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RANGE IMPROVEMENT BY DEFERRED AND ROTATION GRAZING.

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WHAT CAUSES THE RANGE TO DETERIORATE.

The forage crop on approximately 110,000,000 acres of land within the National Forests is available for grazing live stock. Some idea of the money value of this crop can be gained from the fact that during the grazing season of 1912 the land supported approximately 14,000,000 head of stock, including cattle, horses, sheep, goats, and swine. In many localities throughout the West the live-stock industry is the main source of wealth. It depends for its existence upon a permanent crop of good forage on the range, and the maintenance and fullest use of this crop are therefore of the greatest importance both to the individual stockmen and to the stock industry.

A long step toward full use without injury to the forage plants will be made when some of the simple precautions taken in connection with forage crops on farms and ranches are applied on the western range. No farmer who hopes to realize the fullest returns from a permanent hay meadow would think of harvesting the crop as soon as it is tall enough to cut, regardless of whether or not it is mature. He has learned from experience that the maximum food value of the crop is not obtained until it has made its full growth. He has also learned from experience that to graze a permanent pasture closely from the time that growth begins until it ceases will soon result in decreasing its carrying capacity and eventually in depleting it.

The vegetation which furnishes the grazing crop has the same growth requirements as farm crops. Climate and soil conditions on range lands, however, are generally less favorable to the growth of forage than the conditions on most farms. So, if the range is to be kept permanently in good condition, even greater care must be exercised in utilizing the range crop than is necessary with that on the farm.

The serious decline in the carrying capacity of vast tracts of western range lands can be traced almost wholly to failure to recognize the primary requirements of plant growth. During the "free-for-all" grazing period of earlier days the most palatable species were so closely cropped that they were unable to develop the necessary plant food, and so literally starved. In addition, the roots were frequently injured by trampling or killed by exposure. As a result, the best kinds of vegetation grew weaker from season to season, and, where the practice of early and close grazing was continued, the range at last became practically denuded.

Fortunately, on the majority of National Forest lands not only excessive grazing before the forage crop was mature but also continued close grazing was done away with before the vegetation was entirely killed out, although in many localities the best species had given way to less desirable ones. The discontinuance of premature grazing and overstocking, combined with improved methods of handling stock under Government regulations, has resulted in the improvement of range lands within the National Forests to the point where it is again possible to market large numbers of beef and mutton animals directly from the range—a thing which in many places could not be done during the last few years prior to the inclusion of the lands within National Forests.

In order to know exactly how to maintain a satisfactory forage crop, and how to manage lands in need of improvement in the best and most economical way, a study was inaugurated by the Forest Service in 1907, in cooperation with the Bureau of Plant Industry, in which the life cycle of the leading range plants on sheep lands within the Wallowa Mountains of northeastern Oregon was carefully observed. This bulletin points out how, through carefully considering the growth requirements and methods of reproduction of the forage plants, the carrying capacity of the range lands may be still further increased without decreasing the number of stock which use them. Statements and conclusions are based upon results secured from three years of careful study and two seasons of practical application in range management. The subject will be taken up in two parts: (1) The natural growth requirements of range plants; and (2) a grazing system, based upon these requirements, which will insure a maximum forage crop.

REQUIREMENTS OF PLANT GROWTH.

As it affects grazing management, the life cycle of forage plants may best be discussed under the following heads: (1) The production of foliage in the early growing season; (2) the production of flower stalks and seed crop; (3) the scattering and planting of seed; and (4) the establishment of seedling plants.

PRODUCTION OF FOLIAGE IN THE EARLY GROWING SEASON.

The amount of foliage produced early in the growing season and the promptness with which growth begins in the spring are direct indications of the vigor of forage plants and show the possibilities of revegetation. To respond vigorously to the advent of the growing season, the plant must have stored in its roots during the previous season a large amount of starch and other foods which nourish it from the time that growth begins until there is enough foliage to manufacture sufficient food for the rapidly growing parts both above and below ground. If the plant is robbed of its green herbage during the main growing season, especially if it happens in two or more successive years, growth in the spring is not only delayed by several days, but foliage production is scanty and the amount of food which the plant is able to manufacture is consequently decreased. If, when the plant is in this weakened condition, the herbage is again removed while green and tender, growth the following season begins still later and even less herbage than before is produced. If this sort of thing is kept up, the plant is sure to die.

To determine what effect removal of the herbage at different times in the season has on forage production, the herbage on a number of selected plots on which the vegetation had been weakened by continued close and early grazing was clipped experimentally for three successive seasons. On half the plots the herbage was clipped as soon as growth was well started and subsequently clipped once every month; the other plots were undisturbed until August 25, at which time the seed had matured, when the herbage was closely cut.

The vegetation clipped monthly lived through the period of the experiment, but in the fourth year, when none of the plots was disturbed, the herbage was very sparse and short, while the time of beginning growth was so much delayed that no fertile seeds were produced. On the other hand, the vegetation clipped only after seed maturity each year was, at the beginning of the fourth year, approximately 150 per cent greater in volume than that on the plots clipped monthly, while growth began in the spring fully as soon as where the plants were protected yearlong.

