What Is Range Improvement?

LINCOLN ELLISON
Intermountain Forest and Range Experiment Station, Ogden, Utah

THE term "range improvement" is used very freely, but it is seldom defined. The term might appear to be so easily understood as to make definition unnecessary, yet its great variation in significance, as used by range managers in reports of range condition, makes clear that the term means different things to different men. Some consideration of its significance is therefore in order.

We know in a general way what range managers have in mind when they speak of improvement—such as an increase in plant density, an increase in the abundance of the more palatable species, the "healing" of gullies, etc. Perhaps the most unquestionable evidence of improvement is considered to be the appearance of species higher in the normal succession and the disappearance of species representing lower stages. Improvement of the soil is referred to rather incidentally, for if improvement of the soil is considered at all, it is generally assumed to accompany improvement of the vegetation. This, however, is not necessarily true, as will be shown presently.

Broad-scale ecological studies show that the two processes, soil formation and the development of vegetation, are interdependent, that over centuries a deep soil will develop from raw parent material, and at the same time progressive changes of vegetation and animal life take place. The two processes are so interlocked in complexity that each is both an effect and a cause of the other.

There is no reason to believe that the two processes may not seem to be independent for short periods, however. The following example, taken from high summer range on the Wasatch Plateau in central Utah, will illustrate the point.

THE range under consideration is at an elevation of 10,000 feet. The wind is frequently strong and evaporation is rapid. Beginning about November 1 the ground is covered by snow, which lies very deep during the winter so that the soil is not frozen except shallowly in fall and spring. The snow, which on the average contains some 2 feet of water, three-fourths of the annual precipitation of 30 inches, is usually gone about the last week in May. The precipitation in summer is highly erratic in distribution and frequently falls violently, running over and eroding the exposed ground surface. The rills and gullies cut by these summer rains are deepened during the period of snow melting in spring. Active vegetal growth begins as soon as the snow melts, and, unless stimulated by fall rains, is completed toward the end of September. The growing season, then, lasts about 4 months, but it is usually shorter because of cold weather in spring or fall, or because of summer drought.

These climactic conditions have important implications for the range manager. Because the growing season is short, plants do not have much time to recover the vigor which may be impaired in cropping; the maturing of viable seed is not always possible; the seed may be washed away or fall on a sterile subsoil surface bared by summer storms; and the seedling, once it gets its roots into the soil, has all these factors to contend with, in addition to drought and trampling by livestock. It is little wonder, then, that some of these high ranges revegetate slowly.

THE square-meter quadrat chosen for an example lies on a slight ridge on a slope of 20 percent, with a western exposure. The soil is a clay. Other plot records and photographs show that the quadrat is fairly representative of the entire slope. The area is grazed primarily by sheep, but also by a few cattle, from early in August to about the middle of October. The intensity of grazing is now very much less than it was prior to 1916, when the quadrat was established on range badly depleted from excessive use.

Figure 1 shows the quadrat as it appeared in 1919 and 21 years later in 1940; and table 1 summarizes the vegetal changes numerically. For the sake of simplicity, the results from chartings between 1919 and 1940 are not shown; despite the inevitable minor fluctuations from year to year they substantiate the trends suggested by the end figures, and so these alone are used.

In 1919 the predominant species was *Achillea,* and in 1940 *Agropyron,* a very great difference as the photographs show. The outstanding vegetal changes have been the invasion of the grasses, particularly *Agropyron,* and of *Vicia* and *Pseudocymopterus,* and an increase in the importance of *Taraxacum.* The absence of ruderals in 1940 is accidental, for they were present

