Plant Succession with Released Grazing on New Mexico Range Lands[1]

LOREN D. POTTER AND JOHN C. KRENETSKY

Chairman and Graduate Assistant, Department of Biology, University of New Mexico, Albuquerque.

Highlight

After 25 years of protection from grazing, grassland plots tripled in percent of ground cover of grasses. Grazed desert grasslands showed continued increases of mesquite. Protection resulted in remarkable increases in grass cover in ponderosa pine and aspen types.

The increased emphasis of the importance of vegetational cover as it affects the watershed value of range and forest lands requires further ecological understanding of plant succession. Throughout the Southwest, with a history of four centuries of grazing by horses, cattle, sheep, and goats, the productivity and vegetational cover have been greatly modified with almost no areas left ungrazed to serve as a standard of the original climax condition. The retrogressions of vegetational cover and composition cannot be attributed entirely to grazing, for no single factor can be all-destructive or singly effective.

A farsighted research program within the U.S. Forest Service recognized the need for establishing protected areas on governmental forest and range lands to evaluate vegetational recovery with removal of grazing of domestic livestock. Fenced range study plots, approximately one acre in size, were located in representative vegetational types throughout the National Forests. In the Southwest these included semi-desert shrub, desert grassland, blue grama plains, pinyon-juniper, pondersoa pine, mixed conifer, and aspen-meadow. They were located on varying slope exposures and soil types. A method of comparative study inside and outside of the livestock exclosures using permanently marked line transects was initiated from 1939 to 1943, and some plots were sampled. Through a cooperative agreement with the Rocky Mountain Forest and Range Experiment Station arrangements were made to reassess the plots after approximately 25 years of grazing protection within the exclosures. The history of the intensity of grazing for each area is incomplete, and certainly indefinite for the area immediate to the plot. However, the rate of grazing has generally been under better control and has been moderate, with one noted exception, since 1940.

In spite of the several centuries of grazing in the Southwest there is little specific knowledge of the vegetation and its succession in New Mexico as indicated by the sparsity of publications; but pertinent ones include those of Gardner and Hubbell (1943), Bostick (1947), Canfield (1948), and Norris (1950). General vegetational descriptions include those of Watson (1912) and Castetter (1956). The desert plains grassland has been discussed by Whitfield and Beutner (1938) and Gardner (1950). Coactions of range animals and livestock on semidesert range land were reported by Norris (1950) and the succession and grazing capacity of clay soils in New Mexico by Campbell (1931). Gardner (1951) gave a complete discussion of creosote bush plains. The pinyon-juniper woodland of New Mexico was analyzed by

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Woodin and Lindsey (1954). More local studies of pinyon-juniper include those of Watson (1912) in north-central New Mexico, Emerson (1932) in the grama grass and pinyon-juniper tension zone of northeastern New Mexico, Howell (1941) in classifying the type in northern New Mexico, Dortignac (1956) in the Upper Rio Grande Basin, and Potter (1957) in a phytosociological study of the San Augustin Plains. Few studies of grazing succession in ponderosa pine and in spruce-fir are available for New Mexico.

A project for obtaining basic information on plant cover, forage productivity, plant succession, water relations, and soil development seemed appropriate at a time when millions of dollars might be saved with additional knowledge of this kind. The need for a thorough ecological knowledge of watersheds has been stressed by Price (1958). Reservoirs behind large dams built at ever larger costs are rapidly filling with silt. Ranchers reminisce about rangelands of swaying grass instead of dust and thistles, and technicians know too few of the answers about the "why" of the cause or the "how" of restoration.

Methods

To gain the quantitative data necessary for this study, permanent, paired plots had been established by placing one inside and one outside of the exclosures. These plots are 100 ft sq in all forests except Cibola, where they are 50 x 100 ft. The plots were marked by permanent iron stakes at the time of installation in 1939-1943. In subjectively establishing the plots an attempt (not always successful) had been made to place the pairs in similar physiographic and vegetational areas and to orient their sides with respect to the four cardinal compass points. Each 100 ft sq plot was divided, and marked by iron stakes, into two 50 x 100 ft subplots. Depending upon the division, the east or north half was designated subplot A, and the west or south half subplot B. An attempt was made to place the bisecting lines at right angles to any physiographic or vegetational changes.

