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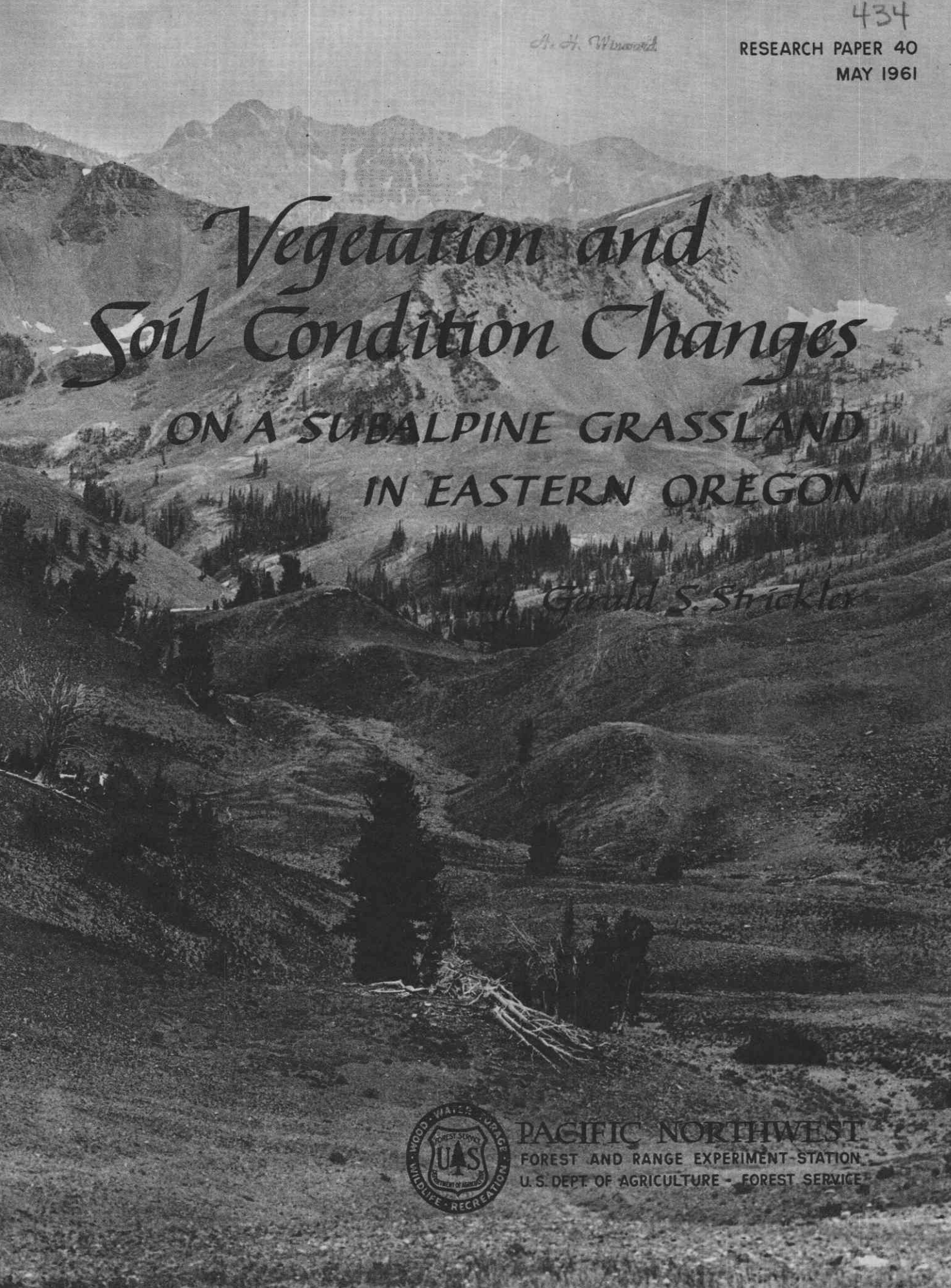

Vegetation and Soil Condition Changes ON A SUBALPINE GRASSLAND IN EASTERN OREGON

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PREFACE

Subalpine lands in eastern Oregon are a resource vitally important to local economy. In good condition, their well-watered, extensive grasslands provide an abundance of nutritious forage for many livestock, deer, and elk at a time when lower ranges are dry and forage is not succulent. As snow catchment areas and headwaters of major streams, they are key areas in maintaining a sustained flow of water to lower lying cities, irrigated valleys, and hydroelectric facilities. Their recreational and esthetic values are significant also; the high-altitude grasslands and streams are enjoyed by hikers, campers, fishermen, hunters, and trail riders.

However, the resource values of all these subalpine lands seriously declined in the early 1900's through mismanagement of the grasslands and the livestock grazing them. Once in poor condition, these lands became difficult to manage because degeneration of the vegetation and the soil usually had to be arrested without completely removing livestock and without reseeding.

Improvement of both land- and livestock-management techniques on some of these degenerated areas has resulted in greatly increased watershed and grazing values. This paper is an account of changes in vegetation and soil characteristics over a span of 18 years on such an area in the Wallowa Mountains of northeastern Oregon. The account is based on comparison of records and photographs made in 1938 and those made in 1956-57. Credit is due Elbert H. Reid of the Rocky Mountain Forest and Range Experiment Station for his assistance in relocating many of the 1938 camera points. Assistance of the range staff of the Wallowa-Whitman National Forests and George A. Garrison and Robert W. Harris of the Pacific Northwest Forest and Range Experiment Station in the 1956-57 resurveys is also gratefully acknowledged.

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INTRODUCTION

In the late 1930's, a subalpine grassland in the green fescue[1/] type in the Wallowa Mountains of northeastern Oregon was known to be in very poor condition. This grassland, located in the headwaters of the Imnaha River and locally known as Tenderfoot Basin, had been subjected to mismanaged sheep grazing for many years. Both quality and quantity of forage had dwindled until grazing capacity of the basin was only 8 percent of its estimated potential. The area of ground surface covered by vegetation was reduced 75 percent. Accelerated erosion was evident, with soil losses averaging 521 tons per acre.

These findings were partial results of a study by the Pacific Northwest Forest and Range Experiment Station on a 690-acre area of the basin in 1938. From the study, "...guides in judging the condition of soil and vegetation, thereby to bring about proper management and use..." were published for recognizing condition of subalpine ranges.[2/] As a result, better range and livestock management techniques were applied on subalpine ranges in northeastern Oregon, including those in Tenderfoot Basin.

The availability of plot records, maps, and descriptive photographs from the original study, plus records of sheep use since 1938, provided an opportunity to determine the effects of improved management on the condition of vegetation and soil in the basin. A comparison with data and photographs taken almost two decades after the original study shows that vegetation cover has increased 30 percent and herbage production about 174 percent. Also, erosion and loss of the topsoil--prominent in 1938--has been arrested. However, recovery of the vegetation cover may have reached almost the maximum possible on the damaged site, and further recovery will be much slower.

[1/] Common and scientific names of plants mentioned are listed on the inside back cover.

[2/] Pickford, G. D., and Reid, Elbert H. Basis for judging subalpine grassland ranges of Oregon and Washington. U. S. Dept. Agr. Cir. 655, 38 pp., illus. 1942.

GRAZING HISTORY

Heavy and prolonged use of the choice green fescue in Tenderfoot Basin possibly began at the turn of the century when sheep numbers in Oregon reached their peak.[3] Especially noteworthy is Griffiths'[4] observation (pp. 20-21) in 1903 that "...immense flocks of sheep..." were driven into the mountains of eastern Oregon "...from all directions... ." He also noted that in areas not under a homesteader's protection, heavy grazing resulted in "...no more feed in some localities than on the deserts below... ."

Pickford and Reid[5] reported that four bands of sheep grazed the Tenderfoot Allotment for 3 months each year before 1916, an annual use of 14,400 sheep-months. Grazing records show that this abuse continued during World War I, when complete utilization of the herbage was encouraged to reduce what was thought to be a fire hazard. By 1930, only one band was using the allotment for 2 months, resulting in 2,700 sheep-months' use annually. In 1938, 1940, and 1941, the annual use was 1,200, 1,185, and 1,116 sheep-months, respectively.

Allotment boundaries were changed and new grazing units were set up after the 1941 grazing season. Calculated use for the original Tenderfoot Allotment was 957 and 827 sheep-months for 1942 and 1943, respectively. The area was not grazed from 1945 through 1948. Further boundary and unit size changes were made in 1951, and the calculated use on the original Tenderfoot Allotment to 1956 ranged from 850 to 600 sheep-months, except for 1,237 sheep-months in 1951.

Thus the degenerating range conditions in the basin, which had caused reduction of sheep numbers before 1938, led to further reductions in the years following the 1938 survey. Resource management was also improved after 1938 through enlargement of the allotment and establishment of grazing units on which deferment of grazing was intermittently practiced. In some years, grazing on the study area was deferred until September 1. Also, the 3-month grazing period was reduced to 2 months, with the opening date of grazing determined by the readiness of the vegetation.

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[3] Oregon State College Federal Cooperative Extension Service. Sheep, lambs, and wool: Oregon. Ext. Cir. 440, 2 pp. 1944.

[4] Griffiths, David. Forage conditions and problems in eastern Washington, eastern Oregon, northeastern California, and northwestern Nevada. U.S. Dept. Agr. Bur. Plant Indus. Bul. 38, 52 pp., illus. 1903.

[5] Op. cit., p. 21.

Management of the sheep also changed. The use of specific areas for bedgrounds, both daily and annually, and the practice of keeping the animals concentrated during herding and trailing on the range were discouraged after 1938. Instead, one-night bedgrounds, restricted use of dogs, and open herding of sheep have been the rule.

Forage use on the study area since 1938 is of special interest. The average utilization of green fescue in 1938, resulting from 354 sheep-months' use, was 44.8 percent. Because the number of sheep-months' use on the allotment between 1938 and 1957 (except 1951) was less in the years grazing did occur than in 1938, the average annual herbage utilization on the allotment and on the study area during this period was probably not heavier than that considered proper: 50 percent of the herbage weight of green fescue. Further emphasis on the conservative use of green fescue comes from records of the sheep-months' use of the Tenderfoot and Northfork grazing units, in which the study area is located. From 1950 to 1957--except for 1951--the records from these units show an annual use of not more than 300 sheep-months on the study area. Therefore, utilization of green fescue during this period was probably much lower than the 44.8 percent recorded in 1938 with 354 sheep-months' use. The 1,237 sheep-months' use on the original Tenderfoot Allotment in 1951 most likely resulted in heavy use of the forage on the study area during that year.

