Regional Range Division, Soil Conservation Service, Portland, Oreg. He was engaged in range and livestock research, Alaska Agricultural Experiment Stations from 1917 to 1932. Since 1935 he has directed the technical phases of planning assistance rendered by the Soil Conservation Service to range-livestock ranchers in the western coastal States.

W. R. Frandsen, a native of Utah and a graduate of Utah State Agricultural College, operated a livestock ranch from 1930 to 1934. He has been a range-planning technician with the Soil Conservation Service since 1935; he is now a range conservationist in the regional office in Portland.

C. V. Jensen is a range conservationist in the Soil Conservation Service. He is stationed in Portland. Before joining S. C. S. in 1941, he was employed in range research in the Forest Service for 9 years. He was born in Montana and is a graduate of the University of Montana.

MANAGEMENT THAT RESTORES THE RANGE

R. S. CAMPBELL, LINCOLN ELLISON, F. G. RENNER

MOST run-down ranges can be improved. By improving the range, the stockman, the community, and the Nation gain. Restoration through wise use is witnessed by many specific examples in all parts of the range country. Many more ranges need such restoration. This article explains how to tell when grazed ranges need to recover, when they are on the mend, and how good livestock and range management can take advantage of natural processes to bring ranges back to greater productivity.

Restoration of range values can be accomplished most effectively and economically and in the shortest period of time by the wise use of all range techniques best suited to the type of operation involved, effectively coordinated with the natural growth habits and requirements of the principal forage plants.

The state of health or productivity of a range is known as range condition. Likewise, the steps or stages in the upbuilding of ranges are known in practical management as range condition classes, from very poor to excellent.

Range condition never stands still for long. It is either improving or declining. Range deterioration is but the effect of a downward trend of condition, the depletion of the plant cover and soil. Range restoration means stopping deterioration and bringing about an upward trend from an unsatisfactory to a satisfactory condition.

Five range condition classes are generally recognized, as mentioned previously.

A range in excellent condition has a fully productive stable soil and is producing all or nearly all the forage that it can. Good condition closely approaches excellent. Fair, poor, and very poor condition are all considered unsatisfactory because the soil is not fully productive and the range is growing only a part of the forage of which it is capable.

Even within each class, there may be a rather wide variation in density, composition, and vigor. Because each range has its own top or excellent condition, ranges must be classified in terms of their own best possible soil development and kind and amount of plant cover and forage production. For example, a mountain meadow naturally has a higher rainfall, deeper, richer soil, a thicker plant cover, and much greater forage growth than a semidesert grassland, even when both are in satisfactory condition. Hence, a mountain meadow cannot be judged by the standards one would use for a desert grassland.

Ranges in excellent condition do not need restoration because they are already producing all the forage possible under the existing climate. The plant cover protects the soil from abnormal erosion and maintains the fertility. The better forage plants, particularly the deeper-rooted, perennial grasses, predominate with palatable weeds and shrubs on some ranges. Better plants reproduce well in favorable years. Some litter covers the ground, and the topsoil is loose and friable, containing dark organic matter—more in areas of high rainfall than in the semidesert. The soil is porous and readily absorbs large amounts of moisture. The runoff water is clear. In other words, ranges in excellent condition serve every purpose as fully as possible.

Ranges in good condition are generally satisfactory although they produce less forage than those in excellent condition. The better perennial plants predominate, but there are some less palatable plants. The plant cover is thinner. There is less litter and the topsoil may show less organic matter. Erosion, if it occurs at all, is slight. Ranges in good condition offer an opportunity to increase production and value through conservative grazing and other management practices that encourage the more palatable plants. The job of restoration is not difficult or time consuming, as the better forage plants and soil are still there for quick improvement.

Ranges in fair condition are definitely unsatisfactory. Both soil and plant cover have been distinctly damaged, and restoration is no longer a quick or easy task. Valuable forage plants are considerably reduced in stand, their places occupied either by bare soil or by less palatable perennial grasses, weeds and shrubs. Annuals have usually increased. There is less total plant cover and litter and there is likely to be active erosion, particularly on the slopes. The dark topsoil layer is seriously disturbed, containing only moderate amounts of organic matter, and with only fair capacity to hold available moisture. The exposed surface of clay and silt soils may be hard and crusted. Runoff water is heavy with silt. If neglected, fair ranges slip quickly to a poorer condition. If handled carefully, they can gradually be restored. Reseeding is often practicable.

