# Recovery of Ponderosa Pine-Bunchgrass Ranges through Grazing and Herbicide or Fertilizer Treatments

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**Highlight:** *Protection from grazing, alternate rest, or seasonal spring or fall grazing did not promote recovery of pine-bunchgrass range in Colorado which had been grazed heavily for more than 23 years. Application of 2,4-D herbicide or NPK fertilizer significantly changed vegetative composition and increased herbage yields of these rangelands under all grazing treatments. The herbicide reduced competition from forbs and permitted the grass species to increase in basal area and produce more herbage than plants on unsprayed, unfertilized control plots. Addition of NPK fertilizer stimulated production of all species and increased yields an average of 500 lb per acre. A combination fertilizer-herbicide treatment increased average yields a comparable amount, with the increase coming mostly from grasses and a few forbs not killed by the herbicide.*

Many native bunchgrass ranges throughout the ponderosa pine type in the Front Range of Colorado have been either closed to grazing or grazed at a reduced rate because of their generally poor condition. These ranges are potentially productive, and are well suited for late spring, summer, and early fall use. But increasing demands on the land for wildlife and recreation use are putting increased pressure on the remaining land for grazing. The ranges will have to support the same number of animals on fewer acres, or if closed ranges are again opened they will need to be maintained in good productive condition, particularly with respect to cover for erosion control.

Simply closing the ranges to grazing has permitted some recovery in terms of erosion control, but it has not solved the basic need of returning ranges to good grazeable condition. Therefore, the problem is how to promote rapid recovery of poor ranges without closing them to grazing. Among the most promising methods for improving these ranges are fertilization, herbicide treatment, grazing, or a combination of these treatments.

## Previous Work

In a partial but substantial review of the literature, Schlatterer (1974) found that response of rangeland to fertilizer was quite variable throughout the western United States. Most single applications of fertilizer gave poor to marginally successful improvement in rangeland production in the Intermountain area, but results were much more successful in the Pacific Northwest and Northern Great Plains. Kilcher et al. (1965) also reported variability in plant response to application of inorganic N, P, and N+P on native grasslands in western Canada. Results were almost all positive, however, with total herbage yields increasing from 300 to nearly 1,400 lb per acre over a 3- or 4-year period from a single N application. The P stimulated very little increase, and yields from N+P were only slightly better than from N alone. Residual carryover effects were important to the increase in yields in the 12 to 16 inch rainfall areas. Fringed sagebrush showed a substantial response to the fertilizer application, particularly the first and second year after application.

Smika et al. (1963) obtained significant increases in native bunchgrass production on the Northern Great Plains from spraying with 2,4-D, primarily to control fringed sagebrush. Increases in grass production were significant whether fertilizer was applied or not, but maximum yield and additional weed control were obtained through a combination herbicide-fertilizer treatment. Nichols and McMurphy (1969) reported similar results in South Dakota. They found a combination treatment of N and 2,4-D increased frequency and yield of perennial grass over either treatment alone or that of an untreated control. Treatment effects were more pronounced the third year following treatment.

On the Northern Great Plains, Rogler and Lorenz (1957) found that applying 90 lb of N for 2 years to a heavily grazed pasture improved range condition and production more than did 6 years protection from grazing.

Grazing systems have also received considerable attention as a means for range improvement (Heady, 1961; Hormay and Talbot, 1961; Sampson, 1952; Stoddart and Smith, 1955). Usually some form of rotation grazing was evaluated, but all of the reports stressed the importance of seasons in the system. The specific season depends entirely upon the life cycle of the plants being grazed. On ponderosa pine-bunchgrass ranges, with Arizona fescue and mountain muhly as the principal grass species, Johnson and Reid (1958) suggested deferring spring grazing to encourage fescue with mid- to late-season deferment to encourage the muhly. Both species might recover vigor and production under some systems of alternate grazing.

## Objectives

On the basis of the work previously cited, combinations of grazing management in conjunction with fertilizer and herbi-

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**Fig. 1.** *Heavy, season-long grazing has reduced the vigor and yield of desirable plants on this range. Undesirable species are abundant. The area shown prior to treatment is where grazing and cultural treatments were applied for one block of the present study.*

cide treatments were tested in the present study to promote range recovery. Specific objectives were to determine if recovery of native ponderosa pine-bunchgrass range could be hastened by:

(a) Reducing the competition from undesirable species through the use of herbicides, specifically 2,4-D.

