# GEORGIA FOREST RESEARCH PAPER

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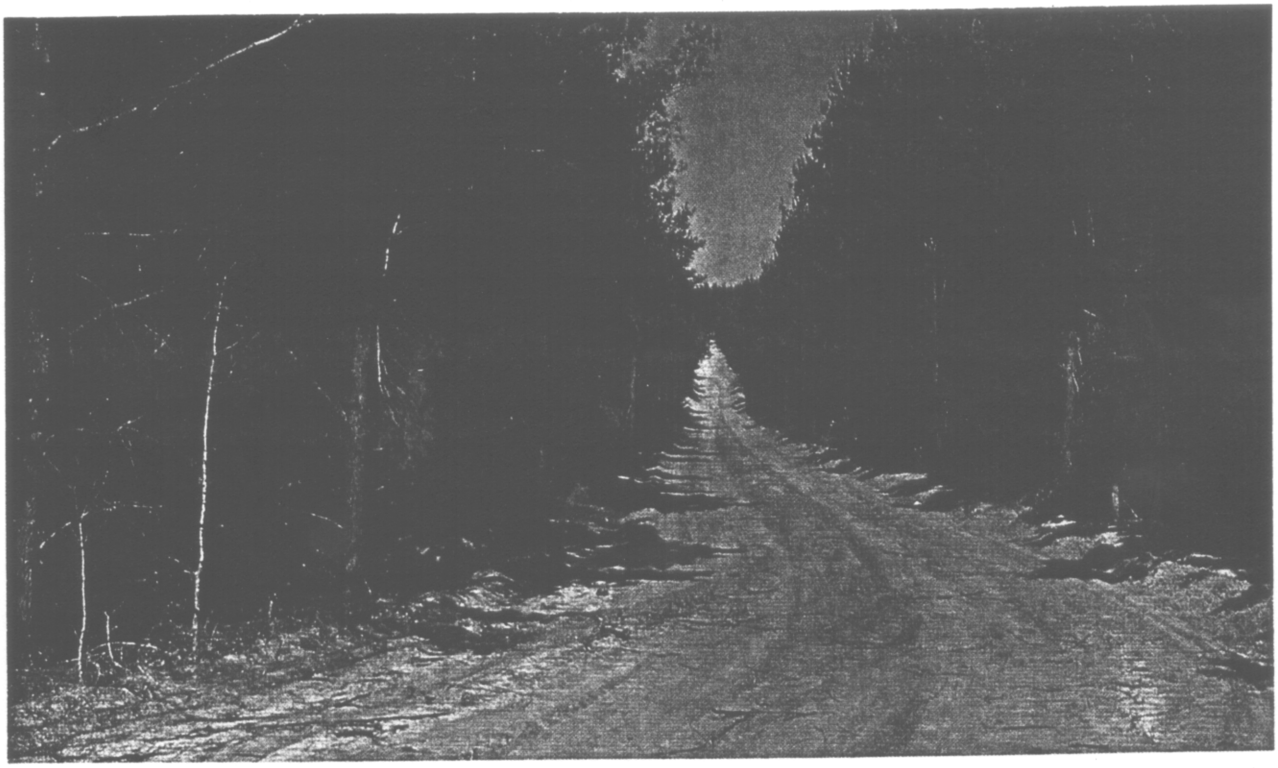
MARCH, 1986



# FOREST FLOOR And SOIL NUTRIENT CONDITIONS In The Georgia Sandhills

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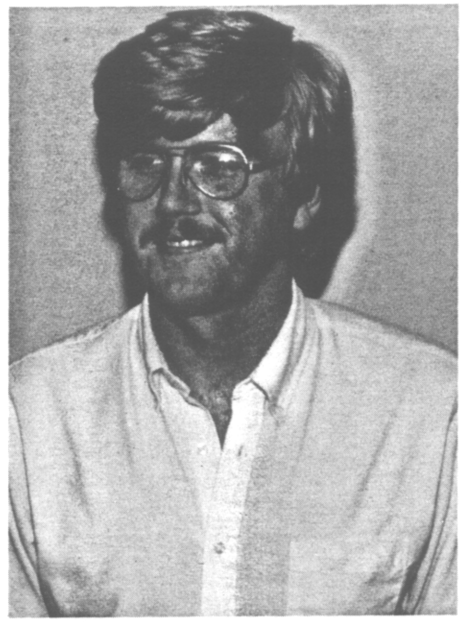

