DEVELOPMENT OF REST-ROTATION GRAZING CONCEPT

The beginning

Jared G. Smith ( ) and H. L. Bentley ( ) were the first to carry out experiments involving resting to effect improvement of vegetation on range lands. These experiments were carried out in Texas over a three year period ending in 1901 and consisted of empirical pasture trials. Highlights of these pioneering efforts together with some background on range conditions that prevailed at the time are described in the following.

RENEWING THE CATTLE RANGES

"That the natural pastures are in need of practical and scientific treatment in order to increase their grazing capacity no one who is acquainted with their past and present conditon will deny. The most obvious methods of bringing about the desired improvement are either resting for several seasons to enable the grasses to retake the land which has been denuded of its most valuable grasses, or cultivating the surface of the pasture in order to accelerate the gradual natural processes.

"For the purpose of carrying on such experiments two sections of land have been leased by this Department, one at Channing, in Hartley County, Tex., which will represent, in a large measure, the conditions that prevail in the high plains of the Panhandle, and one at Abilene, Tex., to serve for the central and western prairies up to the border of the Staked Plains. On each of these sections three 80-acre and two 40-acre pastures have been fenced and are being treated as follows:

"Pasture No. 1.--No treatment except to keep stock off until June 1, pasturing the balance of the season.

"Pasture No. 2.--Cut with a disk harrow and keep stock off until June 1, pasturing the balance of the season.

"Pasture No. 5.--No treatment except pasturing until June 1, and keeping stock off the balance of the season.

The best results have accrued from loosening the surface of the ground in early spring before the grasses commence their new growth. It stimulates the roots of such grasses as are already established, causing them to grow with renewed vigor. At Abilene at the close of the season (October 15, 1898) it was estimated that the grasses on land which had been disked in the early spring had improved at least 25 per cent in carrying capacity--that is, there was 25 per cent more grass on the land at the end of the first season than appeared on adjoining pastures which were not treated in any way. Both pastures were grazed with the same amount of stock and treated as far as

possible alike. The experiments here referred to were commenced in the spring of 1898.

REST VERSUS ALTERNATION OF PASTURES

"A treat many of the stockmen who have reported concerning the state of their ranges have suggested that the resting of the land would be the cheapest and most practicable method of again bringing it up to its highest value. Resting is an excellent treatment wherever sufficient grass remains to reseed the land. It is, however, not the most rapid method, nor can it be considered the cheapest when one takes into consideration the fact that the land to become fully regrassed must be rested sometimes three or four years. Complete resting of a pasture is really a more expensive means of improving the pasturage than many would suppose. As shown above, in the case of range deterioration through the growth of cactus, the grass on an acre of land on a section capable of carrying 64 head of stock cattle is worth 66 cents per acre when the cattle are appraised at a valuation of $20 each. At this rate the cost of the renewal of the pasture in the course of a few years would amount to very nearly the value of the land. Partial resting, or resting during different seasons of the year, a system which may be designated the alternation of pastures, secures the same result at much less expense. Thus a range might be divided up into a number of small pastures provided with water, in each of which the cattle would be allowed to run for not more than two or three months at a time and then be transferred to another. In this way the succession of grasses which normally occurs in nature can be fostered and improved. Let us suppose a range of 100,000 acres in extent divided into ten pastures of 10,000 acres each. At the average carrying capacity for the State this body of land will produce forage enough to sustain 10,000 stock cattle throughout the year. These divided up into their various classes--beef steers, two-year olds, and yearlings, cows and calves--could be held three months in one pasture and then transferred to another which had been kept free from stock during that length of time. A rest of two or three months during the growing season in early spring would enable the early grasses to ripen and shed their seeds, thus perpetuating the early species. After the seed had fallen, the cattle could be turned on the grass for two or three months and again transferred to a fresh pasture. In the same way autumn and winter pastures can be secured. Several stockmen who have employed this method on a large scale for a number of years say that their ranges are continually improving, in marked contrast to the deterioration that had occurred through bad treatment of neighboring properties where the old methods were practiced. It is also claimed that pasture land thus treated will carry more head of cattle through the year and bring them out in better condition than where the herd has access at all seasons of the year to all portions of the range."

RR

Jared G Smith DA Bulletin No 16 1899
Grazing problems in the southwest and
Texas how to meet them

"The plains and prairies of Texas have long been famed as grazing retions. At the time of the earliest settlement this Texas territory was for the most part treeless, excepting along the streams and where the two

bodies of "crosa timbers" entered it on the north and where a wedgeshaped tongue of the east Texan timber belt penetrates the prairies south of Austin and San Antonio. The land was well covered with grasses, and was grazed by immense herds of buffalo, wild horses, and great numbers of deer and antelope.

"It is estimated that the southern buffalo herd contained not less than four million head.* This vast number grazed in the district south of the Platte River, retiring to the plains of western Texas and the Indian Territory at the approach of winter, and turning northward again in early spring. There were also numberless herds of wild horses, according to the narratives of some of the early explorers and hunters.

"There was a constant shifting of the wild herds in their search for the best pasturage, and with the season drifting northward with the spring and southward at the approach of winter, congregating where there was water and grass. The conditions were entirely natural and the movements of the herds were almost unrestricted. The intermittent grazing and resting of the land resulting from the roving habits of the buffalo and mustangs was an ideal method of fostering and improving the natural pasturage. The result of this alternation of pastures, conducted on a gigantic scale, was that the native grasses were allowed to fully ripen their seeds, and perpetuate themselves each year in the most liberal manner. The best grazing grasses were developed by the processes of natural selection and survival of the fittest.

Bontley 1902

SUMMARY.

CATTLE HELD ON STATION PASTURES.

It will be borne in mind that in March, 1898, the capacity of the 640 acres included in the Merchant lease was estimated by experts as being for mixed cattle at the rate of 1 head to every 16 acres—about 40 head altogether. During the third year of station work from 80 to 85 head of mixed cattle were held in the pastures, in the proportion of about 1 head to every 7½ acres. At times the proportion was even greater, as it frequently happened that in addition to the cattle several head of horses and mules were allowed the run of the pastures. At no time, however, were the stock permitted to graze all of the pastures at the same time. The effort was made to give each pasture periods of rest in regular succession. That meant the doubling up of the stock in the pastures in which they were being held; hence it happened that during considerable periods of time the different pastures were carrying quite double as many animals as the average recommended by the inspectors. As one result of this systematic resting, the grasses in each pasture were, to a greater or less extent, permitted to mature seeds, which, falling to the ground, increased the number of grass roots and in that way added materially to the capacity of the range for supporting stock.

Rest

If Mr. Middleton and others of the stockmen who entered the country first with their cattle are correct, namely, that originally all of that section had a capacity to sustain stock equal to 1 head to every 3 or 4 acres, it is evident that the station pastures have not yet been brought back to their original capacity. What has been accomplished, however, justifies the belief that if like methods on the general line of those pursued during three years to April, 1901, be followed during the succeeding three years, as a result of the six years' work the gain will aggregate several hundred per cent. Results quite as satisfactory are certainly practicable as to every pasture in central Texas. Where but 40 head of cattle are now being held it is possible to continue to hold as many on the pastures during a first year's work and at the same time much improve them. During the second year the work of range improvement may be continued, and the number of cattle on the pastures may be increased. During the third year the number can be still further increased and the work of improving the pastures still continued. The work may be continued year after year, the work each year being proportionately greater than that of the year before; and each year the proportion of cattle may be increased. An interested stockman of Taylor County submitted the inquiry: "Do you Government station men believe that the overstocked and almost ruined grass sections of this country may be brought back to their capacity for supporting cows as back in the sixties and seventies?"

The reply was given with every confidence in its absolute correctness: "It is not only possible, but each year while it is being done cattle may be held on the pastures, the proportion increasing year after year as the capacity of the pastures to sustain them shall be increased." It was practicable April 1, 1901, to place as many as 100 head of mixed cattle on the 640 acres included in the grass and forage plant station near Abilene and hold them thereon during the succeeding twelve months without giving them other feed than they could get for themselves. But that could not be done with the 640 acres thrown into one pasture and the 100 head of cattle allowed during the twelve months to range at will over the entire pasture. It pays to build and keep up pasture fences, and every stockman should see to it that instead of one or two large pastures he should have a number of small ones, some of which can be resting while the others are doing, perhaps, double duty.

Rest

THE MATTER OF COST.

In reply to frequent inquiries submitted by interested stockmen and farmers, facts and figures have been given out from time to time as to the cost of cultivating the pasture lands. If, as many suppose, such work meant an outlay of $2 to $3 per acre per year, it would mean that but few pasture owners would take such work in hand. The actual cost to the Department of Agriculture of having the station pastures cultivated can not be considered as fairly determining what the cost of similar work will be to pasture owners. The Department owned no horses, did not employ men to do the work, except from day to day or from week to week, hence had to pay more for the labor in proportion than farmers and stockmen are in the habit of paying for labor by the year. It was estimated that a man working steadily with a disk harrow could go over an average of 12 acres per day and do the work thoroughly. The prices paid were: For two-horse team and driver, $2.50 per day; for three horses and driver, $3, and for four horses and driver, $3.50. At times when there was plenty of work and labor was in demand higher prices had to be paid, but those named were about the average for the pasture work. Taking the highest price, as above, as a basis for calculating the cost of cultivating the station pastures, it would mean a trifle less than 30 cents per acre per year; for the three years' work, 85 to 90 cents. In fact, the cost to the Department did not average 25 cents per acre per year. Taking these figures as the basis of the calculation, it means that a 640-acre pasture would cost $160 per year, or $480 in three years. If the gain in the capacity to sustain stock should equal 100 per cent, it would mean that the income-producing value of the land would be doubled. If the value of the land for pasture purposes should be $5 per acre at

Bentley 1898

HOW THE STOCK RANGES MAY BE RENEWED.

In considering the question of how the ranges may be renewed, the ideas and opinions of the leading stockmen have been solicited. Their suggestions as to the best remedial methods to be employed for bringing the land back to its primal stock-carrying capacity are here given.

NO MORE OVERSTOCKING OF THE RANGES.

There must be no more overstocking of the ranges. On the contrary, as far as practicable, the land must be rested systematically. Some of the leading stockmen of the section are now dividing up their holdings into winter and summer pastures, one being held exclusively for winter use, and no stock being allowed to go into it until after the grasses have ripened and shed their seed, the other being used for spring and summer grazing. An enterprising stockman of Mitchell County reports that in two years, under such treatment, he nearly doubled the capacity of a pasture of about four sections. Riding over this pasture, notes were made of the different varieties of grasses. About fifty were found, more than double as many as were growing on adjoining lands where his cattle were and had been running during the spring and summer months. The reasons for this are obvious, and the good sense of the plan is plainly apparent. This gentleman never allows his stock to run on any one pasture longer than for sixty to ninety days, when they are transferred to another. There is good reason to believe that by adopting this plan the pastures could in a few years be brought back measurably to their original capacity for supporting stock.

Rest

SELECTION OF THE BEST GRASSES.

But something further will be necessary than merely securing more grass or forage. Not only must the stock be given plenty of grass, but it must be the best quality of grass obtainable. In a collection of the native grasses of central Texas referred to the Division of Agrostology for determination there were many varieties that occur in great abundance all over the range country. Some have the appearance of being excellent grasses, although careful consideration of them demonstrates that they are not really valuable, because not relished by cattle. On the other hand, several varieties that did not look promising were found to possess very superior qualities. Quality rather than quantity should be the controlling idea. For instance, an acre of sedge (*Cyperus*) will produce more herbage than an acre of blue grama (*Bouteloua oligostachya*), but the latter will be worth much more than the former for pasturage. Of all persons the stockman should be the most interested and the best informed as to the relative feeding value of the grasses. He should study them carefully and fully, so that in the efforts he must constantly make to improve his range he will be in a position to secure the best results by taking care of and propagating only such varieties as will pay for the care and trouble.

Some RR in This pub

U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY.—BULLETIN No. 13
B. T. GALLOWAY, Chief of Bureau.

page 19

EXPERIMENTS

Jared Smith

IN

RANGE IMPROVEMENT

IN

CENTRAL TEXAS.

BY

H. L. BENTLEY, SPECIAL AGENT,
GRASS AND FORAGE PLANT INVESTIGATIONS.

Reference

Type bracketed in red

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

PREFACE.

[redacted]es to their former condition [redacted] The experiments at Abilene were undertaken to demonstrate the truth of this statement, and the report of Mr. Bentley, special agent in immediate charge of the work, will be of more than ordinary interest, not only to stockmen of central Texas, but to all engaged in the cattle industry on the western ranges, as showing how the result in view was accomplished. What has here been done under Government direction may be done by individuals. In fact, the primary object of this report is to invite attention to the methods pursued and the actual results attained that all interested may take advantage of the experience acquired in the work. The results have demonstrated the practicability of reclaiming the worn-out ranges in central Texas, at least, within a reasonable time and expense. The land selected, which was a range below the average quality, was leased to the Department by Mr. C. W. Merchant for use in these experiments, and was fenced, in accordance with our directions, by the citizens of Abilene, and to this extent the work was cooperative with the people of that town. At the beginning of the experiments the carrying capacity of the pasture selected was 40 head of mixed cattle to the section, or 1 to 16 acres. When the experiments were concluded on April 1, 1901, the carrying capacity was estimated to be 100 head of mixed cattle for the 640 acres, or an increase of more than 100 per cent. The actual cost to the Department did not average more than 25 cents per acre per year, or 75 cents per acre for the three years. The rental of the 640 acres had doubled in actual value as the result of the three years' experiments, or, we will say, had risen from $5 an acre in 1898 to $10 an acre in 1901, giving a net increase of $4.25 per acre, or $2,720 for the section.

This office is under obligations to Messrs. D. W. Middleton, J. W. Parramore, and W. J. Bryan, of Abilene, Tex., who during the term acted as station inspectors and in many other ways cooperated and aided materially in this work. To Mr. P. O. Forbus, also of Abilene, who during three full years was foreman of the working force of the station and in many ways contributed to whatever success was secured, acknowledgments are also due.

F. LAMSON-SCRIBNER,
Agrostologist.

OFFICE OF THE AGROSTOLOGIST,
Washington, D. C., November 19, 1901.

EXPERIMENTS IN RANGE IMPROVEMENT IN CENTRAL TEXAS.

INTRODUCTION.