Examination of the roots in the autumn, after growth had ceased, showed that the plants clipped monthly had stored very little food, while the vegetation clipped only after seed maturity were found to have stored as much food as plants protected yearlong.

Anything which either favors or retards the activities of the roots, which absorb food elements and moisture from the soil, later affects in one way or another the herbage production. One of the chief functions of the part of the plant above ground, especially the foliage, is to manufacture plant food, and if this process is to be continuous

there must be a constant supply of the necessary food material from the soil. Moisture, which is supplied by the minute root hairs, is continuously being given off as vapor by the pores of the leaves and stems, and when the balance between the moisture taken up by the roots and that given off by the foliage is disturbed the plant wilts, and if the disturbance continues finally dies. Anything which destroys the delicate root hairs, therefore, decreases the capacity of the plant to absorb moisture and is at once reflected in a decline in health and vigor of the herbage.

On the other hand, proper development of the root system is dependent upon a supply of food furnished by the part of the plant above ground, and so when the plant loses its green herbage the roots suffer accordingly. If the foliage is continually removed during the season when growth is most active the root system is greatly enfeebled and if the practice is continued is at last starved beyond recovery.

PRODUCTION OF FLOWER STALKS AND SEED CROPS.

If depleted range lands are to be revegetated, the forage must be allowed to produce a fertile seed crop. The vigor of the vegetation greatly influences, in fact, sometimes determines (1) the time of flower-stalk production; (2) the number of flower stalks sent up; (3) the time of seed maturity and the size of the seed crop; and (4) the fertility of the seed.

The time of flower-stalk production depends chiefly upon three factors: The season, whether early or late; the character of the soil or physical conditions; and the vigor of the plants or herbage production. The beginning of the season in mountain lands may vary in a given locality as much as 10 days, and this wide variation of the time when growth begins necessarily brings about a corresponding variation in the time of flower-stalk production.

The influence which the vigor of the vegetation has upon the time of flower-stalk production and the number of flower stalks is illustrated by the following experiment: An area which had been severely overgrazed was fenced against stock, and for five years, while the vegetation gradually recovered, observations were made to determine any changes in the number of flower stalks produced and the time of their production. During the first year of protection no flower stalks were seen until July 25, and it was not until 41 days later that all the stalks had been produced. The following season the stalks began to shoot up as early as July 10, and all had been produced 30 days after the appearance of the earliest ones, a decrease in time of nearly 27 per cent after one year's protection. In subsequent seasons the time required for flower-stalk production was only slightly less than that during the second season of protection. Early production of

FOLIAGE AND FLOWER-STALK PRODUCTION OF (TO THE RIGHT) WEAK AND (TO THE LEFT) STRONG MOUNTAIN BUNCH-GRASS PLANTS.

flower stalks means that the seed has sufficient time to develop and mature before low temperature comes in the autumn. In addition, the earlier the flower stalks are produced the greater is their number and luxuriance.

The time of seed maturity varies to a certain extent with the time of flower-stalk production, but to a less noticeable degree. Both temperature and moisture conditions in a grazing region are more uniform after the time that flower stalks are sent up than before, consequently the development of the vigorous plants is more uniform with the advance of the season than during the spring period. In the case of plants weakened by continuous removal of the herbage during the early part of the season, the time of seed maturity is delayed in proportion to the decrease in vigor. If the plant is greatly weakened, no seed whatever is produced. Delay in seed production may result in either very scant or actually no reproduction, for if the seed is to be fertile it must mature before prolonged low temperatures or killing frosts occur. On the higher ranges these may come at any time after August 20. The big struggle of the vegetation is to mature its seed during a short and none too favorable period before the appearance of low temperatures and frost, and to do this it must be kept in a high state of vigor. Added to the other unfavorable conditions is the fact that the fertility of seed produced from even the most vigorous plants, especially on the higher ranges, is comparatively low.

A good example of the relation of plant vigor to the production of fertile seed is found in the case of mountain bunch grass (*Festuca viridula*), which furnishes a large part of the forage between elevations of 6,500 and 8,000 feet in the mountains of northeastern Oregon. At the time of the grazing study there were found, under the same conditions, all stages of plant vitality, from the final one of depletion through starvation to the most vigorous growth. In the case of uninjured plants the flower stalks invariably began to show about 15 days after growth had started, and from 6 to 15 were produced from average-sized tufts. In contrast to this, the weakest individuals developed no flower stalks, while those less seriously weakened produced none for a month or 6 weeks after growth had begun. Even then the number sent up was invariably small, three being the average, and with a height but little more than half that of the stalks produced early in the season by strong plants. This marked contrast in herbage and flower-stalk production between the weak and strong vegetation is shown in Plate I.

The strong and the weak plants exhibited similar differences in the case of seed production. The most vigorous plants produced a large and early seed crop; those of average vigor developed a much

smaller crop which matured at a later date; the weakest matured practically no seed.

