USDA Forest Service Research Paper SE-82 • April 1971

U. S. Department of Agriculture—Forest Service
Southeastern Forest Experiment Station
Asheville, North Carolina

Forage Response to Nitrogen and Phosphorus Fertilization in a 25-Year-Old Plantation of Slash Pine

by

Ralph H. Hughes
George W. Bengtson
Thaddeus A. Harrington

Forage Response to Nitrogen and Phosphorus Fertilization in a 25-Year-Old Plantation of Slash Pine

by

Ralph H. Hughes, Range Scientist
Forest Resources Laboratory
Lehigh Acres, Florida

George W. Bengtson, Plant Physiologist[1]
and
Thaddeus A. Harrington, Principal Silviculturist[2]
Naval Stores and Timber Production Laboratory
Olustee, Florida

In 1963, a study on forest fertilization was established in an old-field plantation of slash pine *(Pinus elliottii* var. *elliottii)* near Olustee, Florida. High yields of desirable forage species resulted after the plantation received a single application of fertilizer. The responding species, mostly grasses relished by livestock and of importance to wildlife, were relicts of the old-field vegetation. These yields are reported in terms of ovendry weight per acre for the 4-year period that followed the fertilizer application.

STUDY AREA

The study area was a moderately well-stocked, old-field plantation containing 136 trees per acre and a mean basal area of 71 sq. ft. Trees were pole- and saw log-sized and averaged 10 inches d.b.h., with heights ranging from 80 to 95 ft. Height to the base of live crown varied from 30 to 50 ft.

The soil was predominantly Leon fine sand. This moderately deep, acid, sandy soil, with low organic content and natural fertility, occurs on nearly level, moderately wet land throughout the Lower Coastal Plain of the southeastern United States. Textural analysis of the upper 6 inches revealed 95-percent sand, 3.5-percent silt, and 1.5-percent clay, with pH varying from 4.3 to 4.7. Prior to fertilization, total nitrogen (N) content in soil samples varied from 1,500 to 2,500 lb. per acre and available phosphorus (P) from 10 to 45 lb. (according to the Bray No. 2 procedure). In 3 of the 4 years, May to October rainfall exceeded the 33-inch long-term mean, with 29 inches in 1963, 48 inches

[1]Now Research Forester, Tennessee Valley Authority, Muscle Shoals, Alabama 35660.

[2]Now Research Forester (Administration), Southern Forest Experiment Station, New Orleans, Louisiana 70113.

in 1964, 42 inches in 1965, and 41 inches in 1966.

A light cover of herbaceous vegetation was present throughout the plantation at the start of the experiment. Common carpetgrass *(Axonopus affinis* Chase) and broomsedge *(Andropogon virginicus* L.) were the main grasses. Other common grasses were big bluestem *(Andropogon gerardi* Vitman) and creeping bluestem (*A. stolonifer* (Nash) Hitchc.), several panicums including warty panicum *(Panicum verrucosum* Muhl.) and hairy panicum *(P. rhizomatum* Hitchc. and Chase), and bull paspalum *(Paspalum boscianum* Flügge). Elephantsfoot *(Elephantopus tomentosus* L.) and poor-joe *(Diodia teres* Walt.) were common forbs. Low shrubs, mostly sand blackberry *(Rubus cuneifolius* Pursh) and gallberry (*Ilex glabra* (L.) Gray), were widespread, normally occurring in patches.

PROCEDURE

The study area was prescribed burned and divided into ¾-acre plots during the week of April 8, 1963, just prior to the application of fertilizers. These were applied in swaths between rows of trees in a north-south direction with a drill-type spreader (fig. 1). Current growth of the understory vegetation was obtained on 9.6-sq.-ft. quadrats. Each winter thereafter, all understory vegetation was clipped to a height of 3 to 4 inches with a rotary mower. Fire and grazing were excluded during the course of the study, but there was evidence of controlled burning and grazing in earlier years.