STUDY PROCEDURE

In 1938, vegetation density (cover), composition, and production on the 690-acre study area were estimated on 100-square-foot plots by the square-foot density method.[6/] Plots were systematically located within the study area at 3.5-chain intervals. Each plot was classified in one of five soil erosion classes:

A. 76-100 percent of soil surface undisturbed
B. 51-75 percent of soil surface undisturbed
C. 26-50 percent of soil surface undisturbed
D. 1-25 percent of soil surface undisturbed
E. Less than 1 percent of soil surface undisturbed

6/ Stewart, George, and Hutchings, S. S. The point-observation-plot (square-foot density) method of vegetation survey. Jour. Amer. Soc. Agron. 28: 714-722, illus. 1936.

The undisturbed part of the soil surface was identified by remnant soil pedestals. The height of pedestals above the erosion pavement averaged about 6.5 inches for each of the erosion classes. Thus, the difference in percentage of soil surface undisturbed between soil classes was essentially a difference in numbers of pedestals and area covered by pedestals. The soil in the 6.5-inch average height of pedestals was referred to as "topsoil." This usage will be continued in this paper.

Since no plots fell on the "A" soil erosion class in 1938, changes and trends in soil and vegetation characteristics on relatively uneroded sites could not be measured during the resurvey. However, vegetation characteristics from an eroded site found in the basin in 1960 (table 1) provide a comparison with vegetation recovery on the more eroded soils. Apparently, vegetation of the green fescue type, before degeneration, was almost a pure stand of the fescue. On this uneroded site, the soil between the large grass bunches was penetrated by the grass roots. Work in 1956 was primarily concerned with repeating most of the 1938 photographs. This was done to document change in the rate and degree of soil erosion and in the floristic aspect of vegetation. Some areas, photographed in 1938, were not located and rephotographed until 1960. The 1956 and 1960 photographs were taken during the same time of year (August) and approximately at the same phenological stage of vegetation as in 1938.

Also in 1956, weight of green herbage, clipped from 9.6-square-foot circular plots, and percentage of litter cover, measured by the loop-transect method, were obtained from nearby 1938 plots for comparison.

In 1957, 62 of the original plots were selected for remeasurement of vegetation density and composition by the square-foot density method used in 1938. The selection was made so that within each of five principal vegetation units mapped in 1938, approximately 25 percent of the plots in each soil erosion class (except the "A" class) would be sampled. For the purpose of this report, data are combined by soil erosion class.

COMPARING THE RECORDS

Soil Erosion Retarded

Measurements on the plots in 1938 indicated that 73 percent of the land surface on the study area was eroded. Erosion had removed all topsoil on 20 percent of the land surface (E soil-erosion-class plots), leaving a conspicuous, gravelly erosion pavement. Past accelerated erosion was indicated by vertical-sided gullies formed in the heads of drainages, on slopes, and even in the tough sod of a sedge meadow. Past erosion and soil loss was still more noticeable in the widespread hummocked appearance of the ground surface. These hummocks, or pedestals of topsoil, reached heights as great as 20 inches above surrounding pavements.

Table 1.--Vegetation characteristics of uneroded green fescue range in Tenderfoot Basin, 1960[1/]

Species group and species	Density	Composition	Production per acre	
			Green	Air-dry
	Percent	Percent	Pounds	Pounds
Grasses:				
Green fescue	26.2	83.2	5,245	1,872
Bearded wheatgrass	1.0	3.2	174	74
Oniongrass	.4	1.2	120	42
Needlegrasses	.3	.9	30	13
All grasses	27.9	88.5	5,569	2,001
Forbs:				
Hoary velvet lupine	3.6	11.4	701	191
Others	(2/)	.1	11	5
All forbs	3.6	11.5	712	196
All vegetation	31.5	100.0	6,281	2,197

1/ Data are averages of 10 plots. Density (cover) and composition were determined by the square-foot density method. Production was estimated on 10 9.6-square-foot plots, followed by clipping on three of the plots to obtain estimate—clipping ratios.

2/ Less than 0.05 percent.

This loss of soil in the basin was probably activated early in the century, when large numbers of sheep were grazing the area. The records show that early in the grazing history of the basin the thousands of sheep were almost completely utilizing the important forage plants. Augmenting this abuse, the trailing sheep broke down the sod and pulverized the soil, resulting in eroded trenches that ran both across and down slopes. Grass roots were severed as trails cut deeper and many roots in the resultant topsoil pedestals became desiccated. With heavy utilization and concentrated trailing continuing annually, the roots of dead and weakened plants could not hold the soil and much was removed by wind and water.

These processes of erosion were still active in the basin in 1938. More than half of the remnant green fescue plants on soil pedestals were dead, and the vigor of those still alive was poor. Although the roots of both dead and weakened plants were partially holding the soil together, rootbound lumps were still breaking from pedestals and being pulverized by grazing sheep. Using height and area of soil pedestals as guides, calculated soil losses ranged from 212 tons per acre on B plots to 927 tons on E plots. With accelerated erosion still evident, it was believed that more topsoil would be lost through the continued breakdown of pedestals.

The 1956 photographs show that relatively little erosion took place after 1938. Many of the soil remnants remained intact and were supporting vigorous green fescue plants. Major enlargements of the gullies had not occurred and their sides were being stabilized by invading vegetation. The trenches resulting from trailing had not deepened, and the conspicuous erosion pavements in the trenches were being ameliorated by a covering of loose soil that was not being moved by runoff to the extent observed in 1938. Instead, the soil was being stabilized on most of the area by the invasion and spread of needlegrasses, sedges, and other secondary grasses and forbs.

Extensive gravelly erosion pavements (E soil erosion class) prevailed in 1938 where heavy concentrations of sheep had occurred annually, particularly on permanent bedgrounds and natural stock trails. Alpine phacelia, eriogonums, and biscuitroot were the most prominent plants on the bedgrounds. Needlegrasses, nettleleaf gianthyssop, bottlebrush squirreltail, and annual weeds were most prominent on the pavements of slopes. Needlegrasses--aggressive on eroded soils--sometimes had become established on these sites in almost pure stands.

The 1956 photographs and the 1957 plot data show alpine phacelia and Piper eriogonum still prominent on the old bedgrounds, but new plants of Rydberg penstemon, needlegrasses, and bottlebrush squirreltail had become established. Needlegrasses had increased in density on the heavily eroded slope sites, and scattered plants of sedges, spike trisetum, and green fescue were beginning to invade. The presence of these plants--especially the fescue--on severely eroded slopes indicated great improvement in soil stability.

Formation of the erosion pavement in the trenches and on the bedgrounds and stock trails, and the early invasion of secondary species on the pavements, was of some value. The pavement and invading needlegrasses provided a degree of protection against deepening of the trenches, and, eventually, against gully formation during peak runoff periods following snowmelt and torrential summer storms. The extensive pavements and the various species that had invaded the old bedgrounds and eroded slopes provided similar protection against further erosion of these sites.

Just as the early formation of an erosion pavement was helpful in preventing deeper erosion of the soil profile, the soil-holding effect of the roots of some plant species retarded the breakdown of pedestals. Sedges--principally elk sedge--had spread before the topsoil had completely eroded away, and were well established on the pedestals in 1938. The same was true for some forbs. Some pairs of photographs show that the root systems of pokeweed fleeceflower, Rydberg penstemon, gland cinquefoil, Piper eriogonum, and Nuttall gilia--species prominent in 1938--are long-lived, at least for 18 years. Comparing plant size and vigor in the photographs, it is apparent these forbs had invaded, were also well established, and had effectively held together the soil of many remnant pedestals long before 1938. With the improvement in management after 1938, the success of the roots of these plants in holding the topsoil was an important factor in the increasing density of needlegrasses and sedges and in the reestablishment of green fescue by 1957.

Utilization measurements on the plots in 1938 show that herbage growth of most of the long-lived forbs was only lightly grazed, even when small or large amounts of green fescue on the plots were well utilized. Thus these unpalatable forbs not only had a better chance to survive and to continue spreading and retarding soil erosion than the palatable grasses, but much of their annual growth could return to the soil as litter. This was in decided contrast to the amount of litter supplied by the palatable plants--green fescue, needlegrasses, and sedges. Still, the 1938 photographs showed very little litter accumulation. Except for local deposition in depressions and in the limited area on the uphill side of pedestals, litter apparently was being removed from the slopes in runoff waters.

A good litter cover was observed for each of the soil erosion classes in 1956 and 1957. In 1956, the average litter cover measured on 15 transects was 54, 38, 31, and 30 percent, respectively, on B, C, D, and E soil-erosion-class sites. This shows that much of the litter from the 1955 herbage production was not removed in 1956, at least not before the August remeasurement. Equally important, the 1956 photographs show considerably greater amounts of dried green fescue leaves from the previous year's growth than do the 1938 photographs, a result of conservative use of this key species.

Vegetation Density Increased

On the 62 plots resampled in 1957, the area of ground surface covered by vegetation in 1938 averaged 10 percent (table 2). In 1957 the average density was 13.1 percent. Density of grass and sedge species had increased 25 percent; that of forbs, 44 percent. Shrub density, low in 1938, had not changed on the plots measured. However, the photographs show that the major shrub--big sagebrush--had improved in vigor and had spread on some slopes.

Increasing density in the grasses-and-grasslike group resulted from increases in density of green fescue, needlegrasses, and sedges. Most of the increase by green fescue was through extension of basal area by live remnant plants and through reestablishment on the topsoil pedestals. This is shown by photographs. Other 1956 photographs show small green fescue plants invading the thickened stands of needlegrass on the stabilizing soils between pedestals. Needlegrasses have continued to increase on the more heavily eroded soils as soil stability improved. Where some soil had sloughed from pedestals, resulting in a smoother land surface, needlegrasses increased substantially.

The greater part of increased forb density resulted from an increase in average density of Nuttall gilia from 0.8 to 2.3 percent. Grazing records show that this unpalatable plant was spreading over the allotment in 1934 and, with the invasion and spreading of other forbs, was changing the previous grasslike aspect to one of grass and weeds. Having invaded the remnant pedestals, the greatest densities of Nuttall gilia in 1938 were found where the most topsoil remained. In 1957, the species was still prominent on the topsoil pedestals; however, many new seedlings and small established plants were observed on the stabilizing soils between pedestals and on the pavements of benches and channel slopes.