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# FOREST FLOOR And SOIL NUTRIENT CONDITIONS In The Georgia Sandhills

ABSTRACT

The forest floor and soil were sampled beneath a slash pine plantation and longleaf pine-turkey oak association in the Georgia Sandhills of Marion County. Concentration of nutrients in the forest floor and the relatively low soil extractable nutrient levels demonstrated the importance of the forest floor to the nutrient cycle on excessively drained Sandhill sites. Site preparation methods, such as chopping and herbicides which minimize surface soil disturbance were recommended as optimal for dry Sandhills sites.

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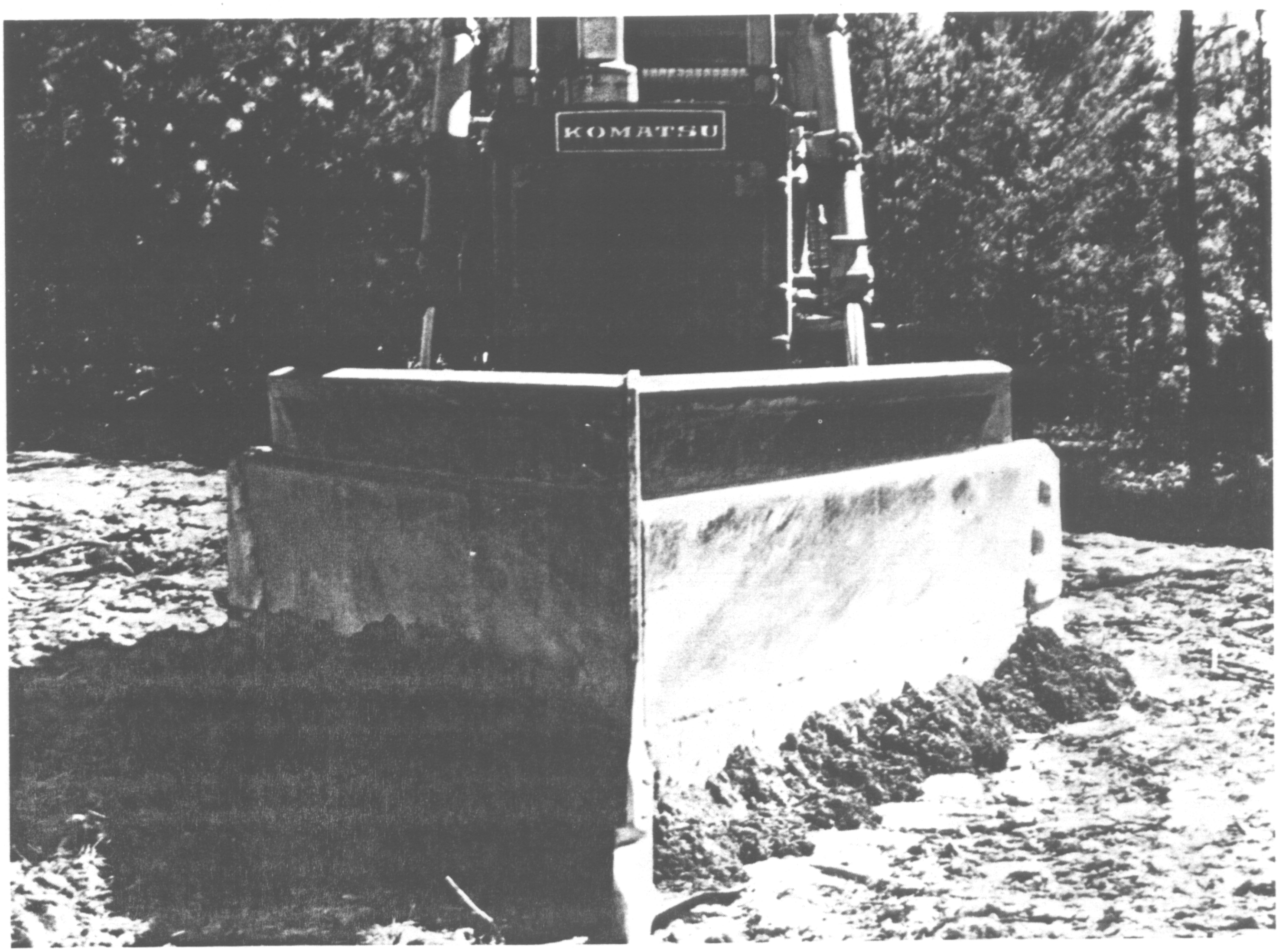
# Introduction

