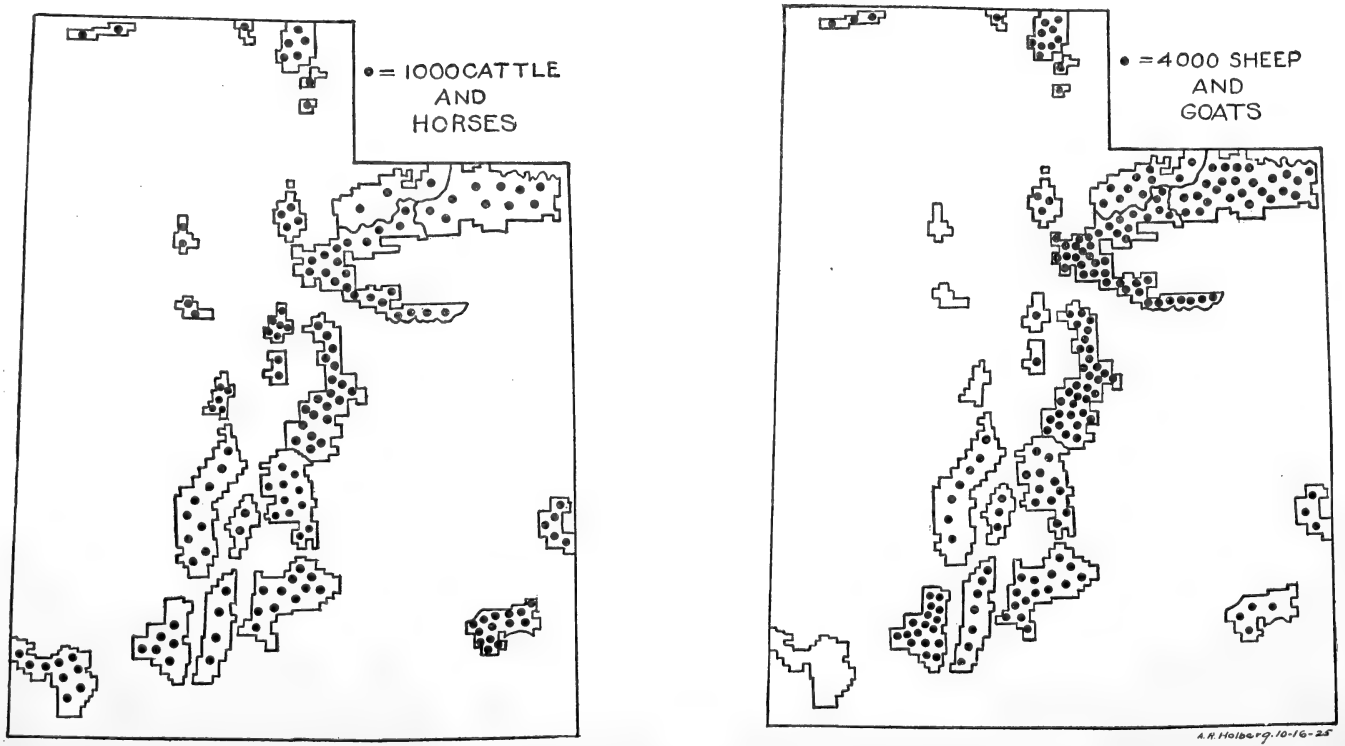

FIGURE 5.—Grazing of cattle, horses, and sheep on the national forests of Utah

IMPORTANCE OF GOOD STOCK

There are four important breeds of beef cattle in Utah. The Hereford, the Shorthorn, the Aberdeen-Angus, and the Galloway, the Shorthorn and Hereford breeds predominating.

Most of the range cattle of the State are grades, often having a large proportion of dairy-stock blood in them. The common practice is to run purebred bulls of one of the four breeds mentioned above, with grade cows. However, one frequently sees on the ranges, herds of purebred bulls and cows.

Well-bred cattle mature earlier than inferior grade cattle. They make their growth and are generally ready for market in less time. Well-bred cattle may dress out a higher percentage of carcass to live weight. The meat is of choice quality, and commands a more ready market and often a higher price per pound. Obviously this means more production from forage consumed and more profit for the owners. Land area can not be increased, so as time goes on and population grows the importance of a maximum production per acre of all commodities, including those from livestock, will steadily increase.

IMPORTANCE OF GOOD HANDLING

To have beef cattle that are well bred is only half the story. Well-bred cattle poorly handled may be poorer producers than grade cattle well handled. The ideal is good cattle well handled. Cattle that are handled quietly are not so wild and unmanageable as cattle that are frequently excited, and they keep in better flesh. In keeping with the practice of quiet handling, the excessive use of dogs is being avoided, and the dehorning and branding chute is replacing the lariat.

It has been demonstrated that better results and more profits are secured in the long run when heifers are not bred until they are 2 years old. This is a desirable practice to follow when range or pasture conditions make it practicable to separate the heifers from the breeding herd.

IMPORTANCE OF A GOOD CALF CROP

A calf crop of from 70 to 80 per cent is considered a good average, but in many cases the average is around 60 per cent or lower. There are very few places where a successful cow business can be conducted if only one calf is produced annually for every two or three cows.

The best cattlemen use only mature bulls and use one bull for every 20 or 25 cows, except on rough ranges when the number of cows per bull is still further reduced. Yearlings are unsatisfactory on the range and two-year-olds are not as efficient as three-year-olds. A yearling bull can breed 10 or 15 cows, and a two-year-old, 20 to 25 cows on small pastures.

If one bull is used for every 25 cows, then for every additional dollar that is paid for a breeding cow, $24 more can be paid for a bull because the added good qualities of the better bull will go 25 times as far as every dollar invested in the better cow.

Many ranchers have increased calf crops on the range by keeping the bulls distributed among the cows.

* * * * * * *

The Forest Service has found that in rough areas judicious fencing, coupled with careful range riding during the breeding season, will result in a 15 per cent increase in the calf crop. If pasture breeding is resorted to, allot about 100 cows to a pasture with 4 thrifty, well-conditioned bulls (*9*).

Under range conditions, April and May calves are most desirable. The danger from severe storms is not great at this time, and grass is usually fair. If good shelter and feed are available it is good practice to have the calves come in March. Other conditions being equal, early calves get more use from grass the first summer and are more valuable in the fall than late calves. Calves should not be dropped later than July 15. July and August calves are too young to wean with the others in the fall, and unless wintered well will not be much larger when two years of age than the calves dropped the following spring.

RELATIONSHIP OF FARMS TO THE RANGE

Three methods are used in the production of beef cattle in Utah. One method is feeding the cattle in feed lots during the winter (as on farms, ranches, or near sugar factories) and grazing them on farm pastures during the summer. Another is grazing the cattle the year round on the open ranges. The third is feeding the cattle

FIGURE 6.—Range land adjacent to farms. There is an interdependence between the farm and the range

in feed lots during the winter but grazing them on the open ranges during the summer. The last is the method most commonly used. Farm lands can ordinarily be used more profitably for crop production than for beef-cattle pasturage. Feeding the cattle such forage as hay in the summer as well as in the winter, does not pay. For cattle raising to be profitable, a large part of the gains in weight must be made on cheap forage, and the range is the very place to secure this. (Fig. 6.)

HORSE RAISING IN UTAH

Horse raising is not now so closely related to the utilization of the natural resources of Utah as is the production of sheep, cattle, and

goats, for horses are generally confined to the farms. However, the wild-horse and wild-burro situation has been one of the most serious of Utah's range problems. Hundreds of such wild, worthless mustang horses and burros have roamed over the range lands, being of no use to any one and using forage needed by valuable livestock. These have been more of a pest on the fall, winter, and spring ranges than on the summer ranges. A State law has been passed making it easier to rid the ranges of wild horses and burros, and much effort has been put forth to eliminate them. Their number is gradually diminishing, and the time will no doubt come when these picturesque but worthless animals will be no more.

SHEEP RAISING IN UTAH

Brief History

About 1870 sheep began to be brought into the State in large numbers. There were a few bands, most of them from New Mexico, previous to that time. Spanish Merinos were introduced from California and fine-wooled rams from Ohio. Long-wooled animals came from Canada, Kentucky, and other regions. In 1883, there were about 450,000 sheep sheared, averaging probably 5 pounds to the fleece. About one-fourth of the wool was used locally by the woolen factories. The remainder was export wool of fair quality. Since sheep were tax exempt, capital was rather freely invested, some of the largest herds being in Cache Valley. A profit of about 40 per cent was estimated for Cache Valley sheep in 1883. Sheep were found generally throughout Utah, extending into the Rio Virgin area.

After about 1884 or 1885 there were no longer any unoccupied ranges, at least in central Utah. Five or six years of unremitting competition on crowded ranges greatly reduced the vegetative cover. In regions where the intensity of overgrazing was cumulative, great areas of bare, dusty hillside replaced previously well-covered forage areas. Spring freshets came with sudden and augmented volume. Heavy summer showers poured down the gullies and flooded neighboring farm lands and even towns. For example, Manti, which had no serious flood before 1889, experienced real difficulties in 1889, 1901, and 1906. In 1903, the Manti National Forest was created, and grazing was completely prohibited on the watershed above the city of Manti from 1905 to 1909. In 1909 a heavy storm barely flooded Manti the range above which had greatly recuperated under protection, whereas Ephraim Canyon was seriously eroded by the same storm.

For the last two decades at least, many of the ranges have been used more judiciously. Also about 14 per cent of the area of the State, practically all of which is in the high mountains that comprise the best summer range for sheep, has been included in the national forests. Permits are granted for the privilege of grazing stock on the national forests only to those who have made provision for caring for their stock during the fall, winter, and spring periods. This has tended to squeeze out the nomadic sheepman.

SOME RANGES BETTER FOR SHEEP THAN CATTLE

It is much more practical to drive sheep than cattle to ranges at considerable distances from settlements. Sheep do not become so

sore footed, fewer men are required to drive them, they can be handled more easily at night on the trail, and they can go longer without water. It is more satisfactory to raise sheep than cattle where deserts at a considerable distance from the summer ranges must be relied upon for winter feed. Sheep are able to graze steep and brushy ranges better than are cattle. They can sometimes do well on ranges that cattle can not use at all.

PLACE OF SHEEP ON THE FARM

Sheep, like cattle, fit into farm activities by utilizing by-products and forage crops that are part of the production under diversified-crop practice. They also furnish a means for marketing farm crops "on the hoof" at points a long distance from railroads.

BREEDS OF SHEEP

Well-bred sheep and scrub sheep differ little in the amount of forage they consume, but they differ a great deal in the production of wool and meat from a given amount of forage.

The advantages of well bred over scrub sheep are numerous: They have a maximum of meat production to a carcass (especially in the mutton breeds). Of the meat produced there is a maximum of the choicer cuts; therefore the meat commands a more ready market and a higher price. With the same feed and care, well-bred sheep grow larger than do scrubs. Other desirable characteristics have been brought out by breeding, such as prolificacy, milking functions (for better lamb growth), and feeding capacity. The wool crop has been bettered in quality and quantity. The improvement in quality has been in greater density and length of the fibers, and in securing fibers that are regular in crimp, bright, clean, sound, and moderately oily. An effort has been made to have the fleeces free from gare hair or black fiber; to have them soft and elastic to the touch. The increased quantity of wool is due to a better growth over the head, legs, and belly, and a heavier fleece in general.

Not many years ago it was customary to classify sheep into three large groups: The breeds having fine wool, those with coarse wool, and the mutton type or medium wool. The fine wooled were the Merinos and Rambouillets, the fleeces of which are made up of very fine, crimpy fibers. Such breeds as the Cotswold and Lincoln made up the coarse-wooled class. The wool fibers of these breeds are long and comparatively coarse. They are large animals, but do not have the proper conformation to be classed as ideal mutton sheep. In the mutton, or medium-wooled class, were placed such breeds as the Southdown, Shropshire, and Hampshire. These breeds have wool which is intermediate in fineness and length of fiber. Lately the tendency has been more to class sheep as wool breeds or as mutton breeds, placing Merinos and Rambouillets in the former class and placing the coarse wooled in the mutton class with the Hampshires, etc. Of course, the wool breeds are used for meat production, but do not produce quite the quality and quantity of meat the mutton breeds do. The mutton breeds produce more or less heavy fleeces, but they lack the fineness, crimp, and other characteristics of the fleeces of the wool breeds.

Both classes of sheep are important and popular on Utah ranges, and occasionally one sees herds of purebred sheep. As a rule, when purebred sheep are raised, the owner is catering to the market for breeding animals. This phase of sheep raising has an important place in Utah. It will be discussed more fully later. Often the range bands are composed of ewes that represent a mixture of several breeds. However, the rams used are generally purebreds of one of the important breeds and are usually of high class. A common practice among some sheep producers is to use rams of one of the mutton breeds (generally Hampshire in this State) for sires when the ewes are mostly of wool type so that the lambs produced will have better mutton qualities. All range flocks need some Rambouillet blood as a foundation.

The Rambouillet is the most important breed in Utah. It is larger than the other fine-wooled sheep. The body is of good conformation and the mutton of good quality, though in both these characteristics the Rambouillet is inferior to the mutton breeds. Rambouillets are very hardy. They keep close together on the open range, so that they are easy to herd. They produce heavy fleeces of very high-grade wool. The ewes are fairly prolific, make very good mothers, and produce strong, large lambs.

Merinos, Southdowns, Shropshires, and Hampshires are all found in Utah but are not so prevalent as the Rambouillets.

SHEEP-RAISING METHODS

There are several methods of sheep production in Utah. Not infrequently small bands are kept on farms the year round. On some farms there may be only enough to utilize the weeds along the fences or ditch banks, or enough to graze in an orchard or small pasture. Other bands may number up to a few hundred, in which case a pasture or piece of range land adjacent to the farm is necessary; for sheep, like cattle, can not be raised profitably if they must be fed cured forage in the summer as well as in the winter.

A cooperative method of raising sheep is becoming more and more common in Utah. Small bands fed on different farms during the winter are placed together in the spring to make up bands to graze on the summer ranges. This practice is most common on the national-forest ranges. By it the overhead costs, which are likely to be high for small bands, are cut down.

Generally when small flocks of sheep are raised, it is not intended that they furnish the entire income of the owner. He usually raises the sheep as one of several farm activities. Sometimes, however, a livelihood can be obtained from a small flock of good quality sheep if the sheep are well managed and cheap summer grazing can be obtained. Barns or sheds should be provided for the ewes during lambing time, and the lambs should be born early, generally in February. The lambs will then attain good size and be ready for market by midsummer, while the price for lambs is still high and before it is crowded by range lambs.

Purebred sheep are often raised in small flocks on farms. Much care and study is given to proper handling and breeding. The increase, especially the rams, is sold as breeding stock at much higher prices than can be obtained for ordinary sheep.

The practice of feeding sheep in feed lots in the winter is becoming more and more extensive. Tests or studies have shown that the losses of sheep are less in the feed lots, and that feed-lot ewes produce more wool and produce more and larger lambs than do desert-wintered ewes, other conditions being the same. Some sheepmen are convinced that the advantages of feed-lot winter feeding offset the extra cost of the feed.

Many of the herds that winter on the deserts are fed corn, cottonseed meal, hay, and other feeds to supplement the often scant native forage. The amount of feed produced on the deserts varies with climatic conditions. A light crop of feed follows dry seasons. Good winter range feed follows moist periods during the late summer and fall. Sheep are dependent upon snow for water on the deserts. Sometimes the snow comes so late in the fall that herds can not be taken far from the few permanent water holes. A scarcity of feed within traveling distance of water holes then results. Sometimes the snow is so deep that sheep can not obtain feed, and supplemental feeding becomes necessary.

With the melting of the snow in the spring the sheep are started toward the mountains. Some of the sheepmen own or lease spring range on the foothills or lower mountain slopes. On these they hold their sheep until the higher ranges are ready for grazing. Other sheepmen use the public domain adjacent to the deserts for spring ranges.

The lambing period varies. Where the sheepmen have sheds to protect the sheep, lambing often starts in February or early March. Most range lambs are born in late April and in May.

During the spring the sheep are sheared. Usually there is a shearing corral on each spring-range district. Men who make their living shearing sheep travel from corral to corral and from State to State.

Almost all of the wool is sold to wool buyers or contractors. These men know where practically all the sheep in their district are wintered. They know what kind of sheep are raised. They know the quantity and quality of wool that will be produced. By watching the trend of the market closely they know about how much to offer for wool, though even they are sometimes fooled by sudden changes in the market prices. Usually these men bargain for the wool some time before shearing time. They make a first payment to the sheepmen to bind the contract.

When the snow has melted on the high ranges and the forage has made a sufficient growth the sheep are driven from the spring ranges to the summer ranges. On the high ranges the forage is generally luxuriant and succulent. The lambs make very rapid growth. Toward fall, generally in September, the lambs to be marketed are separated from the rest of the herd and are driven to the nearest railroad point for shipment. Some sheepmen ship their lambs directly to the packing-house centers. Others contract to deliver their lambs at a stated price to lamb buyers at the railroad points.

The last of September and first of October usually bring snow and cold storms in the mountains. Once more the highways and stock trails resound to the tinkling of bells, barking of dogs, and the bla, bla of desert-bound sheep.

GOAT RAISING IN UTAH

Goat raising has been increasing during the past few years until it has now reached a point where it must be recognized as an important phase of the livestock industry. (Fig. 7.) In 1928 a few hundred goats were being raised in Duchesne County, several thousand in Salt Lake and Davis Counties, about 11,000 in Tooele County, from 15,000 to 20,000 in the neighborhood of Price, and about 32,000 in southern Utah. Southern Utah had in 1927 an output of about 125,000 pounds of mohair.

Most of the goats raised in Utah are wintered on the sage and juniper types of range and are summered on the lower portions of the mountains where browse and water may be found. The management of the goats is much the same as the management of sheep.

Any class of livestock in too great numbers and improperly handled can rapidly deplete a range, leaving it denuded and eroded; goats can bring about these deplorable conditions as surely as either sheep or cattle. Goat producers should be especially alert to guard against the ranges being depleted by overuse.

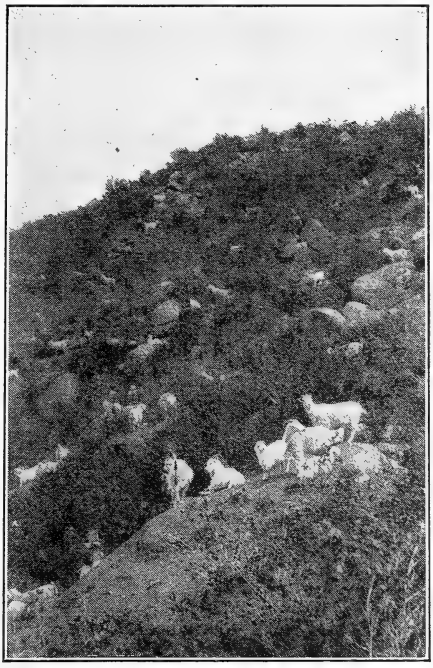

FIGURE 7.—Goats grazing on the Dixie National Forest. Goats can utilize a rough, broken range

RANGE PLANTS AND THEIR REQUIREMENTS FOR GROWTH

Range plants are frequently roughly classified as grasses, weeds, and browse. (Fig. 8.) With the grasses are associated such grasslike plants as sedges and rushes. The weeds are annual and perennial herbaceous plants (those that die down to the ground each year) other than the grasses and grasslike plants. Browse includes all the woody stemmed or shrubby plants, such as snowberry and sagebrush, whose leaves and young stems are eaten.

GRASSES

As forage plants the grasses are extremely valuable. They are very palatable and nutritious. Many of them cure well. By this is meant that when the herbage is dry it is still nutritious and palatable, like cured hay. For this reason dried grasses make good late-fall and winter feed, and frequently furnish an appreciable amount of forage during the spring.

Grasses are more permanent than other forage plants because they are not so easily affected by adverse climatic and grazing

conditions. One condition decidedly in favor of grasses is that the leaves grow from the base. Thus, if the leaves are not cropped too closely they grow again.

THE WHEATGRASSES

The wheatgrasses (*Agropyron*) are very important in Utah, and are eaten eagerly by all classes of stock, although best suited for cattle and horses.

There are a number of species of wheatgrasses in this region:

Slender wheatgrass (*Agropyron tenerum*) and its very close and similar relative, violet wheatgrass (*A. violaceum*) are fairly abundant, especially at medium elevations. Sheep relish the young herbage and the seed stalks, and horses and cattle consume the entire plant at all times.

Bunch grass (*A. spicatum*) called "blue-bunch wheatgrass" in Utah, is one of the most widely distributed of the wheatgrasses, and

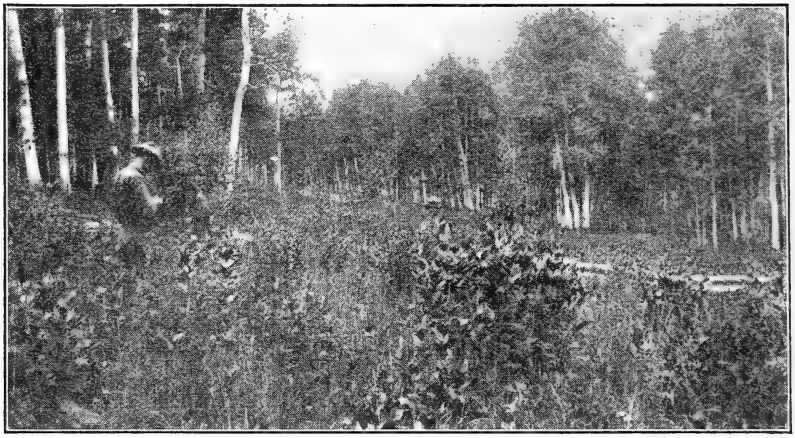

FIGURE 8.—A luxuriant growth of range plants. Under good range management plenty of leafage is left for food making

is a highly drought-enduring grass. This species yields well, is relished by all classes of stock, and has high nutritive value; it therefore ranks among the best forage plants.

THE BROMES

The mountain bromes, especially *Bromus marginatus* and *B. polyanthus*, make a rather coarse, rank growth, but are palatable to livestock, especially to cattle and horses. They supply an abundance of forage at elevations ranging from 5,000 to 10,000 feet.

THE BLUEGRASSES

The bluegrasses (*Poa*) are among the most palatable plants, and there are a great many species in the State. They are chiefly pasture plants, although they can be found growing on almost any range, and sometimes form a major part of the plant cover. Kentucky bluegrass (*Poa pratensis*), smooth mountain bluegrass (*P. epilis*),

Nevada bluegrass (*P. nevadensis*), and nodding bluegrass (*P. reflexa*) are among the species most commonly found at almost any elevation. Two species, Sandberg's bluegrass (*P. sandbergii*) and Fendler's bluegrass (*P. fendleriana*) are among the most common plants on the foothill ranges where they make an early growth, and often form an important part of the forage crop.

THE PORCUPINE GRASSES

The porcupine grasses (*Stipa*) of which there are several species on the ranges, are very important forage plants. These are bunch grasses and may be recognized by a hardened lemma ending in a long, bent, twisted, sometimes feathery awn.

BROWSE

Browse forage is extremely important on Utah ranges. At practically all elevations and in all sorts of habitats, one or more of the many browse species are prominent among the forage plants present.

THE MAHOGANIES

Birch-leaf or common mountain-mahogany (*Cercocarpus montanus*) is one of the most palatable of the browses, and indeed is among the most palatable plants of any kind, being relished by all kinds of stock. It grows in more or less abundance in the mountains up to an altitude of about 8,000 feet in most parts of Utah south of Salt Lake City.

BITTER BRUSH

Bitter brush (*Purshia tridentata*) ranks about the same as birch-leaf mountain-mahogany in forage value, but it has a wider distribution.

SERVICE BERRY

There are several species of service berry (*Amelanchier*) in Utah, the western service berry (*A. alnifolia*) being the most common and probably the most valuable of the group. Service-berry bushes ordinarily do not grow in dense stands, yet they grow abundantly enough to be very valuable from a forage standpoint. All kinds of stock seem to relish service berry.

SNOWBERRY

Snowberry (*Symphoricarpos*) is less palatable than the browse species mentioned thus far, but nevertheless is an important forage species because it is so widely distributed and because it usually grows very abundantly. Its soil-binding qualities and its abundant growth make it an important plant as a protection for watersheds.

YELLOW BRUSH

The yellow brushes (*Chrysothamnus*) are important forage species because they are moderately palatable and grow to some extent over most of the State, in some places furnishing a great deal of forage.

They are most common on open ranges that are capable of supporting a grass cover when overgrazing is not a disturbing factor.

OAK BRUSH

Oak brush (*Quercus*) must be recognized as one of the most important browse plants because of its very great abundance, especially toward the southern part of the State. It is not highly palatable, considerably less than half of its available portion being taken when more palatable species are grazed as heavily as they should be. Yet oak brush forms the main portion of the diet on vast stretches of range because it so completely dominates all other species in abundance.

ELDERBERRY

Elder (*Sambucus*) is among the forage plants most palatable for all classes of stock. They also rank foremost in hardihood, being able to grow vigorously even though grazed to the ground each year.

WEEDS

In the mountains the presence of weeds in abundance usually signifies that natural conditions have been disturbed. This does not mean that weeds do not have a place in nature's scheme on the ranges, for even weeds that are classed as poor competitors of grass and browse may be found growing on ranges that are not grazed at all. There is good reason to believe that a few weed species are fairly abundant even on areas on which the vegetative cover has reached a climax. Fortunately these species are among the most palatable plants and outclass all other weed species in forage value.

BLUEBELL

There are many species of bluebells (*Mertensia*) and there is much difference in their value as forage plants. The large, succulent species are the ones that rank high in forage value. They are relished highly by sheep and by other classes of stock as well. They are especially valuable on sheep ranges because ewes produce a good flow of milk when feeding on them. As they have extensive root-stalk systems they do not need to rely entirely upon seed for reproduction.

Several members of the carrot family are valuable from the forage standpoint.