An even closer correlation is found in the case of seed fertility. The most vigorous plants matured their seed by August 20, with an average germination power of 14 per cent; the less vigorous individuals matured their seed September 1, with an average fertility of 7 per cent, while the very weakest produced mature seed September 12, the fertility of which averaged only 1.5 per cent. Weakened vegetation, then, results in (1) late resumption of growth in the spring and sparseness of herbage; (2) the production of few flower stalks, the majority of these late in the season; (3) late maturity of seed and a small seed crop which is either sterile or has a very low fertility.

SCATTERING AND PLANTING THE SEED.

Almost immediately upon reaching maturity the seeds of the leading range plants are dropped. This is highly advantageous in that it eliminates the possibility of stock consuming the crop after it has been developed. The dissemination varies with the different species. In the case of the grasses and grasslike plants, such as sedges and rushes, the seed drops near the parent plant, while seeds from plants like fireweed and mountain dandelion, which have highly developed contrivances for distribution by the wind, are carried great distances. Plants of the latter kind do not usually occur in as dense stands as grasses, but, on the other hand, are more widely distributed over the range.

The possibility of getting reproduction depends upon whether or not the seed is able to force its way into the soil. The surface soil dries out early in the season, and seeds which germinate on the surface of the ground are unable to extend their limited root system deep enough into the rich and moisture-laden soil. As a consequence the plants soon die from drought.

Under purely natural conditions the likelihood of the seeds getting into the ground is governed largely by their size and structure. The seeds of some of the most important plants, such as mountain bunchgrass and mountain brome grass, for example, are large and chaffy, and even though promptly dropped upon maturity in the autumn, months before germination takes place, are usually found uncovered on the surface of the ground in the spring. Round, heavy seeds, like those of wild onion and some of the sedges, have little difficulty in working beneath the surface soil. The seed of a few species, some of little or no forage value, are provided with strong bristles, which work them well into the ground.

From what has just been said it is clear that if the seed is not planted by artificial stirring of the soil the undesirable species may become established at the expense of the valuable range plants.

ESTABLISHMENT OF SEEDLING PLANTS.

Even if a crop of fertile seed has germinated there is no definite assurance of material increase in the forage stand. The establishment of forage seedlings, especially early in the season, depends largely upon climate and soil conditions.

During the germinating period the soil is invariably well supplied with moisture. In the higher mountains rather severe freezes are common, and as a result of alternating extremes in temperature the soil heaves. When this takes place the seedling roots, then poorly developed, are partly lifted out of the soil and the growth of the plant is arrested. As the season advances the temperature rises and the moisture in the surface soil is largely lost, so that only the deeply rooted and more vigorous plants survive. The loss varies from 20 to 70 per cent, depending chiefly upon the extent to which the soil heaves and the development of the seedling roots at the time the disturbance occurs. (Pl. II.)

On the lower elevations freezing does not usually occur after the seed has germinated, but because of the relatively high temperature the soil dries out seriously, so that even there those seedlings which are poorly planted, and therefore poorly rooted, are likely to be lost.

The thoroughness with which the seed is covered before germination and the character of the soil, therefore, are everywhere important factors in establishing seedling stands. In hard-packed soils, like those of much-used bed grounds, sheep trails, and the like, the seedlings have difficulty in extending their roots, and the loss is naturally great. Heavy loss also occurs on warm, exposed situations, but since these usually have a dense seedling stand in the spring, the final stand compares well with that of more favorable localities.

Once they have passed through the first six weeks of their existence, seedlings are not likely to be affected by drought or adverse temperature. The root system develops rapidly in the autumn of the first year, which not only protects the plant from winter killing, but insures it against moderate gullying and drought the following season.

During the second year of growth the young plants develop a splendid root system. (Pl. III.) This has penetrated deep enough into the soil before the usual spring drought period to enable it to continue its rapid development, and at the close of the season the deepest roots often extend 6 inches below the surface. In the case of some of the bunch grasses from 20 to 40 basal leaf blades (root leaves) from 3 to 5 inches long are produced. By autumn of the third year the perennial plants attain full development and produce fertile seeds. From 3 to 5 flower stalks are usually sent up, and leaf blades and root growth are very prominent. (Pl. IV.)

So far the discussion has dealt with the loss of seedlings under purely natural conditions. It is plain, however, that grazing, especi-

ally in localities where the stand has previously been weakened through drought, is an important factor in connection with reproduction. The injury to seedlings due to grazing depends primarily upon the class of stock grazed, the season of grazing, and the way in which the stock is handled. It can therefore best be discussed in connection with the different systems of grazing the range, the relation of each system to the maintenance of the stand, and the revegetation of the range with the most valuable plants.

EFFECT OF GRAZING ON THE FORAGE CROP.