It has been written that he is a benefactor of the human race who makes two blades of grass grow where but one grew before. Might it not be said with as much reason that he who destroys the single blade is a promoter of civilization? At all events, the suggestion carries an interesting line of thought, and it may be well worth the while briefly to consider very briefly the present conditions of central Texas and the Southwest generally.

The capacity of this section for carrying live stock has been, during the past fifteen or twenty years, diminished four to five per cent as the result of either bad management or a reckless desire on the part of those who occupied it to "get rich in a hurry."

In Grazing Problems in the Southwest, and How to Meet Them, prepared by Jared G. Smith, under the direction of the Agrostologist, it is stated that the Secretary of Agriculture, fully appreciating these conditions, directed the Division of Agrostology early in 1897 to begin investigations of the forage problems and conditions throughout the regions of the Southwest with instructions that particular attention be given the native grasses and forage plants, their abundance and value, their preservation, and the possible methods to be employed in restoring the former carrying capacity of the ranges.

In line with these purposes, Mr. Smith visited central Texas in the spring of 1897. Finding there a condition of affairs that, in view of the large area of country included in his proposed field of work, called for a more extensive investigation than he could make in person, the writer was requested to undertake and make the investigations and submit a report upon the grasses and forage plants of central Texas. It was further suggested that the existing condition of the cattle ranges of the Southwest generally be looked into; that the causes of the radical exhaustion of the pasturage of central Texas particularly be determined, as far as practicable, and that a history of such exhaustion, with suggestions for its restoration, be submitted. This special commission having been approved by the Agrostologist, the writer

entered upon the work, and as a result of his investigations submitted two reports covering the same. One, A Report upon the Grasses and Forage Plants of Central Texas, was published in 1898 as Bulletin No. 10, Division of Agrostology, United States Department of Agriculture; the other, "Cattle Ranges of the Southwest, was published the same year as Farmers' Bulletin No. 72 by the same Department." The former contained brief accounts of the physical character of central Texas, the early and (then) present condition of the ranges, and descriptions and general observations upon the distribution and economic importance of a large number of the grasses and forage plants natural to the region. The latter report was a history of the exhaustion of the pasturage of central Texas particularly, with suggestions for its restoration. These two reports were applicable to a territory 200 miles long and 150 miles wide, between the ninety-eighth meridian and the western edge of the Staked Plains. As one result of these investigations and reports, it was decided to obtain control of a body of overgrazed land in central Texas in order to carry on, during three years, experiments in methods of practical range improvement. In March, 1898, Prof. C. C. Georgeson, then connected with the Division of Agrostology, was sent to Texas to select the land. He chose 640 acres near Abilene, and Prof. Jared G. Smith was commissioned to establish the work. In April the writer was appointed special agent in charge of this work, really the first ever undertaken either by the General Government or by State experiment stations.

The report here presented covers the work done under this appointment during the period between April 1, 1898, and April 1, 1901.

The central Texas country, to quote from Farmers' Bulletin No. 72, above referred to, includes all of the counties of Stonewall, Haskell, Throckmorton, Fisher, Jones, Shackelford, Nolan, Taylor, Callahan, Runnels, Coleman, Tom Green, Concho, and McCulloch, and parts of the counties of Kent, Scurry, Mitchell, Coke, San Saba, Brown, Eastland, Stephens, and Young. It embraces a territory about 100 miles wide east and west and about 200 miles long north and south.

The characteristics common to these counties are:

(1) An open country in the main, with some black-jack, post-oak, and live-oak timber on the uplands and ridges.

(2) A scattering growth of mesquite trees on the lands away from the streams, which, together with the timber on the streams, furnishes ample firewood and posts for fencing purposes.

(3) Numerous streams that furnish an abundance of "stock water," fringed along their banks with groves of pecan, elm, hackberry, wild china, cottonwood, and other trees.

(4) An altitude ranging from 1,500 to 1,900 feet above the sea level.

(5) A climate pure and bracing.

ment took it in hand it was one of the very poorest." Another remarked: "Don't think that because every stockman in these parts hasn't taken up the methods adopted here they are blind or indifferent. Many of them have been watching and taking notes, and are quietly making experiments on their own places, and I predict that the others will do likewise."

The world is slow to adopt anything new, but once let it be demonstrated that it pays to do so, and no people are more ready to take hold than are the farmers and stockmen of the United States. Hence, it is reasonable to believe that within a few years advanced methods of handling the ranges will be adopted in central Texas and throughout the Southwest generally, and that where one blade of grass now grows in a very few years several will be made to grow. The soil of these ranges is quite as rich in food for grasses and forage plants in 1901 as it was thirty years ago. The seasons are as good, in fact better, in that the rainfall is somewhat greater and is more satisfactorily distributed. Hence the belief that after the proper methods for rejuvenating the ranges shall have been generally adopted, it will not be many years before the range capacity for sustaining live stock will be quite as great as it was in the sixties and seventies, when there was no better stock country to be found than that of central Texas.

HISTORY OF THE FIRST YEAR'S WORK.

SELECTION OF THE LAND.

In March, 1899, Prof. C. C. Georgeson, of the Division of Agrostology, was sent by the Agrostologist to select a section of range land on which it was proposed to undertake and prosecute experiments "to demonstrate the most practicable, and at the same time the most economic, way of treating the natural pastures in order to again cover them with the native grasses or with other species from similar regions in other countries." He put in several days looking over the many sections recommended to him for the purposes in view. Some of them were already fairly good ranges, but he was looking for one that had been run down until it was distinctly a very poor range. Some of them were valley lands altogether, the soils being uniformly rich and specially favorable for the growth, under favorable conditions, of grasses and forage plants, but he was looking for one that was poorer and if anything less favorable for range purposes than the average. He was acting on the idea that if a body of land already stocked with grasses, or one specially located, or specially rich in the matter of its soil, should be selected, no matter how successful might be the results of the experiments to be made, they would not be accepted as demonstrating the correctness of the methods adopted. There would be many who could say, with some reason, and would, in

fact, say that "anybody could take as rich a range as that, with a good lot of grass to begin with, and make a favorable showing under fair conditions." What the Agrostologist wished to secure was results which, if satisfactory, would be accepted as being due to the putting into practice of correct theories and pushing them on correct lines. That is what Professor Georgeson had in mind when he selected an irregular body of land containing 640 acres lying about 4½ miles southwest of Abilene, in Taylor County. The following diagram of the land, with the explanation to follow, is submitted:

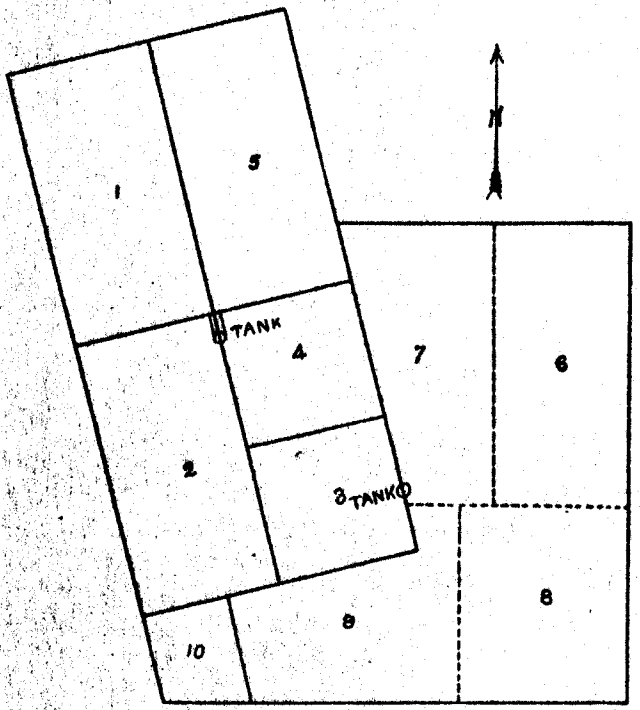


FIG. 1.—Plan of the station grounds.

Mr. C. W. Merchant, who owned the pasture which included this 640 acres, had authorized Professor Georgeson to cut out all he cared to use in any shape to suit himself. There was no running water on any part of the tract selected, but through each of the subdivisions indicated were the beds of dry branches and holes that held water after copious rains, the water flowing into Elm Creek of the Brazos River, which supplied in the main the stock water for the entire Merchant pasture. Next to these branch beds were level lands known, locally, as "second valley lands," to distinguish them from the valley lands lying next to the creeks and rivers. All of these valleys were narrow, and extending out from them were lands known, locally, as "the

uplands," being level stretches, as a rule, above the valley levels, though in the north parts of subdivision Nos. 1, 5, 7, and 8 were rough hills which were considerably higher than the surrounding lands. The purpose of taking in these rough valley hills was to make it certain that a lot of very poor and unpromising land, as well as some average level uplands and some valley lands, might be included. As Professor Georgeson explained.

> If these hill lands, rough, gravelly, and rocky, very poor in quality, and now almost destitute of grass or grass roots, can be reclaimed, it will mean much more to farmers and stockmen than the reclaiming of level and comparatively rich valley lands will mean to them.

How well he succeeded in his efforts to locate the grass and forage-plant station on land below the average of the neighboring lands in favorable position, quality of soil, and quantity of grass and grass roots then in sight, the significant remarks of visitors to the station and the further facts to be hereafter stated will assist in determining.

Ex-Congressman J. V. Cockrell, of the Thirteenth Congressional district of Texas, visited the station in 1899, and remarked: "You have here about the roughest and poorest section of land in all this part of the country;" and it was quite the expected and the usual thing for visitors to the station, in 1898, to notice and comment on the fact that the land was evidently not selected with the view to securing the best. The valleys and uplands, outside of the hills, were of fair average quality as compared with the other rough lands in that part of Taylor County, but the hills mentioned were exceptionally rough and the soil very thin. It was in order to take in these hills, and also some of the richer small valleys, and a fair average of the uplands, that the 640 acres were selected in the very irregular shape indicated (fig. 1).

PLAN OF EXPERIMENTS.

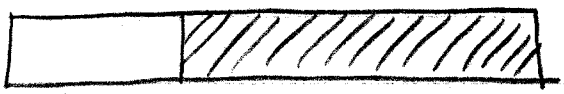
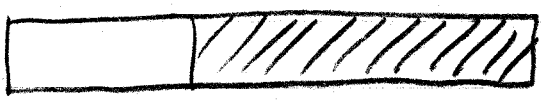
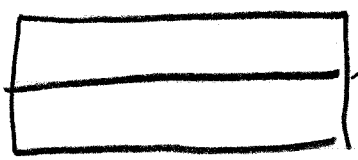
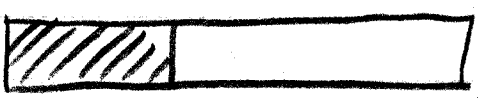
Having secured the land, Professor Georgeson returned to Washington, and Prof. Jared G. Smith, then Assistant Chief of the Division of Agrostology, took charge of the work; but in a short time, his services being more essential elsewhere, he was recalled to Washington, and the writer was placed in charge as special agent, and continued in charge to the latter part of March, 1901, when, the three years' work having been completed, the station was restored to Mr. Merchant.

The section was divided by survey lines into six portions of 80 acres each, and one of 70 acres, the remaining 10 acres being set apart as a grass garden to be devoted to the cultivation of grass and forage plants. It was originally contemplated that all of the division surveys, as shown in the diagram, should be fenced, but in fact, those indicated by the dotted lines were not. The five pastures and garden fenced included 330 acres, and the four subdivisions not divided by fences,

Bentley 1902 Jared Smith

3 year test

Mar. 1899 to March 1901

		Land treatment
No 1	 June 1	none
No 2	 June 1	disk-harrow
No 3 & 4	 Alternate grazing every two weeks	none
No 5	 June 1	none
No 6	Rest 1st season	none
No 7	As in No 6 but	tooth-harrowed
No 8	" " " "	disked

Land flat except rough hills in northern portions of 1, 5, 7 and 8

310 acres. The work of the subsequent three years, as planned, was as follows:

Pasture No. 1 (60 acres): No treatment except to keep all stock off until June of each year, pasturing the balance of the season.

Pasture No. 2 (60 acres): To be cut with a disk harrow and stock to be kept off until June 1 of each year, pasturing the balance of the season.

Pastures Nos. 3 and 4 (40 acres each): To be grazed alternately, the stock to be changed from one pasture to the other every two weeks, thus allowing the grasses a short period for recovery after each grazing.

Pasture No. 5 (60 acres): No treatment except pasturing until June 1 and keeping stock off the balance of the season.

Pasture No. 6 (60 acres): No treatment, except to keep stock off during the first season.

Pasture No. 7: To be harrowed with an ordinary straight-toothed harrow and stock kept off during the first season.

Pasture No. 8 (60 acres): To be disked and stock kept off during the first season.

Pasture No. 9 (70 acres): Reserved for special experiments, viz, to determine—

(1) Whether or not seeds of a number of wild and cultivated varieties of grasses, and forage plants exclusive of the grasses, could be sown directly in the sod with satisfactory results.

(2) Whether the roots of certain sod and pasture grasses could be transplanted to the bare spots and a good stand secured in that way.

(3) Whether the stand of grass could be improved by opening furrows across the pastures, in which the grass seeds blown over the ground by the winds could be arrested and the stand of grass be improved.

The results of these several experiments, with the necessary details, will be stated hereafter.

CARRYING CAPACITY OF THE PASTURES.

In order to determine from year to year the extent of the improvement, if any, in the range conditions, it was necessary to ascertain the capacity of the section for sustaining stock at the very start of the work. To that end, three well-known stockmen of central Texas were invited to make a full and painstaking inspection of practically every part of the section. They were C. W. Middleton, J. W. Parramore, and W. J. Bryan, all of Taylor County and all old settlers in that part of the State, each a large owner of cattle, and, therefore, specially interested in the results to be secured. That each one of them could accurately estimate the capacity of a range to sustain stock no one in the Southwest, where they are extensively known, could for a moment doubt. It was believed, therefore, that an expression of opinion by them on the subject would be accepted as definitely determining the capacity of the particular section under consideration. They made a personal and minute inspection of every acre of the section on March 23, 1898, and unanimously reported that its utmost capacity at that time was the support of mixed stock at the rate of 1 head to every 16 acres, or 40 head to the section, in the proportion of 10 cows with calves, 15 yearlings, and 15 two-year-olds. Mr. Middleton, who during several years prior to 1898 had held his

cattle in a large pasture which at that time included this particular 640-acre tract, is authority for the statement, made by him to his associate inspectors, that when he first knew it, in the seventies, its capacity for supporting cattle was quite 160 head of mixed cattle to the section of 640 acres, including the hills mentioned. He explained that the large difference between its present and its former condition was due to the fact that, in common with all the other range lands of the section, it had for years been overstocked. Prior to the date of its purchase by Mr. Merchant, only a short time before 1898, it had first been part of the open range in which everybody's cattle roamed at will, and later had been held under lease; and in each case the cattle roaming on it had been permitted to graze it closely. This was the situation, say, April 1, 1898, and the problem to be solved was: "Is it practicable, as the result of carefully planned, systematic work, to take this land, which once had four times its present capacity for sustaining stock, and restore it to its original value as a pasture?"