Senecio serra, which is sometimes called tall groundsel and butterweed, has a wide distribution over the ranges, and is abundant, hardy, and very palatable to sheep. Other weed species that are more or less palatable and grow more or less abundantly over the ranges are: Horse mint (*Agastache urticifolia*), common yarrow (*Achillea lanulosa*), Engelmann's aster (*Aster engelmanni*), the geraniums (*Geranium*), and white flowered skunk weed (*Polemonium albiflorum*).

METHODS OF RANGE-PLANT REPRODUCTION

Range plants have several methods of reproduction. Some of them reproduce only by seeds; others produce seeds and also send out stems underground from the roots. Buds are formed on these

underground stems and later develop into new plants. A few plants send out stems above ground that bend over to the ground, take root, and become new plants. Examples of such plants are tame or wild strawberries (*Fragaria*), some of the rushes or wire grass (*Juncus*), and snowberry (*Symphoricarpos*).

By far the largest proportion of range plants depend upon seeds for reproduction. Except in unusual cases, such as very severe climatic conditions, fires, or very intense competition for existence in a habitat, plants produce good crops of seed.

CARRYING CAPACITY AND STOCKING OF THE RANGE

PALATABILITY OF PLANTS TO LIVESTOCK

Grazing animals have a large variety of plants from which to choose. Some plants taste better than others, and the animals are very selective in their choice of foods. They make these choices with remarkable regularity. They will almost completely devour certain species, eat a somewhat regular percentage of other plants, and consistently leave other species untouched. This means that while some plants are being grazed 100 per cent other plants are being grazed 80 per cent or 65 per cent or not at all.

If the number of stock on the range is decreased, the utilization of all the plants and especially the less palatable ones is decreased. If the number of stock is increased, of course the most palatable plants can not be used more than 100 per cent, but the utilization of the rest of the plants is increased. Attempts at further utilization after 100 per cent of the foliage of important plants has been consumed are apt to injure these plants by trampling.

The same plant species sometimes varies in palatability in different regions. Some plants are more palatable during one part of the season than during another. In some cases the reason for this is very apparent. The plants may become tough or grow long awns or beards, as the season progresses. In other cases the seasonal variation in palatability is not so easy to understand. For instance, stock generally do not eat much of the red elder, niggerhead (*Rudbeckia occidentalis*), and several other plants until toward fall.

Men have observed the choices of livestock for plants over long periods of time and have rated the plants according to their palatability to different kinds of stock. Horses, cattle, sheep, and goats differ more or less in the plants they relish and in the character of the country on which they like best to graze. Horses prefer grasses and, if possible, they range on the more open grassy ridges and slopes. Cattle also seem to prefer the grasses and grasslike plants, but prefer to range on the meadows and grassy parks. They also relish and do very well on many of the browse plants and some of the more choice weeds. Goats thrive best on browse. They can utilize the forage on steep, brushy slopes that are not adapted to other kinds of stock. Sheep also like browse forage and are especially fond of the fresh, succulent herbs such as the bluebells (*Mertensia*). Sheepmen prefer to have succulent forage for their ewes and lambs in the summer because it produces large milk-fat lambs which command a high price on the market.

It is a very common practice to graze two or more kinds of stock on the same range. This is called "common use." The theory of this practice is that one kind of stock will use one class of forage while another kind will utilize another class of forage, thus securing a full utilization of the forage on the range unit. Sometimes this practice works out very well. At other times, too many of each kind of stock are placed on the range, and overgrazing results, especially overgrazing of the plants both kinds relish. Again it sometimes happens that the presence of more than one kind of stock on the range makes it difficult to manage any kind very successfully.

In managing the ranges, matters other than the first choices of the livestock need to be considered. Very often economic conditions, or the established practices in a region, make it desirable or necessary to graze a kind of stock to which the range is not best adapted. It is being demonstrated more and more that livestock will do well on ranges other than the kind they like best. For example, in southern Utah, cattle do fairly well on almost straight browse range. May lambs produced on several almost straight grass ranges, have reached about 80 pounds in September.

There are highly palatable plants that do not appear in great abundance, such as clover, mountain dandelion, cow parsnip (*Heracleum lanatum*), and the like. Livestock will search out these dainties in preference to practically all other plants. If it is desired to preserve these plants on the ranges the number of stock would have to be so limited that these plants would not be fully grazed each year. Obviously but few stock could be placed on the ranges under such conditions.

There are many fairly palatable plants on the ranges, however, that are abundant. This is the class of forage that should be maintained. It should be utilized as fully as possible, provided that enough is left each year to assure reproduction and a vigorous, luxuriant growth year after year.

FORAGE PRODUCTION VARIES FROM YEAR TO YEAR

Forage production on the ranges varies considerably from year to year, according to climatic conditions. For example, records kept at the former Great Basin Experiment Station in the mountains east of Ephraim, Utah, show that during the dry season of 1924, forage growth was 65 per cent of average, whereas during the moist season of 1925 the forage production was 125 per cent of average. This seems to be a tremendous variation, but it is believed the greater nutritive value of the less succulent forage during dry years lessens the difference between the production of forage in wet and dry seasons.

The fact remains, however, that years vary much in forage production and the carrying capacity of the ranges. On ranges too fully stocked, the poor forage seasons mean far too heavy utilization of plants already weakened by the adverse climatic conditions. Naturally the plants suffer a severe setback. The stock also suffer, and their poor condition usually means a profitless year to the owner.

A safe and wise way is to stock ranges on the basis of an average year's production, making due allowance for some forage to be left

to assure plant vigor. Then when a bad year comes, a full utilization of the forage can carry the stock. The surplus foliage of the unusually favorable years gives to the heavily worked plants a chance for recuperation that is much needed.

METHODS OF DETERMINING CARRYING CAPACITY AND RANGE STOCKING

Range carrying capacity is the maximum number of stock which the unit will support each season over a period of years without injury to the range or tree growth, or watershed, and without unwarranted interference with game or recreation.

In order to tell whether a range has too many or too few stock, one must know whether it is improving or deteriorating from year to year. When it is definitely known, however, that a range is understocked or overstocked, the increase or decrease necessary to stock the range properly can not always be determined easily. As a help in determining how many stock to place on an area, range surveys are made on the national forests by especially qualified men who know the plants well, know the habits of livestock on the range, and know the value of the various plants for forage. These men determine the density of the plant cover, that is, the proportion of the ground that is covered by forage plants and the average palatability of these plants. By multiplying the percentage of ground covered by plants (density figure) by the average palatability figure, a factor is determined which is multiplied by the total number of acres, to give the number of forage acres. A forage acre is an acre of ground entirely covered with plants wholly palatable to livestock. An acre of dense bluegrass lawn might be called a forage acre. Forage acres give a more or less definite measuring stick for distributing the stock on the range in proportion to the amount of forage on the various units.

The most satisfactory and surest way of determining how many stock a range unit can carry is to keep accurate records of the number of stock, the length of time they graze, their condition at the end of the grazing season, and the amount of forage that is left.

Quadrats are sometimes established, representing average conditions on the range. A plot of ground 40 inches square is marked off into 100 four-inch squares by means of cross straps. The location of each plant is then mapped. Remapping after several years have elapsed will show whether the plant cover has increased or decreased and whether good forage species are increasing or decreasing, thus giving an index to what is happening on the entire unit. (Fig. 9.)

As another help in studying what changes are taking place on the ranges, and what the range is capable of producing, a 1-rod or 2-rod square is fenced. The plants in this inclosure have a chance to grow and reproduce unmolested, thus showing what the range is capable of producing, and offering a comparison between grazed and ungrazed range. Often, abandoned but closed corrals, or patches of range protected from grazing, may afford comparisons with the grazed portion of the range. (Fig. 10.)

Usually those responsible for the management of national-forest ranges make frequent trips to study the use stock are making of the range, the condition of the stock, and the condition of the range. If

FIGURE 9.—Charting a quadrant with a pantograph. Typical plots are studied carefully to determine changes in the plant cover

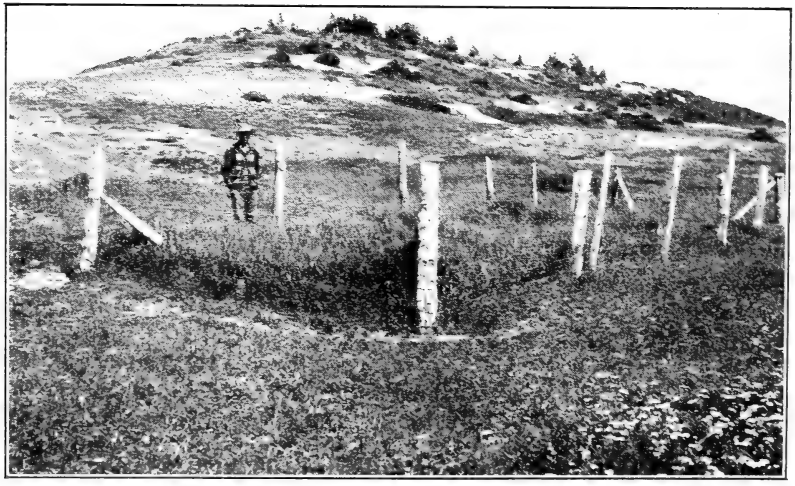

FIGURE 10.—An inclosure which shows what the range can produce if handled properly

a man is experienced and well trained he can tell pretty well from close observation whether the range is properly stocked and handled.

Overgrazing for an extended period will leave "earmarks" which usually can be recognized. The following earmarks are the most reliable indicators of overgrazing:

The predominance of annual weeds and grasses such as knotweed, tarweed, mustard, annual bromes, and fescues. This condition indicates a severe stage of overgrazing such as occurs around sheep bedding grounds which have been used for long periods each year for several years in succession.

The predominance of plants which have little or no value for any class of stock, such as sneezeweed, niggerhead, yellowweed, snakeweed, and gum weed. These and similar plants frequently occur in abundance over large areas of range and indicate that the range needs careful management to give better forage plants a chance to grow.

The presence of dead and partly dead stumps of shrubs, such as snowberry, currant, willow, service berry, birch-leaf mountain-mahogany, and Gambel oak. This condition usually indicates that the most palatable grasses and weeds have been overgrazed. There may be some exceptions to this, as in the case of dwarfed willows on ranges where grasses predominate above timber line. Sheep sometimes kill the willows before the grasses are overgrazed.

Noticeable damage to tree reproduction, especially to western yellow pine reproduction on sheep range and aspen reproduction on cattle range. Lack of aspen reproduction on a weed sheep range indicates overgrazing, provided the natural conditions are favorable to aspen reproduction. On a sheep range where grass predominates severe injury to western yellow pine or aspen reproduction may indicate that the range is not well suited to sheep.

Erosion and barrenness, accompanied by a network of stock trails, where formerly there was a cover of vegetation. These are typical of areas where overgrazing has reached the extreme stage.

The earmarks described are, perhaps, more typical of overgrazed sheep range than of overgrazed cattle range, but the general appearance of the two does not differ greatly when overgrazing reaches a stage to be recognized by one or more of these earmarks. The main differences are in the species of plants indicating the overgrazing. Weeds eaten by sheep are often found in abundance on overgrazed cattle range; coarse grasses palatable to cattle are often abunant on overgrazed sheep range. This fact has given rise to the use of the term "class overgrazing. (*3*)"

The following are some of the indications that a range has been overgrazed in the past, but is improving:

Fifteen to twenty-five per cent of the most palatable species is left at the end of the season and an average of 1 or 2 inches of the twigs is left on the most palatable browse. This can be determined best by inspection at the close of the growing season. During the summer, however, one can watch for dried herbage left from the season before, and note the length of the previous season's growth on the browse twigs. If an inspection is made at the time the spring zone has been grazed over, or after a part of a sheep allotment has been grazed over for the final time that season, one can determine whether a sufficient amount of the palatable forage has been left. Experience has demonstrated that when part of the palatable forage is left, conditions are favorable for range improvement.

When ranges improve, the old trails frequently become overgrown with herbage. The limbs on the browse grow into the space once kept clear by trailing stock. Places where stock, cattle especially, once congregated to an extent that almost denuded the ground, begin to be covered by vegetation and by better forage plants. All the plants are thrifty and vigorous. Evidence of recent erosion is lacking. One can usually see plants growing in the old gullies or along the sides of the washes, which indicates that erosion on those

places has ceased and the denuded ground is being reclaimed by plants. The stock are in good flesh and seem contented.

Proper stocking of ranges is stocking with such numbers and at such seasons that good ranges will remain such and depleted ranges will improve. Few are the range areas that are producing a maximum amount of forage. Most ranges now being grazed produce less forage than they would do under natural conditions. It is a well-established fact, however, that ranges can be improved while being grazed. Sometimes better management of the stock on the range will bring about improvement. Sometimes it is necessary to hold stock off the range until later in the spring, or to reduce the number of stock. The latter method may mean less livestock production for a short time, but the resulting increased carrying capacity of the range will soon make it possible to carry more stock and to take fat stock from the range.

FIGURE 11.—Studying plant vigor at the Intermountain Forest and Range Experiment Station. Plants are clipped at different frequencies to determine the results

It has been demonstrated that clipping plants after they are well started in the spring, and then again toward the end of the season, does not affect the vigor of the plants. (Fig. 11.) Sometimes under good range management plants can be clipped even three times during a season without being injured, if the intervals between the clippings are not too short.

Often under actual range conditions the number of times the plants are clipped can not be controlled. The essential thing is not to stock so heavily that the livestock may have to eat the plants off again and again in order to get enough food. Neither should ranges be so heavily stocked as to prevent seeding. Experience has pretty well demonstrated that if about 25 per cent of the volume of the most palatable plants is left at the time the seeds are ripe, sufficient seeding can take place.

Grazing affects browse plants a little differently from the way it does other plants. Not only is the foliage cropped, but the twigs are

eaten off as well. The growing portion of the woody stems is right at the tip. When a tip is eaten off, growth in length of that twig ceases. If moisture and soil conditions are favorable, new twigs may develop from buds that would otherwise remain dormant. It is not often that this second growth of twigs comes near being as great as the growth produced before the grazing.

Observations on the national forests, during many years, of the effect of grazing browse plants have led to the conclusion that an inch or two of most of the new twigs and a fair amount of leafage should be left if the browse plants are to remain vigorous and healthy. Just as sure as the leaves are stripped too closely and the stems are cropped too much, the plants begin to have a sickly, hedged appearance. They do not make nearly so rapid, luxuriant, or large growth as plants that are properly grazed. Such sickly plants are

FIGURE 12.—An overgrazed range on the Wasatch Plateau in Utah. Overgrazing destroys the valuable forage plants. Inferior species are the first to come in as the range recovers and under proper management they are later replaced by the more valuable plants

common on overgrazed ranges, and there are many plants with dead limbs, and many are killed altogether. (Fig. 12.)

A few years ago several men were inspecting a range on the Dixie National Forest. They noticed that the snowberry (*Symphoricarpos*) appeared to be sickly and not to be making a full, vigorous growth. A fence was constructed to protect a plot of the snowberry from grazing, and within a year or two the plants protected by the fence were vigorous and healthy. Those not protected were still sickly in appearance.

IMPORTANCE OF GOOD DISTRIBUTION OF STOCK ON THE RANGE

If ranges are to be stocked to their full carrying capacity, the stock must be so distributed that the forage will be utilized as uniformly as possible. Usually some parts of the range can not be utilized because of too great distance from water, steepness, rocks and ledges, down timber, etc. The forage on such areas can not, of

course, be considered in estimating the carrying capacity of ranges. If stock are left to follow their own inclinations, they may congregate on one part of a range and overgraze it, while another part is not fully utilized. Proper distribution often requires herding, water development, fencing, etc. Many ranges could support more livestock if more effort were made to get livestock out on the areas where forage is wasting.

GRAZING AND TREE REPRODUCTION

It is appropriate to consider the relationship of grazing to timber reproduction. The following is a quotation from Range and Pasture Management, by Sampson (*7*, pp. 197–198, 211–212):

> The utilization of the forage on the better-timbered areas, especially on important watersheds, has complicated the pasture-management plans. Many instances are recorded of the seedling and sapling stand being badly injured by grazing. In some places this has resulted in a depletion of the normal timber growth, in the production of deformed and diseased trees, and in injury to important watersheds.
>
> * * * * * * *
>
> After many years of intensive investigation and wide observation by many specialists in various parts of the West, it has been concluded that practically all serious damage to timber reproduction is caused by too heavy grazing and by faulty handling of the stock.
>
> The conclusions developed from the studies [made by Sampson] may be divided into two classes (1) those of general application, and (2) those that are applicable to certain regions.
>
> *Conclusions of general application.*—Overgrazing or bad handling of any class of stock may result in injury to tree reproduction in varying degrees of seriousness.
>
> * * * * * * *
>
> Goats are inclined to browse upon a larger number of timber species than do other classes of stock and may cause more damage than do other domestic foraging animals.
>
> Where a good seed crop of the timber stand is produced, large areas often support a good stand of young timber growth notwithstanding moderate grazing each year by the various classes of stock.
>
> Topographic features, the season of grazing, the type of forage, and the way in which the animals are handled are the most important factors that determine the degree of injury to tree reproduction.
>
> Damage to the tree reproduction and, indeed, to other vegetation must be expected on stock driveways or trails which are used annually as such for several seasons in succession. Accordingly, such driveways should be located where the timber is sparse or inferior, or where they will be of value in protecting the forest from destruction by fires.
>
> *Conclusions of regional application.*—Because of the rigorous climatic conditions in the Southwest, notably in Arizona, New Mexico, and southern Utah, the better cut over forest lands should not be grazed by sheep and goats until a satisfactory stand of reproductoin, much of it about 3½ feet in height, has been secured.
>
> As a rule it is safe to graze cattle and horses lightly on cut over or other potential forest lands during the period required for reforestation.
>
> Where trees have been artificially planted, or where, although the timber reproduction is greatly desired, the stand may be unsatisfactory, the area, regardless of the locality, should be closed to grazing until a satsfactory stand is obtained.
>
> From aspen range on which it is desired to perpetuate the aspen cover, sheep and goats should be excluded for at least three years after the cutting. The damage to aspen reproduction from moderate cattle grazing is practically negligible; hence cattle may be grazed on cut over aspen lands.
>
> * * * * * * *

TIME OF YEAR TO BEGIN AND END GRAZING ON A RANGE

EFFECT OF EARLY GRAZING UPON PLANTS

Nature has so arranged things that from food stored in seeds, roots, or stems spring growth can well be carried on until the days are warmer and the new leaves have developed enough to make food. Nature, however, did not provide protection against heavy grazing by hungry livestock during this critical period. What happens when a cow or sheep nips off the plant, or a large portion of it, during this early spring period? Much of the stored food has already been used to make the growth which the cow or sheep consumes. Not many, sometimes none, of the leaves are left to make more food. The plant is greatly handicapped and does not recover its normal vigor during the entire summer. At the Intermountain Forest and Range Experiment Station it was found that plants grazed too early produce 25 per cent less growth in a season than plants that are not grazed until they have a good start. One-fourth less forage produced! This is a great loss to the stockmen and to the people who need the livestock products.

Where a cow, horse, or sheep walks across moist or wet ground the plants are crushed and broken and the soil is packed as a result of the trampling. The roots of the plants need air. The air enters the soil through the air spaces between the soil particles. When the soil is packed these air spaces are more limited, and air is more or less excluded. Also, any condition that lessens the amount of water in the soil should be avoided if possible, because water is one of the main factors affecting forage production. Water evaporates more rapidly from packed soil, for one reason, because in packed soil there is a continuous passage way from soil particle to soil particle and the soil water can travel to the surface where evaporation is going on. In unpacked soils the air spaces between particles check the current to the surface, and the soil moisture is held more as thin films around the soil particles. For these reasons ranges should not be grazed in the spring while the soil is wet from the melting snow. (Fig. 13.)

EFFECT OF EARLY GRAZING UPON LIVESTOCK

Several poisonous plants, especially the larkspurs and death camas, are among the very earliest plants upon the ranges. They make luxuriant growth before many of the other plants are well started. When stock are on the ranges too early, they eat many of these poisonous plants, with fatal results. Poisonous plants are discussed more fully on p. 37.

During the first period of growth, plants are as much as 85 per cent water.

A 1,000-pound animal that is not subjected to work or exercise in procuring his feed, as one maintained in a stall, requires approximately 16 pounds of concentrates and air-dry roughage, such as good hay, every 24 hours as a maintenance ration—that is, a ration ample merely to maintain, not to increase, his weight. When the young feed is short, as, for instance, during the first two weeks after growth begins, it is necessary for an animal to travel over a large area to gather the required 80 pounds or so of this succulent leafage or the equivalent of 16 pounds of air-dry hay. Often an animal, especially a cow poorly wintered, can not gather enough of the young growth

early in the spring to remain in thrifty, serviceable condition. In some cases such an animal can not even gather enough to tide her over the period of recuperation (7).

At the beginning of spring growth in some localities, livestock losses have resulted from the green feed being sparse and containing only a small amount of body and nutriment, and from stock grazing little else but green leafage once they had a fair sample of the new growth.

The amount of protein in the young leafage that is digestible may be comparatively low (8).

WHEN IS FORAGE READY FOR GRAZING

There has been much observation and some experimentation to determine when forage has developed far enough to permit grazing. The following standards have been set up by the Forest Service as general guides in determining vegetative readiness.

FIGURE 13.—Cattle on the high range too early. Too-early grazing is often as harmful as too-heavy grazing

Judgment should be based on conditions on the part of the range that will be used. If a range has both north and south exposures, the south exposures will generally be ready for grazing before those that face the north. If a unit varies much in elevation, grazing may be permitted when the lowest part is ready if the stock are to be confined there. If there is not enough of the low range to carry the stock until the high range is ready, or if stock are to use the entire unit as soon as they go on the range, grazing should not be permitted until most of the range is ready.

The ground must be firm enough to withstand trampling without injury.

Vegetative readiness should be based upon the development of the most important class of forage that will be used. Grass is usually ready for grazing (other conditions being the same) one or two weeks before browse and weeds. If grass is the dominant class of forage, or is nearly equal in importance to the browse and weeds,

it is not necessary to keep cattle off the range until the browse and weeds are ready. Cattle will graze almost entirely upon the grass during the forepart of the season. If browse and weeds are more important than the grass, the time of grazing should be delayed until the browse and weeds are ready.

The following are the generally accepted stages of plant development indicating vegetational readiness:

The important grasses should be from 6 to 10 inches in height. Sandberg's and Fendler's bluegrasses should be in blossom. Downy brome (*Bromus tectorum*) should be starting to head. Bitter brush, snowberry, birch-leaf mountain-mahogany, choke-cherry, rose, currant, and service berry should be in full leaf, or nearly so. Service berry should be starting to blossom. Balsam root, Indian paintbrush, and dandelion should be largely in flower. Geranium should be 3 or 4 inches high. The seed stalks of yarrow should be forming.

Some plants that are not good forage plants may be used as indicators of vegetational readiness. The seeds of Indian potato (*Orogenia linearifolia*), and dogtooth violet (*Erythronium parviflorum*) should be mature and the leafage dried or drying. The flowers of springbeauty (*Claytonia lanceolata*) and yellow bell or crocus (*Fritillaria pudica*) should be gone, and the leafage mostly dried up. Phlox should be in full flower. Generally yellow violet should be starting to dry up and wilt.

A number of species should be considered in determining vegetational readiness. The more important plants used as indicators, the more reliable will be the results.

Generally ranges are ready for grazing about three or four weeks after active plant growth has begun.

The development of forage on the ranges is extremely irregular. Every thousand feet increase in elevation makes a difference of from 10 days to 2 weeks in the development of the vegetation, other conditions being the same; consequently plants may be on a south exposure but still be late developing if they are at a high elevation. There is much variation in the development of plants in different years. The plants may develop as much as three weeks earlier in an early spring than in a late spring.

Sometimes conditions justify early use of the range, even though it is realized that damage is being done. The forage available for winter feed may be limited and no spring pastures available for holding the livestock until the ranges are ready. Some ranges become too hot and dry during the late spring and summer for grazing. Sometimes the only practical way to utilize the forage on such ranges is to place stock on them early in the spring. Such use seems entirely justified. Much of the low foothill range and range bordering the deserts is of this character. Some of this range does not suffer from the early use if a part of the spring growing season is still left after the stock leave, for during the remainder of the season the plants are able to recuperate and mature enough seed to maintain themselves.

On much of the range land, however, spring control of livestock is urgently needed, and can be applied. Just as far as is practical, livestock should be fed on the farms and ranches, or early foothill

ranges, until the lower zones of the mountain ranges are ready for grazing. (Fig. 14.) When stock are turned on these lower zones, all practical steps, such as effective herding, proper salting, the construction of drift fences, and the development of watering places should be taken to keep the stock on the lower zones until the higher range is ready for grazing.

WHEN STOCK SHOULD BE REMOVED FROM THE RANGE

Ordinarily stock must be removed from the deserts in the spring when the snow goes, and from the low foothill ranges when the water dries up or when the ranges become hot and dry. Stock must be removed from the higher mountains before the heavy snows come. It is advisable to remove them from the high ranges before the fall storms come, because much injury results from trampling the

FIGURE 14.—Low foothill range in Utah. Range like this should be utilized in the spring while the higher range is getting ready for grazing

plants after these storms. The amount and condition of forage should be considered, and grazing should cease before the better forage plants are injured. (Fig. 15.)

DEFERRED AND ROTATION GRAZING AND ARTIFICIAL RESEEDING

Most range plants do not live long even under normal conditions, and if the forage resource is to be perpetuated new plants must replace the old. Some plants normally live one year; some two years; some more than two years. Fires, rodents, extreme cold, extreme heat, drought, and overgrazing cut short the life of plants. Even under the best conditions, grazing causes the death of some plants.

The cropping of seed stalks and the nipping off of flowers are very apparent ways in which plant reproduction is affected by grazing. Livestock, especially sheep, have a special liking for the flowers of some plants. Naturally, many of the seed stalks and flowers are eaten along with the foliage, except in a relatively few cases where the seed stalks are rather coarse and tough.

Plants ordinarily produce many more seeds than are necessary to reproduce themselves. This is fortunate, because a large number of seeds do not fall in places suitable for germination and growth, and also because under proper management, plants can be grazed before seed maturity and still produce a sufficiently large seed crop. Far too often, however, ranges are so heavily stocked or so improperly handled that too many of the flowers and seed stalks are eaten, a sufficiently large seed crop is not produced, and the ranges deteriorate constantly.

