Continuous grazing is practiced generally on western range lands - federal, state, Indian and private. It is employed by the Forest Service on the national forests and by the Bureau of Land Management on the public lands. Maintenance of the range with this type of grazing is based on the belief that overstocking is the cause of range deterioration, that with overstocking plants are grazed too closely and killed. Further it is based on the belief that proper use of plants can be obtained by stocking the range with the proper number of animals. Proper use of plants cannot be obtained by this means or any other for that matter. Livestock graze the range selectively by plant species and areas. They graze preferred plants and areas beyond proper use level under the lightest stocking. Plants around water and in riparian areas are examples. Some plants are killed and the range deteriorated as long as the range is used.

Plants are killed by grazing not because they are grazed to closely but because they are grazed closely continuously. With such use the plant can't make adequate food for sustenance. The plant can be maintained under the closest use, however, if it is periodically rested from use so it has time to make and store a normal supply of food, recover growth capacity and reproduce. Resting is provided with rest-rotation grazing. The range is divided into pastures. Some are grazed each year and others are rested so the plant can carry out its normal life functions undisturbed.

The effect of continuous grazing on the vegetation on the Brewer Ranch and of rest-rotation grazing on five range areas in three states is shown in photographs to follow.
1994
-\frac{1862}{137}
The vegetation on these lands has been severely deteriorated by overuses activities. The most widespread and devastating use has been livestock grazing. Perennial plants killed at not replaced by valuable ones. Most scenarios with plants over his been found resulting in soil erosion and decline in soil fertility and lead production capacity. As a result of these actions, the production and quality of all renewable resources have been greatly reduced. Capacity for producing livestock, for example, has been reduced to 30 percent.
Grazing Management

The Problem

High-level production of livestock and other values on western range lands depends on the production of desirable, vigorous plants on the entire range. This can be accomplished mainly through proper management of livestock grazing.

The idea has long prevailed that overstocking is the main cause of range deterioration. This thought has been expressed as follows:

"White man allowed too many of his grazing animals to use the range. He overstocked the range almost from the start. How else explain the depletion of the range by more than half?" (The Western Range, 1936).

This belief has led to a conviction that range improvement depends principally on regulation of stocking rate and that proper use of the vegetation can be obtained through proper stocking. This proper-use philosophy of management is more widely accepted today than any other and is the basis of management on most ranges.

But assumption that plants can be grazed to a proper level through regulation of stocking is unrealistic because of the grazing habits of livestock. Livestock graze the range selectively, by species and areas. They consistently graze the more palatable plants and accessible areas closely, and invariably beyond proper-use level. The pattern of use is very uneven, but much the same from year to year. Plants grazed closely one year tend to be grazed closely the next. So under continuous grazing at any stocking level, the more palatable
and accessible plants are gradually killed out. Livestock then graze on less desirable plants. This process leads progressively to ever enlarging areas of deterioration. Unfortunately, the best plants and best grazing sites are destroyed first.

Destruction of the better plants and sites is accepted as inevitable under the proper-use management:

"Just as there are certain sacrifice areas, there are also some sacrifice plants -- species with high animal preference but never abundant in the stand. These 'dessert' or 'ice cream' plants are usually killed out when the hardier, more abundant, and somewhat less highly preferred key species are properly utilized, a fact that entails little economic loss." (Sampson, 1952).

The question may be asked: After the ice cream plants are destroyed what is sacrificed next? Clearly the degree of use on individual plants cannot be regulated.

The better forage plants and all others can be maintained, however, by periodically resting the range from use. Only by this means can the main objectives of grazing management -- maximum production of vegetation and high-level yield of livestock and other multiple-use values -- be realized.

REST-ROTATION GRAZING

Forage Production

To practice rest-rotation grazing management it is necessary to divide the range into pastures or units. Each pasture is systematically grazed and rested so as to provide for the production of livestock and
Cause of range deterioration

Most people including scientist, stockmen and others have firmly believed that the basic cause of range deterioration is over stocking, too many animals --

"White man allowed too many of his grazing animals to use the range. He overstocked the range almost from the start. How else explain the depletion of the range by more than half? (The Western Range, 1936)."

-- and that the range can be maintained by grazing with a moderate number of animals and paying proper attention to the season of grazing, the kind of animals grazed and livestock distribution measures such as riding, herding and salting. This led to the belief that the range could be grazed continuously and maintained if it was grazed with some low or moderate number of animals.

This idea has prevailed over time and led to the continuous moderate grazing system -- the most widely accepted and practiced grazing system in the west.
and replaced by inferior ones. The plant cover has been thinned in most places, causing erosion and loss of soil fertility. It is estimated that grazing capacity for livestock has been reduced by half or more. Heavy stocking and long seasons of use by livestock year after year have been major factors in deterioration of the range.

Management must recognize that all renewable rangeland values stem directly or indirectly from vegetation. Sustained high-level production of these values therefore depends on proper management of the vegetation. The principal tool the rangeland manager has for managing vegetation is livestock grazing. It is the only force under firm control of the manager that can be applied on practically the entire range area.

Livestock grazing is desirable, if not essential, on rangelands for several reasons. A large portion of the vegetation on rangelands can be converted to more useful products only by livestock. As the Nation's population grows, an increasingly greater portion of its meat supply will have to be produced on rangelands. Arable lands will be used more and more to produce grain, vegetable, and fruit crops for human consumption. Furthermore, desirable vegetation and the overall productive capacity of rangelands can be increased more rapidly with livestock grazing than without. Livestock can be used to perform many important functions that can be achieved no other way over the entire or major portion of the range. They can be used to trample seed into the soil thereby promoting more forage and a better soil cover; to remove stifling old growth on plants, thus increasing plant vigor and production of usable herbage; to stimulate adventitious growth and higher quality forage; and to reduce fire hazard.

The biological facts for development of sound grazing methods have been known for a long time. As far back as 1914, A. W. Sampson outlined many principles of good grazing management. However, relatively little use has been made of these facts and principles. Reluctance to relinquish certain established ideas on management, even though proved ineffective in practice, has been a major deterrent to the development and use of better grazing methods.

Much of this publication is devoted to a review of some of the more important facts on which good grazing management is based. The use of this information in formulating effective grazing methods is described.
DEFINITIONS OF GRAZING CAPACITY

Jardine, James T., and Anderson, Mark

"Grazing capacity, as used here, means the number of stock of a given class or classes which a range unit will support for the period of grazing allowed. The ideal sought is the maximum number of stock which the unit will support each season over a period of years without injury to the range tree growth, or watershed, or unwarranted interference with game and recreation. If this ideal is to be realized, both overgrazing and unnecessary undergrazing must be avoided."

Sampson, A. W., M.A., Ph.D.
Associate Professor of Range Management and Forest Ecology, University of California.
Formerly Plant Ecologist, United States Forest Service, and Director, Great Basin Experiment Station.
- recognized as father of scientific range management


"The grazing capacity of a pasture area may be defined as the number of stock of one or more classes which the area will support in good condition during the time the forage is palatable and accessible without decreasing the forage production in subsequent years."

Forest Service Manual. Vol. 3, Title 8
June 1954

"204.1 Definition of Grazing Capacity.

The grazing capacity of a national forest range area is the maximum number of livestock the unit will support during the regular grazing period over a long series of years without injury to the soil, forage, plants, watershed, or tree growth."

Stoddart, Laurence A., Smith, Arthur D., and Box, Thadis W.

"Grazing capacity, then, has come to be regarded as the maximum animal numbers which can graze each year on a given area of range, for a specific number of days, without inducing a downward trend in forage production, forage quality, or soil."

CONSENSUS DEFINITION

The maximum number of livestock that can be grazed on the range during the grazing season continuously year after year without damage to the range—the vegetation and soil.
In briefest form the specific lines of action required are:

1. First and by all odds most important, the reduction of stocking to the actual present grazing capacity. Since present stocking of the entire range area, now 17.3 million animal units, is 60 percent in excess of its estimated capacity, it will have to be reduced by about 6.5 million animal units.

The guiding principle should be stocking year after year with the number of animals which each unit will support each season without injury to the range. The outstanding need for restoration and the wide fluctuations of climate and hence of forage production require conservative stocking for satisfactory results, and this under most conditions should leave from 20 to 30 percent of the palatable growth of the important forage plants during average years. In addition, stocking should be low enough to prevent injury to watersheds and tree growth, and should be properly correlated with wildlife and recreational requirements.

The practical difficulties involved in such reductions are fully recognized, but the owners of private lands and managers of public lands should not overlook the possibility that actual returns will be greater in the long run from conservation than from continued overgrazing. They may be greater immediately. The reduction figures given are for the entire range. Not all ranges and individual holdings are overstocked. Many stockmen who have overstocked free public ranges in self-protection will undoubtedly welcome the opportunity to make reductions to actual grazing capacity when these ranges are placed under administration and the feed for their livestock is assured.

2. A judicious balance for range rehabilitation between natural and artificial revegetation.

The cheapest and most practical method of halting destruction and of restoration on about 655 million acres or 57 percent of the total range areas is through the control of the stocking and the use of sound grazing systems. This means in essence merely giving the native forage a chance to come back under its own marvelous recuperative powers.

On about 38 million acres, or 5 percent, of the most completely depleted areas such as abandoned farm lands and those which are most critical from the standpoint of watershed protection, the choice lies between artificial revegetation, which has a great advantage in time but will cost about $2.25 per acre, and waiting for natural processes, which according to the best information now available would require from about 20 years as a minimum to perhaps 50 years as a maximum.

3. Putting into effect on the ground the best available systems of grazing, including deferred and rotation grazing, continual moderate grazing, and alternate grazing, which are described in more detail elsewhere in the report. The use of these systems is required in both restoration and subsequent maintenance, as are also all of the following lines of action.

Such systems are in effect on about 80 percent of the national-forest ranges, possibly 40 or 45 percent of Indian lands, and 10 to 15 percent of private and State lands.

4. Adjustments of seasons of grazing to safeguard forage plant vigor and prevent damage to the soil.
Proper use of subdivisions because of destructive grazing by livestock on some plants of the more palatable species on readily accessible areas around small ponds, lakes, and drain courses.

Further developments are constantly being made in the field of scientific grazing management. Under current grazing, the plant is killed. New paper on this subject has been published in public speeches at Indian and other farm congresses, as it attracts attention to the need for such systems of grazing management.

After a year or two at grazing multiples, the plant becomes senescent during the plant growing season, spring, summer, fall or凡事，including the winter period. The range is useless from use.
rectly, as did ungrazed comparable plots. On the other hand, range areas excessively stocked deteriorated more rapidly, recovered more slowly, and consistently supported a poorer stand of forage.

Fenced and conservatively used areas throughout the West are invariably better than excessively stocked and therefore heavily grazed ranges. But drought does not stop at fence lines.

**REASONABLE GRAZING NOT DETRIMENTAL**

Investigations have shown that a reasonable degree of cropping is not detrimental to plant growth. Studies (116) in the mountains of central Utah indicate that "grazing closely twice or even three times in a (summer) season, provided the first grazing is late enough and the intervals are sufficient for the vegetation quite to recover from each cropping, ordinarily does not seriously affect the yield and vigor of the plant cover."

The sand hills of Nebraska already cited are an example of a large area under private ownership, about 12 million acres, where the vegetation has been maintained or improved in recent years under grazing. There, slight deterioration of the vegetative cover is so apt to start blowing of sand that damage can be readily recognized. Rainfall is sufficient, and the character of the vegetation is such that when the cause of damage is overcome a rather rapid recovery is made.

Under regulation of grazing on the national forests an effort has been made to adjust numbers of livestock to the sustained grazing capacity of the range forage. While there is still more or less depletion of ranges from their virgin conditions prevailing within national forests, and while adjustments in recent dry years have not entirely kept pace with depletion, most of the national forest ranges under grazing use have shown improvement in forage conditions since they were placed under administration by the Department of Agriculture.

Even on semidesert grass and shrub ranges of the Jornada Experimental Range in southern New Mexico, where vegetative conditions vary widely from year to year, studies (93) show that, on sandy soils—

* * * the average density of black grama over the 13-year period (1915 to 1927) was practically the same under conservative grazing as under no grazing. The decline during drought was rather similar under both conditions, but the return of favorable rainfall brought more rapid recovery under conservative grazing. Conservative grazing appears to break up the large, separated tufts formed under freedom from use into smaller tufts better adapted to make efficient use of the available soil moisture, * * * black grama remains dominant after drought in spite of the rapid inroads of associated grass and weed species.

A somewhat similar improvement and maintenance of tobosa grass areas on clay soils was noted within the Southern desert shrub type (30).

**PLANT INDICATORS OF OVERGRAZING**

A plant is, in effect, a plant-food factory. It does not draw its food already manufactured from the soil. It must take up water and essential plant-food elements from the soil via the root system and transport them to the leaves where, together with carbon dioxide taken in through the leaves from the air, it manufactures the ma-
terials which make possible its further growth, the development of seeds, and—of particular importance in range management—the storage of food for winter maintenance and the beginning of herbage growth the following spring. If the leaves which form this manufacturing plant are consumed before sufficient foods have been formed to take care of the essential growth functions, the plant’s vigor will be sapped. If the food supply is inadequate, the plant may succumb. It is of vital importance, therefore, to have a substantial leafage available on plants during the growing season.