SEEDING THE GROUND.

Before Professor Smith left he personally superintended the experimental work as planned to be done on pasture No. 9. He had several acres sowed, without disturbing the surface, to the seeds of quite a variety of grasses and forage plants, including several of the weeds recognized by stockmen as having definite value as early stock feed. He also made an effort to get a stand of Texas blue grass and curly mesquite by transplanting fragments of sod to the bare spots, but on account of the dry weather that followed practically none of the seed sown germinated, and all of the sods put in the ground died. He also had the 10-acre garden tract broken, but necessarily, it being sod land, the breaking was shallow—only deep enough to turn under the sod. On this tract he sowed broadcast seeds of many varieties of grasses and several varieties of alfalfa, and later several varieties of cowpeas and velvet beans.

A shower following these sowings, some of the seeds germinated, but after a brief effort to exist only the alfalfa, cowpeas, and teosinte survived the distressing shortage in rainfall that followed. The precipitation during April, 1898, was much below normal, being only 1.78 inches, and the maximum temperature was 92°, much above normal. There were only 2.60 inches of rainfall during May, and the temperature for the month was abnormally great, the maximum being 101°. During June the precipitation was satisfactory, being 4.55 inches, but it came too late to save the garden work. In July the temperature went to 102°, and the rainfall fell off to 1.46 inches. During the next month the weather continued favorable, the rainfall being 1.94 inches, the temperature ranging between 81° and 98°. September promised more satisfactory weather, but while the rain-

fall was 3.44 inches, the heat continued excessive, reaching as high as 100°. There was but a trace of rain during October, and the mercury remained up in the nineties, and went up to 94°. In November less than 1 inch of rain fell, and during the next three months there was not enough to materially raise the average for the twelve months, the precipitation during December being 2.14 inches, only 0.51 inch during January, 1899, and only 0.01 inch during February following. The oldest settlers of central Texas still talk feelingly of the memorable drought year of 1887, but it is a fact that there was even less rainfall in 1898 than in 1887. Early in the spring cattle had been placed in the station pastures, and as long as the stock water lasted the plans for handling them, as set out above, were carefully followed, but from time to time the water supply gave out between rains, and the cattle had to be taken to other pastures in which there were streams of running water. By the end of November the effort to hold them even temporarily in any of the station pastures was abandoned.

When the garden tract (10 acres) had been planted, as stated, its only fence was 5 strings of barbed wire. Soon after the alfalfa, cowpeas, and teosinte began to grow the prairie dogs and jack rabbits from every point of the station and from the outside moved en masse to them, destroyed nearly all the alfalfa roots, and did considerable damage to the velvet-bean and cowpea vines and the teosinte. Enough seed of the cowpeas was saved for another year's trial. The velvet beans, in spite of the long-protracted hot weather and the short rainfall, made a surprising vine growth, but they bloomed and the abundant crop of pods formed too late to mature a crop of beans before the frosts of October, which were much earlier than usual for that section. The teosinte made a vigorous growth of 18 to 32 inches, when the drought began and the growth stopped, the roots being too far gone to do well when the fall rains set in. The roots survived the drought and the shoots made some growth until frost, but no seed matured.

As a result of these several garden experiments a report was made to the Agrostologist under date of November 24, 1898, in which it was suggested that with normal amount of rain during the next year it would be practicable to demonstrate: (1) That alfalfa of all kinds could be grown successfully without irrigation in central Texas; (2) that teosinte would prove a splendid forage plant for the section—in fact, superior for forage purposes to any of the sorghums as tested to date; (3) that the velvet bean would prove a crop of much value; (4) that all of the several varieties of cowpeas, which had been experimented with to date, would be shown to be available crops for forage purposes; (5) that practically no definite results had been secured so far as the grass seeds sown were concerned, only a few of the varieties having germinated, none of them having developed satisfactorily on account of the drought. It was also suggested that the work had given sufficient

promise that definite, tangible results on similar lines, of much benefit to the farmers and stockmen of central Texas, would be secured as the result of further experiments. In the matter of the efforts to secure range improvement as the result of harrowing and disking three of the 80-acre pastures, it was suggested that they had proven satisfactory and justified the belief that a rapid increase in the quantity of grass on the overstocked pastures was practically assured.

This work was done during March and April, and the rainfall during May (2.60 inches) was satisfactory to the extent that notwithstanding the hot weather heretofore mentioned the grass in the three pastures was very much better than that in the station pastures not treated and in those in the same neighborhood outside of the station. In two of the pastures a disk harrow was used which every 4 inches cut furrows from 3 to 6 inches deep, as the surface of the ground was harder or softer, or gravelly, or free from gravel. In the other pasture treated an ordinary iron-tooth harrow was used, heavily weighted at times, the effect being to scarify the surface as thoroughly as possible. There was rather a heavy growth of mesquite trees growing in each of the pastures, and it was not possible, therefore, to cut into every acre of the ground.

In this connection it may be well to explain that the theory on which this work of harrowing was done was: (1) That by cutting into the ground by disk or harrow teeth the grass roots would not necessarily be injured, but on the other hand would be given a better chance for development through the looser ground below the surface; (2) the surface runners from the grasses would be given softer ground in which to take root readily; (3) the storm waters would be saved instead of being allowed to run off into the lower places, and thence into the creek beds and rivers, and the rain would go into the ground where it fell and directly to the grass roots; (4) seed beds would be made in which the grass seeds, as they fell to the ground, or were blown over the hard ground elsewhere by the winds, would be arrested and find suitable places in which to germinate.

Notwithstanding the drought of 1898, there was a very marked improvement in the conditions of the several pastures treated. During the latter part of March, 1899, just one year from the first inspection above mentioned, Messrs. Middleton, Parramore, and Bryan made a second inspection of the station and unanimously reported that the conditions during the year had improved so that the section of 640 acres, taken as a whole, had in March, 1899, a capacity to support mixed cattle at the rate of 1 head to every 10 acres, or 64 head to the section. During the next month Messrs. Middleton and Bryan made another visit to the station, again carefully inspected the pastures, and reported that the capacity of the section for mixed cattle was then at the rate of 1 head to every 8 acres, or 80 head to the section. This was after the

spring rains had begun to fall and the grass was making growth. The gains as reported by the committee were phenomenal, considering the fact of the drought of 1898, being 100 per cent in a single year, and, had the station pastures been stocked during the year to their capacity, as recommended by the committee in March, 1898, it would have been fair to take the result as demonstrating the correctness of the theories underlying the methods adopted to improve the range. But on account of the droughts the pastures were not stocked nearly as heavily as had been recommended during a considerable part of the year, and it was still an open question whether the improved condition of the station pastures, especially those which were harrowed and disked, was not quite as much due to the fact that they had been rested at the season when the grass seeds were maturing and dropping as to the fact that the surface had been treated.

CONCLUSIONS FROM THE FIRST YEAR'S WORK.

At the end of the first year's station work the facts as above set out were reported to the Agrostologist, and the conclusions as submitted were:

(1) That it will pay farmers and stockmen of Texas, especially in the semiarid regions of the State, to cultivate their pastures by use of disk and iron-tooth harrows.

(2) That it will pay them to rest their pastures periodically during the seasons when the grass seeds are maturing and falling to the ground.

It was believed then that the results of the station work to that time, under the conditions set out, clearly demonstrated the correctness of these conclusions, and later results have confirmed them.

HISTORY OF THE SECOND YEAR'S WORK.

EXPERIMENTS WITH VARIETIES.

The conditions under which the work was continued into the second year were very difficult. In the first place the continuous extreme cold during the months of January and February was very unfavorable for experimental work. During January the thermometer frequently indicated several degrees below freezing point, and during February there were but eight days when the temperature was above 32°. The month of January was dry, even for that section, the total precipitation being only 0.51 inch. During February it was but 0.01 inch—practically nothing—and only 0.04 inch during March. During the autumn of 1898 the 10-acre garden tract had been plowed deep with a turning plow, the purpose being to expose the earth to the freezes to follow and to save every drop of rain that might fall there.

forage plants were secured, as of the cowpeas, velvet beans, teosinte, sorghums, and alfalfas. It was determined to experiment with them and also with pearl millet and the common peanut vines with the view to ascertaining whether they could be baled and in that way preserved in good condition for feeding purposes. When the cowpeas were nearly in full bloom, and before they began to turn yellow, the vines were cut and carefully cured as for hay. Velvet-bean vines, with pods on them, but in a very immature state, were also cut, cured, and stacked. Some of the smaller teosinte stalks, which had survived the drought, were also cut, cured, and placed in shocks. Several varieties of sorghums were cut and cured when the stalks were tender and the heads in the "dough" state, and bundles of alfalfa and pearl millet were also prepared for baling. During the season all of these stuffs were baled and the bales packed away under a shed to await developments. After several months a bale of each of the stuffs was opened and examined, and in every case the hay was found to be as sweet as when first baled.

It is recommended that the stockmen and farmers of central Texas and of the Southwest generally test the value of this method of preserving the coarser forage grown on their own ranches and farms.

EXHIBITS AT FAIRS.

In the autumn of 1899 a collection of bales of hay grown on the station, including some of the baled forage plants above mentioned, was sent to the Division of Agrostology, Washington, D. C., where they were included in the general exhibit sent by the Department of Agriculture to the Paris Exposition of 1900. The Agrostologist stated that they made a very interesting and valuable part of the Government exhibit. Duplicates of the collection, with the addition of a few bales of grasses grown in the Abilene country, but not on the station grounds, were made up into an exhibit and turned over to the managers of the district fair held in Abilene in October, 1900. The display attracted much favorable attention from the large number of stockmen and farmers present, many of whom were led to take an interest in the later station work.

SUMMARY.

At the end of the second year's station work the foregoing facts were reported to the Agrostologist with a general estimate as to the results secured. In the report it was asserted that notwithstanding the adverse conditions under which they had been conducted, many of the experiments made during the year had yielded results of substantial value. They had demonstrated the availability of the alfalfas, sulla, sanfoin, the vetches, several varieties of cowpeas, velvet bean, soy

bean, teosinte, and several varieties of sorghum for annual or temporary pastures and for hay purposes. They had shown the possibility of utilizing to good advantage, for permanent pasture purposes, the seeds of such grasses as the gramas, mesquites, wild timothy, cotton top, Canadian rye, and everlasting grass. They had definitely proven that range improvement could be secured by judiciously resting the pastures, by cultivating the sod, and by sowing the seeds of hardy native and improved grasses. These and the other results secured had satisfied many stockmen and farmers that, at comparatively small expense, they could greatly improve their ranges, and that by the cultivation of many excellent grasses and forage plants, up to that time known to them only through their books and papers, they could add very much to the productive capacity of their ranches and farm pastures.

HISTORY OF THE THIRD YEAR'S WORK.

WEATHER CONDITIONS.

From April 1, 1900, to and including the month of March, 1901, when the station work was concluded, the conditions in the main were satisfactory, as were the results secured. Notwithstanding the difficulties experienced during the former two years, enough had been accomplished to give substantial results during the next twelve months.

As stated above, many of the experiments made to date had proven failures, but they had suggested and opened up the way for the adoption of better methods. Of the other experiments some had been in part successful, while still others had proven entirely satisfactory. With two years' experience, and the record well in hand as the basis for future work, that work was begun under very encouraging conditions.

The seasons throughout the twelve months, while not all that could have been desired, were good and in striking contrast to those of the preceding twenty-four months.

During April there was abundant precipitation—5.43 inches—which put the grass-garden land in excellent condition to receive seeds and the pasture lands in like condition to be cultivated and otherwise handled. During May the rainfall was 4.11 inches, which was very favorable to the growth of the garden stuffs and pasture grasses. The temperature during these two months was normal, hence satisfactory. By June 1 a large number and variety of seeds had been sown in the grass garden, and good stands of practically everything planted had been secured. The pastures selected for special treatment, as set out in the original plans, had been disked, and, owing to the abundant rains and the favorable temperature that followed, the grasses in them were developing rapidly; and the grasses in the other pastures were green and vigorous to such extent that it was considered safe to hold on the entire 640 acres of pasture land not less than 85 head of mixed

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 38.

B. T. GALLOWAY, *Chief of Bureau.*

FORAGE CONDITIONS AND PROBLEMS IN EASTERN WASHINGTON, EASTERN OREGON, NORTHEASTERN CALIFORNIA, AND NORTHWESTERN NEVADA.

in 1902

BY

DAVID GRIFFITHS,

ASSISTANT IN CHARGE OF RANGE INVESTIGATIONS.

GRASS AND FORAGE PLANT INVESTIGATIONS.