Fertilization consisted of three levels of N and two levels of P. Rates applicable to the treated area between rows of trees were 0, 100, and 200 lb. of N per acre and 0 and 44 lb. of P per acre. Treatments were replicated three

Figure 1.—Fertilizer application in the old-field plantation in April 1963. The fertilizer is being applied in swaths between rows of trees.

times in a factorial design with randomized blocks. Sources of N and P were ammonium nitrate (33-percent) and superphosphate (8.8-percent). Approximately half the area was in unfertilized areas occupied by rows of trees.

Estimates of herbage yield and ground cover were obtained by clipping three quadrats on each plot to a 1-inch stubble. Ovendry weights were obtained separately for important species and groups. Visual estimates were made of the percentage of ground surface covered by the foliage of each species. Swaths in rows and between rows of trees were inventoried the first year; only the swaths between rows of trees were inventoried thereafter.

RESULTS

Single applications of three fertilizer treatments (200 lb. of N and no P, 100 lb. of N plus 44 lb. of P, and 200 lb. of N plus 44 lb. of P) in April 1963 produced highly significant increases in herbage yields the first year (fig. 2). Only at the highest fertilization level (200 lb. of N plus 44 lb. of P) did the increase carry over into the second year. This high rate of fertilization increased production more than fivefold the first year (2,800 vs. 500 lb. per acre) and nearly twofold (1,500 vs. 900 lb. per acre) the second year. Although the main effect of N was to increase herbage production, N was not effective at the lowest level (100 lb.) without P, and 44 lb. of P had no influence alone. No fertilizer treatments affected herbage yields the third or fourth year.

Species response the first year was characterized by increased growth of grasses (fig. 3). On the average, grasses comprised 80 percent of the harvests on swaths fertilized with N and only 50 percent on unfertilized swaths. The grasses furnished more than 90 percent of the gain in yield, of which about half was by the bluestem grasses—primarily broomsedge, big bluestem, and creeping bluestem. Despite wide distribution of carpetgrass throughout the plantation, its yield was not determined separately because of its low growth form.

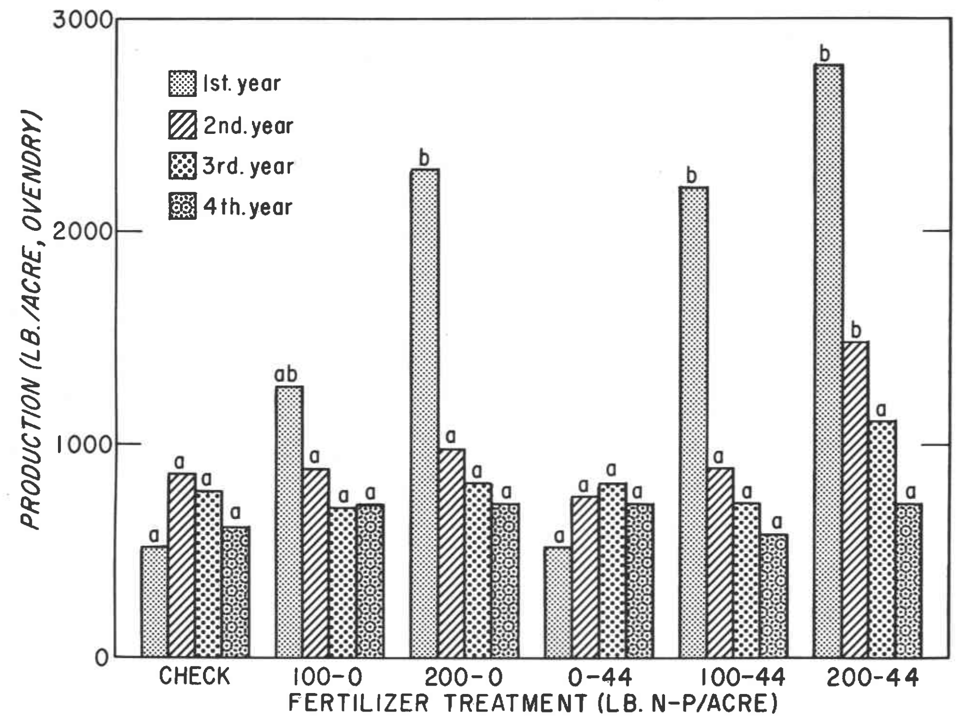

Figure 2.—Annual production of herbaceous vegetation after the fertilizer treatments in April 1963. Bars not labeled with the same letter are significantly different at the 5-percent level.