In the semiarid range country of the West there is naturally a critical balance between the moisture available for growth and the needs of the plant cover, with a resulting competition for moisture. Where grazing is introduced and the range is overstocked, the palatable plants are grazed first and most heavily and are naturally the ones to suffer most in this intense competition. The inevitable thinning of the palatable plants releases the secondary species and gives them the opportunity to increase in density. Where they in turn are heavily grazed, in the absence of the more palatable plants, opportunity is given for still less palatable species to gain dominance.

Overgrazing for an extended period will thus leave “earmarks,” which can usually be recognized (79), especially in the scarcity of the choicest range plants and the predominance of low-value annual weeds and grasses, or other plants which have little or no value for grazing. Along with these signs will be others equally obvious, the presence of dead and partly dead stumps or stubby branches of shrubs, noticeable damage to tree reproduction, and erosion and barrenness of the soil, usually accompanied by a series of stock trails terracing the slopes.

To recognize current overgrazing is more difficult, yet it is important in order to make timely adjustment. It is seldom that all species are of equal palatability on a range. Since it is the important palatable plants which furnish the bulk of the feed, it is essential to use them as helpful criteria, to observe closely the degree to which they are grazed, and to stock on a basis that will not injure them. Many palatable grasses on western ranges can only sustain their vigor and density under a degree of grazing which will utilize by the end of the season no more than 70 to 80 percent of their herbage production. Of sod-forming grasses, such as most gramas, and on soils that are moderately compact, a slightly higher percentage of herbage may be taken in years of favorable rainfall. With some bunchgrasses, however, and on sandy soils, it may not be wise to utilize even 70 percent of the palatable herbage. Palatable shrubs can seldom maintain their vigor when more than 75 to 80 percent of the tender twigs and leafage is grazed. Still, on most ranges, and especially on those inadequately regulated, palatable plants are being grazed more closely than these percentages even in favorable years when maximum herbage is produced on each plant.

On nearly all ranges many plants of moderate and low palatability are present, which give the appearance of considerable “feed” when those that are more palatable have been utilized as fully as they can withstand. Dominance of secondary species prevails on millions of acres of ranges depleted in excess of 50 percent, and even on some
6. For social and economic security.—To prevent further human wastage and insure social and economic security for the population dependent on the combined range-cropland resource.

7. For basic knowledge.—To obtain and apply the information necessary for the conservation and wise use of the range resource for public betterment.

Implicit in these problems and lines of action is the question of the desirability or necessity, if Federal obligations are to be fully redeemed, for the full concentration of responsibility for public action in a single agency. A similar question holds for the States.

TO RESTORE AND MAINTAIN THE RANGE

It is perfectly clear from the preceding discussion that the range resource—the forage and the soil on which it grows—is the key to all forms of use and hence to all the social and economic benefits which should flow from such uses.

The most urgent range resource problems are to stop further deterioration of forage and soil and start both on the upgrade. The ultimate objective is full restoration and permanent maintenance in full productivity. The means which must be employed to accomplish both purposes is to reduce excessive stocking to what the range can carry and improve, and to place all range lands under management.

If the range is to serve its greatest usefulness, plans for stopping deterioration, and for restoration and maintenance, must be formulated around the highest form or forms of use, whether for the grazing of domestic livestock, for the services which watersheds should render, for timber production, for the production of wildlife, or for recreation.

FOR LIVESTOCK PRODUCTION

One specific indication of the size of the job of halting further deterioration, of restoration, and of maintenance is the 728 million acres of range land which it must cover.

A specific indication of the size of the restoration job is the fact that the present grazing capacity of the range as a whole must be increased by about 110 percent to reach its original condition. Still further, as shown by table 3, restoration must provide for more than 633 million acres now depleted more than one-fourth, nearly 390 million acres more than half, and nearly 120 million acres more than three-fourths.

<table>
<thead>
<tr>
<th>Depletion classes</th>
<th>Area depleted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,000 acres</td>
</tr>
<tr>
<td>Moderate (0–25 percent)</td>
<td>94,825</td>
</tr>
<tr>
<td>Material (25–50 percent)</td>
<td>264,697</td>
</tr>
<tr>
<td>Severe (51–75 percent)</td>
<td>272,470</td>
</tr>
<tr>
<td>Extreme (76–100 percent)</td>
<td>117,609</td>
</tr>
<tr>
<td>Total</td>
<td>728,198</td>
</tr>
</tbody>
</table>
GRAZING IN THE FOREST RESERVES.

BY

FILIBERT ROTH,
Chief of the Forestry Division of the General Land Office,
Department of the Interior.

[Reprint from Yearbook of Department of Agriculture for 1901.]
They feed chiefly on grass and refuse weeds, and take little browse (except in some of the southern reserves). Cattle feed less closely than sheep, and being free, each animal travels only when it wants to, mostly to and from water. They use much less of the entire area of the reserve, and take only a portion, often the smaller portion, of the feed.

That cattle do no damage at all, as is so often claimed, is not true. Cattle cut trails on all hillsides, particularly in the vicinity of water. They are filthy about watering places, standing often for hours in and about the water and trampling many springs into unsightly mires; occasionally they browse; they bark trees by rubbing, and they naturally trample seedling trees, just as any other animal would. Being loose footed, there should be less trampling; but this is not always the case, since cattle by their very laziness are apt to stay more persistently on any given small area. That cattle do less harm to the range is only partly true. They crop it less closely, but choosing only grass and leaving the weeds, many a cattle range has been changed into a "weeds patch." That overgrazing and consequent increase of all injuries is possible with cattle as with sheep is self-evident, and has been fully established on a number of ranges.

Numerous suggestions have been made for the restriction of grazing in the forest reserves. The most urgent and weighty of petitions of this kind come from the farmers in the vicinity of the reserves, who see in these mountain forests the protection for their all-important water supply. These petitions are fully considered each year in the allotments, and whenever the presence of sheep or cattle in these mountains appears to seriously endanger important agricultural interests, it is but natural that the principle of the greatest good to the greatest number should prevail.

For a better regulation of the grazing, it has been suggested that, at least for sheep, and probably also for cattle, the ranges be subdivided as far as the mountainous character of the reserves permits, and that each stock owner be allotted a well-defined range. This, as was correctly pointed out several years ago by Mr. Frederick V. Coville, Botanist of the Department of Agriculture, in his bulletin on the grazing in the Cascade Reserve of Oregon, would induce the stockman to care for his range, to protect it against fire, and to improve it by seeding or otherwise, and would prevent needless overgrazing.

To carry out such a system would entail considerable additional expense upon the Government; and it has therefore been suggested that a per capita tax or rental should be imposed on all stock grazing in the reserves.

Though there is still considerable opposition to such a system, it may be said that nearly all of this opposition to-day does not come from the resident, permanent stockman, but comes mostly from those who run stock wherever there is open range, avoiding all responsibility and owning little outside of their herds.
GRAZING IN THE FOREST RESERVES.

BY

FILIBERT ROTH,
Chief of the Forestry Division of the General Land Office, Department of the Interior.

[Reprint from Yearbook of Department of Agriculture for 1898.]
JOURNEY TO THE MOUNTAINS.—In their journey to the mountains the sheep are usually obliged to follow certain natural highways, and their progress and the work of handling them is largely governed by the surroundings. Wherever possible, the sheep are allowed to travel slowly and gracefully as they go. Where these bands are obliged to move right along, as, for instance, in rocky defiles, patches of timber, etc., where no feed exists, the band is held close, the sheep are obliged to crowd closely together, and in consequence the trail takes on some of the appearance of a wide, much-traveled road. The small vegetation is destroyed, the ground is worn into numerous rut-like trails, and the bushes and small trees along these trails are rubbed and nibbled, and in some cases more or less barbed and killed. Since these trails are commonly 50 to 100 yards in width, they are very conspicuous, and since they usually serve for ordinary travel as well as for the sheep, they are seen by many, and often, no doubt, the condition of the range, on the whole, is judged by these unsightly trails.

Where many bands travel the same trail and occupy the same summer range there is considerable rivalry, and in crowded districts the journey into the mountains often becomes a regular race for the better camps, much to the detriment of the sheep and range. Before the time of entrance was definitely regulated, men would start early and follow closely upon the receding snow. The freshly shorn sheep were exposed to the severities of storms, and were exhausted by rapid traveling. The range suffered even more—the ground was still wet, the feet of the animals sank deeply, and the sod was cut and damaged. In addition, the grass had just started; it was still too short to make good grazing, and thus the sheep were induced to run, and required extra moving. In this way considerable areas in nearly all ranges were completely ruined. The result is that the mat of vegetation has disappeared and the ground is bare.

A proper reduction of the number, the regulation of the time of entrance, and the division of the range have done much to prevent these injuries, and in some places a reclothing of such areas has been observed.

OCCUPATION OF THE RANGE.—The manner of occupation of the summer range differs in different reserves. Thus, in the Big Horn several bands go wherever there is room and feed, the same band...
Generally, the sheep do not eat any of the conifers or real forest trees of these mountains. They nibble them and injure them by crowding and nibbling about bedding grounds and along trails, and they feed on young trees and boughs of conifers in cases of dire necessity, but by far the greatest injury to tree growth undoubtedly consists in the trampling of seedling trees.

**SOME RESULTS OF GRAZING ON THE RANGES.** — In all cases of grazing the range is cut close, and this close shaving of the vegetable cover, together with the loosening of the soil, especially on all hillsides, naturally results in an appreciable change of the surface conditions and consequent surface run-off.

That lazy herding, where a camp is fairly “worn” out, and that all overstocking, and consequent over-grazing, increase the several kinds of injury here pointed out, goes without saying.

But while it is thus quite evident, therefore, that sheep grazing can never be conducted without more or less injuries, it is unfair to suppose, as has been too often the case, that grazing always results in serious mischief, and should, therefore, be forbidden.

To be sure, the bedding ground and trail are unsightly wastes, but they form a very small percentage of the entire area and in many cases occupy rough, rocky waste ground, of little importance for any purpose. In addition, it must be stated that the best sheep men have given up the old method of bedding for long periods in the same place and are adopting the proper way, bedding only one or at least only a few nights in a place; also, that most of the ordinary bedding grounds rapidly recover and, when once reclad with grass, far excel the surrounding ground, so that many of these old bedding grounds are conspicuous by the luxuriance of their vegetation.

Similarly, the damage to the forest growth, even along the trails and about bedding grounds, has so far proven a serious permanent mischief only in a few special localities, such as parts of California and Arizona, where unfavorable peculiarities of climate and soil combine to resist the reproduction of the forest, and therefore need but little assistance, supplied by the sharp foot of the grazing animal, to prevent young growth altogether. In other localities, such as the Big Horn, the Rockies of Montana, and the Cascades of Washington, one meets some of the finest cases of natural reproduction of pines in the immediate vicinity of trails and bedding grounds. Such cases demand consideration, and seem to throw much doubt on the sweeping statements commonly made.

In the same way the matter of aggravated erosion due to grazing seems often overdrawn. As above indicated, there is no grazing without disturbance of the surface conditions, and there are numerous instances on record where over-grazed areas (over-grazed by cattle as well as by sheep) have begun to “gully,” and otherwise show serious signs of mischief from erosion. Even in the many districts where a

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"DEPARTMENT OF AGRICULTURE.

...[text continues on the next page]"
It required the cataclysm of the Great War to bring men to realize fully the part which applied science is playing and, more particularly, will play in the life of nations. As men have come to know that everything in modern warfare is controlled in a large measure by science—no gun of large caliber is located or fired without its aid—they have come to know that in the making of things—in the economy and progress of manufacturing operations—science must have a place, an important place too. With this idea in mind, institutions of learning and industries in this country, but more especially abroad, are investigating and studying methods to bring about cooperation between science and industry. The Mellon Institute is proud that, while very young, it has been a pioneer in the field. Its principal claim to distinction, apart from its contributions to specific industries, is based on the service it has been able to render to other institutions in demonstrating the practicability of a system which brings together science and industry for the development of a future and more gracious civilization.

The administration of the Mellon Institute is now constituted as follows:

Raymond F. Bacon, Ph.D., Director (on leave of absence);
Edward R. Weidlein, M.A., Associate Director and Acting Director;
E. Ward Tilleyson, Jr., Ph.D., Assistant Director;
John O‘Connor, Jr., M.A., Assistant Director;
William A. Hamor, M.A., Assistant Director (on leave of absence);
David S. Pratt, Ph.D., Assistant Director;
Martin A. Rosanoff, Sc.D., Head of the Department of Research in Pure Chemistry.

E. R. WEIDLEIN,
 Acting Director
MELLON INSTITUTE OF INDUSTRIAL RESEARCH,
UNIVERSITY OF PITTSBURGH,
March 1, 1918

THE EFFECT OF CATTLE ON THE EROSION OF CANON BOTTOMS

To every explorer in the arid cañon country of southern Colorado the steep-walled arroyo trenchcd in the center of the flat alluvium bottom is a familiar sight. Its vertical banks many times twenty or twenty-five feet high in the soft crumbling soil are no mean impediment to travel and its sandy or stony bottom is a source of constant anxiety to the freighter. Every storm fills this miniature

grazing habits of livestock
gorge with a rush of turgid mud-laden water and even when the rain has passed there is in the air the continual dull crash of the caving banks. At places the arroyo fills all the cañon bottoms, at others it is a mere crack in a wide expanse of alluvium, but it is continually encroaching on the bottom land. The depth of the erosion varies greatly and is controlled apparently by the distance of bed rock from the alluvium surface (which is governed by the amount of alluvial filling that had taken place) and by a fixed minimum grade which is determined by the amount of overloading of the stream and the grade of bed rock. This minimum will become smaller therefore as the alluvium is gradually removed from the cañon bottoms. The maximum depth of erosion observed by the writer is twenty-five feet, the average is probably about ten feet. The former is reached in exceedingly narrow cañons such as the upper Chaquaqua Cañon, and that of the Purgatoire in southeastern Colorado and Yellowjacket and Sandstone Cañons in southwestern Colorado. The arroyos are formed only along intermittent streams. The cañons of McElmo Creek and the Purgatoire River seem to have been dry at least part of the summer in the early days (although they now flow water all the year around) and for this reason they exhibit the arroyo at the cañon bottom.