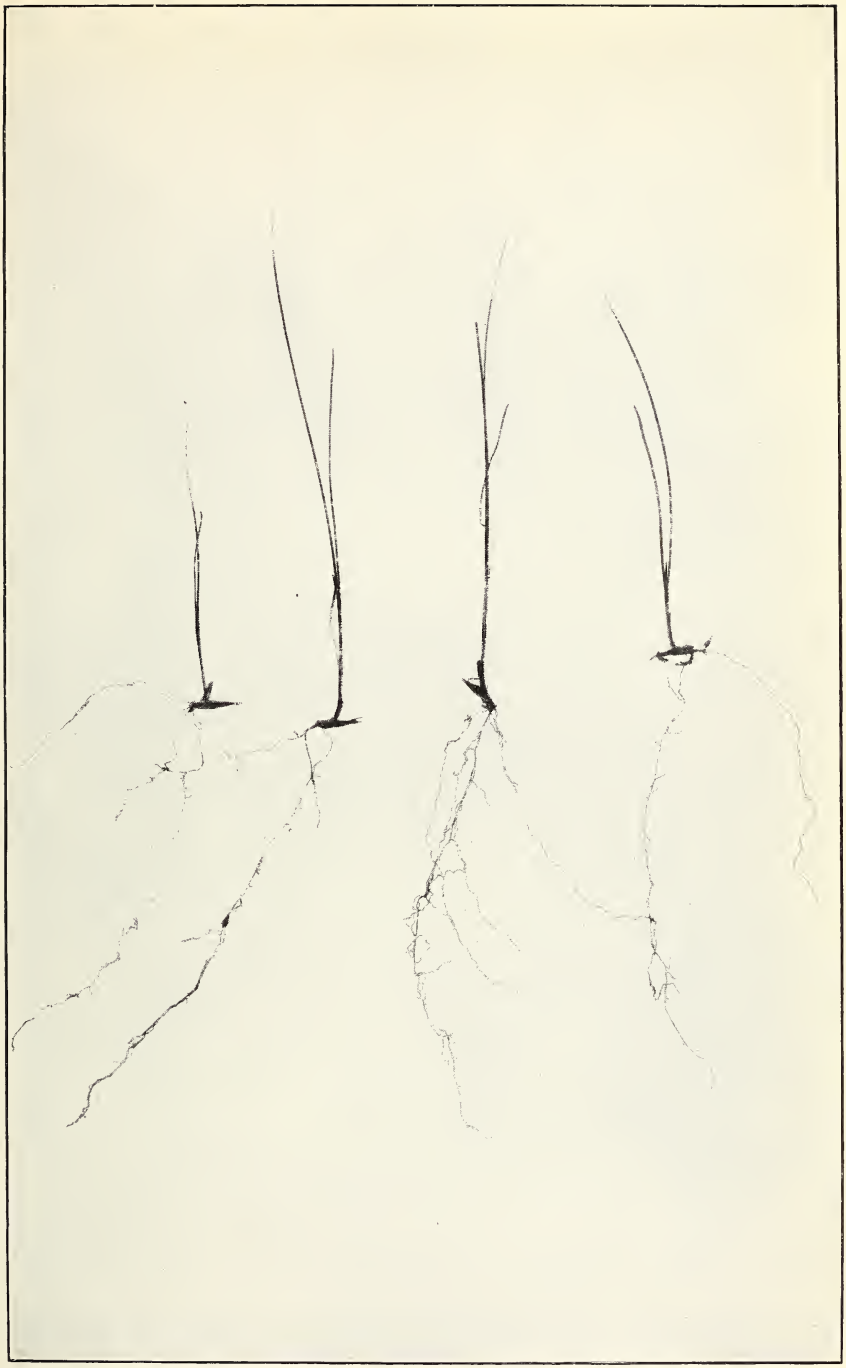
From what has been said about the growth requirements of the principal forage plants, it is plain that the most effective system of range management from the standpoint of the vegetation alone will be the one that interferes least with the growth of the plant up to the time of seed maturity, and then aids in planting the seed. Any system adopted must be practicable from the standpoint of the stockman.

Grazing on western range lands may be divided into three more or less distinct systems: (1) Yearlong or season-long grazing year after year; (2) yearlong or season-long grazing with occasional total exclusion of stock during the entire year to give the forage a chance to reproduce; and (3) deferred grazing, which aims at a rotation in the time of using each portion of the range, allowing the plants on one portion to mature their seed each year before they are cropped, and then grazing it to avoid loss of forage through nonuse, and to assist reproduction by trampling in the seed.

The following discussion aims to show the comparative merits of the three grazing systems from the standpoint of the range plants' requirements for growth and reproduction, and to outline the system which promises the best results to both the range and the stock industry.