The Georgia Sandhills occur in a narrow band, just south of the Piedmont, extending from Augusta to Columbus. Relief is rolling to hilly (Giddens et al., 1960). Native vegetation consists primarily of the longleaf-scrub oak association. Longleaf pine once formed pure open stands, but logging and fire control reduced the pine component in favor of scrub oak (Van Lear, 1980). Poor survival, slow growth and high regeneration costs have prevented extensive longleaf regeneration. Other pine species, slash, loblolly and sand pine have been planted with varying results (Van Lear et al., 1977; Hebb, 1981).

Sandhill soils are deep, infertile, well drained sands, fairly productive agriculturally when fertilized and irrigated frequently. For such nutrient poor soils, the forest floor is an important source of added nutrient to the available soil nutrient pool (Armson, 1977). Through uptake and deposition, forest vegetation concentrates limited nutrients at the soil surface. Decomposition of the floor eventually releases these nutrients for plant uptake. Pine forests normally develop an evenly distributed floor; in the longleaf scrub oak association, however, the floor is often incomplete with large areas of open sand (Wharton, 1978).

The objective of this study was to contrast within a Sandhills site, the influence of a slash pine plantation and a longleaf-scrub oak association on the forest floor and available soil nutrient pool. Such information could then be used by forest managers to evaluate the long-term inflences of various site preparation methods on Sandhills site productivity.




*Typical V-Blade installed on crawler tractor to do site preparation work.*

*Area of harvested forest land prior to site preparation and replanting.*

# Procedures

The study was located in Marion County, Georgia. The area had an average of 127 cm (50 in) evenly distributed, annual rainfall (Giddens, et al., 1960). The site was a long, broad, sandy ridge with a portion regenerated to slash pine, and adjacent areas of scrub oak. From field descriptions, the soil was determined to be a Lakeland series (Typic Quartzipsamment).

The slash plantation, regenerated on an abandoned peanut field was 22 years old. Stand density was 800 trees/ha (320 trees/acre). Average diameter at breast heaight was 19.5 cm (7.6 in); average height of dominants and codominants was 7.4 cm (62 ft) for a site index at base age 25 of 22 m (72 ft). The scrub oak association was predominantly turkey oak with only a few scattered longleaf pine.

Forest floor and soils were sampled for both associations in early June, 1984. Three 0.04 ha (0.1 acre) measurement plots were established in each association for a total of six sample plots. Within each plot, ten o.25$m^2$ (2.7 $ft^2$) quadrats were randomly located. The forest floor (to mineral soil) was removed in two layers. Both layers were oven-dried (70$^oC$), weighed and ground. A lower layer subsample (3.0 g) was ashed (600$^oC$) to determine percent soil contaminant for each quadrat. The floor samples were wet ash digested using a 7:1 concentration nitric/perchloric acid solution (Chapman and Pratt, 1961). Forest floor Ca, Mg and K were determined by atomic adsorption spectrophotometry (Perkin-Elmer, 1976). Total N was determined with a sulfuric and selenous acid, hydrogen peroxide digestion using a technicon II unit (Issac and Johnson, 1976).