The steepness of the alluvial banks testifies to the recent origin of these arroyos. What caused them to appear so suddenly? Rarely is it that the processes of erosion are disturbed yet it appears that the disturbance which caused these arroyos has taken place during the last sixty years. The settlers who first entered these cañons found the bottom lands low and rounded with no suggestion of an arroyo at the center. The writer has talked with pioneer ranchers both in southwestern and southeastern Colorado and on this point they are unanimous. The arroyos have developed since their advent. To this may be added this further physical evidence:

1. Along the bottoms of Yellowjacket, Sandstone and Hovenweep Cañons in southwestern Colorado the arroyos are cutting into the ruins of Indian houses (stone) which are extremely old as they represent a civilization much like that of the Zuni while the Utes have occupied this region since the time of historic record. The houses were built on alluvial flats and it is only recently that the streams have cut into them.

2. Old roads and trails frequently cut straight across gullies which it is now impossible to cross. (Southeastern and southwestern Colorado).

3. Along the sides of the cañon wall where the alluvium has been completely removed from the cliff sides the imprint of roots still remains (Chaquaqua Cañon—Southeastern Colorado.)

4. The fact that water is more abundant in the cañon bottoms now than previously seems to have a bearing on this subject. In the early days (1860–1865 in eastern Colorado) (1870–1880 in western Colorado) water appears to have been very scarce in these cañons. This would seem to be due to the water flowing under a heavy alluvium cover as the precipitation records indicate no perceptible climatic variation. The formation of these arroyos seems to have uncovered a number of these hidden flows of water.

5. No alluvial terraces are found. The cañon floor is usually very nearly flat. If these arroyos were cyclic, we should expect to find a series of terraces representing a series of stages in the erosion of this alluvium. Such is not the case, even in comparatively wide cañons. The usual cañon rock terraces represent cycles exceedingly remote when compared with the one under discussion.

Comparisons of the drawings and photographs of government reports of 1860 to 1870 with recent photographs confirm this hypothesis, as the older reports do not seem to show any arroyos like those now developed.

The development of these arroyos seems to have been, therefore, contemporaneous with development of ranching. To what must we ascribe them then? The writer believes they are caused by cattle. Cattle influence erosion in two ways: first by the wearing of trails; second by the destruction of vegetation.
Cattle make trails along the line of easiest passage, usually the center of a cañon. They differ from the wild animals in that they are not hunted by man and must not shun narrow confined places, but actually converge toward them. Their trails grow rapidly and the writer can recall many which are five feet wide and a foot and a half deep. These trails effect erosion in two ways. First they form channels for the passage of water; second because of the absence of vegetation they form channels of easy erosion. Their compact surfaces are also hard places for the water to sink into the soil. During a heavy shower it is noticeable that water starts to form pools in these trails long before the surrounding surface shows the slightest sign of having reached its saturation point. When the storm becomes heavy each one becomes a miniature torrent and rapid erosion takes place in much the same manner as it does on a steep country road and finally small gullies are worn. Where rounded gullies are already present the walls are broken down and the vertical-walled arroyo finally results.

The influence of cattle on the vegetation of cañon bottoms as a whole is rather difficult to estimate, yet it must be considerable. The writer has seen in cañon pockets inaccessible to cattle deep grass so matted and tangled as to preclude any thought of erosion and cause maximum absorption, while in the same cañon where the cattle have ranged, the bottom is nothing but a trampled field of dust which offers maximum opportunity for erosion and minimum opportunities for absorption. This is particularly true in the mid summer and autumn months when cloud-bursts are frequent. We may, therefore, summarize the effect of cattle by saying that they increase the rapidity of the run-off and the rate of erosion by destroying vegetation, by compacting the soil and forming channels for the passage of water.

The introduction of this new element produced a disturbance in the nicely balanced forces of erosion so that the alluvial flats of the cañon bottoms were no longer planes of equilibrium. The increased volumes of water that swept down the cañons demanded larger channels. These the trails and the small gullies which grew from the trails, supplied, until finally the process formed the arroyos we meet to-day. The present cycle is one of readjustment. In wide cañons the alluvium will be cut away until the width of the stream course becomes so great that water will lack the force to erode and the final channel will be a rounded one of somewhat lower grade and much closer to bed rock than the present one. In narrow cañons the alluvium will be entirely removed (along Chaquaqua Creek this has already taken place) and the stream erosion grade will be formed. Of course this process is small by the side of the great base leveling which is taking place in these regions, but it is interesting in that it shows the extreme nicety with which the forces that erode are balanced. It also shows rather forcibly one of the effects of the influences of human industry on the topography. Its economic effect is not as great as that of deforestation, but it will result in the ultimate abandonment of many small farms along some of the streams. For these reasons it is deserving of further investigation.

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University of Colorado

AN EMERGENCY SUPPLY OF RUBBER

The department of botany of the University of California has undertaken a study of certain West American shrubs belonging to Chrysothamnus and other genera of the Compositae to determine whether or not an emergency or supplementary supply of rubber exists in such native plants. This investigation is one of the projects of the botanical subcommittee of the Pacific Coast Research Conference acting under the Council of Defense of the State of California. Results thus far obtained indicate that the total amount of rubber present in these native species is considerable, but that the percentage yield of individual plants is too small to render its extraction profitable at present prices. If, however, the importation of raw rubber should be curtailed through enemy action, this emergency supply existing within
without the background of experience which some stockmen possess and through which they have developed a facility for judging rangeland potentialities. However, some ranchers through lack of observation have failed to acquaint themselves with facts essential to good management. These problems have led to development of procedures for inventorying the range-forage resource to determine proper and safe levels of use.

Concept of Grazing Capacity

Weather in range areas is subject to great annual variability, and annual forage production tends to vary even more, being correlated especially with seasonal distribution of precipitation. The production may be 2 to 3 times as much one year as another on perennial forage; on annual vegetation it may be 10 times as much one year as another. Such variation necessitates ultraconservative use in productive years or flexibility in number of livestock from year to year.

Great variation of stock numbers permitted on federal lands is infeasible, however. Federal range managers often must grant term permits for specified livestock numbers. Specific numbers are demanded by the livestock growers to maintain stability, and only through occasional and minor adjustment in the duration of the grazing period in a given year can grazing be adjusted fully to annual production of forage. The problem of the administrator, then, is one of designating a specific number of animals which can graze on a unit of land a year after year without injury to the land and which he designates as the grazing capacity of that land (Stoddart, 1952).

DETERMINATION OF GRAZING CAPACITY

A major problem for the range manager is determination of grazing capacity of the land. Many range administrators begin their careers

differences in the degree to which vegetation of different kinds reflect infrared rays, sharp contrasts result, although the colors shown are false and one must learn to interpret these differences by inspections on the ground or through experience.

The field of remote sensing of natural events is growing rapidly. New developments in this area offer promise of exciting new tools, especially for research, that will make range surveys more accurate and easier to accomplish.

Fig. 6.3 A section of an aerial photograph showing dotted vegetative-type lines. Letter-number symbols are index numbers which refer to inventory data for each type.
values. The Federal Farm Credit Administration, through its many subdivisions, can bring about loan policies which will prevent foreclosures of well-managed outfits, heavily mortgaged for depression periods, but fundamentally sound under normal conditions. State and Federal research agencies have an inherent responsibility to formulate specifications by which land values may be related to actual earning capacity and which should markedly influence land transactions and the viewpoints of private credit agencies, the buyer, and the seller of lands.

**RANGE MANAGEMENT, ANIMAL HUSBANDRY, AND GAME MANAGEMENT**

A large number of stockmen have, for one reason or another, failed to practice good range management; as a result, the forage shows an average depletion of about 51 percent. Conditions have led stockmen to overstock during boom periods and to hold their livestock during periods of deflation. Frequently, only partial use has been made of good animal-husbandry practices to reduce costs and to improve livestock quality. Opportunities for game management have seldom been considered.

**WHAT THE PRIVATE OWNER CAN DO**

The insidious process of range deterioration has "crept up" on the range owner. No pronounced improvements can be effected until the range-land owner learns to recognize some of the earmarks of this process on his range and the resultant unfavorable conditions produced. Unless the owner understands that the key forage plants are disappearing, that the rich topsoil is being washed away, and that gullies are devastating valuable lands, no opportunity is afforded for corrective measures, even though he has felt the severe sting of markedly reduced income. The livestock producer must also recognize that the range can be improved and ultimately built up to some approximation of its original forage capacity only through proper range management. The most effective way to assure improvement is to determine the objectives toward which management should be pointed, the necessary action to carry out these objectives, and ways and means to secure accomplishment. In short, it means the development and application of range-management plans.

...either by reductions in numbers grazed or by such seasonal or other changes as will accomplish the purpose. In most cases, such action would produce meat and other animal products at greater profit, partly through better calf and lamb crops and reduction of losses, partly by more efficient animal growth, and partly by curtailment of supplemental feed requirements, already demonstrated as costing much more than range forage.

Unquestionably, the private owner can improve his status by better breeding, feeding, and other animal-husbandry practices. Many of the more progressive stockmen use good quality bulls and rams, limit their breeding seasons, and provide adequate supplemental...
is added to the 11 million acres of privately owned nonsilting principal water-yielding areas it would make a total of approximately 118 million acres which should be acquired because of watershed value. This area will include a very large part of the 113 million acres for which public acquisition is recommended on account of submarginality.

Non-use

CRITICAL WATERSHED LANDS REQUIRING NONUSE BY LIVESTOCK

Since overgrazing has been the primary agency which has caused depletion of the cover and hence impaired watershed values and soil wastage, the primary remedy is to be sought in more moderate stocking. This course may be expected to be effective on most of the 352 million acres of land contributing silt to streams, and now more or less seriously eroded. Earlier discussion has made clear that not all depletion and deterioration are equally rapid, severe, and consequential. Some of the broad types of range, such as the short-grass plains, withstand persistent punishment if not too severe. Such a vegetation mantle may continue under heavy use and neither forage, water yield, nor soil be critically disturbed. Damage, if not too far advanced, can be repaired with comparative ease and speed under moderate use. The foothill type of the Central Valley in California likewise has a high resistance against misuse.

On the other hand, as has been previously mentioned, semidesert types on sloping land are especially susceptible to damage. Likewise, the better plant types are susceptible to further severe damage after they have deteriorated so that most of the fertile top soil has been lost. Under such conditions, rehabilitation under grazing use is extremely slow.

As range types differ in susceptibility to punishment, so do different types and areas vary in their public value for watershed protection. Areas on the Colorado River watershed, where erosive processes are already far advanced, are contributing in a major degree to silting of the Boulder Reservoir. Stopping of such soil losses becomes obviously of the first importance. Similar lands back of the Elephant Butte Dam, likewise pouring mud down, have public value many times greater than their slight value for forage. On the contrary, many areas of flat desert clearly have little or no influence on watershed protection.

Thus, nonuse is necessary principally in range areas which have high watershed values and are highly susceptible to damage. Such conditions are primarily concerned with (1) critical parts of badly eroding areas which are causing destructive floods, and (2) areas contributing silt to streams where soils are of such unstable character and vegetation depletion has reached such an extreme stage that any use by livestock would impair the effectiveness of the scant cover now available and cause undue disturbance of the soil. In the latter instance, ordinarily found on semidesert range types, the grazing capacity is naturally so low that, with the depletion which has occurred, the land is now practically if not actually submarginal for grazing use by livestock anyway.

Most of the 11.5 million acres now roughly estimated as needing permanent nonuse lies in the Great Basin and Southwest. Since these areas recommended for nonuse, aggregating but 1.6 percent of the total usable range areas, are principally in the types having
about desirable changes in use. Thus existing public policy contemplates public ownership, at least, as an intermediate step, for such lands.

Outside of these problem areas a large acreage of land has been cropped at one time or another, and while much of it is no longer under cultivation, it is still in private ownership and may be cultivated again. Part of this has already been abandoned because of low productivity. At least 8 million acres of these scattered tracts of croplands are in such condition that public ownership is the logical outcome.

General information developed through the present studies indicates that the area of submarginal croplands of these types which will need to be taken over by public agencies, including both present problems areas and other scattered units, will reach a minimum of 15 million acres.

THE PROBLEM OF COORDINATING RANGE USE WITH THE NATIONAL AGRICULTURAL-ADJUSTMENT AND LAND-USE PROGRAMS

The center of gravity of crop agriculture lies in the Middle West. Whatever changes in production are worked out there from a planwise approach to the national crop-adjustment problem, will automatically affect other regions which now produce similar crops. If, as is possible, lands devoted to crops are changed to pasture, with a resulting increase in production of meat animals, the number of meat animals required for estimated consumptive needs will be less from the western range country than in the past or the present. A reduction of this sort might be absorbed by the generally lighter stocking of the ranges that, as this report shows unmistakably, is essential to preserve the range itself. Or it might be absorbed through nonuse of certain range areas; or by increased production of supplemental feeds and a shorter season on the range; or by a combination of lighter stocking, nonuse, and shorter grazing season. The general agricultural crop adjustment plan is not now complete and authoritative enough to justify any final conclusion, but it is necessary to recognize that changes in use of range lands and above those suggested in this report may well result.

