United States
Department of
Agriculture

Forest Service

Pacific Northwest
Forest and Range
Experiment Station

Research Paper
PNW-274

June 1980

Green Fescue Grassland: 40 Years of Secondary Succession

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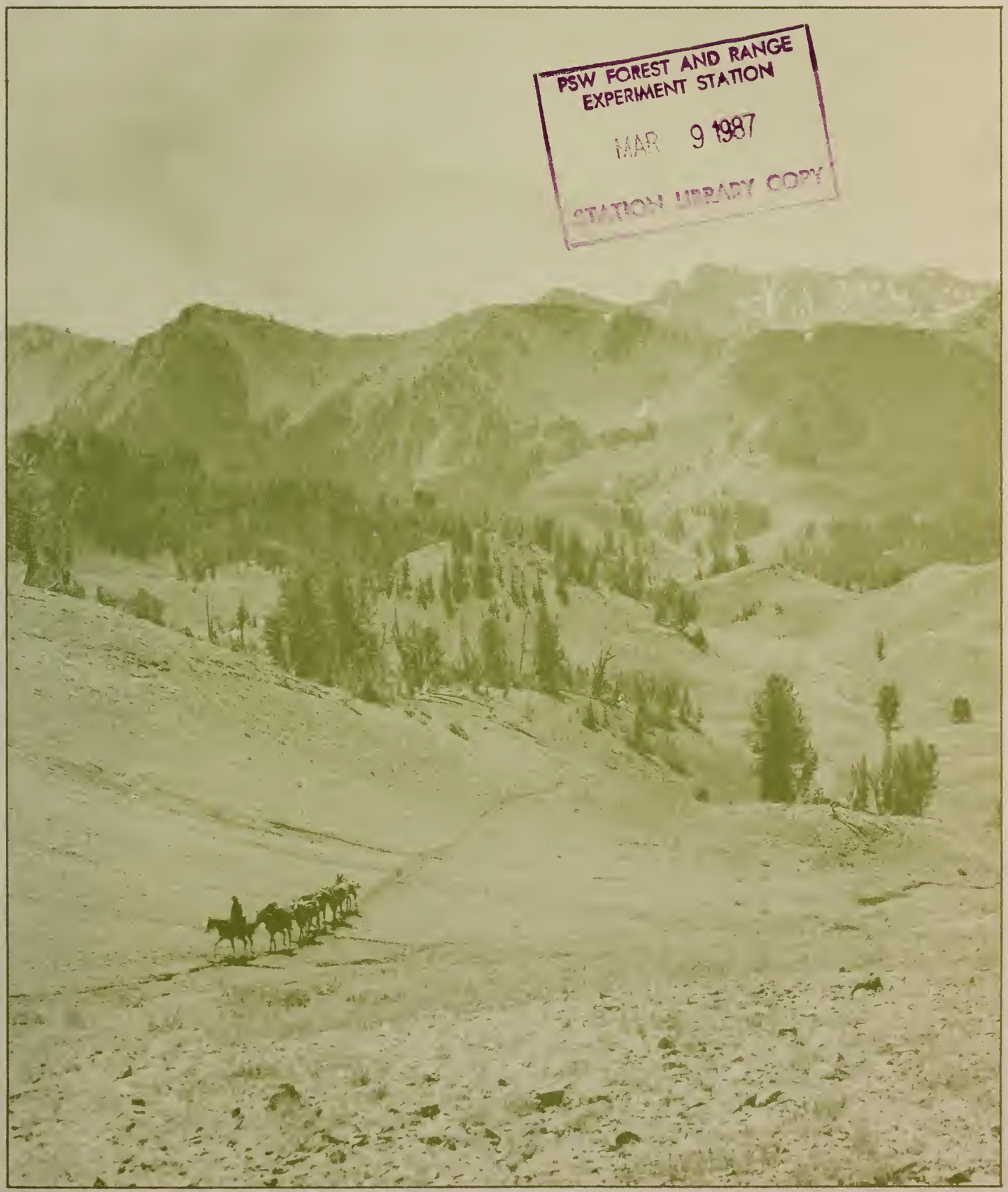

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Metric Equivalents

1 foot = 0.3048 meter
1 inch = 2.54 centimeters
1 acre = 0.4047 hectare
1 square foot = 0.0929 square meter

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Reference Abstract

Reid, Elbert H., Gerald S. Strickler, and Wade B. Hall.
1980. Green fescue grassland: 40 years of secondary succession. USDA For. Serv. Res. Pap. PNW-274, 39 p. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

The 40-year succession of a depleted green fescue (Festuca viridula) subalpine grassland in the Wallowa Mountains, Oregon, was influenced by historic soil erosion. Range conditions of the grassland annually grazed by domestic sheep improved greatly between 1938 and 1978; most of the improvement occurred between the 30th and 40th years. Photographs illustrate the changes.

Keywords: Grassland management, succession, fescue, Festuca, grazing (range), subalpine grasslands.

Research Summary
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1980

A green fescue (Festuca viridula Vas.) subalpine grassland in northeastern Oregon, heavily grazed by sheep for 50 years, was in poor condition when first studied in 1938. Accelerated erosion was evident and much topsoil (6-10 inches) had been lost. Green fescue had been replaced by needlegrass, sedges, and several forbs where erosion had removed all topsoil. On less eroded sites, some topsoil remained in pedestals of sod held in place by masses of dead fescue roots. A few pedestals supported small, weakened fescue plants. Others supported needlegrass, sedges, and deep-rooted forbs, such as Nuttall linanthastrum and fleeceflower. A large percentage of pedestals and the eroded surface between them had no plant growth. Photographs illustrated the conditions.