Eriogonums, fleabanes, and fescue sandwort showed a slight increase in their average plot density from 1938 to 1957. Wyeth eriogonum commonly increased on the deep and less eroded topsoils and Piper eriogonum on some of the heavy pavement areas.

Vegetation Density Changes Variable

The pattern of change in vegetation density between 1938 and 1957 varied between soil erosion classes. Change in average plot densities ranged from a 5-percent decrease on the B plots to 32-, 67-, and 125-percent increases on the C, D, and E plots, respectively (table 2). The differences between 1938 and 1957 average grass and average forb densities within the soil erosion classes followed a similar pattern. The measurement data show a slight increase in shrub density on the B and C plots, a decrease on the D plots, and invasion of the E plots. The nonconforming decrease of shrub density on the D plots was a result of death and decadence of big sagebrush plants on three plots, all located in swale sites.

Table 2.--Average vegetation density of green fescue range in Tenderfoot Basin in 1938 and 1957, by 1938 soil erosion class[1/]

(In percent)

Species group and species	B (14 plots)		C (24 plots)		D (18 plots)		E (6 plots)		All classes (62 plots)	
	1938	1957	1938	1957	1938	1957	1938	1957	1938	1957
Grasses and grasslike:										
Green fescue	4.2	4.6	3.7	5.5	1.9	3.5	0.3	0.5	3.0	4.2
Needlegrasses	2.6	2.1	1.2	1.7	1.0	2.0	.3	.8	1.3	1.8
Sedges	1.8	1.2	.8	1.1	.8	.8	.2	.6	.9	1.0
Others	.6	.3	1.3	.7	.3	.3	.4	.6	.8	.5
All grasses	9.2	8.2	7.0	9.0	4.0	6.6	1.2	2.5	6.0	7.5
Forbs:										
Nuttall gilia	1.6	3.3	0.5	2.0	0.8	1.2	0.5	4.2	0.8	2.3
Eriogonums	1.2	1.0	.7	1.0	.7	1.6	0	.1	.7	1.0
Rydberg penstemon	1.0	.6	.2	.2	.1	.2	0	(2/)	.3	.3
Fleabanes	.4	.2	.1	.1	.1	.6	0	(2/)	.1	.3
Western yarrow	.3	(2/)	.4	.2	.1	.3	0	0	.2	.2
Fescue sandwort	0	.3	.1	.2	.1	.1	0	(2/)	.1	.2
Others	1.2	.4	1.2	.7	1.1	1.9	1.8	1.0	1.4	.9
All forbs	5.7	5.8	3.2	4.4	3.0	5.9	2.3	5.3	3.6	5.2
Shrubs:										
Big sagebrush	0.4	0.5	0.1	0.2	0.6	0.3	0	(2/)	0.3	0.3
Others	0	0	0	(2/)	.2	.2	0	0.1	.1	.1
All shrubs	0.4	0.5	0.1	0.2	0.8	0.5	0	0.1	0.4	0.4
All vegetation	15.3	14.5	10.3	13.6	7.8	13.0	3.5	7.9	10.0	13.1
Percentage change	-5		+32		+67		+125		+31	

[1/] Soil erosion classes: B, 51 to 75 percent of soil surface undisturbed; C, 26 to 50 percent; D, 1 to 25 percent; E, less than 1 percent.

[2/] Less than 0.05 percent density.

Green fescue made its greatest change in density on the more eroded C, D, and E plots: 49, 84, and 66 percent greater, respectively, in 1957 than in 1938. On the B plots, where more topsoil remained, its increase was less than 10 percent of its 1938 density. The secondary needlegrasses and sedges also increased steadily in density on the C, D, and E plots but, unlike green fescue, decreased on the B plots.

Nuttall gilia was the only major forb to show an increase in average plot density for each of the four soil erosion classes. It also was the only major forb present on the B plots in 1938 to show a substantial increase in density by 1957. On the C and D plots, its rate of density increase was greater than on the B plots, but its average 1957 densities were less. Both its greatest increase and its highest average 1957 plot density were on the E plots; in 1957, Nuttall gilia accounted for more than half of the vegetation cover on these plots.

Fescue sandwort was the only major forb species that invaded the B plots. This invasion was more pronounced on shallow soils of ridge sites, where gravelly pavements between pedestals were still conspicuous.

Density of the remaining major forbs--western yarrow, the fleabanes, the eriogonums, and Rydberg penstemon--decreased on the B plots, generally stayed the same on the C plots, and increased most on the D plots. None of these species were recorded on the sampled E plots in 1938, but all except the western yarrow had invaded by 1957.

Vegetation Composition Unchanged

Average composition values of the vegetation on the sampled plots show only one major change: Nuttall gilia increased from 8 percent to almost 18 percent of the total composition. This forb also made the greatest change in the average composition of B, C, and E plots; making up 12, 10, and 39 percent more, respectively, of the composition in 1957 than in 1938. Changes in the composition of other species was less than 5 percent. The forbs on the D plots made the greatest change (increase) in average composition of species groups--from 38 to 45 percent--as a result of the increase in density of all major forbs.

Herbage Production Improved

In 1938, green fescue, the needlegrasses, and the sedges furnished 74 percent of the total herbage grazed on the study area. On 10 study plots representative of the 4 soil erosion classes, these palatable plants in 1938 produced a weighted average of 630 pounds of green herbage per acre (table 3). By 1956, their production had increased to 1,530 pounds per acre, almost 2-1/2 times their 1938 production.

The green herbage weight of forbs increased 450 pounds per acre. Of this, Nuttall gilia production increased 344 pounds, a reflection of its increased density and vigor. The fleabanes and eriogonums accounted about equally for the remaining 106 pounds of increased forb production. The herbage weight of western yarrow, Rydberg penstemon, and other forb species declined slightly.

Table 3.--Average green-weight production of herbage per acre, Tenderfoot Basin, 1938 and 1956[1/]

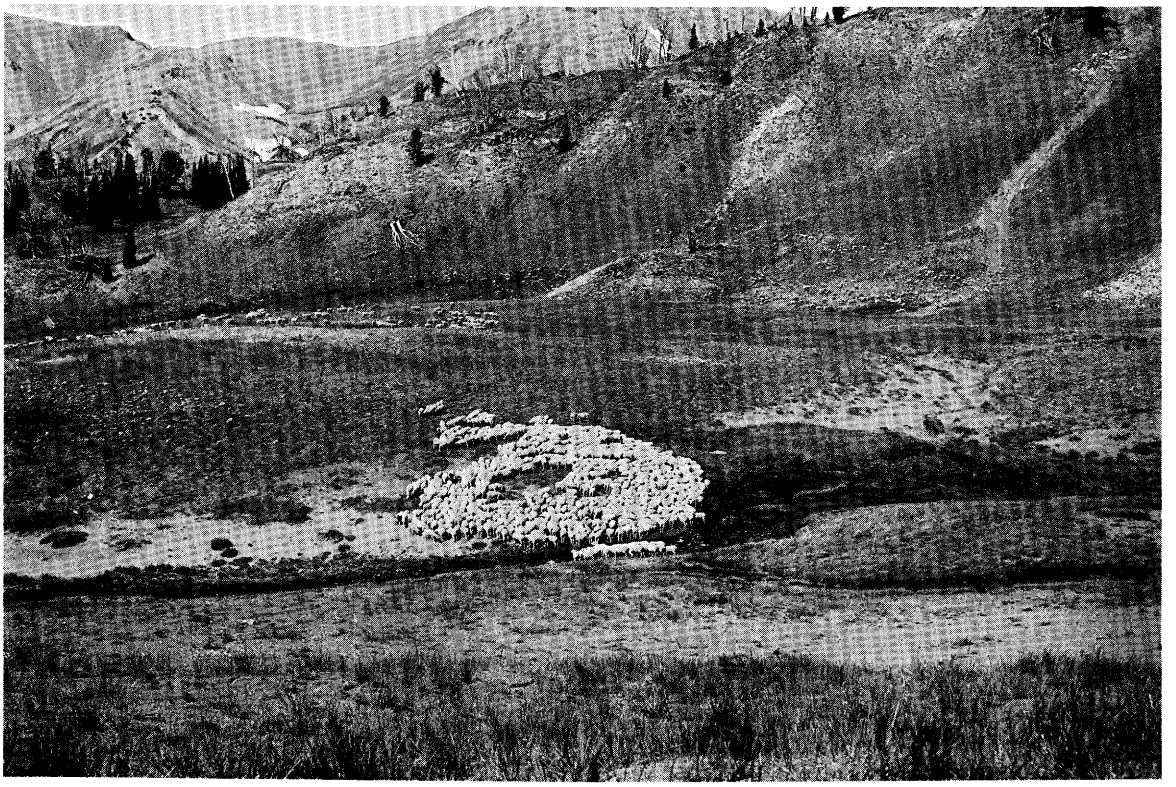
Species or species group	1938	1956
	Pounds	
Green fescue	349	513
Needlegrasses	134	824
Sedges	147	193
Other grass and grasslike	12	33
All grass and grasslike	642	1,563
Nuttall gilia	71	415
Other forbs	64	170
All forbs	135	585
Big sagebrush (all shrubs)	7	--
All herbage	784	2,148