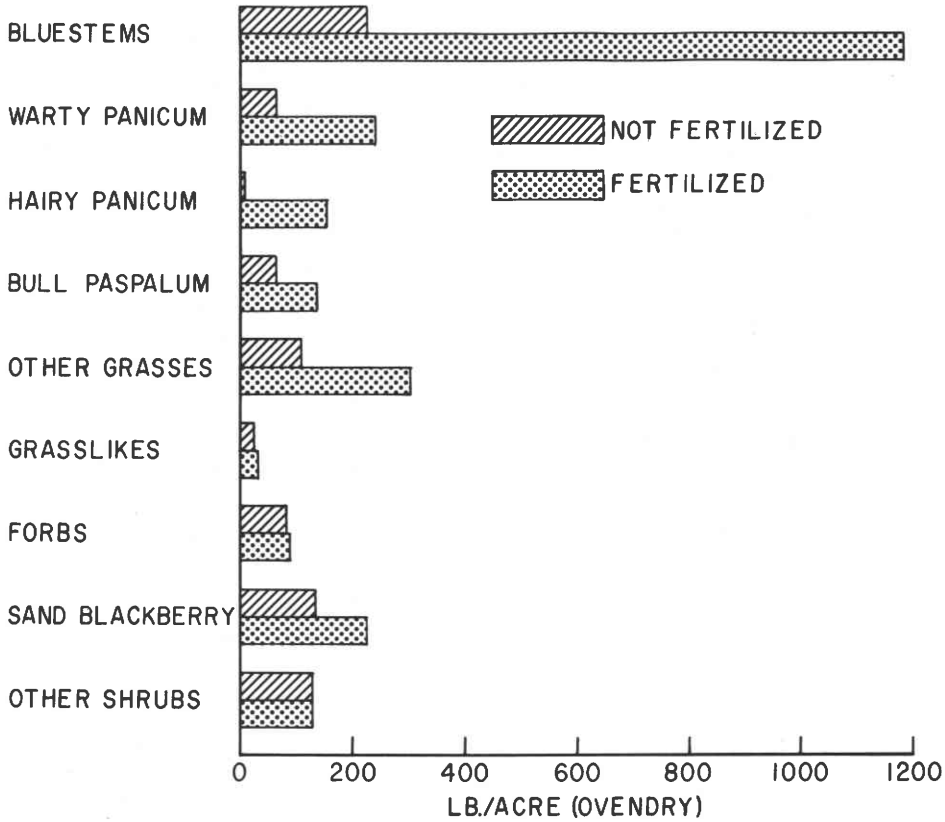

Figure 3.—Composition of understory vegetation clipped the first year from quadrats in unfertilized plots and those fertilized with N. (Average of the following treatments: 100 lb. of N and no P, 200 lb. of N and no P, 100 lb. of N plus 44 lb. of P, and 200 lb. of N plus 44 lb. of P.)

On quadrats where it occurred, sand blackberry appeared to respond to fertilizer. Other shrubs, forbs (including legumes), and grasslikes were encountered in lesser amounts and averaged about the same on fertilized and unfertilized swaths.

Response the second year after the application of fertilizer was limited to increased production of the bluestem grasses in the most heavily fertilized treatment. Yields were 730 lb. per acre in quadrats fertilized with 200 lb. of N plus 44 lb. of P and 240 lb. per acre in the unfertilized quadrats.

Visual estimates of the ground cover also reflected the response to fertilizers containing N (100 lb. of N and no P, 200 lb. of N and no P, 100 lb. of N plus 44 lb. of P, and 200 lb. of N plus 44 lb. of P). When grouped together, grasses other than carpetgrass displayed a strong response (fig. 4). Carpetgrass did not respond to fertilization under conditions of this study, but it did maintain its cover beneath the taller growing bunchgrasses throughout the 4-year period of the study.