OTHER USE ADJUSTMENT PROBLEMS

The report indicates that, on considerable areas, outstanding public values in watershed protection and range for wildlife are deteriorating through overuse by domestic stock. It is possible, and indeed probable, that on part of this land nonuse by domestic livestock may be required, although insufficient detailed work has been done to furnish a final and conclusive answer. In addition, certain privately owned lands are needed for rounding out natural range units within and adjacent to the national forests.

The entire question of the most effective form of ownership to protect public values on range lands of these classes, whether involving nonuse or not, will be examined later in this section. It can best be seen as a whole, rather than through separate study of the parts.
This concept was expressed more or less
dearly in range management circles in 1919
by Sandine and Stander in a publication
entitled Range management on the national forests

The idea has been perpetuated in text range
management text books
Simpson 1973

"The grazing capacity of a pasture area may be defined as the
number of stock of one or more classes which the area will support
in good condition during the time the forage is palatable and
accessible without decreasing the forage production in subsequent
years."

Heddart, Smith and Box 1975

"Grazing capacity, then, has come to be regarded as the maximum
animal numbers which can graze each year on a given area of range,
for a specific number of days, without inducing a downward trend
in forage production, forage quality, or soil."
Rodents are a menace on about 285 million acres of range and must be checked by the use of poison bait, trapping, or by other accepted methods of treatment. The cost will be about 8 cents per acre. A reasonable 10-year program should doubtless plan on control measures on approximately 150 million acres, at a total cost of about $12,000,000.

Although native plants are not seriously injured by disease, it is possible that species developed for artificial reseeding may be. Close watch must be maintained to insure the use of disease-resistant species for range restoration. Some undesirable plants, such as "cheat grass," are subject to smut and may be thus held in check. However, it is much surer and much safer to accomplish the same thing by favoring desirable species through range management and reseeding. In the absence of fire or too severe cropping, the better native species will suppress such undesirables and succeed them in occupying the range.

The range should be stocked with the number of animals which the unit will support each season over a period of years without injury to the range, tree growth, or watershed, or unwarranted interference with game and recreation (79). Figure 85 graphically indicates present grazing capacity of western ranges. Since the various species of plants differ greatly in palatability, it is to be expected that the better kinds will be most heavily grazed. In determining grazing capacity the degree of use of the most palatable of the more abundant species must control. On ranges where the desirable plant species have been seriously reduced in number, stocking should be such as to encourage their return to importance. Thus, on properly stocked ranges the least palatable plants will barely be nibbled.

When a range is stocked more heavily than its true grazing capacity, either (1) the cover will get thinner, thereby exposing bare ground; or (2) the tough, woody, gummy, or unpalatable plants will increase in relative or absolute abundance. Rangers and stockmen should note carefully which plants are not eaten by livestock and check on their increase from year to year as an indication of overstocking. Experience has shown that somewhere near 20 to 30 percent of the palatable growth of the more important forage species should be left ungrazed each year. An adequate series of permanent plots from which detailed annual records of plant numbers and conditions can be kept is essential to really reliable and accurate determination of the proper degree of stocking. Also, on areas covered by range surveys, forage-acre figures arrived at by the method developed on national-forest ranges will be found especially helpful.

Additional considerations in making grazing capacity estimates include, among others: (1) History of grazing use of areas; (2) fluctuations in forage crops from year to year, due chiefly to climate, as previously explained; (3) deductions (on depleted ranges) to provide a safety margin for their improvement; and (4) necessary allowances for unfavorable physical conditions, such as rough to-

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48 U. S. Department of Agriculture, Forest Service. Instructions for grazing surveys on national forests. 40 pp. 1936. [ Mimeographed. ]
pography, young timber growth, inadequate livestock watering places, or poisonous plants.

That range lands in all types and in all ownerships have been too heavily grazed has been fully discussed in a preceding chapter. As a result, drastic action will be required to restore this empire of range lands to something approaching maximum production. Table 81 shows by the major types the original and present grazing capacity of the land now in range and the percent to which each type has been depleted through improper management. In only the tallgrass type is depletion less than 25 percent and in only one other (open forest) is it much less than half. Since depletion is continuing on most of the range area, the task of restoring these ranges will require material reductions in the number of livestock now using the range. Table 82, which is based on the best information available, shows that an average reduction in animal-months' use of 38.5 percent will be required to bring the stocking down to a

**Table 81.—Grazing capacity of western range, by types**

<table>
<thead>
<tr>
<th>Types</th>
<th>Virgin range, grazing capacity</th>
<th>Present range</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acres per animal-month</td>
<td>Animal-months per section</td>
<td>Depletion (percent)</td>
</tr>
<tr>
<td>Tallgrass</td>
<td>1.9</td>
<td>337</td>
<td>21</td>
</tr>
<tr>
<td>Short grass</td>
<td>2.1</td>
<td>306</td>
<td>49</td>
</tr>
<tr>
<td>Pacific bunchgrass</td>
<td>2.2</td>
<td>297</td>
<td>51</td>
</tr>
<tr>
<td>Semidesert grass</td>
<td>2.9</td>
<td>221</td>
<td>55</td>
</tr>
<tr>
<td>Sagebrush-grass</td>
<td>2.9</td>
<td>221</td>
<td>67</td>
</tr>
<tr>
<td>Southern desert shrub</td>
<td>4.4</td>
<td>148</td>
<td>62</td>
</tr>
<tr>
<td>Salt-desert shrub</td>
<td>5.2</td>
<td>123</td>
<td>71</td>
</tr>
<tr>
<td>Pinyon-juniper</td>
<td>3.4</td>
<td>158</td>
<td>50</td>
</tr>
<tr>
<td>Woodland-chaparral</td>
<td>4.9</td>
<td>131</td>
<td>80</td>
</tr>
<tr>
<td>Open forest</td>
<td>4.0</td>
<td>180</td>
<td>33</td>
</tr>
<tr>
<td>Averages</td>
<td>2.7</td>
<td>237</td>
<td>52</td>
</tr>
</tbody>
</table>

**Table 82.—Present stocking, present grazing capacity, and potential grazing capacity (50 years hence) on the western range area**

<table>
<thead>
<tr>
<th>Ownership classes</th>
<th>Present stocking, animal-months per section</th>
<th>Present grazing capacity, animal-months per section</th>
<th>Reduction required to reach grazing capacity, Animal-months per section</th>
<th>Potential grazing capacity, animal-months per section</th>
<th>Change from present stocking, Animal-months per section</th>
<th>Increase over present grazing capacity, Animal-months per section</th>
</tr>
</thead>
<tbody>
<tr>
<td>National forests</td>
<td>95</td>
<td>89</td>
<td>6</td>
<td>6.3</td>
<td>+11</td>
<td>+11.6</td>
</tr>
<tr>
<td>Indian lands</td>
<td>106</td>
<td>78</td>
<td>26</td>
<td>26.4</td>
<td>+14</td>
<td>+13.2</td>
</tr>
<tr>
<td>Public domain, grazing districts, etc.</td>
<td>94</td>
<td>53</td>
<td>43</td>
<td>43.6</td>
<td>+41</td>
<td>+41.4</td>
</tr>
<tr>
<td>State and county</td>
<td>226</td>
<td>113</td>
<td>50.0</td>
<td>50.0</td>
<td>-33</td>
<td>-33.3</td>
</tr>
<tr>
<td>Private</td>
<td>236</td>
<td>146</td>
<td>35.9</td>
<td>35.9</td>
<td>-2</td>
<td>-2.2</td>
</tr>
<tr>
<td>Averages</td>
<td>182</td>
<td>112</td>
<td>70</td>
<td>35.5</td>
<td>2</td>
<td>1.1</td>
</tr>
</tbody>
</table>

1 Ultimate stocking is based on the formula \( \frac{(100 - D) P}{V} \), in which \( D \) is the percent of depletion, \( P \) the animal-months per section of present range, and \( V \) animal-months per section of virgin range. Virgin carrying capacity is modified by percents varying from 70 for public-domain lands (all Federal except national forests and Indian lands) to 85 for national forests, to account for some rearrangement of timber reproduction, retarded improvement under continual grazing use, and especially limitations in recovery due to depleted soil. Credit is given for increased carrying capacity due to anticipated artificial reseeding. The results of the formula were modified slightly where justified by more accurate data.
point where the ranges can recover. It is significant that this reduction from present stocking varies from only 6.3 percent on national forests, where the ranges have been carefully handled for many years, to 50 percent on State and county lands, where, as a

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**Figure 85.—Present Grazing Capacity of Western Range Lands.**

The tall-grass type of the prairies, which has the smallest average depletion, also has the highest grazing capacity, an average of 2.4 acres per animal per month. The short-grass and Pacific-bunchgrass ranges, although depleted one-half, also have a relatively high capacity. The salt-desert shrub type of the Intermountain Region which is depleted most severely, averages 17.8 acres per animal per month. (See figs. 25 and 30.)

result of accessibility and lack of management, use has been heaviest. Perhaps the most significant required reduction is the 43.6 percent for the grazing districts, unreserved public domain, and “other Federal” reservations, because it applies to an extremely large acreage.
Use of the range only during the proper season is equally as important as not exceeding grazing capacity (79). In some regions and on some ranges, where snowfall is so light that stock can normally forage for feed in winter, moderate yearlong continual grazing with definite rest periods is the best system. However, in regions of deep snowfall, such as is common on the high mountain ranges, seasonal use is essential. At the higher elevations it may be midsummer before the vegetation has developed to a point where it can be eaten without injury to the plants or their necessary seed production.

During the early period of plant growth the soil is usually saturated with water and the plants, though palatable, are wasty and lacking in balanced nourishment for stock. During this period use should be lightened or stopped to prevent great damage by trampling of the soft, muddy ground and also the pulling of many plants.

Usually in the foothill zone and valley edges of the northern two-thirds of the mountain region growth begins early as the snow retreats, but almost stops during the hot weather of midsummer. Additional growth often takes place again when the fall storms and cool weather come. In the spring such ranges are extremely valuable for use by stock moving between feed yards or winter ranges and the summer ranges in the high mountains, and vice versa in the fall. Other ranges, such as the salt-desert shrub type, on which the snowfall is light and there is ordinarily no other source of water, can be used only in winter. Thus there are four seasonal types of range, as follows: Spring-fall, summer, winter, and yearlong. On large areas in California where growth continues all winter, there is a fifth type, fall-winter-spring. The greatest shortage exists in the spring-fall class in most regions.

Yearlong ranges should always be stocked sufficiently low that damage does not occur, especially during the growth periods. As pointed out by Dr. E. C. McCarthy, formerly with the Intermountain Forest and Range Experiment Station, excessive stocking will damage the plants at any season, but most seriously during the first few days after growth starts. Winter ranges should not be used at all from the beginning of growth to late fall, thus saving the entire crop for winter use. Spring-fall and summer ranges must be carefully protected from excessive grazing during the period of growth if they are to be maintained.

The tendency to use spring-fall range, which is normally the most accessible, before the proper date must be overcome if depletion is to be halted and the ranges improved. Here is one of the places where the closest kind of coordination is required to balance the use of the resources of range and range. One possible relief is in the increased use of farm pastures and of supplemental foods, both roughages and concentrates, including the expanding list of agricultural byproducts. Another possibility in certain regions is in the possible diversion of either winter or summer range to this season of use with extreme care in stocking and in management. It is certain that the problem will not be solved by abuse of the limited area of spring-fall range available. Such treatment can only aggravate the situation.
CLASS OF STOCK

Each unit of range is ordinarily best suited to use by only one class of stock (79). The factors which control are the character of the forage, distribution of water, and topography.

Cattle and horses do best on a range where the forage is predominately grass with a sprinkling of weeds and some browse; sheep like nearly equal parts of grass, weeds, and browse, and goats more browse. However, this balance is not especially sensitive and the presence of ample forage is the main consideration. Sheep or goats do well on straight grass ranges, and cattle on weed and browse, or sheep on browse and grass.

Frequently other factors than the suitability of the range control the class of stock to be grazed. The local livestock industry may be built around the class of stock for which the range is not best suited. In such instances the important feature is that stocking be based on the feed that the class of stock grazed can be expected to use under good management.

Cattle must have access to water daily during hot weather but sheep can go 2 to 5 days (much longer during cool weather), depending on the succulence of the forage and the amount of dew, and can reach out farther from watering places.

Steep, high, broken ranges are more readily used by sheep, and low brushy ranges by cattle. Goats are capable of using forage on rougher, more brushy, and hotter localities than are suitable for either sheep or cattle. When one class of animals is using a range better adapted by feed, topography, elevation, or water to another class, extreme care must be taken not to overstock. Only the feed within reach and usable by the class of stock on the range should be considered in determining grazing capacity.

Some ranges, at least theoretically, will contribute most if grazed by both sheep and cattle, and some by goats as well. In practice this so-called common use has not been widely successful because of the tendency to introduce the second class of stock without reducing the numbers of the class already there to maintain sufficiently the total stocking rate at the grazing capacity of the range. Common use, thus, has usually meant double use which is fatal to the range. Where forage, water, and topographic conditions are such as to permit of common use without the total stocking being above the grazing capacity for the combined classes, it may be used. Future ranges must be grazed properly in this respect, and this means scientific range management based on the forage supply.