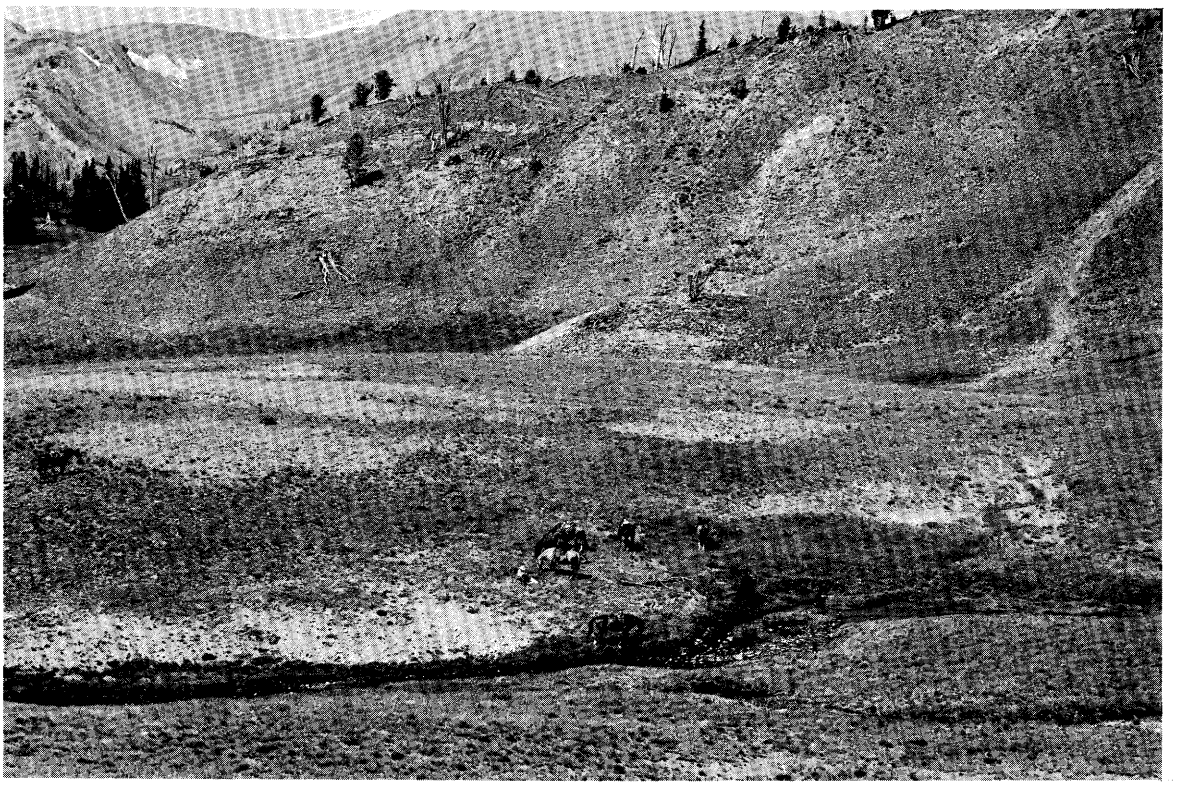
[1/] Data are from 10 sample plots, 3 each in C and E soil erosion classes and 2 each in B and D soil erosion classes. Averages are weighted by the percentage of plots on the study area within each soil erosion class.

Photographic Comparisons Show Range Improvement

1938. Before 1938, concentrations of sheep augmented accelerated erosion and green fescue depletion through trampling of weakened soil pedestals and heavy utilization of forage.

1956. Following 18 years of improved range management and livestock handling, the areas devoid of vegetation in 1938 are supporting a fair vegetation cover--principally subalpine needlegrass--and the accelerated erosion prominent in 1938 has not continued.



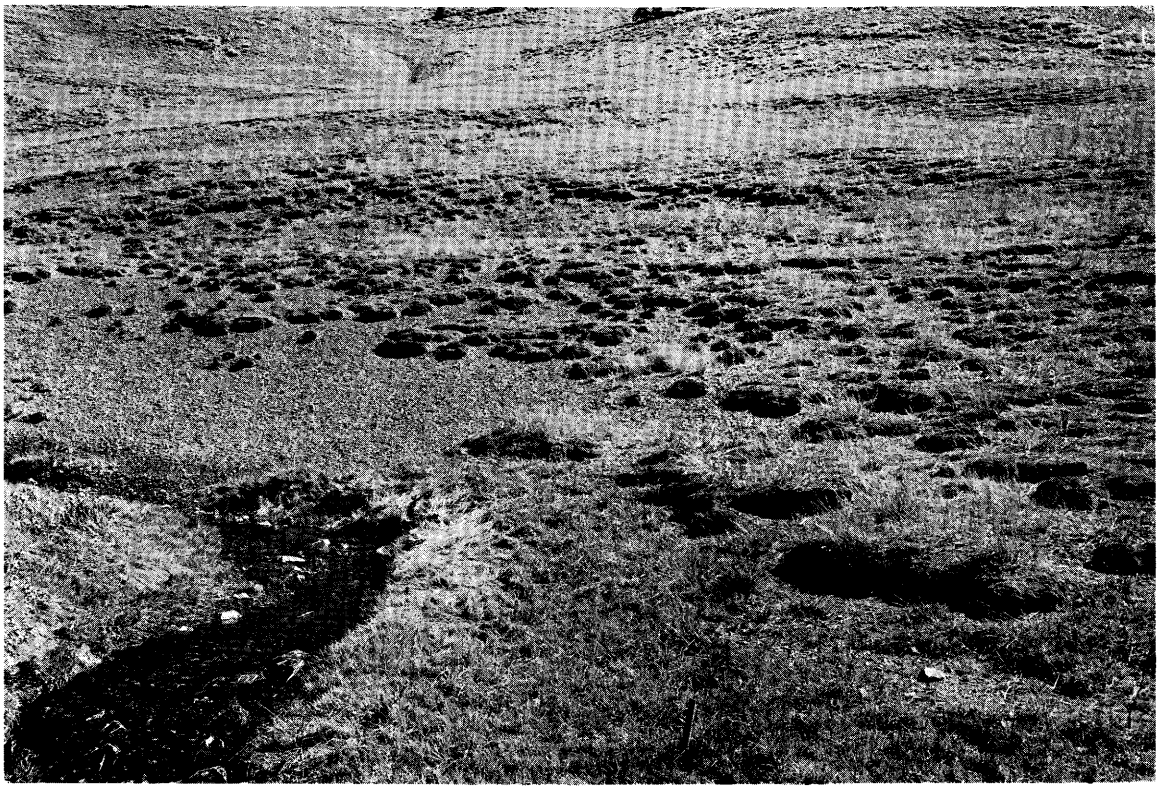


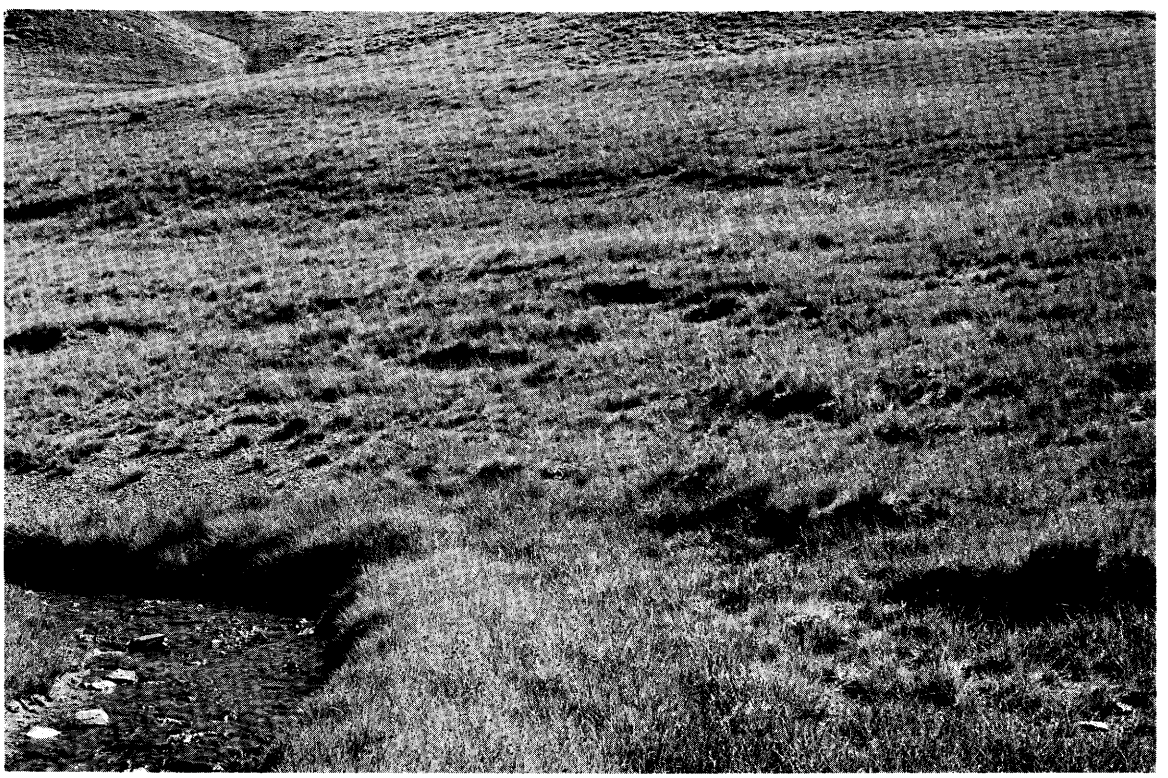
1938. Past accelerated erosion is indicated by the small, steep-sided gully cutting through a tough sod of sedge. Sedges and needlegrasses (dark lines) are conspicuous. Small colonies of Rydberg penstemon occur in the sod.

1956. Lack of appreciable widening or deepening of the gully in the past 18 years attests to a substantial decrease in the amount and rate of runoff water. Continuation of a lowered water table has resulted in the sedges becoming less prominent; Rydberg penstemon spreading considerably; and green fescue (bunches), spike trisetum, and Wyeth eriogonum becoming more prominent in the composition.

1938. A typical range condition in the basin, showing results of heavy and concentrated sheep use near permanent water: a gradation in the amount of topsoil removed and in herbage density, and the trailed pattern of topsoil pedestals. Green fescue and needlegrasses form most of the composition and are generally restricted to the topsoil pedestals. Approximately 80 percent of the foreground pedestals show dead green fescue root masses. (Photo taken after grazing.)

1956. Subalpine needlegrass has spread to become the principal stabilizing cover on the heavy pavement between pedestals. Green fescue has become reestablished on many of the remnant pedestals and is beginning to invade the cover of needlegrasses. Note that many of the pedestals, masked by herbage growth, have remained intact.





1938. Soil erosion class B. Seventy-five percent of the topsoil remnants show dead masses of green fescue roots. The live fescue plants exhibit low vigor. Leaves are short, seed heads are sparse, and the plants are small in comparison with exposed root masses.