Even after a good seed crop is produced, or conditions have favored a good propagation by root stalks and suckers, the work of reproduction is only half completed. The young plants are weak and very susceptible to injury. They need protection until they can become established. Generally, of course, if stocking and man-

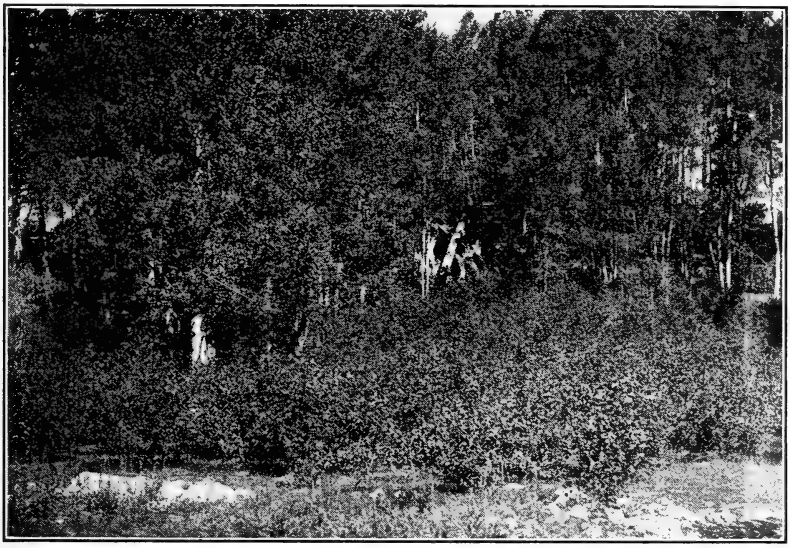

FIGURE 15.—Aspen reproduction spreading on a properly managed range

agement are such that a good seed crop can be produced, the young plants will thrive.

Through considerable experimentation and much study under actual range conditions, both by the stockmen themselves and by special range investigators, it has been demonstrated that ranges can be effectively reseeded while being fully grazed. This is accomplished by protecting a portion of the range from grazing until the seeds are mature. In modern practice a grazing allotment is divided into several areas, usually three or four. The grazing is deferred on one of the divisions until the time of seed maturity. Thus the area is well seeded. After the seeds are mature the livestock are allowed to graze the plants and in so doing they not only utilize the forage, but also shake the seeds from the plants and help, more or less, by trampling the seeds into the ground. (Fig. 16.)

Sometimes a division of the allotment is deferred two or more years in succession so the young seedlings will get a good start before they are grazed or trampled. After a division has been deferred

one or two years, and has had a chance to be seeded, another division is deferred, and so on in rotation.

This system is called "deferred and rotation grazing." The application of the system is becoming more and more widespread. It is being practiced on most of the sheep allotments on the national forests. There are cases, however, where the extremely heavy stocking of allotments, or other conditions, such as the lack of stock-watering places well distributed, make it difficult or impractical to apply this system. Generally the benefits of the system are remarkable. There have been cases where the stand of forage has been

FIGURE 16.—Natural reseeding under deferred and rotation grazing. Seed on these plants will soon ripen, after which the area will be grazed

more than doubled in a few years and the percentage of good forage plants has increased materially.

ARTIFICIAL RESEEDING

Livestock men and others interested in range improvement have been hopeful that some plant or plants might be successfully introduced on range lands that had been depleted, or on which the vegetation was naturally sparse. The research branch of the Forest Service and that of the State Agricultural College have been devoting some attention to this problem. Many stockmen also have tried out seeding in an experimental way. A few plants have yielded fairly satisfactory results where growing conditions have been above average.

This experimental work in artificial reseeding has dealt primarily with the common cultivated or tame forage species. The most promising of these include smooth brome, Kentucky bluegrass, timothy, and sweetclover. These, however, can be established satisfactorily only on areas where the soil, moisture, and other growing conditions are above the average.

Some of the native forage plants have given better results. They are adapted to the growing conditions on the range, and if seed can be obtained at a reasonable cost their use is justified. Large moun-

tain bromegrass and violet wheatgrass have given good results above 8,000 feet where the rainfall exceeds 25 inches a year. The results with native species are encouraging and suggest the desirability of testing out more of them. It appears that it would be worth while also to study the possibility of plant introduction from foreign countries and of plant selection and breeding to develop more hardy strains.

POISONOUS PLANTS

LOSSES FROM POISONOUS PLANTS

In view of the heavy losses caused by poisonous plants in Utah, any plan for handling the natural resources of the State would not be complete without some provision for dealing with this problem. General discussion of stock poisoning plants on the range is given by Marsh in Department of Agriculture Bulletin 1245 (*4*). Statistics on the losses of stock from poisoning in the State as a whole are not available, but for the national forests alone, which comprise only 14 per cent of the area of the State and provide grazing for about one-third of the livestock, the losses for five years are given in Table 2.

TABLE 2.—*Losses of livestock from poisoning on Utah national forests, 1925–1929*

Year	Cattle and horses	Sheep and goats	Year	Cattle and horses	Sheep and goats
1925	1,490	5,928	1928	1,070	5,083
1926	1,326	6,464	1929	990	5,202
1927	920	5,378			

SPECIES

A striking thing is the small number of poisonous plants compared to the many thousands of nonpoisonous plants that grow in the State. Sampson (*6*, p. 242) in Range and Pasture Management states that—

> Of the many species of poisonous plants occurring throughout the United States those contained in six genera are probably responsible for at least 75 per cent of all livestock poisoning.

Of all the plants that occur in Utah, probably not over 10 cause serious losses to livestock. In view of the serious losses caused by such a limited number of plants anyone interested in the raising of livestock should learn to identify these at sight.

The principal poisonous plants occurring in Utah are as follows: Larkspur (*Delphinium*), loco (*Astragalus* and *Oxytropis*), death camas (*Zygadenus*), monkshood (*Aconitum*), water hemlock (*Cicuta*), lupine (*Lupinus*), whorled milkweed (*Asclepias*), and western sneezeweed (*Helenium hoopesii*). Other plants that occasionally cause losses of stock are: Gambel oak (*Quercus gambelii*), and chokecherry (*Prunus*).

LARKSPUR

Larkspur (*Delphinium*) receives its name from the peculiarly shaped blossoms. This is one of the distinguishing features by

which the plants may be recognized. In color the blossoms vary from deep violet to almost white. The palmately veined leaves are deeply cleft in all species. Although there are many species of larkspur, they may be separated into two distinct groups, tall larkspur and low larkspur. Tall larkspur usually grows at high elevations and reaches a height of from 3 to 6 feet when mature. (Fig. 17.) Low larkspur generally grows in the foothill region. Both kinds, but especially tall larkspur, grow best in fairly moist places.

FIGURE 17.—Tall larkspur (*Delphinium barbeyi*) kills more cattle than any other plant

Cattle are more susceptible than other stock to larkspur poisoning. Most of the poisoning losses among cattle are caused by this plant. Horses are seldom affected by it, and sheep will thrive on it. This makes it advantageous to graze sheep on ranges where larkspur occurs. While the plant is more or less poisonous to cattle at all times, it is particularly dangerous after a rain or frost. After

blossom time, usually about July, cattle often graze on the plant without injurious results.

The symptoms of larkspur poisoning are vomiting, bloating, and falling repeatedly. In acute cases death occurs quickly.

LUPINE

Lupine (*Lupinus*), known locally as wild pea or poison bean, is a member of the pea family and is characterized by the typical pea blossom. The blossoms of lupine vary in color from almost white to blue and purple. The plant may be distinguished from loco by its larger size and the pronounced differences in the leaves. The leaves of lupine are digitately compound, that is, the leaflets are all attached at the end of the stem like the fingers of one's hand. Lupine is often found growing along the slopes of ridges. It is commonly found growing amid sagebrush. There are very few summer ranges that do not contain some lupine.

FIGURE 18.—Lupine (*Lupinus*) blossom, leaf, and pod. Mostly poisonous to sheep when in pod

Poisoning from lupine nearly always occurs after the plant has gone to seed. This is because most of the poison is in the pods and seeds. While all of the plant contains some poison, it is unusual for an animal to eat enough of the plant, other than the seeds and pods, to be poisoned. Horses and cattle may be poisoned on lupine, but the chief loss occurs among sheep. (Fig. 18.) Where lupine makes up only a small percentage of the forage on a range so that stock are not forced to eat large quantities at one time, it is a valuable forage plant, being very nutritious and causing no ill effects.

The symptoms of lupine poisoning are frothing at the mouth, jumping stiff-legged, butting against objects, and loss of control of the front legs.

DEATH CAMAS

Death camas (*Zygadenus*) may be recognized by its long narrow grasslike leaves of a bright-green color. They are about one-fourth inch wide and have a peculiar habit of turning down toward the ground, forming a half circle. The small, delicate greenish-yellow flowers are borne in a long cluster on a single flower stalk, the lower ones blooming first. The plant is sometimes called "poison sego" from the bulbs, which resemble those of the sego-lily.

Death camas grows in sandy soils in the foothill region throughout the State, being one of the first plants to begin growth in the spring after the snow goes off. It is particularly dangerous at this time of year, for hungry animals will feed upon it because there is no other forage available on the range so early. It dries up usually by July. After that time it is not readily eaten, because it is less palatable in the dried condition than other plants which have made

sufficient growth to supply the stock. All parts of the plant are poisonous to cattle, horses, and sheep. (Fig. 19.) Swine seem to be immune to the poison. The heaviest losses occur among sheep. Reports from Wyoming record 500 deaths of sheep out of 1,700 poisoned (*7*, p. 262).

The symptoms of death-camas poisoning are frothing at the mouth, vomiting, irregular spasmodic breathing, convulsions, a staggering gait, and inability to rise when down.

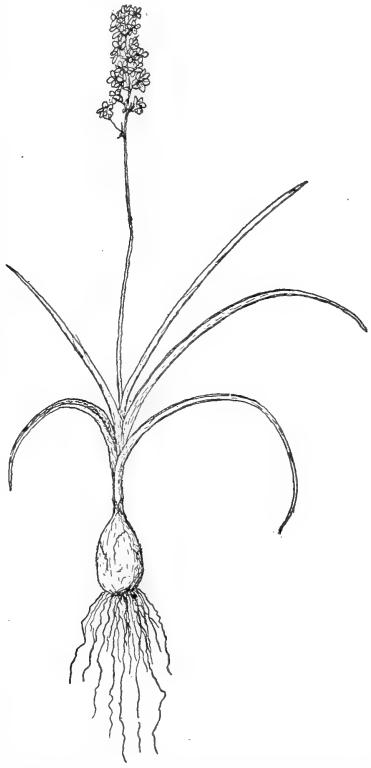

FIGURE 19.—Death camas (*Zygadenus*), a plant poisonous to most animals

LOCO

There is a great variety of loco plants (*Astragalus*) many of which are poisonous. All have a few common characteristics by which they may be recognized. Belonging to the pea family, they all have the peculiarly shaped blossom of cultivated peas. In color the blossoms vary from white to red, blue, and purple. The plants are usually small, seldom reaching a height of over a few inches, and some species are so short as to be called "stemless locos." The leaves are pinnately compound, that is, they have a central stem bearing several small leaflets on each side like the leaves of locust trees.

Locos are not so poisonous as death camas, but will eventually cause death if an animal continues to graze on them. (Fig. 20.) The plants are poisonous at all times to all classes of stock, but cause the greatest loss among young animals. They grow throughout the State in a great variety of habitats. Most of them begin growth very early in the spring, and it is at this time that they do the most damage as stock may be forced to graze upon them for lack of other forage.

The symptoms of loco poisoning are a rough shaggy coat, glassy eyes, irregular gait, emaciation, and abnormal behavior.

WATER HEMLOCK

Water hemlock (*Cicuta*) is the most poisonous plant in the United States. (Fig. 21.) It is a large, coarse plant with pinnately compound leaves having from 5 to 12 leaflets. The small white flowers grow in umbels, and the fruits are smooth, round, and unwinged. It is a member of the parsnip family and is often confused with closely related plants such as Angelica. Water hemlock requires considerable moisture and is found along the edges of

swamps, ponds, and lakes, and along the banks of streams. It commonly occurs along irrigation ditches throughout the State.

Cases of poisoning have resulted from eating the young shoots in spring. The greatest loss occurs among cattle. Occasionally farm stock are killed by this plant, as it is found on many irrigated farms. If the roots should be uncovered by plowing or otherwise, stock should be kept away from the area until the plants are removed.

The symptoms of water-hemlock poisoning are frothing at the mouth, arching of the back, and violent convulsions. In many cases the animal lives but a few minutes after eating the plant.

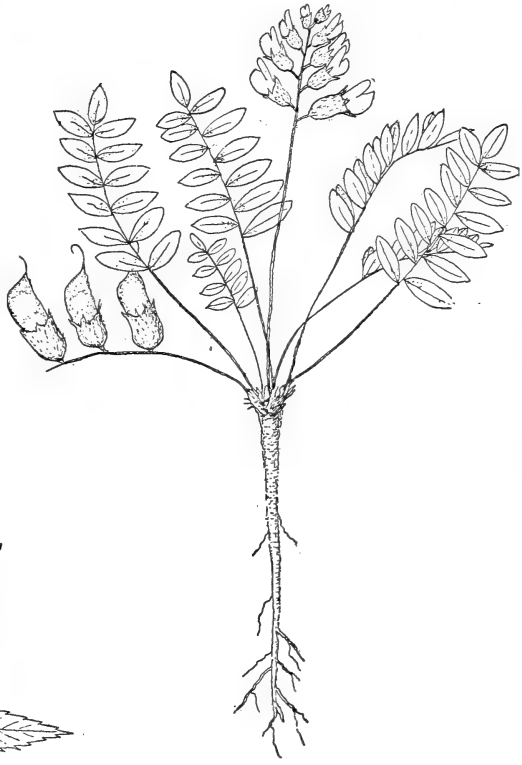

FIGURE 20.—Loco weed (*Astragalus*), one of the most destructive of all poisonous plants

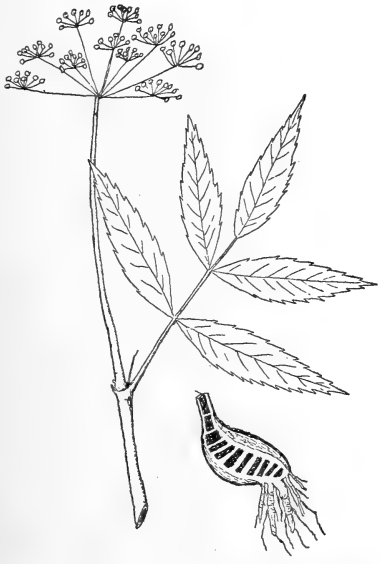

FIGURE 21.—Water hemlock (*Cicuta*). The rootstock and root of this plant are violently poisonous to animals

Deaths among human beings from water-hemlock poisoning are not infrequent. Very often the roots are found near the surface of the ground. Small children at play sometimes pull the plants and eat the roots. If an emetic can be given promptly, so that the stomach is quickly emptied, recovery usually takes place. If no emetic is given death usually results.

MONKSHOOD

Monkshood (*Aconitum*) receives its name from its peculiarly-shaped blossom which is a deep-blue, white, or purple color. Monkshood very closely resembles tall larkspur in size and shape of leaves,

and it grows in similar places. Some species of monkshood are not poisonous, and these may be identified by their yellow blossoms. All parts of the poisonous species are poisonous at all times, the root being especially poisonous. All classes of stock, especially cattle and sheep, are poisoned by this plant. However, it does not grow so abundantly as some of the other poisonous plants, and losses from it are almost negligible.

MILKWEED

Certain species of milkweed are known to have poisonous properties. Whorled milkweed (*Asclepias galioides*) has caused heavy losses of sheep, cattle, and horses throughout its range. It occurs on the dry plains and foothills of Arizona, New Mexico, southern and southwestern Colorado, and southwestern Utah. Although, in general, the plant is not readily eaten by animals, they eat it when very hungry. Poisoning usually occurs when stock come upon a patch of it after they have been driven some distance. It has also been found in hay in sufficient quantities to produce poisoning, as it does not lose its toxicity by drying. This species of milkweed is rather slender but grows from 14 inches to 4 feet high. The leaves are very narrow, from 1 to 4 inches long, and are in whorls on the stem, that is, several leaves arise from one point on the stem. The small, greenish-white blossoms grow in clusters resembling onion blossoms. The pods are erect, from 2½ to 4 inches long, and are long pointed above and short pointed below.

WESTERN SNEEZEWEED

Western sneezeweed (*Helenium hoopesii*) is not so important as some of the other plants discussed because it is not so widespread. In some localities, however, it causes considerable damage. It is a leafy plant growing to a height of from 1 to 3 feet. It branches toward the top of the stalk, and several flowers may be found on one plant. It resembles common sunflower somewhat, the outside of the blossom being a bright orange color and the center a brownish orange. It grows best on sunny slopes of the aspen-spruce belt in moist well-drained soil. All parts of the plant are poisonous at all times. Cattle may be poisoned, and sheep are particularly susceptible under range conditions. (Fig. 22.) Ordinarily stock will not eat the plant on account of its bitter taste, but they may eat it when there is a lack of other forage.

OAK AND CHOKECHERRY

Both scrub oaks and chokecherry probably contain some injurious substances, and they have caused some loss of stock, but as a rule the loss from oak has occurred only when the stock have been forced, by a lack of other forage, practically to subsist upon it alone. The loss usually occurs in the spring, when the oak is just coming into leaf and before other forage has started growth. Cattle are the only class of stock affected. When there is enough other forage available to supply the stock with a variety, oak makes a good forage.

Chokecherry usually causes some loss if stock are forced to live on it alone, or if they have not had any of the plant for some time and then suddenly eat large quantities of it. Infrequently stock are poisoned by eating small quantities of it, as, under certain conditions, it seems to develop the deadly prussic acid. The chief loss from chokecherry occurs among sheep. Properly grazed, chokecherry causes no loss and is a valuable forage.

There are a few other poisonous plants occurring in Utah, but they cause such proportionately small losses that they need not be discussed.

KEEPING STOCK OFF POISON AREAS

If the poison plant occurs on comparatively small areas, the stock may be kept off by fencing or herding; if the plant lasts for only a short time, as is the case with death camas, or is dangerous for only a certain period, as is the case with lupine, stock may be kept off entirely during the danger period. Another method for prevent-

FIGURE 22.—Sheep grazing on sneezeweed (*Helenium hoopesii*). Typical sneezeweed on overgrazed ranges

ing loss is to have the plant grazed by a kind of stock immune to its poisonous properties; as, for example, grazing sheep upon larkspur. It happens in many places, however, that poisonous plants are so widespread that considerable forage is lost if stock must be kept off the area. In some cases it is not practical to graze the area by a kind of stock immune to poisonous properties. In other cases no stock is immune.

ERADICATION OF POISONOUS PLANTS

Studies have been made by the Forest Service of the best methods, the cost, and the practicability of eradicating larkspur. Some results of this study are given in Farmers' Bulletin 826 (*1*).

For National Forest ranges as a whole the most effective way of eliminating loss from larkspur poisoning is to grub out the plants. This method is made practicable by the fact that larkspur grows mainly in isolated patches. * * * Grubbing, furthermore, appears to offer a permanent solution of the problem.

The cost of eradicating larkspur varies from $3.65 to $10 per acre, depending upon the number of plants and the nature and cover of the ground. As to practicability, the bulletin mentioned above states:

> In the Stanislaus Forest, for example, the eradication of approximately 68 acres of larkspur at a total cost for the first and second grubbings of $844.31 saved an annual loss in cattle of 34 head, valued at from $1,200 to $2,000.
>
> On the Sevier National Forest the grubbing of 5 acres of larkspur at a cost of $21.50 cleared an area upon which 15 head of cattle died of larkspur poisoning in 1915, and 9 head prior to the work of grubbing in July, 1916. There was no loss after the grubbing was done.

Very often larkspur grows in such abundance and over such a large area that the cost of grubbing would be prohibitive. In those instances it is often better business to graze the range with sheep, as it is good forage for them and does them no harm.

Although experimental work has also been done upon the eradication of loco by grubbing, so far it has not proven practical.

Much can be accomplished in the eradication of water hemlock by grubbing it out, and this should be done wherever possible. Death camas may also be grubbed out effectively where it occurs in small isolated patches.

REDUCING LOSSES BY RANGE MANAGEMENT

The most practical and effective means for reducing the losses from poisonous plants is intelligent range management. Contrary to the popular idea that range animals will voluntarily seek out poisonous plants and eat them by preference, animals seldom eat poisonous plants except when other forage has been killed out by premature grazing or overgrazing. The only exception to this, perhaps, is the group of loco plants. Many animals, forced to eat loco by a scarcity of other feed, acquire a liking for it and under some circumstances will eat nothing else, even in the presence of good forage. It should be kept in mind, however, that the initial feeding on loco is caused by a scarcity of other feed. This intimate relation of scarcity of feed to stock poisoning can not be too strongly impressed upon the people who handle range animals in the West.

Since animals do not voluntarily eat poisonous plants, the first step in proper range management to prevent losses is to see that no range is stocked to such an extent that the good forage will not supply the needs of the stock. It may take some experimenting to determine just how many animals can be placed on a range so that no considerable amount of forage will be unused and at the same time the stock will not be driven to eat poisonous plants. With careful watching, however, this can be determined. A good practice is to stock the range so that a small percentage of good forage is left at the end of the grazing season. In addition to being a safeguard against poisoning, the forage which is not used will usually produce seed.

Much that has been said of overgrazing also applies to premature or too early grazing in the spring. In fact, most of the heavy losses from poisoning are caused by turning stock on the range before the nonpoisonous forage plants have begun growth. Some of the poison plants—larkspur, death camas, and locos—are the first plants to begin growth in the spring and are too often the only forage available

when stock are first turned out. The only successful way to prevent loss under such conditions is to feed the stock until grasses and other forage plants have made sufficient growth to insure a food supply.

Overgrazing or too early grazing has another harmful effect, in addition to causing actual loss of stock. If the range is stocked to the point at which animals are forced to eat poisonous plants, the good forage will be grazed so heavily that it will be eventually killed out. It is very evident that under such conditions poisonous plants will continue to spread over the area until, if the practice is continued, the area will contain nothing but poisonous plants. On the other hand, if the good forage plants are not grazed too heavily, and a small percentage of them is allowed to go to seed, they will keep the range fully stocked, as under ordinary circumstances the grasses and other forage plants are hardier than the poisonous plants.

Losses from poisonous plants may be reduced by keeping a sufficient quantity of salt out on the range, as lack of salt sometimes causes animals to develop a depraved appetite so that they will eat the bitter poisonous plants in preference to the better forage. Salt also helps keep the animals in a healthy condition so that they can offer greater resistance to the effects of poison.

HANDLING STOCK ON THE RANGE

If range areas were all on level country, with plenty of streams of fresh water and with an even stand of good forage plants, the proper handling of stock on the range would be a simple matter. The surface, however, is very broken, the quantity and quality of the plants vary considerably, and watering places are often very poorly distributed.

If stock are turned loose without management, they go on the high areas in the spring, they graze on areas covered with poisonous plants, they leave forage on the steeper, drier areas, or areas some distance from water, and overgraze such places as flats, basins, and canyon bottoms.

The ill effects of overgrazing and too early grazing have already been discussed. Losses of stock from poison or other causes mean loss of profit to the owner and loss of an economic commodity to the country. A waste in forage on part of the range means either that less stock can be carried or that some other portions of the range must be overgrazed to compensate for the feed not used. Good management is necessary to get full use from a range and to avoid injury to the stock and to the plants.

THE FUNCTION OF A HERDER WITH SHEEP ON THE RANGE

Sheep need constant care to protect them from predatory animals, to prevent them from straying, and to keep them on good feed. (Fig. 23.) The shepherd moves the sheep as necessary. He starts them in the direction in which he desires them to graze in the morning and gathers them at night, keeping ever on the alert for bears, coyotes, and other animals. He places salt where the sheep can have access to it. He lets them go to water as often as he considers necessary, or as often as circumstances permit.

Although handling sheep on the ranges is an age-old occupation, much improvement in methods has been made within the last decade.

One big improvement is the discontinuance of repeated use of the same bed grounds. Under the old method (which is still used by some sheepmen) the sheep were driven to the same bed ground night after night. As a result the range for some distance around the bed ground was overgrazed and trampled. The bedding grounds were dust beds. Poisonous plants took possession of the abused areas. Erosion often formed gullies. Sometimes sheep diseases and parasites spread from the bed grounds. (Fig. 24.)

Under modern methods the sheep are usually quietly rounded up where night overtakes them on the range. Thus no area is used as a bed ground enough to injure it, and the sheep are less subject to infections and are spared the evening and morning trailing from the feed to the bed ground, or from the bed ground to the feed, which is especially injurious to the lambs.

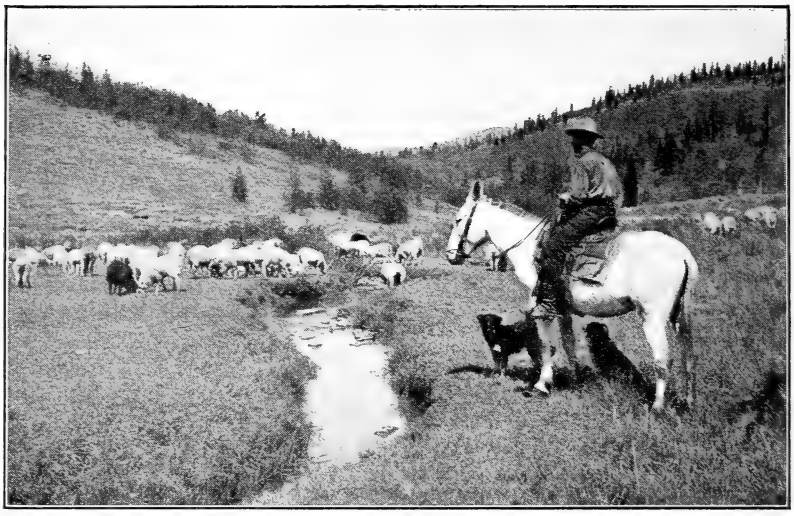

FIGURE 23.—Sheep need constant care

Good herders trail the sheep about the range as little as possible, allowing them to graze quietly and not too compactly bunched.