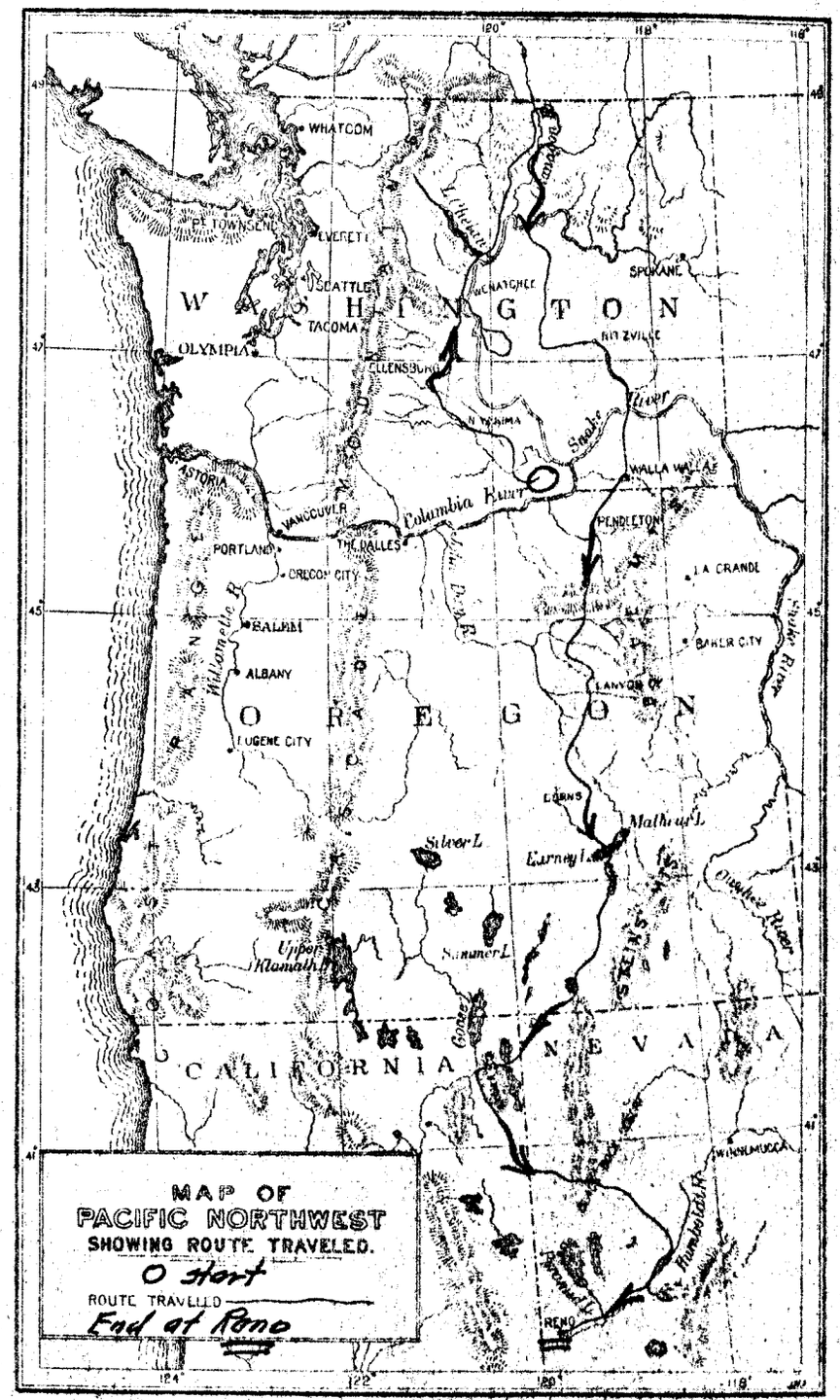
Indicator plants pg 16
Warner Mts
Condition 22-24
Over stocking
RR Page 15

ISSUED JULY 3, 1903.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1903.



CHANGES IN THE HANDLING OF THE WASHINGTON RANGES.

During the past few years there has been great progress toward a more systematic handling and at the same time a more stable and permanent adjustment of the stock industry in the region of the Big Bend and the country adjacent to it. In many particulars the changes are radical, and in some instances the industry has been remarkably curtailed, though probably not permanently, for the reduced area devoted to the raising of live stock will doubtless be made, when the new conditions become adjusted, to support proportionally a much larger number of animals than it formerly did.

One of the greatest factors in the production of these changes has been the extension of the wheat areas to include practically all of the tillable land of the entire region, apparently regardless of the rainfall. Large areas west of Ritzville, near Trinidad and Waterville, and in the "Horse Heaven" country have in recent years been reclaimed for wheat culture. Some of these areas may not be permanently occupied by wheat, since the average annual rainfall on some of them is less than 10 inches, and some of the more conservative farmers think they will eventually revert to the range.

But the most important factor in these changes has been the agitation brought about in recent years in favor of the passage of a lease law by the National Congress. This agitation, though it has not crystallized into any definite action, has induced many of the nomadic sheepmen, who heretofore owned no land, to invest in lands in anticipation of the enactment of lease laws, which, in all bills thus far introduced, give preference to the actual holders of landed interests. The presence of large areas of railroad land in this region has enabled many to secure from the transportation companies, by lease or purchase (usually the latter), tracts of land suited to their needs. Of course much of this purchase is purely speculative, but a very large proportion of the land so acquired has been bought by those who are and have been for years in the stock business on the public domain. As the railroad land consists of alternate sections, the ownership of these tracts virtually gives the investor control of the adjacent sections of the public domain. As is well known, our homestead laws do not adequately meet the necessities of the man who proposes to embark in the stock business in the semiarid regions, particularly where the railroads own alternate sections. Even a whole section of land is too small a unit for range operations, so that a homestead can only be used as a base for a stock range in cases where all the surrounding lands are a part of the public domain. Indeed, the farmer who raises wheat in this region needs more land to obtain a reasonable compensation for his labor than he can secure under our land laws. In recent years most of the land within the railroad grant has been brought under individual control,

and the open-range question is here practically a thing of the past. The greater part of this area is still unfenced, and the boundaries of the different possessions are only approximately maintained, but much of the land is being fenced, section by section, which permits systematic pasturing. This change has yielded results far beyond the expectations of the ranchers.

In one case which came under observation it was estimated by a rancher that the land under his control had increased in grazing capacity about 50 per cent during the past two years, with no decrease in the number of cattle carried on the entire area. One section is pastured at a time, and grass is allowed to attain considerable growth before being pastured, instead of being grazed close to the ground all the time.

In another instance in the same vicinity a year's rest of two and a half sections of pasture land had yielded marvelous results. This land had formerly been grazed by sheep, and the pasture had become so short that the owner disposed of it to the present occupant, who proposed to embark in the cattle business. He allowed his land to rest one year with practically no stock upon it; the gain in feed was remarkable.

Much of this land is used as winter ranges for sheep, which are either herded during the summer months in the mountains to the westward or pastured on the fallow lands in the wheat-growing regions to the east. This treatment will probably increase the capacity of these ranges to a maximum in a few years, provided the summer season of rest is sufficiently prolonged. It is very important in handling these lands as winter pastures not to keep stock on them too late in the spring. In this region the growth of vegetation occurs only in the spring, and stock are sometimes unable, on account of snow, to get into the mountains soon enough to allow much recuperation after the season of grazing before the advent of the dry season, which begins not later than June.

CONDITION AND PLANTS OF THE RANGE.

The best range seen on the entire trip, and indeed the best open range the writer has seen since the early nineties (with the possible exception of the Clear Creek region in the Big Horn Mountains of Wyoming in 1898), was that of the Okanogan hills in northern Washington. The generally good condition of the feed in this region is due to the fact that the country for various reasons has not been overstocked. A large part of this area is occupied by the Colville Indian Reservation, and some of the lands along the river are taken up by Indian allotments which have not been improved to their full capacity for hay production. The length of the winters, the heavy snowfall,

prominent on the high elevations. After reaching the Grand Coulee, however, we were never out of sight of sagebrush until the wheat region west of Ritzville was reached. In many places on the lower, well-drained slopes, there were large patches of giant rye grass (*Elymus condensatus*), while bunch bluegrass (*Poa lævigata*) is of considerable value on the lower portions of the depressions.

The Grand Coulee, which crosses the Big Bend country from north to south, is a deep gorge, 1 to 3 miles wide, and was the bed of the Columbia River during the glacial period. The portions of this coulee visited are in most cases very alkaline. In places there is some seepage from the bluffs which has washed the salt out of the soil over limited areas, and these produce good crops of hay. In the vicinity of the numerous ponds only salt-loving plants are found. In one place was seen a large area, half a section or more, covered with creeping spike rush (*Eleocharis palustris*), which was practically the only forage plant growing in this hay meadow. In the vicinity of the numerous ponds salt grass (*Distychlis spicata*) abounds, and grease wood is always found a little farther from the ponds, while on the better-drained lands the common sagebrush is the most conspicuous vegetation everywhere. The saltbushes (*Atriplex* spp.) are of little account here as compared with the Great Basin region to the south. As would be expected in such a formation and with such physical features, conditions are quite variable. One runs into unexpected areas of grass in pockets in the bluffs where the vegetation is wholly different from anything found for miles around. As an example, might be mentioned a shelf-like recess in the bluffs on the north side of the coulee, where there was an excellent stand of water foxtail (*Alopecurus geniculatus*) covering an area 2 or 3 acres in extent. Usually this grass is not abundant enough to attract much attention anywhere.

On nearly all of the "scab" lands from here south along our route to Trinidad, as well as at other points in the Kittitas and Wenas valleys west of the Columbia River, the black sage of the mountains (*Artemisia arbuscula*) predominates over the common black sage of the lower, more sandy soils. Here also there are large areas of the valuable species of sage known to botanists as *Artemisia rigida*. This differs from the other two closely related species in having finely divided leaves and in being relished by stock, more especially by horses and sheep. It was especially abundant at Trinidad, on the western exposure of the Kittitas Valley, between Ephrata and Moses lakes, and in the vicinity of Lyons Ferry. In all of these localities it showed evidences of being grazed during the past winter.

As far as observed, the areas which have been opened up to wheat culture are not particularly sagebrush lands. On the contrary, they

lands, and the shrubbery, when there is any, is mainly the rayless golden-rod (*Bigelovia graveolens*), which is also sometimes called sage. This was the main shrub on nearly all of the wheat lands traversed, especially in the Ritzville and Walla Walla regions. West of Ritzville, however, at the present time wheat ranches are being opened up very rapidly on the sandy sagebrush lands 8 or 10 miles east of Moses Lake. We did not, however, see the establishment of wheat on these sagebrush areas, and it remains to be proved whether the experiments in wheat growing conducted there will be permanently successful.

From the standpoint of quantity, bunch wheat grass (*Agropyron spicatum*) is without doubt the most important grass in the Big Bend region, although the bluegrasses and sheep fescue heretofore mentioned are of much prominence on the higher elevations as well as on the "scab" lands. Owing to the rapid extension of the wheat area, the localities where this grass grows pure are rapidly diminishing in number. It may be said that the form of the grass which is so important here is that designated by botanists as *Agropyron spicatum inerme*, which is so named from the fact that the chaff which incloses the seed is without awns. As one proceeds southward even a short distance into the Blue Mountains, the awned form appears and the awnless one is almost, if not quite, absent.

Attention was called in last year's report[a] to the two forms of sheep fescue in the mountains of Nevada, and it was stated there that they often grow in nearly distinct areas, the glaucous form at higher elevations than the smooth variety. The two forms are found here also; but, although well marked, they have not been observed in separate areas as in the southern desert mountains. As far as forage value is concerned, there is no apparent difference in the two forms.

Although several newly established wheat areas were passed through, there were but two well-established ones on our route. The first extended from about 20 miles west of Ritzville to the "scab" along Cow Creek; the second, from about 8 miles south of Lyons Ferry to Pendleton, Oregon. The developing areas are located at Trinidad, on the high table-land south of Conden's Ferry, and at Ephrata. All the remainder of the territory traveled over in the State is devoted to cattle raising, and all is pasture land except such regions as North Yakima, Wenas, and Kittitas valleys, and small areas in the vicinity of Checonnully and Loomis and along creeks emptying into the Columbia River, which are devoted mainly to the culture of hay crops under irrigation.

The poorest "scab" land vegetation is well illustrated by a collection made south of Ephrata, near the Ferguson ranch. The shrubs were by far the most abundant form of vegetation. They consisted

[a] Bulletin No. —, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1902, p. 52.

of the eriogonums (*Eriogonum dichotomum*, *E. sphærocephalum*, and *E. thymoides*), tetradymia (*Tetradymia canescens*), audibertia (*Audibertia incana*), gilia (*Gilia pungens*), black sage (*Artemisia arbuscula*), and a little *A. rigida*. Of these the eriogonums and *Artemisia rigida* are of economic value. The former are especially useful as a browse for sheep, as undoubtedly nearly all of the species of this genus are when good feed is scarce. The herbaceous vegetation, aside from the grasses, consisted entirely of a scattering growth of *Gayophytum ramosissimum* and *Lygodesmia juncea*, both of which are of some importance as sheep feed. The grasses were few, scattering bunch wheat grass (*Agropyron spicatum*) being the most important, while there was an occasional bunch of needle grass (*Stipa thurberiana*) growing up through the bunches of shrubs. Fescue (*Festuca microstachya*) occurred in very small quantities, and some of the root leaves of Sandberg's bluegrass (*Poa sandbergii*) were in evidence where protected by rocks. It is to be understood, of course, that the above represents the vegetation at the time of observation (July). In the spring there are other short-lived species which furnish some feed. On the better classes of "scab" lands, along Cow Creek and south of Trinidad especially, sheep fescue and the bluegrasses (*Poa nevadensis* and *P. wheeleri*) are more abundant.

The condition of the feed in the Blue Mountains of Oregon was variable, even in areas where meteorological conditions as well as altitude are very similar. This is due entirely to the method of handling the ranges. In the vicinity of the mountain settlements where sheep are excluded the condition of the grazing lands is much better than in the open country. The "dead lines" established by the ranchers, usually on the watershed of the valley, although not always rigidly maintained, have done much to preserve the original vegetation, for it is not as closely eaten off by cattle, a few of which are possessed by every rancher, as by the immense flocks of sheep which are driven into these mountains from all directions. The great stretches of desert range almost surrounding these mountains furnish abundant winter pasturage for sheep, but the summer supply for the growing lambs in the mountains is comparatively limited. The Blue Mountains, therefore, have been the battle ground of conflicting stock interests which have striven for the past twenty years for the major share of the free grass. The homesteader, by protecting small tracts about him, has improved conditions wonderfully in limited areas. But those areas which are not subject to individual control have been so closely pastured that there is no more feed in some localities than on the deserts below. Plate V, figure 1, shows a moist meadow on the north slope of the mountains where there should be, and where there was formerly, a luxuriant growth of grasses, clovers, and sedges, but which is now all but barren of vegetation. A complete collection of the plants

which grew here showed not a single perennial and no annuals over 2 inches in height. These had apparently developed from seed during the previous month, after the sheep had been moved to higher altitudes. The reduction of a sedgy mountain meadow to an almost bare surface, where nothing is to be found but stunted plants of *Navarretia breweri*, *Linanthus harknessii*, knotweed (*Polygonum douglasii*), *Eritrichium californicum*, *Matricaria discoidea*, and burnet (*Poterium annuum*), is a condition much to be deplored, and is certainly not conducive to the best interests of the stock industry. In sheep territory it can be stated that there are few shrubs, aside from the snow brush (*Ceanothus velutinus*) and a few of the phloxes and gilias, in these mountains which are not browsed; and the timber does not grow too thick for sheep to graze in. Even the second growth of pine (*Pinus ponderosa*) is browsed in many places.