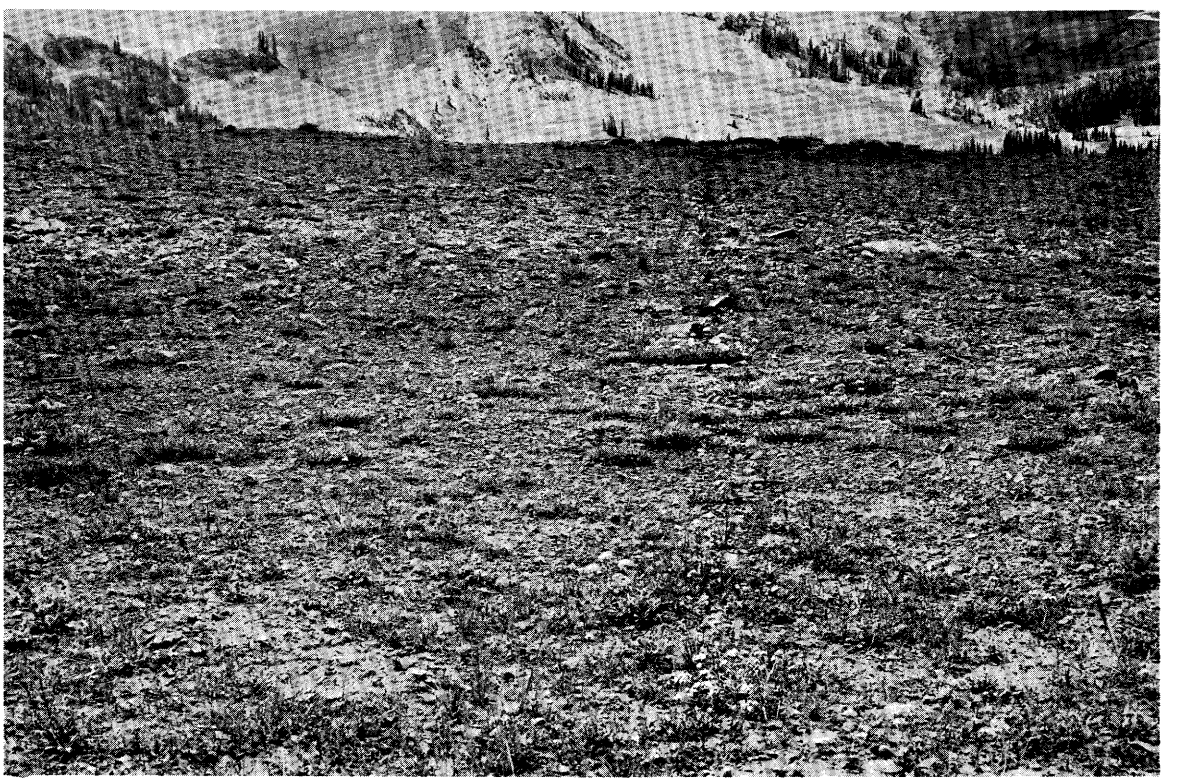
1956. The breakdown of some pedestals has resulted in a smoother land surface. Herbage growth of sedge and the strongly invading needlegrasses hides both the improved vigor of older green fescue plants and the establishment of new fescue plants. Note the abundance of vegetational litter.

1938. Soil erosion class C. Pedestals are 7 inches high and 90 percent of the area of topsoil pedestals contains dead roots of green fescue. Nuttall gilia, sedges, and needlegrasses have invaded these soil pedestals. Needlegrasses and annuals are prominent on the soils between pedestals.

1956. A one-half percent density of green fescue on the remnant pedestals in 1938 has increased to an estimated 13 percent. Needlegrasses, between pedestals, and sedges, on pedestals, have increased slightly in density. The increase in Nuttall gilia's density from 7 to 12 percent tends to be masked by the grass herbage. Note that the gilia is less restricted to topsoil pedestals than it was in 1938 and that the same plant (root system) of pokeweed fleeceflower has survived for 18 years.

1938. A bench site in class E soil erosion condition, used consistently as a bedground. All topsoil has been lost, leaving a rocky and gravelly surface. The vegetation is principally alpine phacelia and Piper eriogonum, with scattered plants of biscuitroot, bottlebrush squirreltail, and Rydberg penstemon.

1956. Improvement of the vegetation and soil condition on this heavily eroded site has been slight. However, the erosion pavement shows amelioration, and there are some new needlegrass and western yarrow plants. New sagebrush plants are conspicuously outlined on the break of the bench.

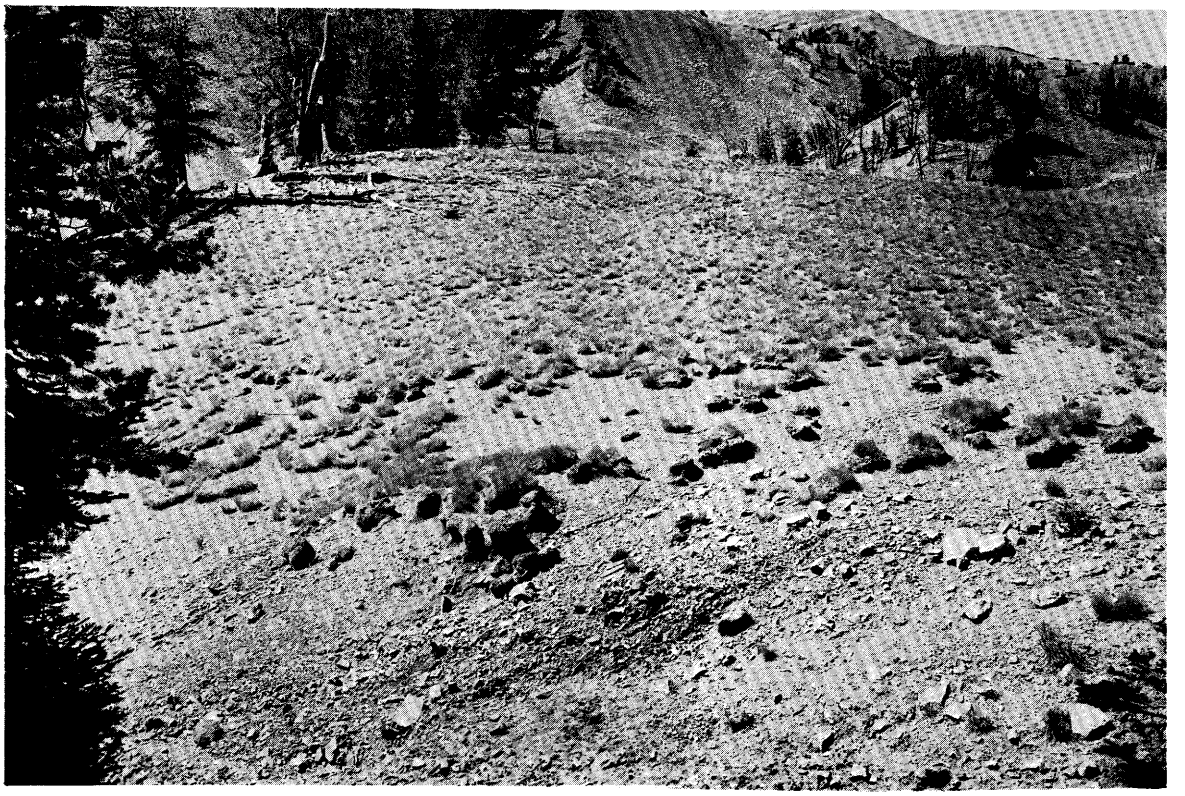


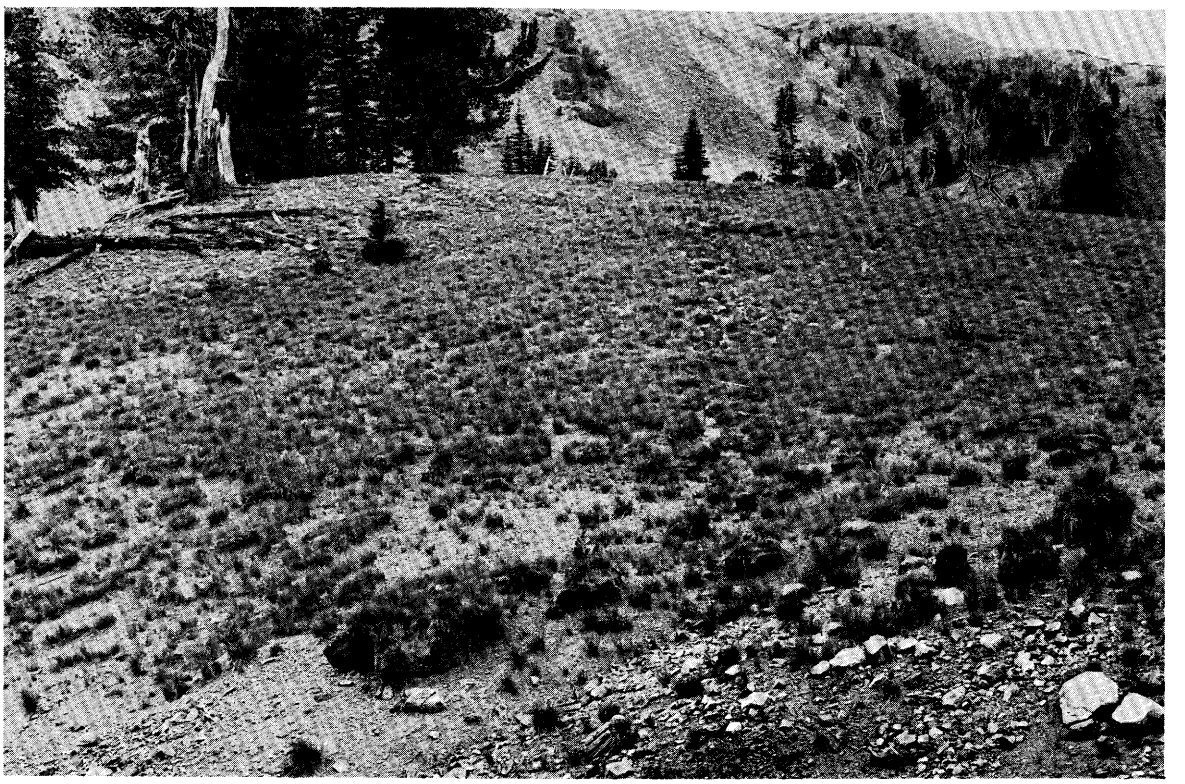
1938. Subalpine needlegrass invading a site that has lost almost all topsoil. Green fescue, showing poor vigor, is surviving on topsoil pedestals at upper left. Nuttal gilia (white flowered) has invaded the topsoil pedestals held together by dead fescue roots.

