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(IN COOPERATION WITH THE BUREAU OF PLANT INDUSTRY, B. T. GALLOWAY, CHIEF.)

THE REVEGETATION OF OVERGRAZED RANGE AREAS.

PRELIMINARY REPORT.

By

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The information contained in this circular was gathered in the course of a series of experiments which are being carried on by the Forest Service and the Bureau of Plant Industry, acting in cooperation, to devise the best methods of enlarging the capacity of the grazing lands included in the National Forests. The grazing capacity of much of this area had been seriously depleted under the practice of unrestricted grazing before the lands came under direct governmental jurisdiction. Since that time it is estimated that the efficiency of forest range lands has been increased 30 per cent through the regulations which provide for their orderly occupancy and prevent excessive grazing. But the lands have not yet been brought nearly to the point of their possible capability, nor even restored to their original productivity. The task of improving them to the state where they will support the largest number of live stock with the least waste is one of great importance, and one that will require time and careful study. The Forest Service, in the prosecution of this undertaking, obtained the assistance of the Bureau of Plant Industry along lines in which that Bureau had expert knowledge. Mr. Frederick V. Coville, a botanist of the Department of Agriculture, who has made a long and detailed study of grasses and grazing technique, assumed the direction of a series of experiments connected with those subjects, in cooperation with the Branch of Grazing of the Forest Service. These experiments cover trials of the artificial reseeding of portions of the grazing lands with cultivated grasses, studies to ascertain how overgrazed areas can be reseeded naturally, and trials of schemes to increase the carrying capacity of the range through modifications in the existing system of handling stock.

A progress report on one of these last-named subjects, an experimental coyote-proof pasture, by Mr. James T. Jardine, special agent, with an introduction by Mr. Coville, has been published as Circular No. 157 of the Forest Service. The present circular, a preliminary report on another phase of these investigations, the natural reseeding of overgrazed areas, is now presented. It has been prepared by Mr. Arthur W. Sampson, expert in plant ecology, and is accompanied by an introduction by Mr. Coville, who planned and supervised the work.

GIFFORD PINCHOT,
Forester.

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As illustrated by conditions in the National Forests, overgrazing may exist in various degrees and produce results of varying seriousness. Natural grazing lands contain a mixture of many kinds of grasses and other plants, some few of which, by reason of their abundance and nutritive value, are considered important range plants; others, constituting usually by far the largest number of kinds, are always sparse in their growth or are innutritious and unpalatable, and therefore have little or no value on a range; others are poisonous, and therefore positively objectionable and injurious.

In the first stage of overgrazing the individual plants are so much weakened by frequent cropping that they produce less than the normal amount of forage. In the second stage a part of the vegetation, usually made up of the most palatable and nutritious species, is killed and its place is occupied by the less desirable kinds. Third, the natural vegetation of a range may be almost wholly killed and its place taken by newly introduced species, or kept in a denuded condition for a large part of the year. The expression "destructive overgrazing" is applied to such a practice of excessive grazing as results in the killing, in whole or in part, of the important natural range plants.

Destructive overgrazing occurs less frequently on the better watered ranges of northern latitude or higher elevation, which are made up largely of perennial plants, than on the more arid ranges of southern latitude and lower elevation, which often consist almost wholly of annuals. The revegetation of a worn-out annual range presents a wholly different problem from that of a perennial range. The studies of the season of 1907 were confined to perennial ranges.

The sheep ranges in the Wallowa National Forest, in northeastern Oregon, were chosen as the place for the revegetation studies because of suitability and convenience. The sheep owners recognized that an increase in the carrying capacity of the overgrazed portions of the range would be to their interest, and some of them advocated the closing of these areas for a few years until the best grasses could

reseed and again establish themselves securely. The studies and experiments outlined for the Wallowa Forest, however, had in view a procedure which would be far more advantageous to the sheep owners and which would avoid the economic disturbance that might follow in a stock-raising community if deprived of the use of any large percentage of the grazing crop. The plan was to ascertain, by a detailed study of the range vegetation, whether by closing an area for a portion of the season the best grazing plants could not be made to reseed and sufficient time be left after the seeding was accomplished to permit the sheep to enter the area and graze off the season's growth of vegetation.

It was of primary importance to ascertain which were the principal grazing plants, and then to determine for each of these the date at which it sent up its flower stalks and the date at which it matured its seed, for it is clear that no natural reseeding experiment can be a success which does not protect the seed plant from grazing animals during the period from the shooting of the flower stalks to the maturity of the seed. Furthermore, it was necessary to ascertain at what time the seed germinates and how long a period is required for the seedling to develop sufficiently to withstand the trampling incident to a moderate grazing.