To have experienced field men subjectively locate the study areas and the paired plots is most economical of both time and money. However, the stratified method was used in selecting the position of each transect within the plots. Ten 50-ft long line transects were located in each 50 x 100 ft subplot to duplicate the original positions located by random numbers. These sample locations are permanently recorded.[2]

The method used in the original analysis had to be repeated to make the data comparable. In using Canfield's line interception method all species under the wire are listed and their total linear coverage, in hundredths of a foot, recorded as basal diameter of grasses and herbs but as live-crown cover of shrubs and rosette-forming herbs. The basal measurements allow even grazed plants to be measured and are less likely to be influenced by the stage of development or short-term environmental conditions (Canfield, 1941).

Results and Discussion

A total of 34 different range study plots from the Apache, Carson, Cibola, Gila, Lincoln, and Santa Fe National Forests were analyzed in 1963 and 1964. Unfortunately, because of incomplete original data, destruction of both inside and outside staked plots, or loss of stakes in the grazed plots so that new transects had to be established, only 26 of the 34 plots could be used in the comparative summary analysis. Additional plots for which original transect data were available were not sampled in the field because the fences around the exclosures had not been maintained to prevent livestock grazing, roads had been built across the plots, trees in the plots had been bulldozed, or lumbering in the grazed plot had artifically changed the community and introduced a major variable not in the intent of the original study.

To represent the vegetational changes since 1939, the sampled range study plots for the entire state of New Mexico were divided into six major vegetative types: Grassland, Desert Grassland, Sagebrush, Pinyon-Juniper, Ponderosa Pine, and Aspen. Because the plots of grassland type were within National Forests, which generally include woodland and forest areas, the type is represented by open grassland sites, or meadows, within pinyon-juniper or ponderosa pine zones rather than extensive grasslands below the woodland zone.

In exploratory studies relating to range conditions in the pinyon-juniper zone of the Rio Grande Basin in New Mexico, H. W. Springfield[3] analyzed the woodland study plots and found that at the time of establishment and initial sampling in 1939 or 1940 there was no real difference in the grass density on the plots selected for protection and those for continued grazing treatment.

Grassland Type. — Eight plots are included in this type with elevational ranges from 5,200 to 9,400 ft. The ground cover of grasses increased in both protected and grazed plots in the last 25 years. Generally, only a few grass species of minor importance invaded either the protected or grazed plots; thus, samples of this type showed little benefit of protection through change in floristic composition.

The cover of forbs averages less than 1% and shows no real increase or consistent trend in relation to grazing.

The average coverage of browse decreased in both protected and grazed areas, due principally to the outstanding decrease in snakeweed (*Gutierrezia* sp.) in two of the eight plots. The occurrence of tree species in the browse category is very minor.

The total coverage of the protected plot increased from 12.78 to 23.88%, an increase of 87% in contrast to a 69% increase (10.33 to 17.46%) in total coverage of

[2] *U.S. Forest Service. 1939. Instructions for obtaining field data on ranger study plots. File Report, U.S. Forest Service, Albuquerque, N. Mex. 6 p.*

the grazed plot. That the increased cover was due to grass species is encouraging but appears to be less than one might expect as a result of 25 years of protection from grazing.

Fig. 1 illustrates the 25-year change in a typical grassland stand at 9,400 ft elevation in the upper ponderosa pine-Douglas fir type. The principal increase was due to Thurber fescue *(Festuca thurberi)* and Columbia needlegrass *(Stipa columbiana)*. There is a definite zone of aspen *(Populus tremuloides)* sprout invasion out into the open, grassland part of the protected plot from an old aspen grove contained within the exclosure, (Fig. 1b). These aspen sprouts were less successful in extending across the fence line into the surrounding area which is frequently grazed by sheep.

Desert Grassland Type.—Only two plots of desert grassland having complete data were available for analysis. Although these were both in southern New Mexico at elevations of 5,800 and 6,000 ft, they are quite dissimilar in vegetational composition. Cibola-11 plot is at the southern end of the Black Mountains, near a ranch where the outside plot is crossed by a frequented cattle trail. The entire area is dominated by honey mesquite *(Prosopis glandulosa)* and American tarbush *(Flourensia cernua)*. The Lincoln-17 plot on limestone soil of the Guadalupe Mountains is characterized by *Agave, Yucca,* and *Ceanothus,* and is in a more isolated area of less grazing. The protected plots of both areas show the same increase in grass cover with accompanying decreases in forb and browse cover. Under grazing the grass cover in Cibola-11, which was originally low, decreased further. All previous species were eliminated except fluffgrass *(Tridens pulchellus)*. Within the exclosure several new species occurred in the transect, and there was a dramatic increase of black grama *(Bouteloua eriopoda)* to 95% of the grass cover.