(b) Promoting the growth of remnant native bunchgrass species by the application of fertilizers.

(c) Finding the season or seasons of use which, applied with (a) and (b) above, will provide a substantial increase in palatable herbage from pine-bunchgrass ranges.

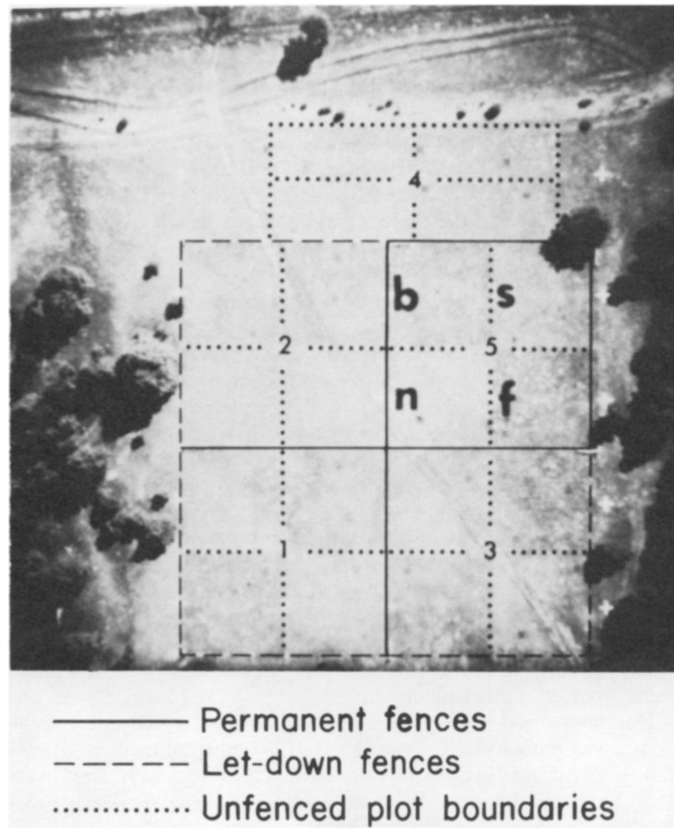


**Fig. 2.** *Aerial view of grazed plots and cultural treatment subplots. Solid lines show permanent fences; dashed lines show letdown fences; and dotted lines delineate unfenced or cultural treatments.*

## Study Area and Methods

The research was done at the Manitou Experimental Forest, in the ponderosa pine zone 28 miles northwest of Colorado Springs, Colorado. In this area, growth of native plants usually accelerates in late March or early April, with the growing season ending in late September or early October. Plant growth is slow early in spring and late fall, however, because of frost in all months but July and August. Daytime summer temperatures are cool and seldom exceed 90°F. Winters are open but cold, and temperatures occasionally dip below −40°F.

Precipitation at Forest Headquarters has averaged 15.9 inches for the 30-year period 1941–1970. About three-fourths of the annual precipitation is received during April through August growing season. July is normally the wettest month, with rainfall averaging 3.5 inches.

Soils are derived from Pikes Peak granite. They are a sandy loam or sandy-clay loam with low fertility and only moderate amounts of organic matter. These soils are porous when wet and very hard when dry. They are highly erodible when the plant cover is removed or damaged.

Treatments were applied within a grassland area which had been under heavy, season-long grazing from June 1 to October 31 for 23 years (Fig. 1). These open grasslands were once the most productive vegetative types on pine-bunchgrass ranges at Manitou, but they were also the most heavily utilized and depleted type because of livestock concentrations (Johnson, 1953; Smith, 1967). As a result, undesirable or worthless species have substantially increased or invaded the grassland type. These less desirable species contribute a large percentage to ground cover and production, but many of them are of low value for grazing. Principal species on these open grasslands are Arizona fescue (*Festuca arizonica* Vasey), mountain muhly (*Muhlenbergia montana* (Nutt.) Hitchc.), blue grama (*Bouteloua gracilis* (H.B.K.) Lag.), and carex (*Carex helophila* Mackenz.). Fringed sagebrush (*Artemisia frigida* Willd.), pussytoes (*Antennaria* spp.), and trailing fleabane (*Erigeron flagellaris* A. Gray) are the most abundant forbs.