Ranges in poor condition have lost so much of the forage stand and topsoil that they produce only a fraction of the forage grown on similar ranges in good or excellent condition. Few of the more valuable perennial forage plants remain, and low-value annuals or perennial weeds and shrubs such as snakeweed, juniper, and mesquite may predominate. Removal of topsoil by washing or blowing has exposed the subsoil or left a gravel "pavement." The soil has little organic matter and a low available moisture-holding capacity. There is active sheet and some gully erosion. Runoff is rapid and heavy with silt. The job of restoring poor ranges to full productivity is a major one. Years, even decades, may be required gradually to build back the organic matter in the topsoil that marks satisfactory condition. Where soil and moisture conditions permit, ranges in poor condition should be reseeded to adapted forage species, to hasten recovery.

Ranges in very poor condition have only a sparse stand of low-value plants, mostly annuals or unpalatable shrubs. Grazing capacity is very low, sometimes 5 percent or less of potential. The topsoil, with its organic matter, is largely gone, and the soil can hold little moisture for plant growth. The remaining soil is exposed to serious wind or water erosion. Gullies are extensive. Runoff from sudden summer storms forms flash floods, muddy with silt. Under such conditions natural restoration is a very long, arduous, and uncertain process. Where rainfall is sufficient, and where enough soil is left to support a forage stand, reseeding will usually aid recovery. Artificial aids such as furrows, terraces, and the like may be necessary on slopes to retain

the soil in place long enough for better plants to take hold.

It is a matter of dollars and cents to the stockman to know the trend of his range condition—to be able to check when his management is improving its productivity. The indicators of an improving range vary in detail from one part of the country to another but in general may be summarized under three heads: (1) Improving soil character and stability; (2) increasing density and amount of vegetation; and (3) change in the kind of plant cover with better plants becoming predominant. All three must be considered together to judge range trend accurately.

Invasions of perennial plants into the bare soil openings are indicators of soil stabilization, as is the rounding of sharp erosional surfaces like the shoulders and bottoms of gullies as vegetation becomes established on them. A darkening and mellowing of the surface soil through addition of humus shows improvement. The old marks of erosion—gullies, wind-blown depressions, plant pedestals, erosion pavement—provide a record of deterioration that is written over, as it were, by a new record of plant invasion and building up of litter and dark soil. Building of soil means not only improving fertility but preservation of humus and tiny spaces between soil particles which store up needed moisture for vegetation. Plants growing on noneroded soil require less water than those on eroded soil. That means rainfall is used more efficiently on ranges in satisfactory condition—more forage is produced per inch of rainfall than on ranges in unsatisfactory condition and the soil is more adequately protected against erosion.

Change in density and amount of vegetation is a second important indicator of range trend. Vigorous forage plants, increasing in abundance by natural reseeding or otherwise on conservatively grazed range, are signs of stands being restored. Grazing must be so regulated that the better forage plants are allowed to spread.

Shifts in the kinds of plants present and the relative proportion of each kind are also important indicators of changes in range condition. From a very poor condition, the increase of any perennial plant cover is usually an improvement. A general thickening of palatable weeds and grasses is a mark of restoration from poor or fair. In most normal perennial forage stands there are young, "middle-aged," and old plants. The old ones die off naturally. A population of young palatable plants is a sign of an improvement in condition.

Conservative grazing keeps rundown ranges on the mend. It allows the more important forage plants to increase their density and vigor, avoids undue disturbance to soil, and retards runoff and erosion. Key forage plants are properly utilized on deteriorated ranges when enough of the leafage or stubble is left to maintain or increase their vigor and productivity and allow them to spread satisfactorily. Less valuable species will naturally be grazed less when the key species are properly utilized. For example, in the Southwest, when about 40 percent of the total herbage production of black grama has been grazed, the dropseed grasses usually are grazed only about 30 percent.