The forage plants, especially the grasses, do not differ materially from those of the higher elevations in eastern Washington previously discussed. The conditions are mostly such as would be recognized only by the critical student of grasses. Bluegrasses (*Poa nevadensis*, *P. wheeleri*, *P. sandbergii*, and *P. buckleyana*), sheep fescue (*Festuca ovina* in both its forms), bunch wheat grass (*Agropyron spicatum*), prairie June grass (*Koeleria cristata*), short-awned brome (*Bromus marginatus*), orchard barley (*Sitanion longifolium*), giant rye grass (*Elymus condensatus*), tussock grass (*Deschampsia cæspitosa*), and needle grass (*Stipa viridula* and *S. thurberiana*) are the main species on the open areas, while in upland shady places and in brush and timber areas are to be found a form of Kentucky bluegrass (*Poa pratensis*), downy oat grass (*Trisetum subspicatum*), oat grass (*Danthonia californica*), melic grass (*Melica subulata*), and mountain rye grass (*Elymus glaucus*), together with pine grass (*Carex geyeri*), which constitute the main feed in these localities at an altitude of 4,500 to 6,000 feet. On some of the bare, rocky slopes on the open range occurs some clover (*Trifolium plumosum*). This is seldom so abundant that seed could be collected in quantity. Its strong root system and general habit in barren soils would lead one to believe that it might be of some value on the upland ranges if some method could be devised for its propagation so that seed could be collected advantageously. Along all the creeks and moist areas throughout the region fine feed is produced by other species of native clovers (*Trifolium beckwithii*, *T. cyathiferum*, *T. altissimum*, and *T. involucratum*), while in the same localities there are many species of sedges and rushes which are really of more importance than the grasses in many situations. In these more moist localities are also found mountain timothy (*Phleum alpinum*) and whitetop (*Agrostis asperifolia*).

The numerous pastures in the vicinity of the settlements are used almost entirely for winter grazing, the stock feeding upon the open ranges dur-

ing the summer season. When not pastured too late in the spring, these were in good condition. Very often they appear overstocked, with the result that the weedy plants predominate to a remarkable degree. A collection of plants made in one of these mountain pastures in Camas Prairie will illustrate the effect of too close grazing, especially when the frost is going out of the ground in the spring. This was an open, rocky meadow, with stiff clay soil. There was here originally a good pasture of Sandberg's bluegrass, bunch wheat grass, sheep fescue, Wheeler's bluegrass, Nevada bluegrass, and prairie June grass. These are now very thin and scattering, having been trampled out to a large extent in late May and early June when no stock should have been allowed in the fields on account of their soft and miry condition. The following species were the abundant and conspicuous plants in the pasture: Yarrow (*Achillea millefolium*), black sunflower (*Wyethia amplexicaulis*), arnica (*Arnica alpina*), erigeron (*Erigeron aphanactus*), gaillardia (*Gaillardia aristata*), balsam root (*Balsamorrhiza incana*), lupine (*Lupinus sulphureus*), *Clarkia pulchella*, onion (*Allium madidum*), *Navarretia breweri*, phlox (*Phlox gracilis*), gilia (*Gilia aggregata*), eriogonum (*Eriogonum heracloides*), geum (*Geum trifolium*), *Pentstemon attenuatus*, *Scrophularia orthocarpus*, *Deschampsia calycina*, knotweed (*Polygonum douglasii*), *Lomatium leptocarpum*, calochortus (*Calochortus nuttallii*), and *Sedum douglasii*. Practically all of these were in bloom when the collections were made, and the field had the appearance of a flower garden rather than a pasture.

A similar substitution of native plants of little or no forage value for the true grasses is common in the region, as well as in similarly treated areas in the more moist regions of Washington. Such substitutions are usually more noticeable in humid mountain areas than on the lower deserts, for, in the latter, when the scattering bunches of grasses are killed out, there is often nothing to take their place. One of these overgrazed native pastures in the wheat region west of Ritzville, Wash., is shown in Plate IX, figure 1. For a list of the shrubs grazed by sheep the reader is referred to subsequent pages, which discuss the conditions in the Warner Mountains of California, and to Bulletin No. 15 of the Bureau of Plant Industry, U. S. Department of Agriculture. It may be stated that no black sage was seen in the Blue Mountains, except small patches of *Artemisia arbuscula* on the north slope, until Bear Valley, near the Great Basin drainage, was reached.

As far as general vegetation is concerned the Warner Mountains of California do not differ materially from the Blue Mountains of Oregon; at least the main features are the same, and the general topographical features are very similar. The water supply, however, is much better in the mountains first mentioned. Indeed, it would be difficult to find an open range region where water is better distributed than in the

Warner Mountains to the east of Jess Valley. These conditions have been taken advantage of to a detrimental extent by the immense flocks of sheep which winter on the deserts to the southward and eastward in Nevada and Oregon. One characteristic feature of those portions of these mountains is the abundance of browse plants, which make them especially attractive to the sheep grower. Sheep need a change of ration in order to thrive to the best advantage, even if that change be to weedy pastures, which are ordinarily considered of little value. Often they appear to be benefited by such a change from a good grass pasture. This testimony of the herder is substantiated by the fact that when grass is abundant the sheep will feed on such bitter plants as the willow, poplar, and some of the so-called sunflowers previously mentioned. In this region such shrubby plants as the gooseberry (*Ribes lacustre*, *R. luteum*, *R. cereum*, and *R. aureum*), snowberry (*Symphoricarpos oreophilus*), willow, poplar, mountain ash (*Pyrus sambucifolia*), service berry (*Amelanchier alnifolia*), and *Purshia tridentata* are very abundant. At the time of this visit immense numbers of sheep were practically subsisting on these plants. There really was no grass. Even the banks of the rivulets were chopped up by the incessant tramping, and the steep hillsides, protected by jagged rocks, were dusty. The writer has never seen a more deplorable condition than existed here. The sheep region was visited about the 1st of August, and sheep were supposed to remain there two months longer. It is difficult to imagine what the animals could find to live on. On an area shown in Plate VI, figure 2, the snowberries had been cropped so that there was nothing left but short, barked stumps and old, woody stems. This is in the vicinity of an old corral, but photographs taken in the same region show that similar conditions exist over a large part of the mountains.

The range regions traversed between the Blue Mountains, in Oregon, and Reno, Nev., with the exception of the Warner Mountains, have much in common. The mesa region does not differ greatly in appearance, although the black sage of the northern part is almost entirely replaced to the southward over large areas, especially in the vicinity of the Black Rock and Smoke Creek deserts, as well as in the Humboldt Valley, by the saltbushes, hop sage, bud sage, red sage, and white sage. These sage plants are of much more value as winter feed than the saltbushes. In this general region eight sinks were passed over. Some of these had water in them in places, but for the most part they were dry, the surface being smooth, showing level narrow fissures, and having no vegetation. The main areas of this character seen were in the Harney, Guano, and Catlow valleys, in Oregon; Surprise Valley, in California; and Long Valley, Smoke Creek, Black Rock, Humboldt Sink, and White Plains, in Nevada. All of these areas located in the lower portion of their drainage basin have as a first distinct zone of

NEEDS OF THE REGION.

On account of such diversity of conditions it will be necessary to consider certain divisions of the territory more or less separately.

The greatest need of the Washington region, aside from the Okanogan River drainage area, is summer feed. As stated, this is principally a sheep region, where the animals are pastured the greater part of the year on the desert mesas of the Big Bend and contiguous regions in the winter and in the mountains for about three and one-half months during summer. The need of having animals in good condition in the fall, both for market and for entering the winter, and the necessity of an abundance of green feed for the best development of the lambs render these limited highland summer pastures of great importance to the sheep grower. On the other hand, winter feed is more abundant; for the deserts are extensive, and the irrigated hay lands, such as those of the North Yakima and Ellensburg regions, are producing more hay every year. For years past such communities have been shipping hay in large quantities to Coast points; in other words, they produce more hay than they can feed at home. For the greatest economy it is evident that the effort should be to increase summer feed so that enough stock can be summered in the region to consume the winter feed at home, thus saving transportation on raw material.

It was considerations of this kind that led Messrs. Benson and Babcock to offer to cooperate with the Department of Agriculture for the purpose of determining what could be done to increase the summer feed in the Wenatchee Mountains, in which they are interested.

Messrs. F. E. Benson and W. H. Babcock have come into possession of a large body of railroad land in the Big Bend at Trinidad, and a similar but smaller area in the Wenatchee Mountains southwest of Wenatchee. Their purpose has been to organize a sheep ranch on a sound basis, having definitely provided both summer and winter feed on lands which they control either by title or rental, instead of depending upon the open range for the larger part of both seasons' feed and being compelled to go out of business sooner or later, as is the case with so many of the stockmen in the West. The recognition of their need of more and better summer feed, which is the need of the region in general, induced them to offer to cooperate with the Department of Agriculture in experiments to improve the forage conditions of the summer grazing grounds by donating the use of an entire section of fenced land wherein experiments could be conducted. This offer has been accepted by the Department, and experiments have been begun under the direction of the Agrostologist. The objects of these investigations will be the introduction of forage plants which will increase the feed on highland pastures; a study of the effect of systematic

meteorological conditions as affecting the growth of forage plants; a study of the native vegetation in its relation to the stock industry, and such other problems as may present themselves during the prosecution of the investigations.

The land set aside for the experiments is well adapted to this purpose. Being located in a typical grazing area and having been excessively pastured for a number of years, any advantage gained by treatment will point to methods of renovating denuded ranges. The land is described in the Government surveys as Sec. 23, T. 20 N., R. 20 E, and is locally known as the Babcock headquarters section, on account of the corrals located there. It has an altitude of approximately 5,000 feet. The region was gone over rather hurriedly in June. At this time there was no feed. Although the snow was still lying on the ground in deep drifts, the tract had already been pastured this season, for at that time none of the land was inclosed. Mr. J. S. Cotton, who has been placed in immediate charge of the work, reports that grasses have been nearly exterminated over a large part of the tract. The section, being located on the line of travel to and from the high mountains, has been grazed twice each season, in June and October, for a number of years. The soil is badly packed and cut by the flocks of sheep which have tramped over the ground while it was still wet from melting snows. In many places the soil has begun to wash badly.

While this is rather an extreme case of denudation, it nevertheless represents the exact condition of much of the range country at the present time, and shows what much more of it will become shortly if present methods are pursued. Any success in reestablishing the grass cover will be extremely important for all highland pasture regions.

Mr. Benson most aptly expresses the necessity for this work, as well as the needs of the region in general, in a letter to the Agrostologist, as follows:

> The shortening of summer pasture by forest reserve regulations and the overgrazing by sheep of the remaining pastures, coupled with the greatly increasing alfalfa production in the irrigated valleys to supplement the winter ranges, make the summer range more and more disproportionate to the winter range, until the important question now is, "How much stock can you carry through the summer?" and not what it has heretofore been in this country, "How are you fixed for hay? And how much stock can you winter?" Therefore it becomes very important to know what grasses or forage plants will do the best and yield the greatest amount of good pasture.

In the Blue and the Warner mountains the main problem is one of hay production. The winters here are more severe and stock must be fed for longer periods each year. Of course, the summer feed is also very short at times on account of the thousands of sheep which summer in these mountains. But the communities established here have managed in a measure to reserve some feed for themselves by establishing "dead lines" against sheep and by maintaining them at times

which are very small, make the profits from the cultivation of large areas for annual crops rather problematical.

In practically all of the irrigated districts where alfalfa is raised the settlers were nearly all looking for some strain of alfalfa which will thrive with less water than the common stock. The introduction of Turkestan seed a few years ago having resulted indifferently, attention has recently been attracted to "dry-land" alfalfa, concerning which much has appeared in periodicals during the past year. The growing tendency in all the irrigated districts to bring more land under cultivation than can be properly irrigated has emphasized the demand for a crop that may be grown with little or no irrigation in arid climates. Correlated with a scarcity of water is the accumulation of alkali, which calls for the development of strains resistant thereto.

The matters just mentioned, together with the determination of the best method of handling the swamp lands and the best hay crops to grow upon them, appear to be the most important forage problems of the region.

PLANTS INJURIOUS TO STOCK.

But little can be added to what was said last year regarding poisonous plants in pastures and meadows. In all swampy places, especially in the vicinity of springs, there occur more or less wild parsnips (*Cicuta vagans*). This and larkspur (*Delphinium scopulorum*) are dreaded by ranchers in the spring of the year, especially in the Great Basin region.

The slender fescues (*Festuca microstachya* and *F. octoflora*) are said to cause injury about the time that the seed is ripening. The injury is done by the seed working its way into the walls of the animal's stomach. This is reported on what is, without doubt, reliable testimony from two observers, both of whom were in position to form opinions from post-mortem examinations. Mechanical injuries of this nature are not at all uncommon, the best-known examples being those caused by squirrel-tail grass (*Hordeum jubatum*), the awns of which work their way into the lining membranes of the mouth, and needle grass (*Stipa* spp.), the seed and awns of which work their way into the wool and flesh of the sheep. To these might be added the triple-awned grass (*Aristida americana*) and six weeks' grass (*Bouteloua aristoides*) of the Southwest, which are dangerous to sheep at certain seasons, the awned seeds in the first instance and the spikelets in the second case acting in the same way as the seed of the needle grasses.

WEEDS OF MEADOWS AND PASTURES.

The ordinary annual weeds of the farm can not combat with alfalfa as handled in the irrigated West. Wild lettuce, which is a serious pest in parts of the wheat region, soon disappears from the field when

properly handled in alfalfa culture. The weeds which thrive in alfalfa are those which propagate by running rootstocks. Two such grasses, salt grass and wild wheat (*Elymus triticoides*), are at times quite conspicuous and much dreaded in the Lovelock district. It is a very common thing here to see patches of these two grasses, but more especially the former, making their appearance in alfalfa meadows and spreading with surprising rapidity. The salt grass is by far the most troublesome, because it finds in these soils congenial conditions, which at the same time are detrimental to the crop. Through cultivation, application of manure, and reseeding with alfalfa, or even a temporary grain-hay crop, which gives a soil cover, this weed can be kept in check. Although the salt grass is looked upon here as a weed, it would seem that the real trouble is with the soil and not so much with the weedy tendency of the grass. If the soluble salt content of the soil is kept down by the methods already enumerated, salt grass will not find congenial conditions. The difficulty seems to be simply one of alkali and not of weeds. The wild wheat, or blue joint, on the other hand, does not thrive in particularly alkaline soil, and is really a plant that can be handled as easily as the western wheat grass (*Agropyron occidentale*) on the prairies of the Great Plains.