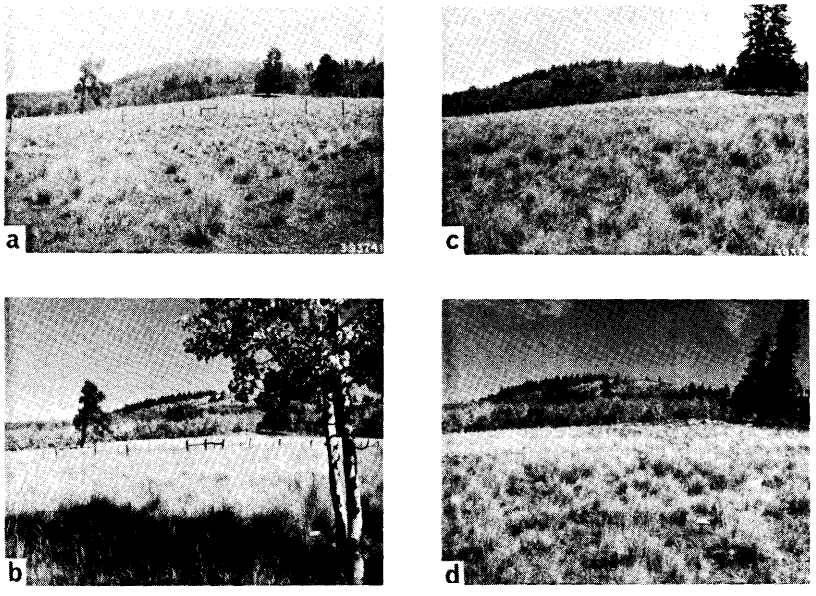

FIG. 1. Grassland at 9,400 ft elevation in upper Ponderosa Pine—Douglas-Fir, Carson 3. Protected: a. 1939, b. 1964. Grazed: c. 1939, d. 1964.

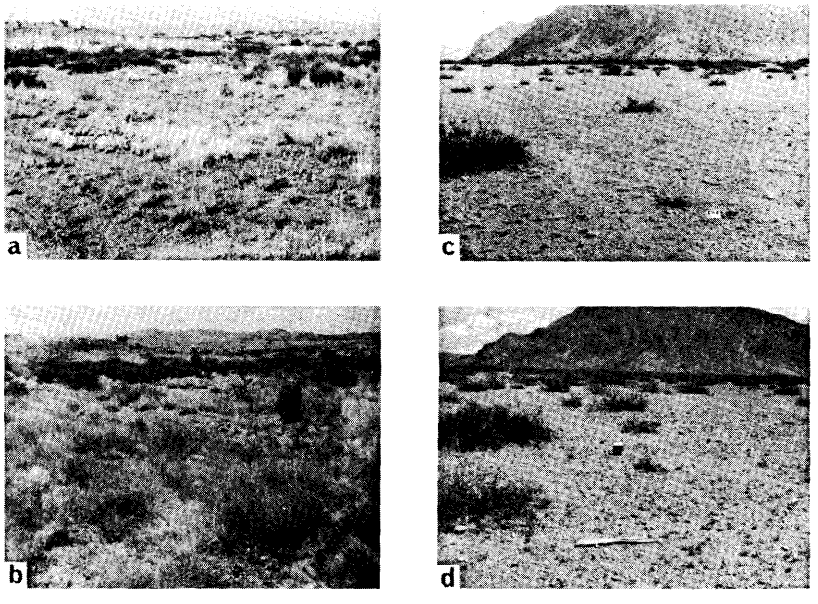

FIG. 2. Desert Grassland at 5,800 ft elevation, Cibola 11. Protected: a. 1943, b. 1965. Grazed: c. 1943, d. 1965.

Forb cover in all transects was very minor and nonindicative.