Mr. Arthur W. Sampson, an expert plant ecologist, was selected to carry out the investigation, and the results of his first season's work, that of 1907, are stated in the accompanying report. Mr. G. A. Pearson was associated with Mr. Sampson in the field work and prepared that portion of the report relating to the zones of vegetation.

Mountain bunchgrass (*Festuca viridula*) proves to be the most important grazing plant of the Wallowa Mountains, where it occurs in abundance on bald summits and open plateaus at elevations of from 6,500 to 8,500 feet. Under the system of unrestricted grazing that prevailed before these mountains were set aside as a National Forest the best areas of mountain bunchgrass were destructively overgrazed. After the individual permit system of grazing was put into effect by the Forest Service destructive overgrazing ceased. The restocking of the overgrazed areas with mountain bunchgrass has made little or no progress, however, because all of the remaining mountain bunchgrass is grazed at one time or another each year before the first week in September, the time at which this grass is found to mature its seed. Under a continuation of the existing grazing practice in this district, therefore, there is little probability that the mountain bunchgrass will be restored on the denuded areas, and, in fact, the new perennial growth coming in on these areas is largely made up of an almost worthless grazing plant known as sickle sedge (*Carex deflexa*), the spread of which is due chiefly to the fact that the plant

matures its seeds very early in the season, before the sheep begin to graze at these elevations.

During the season of 1907 it was found that about one-fifth of the summer grazing season still remains after the mountain bunchgrass has matured its seed, and that during this period the blades of this grass, but not the seed stalks, are eagerly eaten by sheep. Based on this and the other facts brought out in the season's studies, an experiment in natural reseeding has been planned and put in operation for the season of 1908. On each of certain ranges in the Wallowa Mountains occupied by a single band of sheep has been selected an area partially denuded of mountain bunchgrass, not exceeding one-fifth of the total acreage occupied by the band. From this area the sheep are to be excluded until the mountain bunchgrass has matured its seed. The sheep are then to be herded upon the area, grazing off the grass and trampling the seed into the soil. There is every reason to expect that, unless some unusual weather conditions interfere, a good seeding will be secured without expense and without wasting the season's crop of grass. During the following season, or additional seasons if necessary, the same area will be closed for a similar period, to enable the seedling plants to become well established and to secure a supplementary seeding if the first year's seeding is not satisfactory.

OBJECTS OF THE STUDY.

For the last five or six years the effects of the lowered carrying capacity of the summer sheep range on the Wallowa (formerly the Imnaha) National Forest, in eastern Oregon, have been most keenly felt by the stockmen. It seemed in the beginning that the forage supply was inexhaustible, but by continued overstocking and the injudicious removal of the forage crop, as the inevitable result of the lack of a system of range management during the free grazing period, the forage supply was rapidly reduced.

At the present time there are numerous range areas, though usually limited in extent, which have been so much reduced in carrying capacity that they have been rendered practically valueless for grazing purposes, and the original palatable plants in many localities have been succeeded by weedy annuals or by perennial species that are of little or no forage value.

Owing to the great importance of the summer range to the grazing industry in this community, the question of range improvement was strongly agitated by the stockmen. Finally the Government was called upon to make a critical study of the ranges and gather such information as might be of value in finding some practical means of

improving the existing conditions. In the spring of 1907 the Forest Service, in cooperation with the Bureau of Plant Industry of the United States Department of Agriculture, began an investigation. The chief aims of the study were as follows:

1. To determine the relative importance of the native grasses and forage plants by studying (1) their abundance, distribution, seed habits, and forage value, and (2) their life history so far as concerns the handling of these lands as grazing areas.

2. To ascertain the rapidity and extent to which the important forage plants are regenerating upon areas overgrazed in various degrees, both under the present range management and upon areas exempt from grazing animals.

3. To determine what plants under the present grazing system are succeeding upon depleted range areas, and what type of vegetation may eventually predominate.

4. To develop a system of grazing from the information secured through these studies whereby the former productiveness of the range may be restored through natural reseeding.

THE GRAZING AREAS.

The Wallowa National Forest was established by proclamation of the President on May 6, 1905. It comprises about 747,000 acres, of which approximately 500,000 acres, by virtue of the irregular, broken surface of the country, are given over to sheep grazing; the balance, much lower in altitude and composed of more gentle slopes, is used for the grazing of cattle.

The region is characterized by an unusually irregular topography and a wide range of altitudes. The valleys surrounding the mountains have an altitude of approximately 3,000 feet, while the highest peaks exceed 9,000 feet. The greatest elevation is reached in the south-central part of the region, where a number of domes rise above the highest points of forest growth and where snow often remains throughout the summer. From this group of high peaks there pours an immense volume of water, and within a radius of 3 or 4 miles rise practically all of the important streams of the district, which all ultimately empty into the Snake River.