Blue flag (*Iris missouriensis*, Pl. X, fig. 2) is a very serious pest in moist pastures. In portions of the Wenas Valley where pastures were overstocked there was a complete soil cover of this weed in many native meadows. In many places where it develops to this extent it would be hazardous to break the soil, for fear that it might be washed away. However, mowing would do much toward getting rid of blue flag, and an attempt should be made at every favorable opportunity to establish a more complete crop of timothy and redtop in such localities.

The dandelion is also a very serious pest in native meadows and pastures which have been in use a long time in northwestern Nevada and northeastern California. It has spread very rapidly of late in many sections of the West where little or no cultivation is practiced. It has been introduced doubtless with timothy and redtop, which are largely employed throughout the region to supplement and supplant the native vegetation. It is all the more serious because it is introduced in places where, on account of the location of the arable land in narrow strips along rivulets, its destruction by cultivation, which is the only known method of eradicating it, is impracticable or, in certain localities, hazardous, on account of danger of erosion when the sod is broken up.

The native plants which become weedy in the more humid localities under conditions of overstocking have been discussed elsewhere.

the form of *Bromus secalinus* which has escaped from cultivation and grows as a weed seems to be much more pronounced than that of the cultivated form, which, as previously stated, corresponds more closely to *Bromus racemosus*.

Ustilago striæformis.—This common disease did more injury to timothy in Jess Valley, California, than the writer has ever observed elsewhere. It appeared to be confined here to well-drained areas, which were abundantly supplied by seepage from ditches, rather than to the more poorly drained or the drier portions of the meadows.

SUMMARY AND SUGGESTIONS.

NEEDS OF THE REGION.

The sheep industry is more in need of summer pasture than anything else. This is accounted for by the settling up of mountain meadows, the development of alfalfa regions, and the withdrawal of land from the public domain for timber reserves.

The mountain communities of the Blue and the Warner mountains need to have determined what hay and pasture crops can be grown in these highland regions to best advantage.

In the desert basins, where water for irrigation can be obtained for only a very short time, there is need of an early maturing perennial grass.

The alfalfa growers call for two new varieties of alfalfa—one which will survive with less water than the common form, and one which will resist the effect of soluble salts in the soil. The development of these two strains can be secured only through careful experimentation.

Overstocking ABUSES.

The whole subject of abuses can be summed up under the head of overstocking, but there appear to be two practices which need special attention. At present stock are allowed on high mountain pastures too late in the spring. They should be taken from these pastures as soon as frost begins to disappear, so that the sod will not be injured. Even the carefully handled tame pastures of the East will not stand grazing at this period.

The second abuse of the range to which the writer wishes to call attention is the "cayuse nuisance." With the decline in the price of horses about 1894 these animals were allowed to run wild, with practically no attention, many herds not even being rounded up and branded. Under these conditions, of course, the horses multiplied and deteriorated rapidly on account of inbreeding, resulting in the overstocking of the ranges with animals which were all but worthless. It was this condition which led the legislature of Nevada, in 1897, to

Wild horses

Reprinted from JOURNAL OF RANGE MANAGEMENT
Vol. 7, No. 5, September, 1954
Printed in U.S.A.

The Education of Range Managers

ARTHUR W. SAMPSON

Professor of Forestry Emeritus, University of California, Berkeley, California

WHEN the Editorial Board requested an article on range education for the current Student Issue of the Journal I had to admit my enduring—as well as my increased—interest in the subject. This interest, developed over a long and enjoyable span of years in range research and teaching is chiefly centered in three activities: in the selection of courses composing curricula; in following developments of improved range practices and their application; and especially in noting the part that former students have taken in advancing or administering the improved practices.

The effort to relate the ever-evasive reasons for the success of one student over another of essentially equal scholarship is always fascinating and seemingly worthy of much study. While relative scholastic ratings are not necessarily—nor always—correlated with professional attainments, they must nevertheless continue to serve as the primary measure in recommending graduates for jobs until a better aptitude procedure becomes available. In any event, the capacity of a student to master facts in classroom and laboratory is a first essential, for otherwise how would he acquire the necessary background for analyzing the diverse problems of the range? On the other hand, in everyday professional practice scientific knowledge may have to be subordinated, temporarily at least, for decisions made more-or-less by snap judgment, frustrating as this might be at times to the young range scientist. The ability of the employee to cooperate enthusiastically and whole-heartedly with his superiors may be far more important to his technical achievements, in the long run, than his insistence at the outset on applying strictly scientific procedure to the immediate problem at hand (Dyksterhuis, 1953). In many instances study of human relations by the apprentice is fully as important as is use of his technical learning.

Historical Consideration

Although range management as an organized discipline is one of the youngest of college curricula, it is rapidly coming into its own both in the classroom and in the conservation of our vast, renewable range resource. From the earliest formulation of a range curriculum at the Montana State University in 1916 to the most recent at the University of California in 1953, (Table 1) range courses have passed through the characteristic stages of evolutionary growth. The development of range education has taken place in the past forty years, with the most solid growth occurring during the last twenty years or so (Sampson, 1951). In some related disciplines, notably animal production, agronomy and forestry, students interested in range are not offered sufficient range education. Deficiencies of this kind are not widespread and are being corrected where possible (Saunderson and Starch, 1950). The number of schools offering training under formal range curricula has been increasing at a healthy pace. Many eastern schools that formerly offered a single range course are now recommending that interested students elect courses closely allied to range management and essential to a range education. The impact of range training is generally being felt in improved classroom and laboratory teaching, in sounder rangeland research in state experiment stations and federal agencies, in increased personnel (though still far too small) of range extension, and what seems especially encouraging, in the gradual infiltration of range-trained men into the industry of livestock production.

The first historically to call the attention of the entire Western populace to the need for range management were the public land administrators, of which the United States Forest Service was the pioneer. This, in turn, was followed by the Indian Service, the National Park Service, the Bureau of Land Management and the Soil Conservation Service. Lands administered by the states also received management attention. These agencies collectively have been, and still are, the largest employers of range-trained men, and the character of the work demanded by them has greatly influenced the subjects of range curricula as well as the selection of the teaching personnel. From the beginning most of the graduates chosen were those with a broad training in the sciences, much as of today, rather than those of specialized training, for their assignments were many and varied. After the federal range experiment stations were established, men with specialized scientific education and graduate degrees were called for research, but those placed in administrative positions have continued to be chosen for their broad training and not necessarily for their post-graduate education.

Types of Range Training Needed

Vocational Training

Until recent years the western range was not clearly recognized as one of our great but much abused natural resources. The widely needed rehabilitation program could not be carried out by the stockmen alone, for without technical guidance, their hands were tied and too often they had little or no control over the ranges they grazed. Change for the better could be made only after study of the biology of the range and by placing vast tracts of the public domain under Federal control. Even after these steps were taken improvement was slow and not overly encouraging.

The main obstacle to improved range production and condition lies in our meager efforts at educating not only the future grazier but also the present producer in the elements of range management. Guidance of this kind should be regarded as a primary vocational function of range education, for how otherwise are producers to correct faulty management practices? The too-frequent intervals of heated controversy by politically minded stockmen or their representatives over grazing policies on public lands may be traced to lack of understanding of land-use principles. On the whole, producers of range livestock have not had the needed technical guidance to appraise and conserve their basic resources—the soil, the forage, the streams. Proper elucidation of land-management facts, with solid reasons for them, can greatly lighten the worries of public-land administrators and make for a continuous program of range improvement to the financial benefit of all. According to Johnson (1951):

> "Unquestionably, the emotionalism involved in land administration-rancher relations has done much to form mental blocks against the entire subject of range management. A better coordination in the past of the efforts of the various agencies engaged in range education could have produced more economical and effective results from the money spent."

Again let it be stated that the greatest possibility of ultimate advancement of range management lies in the education of the young men who will comprise the future producers. Most of these ranchers-to-be will go through high school and a few will graduate from college; but the greater number will have to be reached through the 4-H clubs, the Smith-Hughes Vocational Agricultural program, the Agricultural Extension Service and in other ways. The far-sighted teacher will simplify the principles of range management as need be without compromise of scientific principles. He will maintain interest by using charts, lantern slides and field materials for demonstration. He will assign readings which will not be overly technical and will be pertinent to the locality. The extension service has a golden opportunity in interesting both the youth and adult in range-improvement practices.

Many people in different organizations are doing extension work. The states have long been active in range extension. They now have an exceptional opportunity to disseminate range knowledge among ranchers and managers of range lands and to demonstrate and interpret locally tested range-use practices.

To date only a limited amount of range extension work has been carried out by state extension specialists because of the limited number of full-time personnel assigned to this work. The extension work now being done in animal husbandry and agronomy should be followed as speedily as possible by a personnel composed of range managers (Young, 1951). Men so trained have taken a leading role in 4-H clubs, in conducting plant identification contests and in range-condition class demonstrations (Saunderson and Starch, 1950). In addition, the Soil Conservation Service has done effective extension work among ranchers in soil conservation districts, and the Production and Marketing Administration has brought about better range use in many localities through cooperative financial aid. Even public-land administrators have occasionally been obliged to enter into extension work in order to carry out their rangeland-use objectives. Each year, more junior colleges and high schools are showing greater interest in conservation of many kinds, although they may not be following an organized program.

Local publicity of range-management practices is obviously important and can be done in many ways (Chapline and Campbell, 1936). Abilene Christian College, among other schools, has effectively presented a series of weekly 15-minute radio discussions on range subjects (Churchill, 1951).

Professional Training

In the present discussion the primary concern centers around the subject matter contained in curricula.

The development of a professional range curriculum may be influenced by such factors as qualifications and special interests of the teaching personnel, arrangements designed to equalize the teaching load, and by the policies of allied departments, such as prerequisite requirements which may hamper or favor inclusion of courses needed for the best possible training. It is desirable at the outset to formulate a broad basic policy representing a realistic ideal toward which to work. This implies a strong program in those sciences and arts that will be most useful in managing rangelands. The curriculum should achieve high professional standards with vocational instruction held to a minimum; it should meet the requirements of the Civil Service and the minimum requirements set up by the American Society of Range Management; it should aim to establish high professional competence in range management. This will call for strong admission requirements, for high scholastic standards and for a staff of competent teachers who will provide adequate and up-to-date coverage of their subject-matter fields.

Range management may be defined as the science and the art of planning and directing range use in such ways as to obtain maximum livestock production consistent with conservation of the range resources. This implies familiarity of the operator and manager with the forage and noxious plants; it implies a sustained yield of livestock over a long period of time; it presupposes the selection of the most suitable kind of livestock and of conservative harvesting of the crop at the most suitable season.

The management requirements as implied in this definition clearly call for a broad knowledge in both the sciences and the arts. It calls for a knowledge of the biology of both plant and animal life. Specifically, a curriculum should include English and public speaking; botany embracing systematics, physiology, ecology, and genetics; chemistry—inorganic and organic; mathematics—trigonometry, college algebra, and statistical analysis; engineering—topographic surveying and mapping; general geology; soil science; economics—theoretical and applied; sociology and philosophy—at least one course of each; zoology—general and applied, including wildlife management; agronomy; animal husbandry; forestry—in regions of commercial timber growth; and range management courses adequately covering vital subjects, including six weeks or so of summer camp and/or guided field inspections.

Because of the wide differences in emphasis of subject matter in curricula, some degree of standardization is needed. In recognizing this fact, the American Society of Range Management, through its Civil Service Eligibility-Curricula Committee, has made a start in recommending minimum unit requirements. It would seem that every school offering a major in range management should set up a minimum number of requirement credits of range and related subject matter (Heady, 1951).

Graduate Training[1]

Advanced training of qualified students is essential to the effective progress of range management. Although the avenues of employment of scholars holding advanced degrees have been chiefly in teaching and research, many with the master's degree and a few with the doctor's, have gone into administration with land-use organizations such as the Forest Service and the Soil Conservation Service.

As research and teaching of range management became more technical, through time, graduate training became more and more necessary. Undergraduate study leading to the bachelor's degree does not allow specialization in any particular field but provides well-rounded training in general principles, with a background in biology and related subjects. Most educational institutions now demand that candidates for teaching and research in range management have at least a master's degree. Indeed, quite a few demand the doctor of philosophy degree, or its equivalent, in filling replacements or in enlarging their professorial staff.

[1] *Professor H. H. Biswell and Assistant Professor H. F. Heady have assisted in the preparation of this section.*

The Master's Degree

Training for the master's degree in range management seems to be fairly well standardized into two disciplines.

One discipline is built around the philosophy of having the student become intimately conversant with the general field of range management and with recent advancements in various subjects, including both research and administration. He thereby spends most of his time taking courses for broad preparation for professional work. He must pass a satisfactory comprehensive examination to demonstrate mastery of the essentials of range management. Ordinarily a thesis is not required. The formal graduate courses may encompass several subjects, such as range literature, advanced grassland ecology, watershed influences, land-use economics and seminars on various range or related subjects.

The other discipline provides for greater specialization on some specific problem and training in research. In this plan the student must present a satisfactory thesis based on his own research, and is required to take somewhat less course work than is required in the first plan.

The Doctor's Degree

The doctor of philosophy degree has a special place of importance in the fields of research and teaching. Procedural methods in range research, analysis of range problems and classroom instruction have, in many instances, required the services of individuals holding the doctorate degree. Schools have been meeting this challenge by strengthening graduate training and providing better facilities and equipment for advanced study.

