Influences of Grazing and Fire on Vegetation and Soil of Longleaf Pine-Bluestem Range

VINSON L. DUVALL AND NORWIN E. LINNARTZ[1]

Principal Range Scientist, Southern Forest Experiment Station, Forest Service, U.S.D.A., Alexandria, Louisiana; and Associate Professor of Forestry, School of Forestry and Wildlife Management, Louisiana Agricultural Experiment Station, Baton Rouge.

Highlight

Herbage yield and density of cover were greater on moderately or heavily grazed than on ungrazed range. Botanical composition remained relatively constant under moderate use but changed markedly on ungrazed and heavily grazed ranges. Grazing compacted soils, but insufficiently to impair herbage growth or accelerate erosion. Fire had little long-range effect.

A fire in late winter or early spring has been reported to improve accessibility, stimulate growth, and increase nutrient content of new herbage on longleaf pine-bluestem range (Campbell et al., 1954). Grasses are generally utilized heavily the first year after burning, but less intensely during the second.

Effects of grazing pressures and burning on forage vegetation and soils were assessed in a 12-year study on Louisiana range. Influences of experimental treatments on herbage yield and litter accumulation during the first 8 years were published in an earlier issue of the Journal (Duvall, 1962). This paper presents final results and reports changes in ground cover, botanical composition, and physical properties of soil as induced by grazing.

Procedure

The area of study, on the Palustris Experimental Forest in central Louisiana, slopes 2 to 5% and has deep, medium-textured soils chiefly of Bowie silt loam but with some Beauregard silt loam. Internal drainage is moderate to slow. Annual rainfall averages 58 inches; all months except October exceed 4 inches.

The longleaf pine (*Pinus palustris*) forest was cut more than 20 years before the study described here began in 1952, leaving relatively open grassland. Slender bluestem (*Andropogon tener*) and pinehill bluestem (*A. divergens*) were dominant grasses. Panicums (*Panicum* spp.), paspalums (*Paspalum* spp.), and miscellaneous bluestems were also prominent. Carpetgrass (*Axonopus affinis*) inhabited small, heavily grazed areas.

Before 1951, the range was open to unregulated grazing, and wildfires were frequent. Effects of prior burning and grazing were indeterminable.

For this study, eighteen ⅓-acre paddocks were constructed on a site that had been burned by wildfire a year previously. Intermittent grazing by cows and calves began in April 1952, and averaged 140 days a year. Through 1960, six paddocks were grazed heavily, six were grazed moderately, and six were ungrazed. Moderate grazing aimed at utilizing 40 to 50% of current herbage averaged 15 animal-unit days per paddock per year, while heavy grazing averaged 30 animal-unit days.

[1] *We are indebted to Chung-Yun Hse, formerly Research Assistant, School of Forestry and Wildlife Management, Louisiana State University, for soil property determinations and statistical analyses of a portion of the study data.*

During 1955, six paddocks were burned by controlled backfire in January, six were burned by controlled headfire in March, and six remained unburned. The grazing-burning combinations were replicated twice in a split-plot factorial, making a total of nine combinations. In 1960 backfire was eliminated and only the headfire was repeated, since no important differences had been detected between the two burning methods following initial application. After 1960, grazing was discontinued on blocks that had originally been backfired. Herbage measurements were omitted on these blocks after 1959. Thus, during the final 4 years of study, burning-grazing combinations totaled six.

Herbage production and litter were measured at the end of each growing season by procedures described by Duvall (1962). Ground cover and species composition were determined in the fall in 1952, 1957, and 1963 by use of a modification of the line-loop frequency procedure described by Parker and Harris (1959). Four 66-ft transects were permanently located in each paddock. Cover components were recorded for each of 100 ¾-inch circular plots per transect.

In 1962 rate of water infiltration into soil was measured (Leithead, 1950), and soil samples were taken from 0- to 4-inch, 6- to 10-inch, and 12- to 16-inch depths on all paddocks. Laboratory determinations were made of specific gravity (Jenkins, 1947); texture (Patrick, 1958); bulk density; percolation rate (U.S. Salinity Laboratory Staff, 1954); and distribution of pore sizes (Hoover et al., 1954).