Owing to the diversity in altitude and wide variation in topography the range is naturally divided into a number of rather distinct zones of vegetation, which are marked by characteristic plants as the result of certain physical factors peculiar to each belt. These zones are not marked by absolute altitudinal limits, as altitude only determines the character and composition of the vegetation in so far as it influences the direct physical factors, the most potent of which are moisture and temperature. Consequently local variations frequently

cause a considerable overlapping and mixing of the different types of vegetation. As a rule, northerly and easterly exposures are more moist and cool than southerly exposures, and consequently the types of vegetation found upon different slopes of the same altitude are often strikingly different. Usually a northern slope presents conditions similar to those of a southern slope from 1,000 to 2,000 feet higher, and a similar though less marked difference exists between eastern and western exposures.

Four zones of vegetation are recognized, whose average altitudinal limits (allowing for local variations) are as follows:

Transition, or yellow-pine, zone	3,000 to 4,500 feet.
Canadian, or lodgepole-pine, zone	4,500 to 6,800 feet.
Hudsonian, or whitebark-pine, zone	6,500 to 8,500 feet.
Arctic-alpine, or timberless, zone	8,000 to 9,500 feet.

The transition zone is confined to a limited area in the lower altitudes and occupies a number of the lower canyons and warm south and west slopes. A comparatively small portion of this zone is forested, and timber is confined principally to the moist lower slopes and canyons. The most characteristic tree is yellow pine, which does not commonly grow in pure stands, but is usually associated with Douglas fir and western larch. Several hardwoods occur in the moist canyons and along the banks of streams, among which the most common are aspen and black birch.

Owing to the open character of the yellow-pine forests, there is usually a fairly dense stand of herbaceous vegetation, of which pine grass (*Calamagrostis suksdorfii*) is the dominant species. This grass is considered low in nutritive qualities, and is only eaten by stock when more palatable forage can not be obtained.

At lower elevations in the transition zone timber is usually absent, and the vegetation is made up largely of bunchgrasses. Those which occur in greatest abundance are blue bunchgrass (*Festuca arizonica*), big bunchgrass (*Agropyron spicatum*), little bluegrass (*Poa sandbergii*), and mountain June grass (*Koeleria cristata*), all of which are of high forage value. The National Forest contains only small areas of typical bunchgrass land. Most of the neighboring lands of this character lie at a lower elevation.

The Canadian zone is the most heavily timbered of the four zones in the region. Lodgepole pine is the most characteristic tree, and grows throughout the entire zone. Upon the moist north and east slopes western larch and Douglas fir are usually well represented. The open grass-land areas in this zone are comparatively small, and are found mainly on old burns or "fire glades;" consequently this belt, though much greater in extent, is of less grazing value than the transition zone. No particular grasses are especially character-

istic of this zone. Among the more common species may be mentioned smooth wild rye grass (*Elymus glaucus*), short-awned bromegrass (*Bromus marginatus*), western needle grass (*Stipa occidentalis*), and pinegrass (*Calamagrostis suksdorfii*), ranking with respect to forage value in the order named.

The Hudsonian zone, which marks the upper limits of the Canadian belt, is probably equal in area to the total of all the other zones in this part of the Forest; it comprises the most important grazing lands, and carries more stock than both the zones previously mentioned. The most typical tree in this zone is whitebark pine. This tree marks the sharpest zonal limits of any tree species in the region. While it has a fairly wide distribution and reaches from timber line down to an altitude of 6,500 feet, where it grows luxuriantly, in no case has it been observed below 6,000 feet, even on northerly exposures. Another tree which grows quite as abundantly in this zone as the whitebark pine is subalpine fir. This species differs from the foregoing in that it is adapted to a wider altitudinal range and grows in a greater variety of habitats. Consequently, when subalpine fir is met with there is no degree of certainty that one is in or even near the Hudsonian zone, and though it occurs in abundance throughout this belt and reaches the normal timber line, it has frequently been observed to occur from 2,000 to 3,000 feet below the lower boundaries of the zone.

The most striking features of the Hudsonian zone are the great preponderance of open grass-land areas and the general broken character of the forests. It may be described as varying from open meadow to scattered woodland. The glades are covered with such a luxuriant growth of mountain bunchgrass (*Festuca viridula*) as to give character to the landscape. This species is preeminent in importance among the forage plants of the entire range. Other valuable grasses commonly associated with this species are the mountain bluegrasses (*Melica spectabilis* and *M. bella*). Here, too, may be mentioned sickle sedge (*Carex deflexa*), a common sedge, important because of its rapid succession on denuded bunchgrass areas. In a variety of situations, particularly in the moist habitats, are found mountain timothy (*Phleum alpinum*), alpine redtop (*Agrostis rossae*), hair grass (*Deschampsia caespitosa* and *D. elongata*), several species of rushes, and a number of showy flowering plants, many of which are palatable to stock.