1960. Density of subalpine needlegrass has greatly increased, and vigor of the scattered fescue plants has improved. Although not prominent in the growth of the grass, Nuttall gilia is still well established on the topsoil pedestals.

1938. Excessive loss of topsoil along a sheep trail. This type of erosion, primarily caused by continued and concentrated movement of sheep over the same trail, has resulted in a pedestaled green fescue range with an erosion pavement between pedestals. Large blocks of topsoil, broken away from remnant pedestals but held together by the dead fescue roots, are shown in the erosion channel.

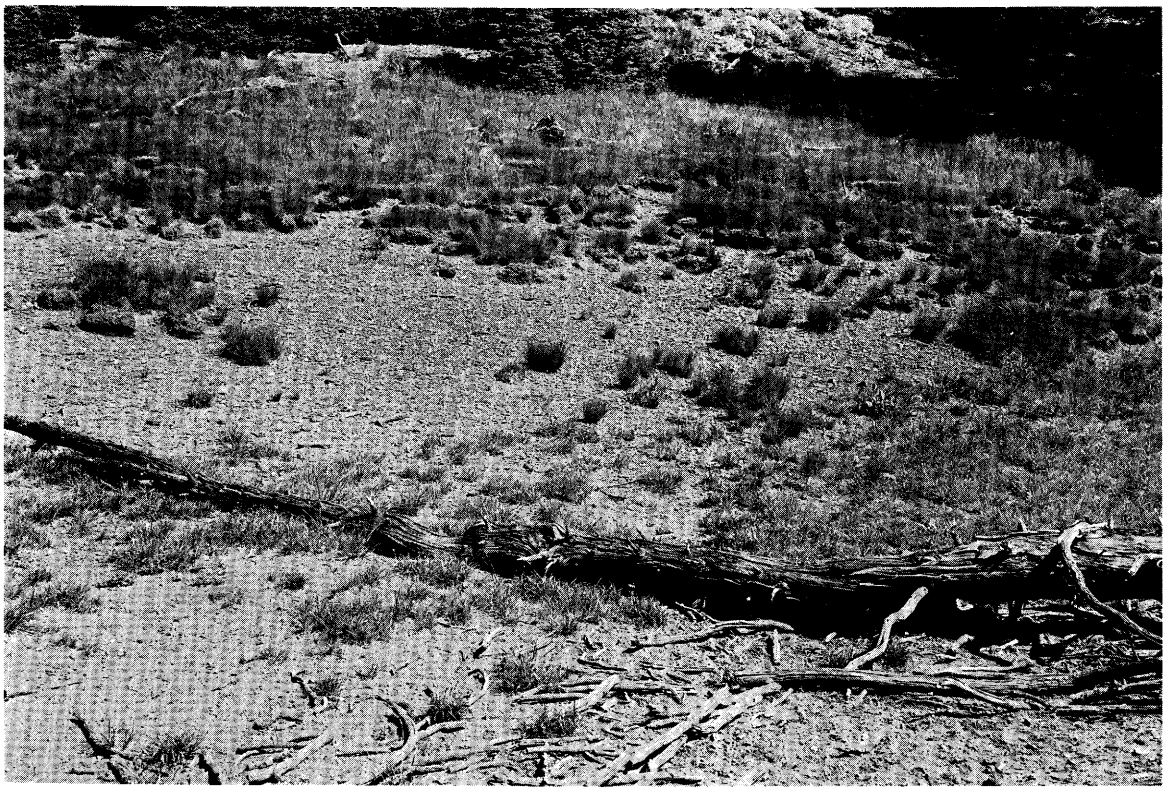
1956. The heavy pavement areas have been invaded by needlegrasses. Most of the remnant soil pedestals supporting live green fescue plants in 1938 have retained their soil during the 18 years, but many of those with dead root masses in 1938 are no longer present. Four young trees of two species, whitebark pine and subalpine fir, were not present in 1938.





1938. A severely eroded slope, showing a great loss of topsoil between pedestals and poor vigor of green fescue on the pedestals. Sedges and needlegrass, also poor in vigor, are established on the foreground pavement. This condition has resulted from concentrated trailing and grazing along a stock trail. The lack of attached litter from the previous year's growth reflects the heavy use of green fescue.

1956. Forage and watershed values on this site have improved. The increase in vigor and density of the palatable green fescue, needlegrasses, and sedges; the presence of attached litter; and the establishment of small plants on the 1938 pavements indicates a more moderate use of forage, a reduction in surface water movement, and less trampling by sheep after 1938.



1938. A bench site in class E soil erosion condition. On the left, Piper eriogonum, alpine phacelia, ballhead gilia and umbellate pussypaws grow on a rocky, shallow soil. On the right, with less surface rock, needlegrasses, fleabanes, and sedges are most conspicuous. Large plants of bottlebrush squirreltail are shown in the foreground.

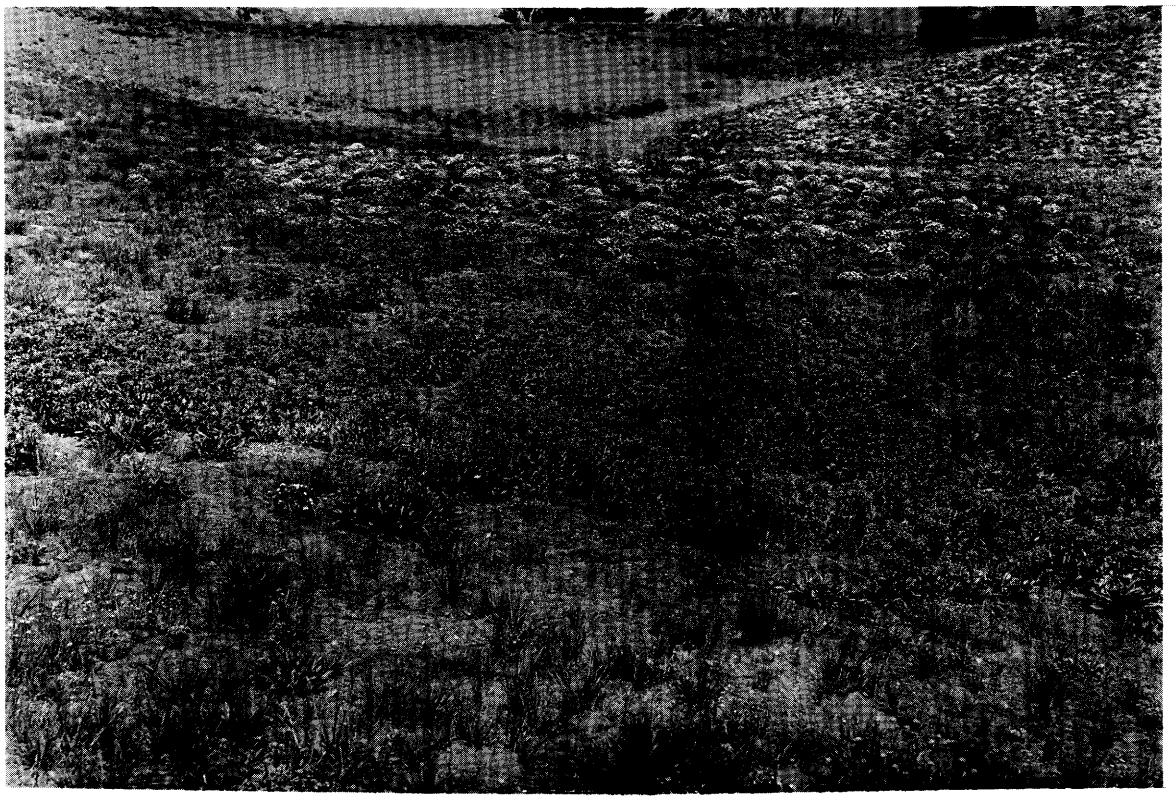
1956. There has been little improvement in vegetation and soil characteristics. Piper eriogonum plants have increased in size and density, and ballhead gilia and umbellate pussypaws are still conspicuous. Sedges, fleabanes, and--most noticeably--bottlebrush squirreltail have decreased in density. Clumps of Rydberg penstemon and seedlings of needlegrass are growing on the shallow, rocky soil.

1938. Deposition of soil on a level area has favored the growth of sedges, fleabane, Wyeth eriogonum, needlegrasses, lambstongue groundsel, umbellate pussypaws, and hook violet. Forbs are 65 percent of the composition; grasses and grasslike, 35 percent. Sedges account for 25 percent of the composition, and needlegrasses account for 5 percent.

1956. Green fescue has invaded and makes up 10 percent of the composition. Needlegrasses are 50 percent, sedges 17 percent. All forbs, principally Wyeth eriogonum and hook violet, are now only 17 percent of the composition. Note the increase in density of big sagebrush on the slope in the upper left.