Improvement of both land- and sheep-management practices after 1938 initiated secondary succession that was measured and photographed again in 1956, 1968, and 1978.

Continued accelerated erosion was not evident in 1956, nor in 1968 and 1978.

After 18 years (1956), green fescue had reestablished where topsoil remained; vegetation density, cover, and production had increased, particularly that of needlegrass, sedges, and Nuttall linanthastrum; and plant vigor had greatly improved. Past erosion had greatly regulated the degree of recovery on individual sites. Needlegrass was conspicuous on eroded surfaces.

At 30 years (1968), density and cover of vegetation had increased, primarily from increases in density of several grasses and sedges on the eroded surfaces. Cover and density of some forbs had declined. Needlegrass was still the dominant grass, although density of green fescue had continued to improve on the deeper soils.

At 40 years (1978), green fescue had become the dominant grass; the density of needlegrass, sedges, and most forbs had decreased on the less eroded soils; and green fescue was as prominent as other species on most eroded surfaces.

It was concluded that the present vegetation on many sites will prevail in the future because of past erosion, but that green fescue density should continue to increase, under good management practices, where sufficient topsoil remains.

Introduction

A green fecue (Festuca viridula Vas.)[1/] subalpine grassland in the Wallowa Mountains of northeast Oregon was studied intensively in 1938 (Pickford and Reid 1942). The area had been heavily grazed by sheep for 50 years and was in poor condition. Photographs recorded the deteriorated vegetation and accelerated soil erosion sampled on the study plots.

This paper summarizes the changes in vegetation and soil erosion that occurred with improved management and illustrates, with photographs, 18, 30, and 40 years of secondary succession on the grassland.

[1/] Plant nomenclature follows Hitchcock and Cronquist (1973).

The Study Area

The 690-acre study area is located on southerly slopes between 7,200 and 8,500 feet in Tenderfoot Basin near the headwaters of the North Fork of the Imnaha River. The vegetation is typical of much of the subalpine fir (Abies lasiocarpa (Hook) Nutt.) zone--large expanses of grassland interspersed by groups of or individual subalpine fir and whitebark pine (Pinus albicaulis Engelm.) (fig. 1).

The underlying rock is primarily limestone and basalt with some shaly and slaty beds (Baldwin 1964, Smith and Allen 1941). Soils are strongly influenced by loess and vary in depth and texture. They are shallow and very stony on ridgetops and around outcrops. On slopes and in drainage basins, soils are 2 to 3 feet or more in depth, silt loam in texture, and generally weakly structured. Without a protective cover of vegetation they are easily eroded by water and wind.

Annual precipitation is between 40 and 50 inches; most occurs as fall rain and winter snow. Snowmelt is usually complete on southerly slopes by July 1. Summer storms account for 10 to 20 percent of the annual precipitation. Growth of vegetation is rapid, peaking near mid-August, and seed dissemination by green fescue occurs about September 1 (Sampson 1914).

Procedures

In 1938, soil erosion classes and estimates of plant species cover and composition, by the square-foot density method (Stewart and Hutchings 1936), were determined from plots gridding the study area at 3½-chain intervals. Photographs were taken to illustrate data obtained on the plots. These methods were repeated between 1956 and 1960, allowing both quantitative and qualitative discussion of 18-year successional trends (Strickler 1961).

The photo sites were photographed again in 1968 and 1978, and changes in plant composition and soil erosion were noted. Resampling the plots in 1968 and 1978 would have provided continuity of the quantitative aspects of the study, but time was not available for this work. Therefore, the 1968 objectives (repeated in 1978) were to: (1) rephotograph the sites reestablished in 1956, 1957, and 1960; (2) estimate, by the square-foot density method, species cover and composition illustrated in the photographs; and (3) make onsite qualitative comparisons of soil and vegetation characteristics with those in the previous photographs and descriptive record. Reid, who did the original 1938 study and assisted in photographing the sites in 1956, and Hall, who also assisted in the 1956 study, did the work. Because of this, the qualitative assessment of the 30- and 40-year changes could be maintained, and a quantitative record of cover and composition of the photographed vegetation was available for the 1968-78 period.

Unfortunately, sheep had grazed the study area 2 days before the 1968 photographs were taken, and only a few sites were ungrazed. In addition, heavy snows on the 1st day of study in both 1968 and 1978 compressed herbage growth to the surface. In 1968, these conditions prevented cover estimates on most sites and allowed only poor comparisons of vegetation and soil characteristics with earlier or later photographs; only three of the 1968 photographs are used. Most sites were snow free, however, when the photographs were taken in 1978, so normal vegetation growth is shown. Where grazing (1968) and snow (1968 and 1978) prevented accurate estimates of cover, relative abundance of species in the photographed area was noted to assess change from similar qualitative descriptions recorded in 1956.

After the 1978 field work, the four photographs and accompanying data from each of 34 photographed sites were examined for changes in vegetation and soil erosion relative to: (1) the 1938 soil erosion class recorded with or observed in the original photograph; (2) the specific habitat, such as swale, slope, or ridge; and (3) the estimated soil depth and moisture characteristics. Discussion of plant successional trends is based on these assessments.

A 5x7 (negative size in inches) camera was used in the 1938 photography, whereas a 4x5 camera was used in subsequent years. Enlarging 4x5 negatives to match the original prints resulted in slight differences in the area covered. Wet soils in the 1968 and 1978 photographs have tones that are similar to the vegetation; and this made it difficult to compare the extent of barren soil with that in earlier photographs. We therefore determined these changes from color positive images taken in 1956, 1968, and 1978. Figures 1-10 (pages 12-37) illustrate the variation in trends.