Design for the study was a split-plot of herbicide and fertilizer treatments applied to a randomized block on grazing treatments with three replications. The five main plot treatments for grazing (Fig. 2) were as follows:

1. Spring only grazing (May 1–July 1)
2. Fall only grazing (September 1–October 31)
3. Spring-fall alternate use. (Dates same as 1 and 2 above, with grazing in spring first year followed by fall grazing the next year)
4. Season-long grazing (May 1–October 31)
5. Protected from grazing

Since the primary objective was to hasten recovery, grazing of each treatment was designed to take advantage of the characteristic July-August precipitation to promote maximum plant growth. Except for season-long use, grazing treatments were not applied during these months because they could confound the effects of moisture with seasonal grazing.

Within each main plot, four split-plot treatments were applied as follows (Fig. 2):

1. (f) Fertilized
2. (s) Sprayed (2,4-D)
3. (b) Fertilized-sprayed (combination of 1 and 2 above)
4. (n) Control treatment (no fertilizer or spray)

Split plot treatments were applied once during the last week of May 1968. Soil temperatures at the time of application were about 50°F at the 24-inch depth, and ranged to as high as 60°F near the surface. A butyl ester of 2,4-D was applied at approximately 2.5 lb acid equivalent per acre. Fifty pounds each of elemental N, P, and K per acre were applied to the fertilizer treatments.

Grazing of the main plots was controlled by letdown fences (Fig. 2). The pasture was stocked to maintain a rather heavy degree of use comparable to the 55% average use established for pasture No. 1 since its inception in 1940 (Smith, 1967). No attempt was made to control the degree of use on either the main or subplot treatments. Percent utilization was estimated for Arizona fescue and mountain muhly on completion of grazing in each treatment area. Utilization was expected to be uniformly heavy and self-limiting by the shortness to which animals could graze the major forage plants.

Each main plot was one-half acre in size. The split-plot areas within a main plot each measured 75 ft by 75 ft. To avoid border effects, sampling was restricted to the 50-ft-square area in the center of each split plot.

Density and cover of all perennial species were measured on five 20-ft transects in each split plot. A 20-ft steel tape graduated in 1/10- and 1/100-ft increments was stretched between permanently established angle-iron stakes. Basal intercept of all perennial plants was recorded on graph paper to provide information on changes in composition, aggregation, dispersal, and plant crown size as a result of treatment.

Density of perennial plants was determined by counting plant numbers in a 1-ft belt along the same transect lines using two contiguous placements of a 1- by 10-ft plot frame. Plants with one-half or more of their basal diameters within the frame were counted. For trailing fleabane or similar trailing species, only the central "mother" plant was counted unless it was definitely established that new plants were separate, independent entities.

Both cover and density were measured in 1967 prior to treatment. Cover was remeasured by the charted line intercept method in 1968 and 1971. Density counts were again taken in 1969. Data were analyzed by covariance to evaluate changes in cover and density resulting from grazing and cultural treatments.

Herbage yields were estimated each year of the study using an herbage meter and the methodology described by Neal et al. (1976). Herbage yield was sampled on 10 plots in each split-plot treatment. Plots in grazed treatments were protected by steel agronomy cages which were moved to new locations within the split-plot areas each year. Plants from clipped plots were oven dried at 105°C before weighing. Differences in yield estimates from the treatments were evaluated by analysis of variance.