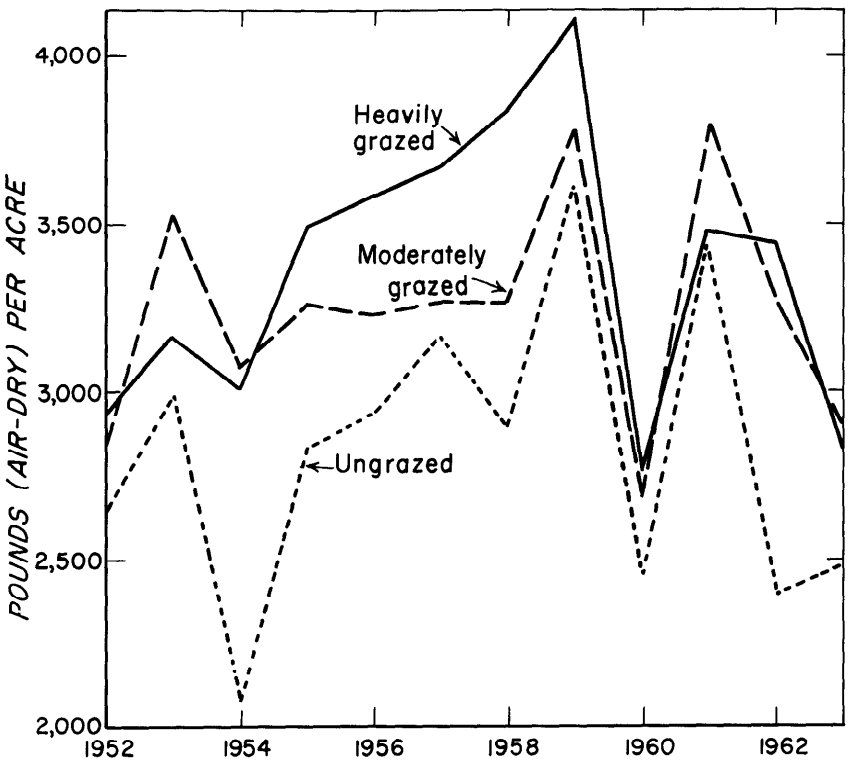

FIG. 1. Grass production, by grazing intensities.

Results and Discussion

Herbage Utilization. — In the 12-year test, herbage utilization averaged 67% on heavily grazed range and 46% on moderately grazed range. Thus, herbage removal under heavy grazing was only about 1.5 times greater than under moderate grazing, although twice as many animals grazed.

Herbage disappearance averaged 34 lb (air-dry) per animal-unit day under moderate, and 26 lb under heavy grazing. Undoubtedly, trampling and wastage was greater under heavy use, but the cattle in moderately grazed paddocks apparently consumed substantially more herbage than those in heavily grazed paddocks. In the heavily grazed paddocks, animals were evidently forced to utilize less palatable herbage and therefore ate less. Also, palatability loss by excreta was greatest on heavily grazed range.

Grass Production.—Grass comprised 97% or more of the herbage under all grazing intensities. The remainder consisted of forbs, except for a few grasslike plants and shrubs.

In the fall of 1952, grass yields were about the same on lands that had been grazed heavily, moderately, or not at all. Within 2 years, however, production on grazed range exceeded that on the ungrazed range by almost 1,000 lb/acre (Fig. 1). After the burn in 1955, the difference between grazed range diminished. For the 12-year period, grass averaged 3,239 lb/acre in moderately grazed paddocks and 3,351 lb in those heavily grazed. These values did not differ statistically, but they exceeded, at the 0.05 level, the 2,828-lb average on ungrazed range. Low yields for all grazing levels in 1954, 1960, and 1963 were attributable to less than average rainfall.

While yields on moderately and heavily grazed paddocks did not differ significantly during the entire study, they differed during the period 1955-59 (Duvall, 1962). Thus, intense grazing benefited production between the third and eighth years, but not thereafter.

Over the 12-year period, fire did not greatly influence grass production. Burning in 1955 significantly increased yields in ungrazed paddocks during the next three growing seasons, but grazed range was unaffected. The difference is attributed to reduction of litter: in an earlier study (Wahlenberg et al., 1939), both slender bluestem and pine-

Table 1. Indices of main cover classes (in percent), by grazing intensities.