Work in all years was done in August when the green standing crop had peaked.

Use by Sheep Before 1938

The openness and productivity of green fescue grassland make them prime summer range for domestic sheep (Ovis aries). In the Wallowa Mountains, sheep began grazing the grasslands in the early 1880's, and their numbers quickly increased (Wentworth 1948).

Early use of the study area is not well documented, but some records indicate Tenderfoot Basin was badly overgrazed and deteriorated by 1900. For example, a July 15, 1903, photograph, from the adjacent Aneroid Basin, shows a wide expanse of green fescue grassland with no visible herbage growth. The photographer noted: "Grass almost destroyed by early grazing. Snow hardly gone but sheep have run over hills through mud."[2/]

In 1938, the 2,256 acres of the upper Tenderfoot Basin allotment had an estimated grazing capacity of 0.44 sheep month (SM)/acre (Pickford and Reid 1942). This estimate closely approximated the actual use of the study area in 1938 when sheep removed 44 percent of the green fescue herbage, slightly below the 50 percent considered proper use. This grazing capacity, however, was apparently a great reduction from earlier capacity. In 1916, four 1,200-head bands of sheep were reported to have grazed the allotment, including the study area, for 3 months, a stocking equal to 6.4 SM/acre or 15 times more capacity than the area could support in 1938. The reduction in capacity was also compared in 1938 with that of an adjacent (Lick Creek), uneroded, lightly grazed, near-climax green fescue range. Its estimated capacity was 5.35 SM/acre or 12 times more than the deteriorated range in Tenderfoot Basin (Pickford and Reid 1942).

2/ Photograph files, Range and Wildlife Habitat Laboratory, Pacific Northwest Forest and Range Experiment Station, La Grande, Oregon.

Use by Sheep, 1938 to 1978

Use of the allotment and study area from 1938 to 1945 by sheep was the same as in 1938; 0.44 SM/acre. No sheep grazed the study area between 1945 and 1948. Grazing use was further reduced in 1949, and grazing was usually deferred until late August or early September in the study area. Except for the years 1953 and 1972 when there was no use, the upper Tenderfoot Basin averaged 0.17 SM/acre from 1949 through 1978. These records indicate use of the study area by sheep for the last 30 years was 60 percent less than the 1938 estimated capacity and only 3 percent of the capacity of a climax vegetation.

Soil and Vegetation in 1938

Measurements in 1938 showed that large amounts of topsoil had been lost through erosion and that the remaining vegetation was in poor condition (Pickford and Reid 1942). The degree of soil erosion varied by site, depending on soil depth, slope, amount of trailing by the sheep, proximity to the bedgrounds, or its use as a permanent bedground. The site, kind of grazing, and degree of erosion influenced the type of vegetation present.

One site was considered to be in near-climax condition (fig. 2). Green fescue accounted for 80-90 percent of the vegetation, and erosion was minimal. The fescue root mass was concentrated in a dense sod, 6 to 10 inches in depth.

Severe erosion had cut the fescue sod in other sites, and there remained only remnant soil pedestals or miniature mesalike hummocks. Much of the fescue was dead, but the sod remnants were held firmly in place by the persistent dead root masses (fig. 3). Open stands of Letterman needlegrass (Stipa lettermanii Vas.), a minor secondary species in climax vegetation, were conspicuous under these erosion conditions (fig. 4).

Where annual sheep trailing was intensive on the slopes, the sod had been cut, giving a stairstep appearance. Although a few pedestals supported low-vigor fescue, most had been invaded by needlegrass, sedges (Carex spp.), and perennial forbs, such as Nuttall linanthastrum (Linanthastrum nuttallii (Gray) Ewan.), cinquefoils (Potentilla spp.), lambstongue groundsel (Senecio integerrimus Nutt.), western yarrow (Achillea millefolium var. lanulosa Piper), and Rydberg penstemon (Penstemon rydbergi A. Nels.). Perennial forbs dominated in some areas (figs. 5 and 6) and needlegrass in others (fig. 7).

Erosion had progressed farther near bedgrounds and on intensively trailed areas; only a few sod pedestals remained on an extensively eroded surface that was covered with an erosion pavement of small stones and gravel. Pedestals were occupied by forbs or needlegrass (fig. 8), but where grazing was not heavy, fescue usually capped them. The eroded surfaces were either barren or occupied by needlegrass.

Perennial forbs commonly occupied areas where all topsoil sod had been eroded away. Where the remaining soil was deep or moist, the sites were usually occupied by penstemon, groundsel, fleabane (Erigeron spp.), and Nuttall linanthastrum in combination with needlegrass and sedges, principally ovalhead sedge (Carex festivella Mack.) (fig. 9). Eriogonum (either or both Wyeth eriogonum (Eriogonum herocleoides Nutt.) and Piper eriogonum (Eriogonum flavum Nutt.)) was the dominant forb on drier sites, especially those with shallow soils (fig. 10).

Results

The First 18 Years: 1938-56

Even with continued sheep use, no further major loss of soil was observed in 1956. Most soil pedestals present in 1938 were still intact (fig. 3) and generally supported a vigorous growth of perennial plants. Soil sloughing from the pedestals had remained on the eroded surface and was stabilized by encroaching plants. The old erosion channels, the extensive pavements on old bedgrounds, and stock trails were also healing with the invasion of plants. Density, cover, and production had increased, particularly that of needlegrass, green fescue, linanthastrum, and sedges.

