Longleaf and Slash Pine Decreases Herbage Production and Alters Herbage Composition

GALE L. WOLTERS

Abstract

An overstory or slash pine on the Palustris Experimental Forest in central Louisiana decreased herbage production as early as plantation age 17 for longleaf pine and plantation age 10 for slash pine. During the years of 1960 through 1975, from 80 to 85% of the variation in herbage production could be explained by the equations, Y = 2094.75 + 10.10P - 106.98BA for longleaf pine and Y = 1606.18 = 14.03P - 88.10BA for slash pine, in which Y = herbage production in kg/ha, P = April through October precipitation in cm, and BA = pine basal area in m^2/ha. Pinehill and slender bluestem were the principal herbaceous species on nonforested plots in 1975, while a mixture of forbs, pinehill bluestem, and other bluestem grasses were most common on forested plots. The study quantifies data on herbage production and botanical composition over time and suggests ways for the forest manager to evaluate timber and herbage tradeoffs.

Cutover southern forest ranges produce appreciable amounts of herbage until shading and competition from regenerated pines reduce understory herbs (Pearson and Whitaker 1974). In precommercially thinned stands of direct-seeded slash pine, herbage yield was related to timber density whether trees were uniformly distributed or crowded into strips and blocks (Grelen et al. 1972). Herbage production was closely associated with basal area of young southern pine plantations in central Louisiana (Wolters 1973) and southern Mississippi (Wolters and Schmidtling 1975). However, information for land managers that quantifies the forest and range resource interactions over time is scant.

This paper describes some timber-herbage relationships in longleaf and slash pine plantations from regeneration through the pole timber stage and reports a way for evaluating timber and herbage tradeoffs.

Study Area

The study site was on the Longleaf Tract, Palustris Experimental Forest, in central Louisiana. Before reforestation, this typical cutover longleaf pine range supported a dense stand of bluestem (*Andropogon* spp.) grasses (Duvall 1962). The area was grazed yearlong by one brood cow/8.1 ha from the mid-1950's until fenced in 1960 to exclude cattle. In early 1952, a portion of the site was reforested with longleaf pine and in 1956 with slash pine. Both species were planted on 1.83 × 1.83-m spacing. Soils, classified as Beauregard and Bowie, were intermingled throughout the area. Annual precipitation averaged about 145 cm with more than 7.5 cm each month. Yearlong temperatures averaged 18° C, and monthly temperatures ranged from 8° C in January to 25° C in July.

Experimental Procedure

Sixteen 0.16-ha square plots were established in longleaf and slash pine plantations in 1960. Four replications of the following treatments were randomly assigned to plots within each plantation: high, moderate, and low pine basal area prescriptions, and a control that had all pines hand-removed in June 1960. Basal area prescriptions in 1969 were 23.0 (high) 19.5 (moderate) and 16.1 (low) m^2/ha for slash pine, and 23.0 (high), 18.4 (moderate), 13.8 (low) m^2/ha for longleaf pine. Eleven of the 12 stocked slash pine plots and 6 of the stocked longleaf pine plots exceeded their basal area prescriptions in 1969, at which time the excess trees were harvested (Wolters 1973). In 1973, basal area prescriptions were changed to 19.5 (high), 16.1 (moderate), and 12.6 (low) m^2/ha for both plantations. Immediately before the 1973 harvest, slash pine stands averaged 25.9 m^2 of basal area/ha and ranged from 21.6 to 31.9 m^2; longleaf pine stands averaged 23.2 m^2/ha and ranged from 19.5 to 28.2 m^2. Because all stocked plots exceeded the 1973 basal area prescriptions, additional trees were harvested.

The longleaf pine plantation had been prescribe burned by headfire in January 1955 to control brown spot needle blight *(Scirahia aircola).* Both plantations were burned by controlled backfire every third year during March since 1960. The plantations were also burned by controlled backfire in March 1974 to reduce residual slash after timber harvest.