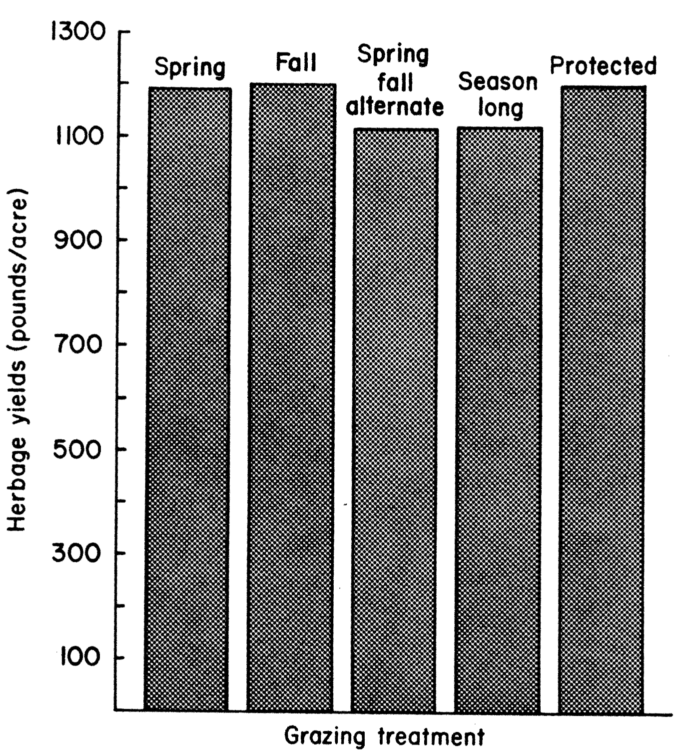


**Fig. 3.** *Herbage yield in relation to grazing treatment. Values are average of 4 post-treatment years.*

## Results and Discussion

There were no significant differences in total herbage yields as a result of grazing treatment. Total dry weight yields averaged between 1,100 and 1,200 lb per acre in each of the treatments (Fig. 3). Yield responses between treatments were consistent each year of the study, and the year by treatment interaction was not significant. Yields increased some each year for the first 3 years of treatment, then decreased considerably the fourth year (Table 1). Yields the fourth year were much lower because rainfall during June, July, and August averaged 2 to 5 inches less than for the same months in the 3 preceding years.

**Table 1. Total herbage yields (pounds per acre) of native bunchgrass ranges in relation to grazing treatment.**

| Grazing treatment | 1968 | 1969 | 1970 | 1971 | Average |
|---|---|---|---|---|---|
| Spring | 1,085 | 1,513 | 1,400 | 765 | 1,191 |
| Fall | 1,120 | 1,606 | 1,420 | 658 | 1,201 |
| Spring-fall alt. | 1,019 | 1,473 | 1,387 | 588 | 1,117 |
| Season-long | 1,193 | 1,474 | 1,272 | 538 | 1,119 |
| Protected | 1,054 | 1,425 | 1,555 | 754 | 1,197 |

Yields in the subplots were significantly different as a result of the cultural treatments applied, and year by treatment interaction was significant. Fertilization more than doubled total yields the first year following treatment, while spraying with 2,4-D reduced yields below that of the control (Table 2). Yield from the fertilizer-spray combination was 1,627 lb per acre, intermediate between yields from the control and fertilized plots. By the second year, following treatment, yields from plots sprayed with 2,4-D exceeded those of the control. The dry weight of herbage produced on the sprayed plots was almost as large as that from the fertilized or fertilized-sprayed plots during the third and fourth years. After the first year, all treatments consistently produced more herbage than the control.

**Table 2. Total herbage yields (pounds per acre) from native bunchgrass ranges in relation to cultural treatments.**

| Cultural treatment | 1968 | 1969 | 1970 | 1971 | Average |
|---|---|---|---|---|---|
| Fertilized | 2,110 | 1,778 | 1,477 | 686 | 1,513 |
| Sprayed | 690 | 1,151 | 1,407 | 646 | 973 |
| Fert.-spray | 1,627 | 1,965 | 1,595 | 765 | 1,488 |
| Control | 1,044 | 1,099 | 1,148 | 546 | 959 |

Yield differences due to the cultural treatments are best illustrated by first-year results (Table 3). Herbicide treatment resulted in an increase in yield of some of the grass species, but death of some forbs reduced forb yield. Fertilization produced highly significant yield increases for all species. Blue grama increased significantly and fringed sagebrush decreased from a combination application of fertilizer and 2,4-D.

Yields for the second and third years followed a similar trend, except difference in mean yield from a combination fertilizer-herbicide application was not significant for either species or total after the second year. By the fourth year of treatment none of the individual species or groups increased significantly in yield over those measured in the control treatment. Cumulative total yields for all species, however, increased significantly over those of the control by 106 lb per acre where plants were fertilized and 116 lb per acre in the spray treatment.