Loss of topsoil and the encroachment and increase of secondary species prior to 1938 had the greatest effect in preventing a substantial improvement in vegetation by 1956. These factors appeared to regulate the rate of plant establishment and increases in density, cover, and production of plants, especially green fescue, although vigor of fescue had greatly improved on all sites. It was concluded that plant density was approaching its potential on the eroded sites and that many secondary and associated species would maintain their prominence in future years (Strickler 1961).

Eighteen to Thirty Years: 1956-68

The major change in the vegetation during this 12-year period was an increase in density and cover of grasses, particularly needlegrass and green fescue, and some decrease in perennial forb cover.

The aspect was of a grass-forb mixture or of a grass sward in areas where topsoil remained in pedestals. Grasses and sedges had thickened on the erosion pavements where they had occurred as sparse stands in 1956, or they had continued to spread, reducing the extent of bare areas. The principal species thickening or spreading were needlegrass, ovalhead sedge, and green fescue. In some areas, California brome (Bromus carinatus H. & A.), bottlebrush squirreltail (Sitanion hystrix (Nutt.) J. G. Sm.), and oniongrass (Melica bulbosa Geyer ex Porter & Coult.) were the main species. Cutting wheatgrass (Agropyron caninum (L.) Beauv.) occurred as occasional plants.

As in 1956, further accelerated erosion of the soil was not evident. A few soil pedestals, recognizable from the earlier photographs, had fallen over. Some had rolled downslope.

Thirty to Forty Years: 1968-78

Between the 30th and 40th year, there was a general reduction in density of needlegrass, sedge, and perennial forbs, a large increase in density of green fescue, and a continued increase in total plant cover.

By 1978, needlegrass had become a secondary constituent of the vegetation in some areas where it previously had dominated, and had become very sparse or was no longer found on other sites. Green fescue had become the dominant grass. The grasses and sedges had continued to invade on bare areas, and green fescue was as much of an invader as were needlegrass and sedge.

Perennial forbs were still prominent in the vegetation. Forb composition was generally the same as in 1938, but density and cover were less. The continued longevity of forbs, noted in 1956, was unexpected. Plants of fleeceflower (Polygonum phytolaccaefolium Meism. ex Small), Nuttall linanthastrum, Rydberg penstemon, and the eriogonums seen in some 1938 photographs were still present in 1978. The fleeceflower continued to increase in some areas in spite of the fact that the plant is quite palatable to sheep. The other long-lived forbs are less palatable, yet they decreased in density.

Again, accelerated erosion of the soil was not apparent. Many soil pedestals observed in 1968 (the same ones as in 1938) were still in evidence in 1978 and were of similar shape and size. Most were more rounded, however, and, being well vegetated, not as conspicuous as in 1968. The slopes still had a stairstep appearance, but the steps were less abrupt and litter covered much of the intervening spaces.

Where green fescue formed dense stands on uneroded soil in 1938, the same situation existed 40 years later. Thus, Clements' (1916) and Pickford and Reid's (1942) concepts are verified; namely, that a subalpine grassland climax is one in which the climax grass species occurs in an almost pure stand. Any severe use by sheep would reduce palatable climax species and allow secondary species to increase, as was observed in 1944 on one site (fig. 2). Essentially uneroded, this site required at least 20 years to recover and to approximate the original climax composition.

Where less residual topsoil remained and green fescue was badly depleted or eliminated, secondary succession was slower and generally proceeded from a perennial forb and/or needlegrass community to one dominated by needlegrass and sedge, then to replacement of the needlegrass, sedge, and some forbs by green fescue. The rate and extent of succession on eroded sites, however, varied with depth of remaining topsoil, soil moisture relations, and species present in 1938.

The eriogonums, particularly Wyeth eriogonum, were the dominant species on the thin soils and erosion pavement of eroded sites in 1938. Grasses were sparse, but needlegrass was the most abundant. By 1956, eriogonum had increased in density, and some penstemon had become established. Needlegrass was still dominant but had not increased greatly. In 1978, after 40 years, eriogonum was still the dominant species, but the needlegrass had been mainly replaced by green fescue.

Moist, yet well-drained sites with shallow topsoil residues were generally occupied by fleabanes, eriogonums, groundsel, sedges, and needlegrass in 1938. Forbs predominated, sedges were secondary, and needlegrass was relatively minor. All forbs had decreased somewhat after 18 years but were still prominent. Needlegrass and sedges had increased greatly, up to half the vegetation cover. There was a general thickening of needlegrass and sedge within 30 years, but there appeared to be no general change in forbs. Some green fescue, about 5 percent of the cover, was apparent. Green fescue was the predominant species at 40 years. Sedge and some forbs, primarily fleabane and eriogonum, remained, but needlegrass had essentially disappeared.

Several successional patterns occurred on well-drained sites where good topsoil remained. On sites where the original green fescue had died out but the root masses were still largely intact, dense stands of forbs, needlegrass, and sedge were well established in 1938. Nuttall linanthastrum and fleeceflower were prominent. Green fescue was prominent after 18 years. By 1968, after 30 years, little change was observed. After 40 years, however, green fescue had greatly increased in density and was the dominant plant. It had largely replaced needlegrass and sedge. Fescue accounted for about half the plant cover, Nuttall linanthastrum about 25 percent, and penstemon 10 percent.