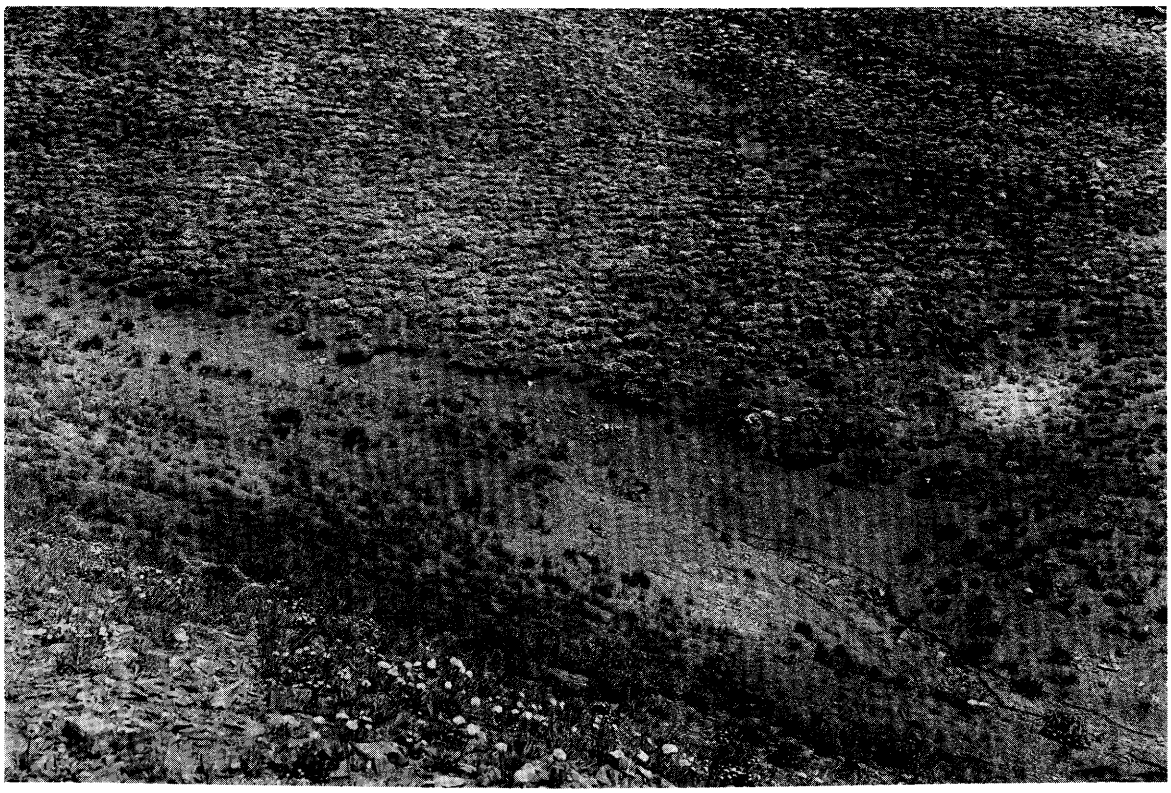
1938. Rydberg penstemon, needlegrass, and Nuttall gilia on green fescue range in class C soil erosion condition. Other, less prominent species on this swale-type site are sedges, Wyeth eriogonum, and fescue sandwort.

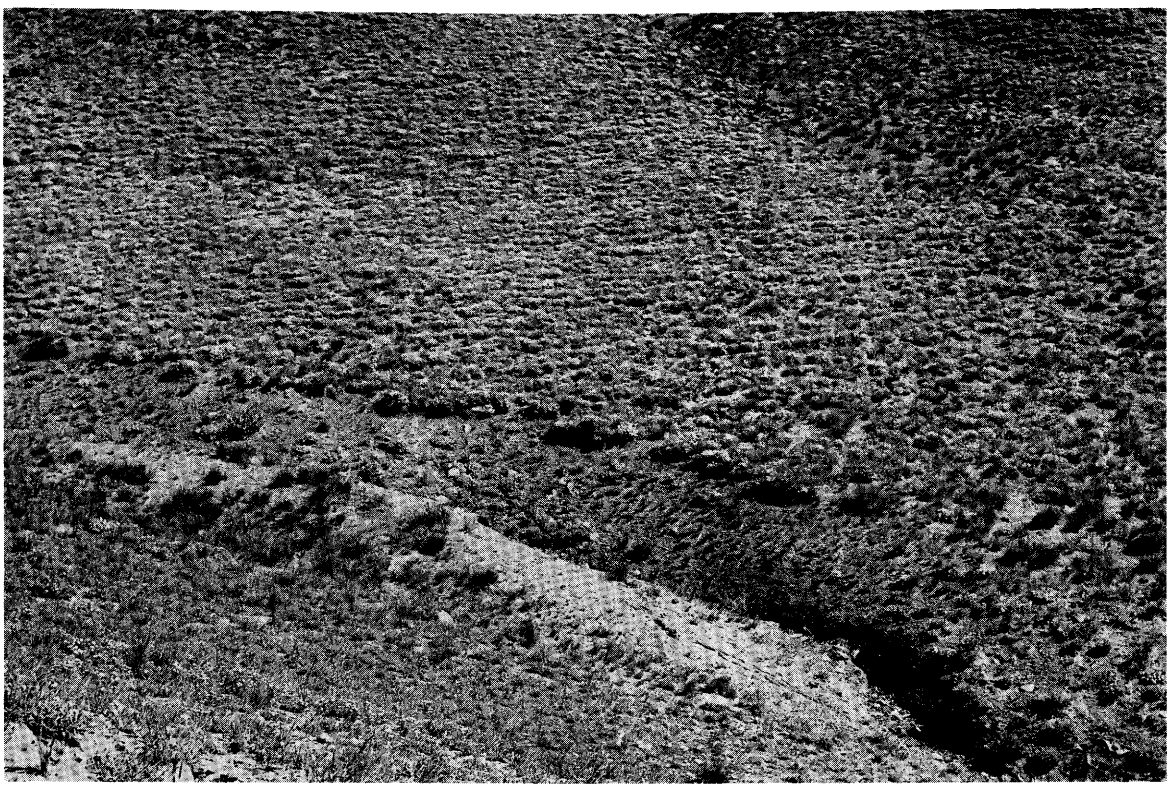
1956. This swale, principally occupied by forbs in 1938, now supports a stand consisting primarily of needlegrasses and sedges. Green fescue is re-establishing in the sod. Rydberg penstemon is less vigorous and exists as scattered clumps. Nuttall gilia and fescue sandwort have almost disappeared.



1938. A heavily eroded green fescue range. Conspicuous evidence of past mismanagement and range degeneration is the abundance of the aggressive white-flowered invader, Nuttall gilia; small degenerate bunches of green fescue on distinct topsoil pedestals; and the V-shaped gully.

1956. Improvement in composition since 1938 has been slight. Continued losses of topsoil are not indicated; however, the deepening of the gully shows that some accelerated runoff occurred after 1938. Establishment of needlegrasses, Nuttall gilia, and some green fescue on the sides of the gully shows the channel is being stabilized. These three species and sedges have improved in both density and vigor, especially Nuttall gilia.



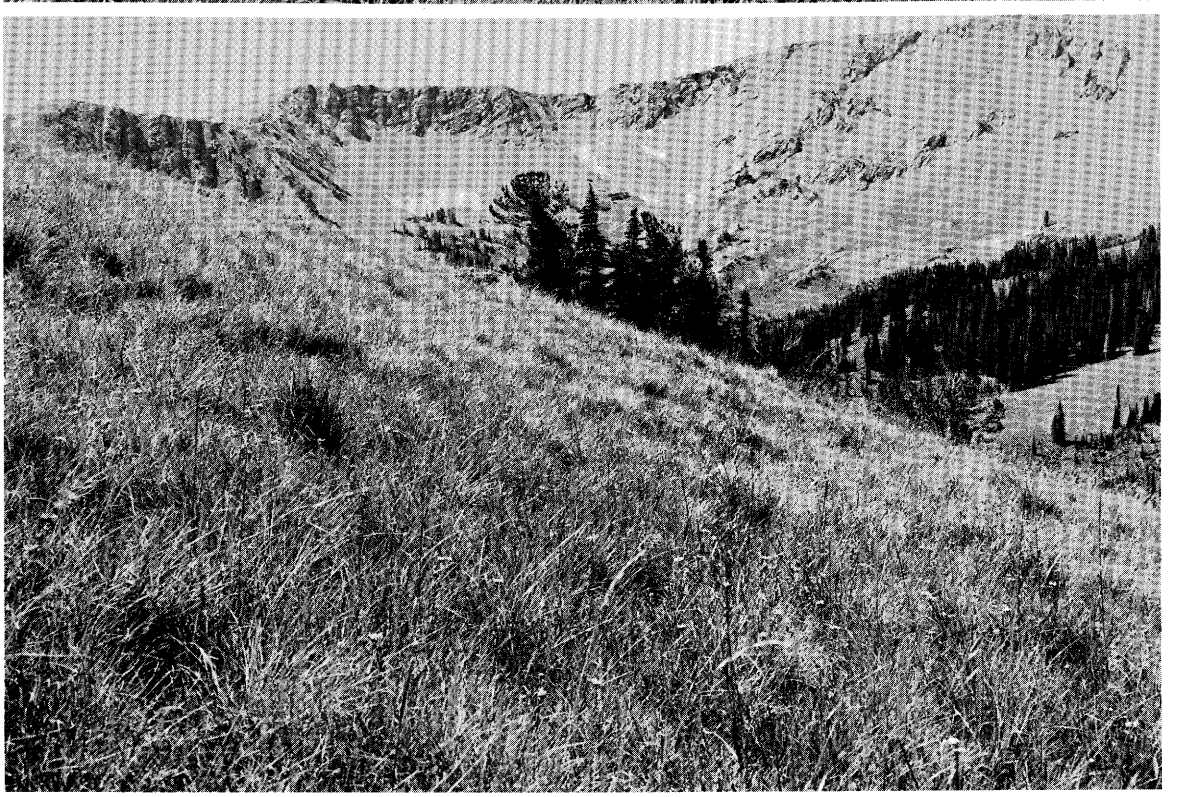


1938. Soil and vegetation degeneration near permanent water. Soil losses range from 100 percent of the topsoil (6.5 inches) near the stream to 26-50 percent of the topsoil on the slopes furthest from water. Note the contour pattern of pedestals. Many of the remnant pedestals have remained intact only because the soil is held together by dead green fescue roots. (Photo taken after estimated moderate utilization.)

1956. The same general view shows improvement in range condition. Subalpine needlegrass has invaded the pavement areas; and sedges, the remnant pedestals. Green fescue has spread on the remnant pedestals and is beginning to invade the clumps of needlegrass.