Less agreement exists among schools regarding training for the doctor's degree than for the master's. In some schools the doctorate program consists essentially of in-

Table 1. Survey of range courses, curriculum requirements and number of students in institutions offering a range management curriculum, 1954

Institution	Year first course offered	Year curric. establ.	No. of range courses		Min. semester units		No. of students, 1954		Grad. Degrees offered	No. of Instructors
			Undergr.	Grad.	Range	Forestry, agronomy, anim. husb.	Undergr.	Grad.		
Abilene Christ. Coll.	1948	1949	6	0	12	0, 6, 6	10	0	—	1
California, Univ. of (Berkeley & Davis)	1920	1953	7	4	18	3, 9, 10	9	4	M.S.	3
Colorado A. & M. Coll.	1916	1936	5	3				6	M.S.	4
a. Range management					25	28, 4, 8	35			
b. Grazing					25	20, 10, 12	6			
Idaho, Univ. of	1917	1917	7	3	14	15, 6, 8	7	5	M.S.	2
Iowa State Coll.	1926	1937	4	1	8	49, 5, 8	7	2	M.S.	1
Montana State Coll.	1941	1941	9	8	14	0, 9, 7	6	2	M.S.	2
Montana State Univ.	1915	1916	6	3	18	40, 0, 0	20	2	—	2
Nevada, Univ. of	1935	1947	6	6	12	0, 4, 10	4	2	M.S.	½
New Mexico A. &. M. Coll.	1933	1942	8	6	27	0, 8, 23	17	2	M.S.	2
Oregon State Coll.	1935	1949	5	1	9	10, 6, 11	3	1	M.S.	3
Texas A. & M. Coll.	1946	1946	11	10	15	6, 8, 9	85	21	M.S., Ph.D.	8½
Texas Tech. Coll.	1938	1942	4	0	12	0, 22, 15	4	0	—	1
Utah State Coll.	1914	1928	17	6	26	12⅔, 3⅓, 11⅔	34	9	M.S., Ph.D.	5
Washington State Coll.	1919	1923	4	0	11	12, 3, 9	5	0	—	1
Wyoming, Univ. of	1935	1947	12	1	15	0, 12, 8	6	4	M.S., Ph.D.	3

tensification of broad training similar to that for the master's degree. In others, the doctor's degree involves a thorough training in some basic science, such as soils, plant physiology and ecology, or economics.

The writers strongly share the latter viewpoint. It is their judgment that sufficient information in the field of range management has been acquired at the bachelor's or the master's level and that the doctorate should require specialization in some basic science. Many of the problems in range research require this specialization, such, for example, as those in nutritional deficiencies of forage, soil-plant relationships and economic benefits of various land-use practices.

Schools Offering Range Courses

To obtain current information on the schools teaching range management, a questionnaire was sent out in May, 1954, to all institutions known to offer range courses. Thirty-eight schools were interrogated and all replied. The author wishes to express apologies for any possible oversight in failing to contact other schools offering range courses and would appreciate being informed of the subject matter taught.

Table 1 reveals that Utah State College was the first—in 1914—to offer range instruction. This was followed by the universities of Minnesota and Montana in 1915. By 1920 seven institutions were giving range instruction. At the present time 31 colleges and universities are known to be giving range training, 15 of these under a curriculum, of which the University of California is the youngest (1953), and 16 without a specialized curriculum. The relative youthfulness of range instruction is indicated by the fact that 9 of the 15 schools with a curriculum have adopted this training program since 1940.

Colorado A. & M. College is the only institution with two curricula: the one for range managers of the professional types, with strong training in forestry; the other for grazing majors, with little or no forestry training, who contemplate entering the range livestock production field.

At Colorado A. & M. College and Montana State University, range majors essentially receive professional training in forestry. All schools, except Montana State University, seem to offer adequate training in agronomy and animal husbandry. Differences may be found in the emphasis placed on the plant and the animal sciences, depending on the geographical location of the institution and the department in which the range work is administered. Most commonly the range work is a part of the department of agronomy, animal husbandry, botany, or forestry. Texas A. & M. College is the only school with an independent Department of Range and Forestry.

Students at all but three of the schools with a range curriculum may earn the master's degree. Three schools hold the distinction of offering the doctor of philosophy degree in range management: Texas A. & M. College, University of Wyoming and Utah State College, the latter formally setting up this training in 1953.

In schools with a range curriculum the number of undergraduate range courses varies from 4 to 12 with an average of about 7 and the number of graduate range courses from 1 to 10, with an average of about 4. Among the schools without a specialized range curriculum (Table 2), all but four offer one range course and only four give graduate range courses. On the other hand, schools such as the universities of Arizona, Nebraska and Kansas State College offer several graduate courses in botany, agronomy and soil technology of inestimable value to range students; indeed, students may earn the doctor of philosophy degree in grassland ecology and management at these institutions.

Except for Iowa State College, all schools with an organized range curriculum are located in the western range states. The fact that timber production is an important industry in many parts of the West evidently accounts for the fact that 6 of the 14 schools offering a major in range require 12 or more semester units of forestry. Five of these schools require no forestry and two schools require six units or less. This variability in forestry requirements is the chief difference in range curricula. All except Montana State University require one or more courses in agronomy and animal husbandry.

The schools lacking a range curriculum offer a number of courses in the plant and animal sciences of great usefulness to those interested in range. Courses such as poisonous plants and economic agrostology, as well as those of agronomy, animal husbandry and soil technology, form the core of this training.

The full-time professorial staffs at schools with a range curriculum vary from 1 to 8½ members with an average of nearly 3. Nearly all teachers hold the doctor of philosophy degree, with ecology as the major subject. Texas A. and M. College, with a full-time professorial staff of 8½ in 1953–54, had 85 undergraduates including 19 seniors and 21 graduate students. Colorado A. and M. College and Utah State College rank next in size of teaching staff and student body. The other schools have from one to three professors and correspondingly fewer students.

Table 2. Courses offered in institutions without a specialized range management curriculum, 1954

Institution	Year First Range Course Offered	No. of Range Courses	
		Undergr.	Grad.
Arizona, Univ. of	1930	1	—
Calif. State Polytechnic Coll.	1948	1	—
Fort Hays State College	1938	3	3
Georgia, Univ. of	1949	1	—
Kansas State Coll.	1919	3	3
Louisiana State Univ.	1944	1	—
Michigan State Coll.	1932	1	—
Michigan, Univ. of	1933	1	—
Minnesota, Univ. of	1915	1	—
Nebraska, Univ. of	?	1	1
New York, Univ. of (Syracuse)	1941	1	—
North Carolina State Coll.	1946	1	—
North Dakota Agr. Coll.	1932	2	—
Oklahoma A. & M. Coll.	?	9	5
Pennsylvania State Univ.	1947	1	—
Washington, Univ. of	1937	1	—
Yale Univ.	1946	Discontinued temporarily, 1953	

Employment Agencies

It is essential that the educational system for the profession of range management be kept plastic to meet the changing demands of employment. With accumulated experience in the management of renewable natural resources, management has tended to become more technical and precise. This fact must be taken clearly into account in shaping curricula and revamping range courses.

Most range men are likely to find employment with one of the following agencies: (1) U. S. Forest Service, in administration and research; (2) Soil Conservation Service, with its research branch and nation-wide coverage of action programs; (3) Bureau of Land Management, Indian Service, Agricultural Research Service and other federal agencies; (4) state organizations, including the colleges and universities, the agricultural experiment stations, the extension service, and the state divisions of forestry; (5) county and municipal services; (6) private agencies, such as managerial positions on large ranches and appraisers of ranch properties as for banks, insurance and loan companies; (7) self-employment, such as ranching services and appraisals of private ranch properties.

Conclusions

The hope of bringing back the rangelands to their potential productive capacity lies essentially in turning out more and better-trained range men. Among other things, it is the responsibility of the schools to provide personnel who will interest the youth in range matters.

Effective range improvement calls for a larger technical range personnel in federal and state land agencies, and in the Agricultural Extension Service. College graduates reared on ranches are needed for leadership in range livestock production.

There seems to be a tendency in some schools toward specialization in the undergraduate years at the expense of a more liberal education.

Range students are often poor in rhetoric, which affects their ability in writing and public speaking. Their background in economics is often deficient, and many receive no training in psychology or sociology. Correction of these weaknesses may be made by increasing the number of electives, by concentrating more on the professional courses, and by setting up a minimum number of required courses and credits in range management and closely allied subjects. The addition of a fifth year, though costly in time and funds, would result in correction of many objections encountered in the overly crowded four-year course, and should pay dividends in terms of more rapid professional advancement and in the satisfaction of having better work tools. To encourage post-graduate training, more fellowships and technical assistantships should be made available for both the master's and the doctor's degrees.

LITERATURE CITED

CHAPLINE, W. R. AND R. S. CAMPBELL. 1936. Range and extension program. *In:* U. S. Dept. Agr. Forest Service. The Western Range. 74th Congr., 2d Sess., Senate Document 199: 523–533.

CHURCHILL, F. M. 1951. Extension practices for range management at Abilene Christian College, Abilene, Texas. Jour. Range Mangt. 4(3): 308–311.

DYKSTERHUIS, E. J. 1953. Some notes and quotes on range education. Jour. Range Mangt. 6(5): 295–298.

HEADY, H. F. 1951. Our range management schools. Jour. Range Mangt. 4(5): 306–307.

JOHNSON, R. G. 1951. Range education. Jour. Range Mangt. 4(5): 315–318.

SAMPSON, A. W. 1951. Range management education. Jour. Forestry 49(7): 507–510.

SAUNDERSON, M. H. AND E. A. STARCH. 1950. Some problems in the development of a range management extension program. Jour. Range Mangt. 3(1): 29–32.

YOUNG, V. A. 1951. Teaching range facts—the role of the schools. Jour. Range Mangt. 4(3): 312–314.

Portion of F.S & BLM Lands Grazed by livestock

	Land Area Administered	Grazed	% Grazed
✓ Forest Service	187,000,000	105,500,000	
✓ BLM		179,000,000	

Forest Service

11,600 range allotments
8850 " " grazed by cattle
7300 " " " " sheep
450 " " common use or others

BLM

13,780 range allotments

Total 12,596,361 AUMs use estimated capacity

✓ Annual Grazing Statistical Report for 1976 Oct 1979 published

Total licensed obligation livestock use

	Number (head)	AUMs
BLM (1973)		
Cattle	2,360,345	8,304,629 AUs
Horses	17,317	91,739 AUs
sheep & goats	3,682,015	1,784,709
Total authorized	6,059,687	10,381,077

F.S. National Forest System Regions 1-6		
Cattle	1,391,209	6,796,279
Horses	18,877	46,095
Sheep & G	1,547,438	3,400,261 ← AMs converted to AUs in total
Total authorized.	2,957,524	7,194,903 AUMs ←

According to experiments made by Dudar' (1952) at the Sheep-Breeding Institute in Stavropol' territory, the yield increased by a factor of 1.5 to 2.5 on an old, trampled fallow pasture when the surface was sown with Euagropyron, perennial rye, and sweet clover.

Excellent results were obtained (1.5 to three times higher yields) as a result of the surface sowing of various local wild grasses and their mixtures on sandy soils in Turkmenistan (Nechaeva, Prikhod'ko, Bashkatove, Kiyanova, 1959).

It is therefore absolutely clear that the self-seeding and re-seeding of grasses must definitely be adopted and included in the measures used for increasing the productivity of pastures.

In the forest zone it is recommended that clover be sown and, of the cereals, timothy, meadow fescue, and orchard grass are recommended for sowing.

In the forest-steppe of western Siberia, on solonetzes complexes, sweet clover or a mixture of sweet clover with Euagropyron is recommended for sowing (after roto-tilling).

In the steppes the following is recommended: on loamy and on clayey soils, Agropyron pectiniforme, Agropyron desertorum, awnless brome grass, Bromus erectus, Festuca sulcata, alfalfa, sweet clover, and Onobrychis should be sown; on soils of light mechanical composition, Agropyron sibericum, sweet clover, and awnless brome grass are recommended.

In the desert, on sandy soil partures, thinned out by excessive grazing, it is recommended that first grass mixtures be sown containing two to three species of four botanical groups: bushes (Haloxylon persicum Bge. and Haloxylon aphyllum (Minkw.) Iljin, Calligonum, Salsola richteri, Salsola subaphylla C.A.M., and Ephedra strobilacea Bge.); semi-brushwood (Artemisia badghysi Krasch. et Lincz., Artemisia turanica Krasch., and Astragalus unifoliatus Bge.); and perennial grasses (Aristida, resin-producing plants, Dorema); and annual grasses (Malcolmia, Isatis, Cutandia memphitica (Spreng.) Richt., annual brome grasses, Eremopyron and others).

For improving the yield of steppe pastures thinned by excessive grazing, it is possible to re-seed with the usual cultivated annual plants; this can also be done in the semidesert and even in the desert. The plants recommended are winter rye, Avenastrum, Sudan grass, and others. It is better, however, to sow them mixed with perennial grasses. In the forest zone, in the forest-steppe, and on chernozem soils these seedings can be done at three different times: in early spring, the second part of the summer (after hay cutting or grazings), and fall. In the desert it is best to sow the grasses in fall or winter.

Larin

INFLUENCE OF REST AND OF LATE USE OF GRASSES ON YIELD

Proper use

All that has been mentioned above helps to demonstrate that it is impossible to maintain a high yield and the species composition of pastures without applying special measures. Ways of raising the yield of pastures and of maintaining it on an adequately high level are many and varied.

Rest-Rotation Grazing

1

The most important method is to periodically exclude certain pastures from use so as to give them a rest. This leads to the normal development of the root system of plants, the stocking up of nutritive substances, and, as early as the following year, results in a sufficiently high yield. In addition, during the rest period the process of self-seeding goes on without interference so that the grass stand is rejuvenated.

In steppe regions a great amount of snow lies for long periods on the pastures. This also contributes to an increase in yield the following year. Table 15 shows the great preponderance of carbohydrates and organs of storage in plants which had not been cut, as compared with plants which had been cut.

3

A somewhat weaker influence on the plants and on the yield is obtained by delayed grazing, carried out after the flowering or seeding of the plants. In this case, of course, there will be more roots and more stored nutritive substances in fall and in spring than in plants used for grazing or for hay cutting, though less than in plants which had been given a rest, as mentioned above.

2

Rest and delayed grazing increase the moisture in the soil (the experiment of V.I. Evseev showed an increase of 41% on a Festuca sulcata Stipa plot). They also increase the yield and improve the botanical composition of pastures. Direct experiments made by V.I. Evseev in Orenburg district and by I.V. Larin, I.V. Kamenetskaya, and T.K. Gordeeva in the region of western Kazakhstan provide an excellent illustration of this (Tables 30, 31, and 32).