Ground cover classes,	Ungrazed				Moderately grazed				Heavily grazed			
	1952	1957	1959	1963	1952	1957	1959	1963	1952	1957	1959	1963
Vegetation												
Grasses	44.1	34.5	20.7	27.1	43.7	44.2	33.2	36.5	49.2	48.7	47.1	48.0
Grasslike plants	1.6	2.1	.8	.6	1.8	1.9	1.0	1.0	1.6	2.7	1.1	1.0
Forbs	3.2	3.9	2.4	1.4	2.5	4.9	3.3	2.0	2.2	4.2	4.1	1.5
Woody plants	.2	.2	.1	.1	.1	.1	0	0	0	0	0	.1
Total	49.1	40.7	24.0	29.2	48.1	51.1	37.5	39.5	53.0	55.6	52.3	50.6
Nonliving												
Herb litter	19.7	56.5	48.2	54.1	21.8	42.9	24.3	26.6	19.8	38.3	12.7	8.4
Woody-plant litter	3.7	2.1	4.7	3.6	2.2	2.1	4.1	1.4	2.6	1.8	1.3	.8
Fecal matter	.5	0	0	0	.9	1.4	1.3	1.2	1.5	1.9	2.3	2.7
Total	23.9	58.6	52.9	57.7	24.9	46.4	29.7	29.2	23.9	42.0	16.3	11.9
Bare soil	27.0	.7	23.1	13.1	27.0	2.5	32.8	31.3	23.1	2.4	31.4	37.5

hill bluestem were smothered by heavy accumulation of plant debris. But in 1960, burning a large volume of litter did not aid grass production even though litter materially exceeded the 1955 level. During the growing season following fire, yield was more than 800 lb/acre greater in ungrazed paddocks that were not burned than in the burned, ungrazed paddocks. This contrary result is attributed in part to sparse rainfall during the ensuing spring—less than half the long-term average—and possibly in part to the high volume of fuel, which generated enough heat to impair the regrowth of the vegetation.

Litter.—After the 1955 fire, litter averaged about 4,400 lb/acre annually on ungrazed paddocks, 2,100 lb on the moderately grazed, and 1,200 lb on the heavily grazed. These differences were significant at the 0.05 level.

Although each fire destroyed about 1,500 lb/acre on heavily grazed range, 2,500 lb on the moderately grazed range, and 5,000 lb on the ungrazed range, accumulations were near preburning levels within 2 or 3 years. For the 12-year period, therefore, burning did not significantly alter quantity of litter. Ungrazed paddocks: unburned averaged 4,748 lb/acre annually and burned, 4,070 lb. Grazed paddocks: litter from unburned paddocks averaged only about 150 lb/acre greater than from burned paddocks.

Although yearly additions on unburned, ungrazed range averaged nearly 2,800 lb/acre, maximum accumulation — measured in 1956—was only about 5,650 lb/acre. The 12-year buildup totaled slightly more than 3,000 lb/acre, with all but 600 lb consisting of new litter. From this it can be seen that dead herbage deteriorated rapidly; after litter accumulations reached 5,000 to 6,000 lb/acre, decomposition equaled or exceeded additions.

Ground Cover.—After the first grazing season, ground cover indices of live vegetation were similar for all use levels (Table 1). They varied only from 48% on moderately grazed range to 53% on heavily grazed range.

During the ensuing 11 years, plant cover declined to 29% on ungrazed paddocks and 40% on the moderately grazed paddocks. Reduction in grass density largely accounted for these changes. Under heavy use, total plant cover and cover by grasses alone remained relatively constant throughout the trial.

Greater density of grasses on grazed paddocks probably accounted for the greater yield of these paddocks. Without grazing, litter and standing herbage apparently impaired establishment and growth of grass seedlings, thereby largely restricting production to older, widely spaced bunchgrasses.

Nonliving cover was mainly herb litter. Ground cover indices of both old herbage and woody plant litter were greatest on ungrazed paddocks, lowest on those heavily grazed. Cattle feces covered slightly more ground on heavily grazed than on moderately grazed range.

Vegetational cover was affected little by burning. Although each fire eliminated most of the nonliving material, these reductions were undetectable in the transect data because measurements preceded burning.