The soil was sampled at four depths; 0-8 cm, 8-15 cm, 15-46 cm and 46-91 cm. The first two depths were sampled beneath each forest floor quadrat for 10 samples per plot. The last two depths were sampled beneath the 3rd, 6th and 9th quadrats for three samples per plot. Bulk densities at each depth were determined in three pits in the slash plantation using the core method (Blake, 1965). Soils were sieved (2 mm) and extracted with a Melich I solution (University of Georgia, 1983) and analyzed for organic matter, total N, P, K, Ca, Mg and pH. Organic matter was determined by the Walkley-Black Method (Jackson, 1958). Total nitrogen was determined by the macro-kjeldahl method using a Technicon autoanalyzer (Technicon, 1975). Extractable Ca, Mg, Na and K were determined by atomic adsorption spectrophotometry (Perkin-Elmer, 1976). Extractable P was determined using a Technicon autoanalyzer II (Technicon, 1975). Soil pH was determined using a 1:1 soil/water paste (Peech, 1965). Nutrients weights (kg/ha) were calculated from extractable concentrations and bulk densitites.

# Results

## Forest Floor Conditions

Based on field observation and measurement, the forest floor beneath the slash pine plantation was continuous with an average thickness of 3.1 (0.4) cm. The scrub oak association floor was generally discontinuous with average thickness 1.3 (0.2) cm with about 38% of the area either bare or with little litter cover. Total floor weights under the slash pine were significantly larger (a = 0.05 level) than under the scrub oak (Table 1), resulting in higher total nutrient weight concentrated in the forest floor under the slash plantation after 22 years.

Forest floor nutrient weights for the Sandhills slash pine plantation were similar to values reported for loblolly pine in the U. S. Coastal Plain and Piedmont as well as mixed hardwoods in the Piedmont and Douglas-fir in the Pacific Northwest (Table 2). The scrub oak forest floor weights were lower, particularly for P, K and Mg.

## Soil Conditions

The soil beneath the forest floor of both associations was strongly acid throughout with low cation exchange capacity (CEC) and low base saturation (BS) (Table 3). Organic matter in the upper 15 cm was significantly higher under the scrub oak. Although organic matter has a CEC of 200 meq/100g, the increase was not sufficient to significantly influence the overall CEC.

With the exception of P, extractable nutrient concentrations were low, reflecting the general low fertility associated with the Sandhills and did not differ significantly with forest association (Table 4). Extractable P was significantly higher in the top 15 cm of the slash plantation, but that probably reflected the long term effects of residual fertilization. Extractable Ca was higher in the surface 8 cm under the scrub oak and Mg higher under the scrub oak at 46 to 91 cm.

Table 1. Forest floor total biomass and mean nutrient weights for two forest associations in the Georgia Sandhills.+

| Association | Floor Weights | N | P | K | Ca | Mg |
|---|---|---|---|---|---|---|
| | (ton/ha) | (kg/ha) | | | | |
| Slash Pine | 28.5 (4.4) | 303 (62) | 10.2 (1.9) | 10.6 (1.9) | 157.7 (42.1) | 7.9 (1.5) |
| Scrub Oak | 11.7 (2.5) | 143 (47) | 3.0 (1.1) | 3.6 (1.4) | 34.1 (14.3) | 2.9 (1.1) |

+Means given with 95% confidence intervals.

Table 2. Comparison of forest floor nutrient weights for various species and regions.

| Association | Region | N | P | K | Ca | Mg | Source |
|---|---|---|---|---|---|---|---|
| | | (kg/ha) | | | | | |
| Loblolly | Coastal Plain | 171 | 8 | 14 | 84 | 14 | Tuttle, 1978 |
| Loblolly Pine | Coastal Plain | 124 | 9 | 16 | 80 | 15 | Switzer and Nelson, 1972 |
| Loblolly Pine | Piedmont | 351 | 21 | 27 | 202 | 42 | Bandaratillake, 1985 |
| Loblolly Pine | Piedmont | 307 | 30 | 28 | --- | -- | Jorgensen et al., 1975 |
| Mixed hardwoods | Piedmont | 408 | 16 | 21 | 366 | 40 | Bandaratillake, 1985 |
| Douglas-fir | Pacific Northwest | 175 | 26 | 32 | 137 | -- | Cole et al., 1968 |
| Slash Pine | Sandhills | 303 | 10 | 11 | 153 | 8 | Present Study |
| Scrub Oak | Sandhills | 143 | 3 | 4 | 34 | 3 | Present Study |