In approaching the higher altitudes of this zone the vegetation decreases in density and is generally much less highly developed than in the lower altitudes, a fact which is partly due to climatic conditions, but mainly to the difference in the physical properties of the soil. On the lower areas and extending approximately to an altitude of 8,000 feet the soils have originated almost entirely from

basaltic lavas, but above this elevation they have been formed mainly from granitic rocks. Basaltic rocks decompose into porous, friable soils, which have a comparatively slow percolatory property and a strong power of retaining moisture. The granitic soils, on the other hand, are poorly decomposed; that is, they are coarse in texture and the moisture is quickly lost by rapid percolation and excessive evaporation, consequently the striking contrast in the vegetation on the two types of soil is primarily due to the difference in moisture.

The arctic-alpine or timberless zone is extremely limited in extent. It exists only in the highest mountains and is confined to those peaks which rise above the timber line. Here the effect of exposure is very marked. On southerly slopes straggling timber persists, though in a much dwarfed and even prostrate habit of growth, to an altitude of about 9,000 feet, while on northerly exposures it is exceptional to find timber beyond an altitude of 7,500 feet.

As a rule, the herbaceous vegetation is exceedingly sparse and the plants are much dwarfed. A rather striking example of the stunted condition of growth was observed in the case of a common grass, *Trisetum spicatum*. In the lower limits of the Hudsonian zone this species usually attains a height of from 18 to 24 inches, while in the timberless belt it seldom exceeds 6 inches. The vegetation is mainly composed of typical arctic species, most of which have no economic value. Among those which occur in considerable abundance here and furnish some forage in the zone below may be mentioned alpine bunchgrass (*Festuca brachyphylla*), *Trisetum spicatum*, and *Carex preslii*.

So far as known, no grazing whatever is done in the arctic-alpine zone. This belt, however, must not be confused with numerous bald buttes characteristic of the upper limits of the Hudsonian zone, many of which furnish a considerable amount of range forage. The absence of timber on these areas is not a question of altitude, but, owing to the steep slopes and the character of the soil, is primarily due to the lack of moisture.

As shown by the different types of vegetation, the climatic conditions are widely varied in different parts of the forest. The records kept in the mountains have not been continued long enough to allow one to make any deductions regarding the conditions. Records kept at Wallowa, La Grande, Sparta, and Joseph, however, for the last ten years, give an average annual precipitation of 18.95 inches in the valleys surrounding the mountains. The average annual temperature of these stations is 45.2° F. This is the mean of wide extremes. At La Grande, for instance, the records show that as much as 110° F. is registered in the summer, while in the winter the temperature drops to —17° F. It would be entirely hypothetical at this time to approximate the precipitation and temperature in the mountains or to com-

pare the mountain conditions with those of the valleys surrounding them; observations, however, warrant the general statement that the precipitation increases and the temperature decreases with the increase of altitude.

The time at which growth starts in the spring depends, of course, upon the season. In normal years conditions are usually such as to stimulate growth upon the main grazing areas by the 1st of June. During this month the snow melts rapidly, and by July 1 only portions of the larger drifts remain in the protected places; and as they recede the ground is rapidly covered with young tender growth. The growing season in the greater part of the Forest is three and one-half months, with a decrease to three months in the higher altitudes.

SCOPE AND METHOD OF THE STUDIES.

Since the physical conditions of this region and the type and character of the vegetation vary widely, it was necessary to select typical range areas upon which to secure conservative and accurate experimental data as a basis for the range improvement work. In advance of the selection of these areas, a careful survey of the region was made early in the spring, which resulted in the establishment of five typical stations representing large tracts of overgrazed range land in the transition, Canadian, and Hudsonian zones, which varied in altitude from approximately 3,000 to 7,500 feet. As a protection against stock, the stations were all substantially fenced before the opening of the grazing season.

At these stations the important forage plants were observed throughout the season in their natural environments, and the detailed studies of the life history and general characteristics of the plants were largely carried on in these small representative areas. Their relative forage value, however, was determined upon the open range by following the sheep as they grazed and noting their choice of forage.

Special attention was directed to the time and conditions under which the seeds germinate in the spring, when the flower stalks are sent up, and when the seeds are matured and disseminated. In addition, seeds of the most important plants were collected as they matured in the fall, and a germination test was later made to determine their viability.

It was considered of high importance to secure accurate and reliable information on the rate at which plants are invading overgrazed areas and becoming established upon them; the character and composition of this succeeding vegetation; the plants which may eventually predominate under the present conditions; and the physical factors

which determine the rate of movement, character of grouping, and composition of the formations.