On similar sites where, in 1938, small tufts of green fescue remained and were growing among plants of needlegrass and sedges on topsoil pedestals, the fescue had gained vigor by 1956 but had not increased materially in density. Needlegrass and sedge had thickened and become the dominant species, making a rather dense sward. Much the same situation existed 30 years later. At 40 years, these areas supported a dense stand of green fescue with only minor amounts of needlegrass and sedges. Forbs had not been involved in this succession.

Less well-drained sites, with good amounts of topsoil, were mainly occupied by forbs in 1938, although some green fescue, needlegrass, sedge, and other grasses were found. Major forb species--penstemon, cinquefoil, fleeceflower, stickseed, and eriogonums--varied from site to site. By 1956, needlegrass and sedge had greatly increased, but forbs were still dominant. Much the same situation existed after 30 years, although needlegrass and sedge had again greatly increased. Green fescue had become the dominant species at 40 years, yet forbs were still prominent. The two most notable changes between the 30th and 40th year were the marked increase in total cover and the replacement of needlegrass and sedge by green fescue.

The observations of ecological changes over the 40-year period demonstrate the benefits of long-term studies to understand plant succession and the effects of good management practices on deteriorated ranges. We cannot readily explain, however, why the major changes in plant composition, particularly the marked increase in green fescue, occurred between the 30th and 40th years. One would have expected this to occur earlier than the 30th year where green fescue had recovered to a co-dominant or dominant position in the vegetation, but not where the fescue was still sparse and competing with dense cover of secondary species for the limited space, nutrients, and moisture of an eroded soil.

Good seed production was observed in all remeasurement years on all sites, indicating that annual seed production was not the limiting factor. Assuming similar seed production for the intervening years, we suggest that certain physical and physiological requirements for survival and establishment of fescue seedlings, or expansion (tillering) of existing fescue plants, were not met in the early years because of the altered microenvironment of the eroded soil (Ellison 1949, 1960).

The changes that occurred between the 30th and 40th years may be closely associated with accumulation of organic matter and the amelioration of the surface environment. These changes would have a significant effect on available water, nutrients, and other factors affecting plant growth (Cundell 1977, Mooney et al. 1965). Recent work on associations of Festuca species, from climax and advanced successional communities, with mycorrhizal fungi (Molina et al. 1978) and small mammal populations (Maser and Strickler 1978), and on the role of mycorrhizal fungi on eroded or otherwise disturbed ecosystems (Hall and Armstrong 1979, Miller 1979, Reeves et al. 1979) suggests that mycorrhiza infection levels may have been a limiting factor for improving growth of green fescue and survival of seedlings until the 30th year of succession.

Nevertheless, we think that the reduction in sheep months of grazing and the deferment practiced in the 40-year period were the major factors in the improvement. In his 40-year successional study of grazed subalpine herblands of the Wasatch Plateau, Utah, Ellison (1954) showed that the upward trend, beginning in 1913 with the initial great reduction in sheep numbers, had virtually ceased after 20 or 30 years and indicated that management practices were still not adequate for continuing improvement.

Figure 1

1938--sheep bunched on one of the main bedgrounds. Such concentration of sheep hastened depletion of vegetation and erosion of soil through heavy forage utilization and intensive trampling. The vegetation was in poor condition, and there were many barren areas. Letterman needlegrass was the dominant plant on the slope in the foreground.

Figure 1

1978--40 years later, after the study area had been under reduced and deferred grazing, the condition of the range had greatly improved. Many bare areas had filled in with grass (fescue and needlegrass) and sedge. Green fescue was the dominant plant on the slope in the foreground. The white in the foreground is snow.

1938

1978

1938

1944

1956

Figure 2

1938--A subalpine grassland community in good condition. Vigorous green fescue was the dominant species; only occasional plants of other grasses and forbs were present.

Figure 2

1944--condition of the community had deteriorated because of heavy use as a sheep bedground for two consecutive seasons. Density and cover of green fescue had decreased and that of needlegrass, yarrow, and fleabane had increased since 1938. Accelerated soil erosion, however, had not occurred.

Figure 2

1956--green fescue was 58 percent, fleabane 22 percent, needlegrass and yarrow 6 percent each, and sedge 3 percent of the plant composition. Plant cover was much improved over that of 1944.

Figure 2 (continued)

1968--vegetation cover and composition appeared much as it did in 1938, having recovered from the deteriorated condition in 1944.

Figure 2

1978--green fescue was 90 percent of the vegetation cover. Secondary species were western yarrow, ovalhead sedge, penstemon, and western needlegrass. Vegetation was again in good condition and approximated the climax community.

1968

1978

Figure 3

1938--an eroded slope near permanent water where much of the original topsoil was lost. Dead roots of green fescue held 80 percent of the foreground pedestals in place; live fescue and needlegrass occupied the remaining pedestals. Needlegrass was the dominant plant on the eroded surface between pedestals. Sedges occurred along the stream.

Figure 3

1956--cover had increased greatly; most was needlegrass that had increased on the eroded surface, with some thickening of plants on the pedestals. Density and cover of green fescue had also increased. Note that most of the soil pedestals were still in place.

Figure 3

1978--vegetation cover on the slope continued to increase, both on and between the pedestals. A majority of the cover was green fescue, needlegrass, and sedges, with minor amounts of other grasses and forbs. Soil pedestals were still present, but the slope had lost some of its stairstep appearance. Green fescue had mainly replaced the needlegrass as the dominant species; most of this replacement took place between 1968 and 1978. Sedges and penstemon were the main species along the stream.

1956

1978

Figure 4

1938--a closeup of the condition on the slope shown in figure 3: The masses of dead green fescue roots hold the topsoil in place; remnant fescue plants of low vigor are widely scattered.