Table 3. Soil chemical properties[+] for two forest associations in the Georgia Sandhills.

| Association | Soil Properties[++] pH | Organic matter | Cation Exchange (CEC) | Base Saturation (BS) |
|---|---|---|---|---|
| | | (%) | (meq/100g) | (%) |
| | | Depth 1 (0-8 cm) | | |
| Slash Pine | 5.1 (0.10) | 1.17 (0.19)$_b$ | 5.5 (0.7) | 6.0 (1.3) |
| Scrub Oak | 5.2 (0.12) | 1.92 (0.20)$_a$ | 4.5(0.7) | 9.4 (2.3) |
| | | Depth 2 (8-15 cm) | | |
| Slash Pine | 5.3 (0.13) | 0.66 (0.07)$_b$ | 4.3 (0.5) | 6.6 (1.4) |
| Scrub Oak | 5.3 (0.12) | 1.03 (0.09)$_a$ | 3.5 (0.6) | 5.7 (0.9) |
| | | Depth 3 (15-46 cm) | | |
| Slash Pine | 5.5 (0.22) | 0.44 (0.12) | 3.8 (1.2) | 5.9 (1.8) |
| Scrub Oak | 5.2 (0.23) | 0.54 (0.23) | 2.6 (1.0) | 8.4 (2.6) |
| | | Depth 4 (46-91) | | |
| Slash Pine | 5.3 (0.08) | 0.39 (0.34) | 3.5 (1.3) | 5.9 (2.8) |
| Scrub Oak | 5.2 (0.17) | 0.42 (0.17) | 2.6 (1.1) | 7.4 (1.9) |

[+]Means given with 95% confidence intervals.

[++]Means with different subscripts differ significantly (0.05).

Table 4. Extractable soil nutrients means[+] for two forest associations in the Georgia Sandhills.

| Association | Extractable Nutrients[++] N | P | K | Ca | Mg |
|---|---|---|---|---|---|
| | (ug/g) | | | | |
| | | | Depth 1 (0-8 cm) | | |
| Slash pine | 368 (44) | 15.2 (2.5)$_a$ | 5.1 (0.9) | 29.3 (7.0)$_b$ | 4.5 (0.7) |
| Scrub oak | 418 (52) | 1.0 (0.2)$_b$ | 6.2 (0.9) | 47.1 (16.0)$_a$ | 6.0 (1.0) |
| | | | Depth 2 (8-15 cm) | | |
| Slash pine | 280 (32) | 12.6 (2.9)$_a$ | 2.8 (0.5) | 28.9 (10.3) | 3.1 (0.6) |
| Scrub oak | 304 (29) | 1.1 (0.2)$_b$ | 4.9 (4.0) | 9.7 (1.6) | 2.4 (0.3) |
| | | | Depth 3 (15-46 cm) | | |
| Slash pine | 206 (49) | 1.8 (1.1) | 1.7 (0.8) | 19.6 (11.6) | 2.6 (1.0) |
| Scrub oak | 223 (53) | 1.0 (0.2) | 3.0 (1.1) | 14.7 (5.3) | 2.9 (1.1) |
| | | | Depth 4 (46-91 cm) | | |
| Slash pine | 182 (67) | 1.7 (0.4) | 1.4 (0.4) | 12.0 (2.7) | 1.6 (0.3)$_b$ |
| Scrub oak | 177 (46) | 1.3 (1.0) | 1.8 (0.7) | 9.6 (2.8) | 2.7 (0.9)$_a$ |

[+]Means given with 95% confidence intervals.