Browse cover decreased in the protected plots. In the Cibola plot decrease was due to the loss of American tarbush and desert-thorn *(Lycium)* and reduction in honey mesquite. In the Lincoln plot browse decrease was due to the death of many *Agave,* "mountainmahogany" *(Cercocarpus), Opuntia,* and "beargrass" *(Nolina)* which more than counteracted the introduction of one-seed juniper *(Juniperus monosperma)*, pinyon *(Pinus edulis)*, oak *(Quercus)*, skunkbush sumac *(Rhus trilobata)*, and *Yucca* spp. Under grazing, the honey mesquite increased greatly (where it had decreased under protection. The decrease of honey mesquite with protection and its increase with grazing is well illustrated in Fig. 2 (a-d). In the grazed plots, Fig. 2 (c) and (d),

the increase of fluffgrass is also evident. The dense grass cover under protection, Fig. 2 (a) and (b) is floristically less complex but is higher in productivity due to the increased coverage of black grama.

Average total coverage under protection increased about 60% (10.60 to 16.38%) with the relative cover of grasses increasing from 23 to 70% of the vegetation. Although the coverage also increased under grazing (6.34 to 12.55%), there were only slight shifts in the relative cover of grasses, forbs, and browse.

Sagebrush Type. — Although three plots of the sagebrush type were studied, the comparison of change is based on the two plots of Carson—4 and -11 with a 10-year comparison since 1953.

Ground coverage of grass, forbs and browse decreased in all plots, protected and grazed, since 1953. Browse cover decreased more than other growth forms under both protection and grazing, with a greater decrease in the protected plots. Just as the pinyon-juniper type showed serious drought damage by 1956 and 1957, the sagebrush was also in a weakened condition which was further degraded by insect attack. These stands probably had not recovered in 1964 to the level of 1953. The results indicate some advantage of protection in reducing browse cover.

Pinyon-Juniper Type. — The summary of the pinyon-juniper type includes six plots with elevational ranges from 6,100 to 7,800 ft. This is the most extensive woodland or forest zone in New Mexico. In 1953 Springfield[3] found a marked response of herbage production to protection from grazing for 10 to 14 years, with the response being greater on the more open woodland than on dense woodland sites. In general, his results indicated poor possibilities for range improvement in dense woodland and sagebrush woodland by grazing management alone. For example, in dense woodlands the forage production was 180 to 229 lb/acre under protection and 119 to 222 lb under grazing. However, in open woodlands and savanna woodland sites the forage production averaged twice as much under protection as under grazing. The increase was also accompanied by an increase in good perennial grass species, indicating a continuing potential and increased watershed protection.

In this summary, which included pinyon-juniper sites from all over New Mexico, no effort was made to divide the six plots into sub-categories of different arboreal cover. The increase in total coverage of all vegetation was the same in protected and grazed plots.

The total number of species of grasses is higher in this woodland type than in the grassland plots; but, as expected, the grass coverage is lower in the woodland. As in the grassland, blue grama *(Bouteloua gracilis)* is the outstanding dominant. There is indication that prairie junegrass *(Koeleria cristata)*, which is never high in percentage cover, decreases or is eliminated under grazing. The increase in total grass cover is consistently higher under protection than under grazing with the increase since 1939-40 being nearly twice as much.

There is a slightly greater variety of forbs on the grazed plots than on the ungrazed but of minor coverage importance in both.

Browse cover increased under both protection and grazing but is greater under grazing. The increase was due principally to species of juniper and pinyon. As in grasslands, there was a slightly greater increase in the coverage of junipers and ponderosa pine when grazed but a decrease in the coverage of oaks.

The pinyon-juniper type illustrated in Fig. 3 is in the upper part of the zone dominated by pinyon. The comparative photos of 3 (a) and (b) under protection show an increase in brush and tree growth, although the 1953 to 1963 data indicate decreases in coverage of all growth

FIG. 3. Pinyon-Juniper at 7,600 ft elevation, Cibola 6. Protected: a. 1940, b. 1964. Grazed: c. 1940, d. 1964.