To this end operations were begun in July. On the inclosed stations a number of areas 1 meter square, called quadrats, were laid off, and the plant formations which occurred within them were accurately mapped. The charting was done on a form especially prepared for the purpose, on which the exact position of every plant within the quadrat was indicated, except in cases where the vegetation formed dense tufts or mats, as is the habit of growth of many of the so-called "bunchgrasses," in which case they were merely outlined in mass. After a formation had been recorded, it was photographed for future record, and rendered permanent by staking the corners to locate the boundaries for future mapping. The methods of study followed were those developed by Dr. F. E. Clements.

Two kinds of quadrats were used, namely, denuded and permanent. Denuded quadrats are charted, photographed, and staked, just as permanent quadrats are, but in addition the vegetation is artificially removed from them. A layer of soil 3 or 4 inches deep is removed, and consequently the greater part of the underground portions of the plants are dug up. Both types of quadrats are of invaluable aid in securing reliable data on the changes in the type of vegetation.[a]

The modifications in a plant formation in any habitat are, of course, the result of the response of the plant society to the physical factors acting upon it, and in order to have a clear conception of the relation of the vegetation to its environment the direct or most potent factors are measured in connection with the quadrat study. The factors taken into account in these investigations are soil and air humidity; air, soil, and surface temperature; and light intensity. Of these, temperature and soil water content are undoubtedly the most important in bringing about succession, since they control germination.

In order to ascertain to what extent the forage plants are regenerating, actual counts were made of forage seedlings on typical range areas. The average density of stand was obtained by counting the seedlings in a large number of unit areas 1 meter square. For these studies several range areas were selected upon which there were normal stands of the type of vegetation characteristic of the region in question. In determining the abundance of seedlings it was the special aim to have the studies include all the range conditions on the areas selected; and a sufficiently large number of counts were made in each situation to secure entirely reliable figures. The following notes were taken in connection with each unit area counted: Locality,

[a] For fuller discussion of the quadrat see F. E. Clements's Research Methods, pp. 161–175.

date of computation, most characteristic vegetation and its abundance. slope and exposure, character of soil, and the number and kind of seedlings found. On all areas examined numerous soil-moisture determinations were made from time to time and an average of the results obtained was taken to represent the moisture condition on each area.

Out of these investigations developed a plan of an experimental nature to determine the actual loss and injury to forage seedlings caused by trampling. The average density of the seedlings on a typical grazing area was secured prior to the time of grazing, by the method just described. After the area had been moderately grazed (allowing ample time for the plants to recuperate) the density of the seedling stand was again ascertained and the loss thereby obtained.

A plan which brought some additional details consisted in establishing quadrats on an open grazing area before it had been visited by stock and comparing them later with similar quadrats on one of the inclosed stations near by, where conditions were similar to those on the open range. In these uninclosed quadrats the time involved in mapping the entire plant formation would have been too great; therefore only seedlings were charted. The quadrats were numbered and marked by driving short stakes in the corners in the usual way. In this manner a control or check was secured through which it became possible to determine the loss of seedlings destroyed through other causes than that of trampling. In both cases soil moisture determinations were frequently made.

OBSERVATIONS AND EXPERIMENTS ON THE MOUNTAIN BUNCHGRASS AREA.

The mountain bunchgrass area, so called because of the tufted, unmatted character of growth of the grasses which predominate on most of the open, unforested glades of this region, is typical of and confined to the Hudsonian zone, which ranges in altitude from approximately 6,500 to 8,500 feet. By virtue of the striking superiority and importance of this portion of the range, as compared with other types in the region, the greater part of the work in the past season was confined to this area.

The predominant grass of this region, and unquestionably the most important forage plant of the entire range, is mountain bunchgrass (*Festuca viridula*). Though its abundance has been materially decreased through overstocking, it furnishes much of the feed during the summer, when succulent and tender, and it is also greatly relished by the stock late in the fall, when the leaves are nearly dry. Local stockmen who have used the range for a number of years maintain that practically all of the areas which are now nearly divested of forage plants formerly supported a dense stand of this valuable grass,

and the numerous large dead grass tufts which still remain on these depleted tracts fully substantiate the statement.

In addition to this important plant there are a large number of valuable grasses, nearly all of which are of the "bunchgrass" type. Some of those which occur in considerable abundance and are relished by stock are: Little bluegrass (*Poa sandbergii*), mountain bluegrass (*Melica spectabilis*), big bunchgrass (*Agropyron spicatum*), tufted hairgrass (*Deschampsia caespitosa*), bromegrass (*Bromus marginatus*), and mountain June grass (*Koeleria cristata*).

Though the grasses in this region furnish the greater part of the range forage, there are a number of sedges, rushes, and nongrasslike plants, particularly in the more moist situations, which furnish a considerable amount of good feed.

PRODUCTION OF FLOWER STALKS.