THE FUNCTION OF A HERDER WITH CATTLE

Cattle do not need the close attention and protection that sheep do, yet the services of the herder are generally necessary. He prevents the cattle from straying from the range on which they should graze. He sees that the cattle drift to the areas where the feed might waste, and prevents them from congregating on areas where overgrazing might result. He prevents them from drifting to the high range too early, and keeps them away from poisonous-plant areas. Very often the herder is responsible for placing salt on the range for use by the cattle. At the close of the grazing season, he helps drive the cattle to the ranches or to the winter range. When cattle are grazed yearlong on the open range the herders must round them up to brand the calves or to cut out the beef steers for market.

FENCES ON THE RANGE

Fences are important in modern range management. Often they are constructed above the spring range to prevent cattle from drifting to the higher ranges too early. Bog holes and poison-plant areas are often fenced to exclude cattle and sheep. Corrals are constructed in which to handle the stock for various purposes, or to hold the stock while they are being gathered for marketing, rounding up in the fall, etc. Stockmen often find fences necessary to prevent trespassing of unpermitted stock.

SALT ON THE RANGE

Sheep will consume about 1½ pounds of salt per head during the summer season. Cattle and horses will consume approximately 2 pounds of salt per head per month from the time the green feed begins until midsummer, and 1 pound per head per month during

FIGURE 24.—A much-used bed ground. Note the trails, the overgrazing, and the poisonous sneezeweed

the remainder of the year. This quantity is in excess of that placed on most ranges, but experience has demonstrated that a liberal use of salt is a profitable investment.

SALTING CATTLE

The craving of range cattle for salt can be used to bring about better distribution of stock on the range, thereby obtaining better utilization of the forage plants. Well-placed salt grounds can frequently do more than several herders to distribute stock properly. (Fig. 25.) Cattle naturally and necessarily go to the watering places. They have also other natural congregating places, such as flats, low passes between canyons, high basins, etc. The forage about such places is fully utilized and often overgrazed. Salt is not placed near water or on any of the natural congregating places. The aim is always to place the salt where there is good

forage and where some inducement is necessary to get full use of the range. Sometimes stock can be discouraged from grazing on areas infested with poisonous plants by keeping salt away from that locality. It is good practice to have salt on the early ranges at the time the cattle are turned out so they will be more inclined to remain there, and it is poor range management to place salt on the high ranges before cattle should graze there, because it induces the cattle to leave the earlier zones too soon.

Crystal sack salt, compressed salt, and rock salt are used for cattle. Much of the rock salt used in Utah is mined near Salina. Stockmen differ in opinion as to which of these kinds is best for the cattle and most economical. Crystal sack salt, usually called stock salt or coarse salt, as distinguished from dairy salt or fine salt, can be distributed so that many cattle can lick at one time, while a large block of rock salt may be monopolized by one cow for an hour or more. Care must be exercised, of course, to prevent

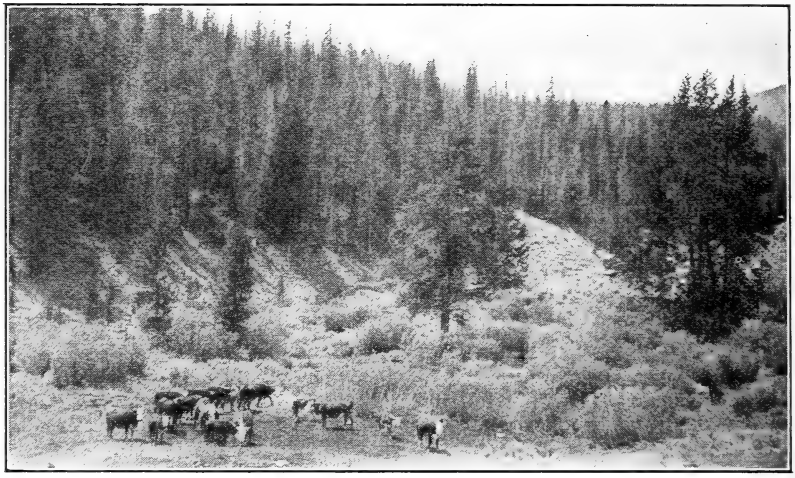

FIGURE 25.—Cattle at a salt ground. Stock need salt. It can often be used as an aid in proper distribution of cattle on the range

cattle exceedingly hungry for salt from having free access to troughs of crystal salt.

SALT CONTAINERS FOR CATTLE

Sack salt fed to cattle on the range is generally placed in long troughs, in wooden boxes, on rocks, or on the ground. The practice of using salt logs or salt boxes is rapidly growing and no doubt will be general within a few years. Where logs are available, the log-trough container is the most economical and most satisfactory. A log large enough to bring the top about 30 inches above the ground is best for cattle. The animals will then feed from both sides; more of them can feed at one time than at a smaller log; and there will be less crowding and less chance for the salt to become foul. Where logs are not readily available, salt troughs made of lumber are used extensively. Where transportation is not difficult troughs can be made in town or at the ranch when labor is not occupied at other work.

SALTING SHEEP

Salt fed to sheep should be of a kind that will allow each individual to get all it requires in a very short time and without injury to its mouth. Rock salt or block salt is very unsatisfactory for this purpose. The broad hard surface prevents sheep from getting the amount they require quickly, because the salt must be dissolved from the surface by licking with the tongue. This slow process takes much of the time which should be spent grazing or resting. The sheep remain on the bed ground longer in the morning in order to lick salt. During the day many of them return to the salt blocks, because they are unable to get a sufficient amount during the night. When rock or block salt is used the sheep are moving to and from the salt throughout the night. This increases the restlessness of the entire band and impairs their growth. Lambs are easily crowded away from the few available chunks. A large percentage of them therefore get only a very small quantity of salt, and, in their hunger for it, eat quantities of dirt and clay. Under these conditions a hard mass soon forms in the stomach which results in death. In their endeavor to get salt with greater facility the sheep gnaw at the hard salt surface. As a result, the teeth most valuable in securing forage are shattered. With poor teeth sheep are unable to withstand the rigors of range conditions. They must, therefore, be marketed as culls at an early age.

Ordinary coarse crystal salt and unrefined fine salt are commonly used for sheep, and give the best results. Besides having all of the qualities desirable for feeding purposes, these salts are easily transported and can be accurately apportioned.

The demands of the sheep should be the basis for salting. In many instances it is found to be an advantage to feed between 20 and 30 pounds of salt per band of sheep each evening. Longer periods than seven days between salting interferes with the management of the sheep, and impairs their condition. The method which seems the most practical from the standpoint of convenience and the requirements of the sheep is to feed all the salt the sheep will utilize regularly every five days.

Most salt is fed on the range by distributing it over the area on which the sheep will bed. Many small piles of about a double handful each are placed upon flat rocks, bunches of sod, or in other spots where it will be kept freest from dirt, and care is taken not to distribute more than the sheep will eat.

SALT CONTAINER FOR SHEEP

In some places portable troughs, in which salt is placed every night, are used to good advantage on the bed grounds. The disadvantage in using troughs is that the salt is not sufficiently distributed for all the sheep to get it at once, but this disadvantage may be overcome to some extent by having the salt on the ground every night.

WATER DEVELOPMENT

Ranges often abound in small seeps and springs that are highly important because they are the only sources of water. Large springs

and streams usually need no special protection or development. The small seeps and springs, however, soon become trampled mires from which stock have difficulty in securing water at all. What they do get is dirty and impure. The seeps and springs can be greatly improved by the expenditure of a little money and effort. A fence, which the stock can not penetrate, should be constructed around the spring or seep. The passageway of the water from the ground should be cleared out and tiled or covered over for a short distance with rockwork, or lumber. A trough or pipe should then be used to convey the water to drinking troughs outside the fence. These should be built so that stock can not get into them or destroy them. They should be large enough to supply water to all stock in the vicinity. Heavy galvanized iron makes a good trough. Good troughs can also be made from 2-inch planks. Satisfactory troughs have often been hewed from trees that grew near the spring. Often the development of springs and seeps makes additional water available, so that it is possible to use areas for grazing that were once unusuable, or to place more stock on a range where the lack of water formerly limited the number.

STOCK TRAILS AND BRIDGES

Bridges of some sort must be constructed at stock crossings over streams where the water is very deep or runs very rapidly. Sheep, especially, need bridges for crossing the larger streams. Often the mountain streams are swollen with water from melting snow about the time the herds of ewes and lambs go to the summer ranges. Under such conditions, the cost of bridges is repaid many times in the prevention of losses from chilling and drowning.

Trails and driveways are often constructed where the country is very brushy or where the hills are extremely steep. The Forest Service has cleared many driveways through the brush and timber where herds travel to and from the summer sheep ranges. In this way, loss of time in sheep trailing is minimized and the injury to the ranges from trailing is confined to as small an area as possible. On the cattle ranges, areas of good feed are often made available by the construction of trails where steepness, dead brush, down timber, ledges, etc., have kept the cattle away.

WILD ANIMAL PESTS OF THE RANGE AND THE FOREST

Wild-animal pests are of two classes: (1) The large carnivorous animals that prey on livestock and game and are commonly termed predatory animals, and (2) the smaller animals that feed on or destroy valuable forage and are commonly called rodent pests.

PREDATORY ANIMALS

The predatory group includes some forms of the following: The bobcat (*Lynx ruffus*), the canada lynx (*L. canadensis*), the coyote (*Canis latrans*), the mountain lion (*Felis concolor*), and the wolf (*C. nubilus*).

BOBCATS

Under natural conditions, bobcats live in the rough, ledgy, and brushy part of the range, and feed largely on rabbits, squirrels,

mice, grouse, and other small animals and birds, sometimes killing young deer and ewes, and often taking lambs. They usually do their hunting at night, and any bird that nests on the ground is easy prey.

A bobcat may destroy annually $40 to $50 worth of poultry and livestock, and game the value of which can not be estimated. Though they do some good in destroying rodents, this by no means offsets the damage they do. Their skins, when prime, sell for from $1 to $8 each and are used for scarfs, muffs, coats, and trimmings on dresses and coats.

Canada lynxes were common through the Wasatch and Uinta Mountains, but now only a few remain.

MOUNTAIN LIONS

Mountain lions, the largest members of the cat family inhabiting North America, live in the roughest parts of the mountain ranges. Deer meat is their favorite food, although they are fond of colts, sheep, and calves, and occasionally kill porcupines, rabbits and other rodents. Often they wander many miles in a night hunting game. They have a keen sense of smell and are very powerful. An adult lion will kill a full-grown deer, elk, colt, or steer with apparent ease and occasionally one will kill a grown horse. Sometimes when they find a herd of sheep they kill a large number.

Where deer are numerous a lion will kill at least one deer a week and will stay around a small bunch of deer in the winter until all are killed. Individual mountain lions may destroy from $500 to $1,000 worth of livestock annually, besides valuable game.

COYOTES

Coyotes are the most abundant and destructive of all predatory animals, and possess great cunning. They appear to thrive under a great variety of conditions, being found in the most barren wastes, throughout the mountains, and even in the outskirts of the thickly settled districts. They range over the same general territory throughout the year. Many of them spend their lifetime in and adjacent to a mountain valley or within a few miles of the same spring or watering place on the desert areas. Through their keen sense of smell they can scent game from a long distance, and they are cunning in detecting the approach of an enemy. They wander about largely at night and hunt rabbits and other small rodents, kill chickens, lambs, and small pigs on the farms, live well on choice mutton, veal, venison, poultry, game birds, and other birds, and will thrive on a diet of crickets, beetles, lizards, and snakes. They often raid the farmers' orchards, gardens, and vineyards, and feed on fruit, vegetables, and grapes, and are very fond of watermelons and peaches.

Coyotes prefer to kill their own meat, usually by biting the animal's throat, and they often kill far beyond their needs. Their custom is to hunt singly or in pairs, and a lone coyote can easily kill grown sheep, small deer, or small calves. Sometimes they hunt in families, and they regularly kill adult deer. They have voracious appetites; a single coyote will eat a good-sized lamb for a meal. Sometimes a coyote will kill several sheep at a time. In some instances this is apparently just to satisfy a lust for killing, though often in the win-

ter months when the snow is deep and feed scarce, the coyotes go back to these old carcasses, dig them up, and pick their bones.

When a coyote den is located near a band of lambing ewes, a kill of one or more lambs each night is made to feed the young. Sometimes a single coyote will kill from $50 to $500 worth of livestock in a night, in addition to game.

Coyote furs, when prime, sell at prices ranging from $1 to $20 each, probably averaging $7 during the past 10 years. Thousands of them go on the market annually and are used for scarfs and muffs, and for the fur trimmings on many kinds of wearing apparel. They are also used as substitutes for many other more valuable furs.

WOLVES

Gray wolves are cunning, powerful, and savage. They ruthlessly slaughter young elk, deer, and any other game available. When the buffalo had been exterminated by wasteful hunting for hides, and elk and deer had been greatly reduced in number, the domestic cattle and sheep placed on the ranges soon became the prey of the wolf. Wolves usually hunt in families, or in so-called packs made up of the old pair and a litter of pups; but a lone wolf will kill large numbers of young cattle and has often been known to kill grown cattle. The wolf frequently attacks an animal from the rear and cuts the cords of the hind legs, commonly called the hamstrings, so the animal can not use its legs. Wolves often get after a bunch of cattle and kill or cripple several without feeding on more than one.

Usually wolves are very sly, and they are seldom seen by man, but at times they are extremely bold and make daytime raids near ranches or sheep camps. A single wolf may destroy annually approximately $1,000 worth of livestock, in addition to game the value of which can not be estimated, and certain individuals have been known to do many times that amount of damage. Stockmen estimated that a lone wolf ranging on the Fishlake Forest killed in three years from $5,000 to $10,000 worth of livestock. When this wolf was trapped by Federal and State hunters in 1925 these losses were stopped.

Wolves have been hunted so persistently that only a few remain, and these are in the most isolated parts of the country.

ECONOMIC LOSSES IN LIVESTOCK, GAME, AND OTHER RESOURCES

The total destruction of livestock and game annually by these animals can not be given. Stockmen for many years have realized that their losses were heavy and have done what they could to protect their herds and flocks, but as more stock was placed on the ranges the losses increased. Probably the heaviest losses occurred between 1910 and 1917. Many sheepmen claimed that they suffered losses of from 8 to 12 per cent annually of their lamb crop, as well as many old sheep. Stockmen who grazed their cattle on the open ranges the whole season lost heavily where wolves or stock-killing bears were numerous. Also many calves were killed by coyotes. If 8 per cent is considered the annual loss, with approximately 2,800,000 range sheep and 360,000 beef cattle in the State, the sheep having an average value of $8 per head and the cattle an average value per

head of $25, the direct loss of livestock must have reached over $2,500,000 annually.

The loss of game can not be estimated in dollars and cents, because game is not a marketable product.

Where predatory animals are on the ranges, the sheepmen must be constantly on guard against raids by these pests. The sheep are carefully rounded up at night and often are driven considerable distances to a point near camp so that they can be protected for the night, a practice which injures both range and sheep, as has been pointed out previously. The Forest Service has carried on experiments with sheep on coyote-proof fenced areas where they were allowed to graze unmolested and with an equal number grazed under the herding system on adjoining allotments. The area grazed under fence had a carrying capacity of about 20 per cent more sheep, a heavier fleece was sheared, and the lambs at marketing time were several pounds heavier.

Control of predatory animals will result in the grazing of a greater number of livestock on the ranges, better methods of handling, and an annual increase of thousands of dollars worth of marketable beef, mutton, and wool. Also, beneficial birds, game birds, and game animals will increase.

RABIES OR HYDROPHOBIA

Predatory animals, particularly coyotes and bobcats, are a serious menace as carriers and spreaders of rabies. They were largely responsible for the spread of a serious outbreak of rabies through California, Oregon, Washington, Idaho, Nevada, and Utah from 1915 to 1917, when several people died and hundreds were bitten by rabid animals and had to take the Pasteur treatment. There were two deaths in Utah, and approximately 150 persons took treatment. A loss in livestock aggregating several hundred thousand dollars also occurred. There have been several minor outbreaks since that time, coyotes or bobcats being the carriers.

These animals when affected by rabies often become very bold, going into corrals, barns, and other buildings, biting everything that gets in their way and even attacking people in houses. They travel long distances and continue to spread the disease until they die from its effects or are killed. Dogs and cats can be fastened up or quarantined in infected districts as a help in checking the disease, but predatory animals must be destroyed.

METHODS OF CONTROL AND RESULTS

Some of the stockmen of the West who realized that they were suffering heavy losses from predatory animals have employed trappers, and some have put out poison. States have passed bounty laws and paid various amounts as an inducement for men to hunt and trap predatory animals. All the Western States have tried some kind of bounty system with different bounty rates and different marking systems. Utah had a bounty law, as early as 1888, even before it had statehood, which permitted counties to pay bounties on predatory animals and rodents. The first legislature that met after Utah became a State passed a bounty law in 1897, and

this has been on the statute books ever since, but was changed and amended at every session of the legislature until 1925, when the present law was enacted.

For a time bounties were paid from county or general State funds, but in 1907 a special tax on livestock was provided for this purpose, and this means of raising funds has continued until the present. Approximately, $1,000,000 has been paid in bounties in Utah, but no detailed records are available prior to 1913. From 1913 to 1924 bounties amounting to $506,930.30 were paid. Bounty funds have all been expended several times and payment stopped until sufficient funds again accumulated.

In spite of everything that could be done, conditions have remained so unfavorable that stockmen have appealed to the National Congress for some relief, and a small appropriation was made in 1915 for the use of the Bureau of Biological Survey in controlling predatory animals. This fund was later increased, and at present (1930) amounts to approximately $560,000 annually for control of predatory animals and rodents in the United States.

SOME OF THE RODENTS OF UTAH

THEIR ECONOMIC RELATION TO THE RANGE AND THE FORESTS

Utah, along with the neighboring States, has many species of rodents. Limitations of space preclude a complete description of each species. For this reason, only the most important species of each group, from the standpoint of numbers and economic relations, will be mentioned.

In the case of some of the rodents, man's advent into the scheme of things has had a directly favorable influence. The tendency to eliminate their natural enemies such as the coyote, badger, fox, owl, hawk, and eagle, and to supplement the supply of natural forage with a variety of more succulent food, has thrown the balance in their favor. Other rodents have decreased in number locally by reason of man's encroachment upon their natural habitat.

GROUND SQUIRRELS

In Utah are found eight species of ground squirrels (*Citellus* and *Callospermophilus*), called also spermophiles (seed lovers). The two most important as to numbers and ranges, and thus of prime economic consequence, are *Citellus armatus*, known locally as the gray ground squirrel, pot-gut, or ground hog, and *C. mollis*, more commonly spoken of as quimp, sage rat, or desert squirrel.

The geographical ranges of the two species are quite different, and although *mollis* occupies a greater area than *armatus*, much of its range includes that portion of western Utah known as the Salt Lake Desert, where little other than sagebrush and salt grass go to make up the vegetation. However, one must not conclude that this mammal is not a menace to the farmers and ranchers. Along the eastern boundaries of its range, in the fertile valleys of Tooele, Millard, and Beaver Counties, as well as on the range within the national-forest boundaries, its numbers cause real concern.

The time of appearance in the spring is naturally governed largely by geographical location and elevation. Generally speak-

ing, the ground squirrels of Utah make their appearance during March in the valley areas and early in May or in June in more elevated situations. Naturally enough, those that went into hibernation earliest during the previous season are first to appear in the spring, the males preceding the females by a few days or perhaps by more than a week. The young of the previous year begin to appear somewhat later. This circumstance is of much importance when one considers control measures, for if bait is placed as soon as the first squirrels appear the effort will have to be repeated when the whole family emerges.

Not only is vast damage done to crops in the cultivated areas each year by the squirrels, but the forest range is injured through the consumption of grass on the higher areas in the spring, and on the lower slopes as the dry season comes on. In addition to the destruction of the green succulent growth, the animal's particular love for seeds results in great damage to grasses that would otherwise produce a seed crop. Then, too, during the growing period the squirrel finds something toothsome in the joints of various grasses and cereal plants. They hibernate during August or early September.

The ravages caused by a colony of these spermophiles in a growing field produces the appearance of an area visited by a hailstorm. Data are not complete as to the amount of forage consumed by *C. armatus* or *C. mollis* within a season. Yet it is not unreasonable to assume that in Utah alone these rodents take a yearly total amounting to hundreds of thousands of dollars.

PRAIRIE DOGS

Prairie dogs (*Cynomys*) are not dogs but typical rodents, first cousins to the ground squirrels or spermophiles. As a rule they may be distinguished from the ground squirrels by their larger size, proportionately shorter and heavier bodies, and shorter tails. In length they vary from 14 to over 17 inches, and in weight from 1½ to over 3 pounds.

Three species of prairie dogs are found in Utah: The black-tailed (*Cynomys parvidens*) of the south-central counties, the white-tailed (*C. leucurus*) of the eastern and northeastern sections, and the Zuni prairie dog (*C. zuniensis*) of the southeastern corner of San Juan County. The Zuni prairie dog in San Juan County has the peculiar ability to detect and reject strychnine in the free state, while the other two species readily accept the same bait. In contrast to the general habits of prairie dogs, the white-tailed species in Utah have adopted the habit of not living in a colony, but of seeking shelter among the sagebrush, where they burrow and construct their characteristic mounds. In poisoning large areas in eastern Utah during the summer of 1927, it was particularly noted that this species disregarded the colonization habit usually so characteristic of prairie dogs.

Unlike the ground squirrel, the prairie dog does not hibernate for any length of time, and one may drive through any of the dog towns of the State during various seasons of the year with full assurance of seeing the usual sentinels perched on guard ready to give timely warning. Litters of from four to six are born early in March, and

after five weeks they appear above ground with an inherited eagerness to take their place in the social life of the village. Feeding on the short grama grass found in most dog towns or ranging out into some near-by cultivated field, they soon take on growth.

Approximately 1,500,000 acres within the State are infested with prairie dogs. Since the diet of these rodents consists of grass and other plant life on the range, and of such forage and grain crops as alfalfa, clover, wheat, corn, barley, and oats in the cultivated regions, great damage is caused each year. In one area on the eastern boundary of Utah, some 512 square miles of infested land were treated with poison during the summer of 1927. It required the labor of 412 men for a day each and 15,000 pounds of poisoned-oat bait to cover this area.

POCKET GOPHERS

The Uinta pocket gopher is perhaps the most widely distributed of the four species (*Thomomys uinta* and its relatives) found in Utah. Inhabiting the fertile valleys where man's effort has made food more abundant, and ranging over mountain slopes to an elevation of 10,000 feet, this burrower is found in most parts of the northern half of the State, reaching southward well down into Tooele and Juab Counties.

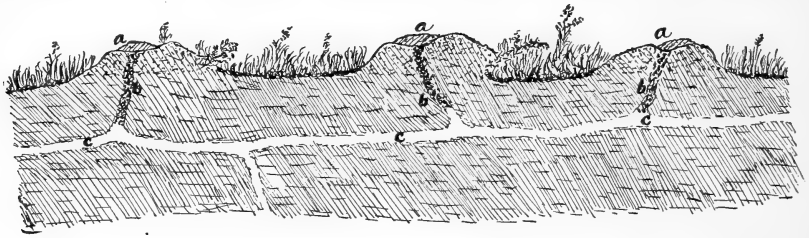

FIGURE 26.—Pocket-gopher tunnels and hills: *a*, Mounds of loose soil; *b*, laterals leading to the mounds, usually closed with earth; *c*, main runways, usually clean

The pocket gopher is a vegetarian, living on roots, bulbs, and tubers, but also includes seeds of grass and grain in his menu. His tunnels or burrows are extended when in search of roots, which he eats as found, or cuts up into pieces suitable for carrying in the two fur-lined external cheek pouches. (Fig. 26.)

It is evident that the pocket gopher has no hibernation period, as activity goes on during the winter months. This is revealed in long branching piles of earth that have been brought up from the underground tunnels.

From one to seven young are born to the litter, but it is not known whether there is more than one litter in a season. The young when about half grown move to unoccupied ground in the vicinity of the home location and start new tunnels.

It is sometimes discouraging to find signs of new activities in a field that has been thoroughly trapped or poisoned, but when one understands that new crops of gophers in some neighboring field look for nothing better than vacant runways in which to set up housekeeping, the discovery revives a determination to interest one's neighbors in control methods.

JACK RABBITS AND HARES

Three species of hares (*Lepus* and its relatives) are found in Utah. These are commonly termed the white-tailed jack rabbit, the black-tailed jack rabbit, and the Rocky Mountain snowshoe rabbit. Black-tailed and white-tailed jack rabbits range over valley and desert areas and often become so numerous as to threaten all crops on large cultivated tracts.

A close relative of the hares is the native cottontail rabbit. However, it rarely becomes so numerous as to cause serious damage in the agricultural areas in the State.

In considering the economic relation of rabbits or hares to forest areas, the snowshoe rabbit is of chief importance. This rabbit has great tufts of hair that pad its large hind feet and assist it in moving about over the snow during the winter. Its brown pelage of summer turns completely white as winter approaches. The chief damage that it does is the cutting of young conifer seedlings either in natural reproduction areas or artificial plantations. Where the black-tailed jack rabbit occurs it may do serious damage to range forage.

THE WESTERN PORCUPINE (ERETHIZON)

The porcupine does not hibernate, nor does it migrate extensively, though there may be well-marked seasonal movements, but spends its somewhat solitary life in rather small areas, feeding upon the bark of trees, making forays into gardens or cultivated fields, or hiding away in some crevice at the base of a rock slide. It is when dusk falls that the porcupine sallies forth on nightly tours, especially on evenings when the moon is up.

The single young one is born in May and remains for some time about the den, which is generally to be found in some rocky slide high on the mountain slope.

