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SOIL-SITE RELATIONSHIPS FOR LOBLOLLY PINE ON SELECTED SOILS

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Abstract.--Between 60 and 74 percent of the variation in site index within three soil series on the lower South Carolina coastal plain was related to soil chemical and physical properties in the A1 and B2 horizons. Results indicate that nutrient properties or factors controlling availability of nutrients should be considered in evaluating and classifying growth potential of pine sites.

Additional keywords: Site classification, site index, forest soil properties.

Systems for predicting tree site index without observing tree growth usually emphasize topography and physical properties of the soil (Carmean 1975). In the lower Atlantic coastal plain of the South, however, such properties have not proved sufficient for predicting the growth of loblolly pine (*Pinus taeda* L.). Here, the effects of such properties are primarily upon soil moisture, and the moderately even rainfall pattern provides sufficient moisture on most sites. Furthermore, soils on the lower coastal plain are normally classified according to drainage where depth to mottling of the soil series normally specifies the drainage conditions. Yet site index for loblolly pine can vary by as much as 40 feet (at age 50) on individual soil series.

The study described here was designed to learn whether loblolly pine site index within individual soil series might be closely predicted from chemical properties of the soil. This approach seemed reasonable because growth of loblolly pine (*Pinus taeda* L.) has been related to soil phosphorus levels on pocosin sites in North Carolina (MacCarthy and Davey 1976) and slash pine (*Pinus elliotti* Engelm) to soil phosphorus levels in Florida (Ballard and Pritchett 1974).

MATERIALS AND METHODS

Soils on the lower coastal plain were sampled on 40 plots for which a detailed history of growth of loblolly pine was available. These plots represented Craven (Aquic Hapludult, clayey, mixed, thermic), Wahee (Aeric Ochraquult, clayey, mixed thermic), and Meggett series (Typic Albaqualf, fine, mixed thermic). Craven is moderately well drained, Wahee is somewhat poorly drained, and Meggett is poorly drained. Both physical and chemical properties of the three soil series overlap. The series are extensive on the lower coastal plain and represent site indices of 84 to 120 feet. The stands ranged in age from 42 to 76 years old. Site index at age 50 was used for comparison of the sites.

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Core samples through the B2 horizon were taken at five points on each site. They were composited by site and horizon, air-dried, and ground to pass a 10-mesh screen. Mechanical analysis was accomplished by the bouyoucos hydrometer method. Organic matter was determined by wet digestion (Jackson 1958); total nitrogen content was obtained by Kjeldahl analysis; and soil pH was measured with a glass electrode in a 1:1 mixture of soil and water. Exchangeable bases were extracted with 1N NH_4OAc and analyzed by atomic absorption. Available phosphorus (Bray P2) was determined by the method of Bray and Kurtz (1945).

Individual physical and chemical properties in the profile were then correlated with site index for each series by simple regressions. Based on these results, combinations of soil properties were selected for entry in multiple regressions for predicting site index. Models were selected containing the minimum number of soil variables that would account for at least 60 percent of the variation in site index.

RESULTS

The sites varied in soil textures in the A1 horizon; sand contents ranged from 21 to 68 percent, silt from 21 to 57 percent, and clay from 11 to 30 percent (table 1). Organic matter ranged from 3.2 to 13 percent but did not reflect a noticeable trend in relation to drainage patterns. The soils were all acid; pH ranged from 3.7 to 5.5. Chemical properties of A1 horizon ranged widely. Exchangeable calcium ranged from 0.6 to 10.6 meq., magnesium from 0.03 to 5.78 meq., potassium from 0.02 to 0.16 meq. and sodium from 0.3 to 1.8 meq. per 100 grams. High and low values for nitrogen in the A1 horizon were 76 and 372 ppm; those for available phosphorus were 2.5 and 88.5 ppm. Values for physical and chemical properties for the B2 horizon were also quite variable and overlapped for the three soil series.

When plots of the three soil series were combined individual physical and chemical properties accounted for no more than 22 percent of the variation in site index. Attempts to use multiple regression analysis independent of series did not greatly improve the relationship of soil properties to site index over the simple regression values.

Within individual soil series, however, relationships between site index and soil properties were often quite close. Individual variables in simple linear regression accounted for 31 to 77 percent of the site index variation.