**Table 3. Dry weight yields and main effects of fertilizer and spray treatments on species and plant groups (pounds per acre) 1968.**

| Measurement and cultural treatment | Arizona fescue | Mountain muhly | Blue grass | Fringed sage-brush | Other grasses | Other forbs | Total |
|---|---|---|---|---|---|---|---|
| Yield | | | | | | | |
| Fertilized | 116 | 472 | 430 | 461 | 131 | 500 | 2,110 |
| Sprayed | 75 | 216 | 339 | 7 | 29 | 24 | 690 |
| Fert.-spray | 198 | 555 | 714 | 10 | 83 | 67 | 1,627 |
| Control | 65 | 245 | 213 | 133 | 37 | 351 | 1,044 |
| Main effect on yields | | | | | | | |
| Fertilized | 87** | 283** | 296** | 165** | 74** | 96** | 1,002** |
| Sprayed | 46* | 27 | 205** | −289** | −28 | −380** | −419** |
| F × S (interaction) | 36 | 56 | 79* | −162** | −20 | − 53 | − 63 |

*Significant 0.05.
**Significant 0.01.

Total plant density did not change significantly from any grazing treatment between the initial measurement in 1967 and remeasurement in 1969. Only Pennsylvania and horse cinquefoil (*Potentilla pennsylvania* and *P. hippiana*) showed a density change in response to grazing. These species averaged about two plants per square foot on plots grazed in spring or season-long, compared with one plant or less per foot on the fall, spring-fall alternate, or protected treatments.

In 1969, total densities of grasses and forbs, adjusted by covariance, differed significantly as a result of the cultural treatments (Table 4). The density of forbs was reduced, as expected, about 65 to 75% by the herbicide or fertilizer-herbicide treatments. A few more plants were killed where herbicide was applied alone than when it was applied in combination with fertilizer, but these differences were not significant.

**Table 4. Total density of grasses and forbs and main effects of cultural treatment on densities (plants per square foot). (Means of 1969 data adjusted by covariance.)**

| Measurement and cultural treatment | Grasses | Forbs |
|---|---|---|
| Density | | |
| Fertilized | 13.3 | 19.5 |
| Sprayed | 16.1 | 5.7 |
| Fert.-spray | 15.2 | 8.3 |
| Control | 15.0 | 22.7 |
| Main effect on densities | | |
| Fertilized | −1.31* | .29 |
| Sprayed | 1.49* | −14.06** |
| F × S (interaction) | .38 | 2.91** |

*Significant 0.05.
**Significant 0.01.

Density of grasses also increased significantly in the herbicide treatment compared to the control. The average increase of slightly more than one plant per square foot was quite small. All grass species showed a slight density increase, and cumulatively they accounted for the total being significant. Presumably the increase of the grass species was brought about by reduction in forb competition.

Applying the NPK fertilizer significantly reduced grass density. Some of this may have been a true reduction in plant numbers due to the nitrogen. Most of the difference, however, was due to aggregation of individual plants. Measurement of basal area showed crown growth of blue grama increased substantially, for instance, and caused an aggregation of individual

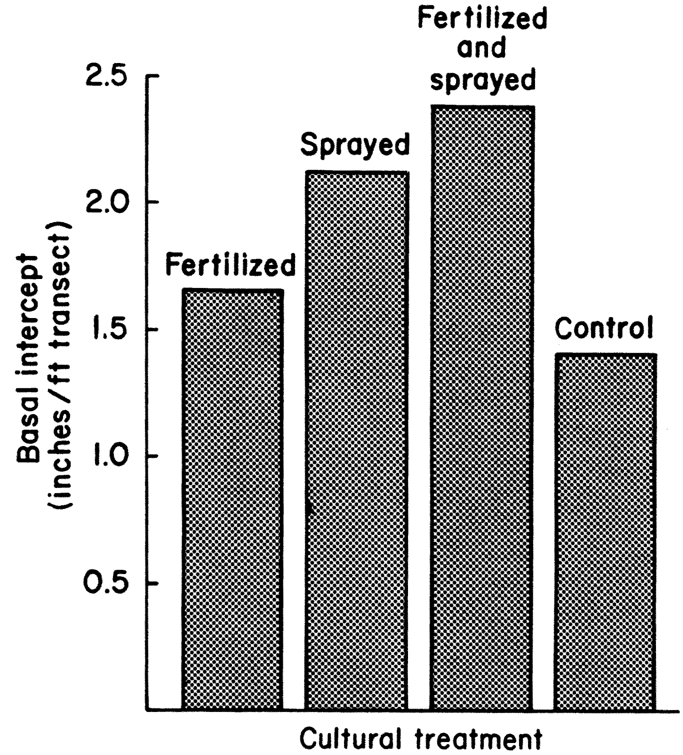


**Fig. 4.** *Total basal area of plant species in relation to cultural treatment. Values based on adjusted means of covariance analysis. 1967 pre-treatment, 1971 post-treatment measurements.*

small clumps into fewer but larger plants.