DISTRIBUTION OF STOCK

Next to the proper rate of stocking, distribution of the stock on the range is the most important feature in range management (79). Any improvement in the distribution of animals is reflected in more even utilization of the forage. Overuse of small areas, especially on cattle ranges, cannot be prevented entirely, since the animals naturally congregate at watering places, at bed grounds, and along routes of travel. All of these conditions are much improved through (1) avoidance of heavy stocking, (2) providing water at short intervals,
(3) the use of sufficient, well-located drift fences, and (4) proper attention to salting and herding.

Water development (15, 159) aids distribution but on many ranges involves heavy expenses for deep wells, for pumping, for the construction of reservoirs, and for the development of springs. For cattle the ideal arrangement is to so locate the watering places that the animals can graze out to the boundary of the area served in half a day—perhaps a mile on gently rolling country, and less where the topography is rough or broken. The high cost, however, usually forces a compromise between travel for the stock and cash outlay for the improvements. On gently-sloping ranges, cattle can travel 2½ to 3 miles to water, but on steep slopes and rough topography 1 mile travel is probably as much as should be required. Sheep can travel roughly twice as far to water as cattle. Table 83 indicates the approximate size of the water development job on range lands in various ownerships.

Properly located drift fences (79) are often essential to good distribution of cattle. Not only do they help to force the use of less attractive ranges but also they are necessary in any attempt at proper seasonal use. Range cattle, particularly, have a tendency to follow the snow line back in the spring and can be successfully held back until the forage is ready for use only by a series of well-constructed and properly located fences. The best estimates obtainable indicate that the investment shown in table 84 will be required to fence properly range land in the different ownership classes.

**Table 83.** Range-water development program, by ownership classes

<table>
<thead>
<tr>
<th>Ownership classes</th>
<th>Number of projects</th>
<th>Costs per acre of range</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>National forests</td>
<td>6,205</td>
<td>0.0407</td>
<td>$3,862,000</td>
</tr>
<tr>
<td>Indian lands</td>
<td>5,000</td>
<td>0.0310</td>
<td>1,550,000</td>
</tr>
<tr>
<td>Public domain—grazing districts, etc.</td>
<td>4,000</td>
<td>0.0202</td>
<td>822,000</td>
</tr>
<tr>
<td>State and county</td>
<td>3,700</td>
<td>0.0150</td>
<td>555,000</td>
</tr>
<tr>
<td>Private</td>
<td>10,500</td>
<td>0.0080</td>
<td>1,301,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>21,515</td>
<td></td>
<td><strong>11,770,000</strong></td>
</tr>
</tbody>
</table>

1 Cost estimates for the private-land program are made on the same basis as for public land. Actually a very large part of the work, if done, will be as a slack-time job. The cash-outlay times will be very much smaller than this figure.

**Table 84.** Range-fencing program, by ownership classes

<table>
<thead>
<tr>
<th>Ownership classes</th>
<th>Miles to build</th>
<th>Costs</th>
<th>Per acre of range</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>National forests</td>
<td>13,300</td>
<td>$3.29</td>
<td>0.0835</td>
<td>$4,376,000</td>
</tr>
<tr>
<td>Indian lands</td>
<td>5,000</td>
<td>2.00</td>
<td>0.0310</td>
<td>1,550,000</td>
</tr>
<tr>
<td>Public domain—grazing districts, etc.</td>
<td>10,900</td>
<td>2.00</td>
<td>0.0490</td>
<td>4,861,000</td>
</tr>
<tr>
<td>State and county</td>
<td>11,600</td>
<td>2.00</td>
<td>0.0490</td>
<td>4,861,000</td>
</tr>
<tr>
<td>Private</td>
<td>10,800</td>
<td>3.15</td>
<td>0.0166</td>
<td>6,346,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>60,600</td>
<td>3.02</td>
<td>0.279</td>
<td>20,108,000</td>
</tr>
</tbody>
</table>

1 See footnote to table 83.
extension work which is the intervening step between research and the practical application of its findings.

In the United States, range extension was to a large degree merged with research until about 1920, and was practically nonexistent as a distinct activity. Since 1923, when a definite range-extension program was first formulated, the extension services of the State agricultural colleges, cooperating with the State agricultural experiment stations and the United States Department of Agriculture, have reported a limited amount of work in each of the 11 Western States, principally in animal husbandry, rodent control, and improved grazing methods. Despite admirable results from the demonstrations and other work already performed, extension specialists attribute the pronounced lag in range extension primarily to (1) high cost of demonstrations, which in order to be effective involve comparatively large areas and herds of sheep or cattle, and (2) inadequate control and administration of the unregulated public domain, resulting in an indifferent attitude of many stockmen toward improved range methods.

EXAMPLES OF NEGLECTED UNSOLVED PROBLEMS OF RANGE RESTORATION AND MANAGEMENT

Studies undertaken to date, as thus outlined, have covered a rather wide scope and have contributed highly useful data; but actually they represent a thoroughgoing attack on only a small fraction of urgent vexing questions that constantly arise to plague the stockmen and land administrator. Facts, clinched by convincing proof, on complex and controversial points are especially inadequate for correction of much range depletion. This serious lack of basic management information applies over a surprisingly large sweep of problems relating to range plants, to animals, and to their environment.

What are some of these challenging management problems of both public and privately owned grazing lands? A few examples will indicate how far research must still go to provide an adequate basis for their solution.

PROBLEMS OF GRAZING CAPACITY

General studies and observations on grazing capacity have for sometime been conducted throughout the West, but intensive studies have been started in only a few places and on a few kinds of range, and chiefly within the last decade—years after their need was painfully apparent. As for other agencies, in the 17 western range States with their multitude of different forage types and varying management needs, only seven State agricultural experiment stations (New Mexico, Arizona, Nebraska, Nevada, North Dakota, California, and Washington) had published by 1920 results of grazing capacity studies. Even in 1930 (15) only two additional stations (Colorado and Texas) were undertaking even limited work in this field (155).

Research on grazing capacity has not yet been conducted on many important western range types.
the natural reseeding provided for on that part of the range to be improved by deferred and rotation grazing, or by continual moderate grazing. In such case the expense and trouble of reseeding require that proper intensity of stocking and proper grazing management be provided in order to prevent failure.

Cost figures for the various methods of artificial reseeding for range use are not too reliable, but using the methods described they should be low. The most serious problem is that of securing a sufficient supply of suitable seed. Assuming that an ample seed source will be developed as needed, and that a market price of around 15 cents per pound may be expected, the cost, using a grain drill and 4 to 5 pounds of seed per acre and figuring on failure half the time, should not exceed $2.50 to $3 per acre. With hand seeding and trampling in by livestock, the cost for two seedings should not exceed $1.50 to $2.50 per acre. Final decision as to the necessity and feasibility for planting any area must, of course, be based on careful consideration of conditions on the ground. Detailed surveys required to select areas are in most cases lacking; therefore the data given in table 80, which gives an estimate of acres and costs, by ownerships, are only indicative of the size of the job ahead.

Table 80.—The extent of the indicated artificial range-revegetation program and costs, by ownerships

<table>
<thead>
<tr>
<th>Ownership classes</th>
<th>Area (acres)</th>
<th>Cost per acre</th>
<th>Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>National forest</td>
<td>780,000</td>
<td>$3.50</td>
<td>$2,730,000</td>
</tr>
<tr>
<td>Indian lands</td>
<td>1,630,000</td>
<td>$2.85</td>
<td>4,645,000</td>
</tr>
<tr>
<td>Public domain, grazing districts, etc.</td>
<td>18,600,000</td>
<td>$2.55</td>
<td>45,900,000</td>
</tr>
<tr>
<td>State and county</td>
<td>2,490,000</td>
<td>$3.06</td>
<td>7,485,000</td>
</tr>
<tr>
<td>Private</td>
<td>15,010,000</td>
<td>$3.20</td>
<td>48,032,000</td>
</tr>
<tr>
<td>Total</td>
<td>37,910,000</td>
<td>$2.87</td>
<td>106,902,000</td>
</tr>
</tbody>
</table>

PESTS, DISEASES, AND POISONOUS-PLANT ERADICATION

Poisonous plants are a menace to the success of range revegetation or utilization. Most poisonous plants occur in great abundance only on ranges so badly depleted that the more valuable forage species are weakened or killed. In the more open spaces, on soil too poor in organic matter to support the better forage grasses, weeds come in. Some of them, like low larkspur, loco, lupine, deathcamas, sneeze-weed, and horsebrush, are poisonous. They tend to increase on noneroded soils on which heavy or untimely grazing removes the valuable forages. Some species like tall larkspur, waterhemlock, and sleepy grass may grow on good ranges with good soils. The real remedy for most poisonous plants is to remove the causes, i.e., to bring about by conservative use, and reseeding when required, the revegetation of the range by the more valuable forages. On a few key areas, especially where tall larkspur or waterhemlock occurs, grubbing or treating with chemicals may be practiced at costs of about $3.50 an acre for grubbing or $6 for treating with chemicals. Even when these practices are resorted to it may be necessary to revegetate the range with good forage, lest the poisonous plants again occupy the area.
Adenents are a menace on about 200 million acres of range land and must be checked by the use of poison bait, trapping, or by other accepted methods of treatment. The cost will be about 8 cents per acre. A reasonable 10-year program should doubtless plan on control measures on approximately 150 million acres, at a total cost of about $12,000,000.

Although native plants are not seriously injured by disease, it is possible that species developed for artificial reseeding may be. Close watch must be maintained to insure the use of disease-resistant species for range restoration. Some undesirable plants, such as "cheat grass", are subject to smut and may be thus held in check. However, it is much surer and much safer to accomplish the same thing by favoring desirable species through range management and reseeding. In the absence of fire or too severe cropping, the better native species will suppress such undesirables and succeed them in occupying the range.

Grazing Capacity

The range should be stocked with the number of animals which the unit will support each season over a period of years without injury to the range, tree growth, or watershed, or unwarranted interference with game and recreation (79). Figure 85 graphically indicates present grazing capacity of western ranges. Since the various species of plants differ greatly in palatability, it is to be expected that the better kinds will be most heavily grazed. In determining grazing capacity the degree of use of the most palatable of the more abundant species must control. On ranges where the desirable plant species have been seriously reduced in number, stocking should be such as to encourage their return to importance. Thus, on properly stocked ranges the least palatable plants will barely be nibbled.

When a range is stocked more heavily than its true grazing capacity, either (1) the cover will get thinner, thereby exposing bare ground; or (2) the tough, woody, gummy, or unpalatable plants will increase in relative or absolute abundance. Rangers and stockmen should note carefully which plants are not eaten by livestock and check on their increase from year to year as an indication of overstocking. Experience has shown that somewhere near 20 to 30 percent of the palatable growth of the more important forage species should be left ungrazed each year. An adequate series of permanent plots from which detailed annual records of plant numbers and conditions can be kept is essential to really reliable and accurate determination of the proper degree of stocking. Also, on areas covered by range surveys, forage-acre figures arrived at by the method developed on national-forest ranges 48 will be found especially helpful.

Additional considerations in making grazing capacity estimates include, among others: (1) History of grazing use of areas; (2) fluctuations in forage crop from year to year, due chiefly to climate, as previously explained; (3) deductions (on depleted ranges) to provide a safety margin for their improvement; and (4) necessary allowances for unfavorable physical conditions, such as rough to-

48 U. S. Department of Agriculture, Forest Service. Instructions for grazing surveys on national forests. 40 pp. 1936. [Mimeographed.]
Results with proper use management

Destruction has continued

Selective grazing leads to overgrazing

Cattle, sheep

However, assumption that plants can be grazed to a proper level through regulation of stocking is unrealistic because of the grazing habits of livestock. Livestock graze the range selectively, by species and areas. They consistently graze the more palatable plants and accessible areas closely and, invariably, beyond proper-use level. The pattern of use is very uneven, but much the same from year to year. Plants grazed closely one year tend to be grazed closely the next. So under continuous grazing at any stocking level, the more palatable and accessible plants are gradually killed out. Livestock then graze on less desirable plants. This process leads progressively to ever enlarging areas of deterioration. Unfortunately, the best plants and best grazing sites are destroyed first.

Destruction of the better plants and sites is accepted as inevitable under proper-use management:

Just as there are certain sacrifice areas, there are also some sacrifice plants—species with high animal preference but never abundant in the stand. These "dessert" or "ice cream" plants are usually killed out when the hardier, more abundant, and somewhat less highly preferred key species are properly utilized, a fact that entails little economic loss. (Sampson, 1952).

The question may be asked: After the ice cream plants are destroyed what is sacrificed next? Clearly the degree of use on individual plants cannot be regulated.

The better forage plants and all others can be maintained, however, by periodically resting the range from use. Only by this means can the main objectives of grazing management—maximum production of vegetation and high-level yield of livestock and other multiple-use values—be realized.
The idea has long prevailed that overstocking is the main cause of range deterioration. This thought has been expressed as follows:

White man allowed too many of his grazing animals to use the range. He overstocked the range almost from the start. How else explain the depletion of the range by more than half? (The Western Range, 1936).