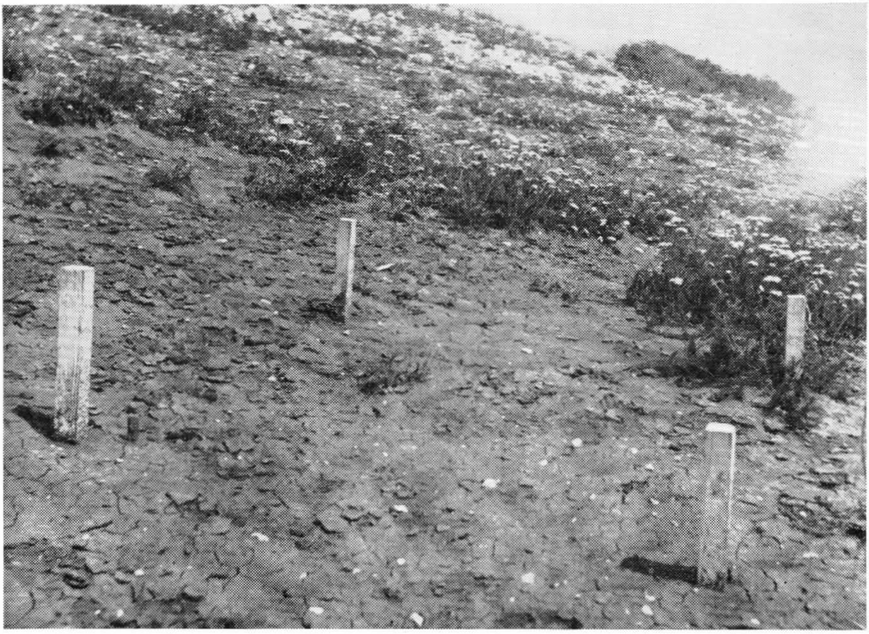

FIG. 1a. *Quadrat as it appeared in 1919.*

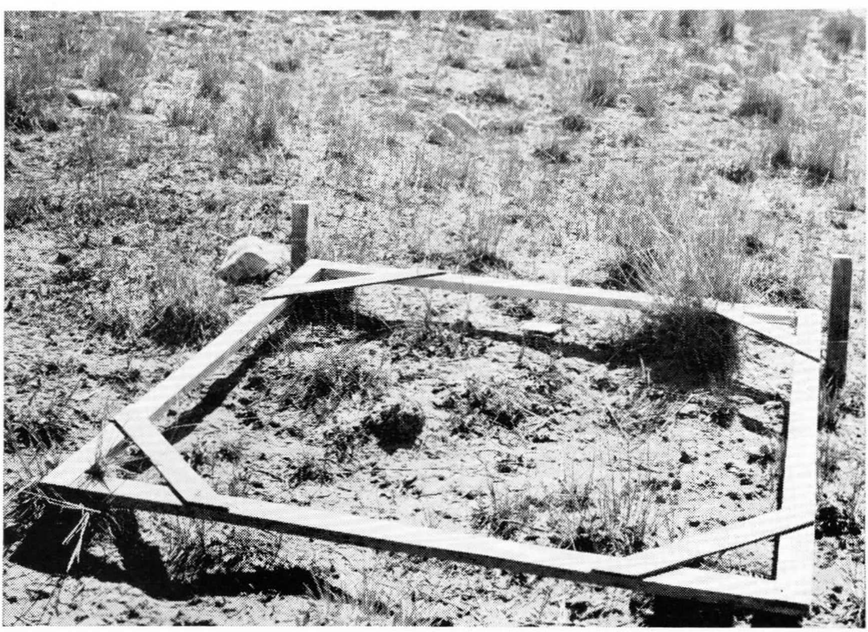

FIG. 1b. *Same quadrat as Fig.* 1a *taken 21 years later. 1940.*

nearby in 1940 and were recorded on the quadrat the next year.

Soil changes are not so easy to describe, for records of soil condition are meager. The soil surface in 1919, as shown in the photograph, was largely exposed to the elements and was no doubt eroding rapidly. At the same time some deposition on the quadrat may have been taking place, for the slope above was eroded down to the rock; but even so, most of the eroded material probably was carried farther down the slope, so that the net change on the quadrat was a loss of soil.