Botanical Composition.—Proportions of the major herb classes remained relatively constant, irrespective of grazing intensity (Table 2). Throughout the study, approximately 85 to 95% of the total vegetation consisted of grasses.

Although total grasses were little affected by grazing, several

Table 2. Botanical composition (in percent), by grazing intensities.

Herb classes	Ungrazed				Moderately grazed				Heavily grazed			
	1952	1957	1959	1963	1952	1957	1959	1963	1952	1957	1959	1963
Grasses												
Slender bluestem	38.9	29.0	16.8	14.7	44.5	32.5	30.2	23.5	41.1	35.8	23.3	28.2
Pinehill bluestem	22.4	29.7	38.3	54.1	23.5	17.6	17.6	31.1	22.8	12.4	8.6	10.0
Carpetgrass	.2	0	0	0	.4	.8	2.9	6.3	.6	4.5	14.5	38.5
Threeawns	1.2	4.7	7.1	1.0	2.1	18.3	19.7	1.5	1.7	17.8	15.5	2.4
Panicums	10.2	10.3	13.0	6.5	6.7	8.0	6.1	3.0	6.2	7.0	5.4	2.2
Cutover muhly	.6	1.0	2.1	5.1	0	.2	0	.2	0	0	0	0
Misc. bluestems	7.2	4.2	3.6	4.2	4.6	3.1	5.8	18.8	8.3	4.6	15.7	9.3
Other grasses	9.1	5.8	5.4	7.2	9.1	6.0	6.2	7.8	12.1	5.6	7.1	4.2
Total grasses	89.8	84.7	86.3	92.8	90.9	86.5	88.5	92.2	92.8	87.7	90.1	94.8
Grasslike plants	3.3	5.2	3.3	2.1	3.7	3.7	2.7	2.5	3.0	4.8	2.1	2.0
Forbs	6.5	9.6	10.0	4.8	5.2	9.6	8.8	5.0	4.2	7.5	7.8	3.0
Woody plants	.4	.5	.4	.3	.2	.2	0	.3	0	0	0	.2

important species showed marked responses. Slender bluestem, which comprised more of the vegetation than any other species in 1952, decreased under all grazing intensities. Reduction was greatest, however, on ungrazed paddocks. Reasons for these changes are uncertain, but vegetation present when the experiment began had been influenced by unrestricted, yearlong use and frequent burning.

Pinehill bluestem, which ranked second to slender bluestem when the study began, increased steadily on ungrazed paddocks, changed little under moderate use, and declined appreciably on heavily grazed range.

The only other species to show important reactions to grazing intensity was carpetgrass, which comprised only a trace of the vegetation in 1952. Although this species subsequently disappeared from ungrazed range, it increased on grazed range, particularly on that used heavily. Thus, after 11 years of utilization averaging 67%, the proportion of this stoloniferous sod-former equaled that of the two principal bunchgrasses combined. Production was greatest in paddocks having the highest proportion of carpetgrass, and consequently the greatest vegetation density.

Generally, threeawn grasses were more common in grazed than in ungrazed paddocks. Since proportions fluctuated widely from one transect inventory to the next, response of these grasses to grazing intensity was difficult to assess. Slimspike threeawn *(Aristida longespica)*, an annual, accounted for much of this variation. Proportions of arrowfeather threeawn *(A. purpurascens)*, the only perennial threeawn encountered, were little affected by grazing.

Frequency of miscellaneous panicums — mainly spreading panicum *(Panicum rhizomatum)* roundseed panicum *(P. sphaerocarpon)*, narrowleaf panicum *(P. angustifolium)*, and woolly panicum *(P. lanuginosum)*—was greater on ungrazed than on the moderately or heavily grazed range. However, differences owing to grazing intensity appeared small and relatively unimportant.

Except for cutover muhly *(Muhlenbergia expansa)*—a low-value perennial that increased on ungrazed range—no other grass comprised as much as 5% at either the beginning or end of the study. The principal tall grasses, big bluestem *(Andropogon gerardii)*, indiangrass *(Sorghastrum nutans)*, and switchgrass *(Panicum virgatum)* showed little response to protection from grazing. These species are often among the first to decrease under heavy use, and are therefore generally expected to increase after grazing ceases. On paddocks ungrazed for 12 years, however, they collectively comprised less than 2% of the vegetation.