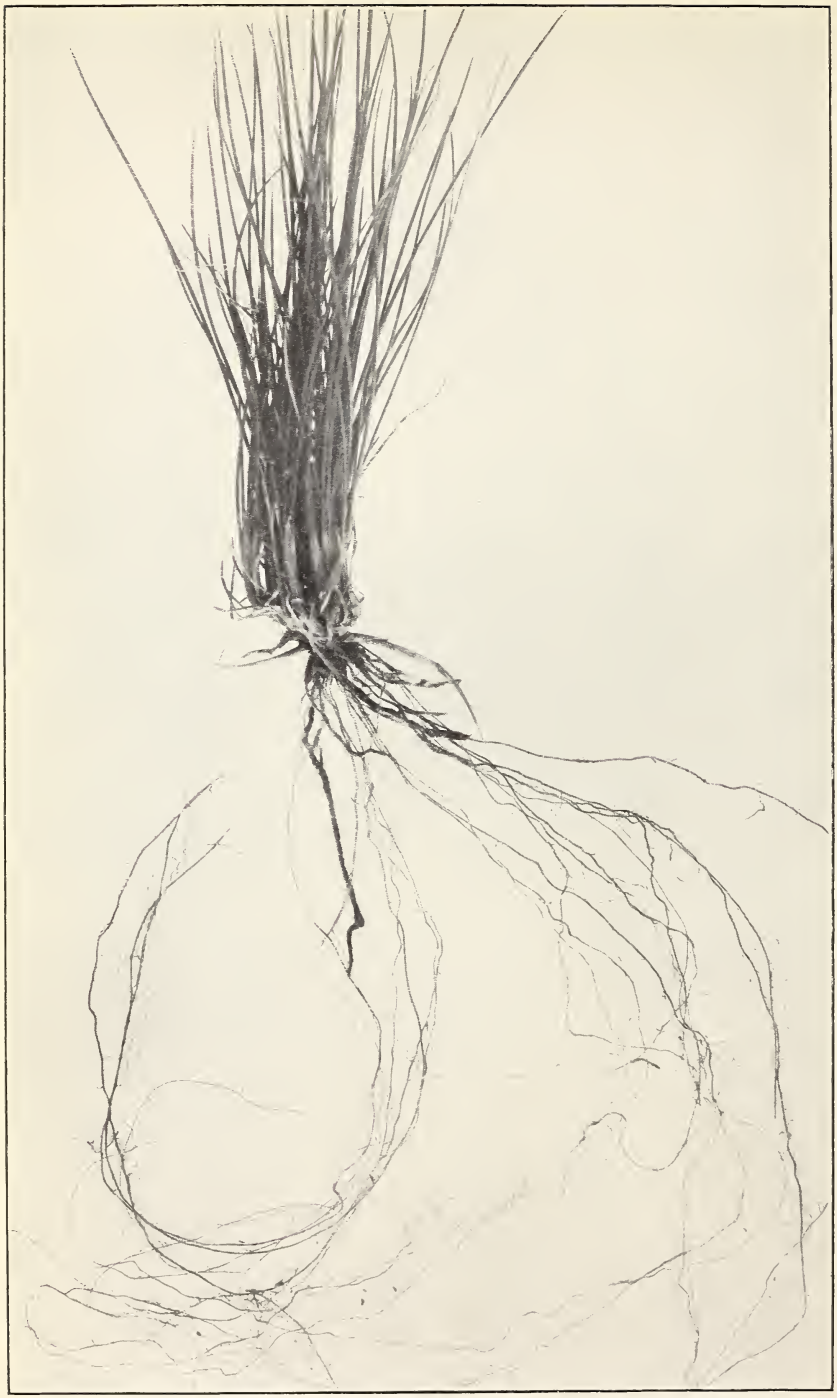
YEARLONG GRAZING.

Prior to the inclusion of lands in the National Forests stock usually had access to the range before snow was entirely off it, and therefore when the earliest growth was appearing in the lower elevations. As the season advanced the stock drifted or were driven to the highest portions, reaching each portion soon after growth had begun. In many localities the range was so crowded that it was grazed continuously throughout the season; the only period of rest was during the time required for the herbage to grow enough after being closely cropped to again permit grazing. Results from such practices were directly comparable to those from the monthly clipping experiments cited, and, in addition, the range was damaged a



DEVELOPMENT OF MOUNTAIN BUNCH GRASS DURING THE SEASON WHEN DEATH FROM DROUGHT IS MOST SEVERE. (NATURAL SIZE.)

Photographed July 27, 1909.



AERIAL GROWTH AND ROOT DEVELOPMENT OF A MOUNTAIN BUNCH-GRASS PLANT AT THE END OF THE SECOND YEAR OF GROWTH. (NATURAL SIZE.)

CHARACTERISTIC DEVELOPMENT OF MOUNTAIN BUNCH GRASS AT THE END OF THE THIRD SEASON, WHEN THE PLANT IS FIRMLY ESTABLISHED AND THE CYCLE OF DEVELOPMENT HAS BEEN COMPLETED.

FIG. 1.—AN OVERGRAZED MOUNTAIN BUNCH-GRASS RANGE FENCED AGAINST STOCK IN 1907.

Photographed July 12, 1907.

FIG. 2.—VIEW OF SAME AREA AFTER THREE SEASONS' PROTECTION AGAINST GRAZING.

The increase in forage is due to vegetative growth and not to reproduction from seed.

good deal by repeated trampling. As in the case of the clipping experiments, the vegetation gradually weakened and no seed was developed; consequently there was no reproduction whatever.

After the inclusion of the lands within the National Forests definite grazing seasons were established, and not only was depletion of the range stopped, but there was a slight increase in its carrying capacity. The improvement, however, was mainly confined to the lightly grazed lands and was due almost entirely to the production of new shoots from the root stalks of the original plants. Under the very best conditions, however, the actual increase in forage by this means is comparatively small, as the plants do not spread over bare areas.