There is a marked variation in the time at which the flower stalks are sent up by the different species and by individuals of a single species which grow on different slopes and exposures, even in the same locality. The wide individual variation within a species in a given locality seems somewhat peculiar at first, but observations revealed the fact that this fluctuation applies almost exclusively to the more palatable and highly relished species, and may, in part at least, be explained from the fact that for a number of years the more desirable forage plants have been deprived of their leaves, which compose the laboratories for the assimilation of their food materials, and as a result their vitality has become so greatly reduced that they no longer function normally.

The earliest appearance of the flower stalks of the various species was June 1, and they continue to be sent up until as late as August 20. The time of maximum production for most species was from July 15 to August 5, and the average length of time during which they were produced was twenty days, which is the mean between wide extremes. In the case of mountain bunchgrass there was a long period during which the flower stalks were sent up. They appeared as early as July 10 and continued to be produced until August 20. During this period there was no appreciable increase in their abundance.

MATURITY OF SEEDS.

Naturally the time at which the seeds of the different grasses and forage plants matured was quite as variable as the production of the flower stalks. The earliest date of ripening was August 1. Until August 20, however, very few mature seeds could be found, and most of those which ripened were recorded between August 25 and Sep-

tember 5. The seeds of mountain bunchgrass began to ripen as early as August 18 on exposed south and west slopes, and by August 25 fully one-third of the seeds of this plant on such areas had matured. As in the case of the other valuable grazing plants, however, most of the seeds of this species matured between August 25 and September 5. Owing to the adverse weather conditions after September 10, the seeds which had not matured at that time were destroyed.

GERMINATION OF SEEDS.

One of the problems of great importance in the range investigations was to determine to what extent, under existing conditions, the important forage plants are reproducing by seeds. An accurate knowledge of the abundance and kind of seedlings which are succeeding on the different range types would undoubtedly determine the possibilities of increasing the carrying capacity under the present system of grazing and show whether other regulations are necessary to improve the existing conditions more effectively and rapidly.

Prior to the time when the stock was turned upon the range, several areas that were overgrazed in various stages were selected for the studies. Upon these areas there are two distinct types of herbaceous vegetation, one of which regenerates much more abundantly than the other. While these types intermix to a considerable extent in certain situations, as a general rule they present well-marked plant formations. For convenience they may be distinguished as follows:

1. *Constant or perennial vegetation.*—Those plants which continue to grow from year to year, and which are more or less in evidence throughout the season.

2. *Temporary or annual vegetation.*—Those plants which spring up from seeds each year, flourish but a few weeks, ripen their seeds, and disappear.

In the group of constant or perennial vegetation are included all the important grasses and, almost without exception, the other valuable forage plants of this region. It is this type which furnishes the summer, fall, and winter forage. The temporary or annual vegetation, on the other hand, is composed of very few valuable range plants. The plants of this group are grazed to a limited extent in the spring, when they are succulent and tender; but in most situations they bloom, mature, and disperse their seeds, wither, and disappear, before the stock has access to them. The seed habits of this group of annual plants, as compared with those of the other type, are exceptionally strong. The seedlings are particularly prevalent over the areas where the original vegetation, which was largely composed of the constant or perennial type, has recently been destroyed; and the fact that the annual plants which propagate solely by seeds often completely cover such areas illustrates their prolific seed habits.

By reason of the predominance of annual seedlings upon the areas studied, and by virtue of the limited supply of forage which they afford, they were only noted in a general way in the counts that were made and consequently are not included in the figures given. The investigations were begun in the latter part of July and continued intermittently through August; and the data here presented were in all cases secured before the forage had been consumed.

Table 1 shows the results obtained.

TABLE 1.—*Seedling reproduction of perennial forage plants on the mountain bunchgrass area.*

Date of computation.	Locality.	Vegetation.		Character of soil.
		Most characteristic.	Per cent of ground covered.	
	Standley range.			
August 5 and 6	Ridge east of Station IV.	Stipa minor, Agrostis rossae, and Carex deflexa.	10	Gravelly clay loam.
August 6 and 7	Near Station V	Festuca viridula, Melica spectabilis, and Bromus marginatus.	50	Light sandy loam.
August 9 and 10	Basin east of Station IV.	Carex geyeri, Carex deflexa, and Bromus marginatus.	50	Clay loam.
August 11	do	Carex geyeri and Bromus marginatus.	40	Do.
August 13	South of Station IV	Festuca viridula, Festuca ovina, and Melica spectabilis.	40	Sandy clay loam.
	Sturgill range.			
August 20	Old bed ground	Carex deflexa	Denuded.	Deep sandy loam.
Do	Above bed ground	Festuca viridula, Poa sandbergii, Stipa minor, and Carex.	20	Shallow gravelly clay loam.
August 21	On top of low ridge	Festuca viridula and Agropyron spicatum.	20	Clay loam.
Do	On slope below ridge	Carex geyeri and Festuca viridula.	30	Gravelly clay loam.
August 22	On low ridge	Festuca viridula, Melica spectabilis, and Carex geyeri.	30	Do.
August 23	Below ridge on slope	Carex geyeri and Agropyron spicatum.	20	Do.
Do	Slope west of camp	Agropyron biflorum and Carex geyeri.	20	Sandy, gravelly.