Grasslike plants, largely pinehill beakrush *(Rhynchospora globularis* var. *recognita)*, were affected little, if any, by grazing.

The forb population remained reasonably stable throughout the experiment. The failure of forbs to increase under heavy grazing was somewhat surprising, because weedy species usually infest areas of concentrated use. Bitter sneezeweed *(Helenium amarum)*, woolly croton *(Croton capitatus)*, and dogfennel *(Eupatorium capillifolium)* are especially common on overgrazed areas. Since none of these was encountered on transects in heavily grazed paddocks, utilization exceeding 65 to 70% is apparently necessary for their establishment.

With the exception previously noted, changes in botanical composition generally proceeded in orderly fashion. Under moder-

ate use, however, miscellaneous bluestems increased sharply between 1959 and 1963, owing mainly to a 20-fold upsurge in paintbrush bluestem *(Andropogon ternarius)*. In 1959, the proportion of fineleaf bluestem *(Andropogon subtenuis)* on heavily grazed range was about three times as great as in either 1957 or 1963, causing a substantial increase in miscellaneous bluestems. This discrepancy probably reflects errors on identification, as distinguishing between slender and fineleaf bluestems is extremely difficult when plants are closely cropped. Thus, in 1959, the true index for slender bluestem undoubtedly exceeded 23.3% while that for miscellaneous bluestem was probably considerably less than 15.7%.

Transect data collected in 1963 on paddocks that were released from grazing after 1960 revealed notable changes in botanical composition. In paddocks that had been grazed moderately, the proportion of pinehill bluestem was about twice the 1959 level. On range that had been grazed heavily, this species increased sixfold. In general, the changes paralleled those during nonuse beginning in 1952, but the rate of increase was much faster between 1959 and 1963.

On range grazed heavily for 9 years, carpetgrass diminished rapidly after use ceased. It comprised more than 15% of the vegetation in 1959, but only about 3% in 1963, suggesting that this low, spreading type cannot persist where it is overtopped by taller herbs. Proportions of other grasses changed little after grazing was discontinued.

Botanical composition was affected little by burning. When the study ended, the proportion of pinehill bluestem was greater in burned than in unburned paddocks, while unburned paddocks contained more carpetgrass than those burned. Similar relationships existed, however, when the plots were established.

Physical Properties of Soil.— None of the soil properties evaluated was significantly altered by burning. This section summarizes changes in soil as a result of grazing. Complete data may be seen in the Journal of Forestry (Linnartz et al., 1966).

Grazing increased soil bulk density significantly, at the 0.05 level, in all layers. Moderate use for 10 years increased bulk density 5% in the surface layer, 2% at the 6- to 10-inch depth, and 1% at the 12- to 16-inch depth. On heavily grazed range, bulk densities increased 7, 4, and 2%. Compaction consistently reached the 16-inch depth, but deeper sampling might have detected even greater penetration, for Rhoades et al. (1964) reported that grazing increased bulk density 3 ft below the surface in sandy soil.

On ungrazed range, total pore space was greater at all depths than on grazed range, but differences were significant in only the two upper layers. Grazing heavily decreased total pore space from 47.0 to 43.4% in surface soil and from 42.5 to 40.4% in the 6- to 10-inch layer. Under moderate use, pore volume decreased 2.4 percentage points in surface soil, but only 0.1 percentage point at the 6- to 10-inch depth.

Large pore volume differed significantly at all depths among areas grazed at different intensities. In the 0- to 4-inch and 12- to 16-inch layers, volumes were greatest in ungrazed and least in heavily grazed paddocks. At the 6- to 10-inch depth, however, large pore space was greatest under moderate use. Greater porosity could not result from grazing, leaving only the explanation that a chance variation in soil structure was the cause of it.

Surface soil had the greatest volume of small pores in heavily grazed and the least in moderately grazed paddocks; deeper layers were unaffected by grazing. The increase in small pores and the reduction in large pores under heavy use suggests that large pores were transformed into small ones. Trampling attending moderate use did not produce this effect.