The clipped herbage contained several plants important as game food. Taken together, panicum and paspalum grasses increased from 180 lb. per acre when no N was applied to 210 lb. per acre when N was applied at the 100-lb. rate to 860 lb. per acre when N was applied at the 200-lb. rate. These grass species are considered to be preferred foods for quail and turkey and emergency food for deer in the slash-longleaf flatwoods of north Florida and south Georgia (Ripley et al. 1965). Bluestem grasses are rated as emergency food for quail, turkey, and deer, and blackberries are rated as

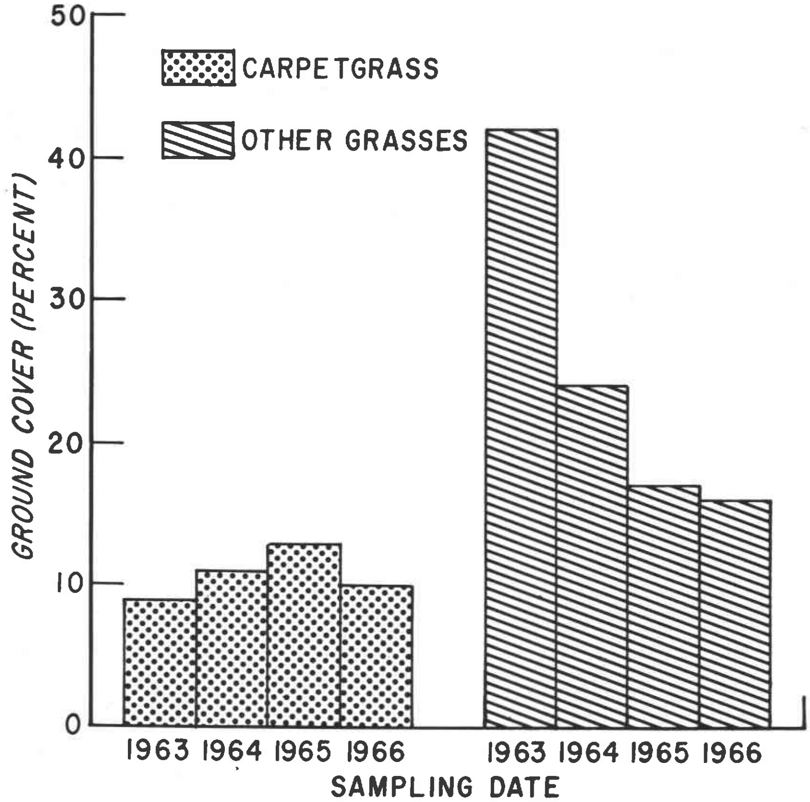

Figure 4.—Visual estimates of ground cover by carpetgrass and other grasses on swaths receiving N fertilization in 1963.

staple food for turkey and deer and emergency food for quail.

Carpetgrass was not harvested separately because of its limited production above the 1-inch clipping height. This species is closely grazed by cattle, and, in a study with penned quail, its seeds were sufficiently utilized to warrant its use in permanent food plantings (Michael and Beckwith 1955). Legumes occurred only sparingly throughout the plantation, and no response was detected. During the course of the study, volunteer seedlings of Pensacola bahiagrass (*Paspalum notatum* Flügge), absent in the initial inventory, appeared as scattered plants throughout the plantation.

When taken for chemical analysis in late September 1963, total herbage samples from swaths receiving N alone contained significantly less crude protein than did herbage from swaths receiving P alone (table 1). In fact, crude protein and phosphorus averaged less in swaths receiving N alone than in swaths in unfertilized plots. Apparently, N fertilization stimulated stemmy growth, which by fall contained less protein per unit of dry matter than did unfertilized growth. When N and P were applied together, the tendency toward stemmy growth was reduced and protein and phosphorus levels remained similar to those on unfertilized plots.

In broomsedge, which was sampled separately, crude protein was not strongly affected by any of the fertilization treatments. Phosphorus contents were similar to those in the total herbage samples noted above. Had samples of total herbage and broomsedge been taken earlier in the season, crude protein and phosphorus levels would likely have been higher. Nitrogen values are usually highest in the spring and then generally decline as plants mature (Koelling and Kucera 1965).