Vegetation samples were collected in a 0.04-ha square sampling unit centered in each 0.16-ha plot. All sampling units were surrounded by a 10.0-m wide isolation strip. Pine basal area was calculated from a complete inventory of all pines 2.54 cm or larger diameter-at-breast-height (d.b.h.) Herbage production was assessed by a pooled estimate from clipping eight systematically selected 0.47 by 0.47-m (0.22-m^2) quadrats on each 0.04-ha sampling area. Oven-dried herbage weights were converted to kg/ha. Pine basal area and herbage production were measured in November at 3-year intervals from 1960 through 1969 and annually thereafter through 1975. Herbage botanical composition was determined in 1960 and 1975.

Precipitation was measured approximately 1.6 km from the slash pine and 2.4 km from the longleaf pine plantation.

Treatment effects on herbage production were compared by Tukey's Test. Herbage relationships with pine basal area and precipitation as the independent variables were determined by regression analysis (Steel and Torrie 1960). Data on herbage botanical composition with unequal replication were compared by Scheffe's Test (Freese 1974). Differences at the 0.05 level of probability were considered significant unless otherwise indicated.

Results and Discussion

Herbage Production

Annual herbage production fluctuated markedly from year to year under all treatments and plantation species (Table 1). By comparing annual herbage production on control treatments I noted that, in the absence of a pine canopy, variables that fluctuate annually substantially affect yield. On the controls, production ranged from about 2100 kg/ha to nearly 3900 kg and herbage production increased as precipitation increased. In 1960, 1963, and

The author was principal range scientist, Pacific Southwest Forest and Range Experiment Station, USDA FS, Berkeley, Calif., stationed at Fresno, Calif. He is now with the Forest Environment Research Staff, USDA FS, Washington, D.C.

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1972, herbage production on the controls averaged about 2250 kg/ha, and April through October precipitation averaged about 60 cm. During 1973, 1974, and 1975, herbage production averaged in excess of 3400 kg/ha, and April through October precipitation averaged about 110 cm. Seasonal precipitation as well as herbage production was generally intermediate in all other years. Grelen and Lohrey (1978) reported that herbage production on longleaf pine plantations was correlated closely with seasonal rainfall.

Slash pine treatments began to depress herbage production significantly at plantation age 10 (1966); however, longleaf pine treatments did not reduce herbage production until plantation age 17 (1969). Forested treatments of either pine species generally produced less herbage than the controls. From the standpoint of range carrying capacity, therefore, longleaf pine plantations could be stocked equivalent to cutover range for approximately 17 years after pines are planted but slash pine plantations could be stocked at cutover range rates for only about 10 years after planting. Thus, herbage production on southern pine range may be influenced by a number of variables including pine species, plantation age, rate of growth, tree density, and other variables such as uniformity of tree distribution in the stand.

The combined value of herbage and timber outputs from young unthinned plantations may be similar. For example, the annual basal area increment growth was less for longleaf pine than for slash pine (Wolters 1973). Similarly, in Mississippi, Schmidtling (1973) reported substantially greater cordwood volume growth in young slash pine plantations than in longleaf pine plantations. Therefore, returns from the higher rate of herbage production from grazed young longleaf pine plantations at least will partially offset the greater value of cordwood growth in young slash pine plantations.

Herbage production response to thinning in 1969 was small and short-lived at best. In 1970, for example, production appeared to increase slightly on all stocked slash pine treatments but in 1971, production declined nearly to or below the 1969 prethinning levels. However, only light thinning was necessary to reduce stocked longleaf pine stands to their basal area prescriptions in 1969. As a result, herbage production did not increase in 1970, but continued its downward trend. The selective thinning in 1969 consisted primarily of removing closely spaced, suppressed trees in both plantations, although a few diseased dominant trees were removed. A more uniform and longer lasting response in herbage production probably would have been obtained with the 1969 thinning if only dominant trees had been harvested.

Herbage production nearly doubled in 1974 after an intensive thinning in 1973. Production was even greater in 1975 than in 1974 due partially to the nearly 50% greater seasonal rainfall in 1975 and further recovery from the 1973 site disturbance. Herbage production after thinning appeared to have peaked in 1975 and slowly declined during successive years as competition with the pine stands increased; however, supportive data were not collected after 1975.