It is apparent that the porcupine is on the increase in Utah. This is especially noticeable in forest areas, where the animal shows a preference for the bark of conifers. The pine seems to be preferred to other species, and the damage is widespread. (Fig. 27.)

USE AND MANAGEMENT OF TIMBER RESOURCES

HISTORY OF THE LUMBER INDUSTRY IN UTAH

Sawmills were built the first year after the pioneers came to Utah. By 1848 there were three mills in Mill Creek, east of Salt Lake, and three in a canyon 10 miles north. The first lumber was manufactured by up-and-down (whip) saws, operated first by man power (Fig. 31), and later by water power. Then came the circular saw, operated first by water power and finally by steam. By 1852, there were sawmills at City Creek, Cottonwood Canyon, Tooele, and Provo. In 1853, there were a hundred or more mills in operation in various parts of Utah.

Smith Bros. cut saw timber from Pine Valley, Provo River, about 1882, and ran the first drive of timber from upper Provo River. The logs were landed near the mouth of Provo Canyon, where Smith Bros. had a sawmill.

Ties were driven down the river every year thereafter until along in the nineties. (Fig. 28.) There were four or five different contractors at work at various times, but all combined in driving their ties, which were landed near the railroad bridges on Provo River,

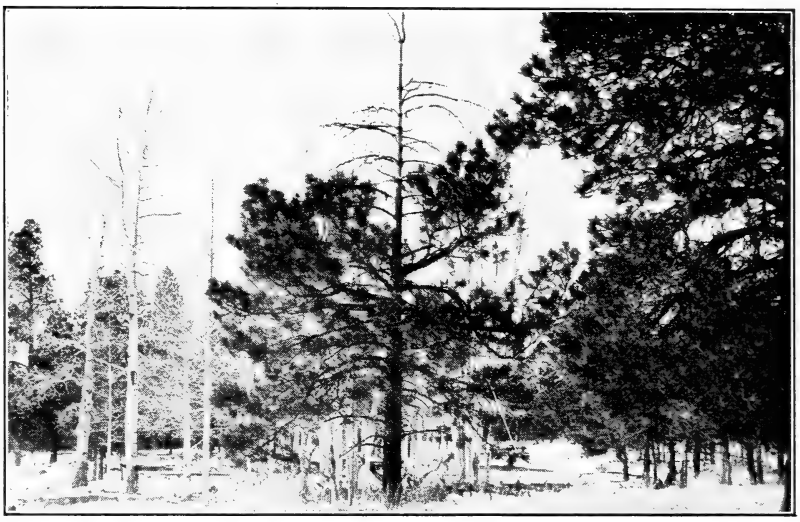

FIGURE 27.—Western yellow pine injured by porcupine

west of Provo. The ties were used by the Utah Southern, later called the Utah Central, which was using standard-gage ties at that time, and by the Denver & Rio Grande Western Railroad, which took narrow-gage ties. The largest drive was made about 1886,

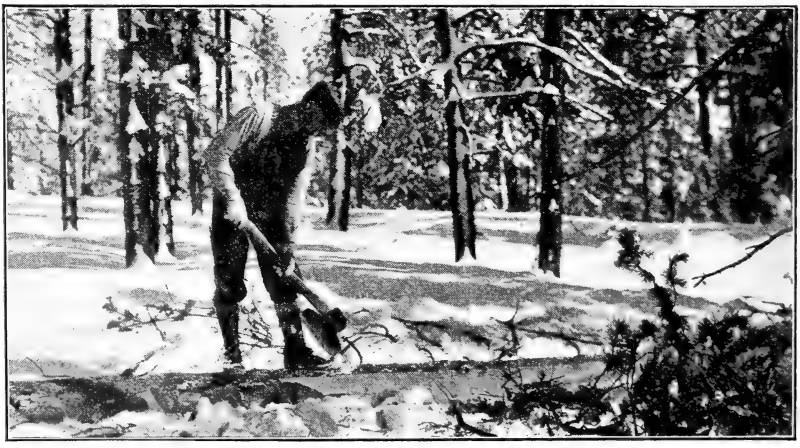

FIGURE 28.—Railroad ties are still largely made by hand. Note the ax used for hewing

when approximately 350,000 ties were driven down the river. (Fig. 29.)

Charcoal kilns were located about 4 miles above the Mill Fork station of the Denver & Rio Grande Western Railroad. About 20

carloads a month were shipped from these kilns, chiefly to the smelters in Salt Lake Valley.

Utah lumber operations have never been on a large scale. There were, in 1927, 81 active sawmills in the State. The annual cut of lumber fell from 25,709,000 feet board measure in 1880 to 7,623,000 feet in 1928.

AMOUNT AND USE OF UTAH TIMBER

TIMBER RESOURCES

About 5,000,000 acres in Utah are timbered. Several million acres more are thought to be suitable for forest planting. The timber resources are capable, under a good system of forest management, of producing one-half the lumber requirements of the State. (Fig. 30.)

FIGURE 29.—Hewn ties in Black's Fork drive

Utah has approximately 4,965,000,000 board feet of saw timber and 10,000,000 cords of fuel, pole, and post material, equivalent to approximately 3,000,000,000 feet of saw timber, all within the national forests. This is divided by species as shown in Table 3.

The saw timber outside of the national forests is insignificant commercially. The aspen, pinon, and juniper outside of the national forests must total many million cords, but since the stands are in many instances inaccessible and have only local use, they play little part in the Utah timber situation.

TIMBER CONSUMPTION

Accurate statistics on the consumption of timber are not available, but rough figures indicate that Utah uses 188,000,000 board feet of forest products annually, divided approximately as follows:

Use	Quantity
Lumber, including sawed material used in mines, feet, board measure	130,000,000
Props for coal mines, do	7,000,000
Railroad ties, do	25,000,000
Fuel and miscellaneous cordwood, do	20,000,000
Posts, poles, etc, do	6,000,000
Total, do	188,000,000

UTILIZATION

At present only slight use is made of the timber resources of the State. Only about 37,500,000 board feet of Utah's timber is cut

annually. More than half of this is cordwood, nearly one-fourth is props, posts, and poles and other round material, and another fourth is saw timber. The entire cut, except approximately 16,000,000 feet

FIGURE 30.—Ranger marking tree for cutting in a typical stand of western yellow pine

of fuel and round material from juniper woodland, comes from the national forests.

TABLE 3.—*Amount of timber of the different species in the national forests of Utah*

Species	Amount
	Feet, board measure [1]
Engelmann spruce	1,436,743,000
Western yellow pine	1,284,575,000
Lodgepole pine	1,470,583,000
Douglas fir	430,162,000
Alpine fir	245,727,000
Various (excluding aspen, pinon, juniper)	96,955,000
Total	4,964,745,000
	Cords [2]
Aspen	6,000,000
Pinon and juniper	4,000,000

[1] Saw timber. [2] Fuel, pole, and post material.

The best timber is the least accessible. Most of the larger timber bodies are far from railroads and markets. Other areas of good timber are located in relatively inaccessible pockets, for the adjacent valleys were settled early and the mountains close at hand were combed for the best timber many years before the railroads brought in material from the Northeast.

Another reason why only scant use is made of local timber resources is that the products of northwestern operators now dominate the

Utah market through the advantage of large-scale production and the wide variety of uniformly manufactured products, such as flooring, ceiling, lath, and finish of all kinds. The small local millman who produces only rough or simply surfaced lumber is under a big handicap in competing in the general market. In most cases the only market left him is the settlement far from the railroad. Imported lumber is found in all yards located on the railroads and in a number of yards in the timbered regions as far as 20 miles from the railroads. Practically 93 per cent of the lumber (excluding props, poles, etc.) used in Utah is imported from other States. More efficient sawmills and more attention to grading of the lumber are needed in Utah if local production is to be increased.

A third reason why only scant use is made of local timber is that it is of somewhat poorer quality than the people have become accustomed to using. The Utah timber yields smaller quantities of high-grade material and more boards of narrow width and more knotty timber.

FIGURE 31.—Making lumber by hand-whip sawing

LUMBERING AND MILLING PRACTICE

There are two main classes of small sawmill operators in Utah: Those who operate the small sawmill as a side line to farming, stock raising, or a small lumber yard, and those who operate the small sawmill as a business and devote all of their time and energy to the work.

These mills can not make finishing stock to compete with the larger mills of the Northwest, because they do not have the necessary machinery. It would be possible, however, for light machines of moderate cost to be used in connection with portable mills (fig. 32), for making all kinds of finishing stock. Many portable sawmills in the United States are manufacturing lumber products and putting them on the market in competition with the larger plants. (Fig. 33.) Utah manufactured lumber, however, has often come to market with the following defects:

Green and heavy. It will shrink and leave wide cracks as it dries after being put into a building.

Thick at one end and thin at the other. To make an even flat surface with such lumber is impossible.

Uneven lengths and widths. All must be sawed off by hand before using.

On the other hand, the lumber from the large mills on the coast or in eastern Oregon comes to local yards:

Dry and ready to use. It does not shrink.

It is surfaced and sized; that is, it is smooth and of equal thickness.

It is trimmed (ends sawed off square) so that it is exactly 10, 12, 14, or 16 feet long, and is exactly the same width at one end as at the other.

The building contractors of to-day will not handle material that has to be put in finished condition by hand. It is a slow and expensive process with the present high wages paid to carpenters. They can well afford to pay a much higher price for the finished product.

It has been demonstrated that just as good lumber can be produced by the portable sawmill as by the larger mills if the following rules are adhered to:

Foundation for saw frame must be solid. This does not mean a cement foundation. Logs will do if properly set and fastened.
Saw and carriage must be in alignment.
Saw must be set tight on arbor or shaft. A loose saw makes snaky lumber.

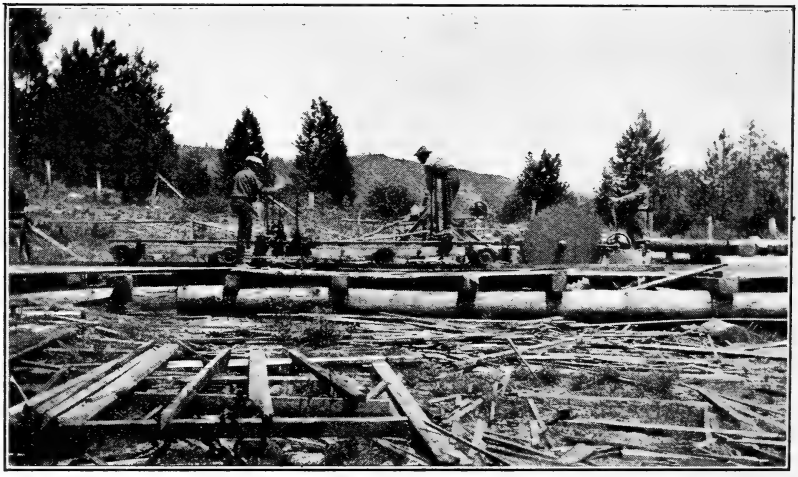

FIGURE 32.—The second method of making lumber—a portable mill

Saws must be filed and swedged properly, otherwise the result will be ridgy lumber, which will not surface smooth, causing a degrade.
Speed must be proper for the size of saw used.
Lead of log into the saw must be proper.
Power must be sufficient to operate the saw at capacity.
Sawyer must understand how to get the best out of the log. On the ability of the sawyer depends more or less the profit of the operation.
Lumber must be graded in order to get the best price.
Better systems of accounting are needed.

HOW TIMBER SHOULD BE CUT

From the standpoint of use, forests can be divided into two main classes: Protection forests, and commercial forests. Protection forests are those whose greatest use lies in the protection which they afford against floods, snowslides, moving sands, and especially against rapid run-off and the resulting shortage of water in the streams later on. All the forests of Utah render an important service in protecting and stabilizing the stream flow essential to irrigation. Commercial forests are those whose principal value lies in the growing of continuous crops of timber and forage.

Some forests are entirely of one class, but those of Utah must be handled with both main purposes in mind.

The first step in handling forests for continuous yield of timber is a general stock taking or an extensive cruise. This is made by cruisers who, working alone, pace a compass line through each forty ($\frac{1}{16}$-section) and at intervals of 10 chains, measure the timber on $\frac{1}{4}$-acre sample plots. On each plot the cruiser records by species the sizes of trees suitable to cut and to leave. He also maps the streams and ridges and the boundaries of the various kinds and age

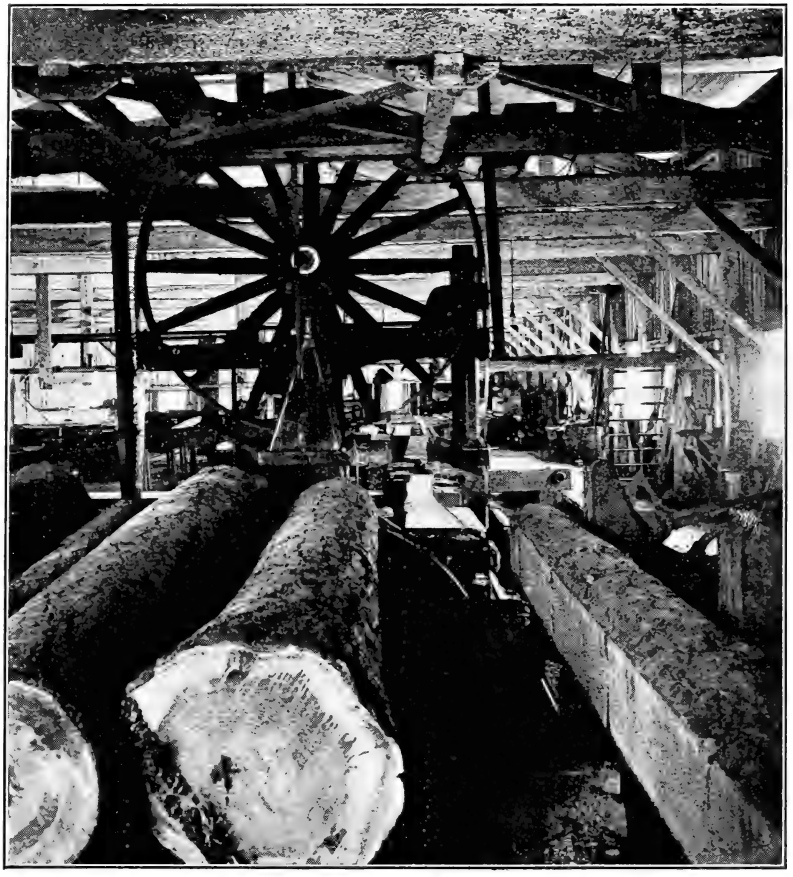

FIGURE 33.—The latest method in lumber manufacture—a modern band mill

classes of timber. When passing through immature timber he makes special note of the age and rate of growth so as to be able to determine when these young stands will reach merchantable size. The age and rate of growth of standing trees are determined by cutting out a core from the bark to the heart with a hollow auger (called an increment borer), counting the annual rings, and measuring the growth. (Fig. 34.) The results of this cruise are worked into a management plan for handling the timber stand. According to this plan the forest is divided into units of continuous timber pro-

duction, called working circles. The growth data are assembled, and from them the amount of timber which can be grown per year, or the sustained annual yield, is determined.

All the national forests are being handled on this principle so that a permanent industry based on productivity can be established. What the State's sustained annual yield will be is not of immediate concern so long as the cut remains as low as it is at present. Nevertheless, it is interesting to consider what the forests of Utah may be able to produce. A rough estimate, the best available at present, is given in Table 4 for the national forests of the State. Other areas play little part in timber production.

FIGURE 34.—How old is the tree? How fast does it grow? Answering these questions with an increment borer

The national forests of Utah can supply around 85,000,000 board feet a year, exclusive of that which goes into cordwood, posts, etc. This is more than one-half of the needs of the State for lumber. Under Forest Service management the amount of lumber produced annually will increase, particularly in the forests close to the cities and towns which were cut heavily in the early days and which now with proper protection are reproducing and growing rapidly.

TABLE 4.—*Amount of timber expressed in millions of board feet which Utah national forests can grow annually*

National forest	Engelmann spruce	Western yellow pine	Douglas fir	Lodgepole pine	Alpine fir	Other conifers	Total
Ashley	4,513	2,136	1,308	11,786			19,743
Coche	143		458	77	110		788
Dixie	1,525	2,911	976		247	231	5,890
Fishlake	1,562	151	493		428	123	2,757
La Sal	709	1,351	9			123	2,192
Manti	2,313	179	446		861	131	3,930
Minidoka			32		24		56
Powell	2,638	11,888	1,674		1,430	1,191	18,821
Unita	1,269		752	271	626		2,918
Wasatch	8,272	25	1,115	17,294	1,459	22	28,187
Total	22,944	18,641	7,263	29,428	5,185	1,821	85,282

SELECTION CUTTING

The system of cutting best suited to the majority of Utah timber types is called "selection cutting," which means that certain trees are selected for removal. (Fig. 35.) This system is applicable to western yellow pine, lodgepole pine, Engelmann spruce, Douglas fir, and alpine fir. In fact, it is suitable for any trees which require some shade in the seeding stage.

To see how it works consider a stand of mature western yellow pine. This stand of timber will probably contain 8,000 board feet (a board foot is the equivalent of a board 12 inches square and 1 inch thick) per acre in trees 12 inches in diameter breast high (4½ feet from the ground) and larger. Such a stand is not increasing in volume, as the growth put on is small and is balanced by the loss of those trees dying out. Most of the timber volume will be in large veterans, but there will be a considerable number of thrifty younger

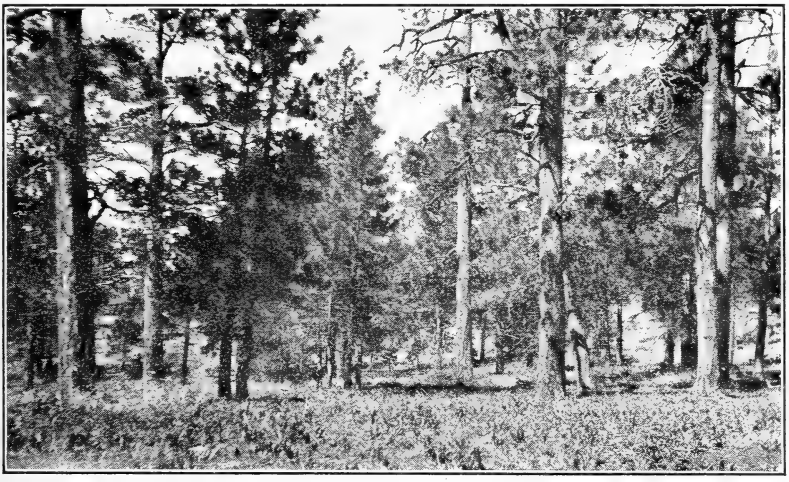

FIGURE 35.—Selection cutting. All trees with white spots on the trunk will be cut

trees from 12 to 20 inches in diameter at breast height and a lot of smaller poles (2 to 6 inches in diameter) and saplings (3 feet high and 2 inches in diameter).

Suppose the whole forest unit has been considered, and it has been determined that this area should be logged over every 50 years. To do this it will be necessary to leave enough trees now to provide a merchantable stand 50 years hence, with the idea in mind that the selection cutting made then will leave ample growing stock for a third cut. Studies of the growth of western yellow pine indicate that 2,000 board feet per acre left in thrifty, well-distributed trees will grow to at least 8,000 board feet per acre in 50 years. The forester in charge therefore goes through the timber and marks for cutting all the mature, overmature, and defective trees, being careful to leave thrifty, fast-growing trees to the amount of at least 2,000 board feet per acre. When the marked trees have been removed, the forest is considerably opened up and the surface soil disturbed

by the skidding out the logs. There are enough trees 12 inches in diameter and over on the ground, however, to assure a second cut in 50 years, and enough seed trees to reseed the openings. As this system is repeated the forest will change its form in that the very large, slow-growing veterans will disappear and the stand will consist of a greater number of smaller, fast-growing trees. (Fig. 36.)

CLEAR CUTTING

The other system of cutting used in Utah is called " clear cutting." As the name implies this means the complete removal of all the timber from a certain area. No seed trees are left, and the next stand must be secured in some other way. In applying this system

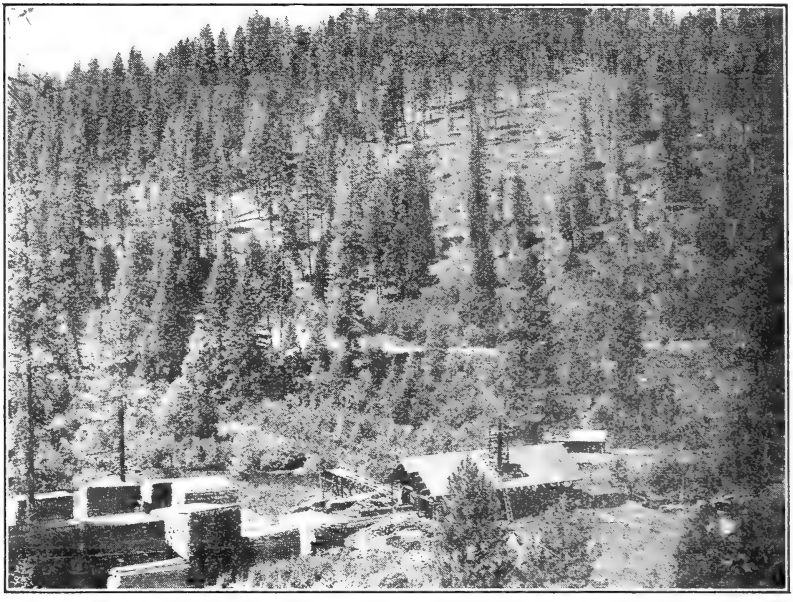

FIGURE 36.—A forest upon which selection cutting has been practiced

to the pine forest of Europe the area is clear-cut when the forest reaches the desired size, and the ground is promptly replanted to the desired species with nursery stock. In Utah this would be too expensive and probably not very successful, because of the difficulties met in making plantations grow in its dry climate.

Applied to aspen, however, the clear-cutting system proves most satisfactory. The area to be logged is cut clean. (Fig. 37.) The limbs and tops are lopped to get them out of the way and to make them rot faster. The aspen promptly sends up a quantity of root suckers or coppice sprouts which reestablish the stand at once. It has been found that cuttings made in the spring produce the best sprouts and that fall cutting is preferable to that made in summer. It has also been demonstrated that an adequate growth of aspen sprouts can be expected from stands up to 110 years of age.

UTILIZATION STANDARDS

The practice of forestry not only requires the harvesting of successive crops of forest products, but implies the most complete utilization practicable so as to secure the maximum amount of usable material from each tree cut. As the price of lumber goes up and as logging and sawmill machinery are improved, utilization becomes more and more complete. There is still plenty of room for improvement, as now not more than 35 per cent of the tree as it stands in the forest is utilized. The principal waste is in slabs, tops, sawdust, branches, stumps, and in the custom of using logs of only even lengths, and in trimming and edging the boards.

The Forest Service requires that on the National forests stumps be cut low, not over 12 inches on the uphill side for poles, ties, and other material up to 12 inches in diameter, and not over 16 inches

FIGURE 37.—A typical aspen stand, ripe for clear cutting

high for larger trees. It also requires that the log lengths be arranged to utilize the whole trunk of the tree down to a diameter of 7 inches inside the bark. Private operators are gradually improving their utilization in both the logging and the manufacturing ends of the business, and it may be expected that waste will be reduced as fast as economic conditions permit.

BRUSH DISPOSAL

One of the most difficult problems in the handling of timberlands for the production of repeated crops is the proper disposal of the slash, brush, or refuse left after logging. This is important both because of the direct effect upon reproduction and erosion, and because of the tremendous influence slash disposal has in protecting the cut-over area from fire.

In Utah it has usually been found advisable to pile and burn the brush in Douglas fir, spruce, lodgepole pine, and fir types of forest in regions of high fire hazard. Such forests, if logged by the selection system, are apt to be left with a tangle of limbs and tops among the smaller trees. These limbs and tops may be left propped up and piled together, and may be so crowded around the remaining trees that any fire running through is sure to crown (get into the tops of trees) and destroy the majority of them. It is almost impossible to control a forest fire running through dry slashings. On Forest Service sales, if the fire hazard is high, all tops must be lopped (limbs cut from main top) and all brush or limbs 4 inches or less in diameter must be piled and burned. These piles are made about 4 feet across and 4 to 6 feet high and should be compact with enough needles in the bottom to insure easy lighting. The brush is piled while green, as logging progresses, and burned in the fall when there has been sufficient rain or light snow to make burning safe.

Brush should not be piled and burned in the aspen and pinon-juniper stands. Aspen should be cut clean. It has relatively light brush, which decays rapidly and does not create a bad fire hazard. Pinon and juniper grow in such open stands and in such dry locations that reproduction is assisted by additional shade. Slash from these cuttings is not heavy enough to cause a fire hazard. It is best to leave the tops to provide shade for the reproduction as it starts. Tops will gradually rot and enrich the soil.

In regions where brush piling and burning are not essential for fire protection, it is often a good practice to lop and scatter the brush for protection of soil against erosion and drying out.

WHAT A MANAGEMENT PLAN IS

With the growing of timber as with any other crop, it is highly desirable that a uniform yearly income be maintained. Then, too, meeting future demands for timber is of equal importance with meeting to-day's demand. This is especially true with Federal or State timber. In Utah the bulk of the timbered area is in the form of overmature virgin stands on which the loss through decay approximately equals the annual growth. Obviously, the sensible thing to do is to cut only the trees in need of cutting and leave those which will add wood rapidly. Here then, are three good reasons for practicing what foresters call sustained yield and for using the selection system of cutting. The selection system has already been described. Sustained yield means simply restriction of the volume of timber cut from a given unit each year to the amount of additional timber added through growth in the same time.

Sustained yield, however, does not mean hoarding mature and overmature timber. That is unbusinesslike and unwise because on such areas as heretofore described, decay and stagnation are likely to maintain a balance between growth and loss. The wise thing to do is to cut out and utilize the mature, overmature, and defective trees so as to increase the rate of growth of those left and also open up the stand enough to get a new crop started below.