Table 1.—Crude protein and phosphorus content of total herbage and broomsedge grass in each fertilizer treatment during September 1963

Treatment		Total herbage		Broomsedge grass	
N	P	Crude protein	Phosphorus	Crude protein	Phosphorus
Lb./acre		- - - - - - - - *Percent*[1]	- - - - - - - -		
0	0	4.4 ab	0.11 ab	3.3 ab	0.11 bc
100	0	3.8 a	.07 a	3.1 ab	.08 ab
200	0	3.7 a	.07 a	3.3 ab	.07 a
0	44	4.7 b	.12 ab	2.9 a	.12 c
100	44	4.3 ab	.13 b	3.3 ab	.11 bc
200	44	4.4 ab	.13 b	3.5 b	.10 abc

[1]Values within a column followed by the same letters are not significantly different at the 0.05 level by Duncan's Multiple Range Test.

DISCUSSION

The results suggest that with fertilization a plantation suitably stocked for timber production can also be made to produce a significant amount of forage. Yields of indigenous herbage in this old-field plantation increased 500 to 1,000 lb. with each 100-lb. increase in the N level, results which compare favorably with yields of improved forage species beneath pine (Hart et al. 1970).

Not all pine plantations could be expected to show such good results. Beneath heavier stands (basal areas of 85 sq. ft. per acre) of slash pine planted on cutover lands in central Louisiana, Duvall and Grelen (1967) reported that forage responded much less favorably to fertilization. However, old-field sites are generally superior to cutover lands for forest growth (Bennett 1956); perhaps some of the factors that promote forest growth on old fields also make for better forage growth when these sites are fertilized.

Conditions within the plantation would seem to favor the introduction of improved forage species. The appearance of Pensacola bahiagrass came as no surprise because this desirable forage species is an aggressive, shade-tolerant grass that will grow over a wide range of soil conditions (Stephens and Marchant 1960). It spreads readily by seed and is widely distributed in its area of climatic adaptation (Beaty et al. 1960).

However, the rapid decline in response shows that, if old-field plantations of low N status are expected to produce an abundance of food for livestock and game, available N probably should be provided at rather short intervals, annually or at most every 2 years. The desirable forage grasses grew abundantly while soluble N and P were available during the first year after fertilization. As the fertilizer leached out of the soil or became unavailable, the grasses declined because they had to rely on nutrients recycled from cast needles of the pines and from other organic sources. Pines, however, seem to derive longer lasting benefits from N fertilization (Hoekstra and Asher 1962).

No realistic measure of herbage quality during the growing season was obtained. Crude-protein content of the mature herbage was somewhat lower than levels reported from improved pasture (Kretschmer and Hayslip 1963) or native range (Hilmon and Lewis 1962) at the same time of year. Nevertheless, in a nearby grazed replicate of the present study, utilization of fertilized plots by cattle approached 100 percent.

In this particular plantation, none of the treatments produced a sufficient increase in volume of merchantable wood to justify the application of these fertilizers at the rates investigated.

If it is assumed that the only positive response to fertilization was made by the forage component when fertilized with 200 lb. of N plus 44 lb. of P, the per-acre cost of fertilizer and application at current (1970) prices would be $32. With a return of 2,250 lb. of additional herbage (dry weight) the first year and 600 lb. the second year, the increased yields cost $22 per ton of dry herbage.

It seems clear, on the basis of these results, that utilization of forage resulting from fertilization of certain pine-forest ecosystems can bear a significant share of the costs of such a practice and, therefore, might tip the balance toward profitability of the operation.

LITERATURE CITED

Beaty, E. R., McCreery, R. A., and Powell, John D.
1960. Response of Pensacola bahiagrass to nitrogen fertilization. Agron. J. 52: 453-455.

Bennett, Frank A.
1956. Growth of planted slash pine on cutover lands and old fields. J. Forest. 54: 267-268.

Duvall, Vinson L., and Grelen, Harold E.
1967. Fertilization uneconomic for forage improvement in Louisiana pine plantations. South. Forest Exp. Sta., USDA Forest Serv. Res. Note SO-51, 3 pp.

Hart, R. H., Hughes, R. H., Lewis, C. E., and Monson, W. G.
1970. Effect of nitrogen and shading on yield and quality of grasses grown under young slash pines. Agron. J. 62: 285-287.