Date of computation.	Locality.	Average per cent soil moisture content.	Slope and aspect.	Number of unit areas counted.	Total number of seedlings.	Average number of seedlings per square meter.
	Standley range.					
August 5 and 6	Ridge east of Station IV	20.1	2° W.	45	428	9.51
August 6 and 7	Near Station V	20.1	5° W.	36	183	5.08
August 9 and 10	Basin east of Station IV	14.6	10–20° E.	35	157	4.48
August 11	do	13.6	12–20° S.	10	16	1.60
August 13	South of Station IV	22.3	5° N.	32	190	5.93
	Sturgill range.					
August 20	Old bed ground	30.2	1–2° SW.	25	674	26.96
Do	Above bed ground	8.3	5° S.	26	70	2.67
August 21	On top of low ridge	8.2	Level.	10	1	.10
Do	On slope below ridge	6.5	5–10° S.	12	23	1.91
August 22	On low ridge	8.9	3–5° SW.	22	55	2.50
August 23	Below ridge on slope	7.2	10–15° S.	26	18	.69
Do	Slope west of camp		5–10° E.	18	10	.55

From this table it is evident that the perennial plants, including the important forage species, are regenerating very sparingly, and that there is a wide variation in the density of their stands in the different localities. It will be observed that the maximum density is found on old bed grounds upon which the vegetation has been almost entirely destroyed. The average number of seedlings obtained per square meter for all counts made upon such lands is 26.96, which exceeds by 17.45 the figures procured on any other type of range examined. An average of all the soil moisture determinations made on the bed-ground areas gives 30.2 per cent, which exceeds by 7.9 per cent any other area studied. This high soil humidity is probably largely responsible for the increased seedling stand. Again, owing to its friable, open character, the soil catches the seeds, which are then worked beneath the surface by the stock, and, since they are exempt from plant competition, they germinate and become established.

The germination tests, which comprised 41 species, with a few exceptions gave negative results; over half of those tested showed no indications whatever of germination. In the summer of 1907 heavy frosts and rather severe freezes occurred frequently after the middle of August, and these conditions were doubtless largely responsible for the results obtained. The point must not be lost sight of, however, that most perennial grasses propagate vegetatively, and since they do not have to depend upon perpetuation by seeds alone, these are often produced imperfectly, and consequently their viability is generally low.

It was conclusively ascertained that on the areas examined the plants of the highest forage value, including mountain bunchgrass, are not reproducing by seeds. Most of the seedlings were sedges, which are plants of secondary forage value. Of these, sickle sedge (*Carex deflexa*), a short, wiry weed which is not at all palatable to stock, composed at least nine-tenths of all the seedlings. This plant is very vigorous, has a wide distribution locally, and is adapted to a variety of habitats. It produces an abundance of seeds which mature so early in the season that the stock does not materially interfere with the seed production, and it perpetuates itself abundantly by offshoots from the rootstocks. Other seedlings which occurred very sparingly were little needle grass (*Stipa minor*), bromegrass (*Bromus marginatus*), and hairgrass (*Deschampsia elongata*). None of these is greatly relished by stock, and consequently an occasional plant is allowed to go to seed.

DESTRUCTION OF SEEDLINGS BY TRAMPLING.

In addition to the determination of the abundance and kinds of seedlings found upon the range, considerable time was given to ascertaining the actual loss of seedlings caused by trampling. The spot

selected was a typical bunchgrass area on a gentle south and west slope. From three-tenths to five-tenths of the ground was occupied by grasses and grasslike plants, of which the most dominant species were mountain bunchgrass (*Festuca viridula*), mountain bluegrass (*Melica spectabilis*), alpine redtop (*Agrostis rossae*), sickle sedge (*Carex deflexa*), and bromegrass (*Bromus marginatus*), named in the order of their abundance.

The average density of the seedling stand on this area was determined by the same method used in ascertaining the seedling density in the former case, and equally full notes were taken with each unit area counted.

Operations were begun in the middle of August, when 68 unit areas were counted, in which an average stand of 5.5 seedlings was obtained. The soil at that time contained 22.3 per cent of water. On August 25 the area was moderately grazed by a band of 2,800 head of sheep. On September 18, when the recounting was begun, the water content of the soil was 19.9 per cent. From 60 unit areas an average stand of 3.7 seedlings was obtained. This gave an average loss during grazing of 1.8 seedlings, or 32.7 per cent, per unit area of 1 square meter.