With a slow-growing crop like timber, with the changing of men in charge of timber units, and with the large areas and diverse con-

ditions for any unit, it has been found essential that a well-thought-out and carefully prepared plan of management be written for each unit. Such a management plan is the guide which tells how, where, and how much timber is to be cut each year. Generally, a management plan is prepared for what is called a "working circle," which may be described as the timber-producing area tributary to one point of manufacture or to one community. The boundaries are usually determined by relief or lay of the land. The working circle is divided into compartments, usually small watersheds within the working circle, which are in turn further divided into subcompartments, which are natural logging units. These divisions are usually necessary in order to build up a really usable management plan.

The following are the main data essential for the preparation of a plan:

A statement of the amount of each kind of timber ready for cutting on each subcompartment.

A table showing, for each kind of timber and age class, the average number of trees, and volume of timber to be left per acre after cutting.

Data showing at what size or age trees of the various kinds cease to make satisfactory growth and the rate of growth until this time arrives.

Maps showing the distribution of the timber by kind and age for the entire working circle.

Besides these data, an intimate knowledge of such things as economic conditions, available markets, accessibility of the timber to market, and other related factors, is necessary to the making of a plan. The rotation (age or size at which timber will be cut), and how often the area is to be cut over, must also be decided.

If the area is not clear-cut the first time, it is possible to take the trees which are left as fast as they mature in sufficient volume to make it worth while. The period between cuttings, once determined, is called a "cutting cycle." Generally the oftener an area is cut over, taking out only such trees as are ripe or defective, the greater will be the growth per acre. For this reason it is best to come back as often as the volume of timber per acre of such timber is sufficient to pay to do it.

The next step is the determination of how much can be cut each year on a sustained-yield basis. There are many ways of determining this, most of which are too complicated to be dealt with here. Suppose that by using the table mentioned above as an essential of a management plan, showing the number of trees of each kind and size left per acre, along with the rate of growth, it is found that an average acre will add 150 board feet of wood through growth each year. Then suppose the working circle consists of 100,000 acres of timber-producing land. It is obvious that 15,000,000 board feet could safely be cut each year and that this cut could be continued forever.

The next thing to answer is where to cut first and in what order to proceed. The logical place to cut first is on the subcompartment where the percentage of overmature timber is heaviest, other things being equal.

The question of how to cut is covered by what are called marking rules. These rules are simply instructions as to what kind of trees to cut and what to leave under different conditions. They are based on experience in Forest Service cuttings, and on research.

The above is a brief description of a forest-management plan and its preparation. A plan should be revised every few years as new and better information becomes available. No two plans are alike, and no plan is workable unless the maker has reliable facts to work with and a clear understanding of the local conditions.

PRINCIPLES OF PLANTING

Although the systems of cutting used in most well-managed forests aim to secure natural reproduction of the stand, it is sometimes necessary to supplement this with seeding or planting to secure the most complete use of the soil. There are also large areas of logged-over or burned-over forest land and of abandoned farms where nat-

FIGURE 38.—Devastated by logging and fire. Only planting will reforest this kind of country

ural reproduction of desirable forest trees can not be expected. (Fig. 38.) These must be seeded or planted if they are to be made productive.

SEED COLLECTING

The native forest trees most important for lumber production in Utah are as follows: Western yellow pine, Douglas fir, lodgepole pine, Engelmann spruce, and alpine fir. They are all conifers—that is, they bear their seed in cones which open and permit the seed to scatter when ripe. To collect this tree seed it is necessary to collect the cones after the seed is mature but before the cones open. This is done by cutting the cones from the trees, by gathering the cones from trees cut in logging, and by collecting cones which have been gathered by squirrels. This last method has proved the cheapest and most successful in Utah, where the squirrels collect much larger supplies than they need for their own use. By September 15 or 20, the squirrels have collected large quantities of cones, which they cache in moist places under logs or brush, or around the roots of seed trees. These cones are gathered in sacks and hauled to a central point, where they are dried either in the sun or by artificial heat.

All local species can be sufficiently dried in the sun, except lodgepole pine, which requires a temperature of about 130° F. to make the cones open promptly. When the cones are thoroughly dry, the seeds are removed by various methods such as raking the cones, flailing them, or putting them through the corn shaker. The seeds are then cleaned by screening and fanning in a machine which breaks off the seed wings and separates the clean seed. Utah species will yield approximately the following amounts of clean seed for each bushel of cones:

	Pounds
Western yellow pine	1.32
Douglas fir	.76
Lodgepole pine	.54
Engelmann spruce	.50

The clean seeds are stored in air-tight containers until needed either for direct seeding or for planting in the nursery.

DIRECT SEEDING

The advantage of direct seeding, either with or without previous preparation of the ground, lies in its cheapness and in the opportunity to use unskilled labor. The two most usual methods of direct seeding are by broadcasting and by seed spots. Broadcasting is most successful where the surface soil is loose and moist, and where the seedlings have some shelter from the sun. In Colorado lodgepole pine has been successfully planted on old burns by broadcasting the seed on top of the snow. In the seed-spot method, small spots regularly spaced over the area are more or less carefully prepared for the reception of the seed. The seed is then planted and covered to the proper depth. In Utah direct seeding has not proved successful, principally because of the long dry summers, which make it very hard for seedlings to establish themselves. In any direct seeding, rodents may be a serious handicap by stealing the seed.

PLANTING SMALL TREES

To fill gaps in a forest or to establish a new stand, the planting of small trees is the accepted method in Europe and in this country. In the early days it was common practice to use wild stock or small trees dug up in the woods, but, as nurseries developed, it was found that nursery stock could be grown to the desired size, and on account of its better root development was more likely to succeed than the wild stock.

NURSERY PRACTICE

To raise forest trees from seed, one should have a rich, moderately light sandy loam, free from coarse gravel and rock. The nursery is divided into beds 4 feet wide and of any desired length, with a path on either side from which they can be worked. The seeds (pine, spruce, and fir) are sown broadcast and then rolled to insure their being pressed into the soil. A thin layer of fine soil is then sifted over the seed and well watered. To prevent drying out, the beds are usually covered with brush or lath screens. As the small trees grow they require less shade and the screens are gradually removed. Western yellow pine, lodgepole pine, and Douglas fir are

usually allowed to remain two years in the seed bed, but Engelmann spruce, on account of its smaller size, is left there three years. At the end of these periods the seedling trees are dug up and transplanted into other beds where they are set out in rows to give them more room for growth. Western yellow pine and lodgepole pine usually remain in the transplant bed one year; Douglas fir and Engelmann spruce two years, before they are large enough to be set out in the forest. When the small trees are ready for shipment they are dug up and tied losely in bunches of 50 or 100. These bunches are then crated or packed in bales with the roots wrapped in moist sphagnum moss and the tops exposed to the air. In shipping small trees the two most important things to remember are that the roots must not become dry for a moment and that the tops must be well ventilated to prevent molding.

PLANTING THE TREES IN THE FOREST

In Utah the long, dry summers are the greatest hardship which the planted forest has to meet. For this reason plantation sites for forest trees should be selected where the species to be planted has grown before and where the small trees will receive some shelter from snags, brush, aspen, or sagebrush. Planting should be done just as soon as the snow leaves the plantation site so that the small trees will get the benefit of spring rains and will have established themselves before the heat of summer.

As soon as a shipment of trees reaches the place for planting, it should be opened and the roots of each bundle of trees well puddled (that is, the roots dipped in a puddle of thick mud which coats them and prevents exposure to the air). The bundles are then set in a shady trench and earth firmly packed about the roots.

When the trees are needed for planting they are dug up, sprinkled, and placed in a sack or bucket carried by the planter. Care should be taken to keep the young trees damp and shaded from the sun at all times. The planting is done by 2-man crews. One man prepares the holes with a mattock, while the second man plants a tree in each hole. Great care should be taken to see that the trees are planted to the same depth as they stood in the nursery; that the hole is deep enough for the roots to be well spread out; and that the earth is firmly packed about the roots to exclude the air. The two most important things to remember in planting trees are that the roots must not dry out even for a moment and that the planted tree must be firmly set with its roots spread out as naturally as possible. (Fig. 39.)

FARM WOODLANDS AND SHELTER BELTS

Farm forestry in Utah is of much greater importance than is usually realized. Fortunately, during the early settlement of Utah, the need for tree planting was recognized, and the older communities are fairly well protected by windbreaks and shade trees. To be sure, the trees planted were generally not the most suitable species for the purpose, but the most available, as for instance cottonwood and box elder, the two trees most used. These trees grow rapidly, but otherwise are not so desirable as many other kinds of trees for planting on the farm.

The purpose of the shelter belt and the farm woodland in Utah is threefold: To provide protection from drying winds in summer and cold winds in winter; to supply cheap material for fuel, posts, and miscellaneous farm timber; and to make the community more attractive to home builders and home seekers. (Fig. 40.)

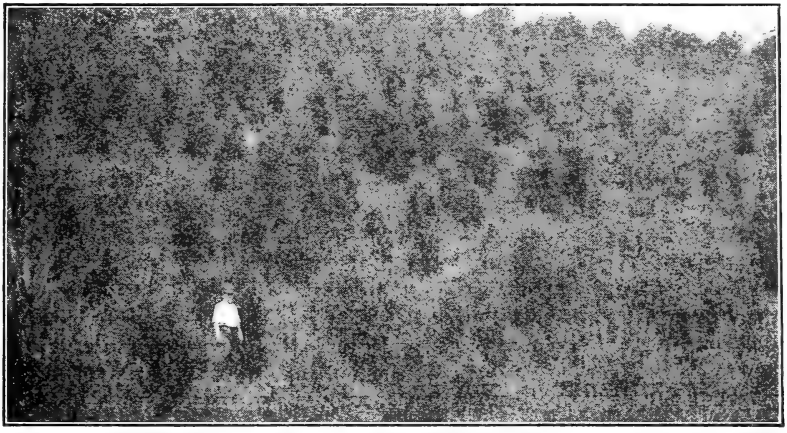

FIGURE 39.—A successful plantation

A shelter belt furnishes a valuable protection to crops. The rate of evaporation of moisture from the soil and from plant foliage varies with the wind velocity. Obviously, any factor that will reduce wind velocity will likewise reduce the evaporation of moisture and cause a corresponding reduction in the amount of water necessary to produce a full crop of any kind on the land. In Utah, where water

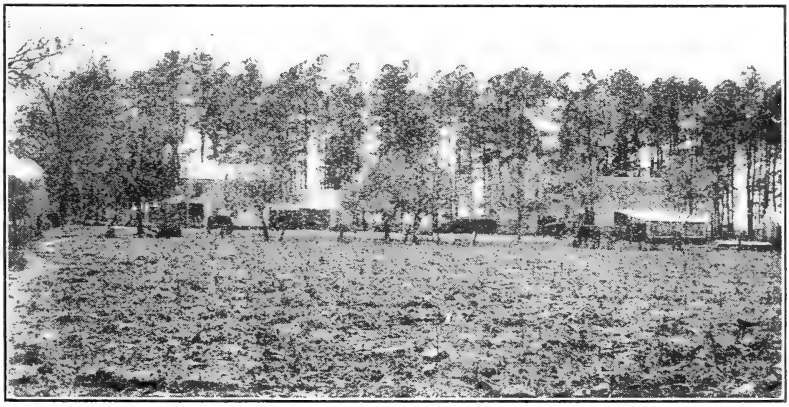

FIGURE 40.—A real farm windbreak—shade for stock, a saving in fuel, and a source of revenue

conservation is one of the main problems, this function of the shelter belt is especially important.

The usefulness of the shelter belt in winter is equally pronounced. A house protected from wind is more comfortable, and can be heated with less fuel. Stock protected from the winter winds do better than

those exposed to wind. They require less feed and remain in better condition.

As a source of supply for fuel, posts, and farm timbers, the woodland can be made a real asset. Utah's fuel bill alone runs into enormous figures. Generally, the remaining stands of timber are inaccessible and the cost in time or money to get good fuel from the mountains is a real problem. The farm woodland can help solve it. The weeding out of undesirable trees and the opening up of the stands as the trees become larger in size provide a supply of cheap fuel. The same is true with regard to posts and farm timbers. If tree species suitable for posts are selected for planting, it will not be long before the woodland is helping to pay some of the bills, or rather, is eliminating them altogether. Woodlands are not advocated, however, for land more valuable for other crops.

Attractive is the farm that has fine shade trees and wind protection. The open prairie, parched in summer and wind swept in winter, does not present a picture that encourages home builders. Appearance value is certainly reflected in the salability of a farm or ranch.

The location of the shelter belt or farm woodland depends on many things. Often there are odd corners of land not usable for regular cropping which are suitable for tree planting. If the purpose back of the planting is wind protection, the trees should be planted on the side from which the most damaging winds come, with a liberal sprinkling of trees on all sides of the home for shade and appearance.

For a windbreak, at least six or eight rows of trees should be planted. The rows should be about 6 feet apart and the trees about 4 to 6 feet apart in the row. It is well to use two different kinds of trees, every alternate tree being some rapid-growing variety and the others some slower-growing trees that are more valuable on account of appearance or the durability of the wood. Evergreens are most desirable, as they retain their needles through the winter and are ideal for winter windbreaks. Larch (or tamarack) should not be used, however, as it sheds its foliage each fall like a broad-leaved tree.

As the trees in the windbreak become large, it will be necessary to cut out some so that the rest can grow.

The selection of species to plant requires a knowledge of several conditions. Some considerations are elevation, length of growing season, and availability of water.

The Forest Service cooperates with Utah under section 4 of the Clarke-McNary Act in the production of forest planting stock for use by farmers in the establishment of shelter belts and farm woodlands. Funds are annually allotted to the State to assist in meeting nursery and distribution costs, and it is thus made possible to sell young trees to farmers at a relatively low price. The extension forester of the State Agricultural College at Logan has charge of this work and distributes the trees.

INSECT ENEMIES AND TREE DISEASES OF THE FOREST

The principal enemies of trees, not including fire, may be divided into three general classes: (1) Insects, (2) fungous diseases, and (3) parasites.

INSECTS

The principal insect enemies of live trees in Utah are the bark beetles. (Fig. 41.) These are usually about the size of the head of a small match and have hard wing coverings. They live for a period of about one year, and during that time spend all but a day or two between the bark and the wood of a tree. Although they are well equipped to fly, they make use of their wings only once during their lives, and that is to fly from the tree where they were hatched to another tree which they are going to attack. Immediately the female begins boring a hole through the bark of the new tree and excavating a gallery between the bark and the wood. Her mate follows her in, and the two eat out a gallery a little larger than the size of a match and more or less in a vertical position. After that they excavate an inch or two of this gallery, and eggs are deposited along the sides. The eggs are nearly white bodies about the size of the head of a very small pin. In a few days these eggs hatch, and the larvæ begin eating small galleries in a horizontal direction around the tree. Their food is obtained from the cambium layer, between the bark and the growing part of the tree, in which are contained the cells that transport the food and water for the tree. When enough of these bark beetles infest a tree, the entire growing surface in an area completely around the tree is consumed, so that neither the leaves of the tree nor the roots are able to function, and the tree is killed. The effect of the bark-beetle work is exactly the same as that of girdling the tree with an ax; although, when a tree is heavily infested with bark beetles, they do a more effective job of girdling than is usually done with an ax and the tree dies within a period of one year.

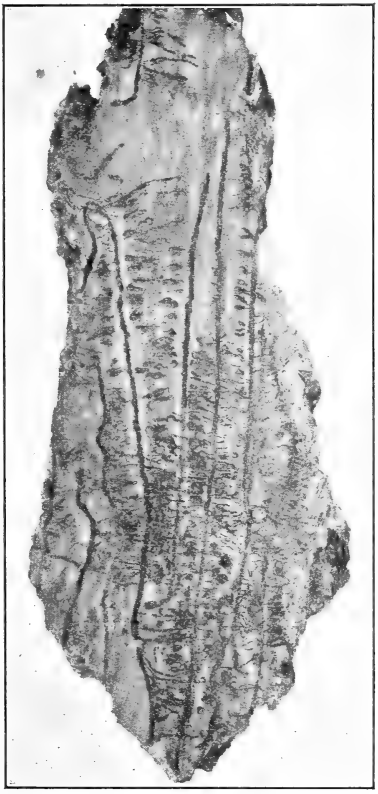

FIGURE 41.—A bark beetle's signature on the growing wood, the death warrant of the tree

During a period of several months the larvæ gradually change to what are called pupæ. These do no feeding at all. As time goes on, legs, wings, head, and body are formed, and in just about a year after the egg was laid the pupa develops into an adult beetle with hard wings. The adult beetles are of different colors, but all of those which infest trees in Utah are either brown or black. The adult beetles that excavated the long vertical gallery die in it.

In Utah the Black Hills beetle infests nothing but western yellow pine. This is a black beetle, and was named the Black Hills beetle

because when it was discovered it was carrying on a very destructive timber-killing campaign in the Black Hills of South Dakota. (Fig. 42.) This beetle was responsible for killing over 150,000,000 feet of western yellow pine timber in the Kaibab National Forest, Ariz., during the period from 1919 to 1925.

For some unknown reason the bark beetles increase in great numbers during certain periods, and at that time kill a great amount of timber. After the epidemic has run for a few years it usually dies down, and the infestation goes back to normal. The causes for the sudden increase and decrease are not known.

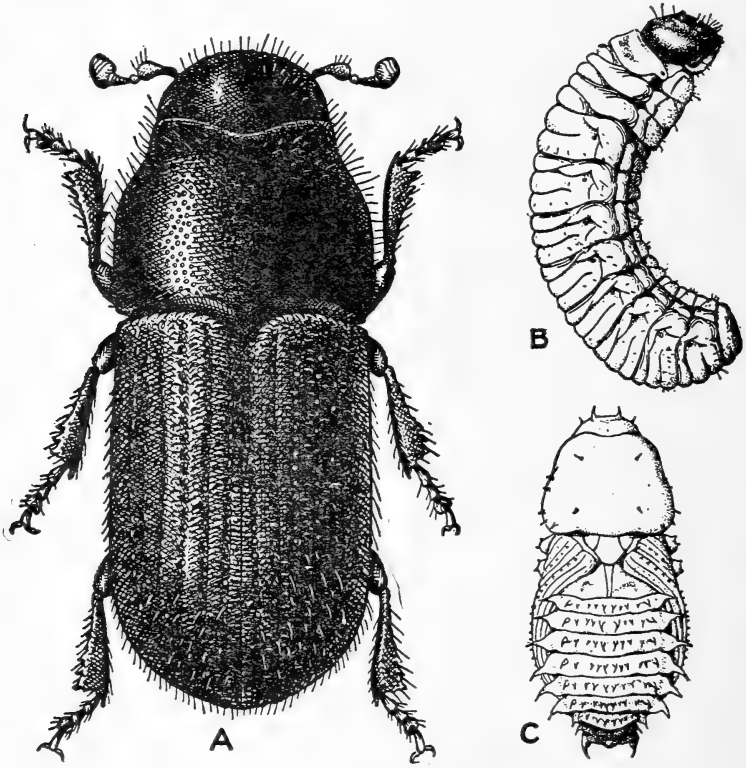

FIGURE 42.—The Black Hills beetle (*Dendroctonus ponderosæ*); A, Adult; B, larva; C, pupa. (A, greatly enlarged.)

The Engelmann spruce beetle is a brownish-colored beetle and is about the same size as the other beetles. In Utah it infests nothing but Engelmann spruce. It works in the same way as the beetles described above.

The Douglas fir bark beetle is a reddish-brown beetle of about the same size as the others, and usually works in Douglas fir, but has been found to a limited extent in a few other trees.

The lodgepole pine beetle works almost entirely in lodgepole pine. There is also a beetle which works in white fir, commonly called balsam, but it has never been known to be very destructive.

In combating bark beetles the infested tree is sprayed with oil and burned, or cut down and the bark burned off, thus destroying the

beetles in whatever stage they may be. There is no chance of saving a tree which is heavily infested with bark beetles, because if left untreated the tree will be girdled and killed by the beetles themselves.

There are also certain butterflies which in their worm or larvæ stage feed upon the buds and tips of the twigs of trees. The spruce-bud worm is one of this family. It attacks and kills the buds and ends of the limbs of Engelmann spruce, Douglas fir, and white fir or balsam.

The pine butterfly acts in the same manner except that it feeds on the needles of the pine trees instead of attacking the buds and ends of the twigs.

FUNGOUS DISEASES AND PARASITES

Although very unfavorable environmental conditions such as extreme drouth, untimely frosts, and chemical fumes can cause diseased conditions, most tree diseases are due to fungi and mistletoes. The fungi are minute plants, consisting mainly of threads visible only under the microscope. Some attack the living tissue of roots, leaves, or inner bark, and the most conspicuous invade the dead heartwood of the trunk and cause its decay. Entrance to woody tissues is usually at wounds. Trunk decay lowers or destroys the commercial value of the tree, and trunk or root rots may so weaken the tree that it is broken off or uprooted by wind. The diseases of aspen in Utah have received special attention in a recent bulletin (*5*).

In the coniferous forests of the drier parts of the West a great deal of damage is caused by the leafless mistletoes, parasitic flowering plants even more degenerate and less conspicuous but much more harmful than the leafy mistletoes of broad-leaved trees. The mistletoe plants grow from a small sticky seed which attaches itself to the bark of the tree and after germinating extends its roots through the bark and into the cambium layer. The nourishment for the mistletoe is obtained almost entirely from the food which is produced for the tree; the stems and flowers of the mistletoe plant grow in the air outside of the bole or limb of the tree and are often mistaken for part of the tree itself. The part of the mistletoe which grows in the air is of a yellowish or greenish color and particularly in the case of the Douglas fir is very small and likely to pass unnoticed. The effect of the mistletoe on the tree is often to cause an enlargement of the limb or bole at the point where the mistletoe is attached and later to stimulate a very heavy growth of branches or twigs which is commonly called a witches' broom. When only a few limbs of a tree are attacked, it is often possible to save the tree by cutting off these limbs at a point considerably below the apparent limit of the mistletoe infection. Heavily infected trees are dwarfed and deformed, and may be killed or so weakened as to be readily killed by insects. The mistletoe itself dies with the tree. In the meantime, it has produced seeds which spread to other trees.

The prevalence of both heart rot and mistletoe in the forest may be lessened when the mature timber is harvested, by including among the trees that are cut all of those in which age, wounds, or visible disease signs show that they are infected or likely to become infected

before the next cut. Protection of the forest against fire will go a great way toward preventing loss from heart rots of the basal portion of the tree, for the reason that these depend largely on fire scars for their entrance.

TREE SPECIES

The distribution of individual tree species in Utah is very largely determined by elevation and the consequent amount of moisture available. (Fig. 43.) This emphasizes the great importance of forests to the State, not only as sources of wood products, but as protectors and conservers of the water on which agricultural developments depend.

SPRUCES AND TRUE FIRS OF UTAH

ENGELMANN SPRUCE

Engelmann spruce (*Picea engelmannii*), with a stand of 1,436,743,000 board feet, ranks second among the timber trees of Utah in quantity. This tree is distinguished by a dense long tapering crown with rather erect upper branches and tasselike branchlets. The foliage is generally a deep bluish green with a decidedly silvery or whitish cast, especially on young trees.

Occurrence.—Engelmann spruce grows in the higher mountains throughout Utah. The most extensive stands in the State are found in the Uinta Mountains, and on the Aquarius Plateau in Garfield County.

Requirements.—Engelmann spruce, especially when young, can grow under heavy shade. It is a typical high-mountain species, requiring considerable moisture and thriving where the growing season is short and the soil cold.

Reproduction.—The cones mature in one season and fall from the trees in the late autumn or early winter. Well-developed Engelmann spruces produce abundant seed at intervals of three or four years after attaining an age of about 30 years. The small winged seeds are widely scattered by the wind and readily establish themselves. They reproduce especially well on fresh burns and raw wet humus and in leaf litter, provided sufficient moisture is present. Because of its ability to endure heavy shade, Engelmann spruce is usually found in dense all-aged stands.

Growth and yield.—Engelmann spruce is a slow-growing tree but has remarkable ability to recover from prolonged crowding. Spruce stands in Utah average 5,000 feet board measure per acre and rarely exceed 20,000 feet per acre.

Fire resistance.—Engelmann spruce has thin bark, a shallow root system, a low dense branch habit, and very inflammable foliage. Because of the high elevations and moisture on its range in Utah, however, there is relatively little loss from fire.

Characteristics of the wood.—The wood (locally called white pine) is soft and fine-grained, practically colorless, and tasteless. It does not split, nor warp, machines well, and when surfaced has a smooth white appearance. The nail-holding ability is about the same as that of western yellow pine. The wood takes and holds paint well. Locally it is used for rough lumber and is manufactured into boxes for butter, cheese, and candy.