This belief has led to a conviction that range improvement depends principally on regulation of stocking rate and that proper use of the vegetation can be obtained through proper stocking. This proper-use philosophy of management is more widely accepted today than any other and is the basis of management on most ranges.
Proper Degree of Use

Proper use publications

1953 Circular No 929 USDA
Effect Grazing Intensity on Veg
and Cattle Gains on Blue-Bunchgrass Ranges
Colorado Wm Johnson Rocky Mt Station

1953 Circular No 918 USDA
Forage Utilization by Cattle on
Northern Great Plains Ranges
Carl E Helscher & E J Woolfolk
Northern Rocky Mt Station

1959 Agricultural Handbook No 162
Forest Service US Dept Agri.
Managing Grass-Shrub Cattle Ranges
in the Southwest
Hudson G Reynolds
Rocky Mt Forest & Range Exp Sta
The Great Boom in Range Cattle, 1880-85

The first era of intensive use of western range by livestock coincided with the great boom in range cattle, which was on the upswing in 1880. By 1881 the price recovery from the 1873 depression generated in the grazing industry a tide of expansion which became a veritable flood in 1883. That year, in Wyoming alone, 20 mammoth cattle companies were organized with a total capitalization of over $12,000,000 (98). Of these, the Union Cattle Co. was incorporated for $2,000,000; and the North American Cattle Co. and the Spearman Cattle Co. for $1,000,000 each. Six others each floated stock of a half million dollars or more. Wyoming, however, was merely a representative area—the same thing was happening, or had just happened, up and down the Great Plains from Montana to Texas and across the Southwest to California. Even Colorado, Utah, Nevada, and Idaho felt the surge of this tide. In a few short years practically all ranges were under use and in many cases depletion had commenced on a scale in keeping with the size of the herds.

Outfits owning 5,000 to 100,000 cattle were common on the Plains and in the Southwest, and properties of small owners were often consolidated by purchase or by incorporation. The world-famous Santa Gertrudis Ranch of 500,000 acres near Brownsville, Tex., was built up by purchases and additions to the original Spanish grant of 12 sections of 4,428 acres each (118). The Swan Land & Cattle Co. was started by combining three ranch properties, totaling about 30,000 acres and 100,000 cattle, with a half-million-acre range extending irregularly from Ogallala, Neb., westward to Fort Steele, Wyom., from the Union Pacific Railroad northward to the Platte River (98). The XIT outfit in the Texas Panhandle ran about 150,000 head on 3,000,000 acres of land—25 miles east and west by 200 miles north and south. Hundreds of other ranches running somewhat fewer cattle, chiefly on public land, had occupied most of the range by 1883 and all of it in the Plains Region by 1885 (99). The cattle numbers by States, shown in table 26 for 1870, 1880, and 1885, indicate how rapidly the range forage was appropriated.

Table 26.—Cattle numbers in the 17 western range States, for 1870, 1880, and 1885

<table>
<thead>
<tr>
<th>State</th>
<th>1870</th>
<th>1880</th>
<th>1885</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Dakota</td>
<td>2</td>
<td>70</td>
<td>159</td>
</tr>
<tr>
<td>South Dakota</td>
<td>40</td>
<td>334</td>
<td>438</td>
</tr>
<tr>
<td>Nebraska</td>
<td>1,000</td>
<td>1,712</td>
<td>2,434</td>
</tr>
<tr>
<td>Kansas</td>
<td>571</td>
<td>1,267</td>
<td>2,434</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>4,000</td>
<td>6,952</td>
<td>8,569</td>
</tr>
<tr>
<td>Texas</td>
<td>4,900</td>
<td>9,016</td>
<td>12,598</td>
</tr>
<tr>
<td>New Mexico</td>
<td>186</td>
<td>454</td>
<td>1,060</td>
</tr>
<tr>
<td>Arizona</td>
<td>20</td>
<td>142</td>
<td>302</td>
</tr>
<tr>
<td>Wyoming</td>
<td>71</td>
<td>593</td>
<td>857</td>
</tr>
<tr>
<td>Montana</td>
<td>117</td>
<td>622</td>
<td>1,000</td>
</tr>
<tr>
<td>Idaho</td>
<td>18</td>
<td>182</td>
<td>220</td>
</tr>
<tr>
<td>Oregon</td>
<td>10</td>
<td>45</td>
<td>92</td>
</tr>
<tr>
<td>Washington</td>
<td>177</td>
<td>551</td>
<td>1,060</td>
</tr>
<tr>
<td>California</td>
<td>1,001</td>
<td>916</td>
<td>1,258</td>
</tr>
<tr>
<td>Nevada</td>
<td>33</td>
<td>128</td>
<td>196</td>
</tr>
<tr>
<td>Total</td>
<td>7,907</td>
<td>12,881</td>
<td>21,999</td>
</tr>
</tbody>
</table>

1 Tonnage revisions of the Bureau of Agricultural Economics.
have been of major consequence at San Luis Rey where 80,000 cattle, 10,000 horses, and 100,000 sheep, goats, and swine grazed.

Texas proved to be especially well suited for cattle. In 1821 the Mexican Government contracted with Moses Austin to bring settlers into Texas, and many came, enticed by liberal tracts of land; and the success of Austin’s colonization scheme then brought a host of requests for similar grants (100). In 1830 further American immigration was prohibited, but already about 20,000 Americans were there whose attention to cattle growing, together with the mild climate, so favored cattle that the stock multiplied to 100,000 in 1830; to 330,000 in 1835; and to 3,583,000 in 1860 (120).

With the Civil War came the first large cattle shipments from Texas to the Confederate Army. Despite the restraining influence of the northern blockade, the consequent stagnation, and the fall of prices in $3 or $4 a head, ideal range conditions favored still further increase, and made Texas a hive of cattle ready to swarm forth at the first opportunity. This came after the war, when currency inflation and rising prices in northern manufacturing centers, together with a decrease of 7 percent in total cattle in the United States, brought market offerings of $40 to $60 for beef steers (98).

The railroads in Missouri, central Kansas, and Nebraska offered outlets for these crowded Texas herds. In 1866, rail drives to Sedalia and Abilene began, and in 1867 when the demand and prices were up, more than 1,000 cars left Abilene. Actual demands reached such a volume in 1871 that 600,000 cattle were driven northward to the railroads in that year. The heavy range use in western Kansas and Nebraska that began with these drives never ceased until the grass was plowed under, although dropping prices decreased the profits and hence the number of drives. By 1885 a total of more than 5 million cattle had been driven northward from Texas (98).

In a few years, however, fences began to be built, settlement was well under way, and railroads were extended into the arid region. Advance of main and branch railroads into the range country brought the market to nearby railheads. Drives were no longer necessary and, as the use of barbed wire for fencing cattle away from farms and towns became general, they were discontinued entirely in 1885. Intense range use was encouraged by the railroads, and by 1890 had been extended with their help to every nook and corner of the region.

Meanwhile the Mormons filled the Utah ranges with foundation stock which they themselves drove across the Plains, and with lean cattle and horses obtained by trading with other emigrants. By about 1880 the ranges in northern and central Utah were occupied with 160,000 Shorthorns, Devons, and Herefords (127). With the discovery of gold in the Rocky Mountains during the sixties, cattle were taken from Utah and California into Colorado, Montana, Idaho, and Nevada. The strong markets of the late seventies and early eighties carried grazing onto most of the accessible ranges in the mountain region. Here, however, development of the country was slower and more substantial, since it came in connection with homes and farms. Wild hay and irrigated alfalfa produced abundantly and from the first lent stability to range use on a community basis.

The tremendous growth in range cattle, however, carried with it a weakness that in the end proved fatal. It was based on a husbandry transplanted from Mexico, which brought to English-speaking people for the first time in history the practice of rearing cattle in great droves without fences, corrals, or feed. The lariat, the type of saddle, chaps, and the sombrero came along with the manner of conducting the business. The very newness of it, as well as the immensity of the outfits left the Americans without guide or standard by which to gauge either the security of the cattle as they roamed at large or the ability of the forages to stand up under continual intense utilization. It is little wonder, therefore, that cattle instead of grass came to be regarded as the raw resource and that the neglected forages began to give way before the heavy and unmanaged use to which they were subjected.

This almost explosive expansion of cattle grazing was based on a great natural resource which the stockmen obtained with little cost. Grass was the magnet and living bonanza that irresistibly drew cattle and cattlemen to this range El Dorado.

Like the El Dorados of precious metals, the discovery of the grass bonanza fired the imagination of cowboys, lawyers, farmers, merchants, laborers, and bankers, who rushed in to seek their fortunes, the poor by personal effort and the rich by investment. Both eastern and Old World capital, the latter largely from England and Scotland, fevered through the expectation of profit of 25, 33, or 40 percent. A large promotion literature flourished, including such widely circulated books as Brisbin’s Beef Bonanza. After presenting several actual cases, Brisbin showed on paper how $25,000 would in 6 years pay all expenses and leave a fortune of $51,278. Estimated Fortunes and Millions in Beef are significant chapter headings (27).

Since a boom was in progress, the stories were believed. Swan, of the Swan Land & Cattle Co., promoted in Scotland the corporation with the capitalization of $3,000,000 already mentioned, and later increased this to $3,750,000—and paid a few dividends from the capital (98). Some companies really did make money for a while, but lax methods accompanied this “easy” money. Cattle were bought on “book” count, and newly purchased cattle were seldom counted. Purchase prices soared, because purchasers bid against each other, and because of the buying of breeding stock whose offspring started other breeding herds, most of which never went to a consumer market but accumulated as capital inventory until the collapse of 1886.

The Collapse of the Boom

The expectation of fortunes to be made in a few years led to gambling in futures and caused overexpansion both in investments and in range use. In this process the accumulated forage of several years was mined, overuse taking not only the current growth but sapping as well the vigor of the forage plants. The better stockmen recognized the danger (98, 128), but warnings in a minor key during a boom get no hearing, and exploitation raced on.

This constant drain, without allowing any chance for recuperation, caused the forage “mine” to peter out. In 1898 Bentley (16) reported that some stockmen considered that in parts of Texas “the injury has gone almost past the point where redemption is pos-
sible.” Ranges that should have carried a cow on every 40 acres had one on every 10 acres.

While this dangerous process of depleting the ranges by overuse and by too early and too continuous grazing was going on, scarcely anybody was making provision for supplementary feeding or for setting aside winter ranges. Neglect of cattle diseases, too, made the risks still higher. All business was conducted on the basis of open winters, notwithstanding the fact that Shortlands brought from the farms of the East and Texas stock arriving in late season did not go through the first winter safely. Investors, believing implicitly in the security of their capital, did not realize they were “betting against God Almighty and a sub-Arctic winter” (28).

Whole fortunes, either owned or borrowed, and speculative loans of millions each were all staked on cattle. With no source of income save cattle, the stakes were high and the risks breath-taking; but since it was a boom, men were irrational. The waste, too, was exhausting; cowboys, fully employed only a few weeks at roundup and branding, lived during the winters mostly at the expense of the ranch owners.

And just at this point nature spun a “double blank” and collected the stake. The winter of 1885–86 was severe from Kansas southward to Texas and New Mexico. Osgood says 85 percent of the cattle were killed in some areas. In the north the summer of 1886 was hot and dry, grass was short, and cattle were forced on the market at reduced prices. In November an Arctic winter set in; snow was deep; blizzard followed blizzard; the chinook was followed at once with snow. Young stock fresh from the East and from Texas died in great droves, with a mortality of 40 to 60 percent (40). Ranges were so closely cropped that cattle losses would have been heavy in a mild winter, but with severe cold and deep snow, the lack of feed was economically fatal to many stockmen, especially to the speculatively financed corporations. The somewhat inaccurately recorded numbers of assessed cattle in Montana decreased from 663,716 in 1886 to 471,171 in 1887; in Wyoming from nearly 300,000 in 1886 to just over 750,000 in 1887. Financial confidence, which started to wane in 1885, was almost completely lost, and the winter of 1886–87 gave a body blow to the beef bonanza. When the depression caused loans to be called, credit liquidation brought forced sales and bankruptcy.

Starvation of cattle followed severe droughts in the Southwest in 1886 (75), in Colorado in 1888–90, in the Plains and Southwest in 1893–94; in the Coast States in 1898–99, and from Montana to Arizona and New Mexico in 1901-4.

Recovery—Striving for Security on the Cattle Range

So weak had the boom structure been and so severe the shock of its fall that only a wreck of the range-cattle industry remained. Range use had been so concentrated and relentless that the best coulees were hopelessly trampled, and the back slopes weakened in productive power. Herds were broken and scattered; confidence was wiped out; and forced sales for liquidation of debts pressed down the already broken prices. Cattle which were worth $9.35

teriorated so greatly during the major droughts of 1893, 1903, 1924, 1928 to 1931, and 1934. All of these factors combine to indicate that at least the drier part of the southern half of this great semi-desert zone may be marginal for permanent ranching. The northern half, where cooler temperatures encourage longer retention of soil moisture, has better forage production and offers better potential permanent range use. Actually the whole area has been badly depleted by continued overgrazing, especially during severe drought.

Dry farming has been attempted on many western range areas, where even ranching is difficult. Misguided settlers tried to grow cultivated crops without irrigation where rainfall is too low for other than range use in parts of every western State. The range was plowed under, cultivated for a few years, and then abandoned. Outstanding examples of such settlement in zones with less than a 15-inch rainfall have occurred in eastern Montana, eastern Colorado, southern New Mexico, and northwestern Utah, within the past decade. The net result has been the financial ruin of the hopeful farmers, and the physical ruin of the range area involved. Best permanent use of the range resource requires a national land-use program that will prevent repetition of such ill-advised exploitation.

The climatic characteristics prevailing on the principal range types, and their effect upon the depletion of such types, are major problems affecting range use, as will be evident later in this report in the classification of types for land use. Where the fluctuations and adversities of climate are not too great to permit range use, probably the outstanding prerequisite of management is the necessity for conservative grazing. Stocking the range at a point sufficiently below average forage production to provide adequate feed for the livestock in all but the most severe drought years is almost axiomatic in management to minimize drought losses, assure stable livestock production, and maintain the range resource. Beyond that, however, much more intensive study and analysis is required for a final solution of the climatic phases bearing on range land use.