Percolation through the surface layer was not significantly impaired by trampling, despite a substantial reduction in large pores under heavy use. Aggregation of surface soils, as evidenced by low bulk densities, was probably responsible. In the 6- to 10-inch layer, percolation was slower in heavily grazed than in ungrazed and moderately grazed paddocks. Thus, percolation rate and large pore volume were similarly related to grazing intensity.

On grazed range, compaction of the 12- to 16-inch layer materially restricted the movement of water through the profile. On ungrazed range, water percolated through this layer at 0.242 in/hr whereas percolation under moderate and heavy use averaged only 0.145 and 0.133 in/hr. From this it is clear that grazing could materially accelerate runoff during prolonged rains; with the surface foot saturated, runoff could be 40 to 45% greater in grazed than in the ungrazed paddocks.

Infiltration rates were lowest on heavily grazed and highest on the ungrazed range. During the first 30 min, for example, infiltration averaged 2.26 in/hr in ungrazed paddocks, and 1.39 in/hr under moderate and 1.03 in/hr under heavy grazing.

In the study area, storms yielding 1.4 to 1.6 inches of rain in 30 min average once annually (Hershfield, 1961). Ungrazed range can absorb most of the rainfall from such storms, unless

pre-storm level of moisture in surface soil is high. On heavily grazed range, however, a substantial portion would be lost as runoff.

Although grazing slowed the movement of water into and through the soil profile, thereby increasing runoff, it did not appreciably accelerate loss of topsoil. No evidence of gullying or sheet erosion was observed in measuring transects. Moreover, soil texture did not vary significantly among the areas under different grazing pressures. If grazing had accelerated erosion, the proportion of sand in the surface layer should have been greater on grazed than on ungrazed range.

Conclusions

Grazed range consistently yielded more herbage than ungrazed range. During a substantial portion of the study period, production was greater under heavy than under moderate use. These findings are generally contrary to those reported from bluestem range areas receiving less rainfall (Ehrenreich, 1959; Riegel et al., 1963; Tomanek and Albertson, 1953).

Under heavy use, bunchgrasses diminished and carpetgrass increased sharply. This change, since it was accompanied by an increase in grass production, improved grazing capacity during the growing season. A high proportion of carpetgrass would be undesirable on range grazed during the entire year, however, because the high utilization needed to maintain it would leave little herbage for winter use.

Pinehill bluestem, considered the key management species on most sites, increased slowly on ungrazed range, and increases by big bluestem, indiangrass, and switchgrass were negligible. Therefore, protection from grazing would have little practical value for improving species composition on cutover longleaf pine-bluestem range, except possibly where overuse has been severe.

During the 12-year test grass production, litter, vegetational cover, and botanical composition were little affected by burning.

Grazing was generally detrimental to water infiltration and percolation. Both were reduced sufficiently to limit water intake during intense storms and curtail water movement through the profile during prolonged rains. Water losses were not serious enough to reduce herbage yields, even on heavily grazed range. Where soil is highly erodible or inherently low in rate of water movement, however, moderate grazing during the grazing season could seriously accelerate runoff and soil losses.

On forested ranges, utilization averaging 45 to 50% appears best. For the 12-year period of this study, it stimulated grass production as much as heavy use, and without great changes in composition of forage vegetation. Since soils in most longleaf pine-bluestem ranges are fairly permeable and stable, moderate grazing should be reasonably compatible with other land-use objectives. It not only impairs soil conditions less than heavier use, but leaves more herbage to protect the soil and provide a forage reserve for drought periods. Other factors also favor moderate use. Campbell (1957) reported that trampling and browsing damage to pine regeneration was light under moderate grazing but serious under heavy grazing. Soil compaction induced by heavy grazing, even though not deterimental to herbage production, might reduce survival and growth of pine seedlings.

On cutover forest lands utilized solely as range, beef production may be greater with heavy than with moderate grazing. For use averaging 65 to 70%, cattle per unit of area could number twice those for 45 to 50% use. But increased beef production would be at least partially offset by lower weight gain per animal, since forage consumption is less with heavy than with moderate use. Also, grazing the entire range heavily would probably prove impractical because reserve forage might be inadequate during drought. To minimize runoff and erosion hazards, intense grazing should be confined to gently sloping sites having highly stable soils.

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