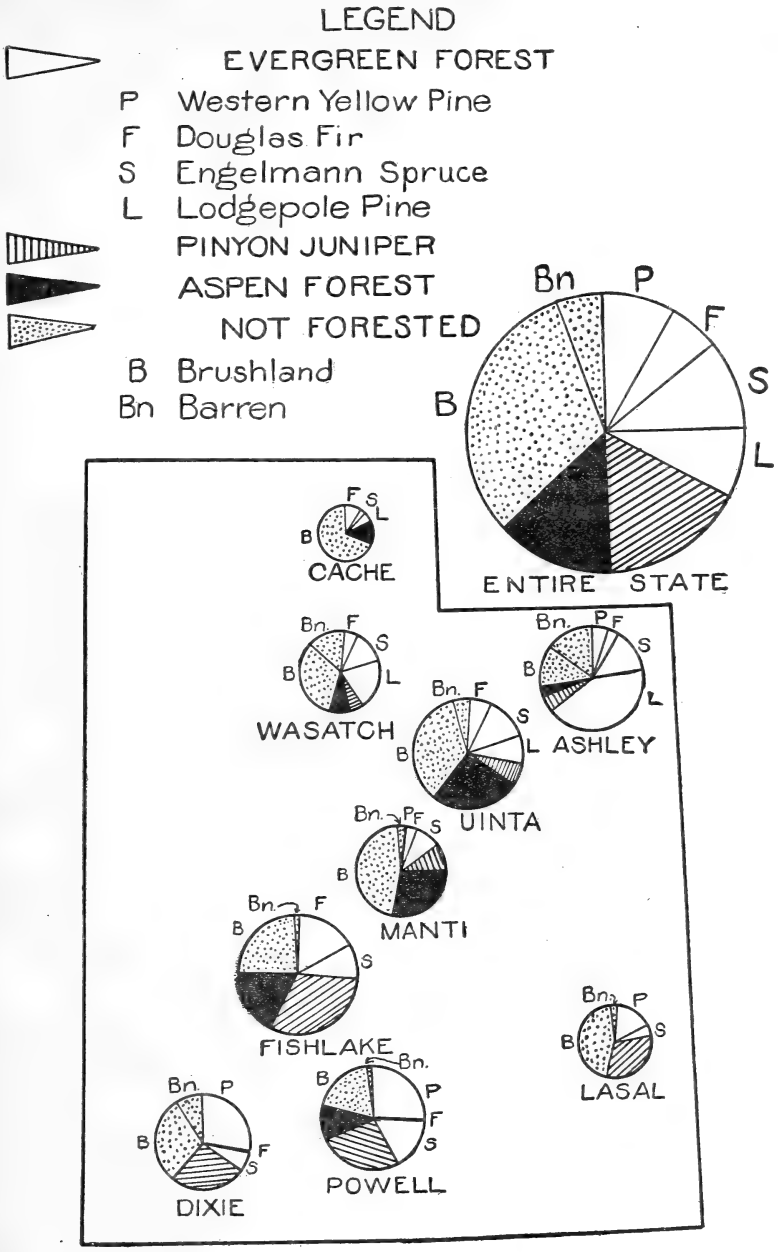

FIGURE 43.—Types of vegetation on the national forests of Utah. Each small circle represents the area of the national forest named and the large circle the total of all the forests in the State. In connection with this diagram, note that only part of the Cache National Forest lies in Utah, and that data for the small portion of the Minidoka lying in this State are entirely omitted

BLUE SPRUCE

The beautiful blue spruce (*Picea Pangens*) is very similar to the more abundant Engelmann spruce. It is most readily distinguished from Engelmann spruce by the decidedly bluish color of the newer foliage and by the short, stiff, sharp-pointed leaves. In Utah blue spruce occurs individually or in small groups along streams at elevations of from 6,500 to 10,000 feet.

The wood of blue spruce is light, soft, close grained, weak, and pale brown or nearly white. It is used to a small extent locally, along with Engelmann spruce, but it is best known as a cultivated tree for decorative planting.

WHITE FIR

White fir (*Abies concolor*) is another characteristic tree in the Great Basin region, though of minor commercial importance. Its range extends from Colorado westward to the mountains of California, north into Oregon, and south into Mexico. It is the only fir found at lower elevations in the Great Basin.

The wood is pale brown to white, very light, soft, cross-grained, and not strong or durable. It has been cut considerably for local use because it is more accessible than most timber.

ALPINE FIR

Though of secondary importance commercially, Alpine fir (*Abies lasiocarpa*) with an estimated stand of 245,727,000 board feet is very generally distributed over the higher mountains.

The most distinctive characteristics of Alpine fir, or white balsam, are the long narrowly conical crown terminating in a conspicuous spearlike point and the clusters of upright purple cones. The foliage is deep blue green, that of the season's growth having a silvery tinge.

Occurrence.—This is distinctly an alpine tree. In Utah it is found in all the national forests, appearing in mixture with Engelmann spruce or Douglas fir at elevations from 7,000 feet up to the timber line.

Requirements.—Alpine fir always grows in cool, moist or subalpine situations. It is found on all slopes at timber line and on north slopes or along streams at lower elevations.

Reproduction.—Some seed is produced every year, especially heavy production coming at about 3-year intervals. Seedlings spring up abundantly on exposed mineral soil in the open and also on moist duff under light or heavy shade. Alpine fir can endure more shade than any of its associates except Engelmann spruce, and wherever it occurs, there is usually a dense understory of seedlings and saplings.

Growth and yield.—Alpine fir varies widely in size with its location. It rarely attains a diameter of more than 2 feet, or exceeds 80 feet in height.

Fire resistance.—Because of its thin bark, shallow root habit, and extremely inflammable bark and foliage, alpine fir is more susceptible to fire damage than any of its associates.

Characteristics of the wood and commercial importance.—The wood of alpine fir is soft, brittle, not durable when exposed to the

weather, does not hold nails well, and tends to twist. It is sawed to some extent into rough lumber, but for the most part is used locally for fuel, house logs, and corral poles. On account of its freedom from any taste or odor it is being used more and more in the manufacture of boxes for butter, cheese, and candy.

THE PINES

LODGEPOLE PINE

With a stand of approximately 1,470,583,000 board feet, lodgepole pine (*Pinus contorta*) ranks first among commercial timber trees in Utah.

Occurrence.—Practically all of this species in Utah is found in the Uinta Mountains, where it forms the most extensive timber bodies in the State, at elevations ranging from 8,000 to 11,000 feet. Lodgepole pine is characteristically found in almost pure stands.

Requirements.—Lodgepole pine is classed between Douglas fir and western yellow pine in its demand for light. It is unable to endure much overhead shade but can survive and recover from long periods of extreme crowding if not overtopped.

Reproduction.—Typical lodgepole pine cones require two years to mature, and ripen in late August or September. A large seed crop can be expected every year.

Lodgepole pine extends itself over unburned areas but on burned-over areas reproduction is exceedingly thick and even. Exposed mineral soil and freshly burned surfaces make the best seed beds. The only disadvantage in the restocking of burns is the extreme density of the young stands, which is a serious hindrance to growth.

Growth and yield.—As a forest tree lodgepole pine forms a characteristically straight, slim, gradually tapering trunk with compact conical crown. It rarely becomes more than 75 feet high and 20 inches in diameter. Average stands yield from 5,000 to 8,000 board feet per acre.

Fire resistance.—On account of its very thin bark and the abundance of resin in the old bark, lodgepole pine is more susceptible to injury than western yellow pine or Douglas fir. Its fairly deep root system and moderately high open crown make it more resistant than Engelmann spruce and alpine fir.

Characteristics of the wood.—The wood of lodgepole pine is straight grained, fairly soft, and slightly stronger than western yellow pine. Lodgepole pine is not durable in contact with the soil and should always be given preservative treatment when used for telephone poles, fence posts, or railroad ties.

Commercial importance.—Lodgepole pine is the most important tree species on a number of Utah forests. Because of the form and size of the tree and the character of the wood, lodgepole when treated with creosote is exceptionally valuable for railroad ties and mine props.

WESTERN YELLOW PINE

With a stand of 1,284,575,000 board feet, western yellow pine (*Pinus ponderosa*) ranks third among the timber trees of Utah.

Its massive trunk and heavy limbs with clusters of deep yellow-green leaves on thin upturned tips make it easy to distinguish.

Occurrence.—The tree is found rather generally over Utah but is abundant enough to be of commercial importance only in the southern part of the State, where it is found at elevations of from 6,000 to 9,000 feet.

Requirements.—Western yellow pine is distinctly a light-demanding species. Up to 15 or 20 years of age it will thrive when densely crowded, but as the tree becomes older it demands almost full sunlight and dies rapidly if overtopped. In regard to soil and moisture conditions, this species is not so exacting. Though generally found on dry sandy exposures, it will thrive on moist sites if the competition from tolerant species, such as Douglas fir and alpine fir, is not too great.

Reproduction.—The cones, from 3 to 6 inches long, require two seasons to develop. They mature in late August and scatter their seed mainly during September. Some seed is borne every year, but crops usually occur at intervals of three to five years. In favored localities trees may bear seed when less than 50 years old, but in forest stands a tree is normally 80 to 100 years old and over 20 inches in diameter before it becomes valuable for seed production. A mature tree can seed about one-fourth acre in a good seed year.

Growth and yield.—Western yellow pine is a massive straight-trunked tree which lives to a considerable age and attains a large size. Trees in commercial stands average 30 inches in diameter and 200 years in age. A tree 60 inches on the stump was recently found to be 575 years old. The average yield of good western yellow pine in Utah varies from 5,000 to 10,000 board feet per acre.

Fire resistance.—Western yellow pine is very resistant to fire after reaching maturity, largely because of its thick bark and deep root habit, its high open branch habit, and the freedom from undergrowth in the mature pine forest. Saplings and small poles less than 8 or 10 inches in diameter are easily killed by fire.

Characteristics of the wood.—Young trees have moderately hard, resinous, strong wood. The wood of large mature trees is soft, even textured, and only slightly resinous. Great care must be exercised to prevent damage from blue stain during the summer months. The sapwood of logs or green lumber is quickly attacked by the stain during warm, moist weather. While blue stain is not a form of decay and does not materially weaken the lumber, it makes it unsuitable for a natural finish and greatly reduces its value. To prevent bluing, logs cut in July and August should be sawed at once when they can not be put into a mill pond. During the summer months special care should be taken to pile lumber which can not be air-dried in a kiln, so that it will dry as rapidly as possible, and thus reduce the damage from blue stain to a minimum.

Commercial importance.—Practically half of the annual cut of lumber in Utah is western yellow pine. For the most part this lumber is cut far back from the railroad and utilized locally.

PINON PINE

There are two species of pinon or nut pine in Utah, *Pinus edulis* and *P. monophylla*. *P. edulis* has two short needles in a bundle;

P. monophylia, which is most common in Nevada but extends over into western Utah, has a single needle. Both kinds of pinon are small short round-topped trees growing at low elevations in the mountains, usually in hot, dry situations. They have little commercial value but are used locally for mine props, second-grade railroad ties, and fuel. The edible seeds or nuts are often borne in great profusion and are collected in large amounts for the market.

LIMBER PINE

Limber pine (*Pinus flexilis*) is a crooked, stunted tree growing on dry ridges and exposed hillsides. Its only use is for mine timbers and for fuel at high elevations.

BRISTLECONE PINE

Bristlecone pine (*Pinus aristata*) which is also known as foxtail pine and cattail pine, is distinguished by the long taillike branches to which the needles cling from 10 to 12 years. Bristlecone pine is found only as a scattered tree near timber line and on the sterile soils of southern Utah. It is an open round-topped tree sometimes 2 or 3 feet in diameter but seldom over 30 to 40 feet high. The pale reddish-brown wood is light, soft, and brittle and has no value except for fuel.

DOUGLAS FIR, ASPEN, AND JUNIPERS, ALSO COTTONWOOD, OAK, AND MAPLE

DOUGLAS FIR

With a stand of 430,162,000 board feet, Douglas fir (*Pseudotsuya taxifolia*) ranks fourth among the timber trees of the State, but is nevertheless very important.

Occurrence.—Douglas fir is very generally distributed in the mountains of Utah, being found on all the national forests in the State. This species seldom forms pure stands in Utah but is usually found in mixture at the upper edge of the western yellow pine and the lower edge of the Engelmann spruce types.

Requirements.—Douglas fir is moderately tolerant of shade in youth, becoming less so as it matures. It can endure more shade than western yellow pine or lodgepole pine, but less than Engelmann spruce or alpine fir. This species is found under a wider range of climatic conditions than any other of the important timber trees from the dryness of the Utah Mountains to the moisture of the Pacific coast, and is adapted to a variety of soils. In Utah it is characteristic of cool coves and north slopes at elevations of 6,000 to 9,000 feet.

Reproduction.—One of the surest and easiest ways of identifying Douglas fir is by the 3-pointed thin bracts protruding from among the cone scales. The cones mature in one season, ripening about the middle of August and dropping from the tree the same fall. The winged seeds are widely scattered by the wind, and cones containing seed are transported both by wind and animals. Reproduction comes in best on mineral soil under partial shade.

Growth and yield.—The Douglas fir of Utah, probably because of the lack of moisture and the short growing season, is a distinctly smaller and slower growing tree than the Pacific coast variety.

Diameters over 30 inches breast high are unusual, and the tree seldom reaches a height of more than 100 feet.

Fire resistance.—Young Douglas fir is almost sure to be killed by any fire which burns through the stand, because of its thin bark, dense stand, and inflammable foliage. After becoming mature, Douglas fir suffers less on account of the heavier bark, but remains more liable to damage than western yellow pine.

Characteristics of the wood.—The wood is strong, hard, durable, coarse, and knotty. It holds nails well and is valuable for ties, mine timbers, poles, and lumber, especially dimension material.

Commercial importance.—Because of its relative accessibility, much Douglas fir was cut by the pioneers in Utah. It is still one of the most important timber trees of the State, being extensively used for mine props, railroad ties, farm timbers, and lumber.

ASPEN

The most important broadleaf tree in Utah is aspen (*Populus tremuloides*), of which there is believed to be 6,000,000 cords in the State.

Occurrence.—In Utah aspen is very generally distributed, being found at elevations between 7,000 and 10,500 feet on all the national forests in the State. It forms the most extensive stands and attains its largest size in the mountains of central Utah and western Colorado.

Requirements.—Aspen is not very selective as to soils, being found on all kinds from loamy sand to heavy clays. It does best, however, on a deep soil and requires considerable moisture.

Reproduction.—At present, there is practically no reproduction of aspen by seed in Utah. It is believed that in geological times when the climate of this region was more favorable, aspen became generally distributed through the forests by seed. Then as conditions became less favorable to germination, reproduction by seed was reduced until now it has been almost entirely replaced by suckering from the roots. As a result, aspen stands extend themselves very slowly. Roots sprout vigorously at all ages up to 110 years.

Growth and yield.—Aspen has a variable development in the Rocky Mountain region, from a low twisted shrub to trees that reach a diameter of 38 inches at breastheight and a height of 90 feet. In general it ranges from 8 to 14 inches in breast-high diameter and from 50 to 60 feet in height. Most of the large aspen trees seen in the mountains of Utah are over 100 years old, and specimens 200 years old have been found.

Fire resistance.—A very light fire will kill aspen, as the bark is thin and green, with no protecting corky layers. Scars which lead to heart rot will be made on the large trees by the lightest fires. The aspen leaf fall and litter are too scant to carry fire readily, and since the accumulation of dry grass and weeds has been prevented by grazing there have been almost no fires in the aspen stands of Utah.

Characteristics of the wood.—The wood of aspen is straight grained, of smooth texture, white in color, and light when dry. The green wood contains a large percentage of moisture, losing almost 50 per cent in weight when kiln-dried.

Commercial importance.—In Utah aspen is chiefly used for mine props, poles, posts, and fuel. It is occasionally sawed into bridge planks or barn flooring. An excelsior mill at Salt Lake City handled aspen from Sanpete County. This mill converted from 2,500 to 3,000 cords of aspen annually into high-grade excelsior, which found a ready market both in Utah and on the Pacific coast.

ROCKY MOUNTAIN RED CEDAR

Rocky Mountain red cedar (*Juniperus scopulorum*) is very similar in general appearance to the red cedar of the East. It can be recognized by the bluish berries about the size of BB shot, scaly bark, slender graceful twigs, and red heartwood. It is found most frequently as single trees or in open stand scattered over dry rocky ridges. One of these trees in Logan Canyon, Utah, is estimated to be nearly 3,000 years old—probably the oldest tree in this region. These cedar trees rarely become large enough to be sawed for cedar-chest construction but make posts, though the wood is not as resistant to decay as the Utah juniper.

UTAH JUNIPER AND 1-SEED JUNIPER

Utah juniper (*Juniperus utahensis*) and 1-seed juniper (*J. monosperma*) may be recognized by the berries about the size of peas, fibrous and shreddy bark, stiff and stout twigs, and the brown heartwood. They are usually found on hotter, drier situations than the Rocky Mountain red cedar and are frequently associated with the pinon pines. The Utah juniper makes excellent posts and is much more durable than the Rocky Mountain red cedar. The 1-seed juniper, however, tends to form a many-topped tree with no stem of any size and hence is not so desirable for posts as the Utah juniper.

COTTONWOOD, OAK, AND MAPLE

Cottonwood, oak, and maple have very little commercial importance as timber in Utah. Cottonwood is found along canyon bottoms, but never in very extensive areas. Maple is also found in canyon bottoms and in small patches on somewhat moist sites elsewhere. The native species is small and does not become large enough for lumber. It is a scrubby tree. Native oak is very abundant and does well on dry sites, but does not reach tree size except in very favorable sites, and even then it is too small for lumber.

WATER RESOURCES AND THEIR PROTECTION

THE WATER SUPPLY AND ITS USE

THE ORIGIN OF THE WATER SUPPLY

Studies made up to the present time indicate that almost all of the water flowing in streams and from springs and held in lakes and wells in Utah, comes from the high-mountain watersheds, mostly above an altitude of 7,000 feet. (Fig. 44.) Approximately 60 to 70 per cent of the annual precipitation above 8,500 feet elevation, according to the observations made at the Intermountain Forest and Range Experiment Station near Ephraim, falls during the period

from November 1 to May 1. During this period, at that elevation, the temperature does not rise high enough for much of the snow to melt, and most of it is stored on the ground under the timber and in big drifts in the open. When warmer temperatures come in the spring, the accumulated snow melts rapidly. Most of it disappears within from four to six weeks, although where deeply drifted and well packed some snow may remain late into the summer. It is in the spring that most of the high water occurs in streams and that the ground water supply is replenished. Observations have shown that under some conditions up to 95 per cent of the annual surface run-off in the high mountains comes from snow and only 5 per cent from rain.

When water falls in the form of rain or snow it is removed from the place where it falls in a number of ways. Some of the water is

FIGURE 44.—Snow scene in the mountains east of Ephraim, Utah. Snow which accumulates to great depths during the winter is the principal source of the water supply for irrigation, domestic use, and hydroelectric power

intercepted by the leaves and branches of trees and other plants, evaporates, and is returned to the air; some evaporates from the surface of the ground directly into the air; and some sinks into the soil. If the rain is heavy enough, or in the case of snow if it is melting fast enough, part of the water runs off on the surface of the ground and finds its way directly into streams and lakes. One or more of several things may happen to that which sinks into the ground. A part is held in the soil by capillary action and may evaporate from the soil directly into the air and be lost. Another part is taken from the soil by growing plants and is returned to the air through the leaves of the plants by the process of transpiration. If more moisture is absorbed by the soil than can be held by capillary action, it finds its way down between the soil particles and broken rock to impervious rock strata below, which it follows underground. Most of this eventually reappears in springs to feed

streams and lakes. Ground water moves very slowly, especially when it reaches the nearly horizontal bed rock or other impervious material, and it may accumulate in varying depths in the overlying gravel and other incoherent material. This is the supply that furnishes the water in wells. The slow movement also accounts for the regular flow of springs, since the water may not reach such outlets for many months after it first enters the ground on the watershed, and the water table may hold a large amount of water and give it forth very slowly.

Observations made on high-mountain watersheds in central Utah show that during the summer, when water loss by evaporation is high and growing plants are using a great deal of water, the precipitation is insufficient to contribute to the ground water supply and underground run-off. During the heavier rainstorms in summer a part of the water runs off on the surface of the ground and finds its way directly into the streams. This is the only portion of the summer rainfall contributing to the usable water supply. That which goes into the soil penetrates only a relatively few inches, and between rainstorms it is exhausted by evaporation and through use by growing plants. It is only during the period of melting snow in the spring when water becomes available very rapidly and when the vegetation is not yet growing that the underground water supply is replenished and the streams receive most of the surface run-off.

At the lower elevations, where the snowfall is comparatively light, melting usually takes place so slowly and intermittently that the soil can hold all of the water until it is returned to the air by evaporation and transpiration. At the lower elevations sudden melting of snow in the spring or heavy rains in the summer may contribute some surface run-off directly to the streams. This constitutes virtually the whole contribution of the lower watershed to the usable water supply. The 7,000-foot elevation or contour in Utah is approximately the dividing line between the areas that contribute very little or no water except occasional surface run-off and the high mountain watersheds with heavier precipitation and winter-snow storage.

CITY AND TOWN WATER SUPPLY

Much of the town and smaller city water supply is taken directly from springs. Logan, a small city, has one of the larger water supplies taken from springs. Some of the smaller towns obtain their water by pumping from wells. Ogden is a notable example of a fair-sized city that obtains its water supply from artesian wells. Wells and springs afford the best and purest, although usually not the most abundant, water supplies. Cities as large as Salt Lake City take their water supply directly from the open streams or from reservoirs into which the streams are diverted. The watersheds of such streams require protection against pollution and erosion.

WATER FOR IRRIGATION

By far the greatest use of water in Utah is for irrigation. (Fig. 45.) It has already been pointed out that most of the farm land in Utah is irrigated. The Utah Agricultural College estimates that the mean annual run-off of streams of Utah is about 9,000,000 acre-feet.

Much of this is in undeveloped territory on the Green River watershed.

In a great many irrigation projects the water is diverted directly from the streams into irrigation ditches and onto the land. This requires a steady stream flow far into the growing season for late irrigation. Frequently all of the high water in the spring can not be utilized to good purpose, and in some cases storage reservoirs have been constructed to make available this surplus water as well as that which would otherwise go to waste during the fall and winter.

Considerable irrigation water comes from pumps and flowing wells. The well supply depends largely upon the amount of water taken into the ground at the source of the watersheds.

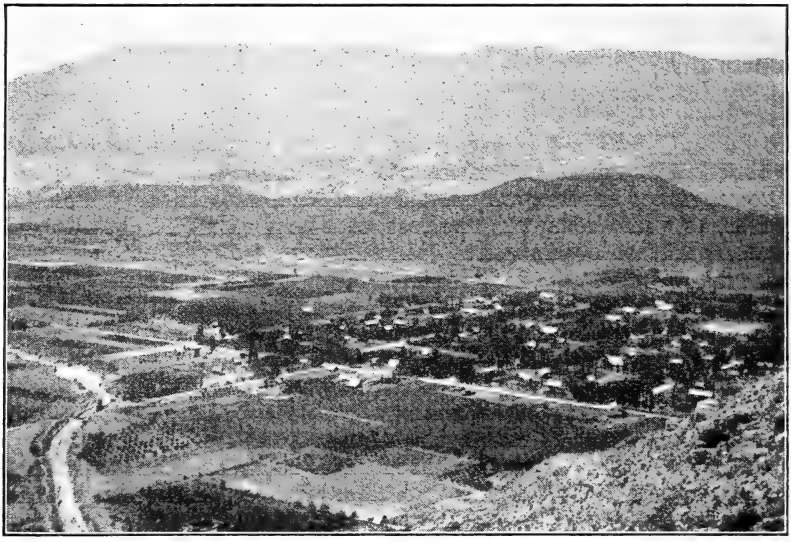

FIGURE 45.—Irrigated crops are supplied with water from the mountain watersheds. Protection of the watershed is essential for maximum regularity in stream flow

WATER FOR THE GENERATION OF POWER

The most economical generation of water power requires a steady stream flow throughout the year, which is fostered by the maintenance of the vegetative cover on the watersheds. The sustained output of power plants depends upon the period of minimum flow. Reservoirs are often used to equalize the flow and eliminate the low point during the fall and early winter, but their construction adds to the initial and maintenance costs.

THE PROTECTION OF WATERSHEDS

The limited amount of water available and its many direct and indirect uses in the home and in the industrial and agricultural life of Utah make water conservation one of the foremost problems of the State. It has already been pointed out that water is the limiting factor in agriculture. Utah has many million acres that could

be farmed if water for irrigating the land were available. Every possible step should be taken to conserve and utilize efficiently what water there is.

THE VALUE OF DIFFERENT KINDS OF VEGETATION ON WATERSHEDS

The denser the vegetation, the more of a physical obstruction to the flow of water it forms. The more extensive its network of roots, the more effective it should be in checking erosion and rapid run-off. Dense coniferous forests afford great protection. The extensive root systems bind the soil and open it up to absorb water more readily. The needles and other material that accumulate on the ground serve as a blotter and hold back more of the water so that it may soak into the soil more readily. The trunks of the trees, down logs, and the larger roots form physical barriers against run-off. More open stands of coniferous timber, deciduous trees, and large shrubs act in a similar manner but to a less marked degree.

Grasses, weeds, and low shrubs, are also effective and are highly valuable in checking erosion and regulating run-off. When water falls or originates from snow in sufficient quantities to cause surface run-off on a slope where there is a fairly dense stand of grasses, weeds, or low shrubs, the run-off can only find a meandering course down the slope. The individual plants serve to turn the small streams of run-off first to one side and then to the other, checking their velocity, and thus preventing the water from forming rills of any size. Those formed do not erode deeply because the soil is held by roots. Consequently the ability of the run-off to carry a load of soil from the watershed is kept at a minimum. Even though rains continue until the soil becomes saturated and the water runs off the surface, it must run off more slowly because of the obstruction afforded by the vegetation. As a result a sheet of comparatively clear water is discharged gradually from the hillside into the streams.

Now contrast the results on a similar slope where the vegetation has been more or less depleted or destroyed. The water in seeking lower levels soon accumulates in small rills, which, in the absence of any obstruction, run directly down the slopes. In these comparatively straight channels, the velocity of the water, and hence its power to carry soil and other sediment, is greatly increased. It has been found that if the velocity of a stream is doubled its carrying power is increased 64 times. In other words, if the velocity of a stream just able to carry along a rock that weighs a pound is doubled, it will be able to carry a rock that weighs 64 pounds. The soil, gravel, and rocks, torn loose and carried down by the water, further increase the volume and the corrosive action. Small gullies soon join to form larger ones, in which the volume of water is concentrated, and the carrying power increased still more, until eventually a veritable torrent, capable of moving large rocks, is being poured into the streams which have probably already been swollen from other tributaries. The result is a flood, usually of short duration, but with a high head while it lasts. The rapid discharge of water from the highly efficient drainage systems that have been formed on the denuded hillsides may cause the most destructive phase of the flood, the rapid accumulation of water into a high head.

Where the run-off spreads over a longer period, as is usually the case where there is adequate plant cover, the flood head also would be extended over a longer time, and its destructive power would be less.