Yearlong or season-long grazing is the common practice in most localities. For example, on the Wallowa National Forest sheep, the only class of stock grazed in the high mountains, are allowed to enter early in July as soon as growth is well started and when the flower stalks of the vigorous plants are being sent up. At this time the stalks are succulent and are eaten with about the same relish as the herbage. The areas grazed earliest are occasionally cropped again after the second herbage crop has partly developed. In such cases the vegetation is again deprived of its food-manufacturing parts. Even though grazed but once during the early stage of development the range plants are unable to recover and reproduce. Careful observations made in the case of 300 experimental areas on the important forage types showed (1) that the palatable and dependable perennial plants were not reproducing at all; (2) that only one perennial herb, known as sickle sedge (*Carex umbellata brevios-tris*), an unpalatable and useless species, was reproducing; and (3) that unpalatable annual weeds which mature their seeds at about the same time that the stock reach the mountain grazing lands, were increasing at a rapid rate, especially on the most seriously depleted areas.

A relatively small percentage of this undesirable seedling stand became established, however, because of the high moisture content of the soil and the consequent ease with which the seedling roots of the forage plants were pressed out of the ground by the early grazing stock. In general, however, the loss in forage plants bore a direct relation to the time that the lands were grazed, the greatest loss occurring on the lands grazed earliest.

To sum up the result from continued season-long grazing: Where there is enough stock to use all the forage each year the requirements of plant growth are seriously interfered with, the forage crop becomes weakened and is materially decreased, little or no seed is produced, reproduction is therefore prevented, and there is a gradual decline in the carrying capacity of the range.

YEARLONG PROTECTION OF THE RANGE.

It is plain enough that yearlong or season-long grazing, as just discussed, tends neither to maintain the forage crop nor to improve the carrying capacity of overgrazed lands nor does it favor the best interests of the stockman. On the other hand, the plan of closing certain depleted lands during the period required for revegetation might seem at first sight to meet the requirements in a practicable way. It might seem best to carry out such an alternating system of season-long grazing and protection, so that when one portion of the range is thoroughly reseeded another may be protected until the original productivity of the entire range is restored. This plan implies, of course, that protection would result in satisfactory revegetation. Moreover, if the grazing industry is not to be seriously interfered with the extent of range protected must be determined by the demands upon the grazing land.

To determine definitely the practicability of reseeding the range in this way several plots, lying between elevations of 3,000 and 7,000 feet, on which vegetation had been weakened through overgrazing, were fenced in 1907. An area at 3,000 feet supplied a sparse stand of vegetation, consisting mainly of annual species, chiefly soft cheat or chess (*Bromus hordeaceus*). A few widely scattered tufts of two perennial grasses, big bunchgrass (*Agropyron spicatum*) and June grass (*Koeleria cristata*) were also found. The plots located at about 5,200 feet elevation supported a variety of annual and perennial grasses and other plants. The high mountain plots, shown in Plate V, supported mainly perennial grasses, annual weeds, Douglas knotweed (*Polygonum douglasii*) being particularly conspicuous in places. Each plot contained enough vegetation to produce at least a small seed crop after vigor had been regained through the much-needed rest. During the first two seasons of protection, especially the second year, the herbage of the perennial vegetation increased to a notable degree. In addition, the stand was somewhat improved by new shoots from the rootstocks. But there was no reproduction from seed. The annual species, of course, have no rootstocks, but their reproduction from seed is relatively good. During the first season the perennial vegetation produced very few flower stalks and practically no fertile seed. At the end of the second season all species appeared to be fairly vigorous, and while at least a small seed crop was developed on each plot, virtually no new plants of the perennial species had come up from seed. By the close of the third season the plants appeared to have fully recovered their vitality, and a thoroughly satisfactory seed crop of average germinative power lay scattered over the plots in the autumn.

In the spring of the fourth season the lowest areas had improved to a marked degree in carrying capacity through the increased stand

of the annual plants, of which cheat constituted the greater part. The perennial species, despite the seed crop produced, had revegetated only to a very limited extent. On the medium and high plots, with the exception of porcupine grass, the seed of which is planted by means of a bristle or awn, there was practically no reproduction.

Plate V shows the increase in herbage of the original plants on the mountain lands after three years of protection. Even after five seasons of protection, however, practically no new perennial plants were found. This lack of seedlings was not due to low fertility of the seed, for after two seasons of protection the large seed crop produced had at least average viability, the seed of many species germinating more than 50 per cent. In each locality it was evident that the failure to produce new plants from seed was due to the fact that the seed did not penetrate the soil. The larger-seeded species, such as mountain bunch grass, failed almost completely to reproduce where the soil was not stirred, while the seedlings which originated from unplanted seed soon died from drought. Small areas, artificially planted, were revegetated by all species regardless of the size and character of the seed.

This shows conclusively that (1) yearlong protection from grazing restores the vigor of the impoverished vegetation and promotes the forage production of the plants in existence; (2) the annual species with strong seed habits reproduce satisfactorily, but the more desirable and nutritive plants, especially the large-seeded species, reproduce only to a limited extent; and, (3) while yearlong protection is favorable to the growth of the vegetation, it does not accomplish the planting of the seed, which is essential if the range is to be revegetated.