Sample utilization standards for ranges in good condition are shown in the table. Such general standards can be applied only with close study of the individual range, its soil, dominant forage plants, and their reaction to grazing use from year to year. Thus good condition and proper utilization of blue grama ranges are quite different in the Central Plains of Colorado than in the semidesert grasslands of Arizona and New Mexico. The stand is much more dense, and proper utilization may be closer under the favorable conditions of the Plains than under almost comparable rainfall, but shorter growing season, higher temperatures, and dry spring and fall periods of the Southwest.

One must know the condition of a

Indicators of Good Condition and Proper Utilization for Selected Range Types[1]

Type	Location	Soil	Plant cover	Proper utilization at end of grazing season
Short grass	Central Great Plains—Colorado and Wyoming.	Sod pieces not pedestaled. Slight to no erosion.	Almost unbroken sod of blue grama, buffalograsses; scattered tall grasses.	Blue grama—50 percent. Stubble height 1.5 inches.
Pinyon-juniper woodlands.	Southwest—Arizona, New Mexico.	Plant litter on surface. Little soil blowing or washing.	Blue grama predominant. Scattered other grasses, weeds, and shrubs.	Blue grama—40 percent. Stubble height 2.5 inches. One-fourth of stems ungrazed.
Sagebrush-grass spring-fall range.	Intermountain—south Idaho, north Utah, and Nevada.	Well protected by plant cover, accumulated plant debris. Sheet erosion limited, gullies lacking.	Slender bluestem, thick spike, and bluebunch wheatgrasses Idaho fescue dominant. Some arrowleaf balsamroot.	Grasses 50–60 percent. Stubble—3–4 inches. Equal use spring and fall. Reduce grazing as needed on steep slopes or erosive soils.
Subalpine grassland.	Pacific Northwest—eastern Oregon and Washington.	Half of surface covered by live vegetation. Soil stabilized by perennial grasses and weeds. Gullies lacking or stabilized.	Green fescue dominant, other grasses and weeds less than one-third of plant cover.	Green fescue—50 percent. Stubble—3 inches. Avoid undue soil disturbance by animals.
Mountain meadow.	Pacific Northwest—eastern Oregon and Washington.	Unbroken sod. Organic matter abundant. No erosion.	Tufted hairgrass dominant. Kentucky bluegrass, winter bentgrass, red fescue, sedges, and weeds scattered.	Tufted hairgrass—55 percent. Stubble—3 inches. Utilization even, giving mowed appearance.

[1] The information in this table is only approximate. For standards on range in poor condition, the references listed for further reading should be consulted for details. The proper utilization percentages are in terms of weight of the total herbage that may be removed by grazing.

range in planning grazing use that will allow forage production to improve. Let us illustrate with an example on mountain meadows of the Pacific Northwest. On ranges in good condition, tufted hairgrass is predominant, and dense vegetation covers about two-thirds of the ground surface. In poor condition, tufted hairgrass is limited to wet spots; vegetation is thin, patchy, and covers only about one-third of the ground surface; and weeds are abundant. When the condition is dropping from good to fair, the tufted hairgrass is replaced on drier spots by sod-forming grasses, such as Kentucky bluegrass. On the other hand, when a meadow in poor condition is improving, the perennial plant cover is vigorous and thickening, and weed patches are being taken over by sod-grasses. Later, as a fair condition improves toward a good condition, the more valuable tufted hairgrass will crowd out the sod grasses.

Grazing of palatable plants should be lighter on ranges in poor condition than on those in good condition. In the Southwest, for example, a properly grazed blue grama range in good condition will have about 40 percent of the weight of blue grama herbage removed at the end of the season. Average stubble height should be 2½ inches and one-fourth of the flower stalks left ungrazed. On deteriorated range, however, the blue grama is less abundant, has less vigor, and produces less forage, and the soil is eroding. Utilization of blue grama, therefore, must be lighter, not exceeding 30 percent, and leaving an average stubble of about 3 inches and two-fifths or more of the flower stalks ungrazed.

Conservative grazing is especially necessary in providing sufficient live-plant cover and litter to protect highly erosive soils from washing or blowing and to give the forage plants a chance to produce satisfactorily. Some soils on steep slopes practically melt away unless protected by plant cover. On heavily grazed range pastures within the ponderosa pine-bunchgrass type, in fair condition on such soil in central Colorado, 51 percent of the herbage was utilized each year. After 5 years of such heavy use, plant cover was reduced about 12 percent, and herbage production was only 449 pounds per acre. On nearby moderately grazed pastures, where only 33 percent of the herbage was utilized each year, the grass density increased about one-third. Herbage production was more than 1,200 pounds per acre and of better quality. Thus, even though only a third of the herbage grown in 1946 was utilized on the moderately grazed range, the cattle had almost twice as much forage as with 51 percent utilization on the heavily grazed range.