TABLE 1

NUMBER OF SHOOTS, BY SPECIES, ON THE SAME SQUARE-METER QUADRAT IN 1919 AND 1940[1]

	1919	1940
Agropyron trachycaulum (slender wheatgrass)		412
Stipa lettermani (Letterman needlegrass)		6
Achillea lanulosa (western yarrow)	3	12
Taraxacum officinale (common dandelion)		85
Vicia americana (American vetch)		5
Pseudocymopterus montanus		5
Polygonum douglasii (Douglas knotweed)	3	
Lepidium ramosum (pepperweed)	3	

[1] In 1916 when the quadrat was established the composition was much like that in 1919: *Achillea* 98, *Taraxacum* 2, *Polygonum* 4, and *Chenopodium album* 4 shoots. The occurrence of the rhizomatous *Achillea* on a particular quadrat may be very erratic. Its significance, whether in 1916 when 98 shotts were recorded on the quadrat, or in 1919 when only 3 shoots were recorded, is that it was the predominant species at that time.

The pedestaled grasses in the 1940 photograph suggest further soil loss. Soil pedestals may of course be formed by deposition as well as by erosion, or by a combination of the two processes, so that it is necessary to examine pedestals closely to interpret their significance. On this area the pedestals probably represent soil remnants: not more than a third to a fourth of their height of 3 inches looks like deposited material, while the exposed roots and dying plants, as in the pedestal just left of the center of the quadrat in the 1940 picture, testify to removal of soil. This pedestal was the remnant of a grass clump which gained a foothold sometime between 1929 and 1932. It supported 2 living shoots in 1940 when the picture was taken, and within the ensuing year it disappeared. The raw surface and the gullied character of the area as a whole further substantiate these evidences of soil loss.

Something as to the rate of loss may be ascertained from a knowledge of the age of the grass clumps. Grasses first appeared on the quadrat between the chartings of 1927 and 1929. The oldest plants still existing in 1940 appeared sometime between the chartings of 1929 and 1932. If we assume, for the sake of a definite date, that they appeared in 1930, then there has been a net soil loss of some 2 inches in 10 years, if we estimate, conservatively, that two-thirds of the pedestal height represents eroded material. Actually the loss has probably been greater, for the hummocks have themselves been subject to some erosion.

It is not important for our purpose to measure exactly the soil loss between the times the pictures were taken, nor to know how much soil had been lost before 1919. The evidence is sufficient to show that the soil surface has been very unstable. This instability may explain in large measure why the plant population in 1940 is no greater, for it is clearly to be seen from the photograph that the ground cover is still very scant. Yet, by many criteria, the range has "improved," for the plant density and the proportion of palatable species have increased, and so far as the gross features of the vegetation may be used as a guide, progressive succession seems to have taken place.

This is indeed a paradox. It is not a special case: on sloping mountain lands this phenomenon is by no means uncommon, and if adequate records were available it would probably be more generally recognized. On the one hand we have an improvement in vegetation, but on the other hand and at the same time, we have a depletion of soil—two antagonistic processes occurring side by side! It is not to be supposed that this situation can continue indefinitely, for unless the soil loss is checked there will be nothing left but raw parent material, and on such a substratum little vegetation will be able to exist. But for a short time soil and vegetation are clearly out of step, the one going forward, and the other backward.

How, by any process of ecological rationalization, is this paradox to be explained? We must first clarify our concept of biotic succession. Without going into a detailed discussion, it should be pointed out that the normal successional process from bare area to climax, is exceedingly complex. Involved in it are not only a succession of the higher plants and animals, but an intricate succession of microfloras and microfaunas, a succession of chemical and physical characteristics of the soil involving structure, aeration and water relations, and a succession of microclimates near the soil surface.

In speaking of "plant succession" all the less apparent phases of the process are properly implied; but it must not be assumed, because certain superficial changes have been observed, like the rise of grass on our quadrat, that all the other essential changes have taken place also. Considering the absence of organic matter in the topsoil and the absence of litter on the soil surface, as well as the presence of extensive bare spaces between the plants, over which the vegetation is able to exert but little influence, it is obvious that the concomitant changes in progression toward a climax are definitely lacking.