Aside from failure to insure revegetation with the most desirable species, the method entirely wastes the forage during the period of protection. Nonuse of the herbage is a serious drawback, and yearlong protection could not be economically carried out on a large scale. Furthermore, the accumulation of inflammable material during the period of protection would result in increased fire danger.

DEFERRED GRAZING.

In contrast to the two grazing systems discussed, deferred grazing is based upon the growth requirements of the vegetation from the germination of the seed until new plants have been established. The essential principles of the system are: (1) An overgrazed portion of the range, sufficiently large to supply the forage from the time of seed maturity until the end of the grazing season, is protected from stock until the seed crop has matured; (2) upon maturity of the seed crop the forage is grazed closely during the first season, but not to the extent of injuring the seed plants; (3) the same area is pro-

tected in the same way during the second and, if necessary, subsequent seasons, or until the new plants have been securely established; (4) when the area has been thoroughly reseeded, it is grazed early in the season and a second area, of sufficient size to accommodate the stock from the time of the ripening of the seed to the end of the grazing season, is protected until the forage has matured; (5) this method of alternating late grazing from one area to another is continued not only during the period required for the restocking of the lands, but even after the areas have been fully revegetated. It has been found both from the experiments and from practical application in range management that weakened vegetation thus protected recovers its vitality quite as readily as when the land is closed to grazing the entire year. The amount of forage produced was the same, and the flower stalks were sent up and seed matured at the same time on deferred-grazed and yearlong-protected lands. This point is further substantiated from results obtained from clipping matured forage and protecting it throughout the year—the vigor of the vegetation being rapidly restored and equally well maintained in both cases.

One of the greatest advantages of the deferred system of grazing is that the forage may be fully utilized while the lands are being reseeded. Though the range is not available for grazing until after seed maturity, the herbage, while not succulent at that time, is eaten with relish. Stock are not in need of succulent food in the latter part of the season, since a small milk flow is then sufficient for the lambs. Where deferred grazing has been thoroughly tried, sheep have been found to scatter more widely over the land than when the herbage was succulent, but practically all the valuable forage plants were closely cropped. Lambs as well as dry sheep made satisfactory gains, and the fat was of a solid, substantial nature.

The nutritive value of the forage in the autumn, as shown by the condition of the stock, is further proved by a chemical analysis made of the herbage. For example, the leaf blades of mountain bunchgrass after maturity contain about twice as much nitrogen, or bone and muscle building material, and nearly the same amount of fat, as well-cured timothy hay, while the crude fiber, or indigestible material, is appreciably less than in timothy.

Perhaps the main advantage of deferred grazing, however, is that it plants the seed, which is so essential to reproduction. On an area grazed after seed maturity there were found seedlings of all important forage plants; on an adjoining yearlong-protected area only such species as white foxtail (*Sitanion velutinum*), the seeds of which have stiff barbs, were reproducing. Wherever enough plants were left on a deferred-grazed area to produce the necessary seed, no matter what its size and character, seedlings were in evidence. In

some localities the stand more than doubled in some seasons, though the forage was grazed each year. Grazing thins the seedling stand, of course, even when confined to the autumn, but in the latter case destruction is not nearly as great as when the lands are cropped before the seedling roots are developed. Moderate autumn grazing on lands at medium elevations resulted in an average loss in seedlings of 51.9 per cent. On the higher ranges 56.7 per cent of the seedlings which had survived the drought period were destroyed by sheep. This loss is largely offset, however, by the planting of another seed crop, from which a stand of seedlings is produced the following year. In view of this and of the urgent need for feed in the autumn, the loss of seedlings due to grazing can not be considered serious enough to justify closing the range.

The seedlings are not subject to loss by moderate autumn grazing after the first season of growth, since the root system is then so well developed that the plants are not pulled up by cropping or seriously injured by trampling.

To sum up the advantages of deferred grazing over yearlong grazing and season-long protection: (1) It restores and maintains the vegetation without the loss of the forage crop in any year; (2) it insures the seed being planted, thereby overcoming the chief disadvantage of yearlong protection; (3) it does away with the fire danger resulting from the accumulation of inflammable material under yearlong protection.

In addition, if overstocking and bad management are guarded against, there will be no material injury to forest reproduction or the cover on watersheds.

APPLICATION OF DEFERRED GRAZING TO RANGE MANAGEMENT.

Deferred grazing can be applied on any range where the forage is palatable and nutritious after seed maturity, and where water is available for stock. The food value of the herbage of most species in the autumn is relatively high. The herbage of grasses and grasslike plants after seed maturity is somewhat better preserved than that of certain succulent weed species, whose leaves may either be dropped or partly decomposed. Consequently, grass lands need not be grazed as promptly after the seed matures as weed areas. The weed type of vegetation, however, matures its seed earlier than grasses and grasslike plants, and so offers an exceptional opportunity for deferred grazing.