Herbage production is adversely influenced by competing vegetation on forested range. Local environmental factors also affect herbage production. Regressions were fitted to the present data to illustrate the relationship of herbage production to precipitation and/or pine basal area; however, the equations may not necessarily show the basic cause and effect of the relationship. The relationship of the present herbage production, pine basal area, and precipitation data can be expressed by the equations $Y = 2094.75 + 10.10P - 106.96BA$ for longleaf pine and $Y = 1606.18 + 14.03P - 88.10BA$ for slash pine, in which Y = herbage production in kg/ha, P = April through October precipitation in cm, and BA = pine basal area in m^2/ha. The equations, in which N = 160, explained 85% of the variation in herbage production in longleaf pine plantations and 80% in slash pine plantations. Standard error of the estimates was 414.42 kg/ha for longleaf pine plantations and 488.16 kg/ha for slash pine plantations. All equations used data of April through-October precipitation which ranged from 53.6 to 125.7 cm. Basal area data of stocked treatments ranged from 1.86 to 28.31 m^2/ha for longleaf pine and 1.01 to 31.89 m^2/ha for slash pine.

Precipitation contributed significantly to the explanation of variation in the dependent variable in both equations but basal area alone explained 80% of the variation in herbage production under longleaf pine and 71% of the variation in slash pine. The simple linear equations, with pine basal areas as the independent variable, were $Y = 2853.58 - 102.25BA$ for longleaf pine and $Y = 2690.92 - 84.66BA$ for slash pine. Standard error of the estimates was 472.68 kg/ha for longleaf pine and 583.82 kg/ha for slash pine.

Regression coefficients calculated from the present data sets with basal area as the independent variable are similar to the simple linear regression coefficients reported earlier by Wolters (1973) if the influence of precipitation is considered. For example, seasonal precipitation during this study averaged about 20% more than that reported for the earlier study. Grelen and Lohrey (1978) presented a linear equation relating herbage yield to longleaf pine basal area. After converting the Grelen-Lohrey equation to metric units, the regression coefficients were substantially smaller than those calculated for the present data. Differences resulting from precipitation, inherent site quality, and related physical factors may account for the large differences in regression coefficients.

Because our present state of knowledge does not permit us to accurately predict seasonal precipitation, the forest manager's primary consideration is to decide on the level of multiple resource outputs desired. Maximizing either herbage or timber essentially eliminates the other resource, although at intermediate pine basal area levels (12.5 to 21.0 m^2/ha) from 800 to 1600 kg/ha of herbage can be produced annually. Using information from this study the manager or landowner can apply present or projected values to herbage and timber yields when assessing the most appropriate mix of resource outputs.

Table 1. Herbage production (kg/ha) on longleaf and slash pine range, by prescribed basal area treatment and year.

	Slash pine basal area				Longleaf pine basal area			
Year	High	Moderate	Low	Control	High	Moderate	Low	Control
1960*	2401a[1]	2153a	1998a	2094a	1994a	2360a	2218a	2379a
1963*	1394a	1760a	1620a	2242a	1945a	1708a	2067a	2236a
1966*	874b	1176b	908b	2813a	1802a	1994a	2073a	2600a
1969	341b	649b	396b	2970a	791b	1206b	1403b	2973a
1970	399b	801b	745b	2267a	498b	555b	1329b	3353a
1971	204b	395b	519b	2462a	240c	447bc	615b	2715a
1972	364b	399b	604b	2168a	193b	262b	619b	2304a
1973	347b	499b	414b	3336a	352b	418b	832b	3450a
1974	1283b	1268b	661b	3250a	688b	1003b	1363b	3478a
1975	2190b	2385ab	2387ab	3683a	1049b	1445b	1661b	3853a

[1]Means within years and species of pine followed by the same letter are not significantly different at the 0.01 level.
*Values are from unthinned plantations.

Table 2. Botanical composition (%) of longleaf-slash pine range in 1960 and in 1975 under various pine basal areas levels.

Species	1960 (N=32)	1975 High (N=8)	1975 Medium (N=8)	1975 Low (N=8)	1975 Control (N=8)
Pinehill bluestem	26.3ab[1]	20.2b	33.8ab	31.7ab	42.0a
Slender bluestem	24.6a	4.2b	7.5b	4.9b	18.0a
Other bluestems	8.1a	15.2a	8.0a	18.0a	4.5a
Panicums	13.2ab	23.1a	14.8ab	10.1ab	4.1b
Other grasses	23.4a	11.2b	13.9b	14.9b	23.9a
Forbs	4.4b	21.1a	22.0a	20.4a	7.5b
Total	100.0	100.0	100.0	100.0	100.0

[1]Like subscripts in rows indicate no significant difference at the 0.05 level of probability.