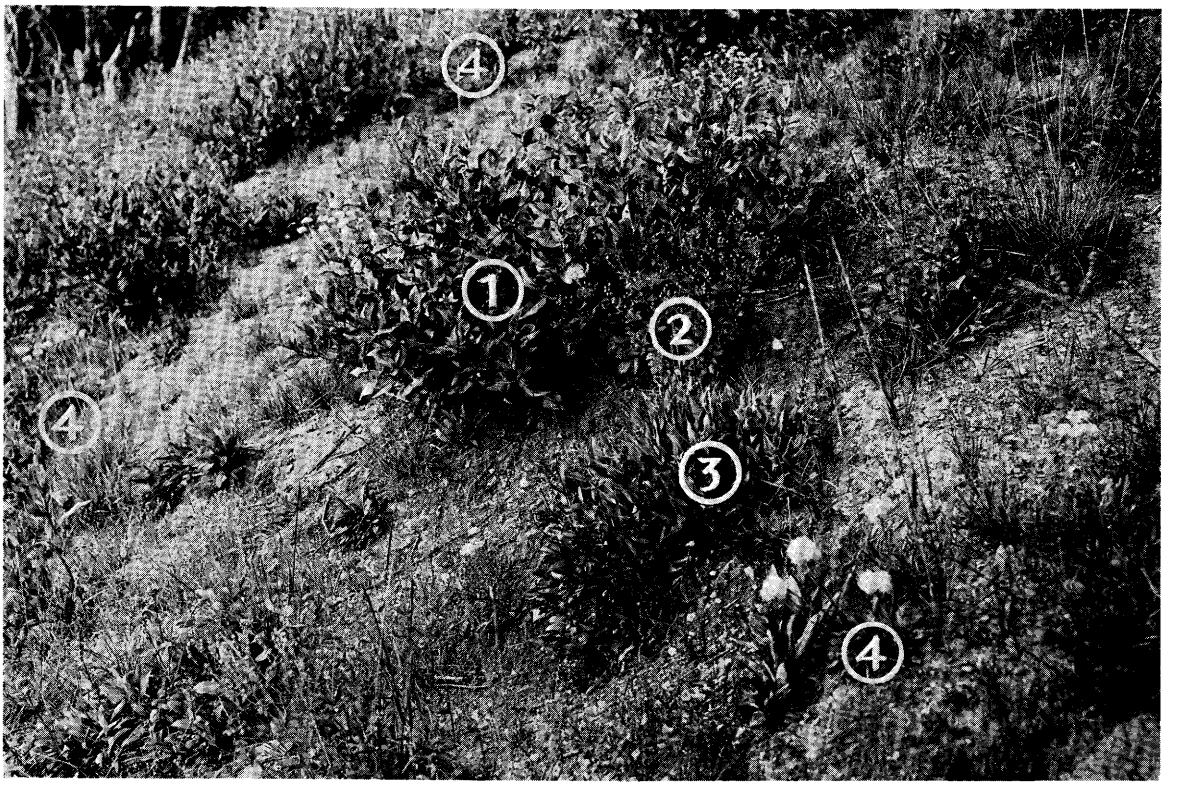
1938. Green fescue range in good condition. Less than 25 percent of the topsoil has been lost, and vigorous green fescue forms 85 to 100 percent of the composition on sample plots. Occasional plants of subalpine needlegrass, sedge, western yarrow, and Wyeth eriogonum are scattered between the fescue bunches.

1956. Green fescue is only 58 percent of the composition. Fleabanes are 22 percent; needlegrasses, 5.5; western yarrow, 5.5; and sedges, 3. This composition represents the stage of vegetation recovery from a degenerate condition noted in 1944, a result of heavy use of the site as a sheep bedground for two consecutive seasons.



1938. Pokeweed fleeceflower (1), gland cinquefoil (2), Rydberg penstemon (3), and Piper eriogonum (4) are established on and between scattered topsoil pedestals. A former stand of green fescue has completely disappeared. Needlegrasses and sedges are well established within the forb clumps, and bottlebrush squirreltail and small plants of needlegrasses are observed on the loose soil between clumps.

1956. Most of the same forb plants (root systems) observed in 1938 have apparently survived. Density and vigor of pokeweed fleeceflower shows little change, but new plants of this species have become established. Coverage of gland cinquefoil, Rydberg penstemon, and Piper eriogonum have decreased, but new plants of the same species are noted on the stabilizing soils between pedestals. Needlegrasses and sedges have increased their coverage, and green fescue (28 percent of the composition) has become reestablished on the topsoil remnants.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CONCLUSIONS

The degeneration of vegetation and soil in Tenderfoot Basin was continuing in 1938. Erosion was still active, as indicated by the breaking down of pedestals, the erosion pavement, and the eroding channels on slopes. Almost complete use of green fescue in previous years was indicated by its low vigor, the large number of topsoil pedestals containing dead fescue root masses, and the absence of fescue litter.

Photographs and plot records taken in 1956-57 show a tremendous improvement since 1938 soil and vegetation conditions in the basin. Although most of the soil pedestals seen in 1938 photographs were present in 1956, these pedestals were no longer steep sided. Neither were they supporting plants of low vigor nor dead green fescue roots. Instead, they generally had sloping sides and supported a vigorous growth of fescue or other perennial species. Soil, sloughing from the pedestals, had remained on the pavements and was being stabilized by invading plants. The extensive pavements on old bedgrounds and stock trails and the eroding channels were also healing with the invasion of vegetation. Herbage density and production had increased. Importantly, the increase in density and production of green fescue, needlegrasses, and sedges--the principal forage species on the study area--showed that overall use in the basin had been controlled by obtaining conservative use of the key species--green fescue. Conservative use in 1955 was reflected in the abundance of vegetational litter photographed and measured in 1956-57.

Although sheep numbers in the basin had decreased before 1938, forage use was still heavy and soil erosion had continued. However, erosion and vegetation depletion after 1938 was less than expected on the basis of various indicators observed during the early study. This is significant because improvement between 1938 and 1957 came about in an area characterized by heavy runoff from deep winter snows, torrential summer storms, and strong winds. Therefore, retarded soil erosion and improved vegetation density and vigor after 1938, with normal climatic conditions prevailing, was undoubtedly the result of improved management of sheep and land.

By obtaining a better balance of sheep numbers with the degenerate range conditions, by using one-night bedgrounds, and by allowing sheep to graze freely, accelerated erosion was stopped and vegetation was given a chance to improve. Further recovery and improvement was enhanced by applying good land-management principles, such as deferring use, regulating the opening date and season of use, and obtaining nonuse in the basin for 4 years. As a result of these practices, the Tenderfoot Basin allotment, as a range watershed resource, has increased in value.

The studies also show the effect of loss of topsoil and the invasion and increase of secondary species on the succession of vegetation after 1938. Essentially, the modification of these habitat factors has prevented improvement of

vegetation composition and has regulated the rate, amount, and variation of density change of species and of total vegetation.

Loss of topsoil has had the greatest effect in preventing any large increase in vegetation density in the basin since 1938. The loss of topsoil has meant loss of fertility and capacity for moisture infiltration and retention, which in turn has greatly reduced potential plant density. Changes in total density on the B erosion class soils were not significant, indicating that the density potential of these soils (with the present composition) had also been measured in 1938. Since the greater part of the land surface lost more topsoil than the relative average of 1-1/2 inches measured on the B plots, the present potential plant density for soils over most of the basin is apparently not greater than the densities measured on the B plots in 1957, at least for any reasonable length of time.

The similarity of the average plot densities of B, C, and D erosion class soils in 1957 show these soils to have an approximately equal potential for total plant density. Loss of topsoil (surface 6.5 inches) in average amounts of 1.5, 2.5, and 4.2 inches, respectively, resulted in quite different average plot densities in 1938, but differences were not significant following 18 years of improved management. The difference in soil loss was sufficient, however, to bring about differences in change of species density. The increase of the grass and grasslike plants and associated forbs on the C and D plots resulted in a total cover that approached the vegetation density maintained on the B plots. More striking, the density of the major species on the C or D plots in 1957 was similar to their densities measured on the B plots in 1938.

These foregoing comparisons of density changes and differences between 1938 and 1957 suggest that the changes that occurred on the C and D erosion class soils principally involved attainment of the full density potential. All of the major species present in 1938 increased in density to utilize this potential. The slight changes in species densities on the B plots indicate that green fescue is very slowly replacing most of the secondary and associated species on B class soils.

The slight change in green fescue density on the B plots was not only affected by soil loss but also the competitive abilities of the secondary and associated species. This relationship was more pronounced in 1938, when the dead and weakened fescue plants offered very little opposition to the invasion, spread, and growth of these species on the topsoil pedestals. In 1938 the secondary and associated species had reached greater densities on the B plots than on the C or D plots. Therefore, more topsoil had been held in place and, with management improved after 1938, more favorable soil conditions were present than on the C or D plots for the increase of green fescue density. On the other hand, the greater density of the well-established, unpalatable, and usually long-lived secondary and associated species provided considerable competition for the recovering fescue after 1938.

The continued use made of green fescue by sheep may also have influenced the amount of fescue recovery on the B plots. Although stocking has been

conservative since 1938, the almost exclusive use made of green fescue would have slowed the reestablishment of this grass, and, in effect, would have helped the secondary and associated species be more competitive. The 1956 photographs and the 1956-57 plot measurements show these species have continued to be adapted to the modified environmental conditions as well as, if not better than, the fescue. This is especially apparent for the needlegrasses, Hood sedge, and Nuttall gilia. In future years, with normal climatic conditions and the present degree of management continuing, these species and others of the long-lived, unpalatable forbs can be expected to maintain their prominence in the plant communities of the Tenderfoot Basin.

GPO 995873

COMMON AND SCIENTIFIC NAMES OF PLANTS MENTIONED

Grasses and Sedges

Fescue, green	Festuca viridula
Needlegrass, Letterman	Stipa lettermani
Needlegrass, subalpine	Stipa columbiana
Oniongrass	Melica bulbosa
Sedge, elk	Carex geyeri
Sedge, Hood	C. hoodi
Sedge, ovalhead	C. festivella
Sedge, Raynolds	C. raynoldsi
Squirreltail, bottlebrush	Sitanion hystrix
Trisetum, spike	Trisetum spicatum
Wheatgrass, bearded	Agropyron subsecundum

Forbs

Biscuitroot	Lomatium spp.
Cinquefoil, gland	Potentilla glandulosa
Eriogonum, Piper	Eriogonum piperi
Eriogonum, Wyeth	Eriogonum heracleoides
Fleabane, Eaton	Erigeron eatoni
Fleabane, Oregon	Erigeron speciosus
Fleabane, peregrine	Erigeron peregrinus
Fleeceflower, pokeweed	Polygonum phytolaccaefolium
Gianthyssop, nettleleaf	Agastache urticifolia
Gilia, ballhead	Gilia congesta
Gilia, Nuttall	Gilia nuttalli
Groundsel, lambstongue	Senecio integerrimus
Lupine, hoary velvet	Lupinus leucophyllus canescens
Penstemon, Rydberg	Penstemon rydbergi
Phacelia, alpine	Phacelia alpina
Pussypaws, umbellate	Spraguea umbellata
Sandwort, fescue	Arenaria formosa
Violet, hook	Viola adunca

Shrubs

Sagebrush, big	Artemisia tridentata

Trees

Fir, subalpine	Abies lasiocarpa
Pine, whitebark	Pinus albicaulis