[3] *Springfield, H. W. 1959. Exploratory studies relating to range conditions in the pinyon-juniper zone of the Rio Grande Basin of New Mexico. Unpub. report, Rocky Mt. Forest & Range Exp. Sta. 21 p.*

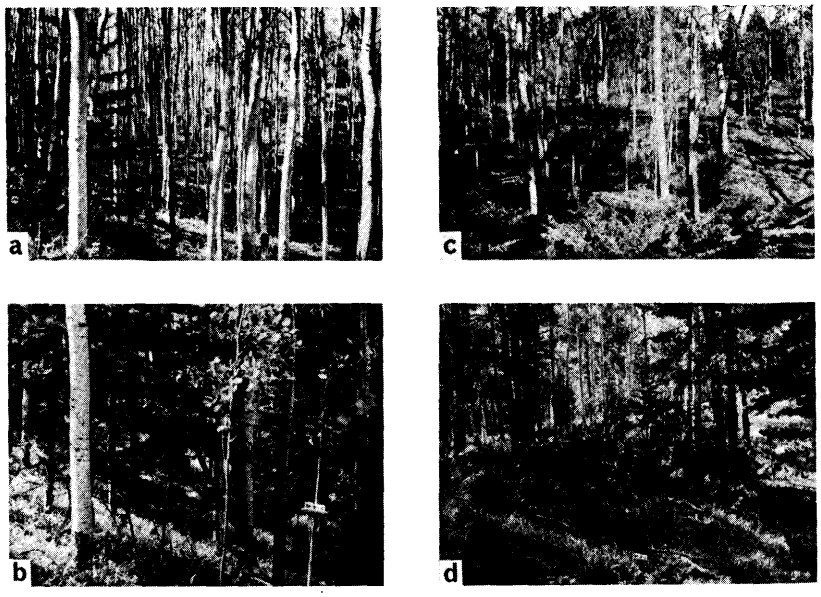

FIG. 4. Aspen at 9,200 ft elevation, Santa Fe 3. Protected: a. 1939, b. 1964. Grazed: c. 1939, d. 1964.

forms. The grazed plots, (c) and (d), appear relatively unchanged.

Ponderosa Pine Type. — Six plots were used in this analysis. Elevations ranged from 6,100 to 9,211 ft. The plots of this type under protection show a definite increase in grass cover which nearly equals the increase in cover of arboreal browse. The grass species of principal importance in the increase are blue grama, Arizona fescue *(Festuca arizonica)*, prairie junegrass and creeping muhly *(Muhlenbergia repens)* of which the first was outstanding in its increase. This is in contrast to the grazed plots where there was only a slight increase in grass and browse cover.

Forbs, of universally minor importance, decreased in all plots whether grazed or not.

The increase in browse cover of 8 and 2%, under protection and grazing, was generally due to the introduction of several woody species of both shrubs and trees with a consistent and principal increase in the cover of ponderosa pine. The definite inhibition of browse increase under grazing was outstanding in this type. This is the only type where ponderosa pine had a greater increase under protection than when grazed. When the species occurred at lower zones in pinyon-juniper and grasslands, it generally increased more on the grazed plots than under protection. This might well be the result of destruction of the grass cover and reduction of its competition so that pine seedlings can become established in years of favorable moisture. The dominance of ponderosa pine *(Pinus ponderosa)* was replaced by Douglas-fir *(Pseudotsuga taxifolia)* in a plot at 9,200 ft which is in the upper part of the ponderosa pine type. Here, under protection, the reproduction of Douglas-fir comprised 23% of the 29% of browse cover while under grazing it was 2% of the total 5%. The Gila plot exemplifies very well the browsing and trampling effect of grazing on the two dominant tree species of the type. It is this influence, along with fire, which produced the "typical open stands of ponderosa pine" so frequently cited in forestry texts. Where protection from fire and grazing have been provided, dense coverages of pine seedlings have developed, as is illustrated by photos taken after 25 years of protection from grazing.

While there was an increase in total cover of 14% under protection, the increase was only 4% under grazing.

Aspen Type.—The only plot of fire subclimax aspen included in the study was at Santa Fe-3 in the area generally burned over by an extensive fire in 1886. The plot is in a site which was probably dominated by a mixed-conifer type before the fire and is located at 9,200 ft elevation.