Table 30

Influence of rest and of delayed grazing on the yield of pastures (experiment of V.I. Evseev)

Pasture type	Indexes	Grazing 3–4 times each summer	Delayed grazing	Rest
Stipa · Festuca sulcata - motley grass	centners/ha	6.0	14.3	16.0
	%	100	238	267
Cereal – motley grass in ravines	centners/ha	7.7	15.3	19.9
	%	100	200	258
Euagropyron	centners/ha	4.9	–	21.2
	%	100	–	432

The experiment of V.I. Evseev has shown that rest increases the yield for a duration of only three years. Thus, a pasture which had been left undisturbed for the period from 1930 to 1931 (in the sovkhoz "Akrab" in Aktyubinsk district) gave in the following years a green grass yield (in centners/ha) as follows: 46.2, 16.6, 29.2, and 15. A pasture which had been grazed systematically gave a respective yield of 20.4, 11.7, 20.0, and 15. Over the three first years the former pasture gave an additional yield of 39.9 centners of green grass, which constitutes a yield

almost as high as that given by a grazed pasture over a period of three years. In addition, the daily weight increment of young cattle on an undisturbed pasture is 220 g higher than on a grazed pasture.

Table 31

Influence of rest on the botanical composition of pasture grass (experiment of V.I. Evseev)

Pasture type	Exploitation the previous year	Grass composition (in %)			
		cereal grasses	worm-woods	other motley grasses	legumi-nous grasses
Euagropyron – Koeleria on sandy loamy soils	resting	89.1	9.00	1.90	–
	grazed on	33.2	66.08	0.72	–
Euagropyron – Stipa	resting	88.9	–	8.40	2.7
	grazed on	63.6	27.50	8.90	–

Table 32

Influence of rest on the yields of semidesert cereal grass pastures (experiment of I.V. Larin, I.V. Kamenetskaya, and T.K. Gordeeva in the Dzhanybek – western Kazakhstan region)

Association	Dry mass yield in centners/ha in 1953		
	at mowing in 1951, 1952, and 1953		at mowing only in 1953
	3 times	once in the full flowering phase	
Agropyron pectiniforme on meadow chestnut soil in a hollow	5.1	9.3	14.5
Stipa on meadow chestnut soil in a hollow	6.5	9.0	16.6

In the experiment of I.V. Larin, I.V. Kamenetskaya, and T.K. Gordeeva, the yield of a pasture left to rest for two years exceeded the yield of an exploited pasture by a factor of 2.1 (average is from an intensive threefold and a single slight utilization).

The experiment of N.G. Andreev (Saratov) showed that a thicket of five-year Agropyron ramosum gave a yield increase of 44 % after a year's rest.

According to data collected by the Canadian Department of Agriculture, the periodical rest of pastures enables three times more cattle to be fed on them (V.I. Evseev).

Complete rest coupled with delayed grazing can be recommended in the steppe, semidesert, and desert regions, where fertilization is not a sufficiently effective measure for raising yields. In forest, forest-steppe, and mountain regions, the most effective measure is fertilizing combined with the additional surface sowing of grasses; in these regions rest and delayed grazing can be applied only in areas where there are ample grazing grounds.

It ought to be mentioned that there are not yet sufficient data which would permit the establishment of the length of the periods (number of years) during which pastures should be left undisturbed or grazed late in the season. One may only presume that rest should be given to pastures not less than every four years; the same applies to delayed grazing. It is also necessary to combine the year of rest with the additional sowing of grasses, or else to carry out the sowing the year preceeding the year of rest. This, however, should be done only when the grass stand is impoverished, that is, has lost a considerable quantity of good fodder grasses. When the grass stand is strongly depleted by excessive grazing, it is necessary to stop using the pasture for at least three to five years.

INFLUENCE OF FERTILIZATION ON GRASS YIELDS

It is possible to maintain a high pasture yield by applying fertilizers. In the experiment of S.P. Smelov (Fodder Institute) the following quantities of stored carbohydrates were found in the roots and rhizomes of awnless brome grass (in percentage of dry weight): without fertilization, 11.4; after fertilization with NPK, 19.7. Five thousand cubic centimeters of timothy grass had the following quantities of roots (in g): without fertilization, 5.04; after fertilization with NPK, 8.0.

In the experiment of G.Ya. Bronzova of the Moscow Experimental Station for Cattle Breeding, the weight of the roots of awnless brome grass (in g with a lysimeter) was the following: without fertilization, 70.6; after fertilization with NPK, 386.8; timothy grass unfertilized, 87.5; fertilized with NPK, 153.3.

The yield of the plant tops also increased accordingly under the influence of fertilizers. G.Ya. Bronzova obtained the following hay yield from an average of five plants over a period of two years (manure was applied the first year of the experiment): years without fertilizers, 28.6 centners/ha; yearly applications of P.K., 33.6 centners/ha; yearly applications of NPK, 60.9 centners/ha.

The first variant yielded 2.4 centners of albumin, the second, 3.1, and the third variant, 8.8 centners – that is, 366 %.

According to the review made by P.I. Romashov (1941-1949), the weight increase which resulted from the application of full mineral (NPK) fertilizer was (in percentage): in the forest zone on dry valley pastures, 98.0 (average of 109 experiments); on lowland meadows, 111.0 (average of 60 experiments); in swamps, 133.4 (91 experiments); on flood meadows, 47.0[10] (140 experiments); in the steppe and in the southern forest-steppe, 45.9 (23 experiments); on hill meadows, 101.1 (32 experiments). The application of manure produces an even greater increase in yield. Its effect continues for at least three years; in the forest and forest-steppe

zones and in mountain regions the yield increase for the year in which manure is applied amounts to 70% to 90%; on the following year, the increase is 80% to 100%, and on the third year, 40% to 60%.

An interesting experiment in the protracted application of fertilizers was carried out in England at the Rothamstead Experimental Station. The experiment was conducted over 70 years. One part of a certain meadow was fertilized every year, the other part was not fertilized at all. When the fertilizers were applied every year, the yield of the fertilized part of the meadow was invariably high (2.3 to 4.8 times higher than that of the unfertilized part of the same meadow). The yield from the unfertilized part of the meadow showed a 100% decrease. The yield of motley grasses in the plots receiving yearly applications of fertilizers was reduced. The results of this experiment are shown in Tables 33 and 34.

In the experiment of S.K. Pavlovich (1953) in the Armenian SSR, on a fertilized mountain meadow with motley grass - cereal grasses and Stipa stenophylla, the following yield increases (in percentage) were obtained, as compared with an unfertilized meadow: in the year of fertilizer application, 260.1; second year, 88.9; third year, 72.4; fourth year, 101.4; fifth year, 221; and sixth year, 42.8. The average over six years was 91.3. When 20 tons of manure were applied in the first year of the experiment and 60 kg of active NKP were applied every year, an annual increase of 77.1 centners per hectare of hay were obtained over the six-year period.

Table 33

Influence of fertilizers on yield of a meadow (centners/ha)

Variants of experiment	Ten-day periods							Average over a year
	1st	2nd	3rd	4th	5th	6th	7th	
Without fertilizers	28.4	25.1	22.0	21.1	16.6	13.7	14.5	20.2
With fertilization every year	66.7	76.0	67.6	57.3	62.8	59.0	60.9	65.5

Table 34

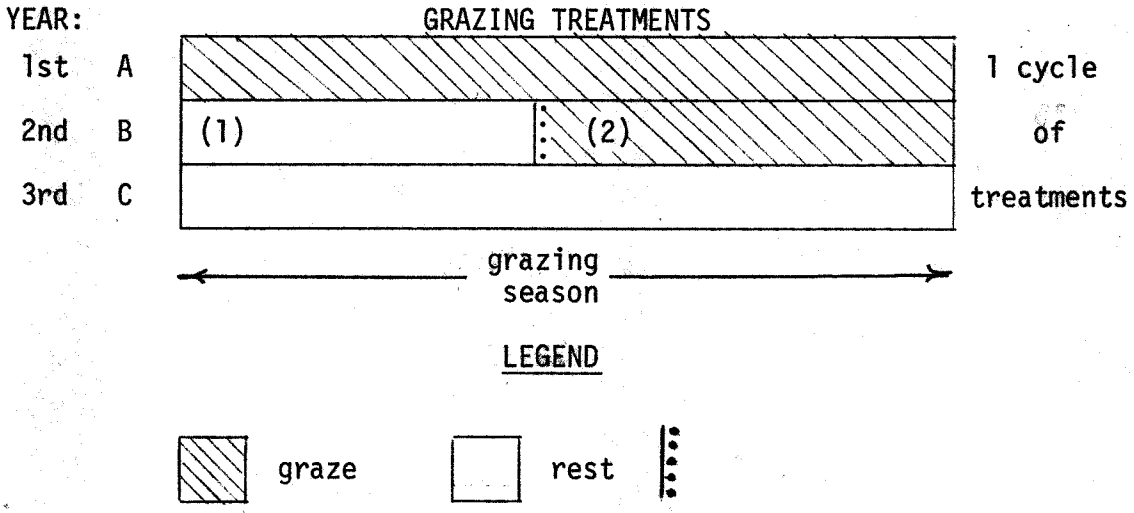
Influence of fertilizers on botanical composition of meadow hay

Variants of experiment	Composition of grass stand (in %)			
	cereal grasses	leguminous grasses	motley grasses	other grasses
Without fertilizers . . .	58.3	5.4	35.4	0.9
PK every year	59.0	19.6	21.3	0.1
NPK every year	89.0	0.7	9.5	0.8

Rest-rotation grazing

The minimum amount of rest now recommended for restoring plant vigor in plants on dry (upland) sites, is two growing seasons through completion of food storage, and for seedling establishment one full year. Near complete defoliation must be assumed in determining the amount of rest for vigor because some plants, on heavy concentration areas, are invariably grazed this way.

Resting should be started immediately after, but one year of grazing during the critical green period so as not to compound the harmful effects of grazing•the rest needed for vigor, seed production and seedling establishment can be obtained in two years. This is shown in the following diagram of grazing and resting that would be applied on an area over time.



Two years of rest are provided in treatments B(1) and C for restoration of plant vigor following a year of grazing, treatment A. Production of ripe seed is provided by treatment B(1) and trampling of seed by B(2). Also with treatment C all vegetation is left ungrazed providing surface litter which helps control soil erosion and enhances soil fertility. The

highways, the agricultural colleges, private and State forest lands, and others. In all of these one common denominator appears: The Federal Government deals with and through a strong professional State administrative organization, so that the relationship is between single units of Federal and State Government and is on a professional basis. That there may be a place for Federal aid as a means of helping to solve problems of private range-land ownership is clear. But the barriers to immediate adoption of this as a general formula are evident. At present there are no State governmental organizations, professional in character, to deal with in the field of range-land management. As an immediate step, the Federal agency would necessarily deal directly with a multitude of individual owners, thus setting up a relationship undesirably ignoring the States. Certainly adequate State agencies could be developed over a term of years, as the States assume their part in the whole range-management undertaking, but such a process takes years, as experience in other fields shows.

The stockmen are organized in trade associations, varying in strength and character. But to deal with the livestock associations would be to expect a high degree of self-regulation, since the return to the Federal Government to offset the aid would be in the form of better condition of range lands. This could be obtained only by improving land-husbandry practices and the enforcing agency—the association—would consist of landowners who were regulating themselves. The record of self-regulation in other fields hardly justifies a strong conviction that it would be more effective in this. Thus, the inherent weakness of the subsidy as a weapon of attack on this sort of problem, and the innate defects of self-regulation seem entirely clear.

The need for subsidy arises because the individual landowner, in failing to do things in treatment of his property that it is in his own interest to do, has finally done injury to the public interest. In this situation public aid is justified, usually because the owner is in a more or less desperate situation in his own business. It comes to him necessarily as individual assistance, and unless it is coupled with tight regulation in use of land the results are unlikely to be satisfactory from the public viewpoint.

U.S. Management

POSSIBILITY OF PUBLIC ACQUISITION

The record of both the Federal and State Governments in constructive management of range lands is decidedly inconsistent and spotty.

The Federal Government has for 30 years, through the national forests, conducted a large-scale demonstration in range management on public lands, during the course of which many constructive developments of major consequence have been worked out through trial and conflict, and the application of improved management developed by research and experience. And though the record of accomplishment is far from perfect, national-forest range management has, on the whole, been markedly successful; the mechanism and much of the technique have been worked out; and the development of a professionally competent and resident organization has set a workable pattern for similar public ventures.

But an even larger area of Federal range land—the public domain—has until very recently drifted with no pretense of administration, and has paid in depletion the penalty of long-continued neglect. Even now but half of this Federal property is in process of being placed under administration.

The Indian range lands, too, have suffered severely through overgrazing, though supervised by the Federal Government. It is only recently that more constructive policies and plans have been developed, looking to rehabilitation of this resource on all these lands, though some have been well handled for years.

Thus the record to date of the Federal management of range land is part reasonably good, part bad. The national-forest experience at least demonstrates what can be done and shows it to be within the capacity of the Federal Government to do an effective job.

The record of the States in management of their range land is on the whole discouraging. The general desire, largely set by Federal grant laws, to obtain immediately cash income and the handling of lands by State bodies having a real-estate point of view, have meant exploitative use and range depletion on most State lands. Effective ownership and management of low-grade range lands, and those possessing public values, usually demands cash outlays as investment or administrative cost which may not be immediately returned through severance charges for forage.

In its financial ability to make the expenditures required to do the job thoroughly, the Federal Government has the advantage of outstanding financial strength. It has also unique and far greater opportunity to reimburse itself over a period for capital investments required to develop the range property and for current costs of administration, than does any other kind of ownership, private, State, or county. For any source of wealth, such as the range, produces commodities which, between the point of production and the final consumer, pass through the hands of many businesses. Each of these is subject to the operation of the corporation- or income-tax laws, and some part of the profit created at each step of the producer-to-consumer chain finally finds its way to the Federal Treasury. So, in addition to a direct and equitable severance charge for forage, which the Federal Government can collect in common with other kinds of ownership, and which in effect can be used to help defray costs of ownership and management, the Federal Government through other and indirect means can reimburse itself and even make a profit as a landowner.

Some States have already adopted the income tax as a revenue-producing mechanism, and so enjoy in part the same opportunity as the Federal Government to obtain revenue from each step in the progress from production to consumption. But, since a large part of the products of the range finds its way into interstate commerce, no State can well be on competitive equality with the Federal Government in this respect.

Thus, except where costs of range-land ownership are grossly above the direct severance charge, the Federal Government, in particular, in preserving range values through ownership and constructive management, accomplishes several things. In the narrow and restrictive sense of repaying its own Treasury for costs, it can usually come