There need be no mystery about the invasion of *Agropyron* directly onto this depleted soil, even though this grass is considered by some to characterize the herbaceous climax. Given a seed source—which presumably a change in grazing practice permitted in the early 1900's—some management and good luck, there is no reason why *Agropyron* shouldn't become established. After all, given management and good luck, it can be successfully seeded artificially. It seems obvious that the potentialities of the soil were sufficient in 1916 and 1919 to have supported *Agroypron* had seen been available and had conditions for establishment been favorable. Similarly, the appearance or increase of the other species—*Stipa, Taraxacum, Vicia*, and *Pseudocymopterus*—need be explained by no occult evolution, but simply by a combination of lessened grazing pressure which permitted seed to be produced and by favorable micro-environmental conditions which permitted seedlings to become established.

THE paradox, then is only apparent. There has been succession in the broad sense that changes have taken place, but in the restricted sense of constructive change, change toward a deeper, richer, more productive soil and more abundant vegetation, the trend has been essentially retrogressive.

The idea has become current, unfortunately, that certain plants are unquestionable indicators of successional status. But in so complex a system no single indicator is infallible, and if he depends upon any one alone, the range manager may be misled by appearances. If the range manager, looking at the 1940 photograph, supposes he is looking at the herbaceous climax reached after centuries of slow soil building, simply because of the predominance of *Agropyron*, he is ignoring the glaring absence of supportive evidence in the raw, eroding soil surface, the lack of litter, and the general sparsity of cover. Any successional stage is not indicated by some certain plant alone or group of plants, but by the entire complex, of which those plants are but a part. It is this complex, involving both soil and vegetation, that must be generally recognized if range management is to become a science.

LET US return to the original question, what is range improvement? Under certain circumstances it may be simply an increased productivity of forage. These circumstances are probably rare. Even in the grazing of meadows not subject to erosion there is likely to be a depletion of mineral salts in time, which must be replaced if productivity is to be maintained. In the example we have used, the grazing capacity is certainly greater in 1940 than 1919, and the range manager who considered the vegetation alone, overlooking the soil, would conclude that great improvement had taken place.

Unfortunately it is very easy to overlook the loss of soil, for when the surface is scarred and some soil is carried away, a host of natural processes operate to erase the signs of loss. The ground surface is astonishingly mobile, especially on slopes, and after a short time the action of freezing and thawing, swelling and shrinking, the penetration, expansion, and death of numberless roots, the burrowings of numberless soil organisms, and the trampling of grazing animals, all operate to smooth out inequalities. The observer has almost no way of telling how much loss has taken place, except crudely under special circumstances, with the help of such phenomena as pedestaled plants or exposed root crowns. Even these indications may last only a short time under continuing erosion.

However difficult the detection of soil change may be, a way must be found to do it, for an appraisal of soil condition should enter any sound estimate of range improvement. Perhaps the soil should be the major criterion—the soil after all, is the capital resource and the vegetation only the interest on that capital. Perhaps an evaluation can be made by integrating the conditions of soil and vegetation, considering a certain advancement of vegetation to be of equal value to a certain loss of soil. Perhaps relative rates of soil loss can be used. In our example it might be argued that the rate of loss in 1940 is less than it was in 1919, since the vegetal cover is better, and that therefore an improvement of the range has actually taken place. To use this argument, however, one must be assured that the decrease is sufficiently rapid so that stability is in sight, which does not seem to be the case in our example. Otherwise, what is to prevent ultimate disaster?

I AM not offering an answer; I am not defining "range improvement"; I am simply raising the question. It would almost seem that, before we know what range improvement is, we must know a great deal more about range ecology. We must comprehend the physiological basis for succession as well as the physiological response of plants in the varied range environment. We must understand the role played by the multitudes of accessory organisms, in the soil and on the surface, which indirectly affect the range through their influence on the soil and on the vegetation. We must understand the details more completely than we do now, of the processes of soil formation and soil loss. We need some means of measuring soil stability, and as stated above, we need a means of synthesizing our knowledge into an estimate of range condition. It is clear, then, that range management is no cut-and-dried affair with all procedures worked out in detail and described in bulletins and text books. Rather, the difficulties of getting the necessary information are sufficiently great so that it may be said with certainty that the solving of the most important problems of range research and range management is still reserved for the future.