The livestock production advantages of conservative grazing are well illustrated on two experimental ranches in the Southwest. After 27 years, these ranges, grazed conservatively yearlong, grow twice as much forage, have 50 percent greater net calf production, and have only one-fifth to one-third the death losses as compared to similar ranges that are heavily stocked.

Other Phases

In addition to conservative utilization, the other three basic principles of good range management—proper kind of animals, proper season of grazing, and even distribution of grazing use over the range—are important.

If overgrazing prevails, adjustments in livestock numbers or in season of grazing or both are essential. Sometimes changing the kind of livestock, combined with change in season and degree of use, is helpful. For example, a moderately steep range in central Arizona with erosive soil was used for many years by cattle yearlong. The valuable perennial grasses were grazed so constantly and closely that the trend continued downward until the range was in poor condition. Then a change was made from heavy yearlong cattle grazing to conservative winter sheep

757150°—48——16

use. This allowed the vegetation to develop ungrazed during the full growing season. As a result, in fewer than 20 years, the range has improved greatly in both amount and quality of forage. Furthermore, since it is part of the watershed of an important irrigation project, the greater plant cover and improved stabilization of soil and runoff are protecting important values in the irrigated valley below.

Natural revegetation through deferred or deferred and rotation grazing has proved to be a very effective method for range recovery on many western ranges. It consists of deferring grazing on a part of a range each year until the more important palatable forage plants have matured a vigorous growth and gone to seed, or otherwise reproduced. The rotation feature comes through deferring grazing on different parts of the range in succeeding years. Under this practice, the mature seeds are shaken to the ground where they may be partly covered by trampling. During the following year light grazing or deferred use again may be desirable to promote establishment of seedlings. In a 10-year test in Colorado, for example, there was 47 percent more wheatgrass and 22 percent fewer weeds on a range where deferred and rotation grazing was followed, as compared to one grazed continuously. On the average, ranges grazed according to this method with conservative numbers of animals for 10 to 15 years have gained about 20 percent or more in forage value, an important step upward in condition. Through such management, which permits full use of the forage each year after maturity, individual range areas have improved in a period of 20 to 25 years from poor to good condition. Such improvement has usually meant doubling forage production.

Water-spreading devices and other structural aids speed up natural improvement where the plant cover has thinned by holding back the rainfall that is otherwise lost as surface runoff. Contour furrows have been found valuable in the Great Plains, where blue grama, buffalograss, and other grasses make up most of the vegetation. Outside of the Great Plains, if there is a fair stand of grass, conservative grazing and other good management practices are likely to result in fully as much improvement as furrowing.

Water-spreading devices as a rule consist of a dam across a gully or arroyo, and a system of low dikes of earth, brush, or rock to spread the water on rather flat adjoining grasslands. Like contour furrows, water-spreading systems are chiefly effective by holding back the runoff water until the range grasses can use it. In the Southwest, as much as 1,500 pounds of forage per acre has been produced as a result of natural seeding and increased growth of forage on an area which was practically barren 2 years earlier. Small, inexpensive installations, which cause little damage in case of failure, have been found most satisfactory.

THE AUTHORS ⟿ *R. S. Campbell has been engaged in range research with the Forest Service since 1925. Dr. Campbell holds two degrees in ecology from the University of Chicago. He is now chief of the Division of Range Research, Southern Forest Experiment Station, at New Orleans.*

Lincoln Ellison, a native of Oregon and graduate of the University of California at Los Angeles, has a doctor's degree in ecology from the University of Minnesota. He has been in range research in Montana and Utah since 1933. He is in charge of grazing management studies, Intermountain Forest and Range Experiment Station at Ogden.

F. G. Renner was educated in forestry and animal husbandry at the University of Washington and Oregon State College. He was in administrative and research work with the Forest Service from 1916 to 1936, when he transferred to the Soil Conservation Service, where he is now chief of the Range Division. He works in Washington, D. C.