[++]Means with different subscripts differ significantly (a = 0.05)

Conversion of extractable concentrations and organic matter to kg/ha illustrates the relative importance of the top few centimeters of soil. Although 8% of the total soil (0-91 cm) by weight, the surface (0-8 cm) accounts for 24, 15, 17, 16 and 13% respectively of the percent organic matter, N, K, Ca, Mg (Table 5). Surface soil P was only 7%.

The general infertility of the Sandhills' soil nutrient pools from the apparent in comparison with extractable soil nutrient pools from the Georgia Piedmont (Table 6). The soil for both Sandhills forest associations is low particularly in N, P, K, which may be limiting on these sites. Increased annual growth was reported for similar slash pine Sandhills sites in Florida (Typic and Aquic Quartzipsamments) when fertilized with an NPK treatment (Pritchett and Comerford, 1982).

Comparison of nutrient weights in the soil and forest floor of both Sandhills associations emphasizes the importance of the forest floor to the stand's capacity for resupply of the soil available nutrient pool (Figure 1). Forest floor N levels for both associations are nearly 100 times the levels extracted from the soil (0-91 cm). For these sites, the forest floor is also a major source of P, K, Ca and Mg.

Table 5. Mean nutrient weights for soil beneath a Longleaf-Scrub Oak association in the Georgia Sandhills.

| Depth | Organic Matter | Extractable Nutrients N | P | K | Ca | Mg |
|---|---|---|---|---|---|---|
| (cm) | -(kg/ha)- | | | | | |
| 0-8 | 194.1 | 4.2 | 0.01 | 0.06 | 0.30 | 0.05 |
| 0-91 | 802.8 | 28.3 | 0.15 | 0.36 | 1.82 | 0.38 |

Table 6. Comparison of soil extractable+ nutrients from the Piedmont and Sandhills of Georgia.

| Species | Region | Depth | N | P+ | K | Ca | Mg | Source |
|---|---|---|---|---|---|---|---|---|
| | | | -(kg/ha)- | | | | | |
| Loblolly pine | Piedmont | (0-60 cm) | 2984 | 13 | 466 | 569 | 464 | Bandaratillake, 1985 |
| Mixed hardwood | Piedmont | (0-60 cm) | 3239 | 16 | 503 | 199 | 565 | Bandaratillake, 1985 |
| Slash pine | Sandhills | (0-91 cm) | 27 | 0.5 | 0.2 | 2.2 | 0.3 | Present Study |
| Scrub Oak | Sandhills | (0-91 cm) | 28 | 0.2 | 0.4 | 1.8 | 0.4 | Present Study |

+Melich I extraction used for both studies.

# Conclusions

The contributions of the forest floor to the Sandhills nutrient cycle and the generally low soil nutrient levels have important silvicultural implications when regenerating these sites for forest production. Research on Lakeland series sites in the western Florida Sandhills reported that mechanical site preparation gave consistently good results when sites were completely denuded. However, growth was better on double chop treatment areas than on root raked areas in which much of the surface soil had been removed as a result of the operation (Woods, 1959). Furthermore, soil organic matter was consistently higher on the chopped sites.

Site preparation increases seedling survival and growth through control of non-crop vegetation which competes with the crop species for light, water and nutrients (Prtichett, 1979). On excessively drained sites such as the Sandhills, water and nutrients are critical. Methods such as shearing or root raking which scrape the site and pile vegetation in windrows produce the most intense competition control but also remove much of the limited nutrients available for stand generation. Chopping retains organic material on site by incorporating organic material into the surface, but results in less intensive vegetation control. Choice of site preparation method then becomes a tradeoff between control of competing vegetation, available water and nutrient resupply. The optimal site preparation prescription for excessively drained Georgia Sandhills sites would be similar to those recommended for sandhills in Florida, double chop with some additional vegetation control from herbicides (Brendemuehl, 1981; Hebb, 1981; Burns and Hebb, 1972). Competing vegetation control is optimized with minimal surface soil disturbance.