Of course, the herbage can not be used unless there is an adequate supply of water for the stock. Water facilities may be developed on many ranges by the construction of dams, by the protection and development of springs, and even by digging wells and building

windmills. In years of normal rainfall the springs and small mountain streams are often replenished by the autumn rains, so that grazing after seed maturity is usually possible in all but the driest situations.

In range management under a system of deferred grazing the first things to consider are (1) the time at which the seeds of the important forage plants mature and (2) the proportion of the grazing season remaining after seed maturity. These things must be known in order to determine what portion of the range may be set aside for autumn grazing. In the Wallowa Mountains one-fifth of the grazing season remained after the seed had matured, and accordingly one-fifth of the carrying capacity of each summer grazing division or allotment could be reserved annually for reseeding. The time of seed maturity varies, of course, with elevation and climate, and so will the proportion of range which may be set aside for deferred grazing. Since range lands are usually grazed by camps, the user will have no difficulty in selecting such areas.

Once the area in need of reseeding has been selected, no stock should be allowed on it until after the seed has ripened. It should then be closely grazed, but not destructively. The stock should pass at least once over the entire area, so that the seed may be worked thoroughly into the ground. During the following season the same area should again be protected from grazing until the seed crop has matured. This is essential not only for the production of another seed crop but also to allow the young plants resulting from the seed of the previous year to become established. Early grazing must be avoided until the young plants are thoroughly established. Grazing during the second season should be lighter than in the first year in order to keep down destruction of the seedling stand. Massing and running the stock by dogs should be done away with as far as possible, and the stock should have the greatest practicable freedom. Ordinarily, an area should once more be grazed by the deferred method the third season, to insure the final establishment of a reproduction from the first year's seed crop and to give the seedlings from the second year's crop a chance to develop.

If three seasons of deferred grazing prove ample time for thorough revegetation of an area, a new portion of the range in need of reseeding should be selected and managed in the same way. Through this continuous rotation it will not only be possible to restore the entire range, but, once it has been restored, to maintain the full carrying capacity of the lands.

SUMMARY.

REQUIREMENTS OF PLANT GROWTH.

1. The vigor of the vegetation determines the promptness with which growth starts in the spring.

2. Prompt spring growth and luxuriant herbage are necessary for early and prolific production of flower stalks and for the development of a large and fertile seed crop.

3. Repeated removal of the herbage during the growing period weakens the plant and delays the resumption of growth the next spring, retards the time of flower-stalk production, reduces the number of stalks produced, retards the time of seed maturity, and results either in nonfertile or very few fertile seeds.

4. Removal of the herbage after seed maturity in no way interferes with plant growth, while seed production and viability are the same as when the herbage is undisturbed year after year.

5. Germination of the seed and establishment of seedlings very largely depend upon the thoroughness with which the seed crop is planted. Artificial stirring of the soil after the seed is dropped is necessary to the permanent establishment of practically all seedling plants.

6. Even when a fertile seed crop is well planted, there is a heavy loss in seedlings from freezing and drought during the first year. After this, however, there is no loss from this cause.

THE MAINTENANCE OF A MAXIMUM FORAGE CROP.

YEARLONG GRAZING.

1. Continued removal of the herbage year after year seriously interferes with the growth and seed production of the forage plants.

2. The vegetation is soon weakened, and in the absence of reproduction the range steadily loses its carrying capacity and finally becomes depleted.

YEARLONG PROTECTION.

1. Yearlong protection is favorable to the growth of the vegetation, and under it weakened plants readily recuperate.

2. Practically no reproduction from seed is obtained, however, regardless of whether or not a fertile seed crop is produced, because the seed is not planted. Only the species whose seeds are provided with barbs or awns revegetate under yearlong protection.

3. Economical yearlong protection is not practicable, since the forage crop is lost during the long revegetation period. In addition, the accumulation of inflammable material increases the fire danger.

DEFERRED GRAZING.

1. The removal of the herbage crop after seed maturity allows the vegetation to recover its vitality as readily as when protected yearlong.

2. The fertile seed crop produced is planted by the trampling of the stock.

3. The nutritive value of the forage after seed maturity is relatively high; the herbage is grazed with relish, and there is no loss of forage.

4. The lands must be grazed moderately during the time required for the seedling plants to become securely established.

APPLICATION OF DEFERRED GRAZING TO RANGE MANAGEMENT.

1. Deferred grazing can be applied wherever a fertile seed crop may be produced and where there are ample water facilities for stock while grazing.

2. The area of the range to be set aside will be determined by the time of seed maturity and the amount of forage required between that time and the end of the season.

3. The time required to reestablish a satisfactory forage stand will depend upon (*a*) the extent to which the range is depleted, (*b*) fertility of the seed and the thoroughness with which it is planted, and (*c*) climatic conditions and the care with which the lands are grazed after the planting of the seed crop.

4. After the first area selected has been thoroughly revegetated it may be grazed early in the season and another area set aside for deferred grazing. The system should be continued after the entire range has been revegetated in order to maintain the vigor of the vegetation and allow the production of an occasional seed crop by which the forage stand may be maintained.

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