Basal intercept of plant species increased over that of the control in each of the cultural treatments (Fig. 4). Plants in the combination fertilizer-herbicide treatment increased more—their basal areas occupied almost one inch more per foot of distance than plants in the control treatment. Plants in the sprayed-only and fertilizer treatments had basal areas which occupied three-fourths and one-half inch more per foot of distance, respectively, than those of the control. There were no differences in total basal area of plants due to grazing treatments.

Cultural treatments were very effective in promoting basal area increases in a short time period. Fertilizer and herbicide applied together caused the largest percentage increase (Table 5). In this treatment, basal area of sedges and two grass species

**Table 5. Percent increase or decrease, by main effect, in species density and basal area (BA) from cultural treatments.**

| Species | Fertilized | | Sprayed | | Fert.-spray | |
|---|---|---|---|---|---|---|
| | Density | BA | Density | BA | Density | BA |
| Grasses | | | | | | |
| Arizona fescue | 11 | −57 | 55 | 34 | 0 | 124 |
| Mountain muhly | − 7 | 39 | 16 | 61 | 4 | 49 |
| Blue grama | −20 | 37 | 3 | 83 | −15 | 108 |
| Sedges | − 6 | 71 | 11 | 30 | 29 | 116 |
| Other grasses | − 9 | 15 | 25 | 54 | 19 | 70 |
| Forbs | | | | | | |
| Fringed sagebrush | 23 | 64 | −73 | −56 | −63 | −33 |
| Pussytoes | −18 | −43 | −62 | −88 | −58 | −82 |
| Sandwort | 7 | −38 | 17 | −24 | −15 | 11 |
| Trailing fleabane | −26 | −36 | −94 | −83 | −91 | −72 |
| Pennsylvania and horse cinquefoil | 8 | −43 | −42 | −72 | 62 | 18 |
| Other forbs | 22 | −13 | −51 | −46 | −62 | −74 |

increased over 100%. The smallest increase was almost 50% for mountain muhly.

Reduction in forbs less desirable for grazing, such as fringed sagebrush and pussytoes, was not as large in the fertilizer-herbicide treatment as in the herbicide-only treatment (Table 5). In both, however, the percent reduction in plant densities and basal areas was appreciable, particularly for fringed sagebrush pussytoes and trailing fleabane which were by far the most abundant of the less-desirable forbs.

Applying fertilizer caused a decrease in density and an increase in basal area for all grasses but Arizona fescue. This pattern resulted from the grasses aggregating into fewer discernible plants with much larger basal areas. They were mostly plants which were residual but reduced in size and stature from years of heavy grazing. Very few except the Arizona fescue were newly established plants derived from seed. A few new fescue plants did become established, but the density of this species remained low.

Trailing fleabane and pussytoes were both reduced by fertilization. The other major forb, fringed sagebrush, was stimulated by the fertilizer treatment. Both density and basal area increasec substantially.

## Conclusions

Depleted ponderosa pine-bunchgrass ranges in the centra' Rocky Mountains can be effectively brought back to a good level of production in a rather short time through the application of fertilizer and herbicide. The most beneficial effect for livestock forage comes from a combination application of fertilizer and herbicide. Spraying alone is also effective, but grasses require more time to take advantage of removal of forb competition than when fertilizer is also used. Fertilizer alone also increases ground cover and yield, but does so on plants which may not be forage-producing species. It is, however, an effective treatment for simply encouraging ground cover.

The season and systems of grazing management did not influence herbage yields, basal areas, or plant densities during the 5-year test period. No season or system of grazing was any more efficient than any others, including complete protection, in promoting recovery. Thus instituting a complex rotation or management system is a questionable management practice for promoting improvement or recovery of pine-bunchgrass ranges.

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