It is obvious from these figures that there is a considerable loss of young seedlings from trampling even in the summer and fall when it might be expected that a sufficiently strong and elaborate root system had been developed to withstand moderate grazing. It is generally considered that trampling is most injurious in the spring, when, by virtue of the high moisture conditions of the soil, the shallow fibrous seedling roots are easily pressed out of the ground and the plants at once wilt and die. This conception, however, is not based upon actual experimental data and the exact injury is not known.

The effect of trampling in moderate grazing is no serious obstacle to the revegetation of these areas, if the seedlings of the important forage plants are as resistant to trampling as the seedlings on which these observations were based, a question which remains to be answered; for if two-thirds of the seedlings survive in good condition after grazing, ample reproduction is assured.

PROPOSED SYSTEM OF NATURAL RESEEDING FOR DEPLETED MOUNTAIN BUNCHGRASS RANGE.

The field studies thus far conducted upon the mountain bunchgrass areas have been extensive and thorough enough to show clearly that the present regulations are ineffective in bringing about the natural regeneration of the valuable grazing plants. Even under the most conservative and moderate practices of handling stock on

this range under the present system, it is questionable if the lands would be restored to their former productiveness within a reasonable length of time.

The majority of the stockmen interviewed during the past season regarding the restoration of the range maintained that complete rest for a period of years would be the speediest and most practical means by which the range forage might be appreciably increased. There is no doubt whatever in the minds of those who have studied the conditions that if this suggestion were followed, beneficial results would be derived, for upon the greater part of the range there are sufficient valuable forage plants still remaining to reseed the land. Such a treatment, however, would by no means be an economical one, because the entire forage crop during the reseeding period would be wasted. Furthermore, it would be practically an impossibility to follow such a system, because this portion of the range is largely depended upon to supply the bulk of the late summer and fall forage; consequently it would become necessary to decrease the number of stock so materially as seriously to interfere with the welfare of the many ranchmen who rely upon the Wallowa Forest for their summer forage supply.

As a conclusion to these studies it may be stated that equally effective results in the way of range improvement may be obtained by the application of a system of range control whereby the overgrazed areas may be protected from grazing animals during the period required for the maturing and dissemination of the seeds. Moderate fall grazing after the forage plants have performed their full functions would in no way interfere with their regeneration, but, on the contrary, it might prove beneficial, since the stock would do the work of a harrow by trampling most of the seeds beneath the surface of the soil, and thereby insure a higher percentage of germination. Nor would the consumption of the vegetative portion of the forage, after the plants had completed their work, be detrimental to their general vitality, for there would then be in store in their roots a large supply of nutritive material, which would enable them to withstand extreme winter temperatures and which would induce a vigorous spring growth.

It is not the intention to reserve the entire mountain bunchgrass range from grazing in a single year, for, as already stated, the importance of this vast tract for summer forage is so great that it would be impossible without it to support the number of stock usually grazed on the Wallowa Forest; nor is such an extensive treatment desirable, for there are numerous areas in which the forage supply has been only slightly decreased and the general vigor of the vegetation but little weakened. In the beginning only the more severely overgrazed areas should be closed to stock during the period required for the grazing plants to fully develop and mature their seeds.

The time required for badly deteriorated areas to regain a reasonable state of productiveness can not be accurately predicted. It is not to be expected, however, that the lands with sparse and invariably much weakened vegetation would reseed to sufficient extent in a single season; but this same practice of partial closing should be applied for a second or even additional years until the increase in the carrying capacity becomes so manifest as to warrant the grazing of the lands during the regular period. In some areas that need improvement there is a sufficient number of vigorous plants of mountain bunchgrass and other important forage species to reseed the land thoroughly in a single season, provided the year chosen proves favorable to the production of seeds.

The time when the stock could safely be allowed on the range without interfering with the reseeding will, of course, depend upon the season. In 1907 the seeds of the leading forage plants were matured and dispersed by September 5. As the regular grazing on this range continues until September 20 to 30, ample time would be left in which to utilize the forage crop by the system advocated. According to the local stockmen, the season of 1907 was unusually late and the summer exceptionally cold, and this condition may have delayed the seed maturity to some extent. As the studies have covered only one year, the seasonal variations are not known.

The investigations carried on indicate that the overgrazed mountain bunchgrass range may be greatly improved in carrying capacity by the judicious application of the economical method of treatment herein proposed. The soil is in a high state of fertility, and the native grasses and forage plants, through their ability to adapt themselves to the existing conditions, have survived through the struggle for existence; and though they appear to have an inherent tendency toward weak seed habits, if their functions are not seriously interfered with they are bound to succeed.

Approved:

JAMES WILSON,
Secretary of Agriculture.

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