Furthermore, although the land that is too dry or otherwise unsuitable for range use may be taken out of production, there still remains the major problem, in the face of climatic risks now known to occur, of developing systems of range management that will enable restoration and maintenance of the forage resources for those areas that remain in use. Years such as 1934 make a dismal picture, but there are always years of plenty that brighten the aspect. The problems are not insurmountable; they are susceptible of solution, as outlined in the program sections of this report.
HISTORY OF RANGE USE

By GEORGE STEWART, Senior Forest Ecologist, Intermountain Forest and Range Experiment Station

THE GREAT BOOM IN RANGE CATTLE, 1880–85

The first era of intensive use of western range by livestock coincided with the great boom in range cattle, which was on the upswing in 1880. By 1881 the price recovery from the 1873 depression generated in the grazing industry a tide of expansion which became a veritable flood in 1883. That year, in Wyoming alone, 20 mammoth cattle companies were organized with a total capitalization of more than $12,000,000 (98). Of these, the Union Cattle Co. was incorporated for $2,000,000; and the North American Cattle Co. and the Sears & Co. for $1,000,000 each. Six others each floated stock of a half million dollars or more. Wyoming, however, was merely a representative area—the same thing was happening, or had just happened, up and down the Great Plains from Montana to Texas and across the Southwest to California. Even Colorado, Utah, Nevada, and Idaho felt the surge of this tide. In a few short years practically all ranges were under use and in many cases depletion had commenced on a scale in keeping with the size of the herds.

Outfits owning 5,000 to 100,000 cattle were common on the Plains and in the Southwest, and properties of small owners were often consolidated by purchase or by incorporation. The world-famous Santa Gertrudis Ranch of 500,000 acres near Brownsville, Tex., was built up by purchased additions to the original Spanish grant of 12 secios of 4,428 acres each (118). The Swan Land & Cattle Co. was started by combining three ranch properties, totaling about 30,000 acres and 100,000 cattle, with a half-million-acre range extending irregularly from Ogallala, Nebr., westward to Fort Steele, Wyo., and from the Union Pacific Railroad northward to the Platte River (98). The XIT outfit in the Texas Panhandle ran about 150,000 head on 3,000,000 acres of land—25 miles east and west by 200 miles north and south. Hundreds of other ranches running somewhat fewer cattle, chiefly on public land, had occupied most of the range by 1883 and all of it in the Plains Region by 1885 (19). The cattle numbers by States, shown in table 26 for 1870, 1880, and 1886, indicate how rapidly the range forage was appropriated.

Table 26.—Cattle numbers1 in the 17 Western Range States, for 1870, 1880, and 1886

<table>
<thead>
<tr>
<th>State</th>
<th>1870</th>
<th>1880</th>
<th>1886</th>
<th>State</th>
<th>1870</th>
<th>1880</th>
<th>1886</th>
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<tr>
<td>North Dakota</td>
<td>70</td>
<td>189</td>
<td></td>
<td>Montana</td>
<td>1,650</td>
<td>1,650</td>
<td>1,650</td>
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<tr>
<td>South Dakota</td>
<td>40</td>
<td>389</td>
<td></td>
<td>Idaho</td>
<td>250</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>Nebraska</td>
<td>159</td>
<td>1,712</td>
<td></td>
<td>Utah</td>
<td>215</td>
<td>215</td>
<td></td>
</tr>
<tr>
<td>Kansas</td>
<td>1,247</td>
<td>2,438</td>
<td></td>
<td>Nevada</td>
<td>238</td>
<td>238</td>
<td></td>
</tr>
<tr>
<td>Oklahoma</td>
<td>590</td>
<td>550</td>
<td></td>
<td>California</td>
<td>1,228</td>
<td>1,228</td>
<td>1,228</td>
</tr>
<tr>
<td>Texas</td>
<td>4,590</td>
<td>8,587</td>
<td></td>
<td>Oregon</td>
<td>625</td>
<td>625</td>
<td></td>
</tr>
<tr>
<td>New Mexico</td>
<td>545</td>
<td>1,665</td>
<td></td>
<td>Washington</td>
<td>229</td>
<td>229</td>
<td></td>
</tr>
<tr>
<td>Arizona</td>
<td>142</td>
<td>532</td>
<td></td>
<td>Total</td>
<td>21,599</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colorado</td>
<td>857</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wyoming</td>
<td>72</td>
<td>532</td>
<td>857</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Tentative revisions of the Bureau of Agricultural Economics.

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Because such immense numbers could not be run on the range without cattle of different ownerships intermingling, the managers mutually agreed to honor each other's "range rights." These "rights", for the most part, had no legal status but were respected for many years; and when smaller operators and settlers began to push in, the large outfits often used extra-legal pressure to preserve the monopoly they had enjoyed under these illicit "range rights." Original outfits with only a few hundred cattle were accepted as part of the country, but after 1888 whenever newcomers tried to enter what the established residents regarded as fully occupied range they were practically frozen out by the resident stockmen, who refused to cooperate at round-ups and other group efforts (98).

Genesis of the Boom

The buffalo, deer, elk, mountain sheep, antelope, and other forms of wildlife, large and small, that were the first users of the range had little or no discernible effect upon it in terms of depletion. Heavy use by vast roaming or migrating herds of buffalo was common, and around strategic watering places, salt licks, and on favorite breeding grounds range forage would be so fully grazed that little or no feed remained. Yet in every instance seasonal migrations of the herds permitted recovery of the vegetation between grazing periods.

In all other instances of temporary exhaustion of the range resource, such as overuse by huge colonies of prairie dogs (88), or utter destruction of forage by locusts (172), or crickets (17), sufficient periods of recuperation occurred to maintain the productive power of the original range. No evidence remains to us from those times of such persistent overuse as came when the white man began to pasture his cattle year after year on the same range, without affording any opportunity for restoring plant vigor.

The Spanish brought to their settlements in Cuba, Florida, and Mexico ancestors of the livestock destined to use much of these ranges. Stock have grazed intermittently on the southern plains since 1540 when Coronado there sought the Seven Cities of Cibola, taking with him 1,000 horses, 500 cattle, and 5,000 sheep. The period of continuous grazing began about 1700. At this time, Father Kino, a Jesuit missionary, was very active in promoting livestock raising among the missions in southern Arizona (70).

Missions established in Texas, New Mexico, and Arizona between 1670 and 1690, became livestock centers soon after 1700. It seems likely that from 40,000 to 50,000 sheep and 10,000 to 20,000 cattle were brought to Texas during the mission period. The more settled Indians of New Mexico and Arizona fostered sheep and ponies. The latter proved well adapted to range grazing, became prized Indian property, and multiplied so rapidly and were so widely distributed that by 1805 Lewis and Clark found 700 Spanish ponies at one small village of Shoshone Indians in northern Idaho (57).

California missions, established between 1769 and 1800, so prospered under the guidance of the padres that in 1834, when the 21 missions were taken from the church, they had 423,000 cattle, 61,600 horses, and 321,600 sheep, goats, and swine (58). Range use must
have been of major consequence at San Luis Rey where 80,000 cattle, 10,000 horses, and 100,000 sheep, goats, and swine grazed.

Texas proved to be especially well suited for cattle. In 1821 the Mexican Government contracted with Moses Austin to bring settlers into Texas, and many came, enticed by liberal tracts of land; and the success of Austin's colonization scheme then brought a host of requests for similar grants (100). In 1830 further American immigration was prohibited, but already about 20,000 Americans were there whose attention to cattle growing, together with the mild climate, so favored cattle that the stock multiplied to 100,000 in 1830; to 330,000 in 1850; and to 3,538,000 in 1860 (128).

With the Civil War came the first large cattle shipments from Texas to the Confederate Army. Despite the restraining influence of the northern blockade, the consequent stagnation, and the fall of prices to $3 or $4 a head, ideal range conditions favored still further increase, and made Texas a hive of cattle ready to swarm forth at the first opportunity. This came after the war, when currency inflation and rising prices in northern manufacturing centers, together with a decrease of 7 percent in total cattle in the United States, brought market offerings of $40 to $60 for beef steers (98).

The railroads in Missouri, central Kansas, and Nebraska offered outlets for these crowded Texas herds. In 1866, real drives to Sedalia and Abilene began, and in 1867 when the demand and prices were up, more than 1,000 cars left Abilene. Actual demands reached such a volume in 1871 that 600,000 cattle were driven northward to the railroad in that year. The heavy range use in western Kansas and Nebraska that began with these drives never ceased until the grass was plowed under, although dropping prices decreased the profits and hence the number of drives. By 1885 a total of more than 5 million cattle had been driven northward from Texas (98).

In a few years, however, fences began to be built, settlement was well under way, and railroads were extended into the arid region. Advance of main and branch railroads into the range country brought the market to nearby railheads. Drives were no longer necessary and, as the use of barbed wire for fencing cattle away from farms and towns became general, they were discontinued entirely in 1885. Intense range use was encouraged by the railroads, and by 1890 had been extended with their help to every nook and corner of the region.

Meanwhile the Mormons filled the Utah ranges with foundation stock which they themselves drove across the Plains, and with lean cattle and horses obtained by trading with other emigrants. By about 1880 the ranges in northern and central Utah were occupied with 160,000 Shorthorns, Devons, and Herefords (17).

With the discovery of gold in the Rocky Mountains during the sixties, cattle were taken from Utah and California into Colorado, Montana, Idaho, and Nevada. The strong markets of the late seventies and early eighties carried grazing onto most of the accessible ranges in the mountain region. Here, however, development of the country was slower and more substantial, since it came in connection with homes and farms. Wild hay and irrigated alfalfa produced abundantly and from the first lent stability to range use on a community basis.
The tremendous growth in range cattle, however, carried with it a weakness that in the end proved fatal. It was based on a husbandry transplanted from Mexico, which brought to English-speaking people for the first time in history the practice of rearing cattle in great droves without fences, corrals, or feed. The lariat, the type of saddle, chaps, and the sombrero came along with the manner of conducting the business. The very newness of it all as well as the immensity of the outfits left the Americans without guide or standard by which to gage either the security of the cattle as they roamed at large or the ability of the forages to stand up under continual intense utilization. It is little wonder, therefore, that cattle instead of grass came to be regarded as the raw resource and that the neglected forages began to give way before the heavy and unmanaged use to which they were subjected.

This almost explosive expansion of cattle grazing was based on a great natural resource which the stockmen obtained with little cost. Grass was the magnet and living bonanza that irresistibly drew cattle and cattlemen to this range El Dorado.

Like the El Dorados of precious metals, the discovery of the grass bonanza fired the imagination of cowboys, lawyers, farmers, merchants, laborers, and bankers, who rushed in to seek their fortunes, the poor by personal effort and the rich by investment. Both eastern and Old World capital, the latter largely from England and Scotland, fevered through the expectation of profit of 25, 33, or 40 percent. A large promotion literature flourished, including such widely circulated books as Brisbin’s Beef Bonanza. After presenting several actual cases, Brisbin showed on paper how $25,000 would in 6 years pay all expenses and leave a fortune of $51,275. Estimated Fortunes and Millions in Beef are significant chapter headings (21).

Since a boom was in progress, the stories were believed. Swan, of the Swan Land & Cattle Co., promoted in Scotland the corporation with the capitalization of $8,000,000 already mentioned, and later increased this to $3,750,000—and paid a few dividends from the capital (98). Some companies really did make money for a while, but lax methods accompanied this “easy” money. Cattle were bought on “book” count, and newly purchased cattle were seldom counted. Purchase prices soared, because purchasers bid against each other, and because of the buying of breeding stock whose offspring started other breeding herds, most of which never went to a consumer market but accumulated as capital inventory until the collapse of 1886.

THE COLLAPSE OF THE BOOM

The expectation of fortunes to be made in a few years led to gambling in futures and caused overexpansion both in investments and in range use. In this process the accumulated forage of several years was mined, overuse taking not only the current growth but sapping as well the vigor of the forage plants. The better stockmen recognized the danger (98, 198), but warnings in a minor key during a boom get no hearing, and exploitation raced on.

This constant drain, without allowing any chance for recuperation, caused the forage “mine” to peter out. In 1898 Bentley (16) reported that some stockmen considered that in parts of Texas “the injury has gone almost past the point where redemption is pos-
When sheep outfits crowded in upon the isolated settlers or upon a small irrigated community, the sheep seldom left much forage for domestic farm stock, making it necessary to feed teams and milk cows the entire year or else provide irrigated pasturage. This the settlers considered decidedly unfair (94). This three-cornered fight among cattlemen, settlers, and sheepmen was a complex pattern of bitter feelings, especially when a huge incorporated stock outfit was involved. Worst of all, it put a premium on forestalling another outfit, and stripping a neighborhood nearly bare of forage in order to keep out a competing user.

This competition led to increased operating expenses and to investment expenditures the purpose of which reached beyond forage management. Heavy investments in land, buildings, fences, water developments, and miscellaneous supplies were made to provide shelter, feed reserves, pasturage, and better grades of livestock. However, little or nothing was spent for management of ranges, a phase in urgent need of improvement.