DAMAGES CAUSED BY LACK OF WATERSHED PROTECTION

With serious depletion of vegetative protection, streams from watersheds become turbid, more of the water runs off on the surface, and stream flow becomes less regular with unusually high water in the spring and a low flow later in the season, thus making the water less usable for irrigation, water power, and other purposes. Under such conditions floods are more likely to occur during heavy summer rainstorms. These floods often cause heavy financial loss by washing out roads, railroads, ditches, and other improvements, by depositing débris on farm lands, and by flooding towns and farm buildings. Erosion removes the fertile soil and reduces the carrying capacity of livestock ranges. Sediment is carried down into the reservoirs, and thus their storage capacity and their value are reduced. The whole economic life of the people living below the watersheds may be affected, or their continued occupation of the land threatened. Sometimes even human lives are lost in the floods.

It can not be claimed that a normal plant cover will prevent all floods, nor that the destruction of the vegetation is the cause of all floods; for if the precipitation is heavy enough and lasts for a sufficient period, or if it falls on bare rock slopes, heavy run-off is bound to occur regardless of plant cover. However, good vegetation will check the greater floods and prevent many of the smaller ones entirely.

Even on the foothills and other watersheds under 7,000 feet in elevation a vegetative cover is necessary. These areas are subject to heavy summer rainstorms, often called cloudbursts, and the soil on them is easily eroded. All areas, in fact, with the exception, perhaps, of those which are so nearly level that the water can not attain great velocity, require the maintenance of plant cover as a measure of protection against excessive run-off and erosion.

CAUSES OF PLANT DEPLETION

The primary causes or depletion of the cover on watersheds are overgrazing (fig. 46, A and B), fire, and destructive logging. Consequently, watershed protection centers around the prevention of these things. All of them, except fires started by lightning, are attributable to man and are preventable. Not only do they cause injury to the watershed, but they destroy the timber and forage resources, the renewal of which is made difficult because of the depletion of the soil. It has been found, however, that watershed protection does not require retention of all of the timber and forage. A careful system of logging removes the older, mature trees and leaves the young growth on the ground. This is adequate to protect the watershed. Under average range conditions, where the cover has not already been badly depleted and the soil much exposed, the grazing practice that is most profitable to the stockman and that will maintain the maximum carrying capacity of the range will also maintain the plant cover in a condition for satisfactory protection of the watershed.

Under exceptional conditions, such as those on steep slopes where the soil is easily eroded or where the timber or other cover is sparse, it may be the best plan to graze or log lightly or not at all, because

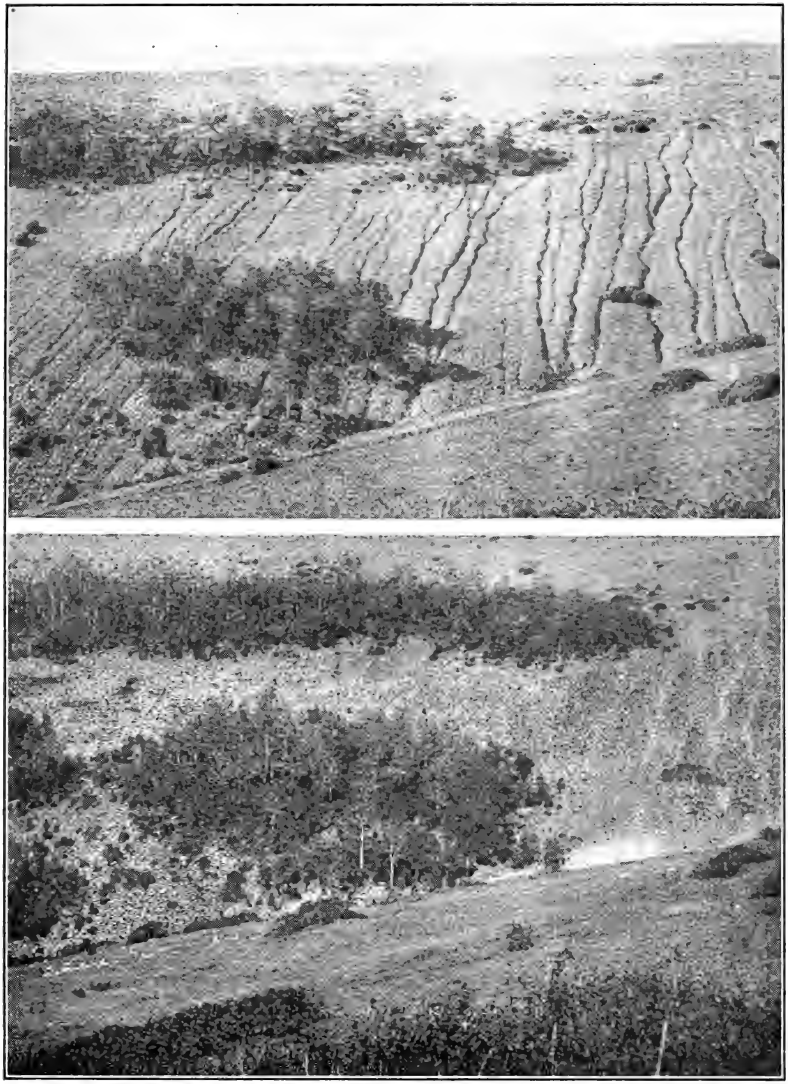

FIGURE 46.—*A*, This view on a high mountain watershed taken in 1910 shows the serious erosion that followed destruction of the plant cover by overgrazing; *B*, the same area 15 years later. In the meantime, grazing has been regulated. The gullies have rounded out and vegetation is gaining a foothold between and in the gullies. Recovery following erosion is a very slow process.

such areas are of greater value for watershed protection than for the forage or timber they produce. In general, however, the harvesting of forage and timber need not injure the watershed, and is a far better practice than allowing these crops to decay and be wasted.

MANAGEMENT OF WILD LIFE AND RECREATIONAL RESOURCES

GAME, FISH, AND FUR

The early settlers in Utah found the abundance of fish and game of great assistance during the struggle to support themselves. Records indicate that there were great numbers of antelope on the open plains and deer in the rougher sections. (Fig. 47.) Elk, mountain sheep, and game birds were abundant, and fish were in most waters.

FIGURE 47.—Mule deer are abundant in Utah

The establishment of game preserves, the protection provided by the permanent closed season followed by the short open season for the killing of bucks only, and the better control of predatory animals has resulted in a decided increase in the number of deer. The number of bucks killed by hunters steadily increased, until in in 1927 it was over five times what it was in 1919. It was estimated that in 1926 there were four times as many deer on the national forests of Utah as there were in 1922. Elk also have increased, particularly on the Cache National Forest, on Mount Nebo, and on the Manti National Forest. (Fig. 48.) There have been several plantings of elk from Wyoming. Mountain sheep are rare, occurring principally along the Green and Colorado Rivers and in the Uinta Mountains. Antelope are found in relatively small numbers, chiefly in the western part of the State.

METHODS OF PROTECTION

Game and fish have been protected in Utah by reducing the length of the open seasons, protecting breeding stock, limiting the catches (bag limit), placing a minimum on size, preventing sale, establishing game sanctuaries or closing sections to all fishing or hunting, and limiting methods of capture.

Many millions of trout are reared in hatcheries to be planted in the various waters of the State. A considerable proportion of these are held in the hatcheries or rearing ponds until they are several inches long and well able to care for themselves. The advantage of hatchery practice is that more than 95 per cent of the eggs may be

fertile, while under natural conditions it is believed not more than 5 per cent are fertile. Also, the young fish are protected from their natural enemies until well grown. (Fig. 49.)

Fish culture has resulted in the establishment of several desirable species such as the rainbow, eastern brook, and mackinaw trouts, and bass. However, cultural methods must be charged with the introduction, many years ago, of the very undesirable carp, which, by destroying natural vegetation, has made many waters unfavorable for both fish and game birds.

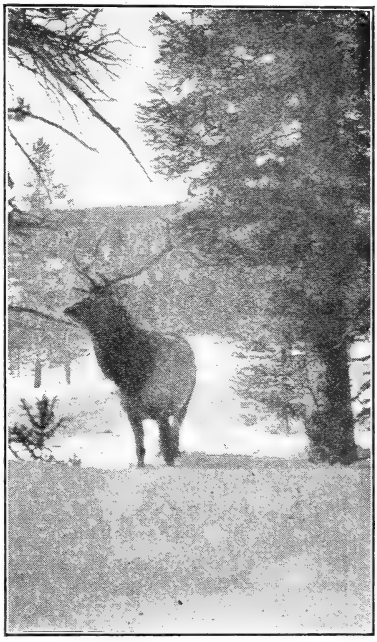

FIGURE 48.—Elk have been successfully reestablished in Utah

The development of associations of sportsmen interested in game and fish propagation has been a potent factor in creating local interest and a public sentiment supporting laws for fish and game conservation. In many cases active measures have been taken for fish and game propagation. Without the financial support and moral backing of protective laws by fishermen and hunters, most of the game species would have disappeared, and game fish would have become a rarity.

All of the above methods have helped to conserve the natural supply of fish and game but have by no means completely remedied the situation. For instance, in one season more migratory birds (ducks, geese, etc.) died of alkali poisoning [9] in the Bear River Bay marshes than had been shot by all the gunners of the State in all of the preceding years combined. Large numbers of cougars (mountain lions) roamed the forests, and one of these pests would destroy at least one deer per week during the entire year. Certain species of hawks and owls, as well as coyotes, bobcats, lynxes, and semiwild homeless house cats destroy many game birds and smaller game animals. Crows, magpies, snakes, and red squirrels search out the nests of

[9] Bear River Bay Migratory-Bird Refuge. Bear River Bay is one of the largest marsh areas in the intermountain section and besides being the breeding ground of many thousands of ducks is a natural resting ground of migrating waterfowl. The draining of natural marsh areas has restricted the natural breeding ground and feeding areas so that the birds, even when protected, have difficulty in finding suitable areas to feed and breed. Birds from Bear River Bay have been banded and have been found in practically all the Western States. For many years there have been periodically immense losses of all forms of migratory birds there, amounting to millions of birds, generally attributed to alkali poisoning. A sure remedy is the supplying of fresh water. The large expanse of barren mud flats has been unproductive of duck food and under certain conditions has also contributed to heavy losses of the birds. Recognizing the importance of this area to the migratory birds of North America and the necessity of preserving favorable conditions there, Congress in 1928 authorized an appropriation of $350,000 to purchase land and build dikes. Under the direction of the Bureau of Biological Survey this work is being undertaken. The dikes are low barriers of dirt that impound the fresh water and make shallow lakes, keeping out the salt water from Salt Lake, which destroys the duck foods. The dikes will eventually flood 50,000 acres of land and will provide a wonderful refuge for wild fowl and an opportunity for hunters to enjoy their sport on not to exceed 40 per cent of the area, the remainder to be a permanent sanctuary.

game and song birds and devour the eggs or young found therein. These depredations must be controlled if fish and game resources are to be fully developed.

MANAGEMENT OF THE GAME AND FISH RESOURCES

Certain definite requirements must be met in order to provide for the greatest production and use of these resources. Very briefly these requirements are as follows:

SUITABLE ENVIRONMENT

Without suitable cover, shelter, and food, game and fish can not thrive. The settling up of the open areas made the preservation of the buffalo as a game animal impossible and has greatly restricted the antelope. The utilization of forage by livestock on essential winter range may destroy game. When the winter feeding grounds

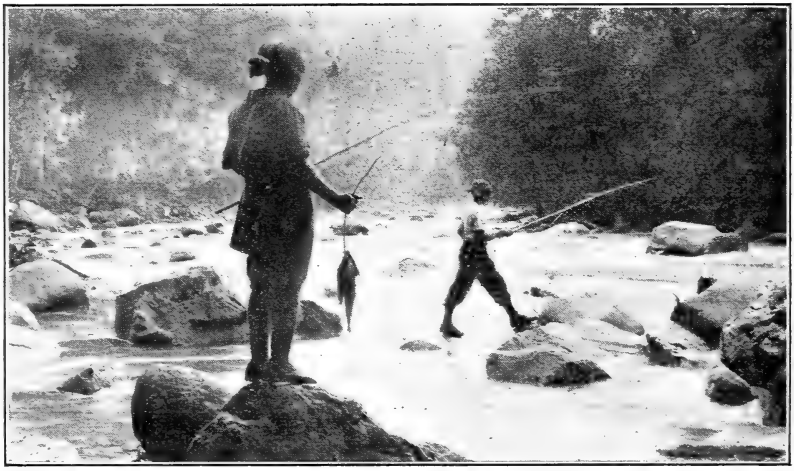

FIGURE 49.—Protection of the forests and mountain slopes means good fishing.

are occupied by settlers, some substitute may be provided, such as protecting winter feed areas from use by domestic stock and supplementing natural feed as necessary. The planting of shrubs producing fruits available in winter may benefit game birds. The pollution of streams or the diversion of a large proportion of the water destroys the fish. Conditions causing erratic stream flow and more frequent floods make difficult the existence of fish life.

CONTROL OF NATURAL ENEMIES

Predatory animals or birds may utilize all the game produced and make protective laws unavailing. It is sometimes claimed that where predatory animals are at all numerous they kill more game than do hunters.

PROVISION FOR INCREASE

An adequate brood stock, or in the case of fish, a stock to supply spawn must be maintained. Protection during the breeding, rearing,

and hatching seasons is necessary. A series of relatively small game sanctuaries is an excellent conservation measure for game animals and game birds. These sanctuaries also provide areas for the observation and study of game species.

USE OF SURPLUS

A check must be placed on fish and some forms of game so that they will not increase beyond the capacity of an area to support them in a healthy condition. The amount of forage available for big game particularly should be determined and the number of game animals restricted accordingly. Removal of surplus may be by a natural drift or by transfer alive to other sections, or by hunting.

FLEXIBLE ADMINISTRATION

Flexibility in matters of protection, propagation, and utilization is necessary. During a favorable season greater numbers may be removed. Unfavorable circumstances may justify additional protection. For this reason, it is desirable to have considerable authority vested in a commission or commissioner who may take appropriate action as circumstances indicate.

RELATION OF FISH AND GAME TO OTHER RESOURCES

Big-game species are more or less competitive with livestock as grazers on the range. This is particularly detrimental to game animals where forage upon which they must depend in winter is heavily grazed by domestic stock. Overgrazing of any area intensifies the conflict. A moderate grazing of summer ranges by domestic stock is seldom detrimental, as the game generally occupies the rougher sections not easily utilized by domestic stock. But game animals directly dependent upon the forage supply may themselves become so abundant as to damage range or cause unjustifiable conflict with the established use by livestock. This is often overlooked in game-protective measures. In excessive numbers, game may even be directly detrimental to forests by destroying young trees. On the other hand, the value of game from both a recreational and an economic standpoint justifies the maintenance of the greatest supply consistent with other interests.

Destruction of plant cover and game food, either by fire or overgrazing, is detrimental to game birds and, owing to the increase in erosion, indirectly to fish life.

Watershed protection helps fish life, and if it results in forage conservation, it may benefit game. In like manner, an overstocking by game would be detrimental to water conservation by destroying the protective cover. The formation of reservoirs is beneficial to fish life, but the alternate raising and lowering of the water may destroy aquatic vegetation and thus adversely affect the production of food for fish or water birds. The development of an inexpensive and efficient screen to prevent fish entering irrigation ditches would prevent the loss of thousands if not millions of fish annually.

Conservation of the forests is very essential in maintaining a proper environment for both fish and game. Forests provide homes and protective cover for game birds and animals and have a favor-

able influence on fish life in that they help secure a constant flow of cold water in the streams.

VALUE OF FISH AND GAME

The esthetic value of game and fish is great and is rapidly increasing. Fish and game make a substantial contribution to the food supply. In Utah, deer alone furnish 500,000 pounds of meat a year. Fur bearers contribute valuable skins. And there is the indirect economic benefit to communities visited by hunters and fishermen. Opportunities for study and observation of wild species and their relationships to one another are of importance to the scientist.

FUR SUPPLY

The earliest development of the West was largely centered in the fur industry. The supply of fur bearers, however, has been so much

FIGURE 50.—Beaver dam. Beavers are not only valuable fur bearers, but store water and prevent erosion

reduced that fur has been a minor product of the State for a long period.

Beaver in reasonable numbers are desirable not only in producing valuable fur but also in equalizing stream flow by the construction of dams. (Fig. 50.) In irrigated sections, however, they cause considerable damage by clogging ditches. They may also cause damage by flooding timber areas.

Muskrats are confined chiefly to marsh areas but are remarkably productive and under management can furnish a valuable product from sections which otherwise are largely waste.

The marten (fig. 51) is an animal of the mountains and is the chief enemy of the pine squirrel. It not only provides a valuable fur but acts as a check on an excessive number of the squirrels, which live largely on the seeds of coniferous trees.

In many sections large weasels or ermines are abundant. These not only supply a valuable fur in winter but serve as a check on mice and other harmful rodents.

The coyote, although classed as a predatory animal, has a valuable pelt, which offers an inducement for its capture. The same may be said of the bobcat.

Minks, while destructive of fish, are not particularly objectionable in waters where nongame fish are abundant. They furnish a valuable fur.

Otters are valuable fur bearers, but are rare and are very destructive to fish.

Foxes, though never numerous in Utah, are not uncommon, and their fur is valuable. Badgers and skunks have a value as fur bearers but are probably worth more in the destruction of rodents and insect pests.

The laws in Utah provide for the licensing of trappers and give an open trapping season when the furs are prime and the animals are not breeding.

FIGURE 51.—Marten, a valuable and interesting fur-bearing animal of the high mountains

STATE FISH AND GAME DEPARTMENT

Utah maintains a State fish and game department consisting of a fish and game commissioner, a chief deputy, a construction superintendent, a force of deputy wardens or game and fish protectors, a crew of trained fish culturists, and an office force. There are some 60 fish and game protective associations organized and functioning throughout the State to encourage fish and game conservation and otherwise assist the State fish and game department in carrying on its work.

The State fish and game department is financed by the proceeds from the sale of fishing and hunting licenses, and no general tax money is used for this purpose. This department operates 10 fish hatcheries, together with a suitable number of nursery or rearing ponds, where 12,000,000 trout are hatched annually, reared to a length of from 4 to 7 inches, and transferred to various streams and lakes to assist nature in maintaining the supply necessary to meet present-day demands. Approximately 12,000 adult rainbow trout are maintained at these hatcheries for the sole purpose of furnishing a reliable and adequate egg supply. Eggs in large numbers are also stripped from wild fish and placed in the hatcheries. The department operates a game farm which, during 1928, produced 10,000 ring-necked pheasants to be used in stocking the valleys for hunting purposes. Utah has also constructed and is successfully operating a public migratory-bird refuge and shooting grounds, the first of its kind in North America.

Details of game laws can be secured from the State authorities and from the annual compilations by the Bureau of Biological Sur-

vey of the various Federal and State game and fish laws, published in the Farmers' Bulletin series of the United States Department of Agriculture.

Hunting from an airplane or shooting from an automobile or highway is prohibited. Aliens are not permitted to hunt or fish in Utah.

Description of the game preserves and copies of the fish and game code of Utah may be obtained from the office of the State fish and game commissioner.

RECREATIONAL RESOURCES

Three different classes of recreation areas are found in Utah—national parks, national forests, and national monuments.

According to a resolution adopted unanimously by the National Conference on Outdoor Recreation (*6*) called by President Coolidge in May, 1924:

> The national parks system consists of permanent national reservations protecting inviolate those wonderful or unique areas of our country which are museums representing the scenery and principal natural features of the United States available in our great heritage of animate and inanimate nature; that these parks must be protected completely from all economic use; that their scenic qualities should represent features of national importance as distinguished from those of sectional or local significance; and that they must be preserved in a condition of unmodified nature.

There are two national parks in Utah, viz, Bryce Canyon and Zion, and they represent wonderful and unique scenery of national importance.

On the other hand, the above-mentioned conference stated:

> National forests are areas set aside to protect and maintain in a permanently productive or useful condition lands unsuited to agriculture but capable of yielding timber or other general public benefits, and thus all resources of national forests, including recreation, should be developed to the greatest possible extent consistent with permanent productivity in such a way as to insure the highest use of all parts of the area involved.

While the national forests are created primarily to conserve the timber and stream flow, many sections of value for recreational purposes are included within their boundaries. This value is recognized and national-forest management seeks to conserve it and make it usable. Certain national forests containing recreational resources located near centers of population, such as along the Salt Lake Valley, are intensively used. The large area and wide distribution of the national forests make them valuable recreation areas for many localities.

The 10 national forests which are wholly or partly in Utah are: Ashley, Cache, Dixie, Fishlake, La Sal, Manti, Minidoka, Powell, Uinta, and Wasatch.

National monuments are designated areas of land owned by the United States on which are found historic landmarks, historic and prehistoric structures, or other objects of historic or scientific interest. Some of them are located within the national forests. There are six national monuments in Utah—National Bridges, Rainbow Bridge, Dinosaur, Hovenweep (part in Colorado), Arches, and Timpanogos Cave. They, too, are areas of recreation as well as of scientific or historic interest.

Besides the above national parks, monuments, and forests, any mountainous section easily accessible to people may have recreational resources. Most of the water areas and marsh areas, such as are included in the State public-shooting ground on Bear River Bay, also furnish recreation.

RELATION OF RECREATIONAL RESOURCES TO OTHER RESOURCES

There is often a conflict between the use of the recreational resource and the other resources of an area. Grazing may sometimes need to be excluded from limited portions of intensively used recreation areas. On the other hand, recreation seekers in large numbers may disturb stock. The practice of forestry, in that it maintains a forest in healthy condition, is an advantage to recreation. The presence of recreation seekers, however, definitely increases the fire hazard and complicates the management of timberlands and the harvesting of timber. On watersheds supplying water for domestic purposes, the presence of people creates a hazard which requires special sanitary precautions.

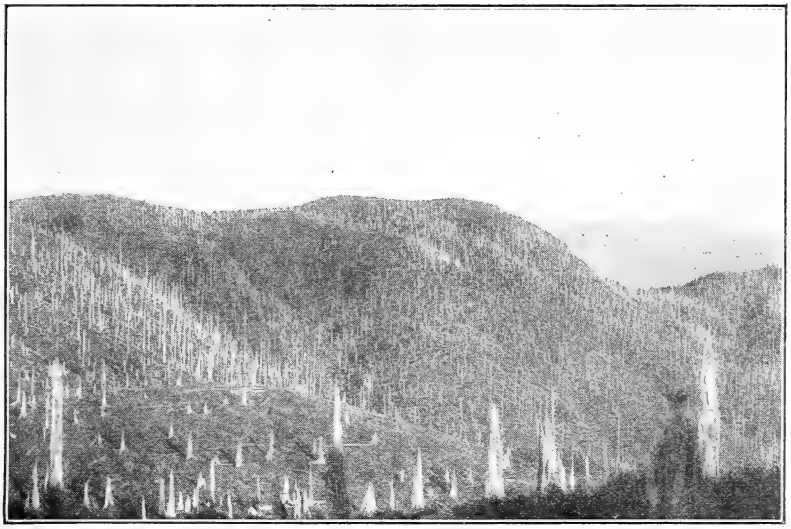

FIGURE 52.—Fire has laid waste enormous areas of virgin timberlands

The biggest problems brought about by recreational use of the forests are fire, vandalism, and poor sanitation. These problems can not be satisfactorily solved without an attitude of respect for these recreational resources and a sense of personal responsibility for them on the part of the individual. Such attitudes are best fostered by appreciation of the value of these resources and by a sense of proprietorship in them.

PROTECTION AGAINST FIRE

Every one of the renewable natural resources of Utah is subject to damage by fire. There occur on an average 53 fires a year in Utah on and near the national forests, burning an average area of

6,200 acres of grass, brush, and timber. (Fig. 52.) These are mostly man-caused, the majority being smokers' and campers' fires. Many are started by discarding matches and cigarette and cigar stubs before they are extinguished, and by leaving camp fires without putting them entirely out. Not infrequently fires are set to burn brush on private land at times when the hazard is too great, or are left unattended and allowed to escape. Lightning fires, so prevalent in some parts of the country, are not numerous in Utah. The big problem in Utah is the elimination of man-caused fires.

LAWS AND PENALTIES RELATIVE TO FOREST FIRES

Both the Federal Government and the State of Utah have passed laws for the punishment of persons who are responsible for fire on forest areas. Under the Federal law, designed, of course, to protect Federal lands, it is either a felony or misdemeanor, depending on the circumstances, to set or cause to be set on fire any timber, under-

FIGURE 53.—Even a grass or brush fire will destroy bird life

brush, or grass upon the public domain, or to leave unextinguished a fire built in or near any forest, timber, or other inflammable material upon the public domain. (Fig. 53.) If the offense is a felony, the maximum punishment is a fine of not more than $5,000 or imprisonment of not more than two years, or both. If the offense is a misdemeanor, the punishment is a fine of not more than $1,000 or imprisonment of not more than one year, or both.

Under the authority of laws passed by Congress, the Secretary of Agriculture has made certain regulations concerning the setting of fires on national-forest lands. The violation of these regulations is punishable in the Federal courts by a fine of not more than $500 or by imprisonment for not more than 12 months, or both. In general, the regulations of the Secretary of Agriculture on national forest land prohibit:

(1) Building camp fires at times or in places where they are likely to spread or to be difficult to extinguish.

(2) Leaving a camp fire without completely extinguishing it.

(3) Building a camp fire on any portion of any national forest which has been closed to such fires by the proper authority during a period of exceptional fire hazard.

(4) Smoking on the national forests during periods of great fire danger when public announcement of the danger has been made by the proper forest official.

(5) Throwing a burning cigarette, cigar, match, or similar substance in any place where it may start a fire.

(6) Entering national-forest land without permit from the local forest ranger in exceptional cases when the fire danger is extremely high.

Paragraphs 4 and 6 apply only during extremely hazardous periods, and the public is given notice in such cases.

Congress has authorized the Secretary of Agriculture in his discretion to offer rewards not exceeding $500 for information leading to the arrest and conviction of persons who have set fires on national-forest land.

The 1926–27 Legislature of Utah passed a law which makes it a misdemeanor to set on fire or expose to danger of destruction by fire, in the State, any growing trees, shrubs, brush, grass, undergrowth, or cultivated crops on any lands, public or private, except on a man's own property. In Utah misdemeanors are punishable by a fine of not more than $299 or imprisonment of not more than six months, or by both such fine and imprisonment.

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