While the grass cover increased from 0.5 to 11.1% under protection, it increased from 2.2 to only 4.2% under grazing. This is the principal change in growth form resulting in the type. The increase in both treatments was due almost entirely to the introduction and spread of brome *(Bromus* sp.) and prairie junegrass. Of five minor grass species present in 1939, only Kentucky bluegrass *(Poa pratensis)* remained in 1964. It is the coverage of grasses with their extensive fibrous root systems and litter of neutral pH which are principally responsible for the increase of organic matter in the A_1 horizon, which in turn improves the water-holding capacity, the fertility by increasing the percentage of base saturation, the structure, and the permeability. The near-neutral pH of the aspen litter is also an improvement over the acid, resinous litter of conifers. The upgrading of the podsol soils which results from this fire subclimax is a real benefit of burning.

Many new species of forbs are now present; but the outstanding taxon, under both protection and grazing, is vetch *(Vicia)* which comprises about half of the total forb cover.

During the 25-year period there has been little change in the aspen cover as indicated by the transect data or the comparative photos of Fig. 4 (a-d). Photos (a) and (b) within the exclosure illustrate the 25-year

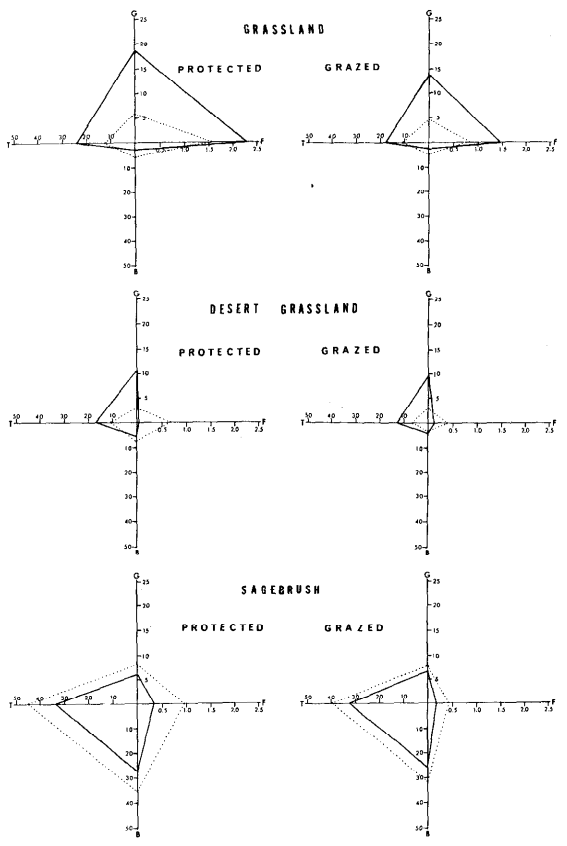

FIG. 5. Polygraphs of grasslands and sagebrush types indicating actual ground cover of grasses (G), forbs (F), browse (B), and total (T). Dotted lines represent initial coverage in 1939-40, solid lines the coverage in 1963-64.

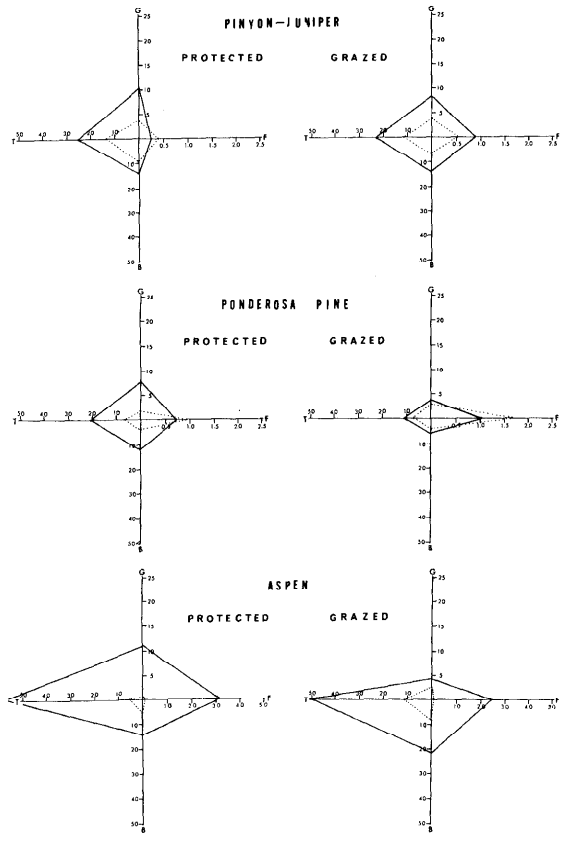

FIG. 6. Polygraphs of woodland and forest types indicating actual ground cover of grasses (G), forbs (F), browse (B), and total (T). Dotted lines represent initial coverage in 1939-40, solid lines the coverage in 1963-64.