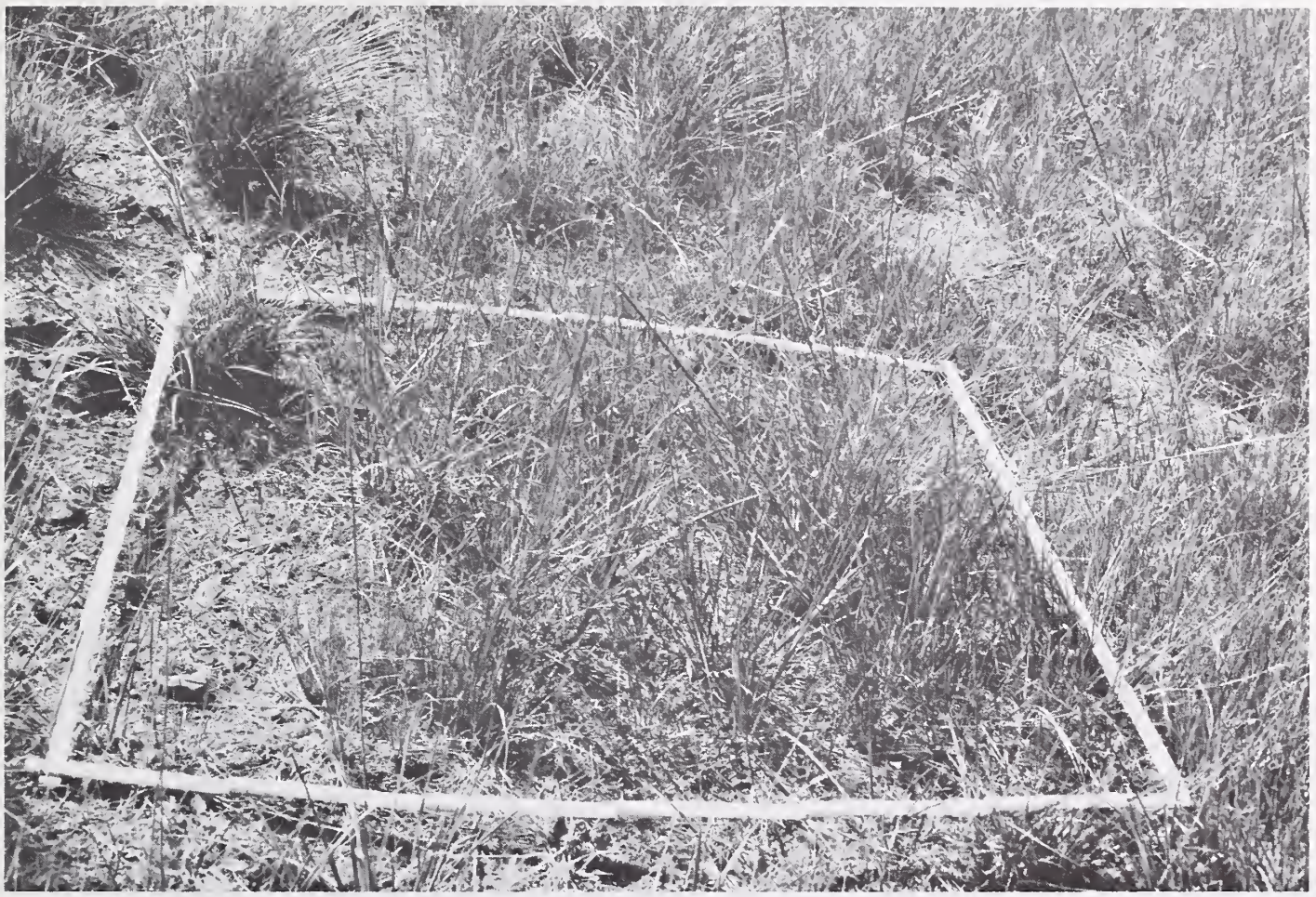
Figure 4

1956--18 years later, there had been a major increase in needlegrass; it was the dominant species. Green fescue plants had increased greatly in vigor but not much in density. Litter had increased, and the soil pedestals, though still present, were not as prominent as in 1938.

Figure 4

1978--green fescue, accounting for 80 percent of the cover composition, was the dominant plant within 40 years. Needlegrass and sedge (mainly ovalhead sedge) accounted for most of the remaining cover. The area was well sodded. Soil, sloughing from the pedestals, had remained in the interspaces, resulting in a smoother surface.

1938



1956

1978

Figure 5

1938--a slope where grass sod was severely cut by sheep trailing; 90 percent of the green fescue root masses, contained within 7-inch topsoil pedestals, were dead, but the pedestals were becoming occupied by secondary species, primarily by Nuttall linanthastrum, sedges, and needlegrass. Groundsmoke (Gayophytum sp.) and fleeceflower were becoming established between the pedestals.

Figure 5

1956--green fescue cover had increased from 0.5 percent to 13 percent. Nuttall linanthastrum cover had almost doubled (7 to 12 percent), but that of needlegrass and sedge showed only a slight increase. The pedestaled root masses had become somewhat rounded, but the eroded surface configuration remained about the same.

Figure 5

1978--density of green fescue had increased greatly and constituted half the vegetation cover. Linanthastrum made up about 25 percent of the cover and Rydberg penstemon 10 percent. Western yarrow and eriogonum had also increased, but needlegrass and sedge had greatly decreased. Note that the fleeceflower plant in the 1938 photograph was still present 18 and 40 years later.