Hilmon, J. B., and Lewis, C. E.
1962. Effect of burning on south Florida range. USDA Forest Serv. Southeast. Forest Exp. Sta. Pap. 146, 12 pp.

Hoekstra, P. E., and Asher, W. C.
1962. Diameter growth of pole-size slash pine after fertilization. J. Forest. 60: 341-342.

Koelling, Melvin R., and Kucera, C. L.
1965. Dry matter losses and mineral leaching in bluestem standing crop and litter. Ecology 46: 529-532.

Kretschmer, Albert E., and Hayslip, Norman C.
1963. Evaluation of several pasture grasses on Immokalee fine sand in south Florida. Univ. Fla., Fla. Agr. Exp. Sta. Bull. 658, 25 pp.

Michael, Victor C., and Beckwith, Stephen L.
1955. Quail preference for seed of farm crops. J. Wildlife Manage. 19: 281-296.

Ripley, T. H., Wilhite, L. P., Downing, R. L., and Harlow, R. F.
1965. Game food plants in slash-longleaf flatwoods. Sixteenth Annu. Conf. Southeast. Assoc. Game & Fish Comm. Proc. 1962: 35-44.

Stephens, J. L., and Marchant, W. H.
1960. Bahiagrass for pastures. Univ. Ga. Coll. Agr. Ga. Agr. Exp. Stas. Bull. N.S. 67, 12 pp.

Hughes, Ralph H., Bengtson, George W., and Harrington, Thaddeus A.
1971. Forage Response to Nitrogen and Phosphorus Fertilization in a 25-Year-Old Plantation of Slash Pine. Southeast. Forest Exp. Sta., USDA Forest Serv. Res. Pap. SE-82, 7 pp.

In a 25-year-old plantation of slash pine near Olustee, Florida, a single application of 200 lb. of nitrogen and 44 lb. of phosphorus per acre increased production of herbaceous understory (primarily native bluestem grasses) to more than a ton per acre the first year, a fivefold increase. Production declined sharply the second year, and the response disappeared in the third.

Hughes, Ralph H., Bengtson, George W., and Harrington, Thaddeus A.
1971. Forage Response to Nitrogen and Phosphorus Fertilization in a 25-Year-Old Plantation of Slash Pine. Southeast. Forest Exp. Sta., USDA Forest Serv. Res. Pap. SE-82, 7 pp.

In a 25-year-old plantation of slash pine near Olustee, Florida, a single application of 200 lb. of nitrogen and 44 lb. of phosphorus per acre increased production of herbaceous understory (primarily native bluestem grasses) to more than a ton per acre the first year, a fivefold increase. Production declined sharply the second year, and the response disappeared in the third.

Hughes, Ralph H., Bengtson, George W., and Harrington, Thaddeus A.
1971. Forage Response to Nitrogen and Phosphorus Fertilization in a 25-Year-Old Plantation of Slash Pine. Southeast. Forest Exp. Sta., USDA Forest Serv. Res. Pap. SE-82, 7 pp.

In a 25-year-old plantation of slash pine near Olustee, Florida, a single application of 200 lb. of nitrogen and 44 lb. of phosphorus per acre increased production of herbaceous understory (primarily native bluestem grasses) to more than a ton per acre the first year, a fivefold increase. Production declined sharply the second year, and the response disappeared in the third.

Hughes, Ralph H., Bengtson, George W., and Harrington, Thaddeus A.
1971. Forage Response to Nitrogen and Phosphorus Fertilization in a 25-Year-Old Plantation of Slash Pine. Southeast. Forest Exp. Sta., USDA Forest Serv. Res. Pap. SE-82, 7 pp.

In a 25-year-old plantation of slash pine near Olustee, Florida, a single application of 200 lb. of nitrogen and 44 lb. of phosphorus per acre increased production of herbaceous understory (primarily native bluestem grasses) to more than a ton per acre the first year, a fivefold increase. Production declined sharply the second year, and the response disappeared in the third.

The Forest Service, U. S. Department of Agriculture, is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

Forest Service, U.S. Department of Agriculture
Southeastern Forest Experiment Station
Asheville, North Carolina