The serious effects of poor range management were increased in many sections by fires, particularly in California, where forest and brush fires have played an important part in molding and shaping the vegetation. Historic evidence and the reconstructed story through fire-scarred tissue on century-old trees indicate that fires frequently swept forest and foothills alike. But the damage caused by these presettlement fires was less serious because nature in her own way slowly started anew the process of rehabilitation and building back to climax vegetation. Once civilized men entered into the picture, fires increased in number and restoration was indefinitely retarded. The miner, the early sheepman, and the careless traveler all contributed annually to the inevitable smoky skies and burned forests (128, 145). The net result was the extension of vast areas of chaparral, chamiso, and other brush areas of lowest forage values, replacing on the upper elevation coniferous forests and on the lower levels the more open parklike woodland and savanna types. In this process grass and herbs were replaced by undesirable woody shrubs, which in repeated fires of the timber type produced forage for a short period, followed in a few years by impenetrable thickets of manzanita and ceanothus. On areas where fires were used freely and where overgrazing followed, perennial grasses frequently were replaced by a host of “immigrant” annuals from the Mediterranean region of much lower forage value.

Establishment of Public-Land Control a Stabilizing Factor

The creation of the national forests, on which are grazed 12 percent of all the cattle and 23 percent of all the sheep in the West, greatly stabilized range use and livestock production. An effort was made to administer grazing on the national forests for the benefit both of the permanent stockmen and of the adjacent agricultural communities. Having a definite range allotment with 3 to 5 months of dependable summer feed of high quality helped the stockmen to make the adjustments necessary to supply feed for the remainder of the year.
Prior to 1930 some organized attention was given to the principles of range management on northern Indian lands. In 1930 responsibility for the supervision of all grazing was delegated to the forestry branch of the Indian Service, and a distinct forward step was taken by inaugurating a plan of management similar to that developed on the national forests.

The Taylor Grazing Act of 1934 provided authority to administer 80 million acres, or about half the public domain, and made possible a step toward the management of the grazing on these lands.

Recently wildlife and game management have come to the front in the national forests as problems to be correlated with grazing. Recreation, both on national forests and on national parks, has also increased greatly in importance since automobiles came into general use. The parks, as reservoirs for wildlife, have become much better known than formerly. Under the previous near absence of control, game and other wildlife in the country as a whole decreased to small populations, whereas under the unplanned protection used in the West from about 1915 until recently game became so congested in some areas as to require serious attention. It is likely that use of the range by game will increase in many places, but under good management it need not conflict in an important way with livestock grazing.

Both game and recreation have such high public values that they will undoubtedly receive preference in the use of small areas of range land especially suited for these purposes.

World War Boom and Post-War Depression Bring Heavy Demands on Range

The participation of the United States in the World War again intensified range use by bringing about a great increase in numbers of livestock, stimulated by rising prices and by war demands for increased food production (66). In 1918-19, the number of animal units in the Nation was the highest ever attained (18), and by 1920 a great potential meat surplus had been built up. This important increase in numbers of livestock had the effect of speeding up depletion.

The additional stocking, together with dry seasons, proved a heavy blow to the program of range management on national forests. The national-forest administration responded to these urgent national demands and in 1918 allowed 1,063,000 extra animals to graze on the forests, receiving them earlier in spring and keeping them later in the fall (60). Justification for it lay in the fact that, although the ranges were being depleted, it was difficult to supply the meat demands of the war period. In addition there was the desire of stockmen to benefit by the high war prices. In places the damage done to the national-forest ranges has not as yet been fully repaired.

Also between 1910 and 1929, but mostly after 1915, some 50 million acres of range land, largely on the Great Plains, was plowed up for dry farming by a horde of new farmers. Later many of these farms were abandoned.

During the World War and in the post-war inflation period, as in the boom of 1883, the easy credit available led to overborrowing.
DECLINING NUMBERS ON RANGE THROUGHOUT THE WEST INDICATE EXCESS

In the range portion of the Plains States, numbers on ranges reached an early peak of over 8.5 million animal units about 1900. After a decline of around 10 percent to 1910 a new peak was established about 1920 when approximately 9.5 million animal units were on these range lands. Since 1920 there has been a decline of about 24 percent, especially marked in 1934. These figures may not be an entirely true picture of range stocking in the Plains States because of a number of uncertain factors. There are, for example, large quantities of unrecorded grain and other feeds shipped into this area, an unestimated area of grain fields that are grazed in winter and as stubble, and some of the cattle recorded as on farms and ranges on January 1 are shipped out of the area in the spring. The difficulty of taking adequate account of these features in the Plains States tends to show larger numbers of livestock on ranges throughout the year than is probably the case.

In the 11 far-western States the peak of livestock on ranges was reached about 1890, when 12.5 million animal units were obtaining their feed from range lands, 88 percent of the livestock then in these States. By 1910, around 10.4 million animal units were on range, about 60 percent of the total animal units. Following another rise to 1920 there has been a declining trend to 1935 when about 10 million, 57 percent of the total animal units, were on range lands. Thus a net decline of about 20 percent has occurred on range lands since 1890.

Figure 53 brings out the decline which occurred in the stocking of range lands between 1890 and 1910, and again between 1920 and 1935. While the grazing of heavier animals, as a result of better breeding and other improved animal production practices, may account in part for these declines, they are also undoubtedly due partly to a declining range-feed supply caused by overstocking.

The rise from 1910 to 1920 represents primarily the increase caused by war demands and does not indicate that there was range forage available for the excess livestock. In fact there are many indications that excessive stocking became the rule. In western Texas, for example, the upward trend was abruptly halted in 1916 and 1917 when range conditions failed, starvation losses were widespread, and forced shipments of livestock were made as ranges became more depleted. Along the Texas & Pacific Railroad in the Trans-Pecos country, ranges presented a pitiful sight. Feed gone, carcasses of cattle in great numbers around water holes, and gaunt, stary-eyed cattle still alive, their ribs all but protruding through the flesh—all these evidences told a tragic story of failure to keep numbers within safe limits of range-feed production.

The opening up of new areas by water developments, trails, and other means, has also been a factor in holding up livestock numbers grazing range lands. At first the more readily accessible ranges were stocked. As high prices stimulated expansion or as exhausted feed supplies, especially during drought, compelled removal of livestock from overgrazed ranges, stockmen have drilled wells, constructed reservoirs, and made other improvements in order to utilize formerly unused or lightly used ranges. Such improvements expanded the range livestock industry to the point of compensating
Products furnished by livestock grazing

Meat
Hides
Wool
Tallow
Insulin

and a long list of other by-products

Permanent
Principal demands for sheep grazing

1. Meat (Beef)
2. Change in prices of feed stuffs
3. Change in tech to key production feed stuffs

Range Grazing Demand's Entice (Project in 1978)

See cathedra

Beef cattle
Dairy steers
Sheep and goats
In addition, the heavy substitution of grains for grazing in beef production cannot be repeated. In fact, the desire for less fat in beef may result in less grain used in beef production, resulting in further increases in demand for grazing. Thus, increases in beef production will require additional quantities of grazed roughages.

Projected Regional Demands for All Grazing

Projections of demand for grazing by geographic regions are based on the distribution of the demand for all grazing (table 5.13). Projections were based upon the traditional pattern of grazing and do not include alternatives that consider the relative production capabilities and costs of grazing among the regions. It is assumed that the regional distribution of demand for all grazing will be the same for both range and nonrange grazing.

<table>
<thead>
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<tr>
<td>Northeast</td>
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<td>100</td>
<td>153</td>
<td>170</td>
<td>177</td>
<td>181</td>
<td>185</td>
</tr>
<tr>
<td>Rocky Mountains and Great Plains</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Rocky Mountains</td>
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<td>108</td>
<td>128</td>
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<td>Great Plains</td>
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<td>122</td>
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<td>135</td>
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<td>138</td>
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<tr>
<td>Total</td>
<td>100</td>
<td>132</td>
<td>143</td>
<td>148</td>
<td>151</td>
<td>154</td>
</tr>
</tbody>
</table>
no major impacts on storm runoff or sediment yield.

Intensities of land use rise slightly on National
Forest and other Federal lands, but increases much
more significantly on Bureau of Land Management
lands, and State and private lands, which comprise
about two-thirds of the total land base in this region.
As a result of this increased management, total costs
increase. Likewise, the marginal costs for both timber
and range grazing rise substantially with time.

Pacific Northwest.—In the Pacific Northwest, while
the allocated softwood timber demands rise only
slightly with time, the model results indicate meeting
these demands induces some important changes in
other resource use, and environmental effects occur.
To meet timber and range grazing targets, dispersed
recreation growth is limited to about 10 percent of
the 1977 use, and wild ruminant grazing will fall
below the 1977 level by the end of the projection
period. On the other hand, water yield and storm
runoff again show an insensitivity to changes in
projected demands.

The intensity of land resource use figures reflects
the increases in range grazing demands, as they rise
significantly on State and private and Bureau of
Land Management lands. Associated with these
increases in intensity of land use is a rise in total
land resource use cost. As expected, the marginal
cost for timber increases only slightly, in response
to the similar small rise in timber demands. The
range grazing marginal cost increases rapidly.

Pacific Southwest.—The allocated demand for soft-
wood timber and range grazing in the Pacific South-
west increases with time, but at a lower rate than
in most of the other regions. However, some signifi-
cant changes in resource use and environmental effects
accompanied the meeting of these projected demands.

Dispersed recreation can be increased by 46 percent
during the projection period. This trend indicates that
dispersed recreation use can be increased while
meeting projected demands for timber and range
grazing. Herbage and browse increase slightly with
time, a result of the management practices neces-
sary to meet range grazing demands. A slight
reduction in dispersed recreation signals possible
increase in competition as projected demands rise.

Wild ruminant grazing rises by 17 percent in 1985,
but then drops. Range and wild ruminant grazing
production begin to compete at higher levels of
range grazing demand. The hydrological outputs
water yield, sediment, and storm runoff display
little sensitivity to the projected demand changes
in this region, a result both of the low demand
increases and the characteristics of the local geo-

Examination of the intensity of land resource use
data shows a very substantial rise in intensive use of
National Forest and especially State and private
lands, compared to little change in intensity on
Bureau of Land Management or other Federal lands.

Despite the large increases in intensive use, total
land resource use cost rises over the projection period.
This moderate rise is necessary to meet the increased
timber and range grazing demands. Likewise, the
marginal costs rise only slightly, except for the large
increase in range grazing marginal cost.

Conclusions

Three major conclusions can be drawn from the
foregoing analysis of resource interactions.

The first conclusion is that projecting renewable
resource supplies requires an understanding of the
complex interactions between the biological poten-
tial of the land to produce combinations of goods
and services, the impact of various management
strategies, and the motives of various types of land-
owners. At the present time, knowledge of these
interactions is limited and should be the focus of
increased attention from the forestry research com-

The accuracy of any modeling efforts to quantify
these resource interactions will be limited
by the understanding of both the biology and eco-

A second conclusion is that a model has been
developed which can be used to examine a large
number of land areas of different productive capacity
and to quantify the impacts of meeting increased
demands for timber and range grazing. This effort
not only lays the groundwork for a more sophisticated
way to assess the capability of the Nation's forest
and range lands to produce goods and services, but
it also can be used to analyze in more detail the
benefits and costs of particular management strat-
egies as they are applied to particular regions of the
country.

The third conclusion is that the Nation's forest and
range lands have the productive capacity to meet
the ever-increasing demands for nearly all renewable
resource products through the next five decades.
Though the inherent productive capacity is there,
several changes in land management will have to
take place. There will have to be more intensive man-
agement, which will require larger investments than
are currently being made. There will have to be shifts
among regions in the proportionate share of certain
goods which they produce. There will have to be
shifts in supply among ownerships with increasing
share of goods and services being provided from
private ownerships.
stocked and overgrazed that drastic environmental changes began to occur (see Chapter III).

Edible vegetation was so depleted that livestock starved to death during periods of drought or heavy snow, and in some places even during benign weather. In January 1887, for example, starving cattle ate the wool off dead sheep and then fell dead themselves. Massive die-offs occurred periodically during the latter decades of the 1800s, and to a lesser degree during the early 1900s (as they still do occasionally). Some die-offs were so bad that most livestock were lost over huge areas, even entire states. Emaciated cattle ate wood from trees. Rotting carcasses were sometimes so thick a person could throw rocks from one to the next.

Stockmen blamed these disasters on drought or storm, though such periodic atmospheric fluctuations are natural occurrences. Likewise, many contemporary ranching advocates make claims such as this one by grazing industry spokesman Thadis W. Box: "The period from the [sic] 1880 to 1905 was one of the driest in the past 1500 years" (Box 1987). Scientific studies and precipitation records prove these claims unfounded (see Air section in Chapter III).

In truth, the range was simply so devastated by livestock grazing that biological population controls began to kill off the cattle and sheep (which, unlike today, were rarely given supplemental feed to mitigate starvation). In retrospect the massive die-offs were a blessing -- Nature's method of self-protection -- for without them much of the West might have been transformed permanently into Sahara-like wasteland. Nature reduced 1884's estimated 35-40 million cattle to an estimated 27 million in 1890 (Holechek 1989). And despite it all the frenzied, profit-crazed cattlemen were eager to

The range itself got little relief from heavy use, and there may not even today be a truly widespread recognition of the lasting impact of the damage to forage and soil started during that boom era.

—William Voigt, Jr., former Executive Director, Izaak Walton League, Public Grazing Lands (Voigt 1976)

The land suffered. Livestock stripped vast areas of ground cover as clean as a billiard table. By the early 1880s the Western range was so over-

Roundup following a hard winter in the late 1800s. (Unknown)