1938

1956

1978

Figure 6

1938--a moist slope, with topsoil held in place by dead fescue root masses, was occupied by Rydberg penstemon, gland cinquefoil (Potentilla glandulosa Lindl.), Wyeth eriogonum, and stickseed (Hackelia sp.). A few plants of needlegrass and fleeceflower were present on the eroded soil between pedestals.

Figure 6

1956--the perennial forbs were still predominant, but green fescue and needlegrass had greatly increased and sedge was encroaching on the pedestals. Penstemon made up 33 percent of the cover, needlegrass 15 percent, and green fescue 38 percent. Barren soils between pedestals were still conspicuous.

Figure 6

1978--by 1968 (no photograph), grasses had increased and most perennial forbs had decreased, although many individual forb plants identified in 1938 were still present. Density of fleeceflower had greatly increased. In 1978 green fescue had largely replaced needlegrass as the dominant plant, fleeceflower had become the most abundant forb, gland cinquefoil was common, and the other forbs were still present. Pedestals, rounded off, could still be identified, and the plants growing on them had moved or were moving onto the spaces between pedestals.

1938

1956

1978

Figure 7

1938--years of trailing on this site had resulted in the loss of most topsoil by erosion and the elimination of green fescue. A few remnant soil pedestals (on the right and upper left) indicated the severity of the erosion. Needlegrass and a single plant of fleeceflower had become established on the pavement, and a few plants of Nuttall linanthastrum were established on pedestals.

Figure 7

1956--green fescue, spiked trisetum (Trisetum spicatum (L.) Richt.), sedge, and additional plants of fleeceflower had become established. Needlegrass was still the principal species.

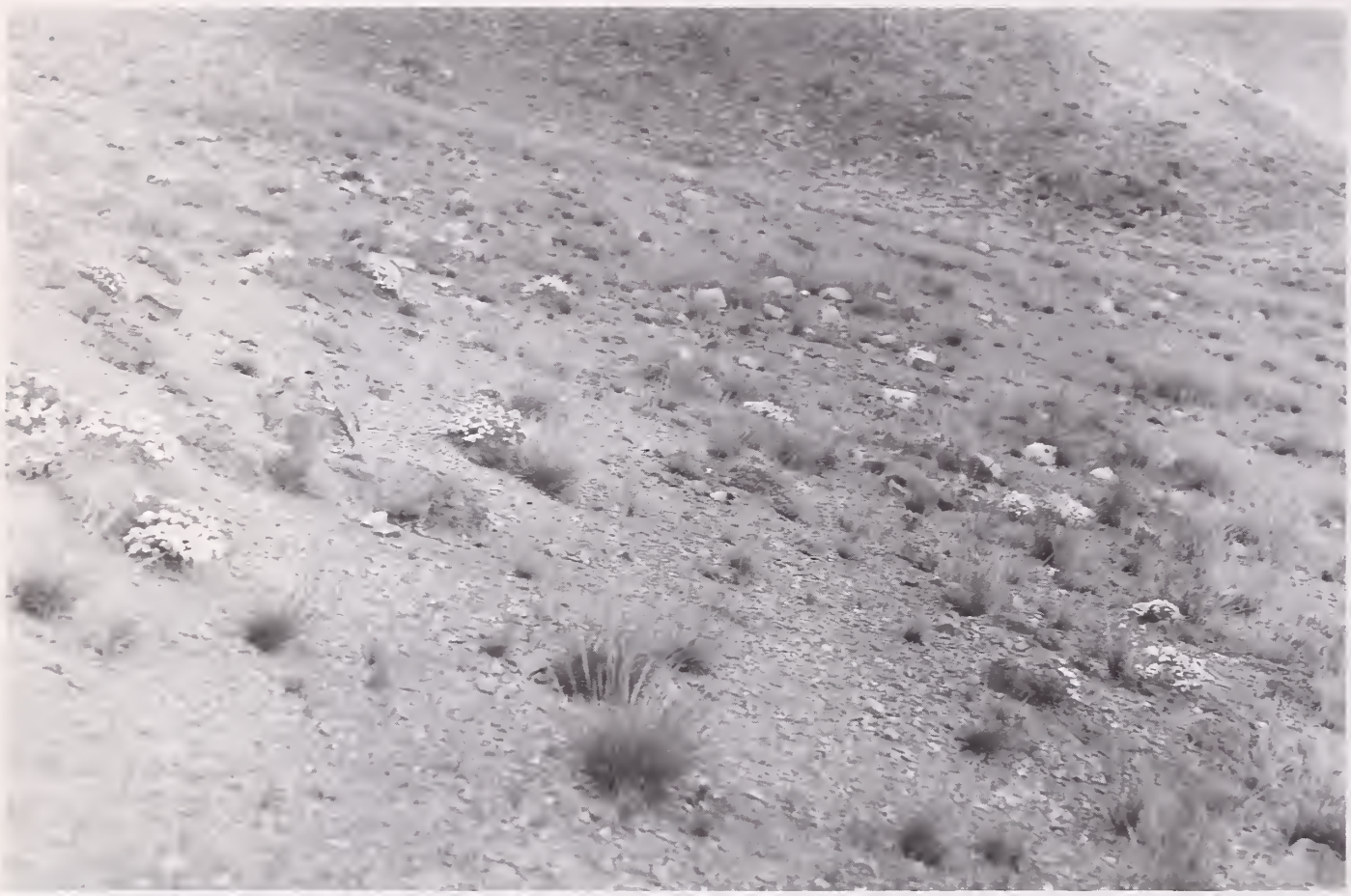
Figure 7

1978--green fescue, sedge, needlegrass, and linanthastrum, in order of abundance, were the predominant species. Other perennial forbs that were becoming established in 1968 included western yarrow, pussytoes (Antennaria sp.), Rydberg penstemon, eriogonums, and fleabane. The fleeceflower, present in 1938, was still present, along with several new plants of the species. The remnant pedestals were still intact.