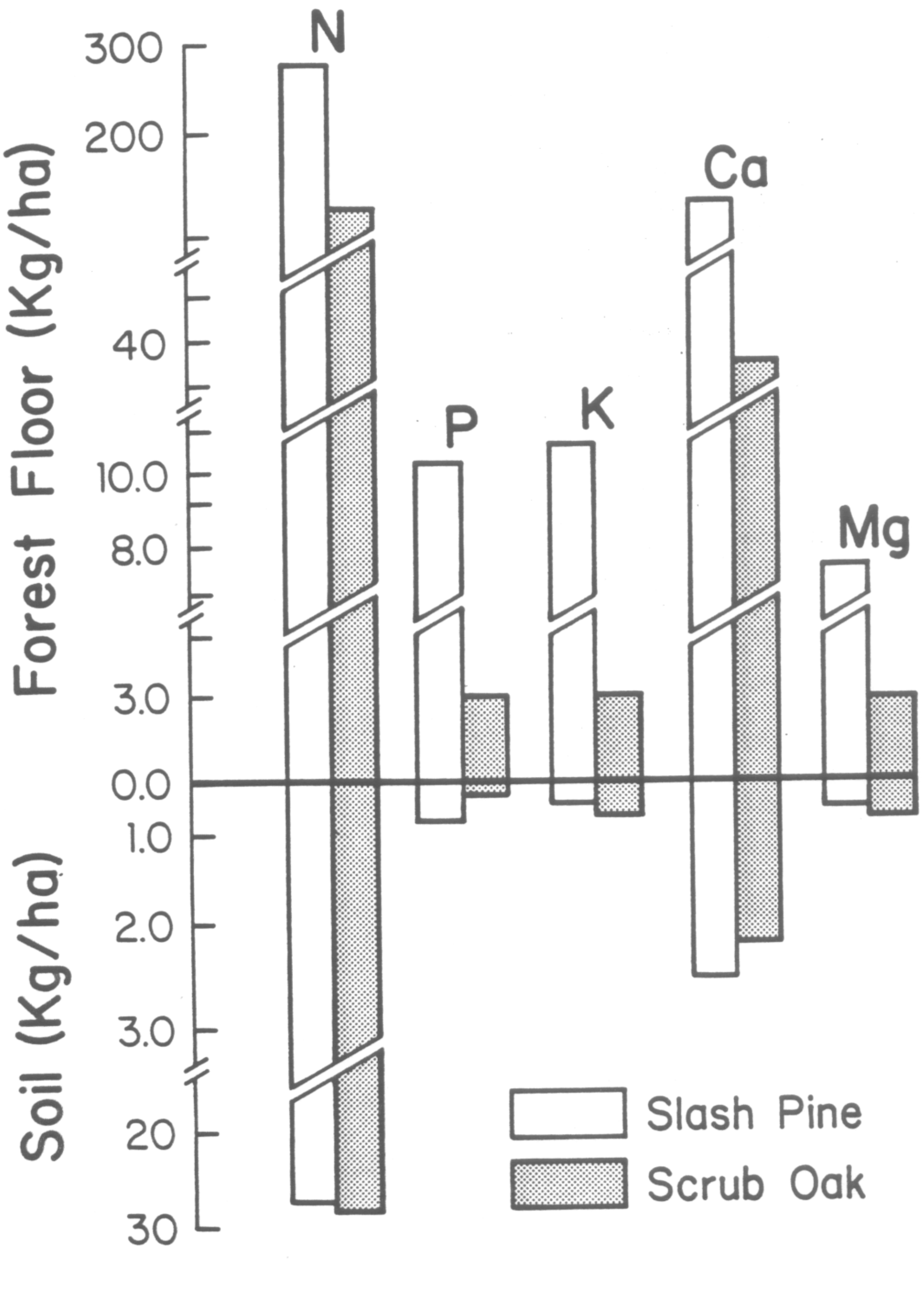



Figure 1. Forest floor and soil nutrient weights (kg/ha) for two forest types in the Georgia Sandhills.

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