growth of individual aspen trees including the configuration of individual lenticels on the smooth-barked aspens. Under protection there was a marked increase in the cover of white fir *(Abies concolor)*. Common juniper *(Juniperus communis)* of the under-story level increased tenfold under both protection and grazing. In the grazed plot, most of the increase in browse cover from 8.4 to 21.5% was due to common juniper.

Under protection the relative cover of grasses increased from 7.4 to 19.4%; while under grazing there was a decrease from 19.8 to 8.3%.

In these plots, it appears that grazing will delay the succession from aspen subclimax to conifers by reducing the rate of reinvasion of white fir and Douglas-fir.

Summary and Conclusions

The best summary of the change in growth form composition can be presented by the use of polygraphs as in Fig. 5 and 6. In clockwise direction from the vertical the radii represent the following: G — average percent ground cover of grasses, F—average percent ground cover of forbs, B — average percent ground cover of browse, and T—total percent coverage. The dotted line represents the composition at the initial time of sampling, 1939 or 1940 (except for the sagebrush plots for which the earliest data available is 1953); the solid line represents the same plots in 1963 or 1964—approximately 25 years later. Only those range study plots having comparative data for the protected and grazed plots were used in this summary.

In the grassland plots the coverage of grasses tripled under protection, with somewhat less increase under grazing. Although the increase from 12.8 to 23.9% total cover under protection may not seem rewarding enough as a gain for 25 years of protection, the doubling of cover in an area of limited rainfall, where root competition for moisture results in spacing of plants, is truly an encouraging ecological trend. The one-third higher grass and total cover under protection vs. grazing is a significant indicator of potential, continuing forage productivity, increased control against surface erosion, and an important factor toward soil improvement.

In the desert grassland plots, as in grassland, both grass and total cover increased. Outstanding was the decrease in forb

cover, especially in the protected plots. Browse decreased slightly under protection while it increased slightly under grazing.

The sagebrush comparisons are with 1953 data which seem to be uniformly high, and both treatments resulted in a decrease of all growth forms during the decade, probably the result of serious drought and insect damage which was observed in 1956 and 1957.

While the increases in total cover and browse were about the same under protection and grazing in the pinyon-juniper type, the grass cover increased nearly three-fold under protection and only slightly more than two-fold under grazing. While forbs decreased under protection, they increased under grazing. The increased forage, as indicated by cover, resulting from protection from grazing in pinyon-juniper is of questionable value.

In the ponderosa pine type protection from grazing resulted in the greatest increase in grass cover of any of the climax vegetational types. Here the grass cover averaged an increase of over five-fold while under grazing the increase was only one-third. The ponderosa pine type was the only one in which woody species, principally ponderosa pine, increased more under protection than under grazing. This is because of the sensitivity of ponderosa pine to grazing, particularly in the seedling stage, and its dominance within the forest type. In contrast, brushy species, commonly with the root-sprouting habit, have been observed to increase in cover with the pruning process of cattle browsing and even trampling. The total coverage produced under protection is twice that under grazing and is a significant benefit in the multiple-use of these forest lands used for grazing, game, lumbering, and watersheds.

In the aspen fire subclimax type the grass cover increased 22-fold under protection and was nearly three times greater than when grazed. The lower increase in grasses under grazing was balanced, however, by a greater increase of browse cover so that total coverages were similar. The aspen stand, approximately 75 years old, was in a stage of successional recovery toward mixed-conifer represented by white fir and Douglas-fir which had not yet reached the tops of the healthy aspen trees; nor had they produced enough cover and litter to have had much influence on the ground cover, litter or soil development. Under the deciduous tree regime with greater light penetration and more nearly neutral litter the grasses have probably reached their peak in coverage and productivity.

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NOTICE

There will be a business meeting of the Society at the Santa Barbara summer meeting on July 19.

C. Wayne Cook, President