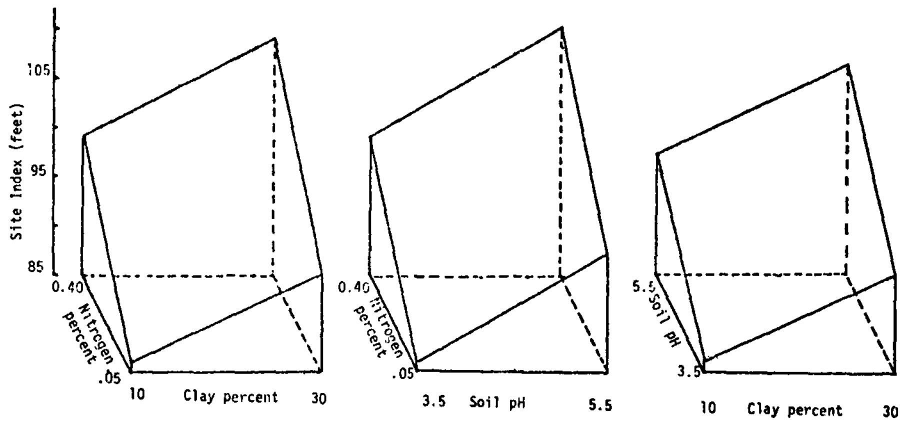
Site index ranged from 87 to 108 feet for the 18 sites sampled on Craven soils. Exchangeable calcium in both the A1 and B2 horizons plus exchangeable potassium, percent nitrogen, and soil pH in the A1 horizon were significantly related to site index. A multiple regression using clay, nitrogen, and pH in the A1 horizon accounted for 60 percent of the variation in site index (fig. 1). The effect of all three soil properties was positive.

Table 1. Relationship of selected soil properties to site index at age 50 for three lower Coastal Plain soils of South Carolina

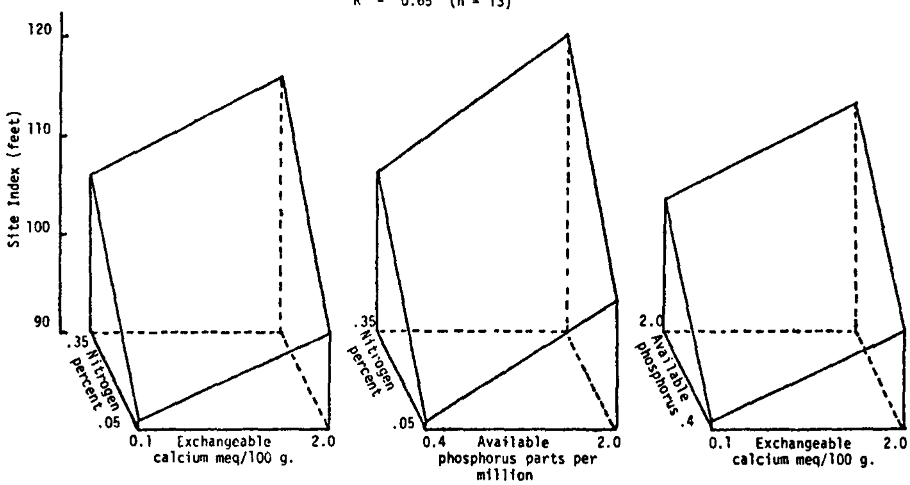
Soil and Stand Properties	SOILS Craven (n = 18) Minimum level	 Maximum level	 r value	 Wahee (n = 13) Minimum level	 Maximum level	 r value	 Meggett (n = 9) Minimum level	 Maximum level	 r value
Site index (feet)	87	108	--	84	120	--	102	116	--
A1 horizon									
Sand (percent)	29	68	.00	21	57	-.02	21	63	.84*
Silt (percent)	21	52	-.13	27	55	-.12	21	57	-.88*
Clay (percent)	11	28	.25	13	30	.05	17	27	-.16
Organic content (percent)	5.10	12.10	.20	4.60	13.8	-.39	3.2	13.0	-.60
Soil pH	3.73	5.48	.65*	4.10	4.80	.25	4.10	5.20	.52
Exchangeable Ca (meq/100 g)	.60	10.30	.47*	.30	5.20	.22	2.00	10.60	.37
Exchangeable Mg (meq/100 g)	.03	5.78	-.15	.22	.71	.22	.64	1.27	.07
Exchangeable Na (meq/100 g)	.30	1.79	-.13	.21	.80	.42	.34	1.22	.52
Exchangeable K (meq/100 g)	0.02	0.15	.54*	.04	.09	-.04	.04	.16	-.27
Nitrogen (Total) (percent)	0.076	0.352	.62*	.098	.352	-.05	.143	.372	-.06
Available phosphorus (ppm)	2.5	36.0	.29	2.8	88.5	.20	3.6	15.7	.34
H_2O soluble phosphorus (ppm)	0.9	22.7	-.31	1.20	22.7	-.08	2.6	22.0	-.37
Aluminum phosphorus (ppm)	6.6	35.3	-.40	6.9	24.3	-.21	15.7	45.2	.44
Iron phosphorus (ppm)	6.7	25.0	-.10	8.5	31.9	.07	5.2	36.1	.40
Calcium phosphorus (ppm)	0.7	26.2	.17	0.7	4.1	-.21	0.7	3.4	.21
Occulied phosphorus (ppm)	0.0	15.1	.07	1.9	17.9	-.53	1.3	17.4	00
B2 horizon									
Sand (percent)	10	57	.23	12	37	.06	11	47	.73*
Silt (percent)	16	41	-.04	19	41	-.12	14	38	-.71*
Clay (percent)	23	62	-.24	30	56	.05	29	59	-.17
Organic content (percent)	0.0	2.1	.16	.10	1.50	.05	0.4	1.3	-.63
Soil pH	4.55	5.03	-.06	4.63	5.08	-.34	4.40	7.50	.71*
Exchangeable Ca (meq/100 g)	.20	2.70	.49*	0.10	2.10	.56*	0.40	9.90	.54
Exchangeable Mg (meq/100 g)	.27	6.21	-.28	0.27	0.75	-.07	0.43	5.64	.53
Exchangeable K (meq/100 g)	0.02	0.08	.15	0.01	0.09	.36	0.02	0.28	.52
Total nitrogen (percent)	0.013	0.169	-.16	.047	.352	.55	0.089	.301	.08
Available phosphorus (ppm)	0.2	75.0	.25	.40	2.10	.45	0.3	99.9	.51