1938

1956

1978



1938

1960

Figure 8

1938--a site used as a bedground where most of the topsoil had been lost to erosion. Needlegrass and Nuttall linanthastrum were the only conspicuous species. The linanthastrum was primarily restricted to growth on the remnant pedestals, whereas the needlegrass plants were restricted mainly to growth on the extensive erosion pavement.

Figure 8

1960--density of needlegrass had greatly increased on the erosion pavement. Green fescue, in good vigor, had established on the intact pedestals, although linanthastrum, hidden by the grass herbage, was still present on the pedestals.

Figure 8 (continued)

1968--the area had just been grazed by sheep, so herbage growth could not be compared with that in earlier photographs. Small plants of both needlegrass and green fescue were present in the area; most of the larger grazed plants were green fescue. There was an apparent loss, however, of the needlegrass plants that showed in the foreground of the 1960 photograph.

Figure 8

1978--the vegetation cover was similar to that in 1938, but green fescue had almost entirely replaced the needlegrass. Linanthastrum was still evident, and there were a few plants of sedge, Wyeth eriogonum, and Rydberg penstemon. Erosion pavement was again a prominent feature of this site. Some pedestals present in 1938 were still intact.

1968

1978

Figure 9

1938--a swale site where most of the topsoil had eroded away, but remaining soil depth and moisture were favorable for establishment of moderate to dense patches of Rydberg penstemon (center), Nuttall linanthastrum (upper center and right slope), and needlegrass. Sedges, eriogonums, and sandwort (Arenaria capillaris Foir.) were less prominent. Note the barren slope in the background.

Figure 9

1956--after 18 years under reduced grazing, green fescue had reestablished on the site. Needlegrass, spiked trisetum, and sedge dominated the species composition. Penstemon, eriogonum, and linanthastrum had decreased, but total cover had increased. The barren slope in the background had greatly filled in with ovalhead sedge, needlegrass, spiked trisetum, and bottlebrush squirreltail.

Figure 9

1978--after 40 years, green fescue dominated a dense stand of vegetation in the foreground and middle section. Penstemon and linanthastrum were still the main forbs, although they were not as abundant as in 1956 and 1968. Needlegrass and bottlebrush squirreltail were the main species on the slope in the background. In the foreground, about 30 percent of the area between plants was covered with litter. About 10 percent of the more eroded slope in the background was covered with litter.

1938

1956

1978

1938

1956

Figure 10

1938--a bench site where a shallow topsoil was lost through erosion followed by light soil deposition (on the right). Piper eriogonum, alpine phacelia (Phacelia alpina Rydb.), ballhead gilia (Gilia congesta Hook.), and umbellate pussypaws (Spraguea umbellata Torr.) are prominent on the eroded site, and needlegrass, sedges, and fleabanes on the deposited soil. The large grass plants in the foreground are bottlebrush squirreltail.

Figure 10

1956--there was little change in plant composition or cover. Piper and Wyeth eriogonum were the dominant species; ballhead gilia and umbellate pussypaws were still conspicuous. Cover of sedges, fleabanes, and bottlebrush squirreltail had decreased. Needlegrass seedlings and Rydberg penstemon were established on the eroded soil.

Figure 10 (continued)

1968--the site, grazed 2 days before the photograph was taken, had changed little in cover since 1956; however, some shifts in composition had occurred. Eriogonums (mainly Wyeth eriogonum) were still dominant and needlegrass was the main grass species, but Rydberg penstemon and fleabanes were not observed and some plants of Nuttall linanthastrum, western yarrow, and sandwort, not recorded previously, were present.

Figure 10

1978--Wyeth eriogonum was the dominant species, accounting for 50 percent of the vegetation cover. Grasses had greatly increased and included California brome, oniongrass, cutting wheatgrass, needlegrass, and green fescue, the latter accounting for 3 percent of the cover. The fescue was not recorded in earlier years.

1968

1978

Conclusions

The vegetation of Tenderfoot Basin has improved greatly since 1938. Obvious signs of improvement were the abundance of established fescue plants (and plants of other species palatable to sheep) on the better sites and the accumulation of litter. With good management practices, the Tenderfoot Basin range should continue to improve for several decades, particularly on less eroded sites that apparently are not yet supporting their green fescue potential. In the future, many sites may maintain only sparse stands of green fescue because of past soil erosion. Yet the density of secondary grasses and forbs appears to be sufficient to provide the cover necessary to prevent accelerated erosion.

Acknowledgments

We are grateful to Chris Maser (Bureau of Land Management, Range and Wildlife Habitat Laboratory, La Grande, Oregon) for the consultations, his critical review, and suggestions which greatly improved the manuscript.

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The 40-year succession of a depleted green fescue (Festuca viridula) subalpine grassland in the Wallowa Mountains, Oregon, was influenced by historic soil erosion. Range conditions of the grassland annually grazed by domestic sheep improved greatly between 1938 and 1978; most of the improvement occurred between the 30th and 40th years. Photographs illustrate the changes.

Keywords: Grassland management, succession, fescue, Festuca, grazing (range), subalpine grasslands.

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GPO 990-974