Botanical Composition

Botanical composition of herbage by weight, at 3-year intervals from 1960 through 1969, was reported earlier (Wolters 1973). Because differences in herbage botanical composition from forested and control treatments were not discernible in 1970, all observations (N=32) were pooled. Similarly, differences in 1975 botanical composition were not discernible between tree species and, therefore, botanical composition data were pooled by prescribed basal area treatment. The 1960 and 1975 pooled estimates were compared to determine the effects of treatment and time on botanical composition.

Pinehill bluestem *(Andropogon scoparius* var. *divergens)* and slender bluestem *(A. tener)* each produced about one-fourth of the total herbage in 1960, and their proportions did not change significantly on the control in 1975 (Table 2). However, treatment levels influenced their proportions in 1975. Pinehill bluestem was found in greater proportions on the control than on the high basal area treatment and all treatments stocked with pine in 1975 depressed the proportion of slender bluestem herbage. Pinehill bluestem is a vigorous competitor on nongrazed range, but the vigor of slender bluestem was apparently reduced by nonuse, particularly under moderate to dense pine canopies. Similar responses of pinehill and slender bluestems to nonuse were reported by Grelen and Duvall (1966), Duvall and Linnartz (1967), Wolters (1973), and Grelen and Lohrey (1978).

The other bluestems, primarily big *(A. gerardi)*, Elliott *(A. elliottii)*, fineleaf *(A. subtenuis)*, paintbrush *(A. ternarius)*, and broomsedge *(A. virginicus)*, did not change in proportion from 1960 to 1975, regardless of the treatment imposed. Big bluestem, however, generally increased on forested treatments and particularly under slash pine where it occurred in large scattered clumps. Big bluestem was the only species of this group that sustained or increased its proportion under a pine canopy.

In 1975, panicums (*Panicum* spp.) were found in greater proportion under the high basal area treatment than on the control, although the proportion of panicums on forested treatments in 1975 did not differ from the 1960 pooled estimate. Switchgrass *(P. virgatum)* was the most abundant species of the panicum group under a high pine basal area, and the proportion of low panicums generally increased with reductions in pine basal area.

The other grasses, consisting primarily of paspalums (*Paspalum* ssp.), cutover muhly *(Muhlenbergia expansa)*, green silkyscale *(Anthaenantia villosa)*, and arrowfeather threeawn *(Aristida purpurascens)*, produced the same proportion on the control in 1975 as in 1960. However, the proportion of other grasses diminished under all forested treatments in 1975.

Forb composition was similar on the control in 1975 as in 1960; however, forbs increased under forested treatments. Poor-joe *(Diodia teres)*, white eupatorium *(Dupatorium album)*, and southern bracken *(Pteridium aquilinum* var. *pseudocaudatum)*, were the principal forbs on forested sites; grassleaf goldaster *(Heterotheca graminifolia)* and swamp sunflower *Helianthus angustifolius)* generally were the most abundant on the control.

The conversion of pinehill-slender bluestem range to a bluestem-forb range with reforestation enhances herbage diversity and may lengthen the green herbage season. The response of herbivores, however, to increased forbs in terms of daily consumption, nutritive value of diets, and animal weight change has not been determined.

Conclusions

Longleaf pine plantations can be stocked with cattle equivalent to cutover range for approximately 17 years after planting of pines, but slash pine plantations can be stocked only about 10 years after planting before a significant decrease in herbage production occurs. However, herbage productivity can be partially restored by intensively thinning the pine stand periodically.

Herbage production was correlated with seasonal rainfall; it increased as precipitation increased. Herbage production decreased as pine basal area increased.

In this study, regression equations explained 80 to 85% of the variation in herbage production on both longleaf and slash pine plantations. These data, along with herbage botanical composition information, can aid the land manager in evaluating timber and herbage tradeoffs for obtaining the best returns from his land.

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