* - Denotes r value statistically significant at .05 level.

Craven Series Site Index = 58.68 + (39.71 nitrogen A1) + (0.489 clay A1) + (5.72 soil pH A1) R^2 = 0.60 (n = 18)



Wahee Series Site Index = 84.16 + (5.18 calcium B2) + (53.88 nitrogen B2) + (8.25 phosphorus B2) R^2 = 0.65 (n = 13)



Meggett Series Site Index = 96.9 + (0.19 phosphorus A1) + (0.28 sand A1) R^2 = 0.74 (n = 9)

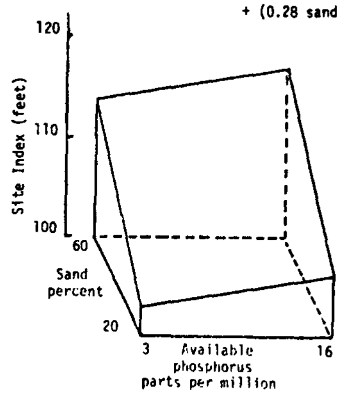


Figure 1. Response surfaces for soil properties which were closely related to site index on Craven, Wahee, and Meggett soils.

Site index ranged from 84 to 120 feet on 13 sample sites on Wahee soils. Only calcium in the B2 horizon was significantly related to site index. On Wahee soil a multiple regression with exchangeable calcium, available phosphorus and total nitrogen in the B2 horizon as independent variables accounted for 65 percent of the variation in site index. Each of the three variables had a positive effect on site index.

Site index ranged from 102 to 116 feet on the 9 plots with Meggett soils. Sand in the A1 and B2 horizons plus soil pH in the B2 horizons were significantly and positively related to site index. Silt in the two horizons had a strong negative effect. On Meggett soil, sand content and available phosphorus in the A1 horizon accounted for 74 percent of the variation in site index. The effects of both variables were positive.

DISCUSSION

The results from a limited number of sites in the lower Coastal Plain show that between 60 and 74 percent of the site index variation of loblolly pine within soil series can be accounted for by chemical and physical properties of the A1 and B2 horizons. These relationships did not hold across soil series, and the specific properties related to site index varied with the series. It is possible that a number of soil series may be grouped together using regression analysis for predicting growth potential, but the limited sampling done in this study does not permit this type of comparison.

The strong influence of sand on the Meggett soil probably reflects sand's influence on internal drainage. Since this soil is inherently high in exchangeable bases and is frequently associated with phosphate deposits near the soil surface, it is probable that these nutrients are not in critical supply. On the Craven soil the dependence on increasing clay content may be related to nutrient-holding capacity since the soil is classed as moderately well drained and is inherently less fertile. Also, the influence of pH on Craven sites may be an indirectcalcium effect as found on the Wahee series since calcium is the dominant base of the exchange complex.

The results demonstrate that the prediction of growth potential of individual soil series can be improved by considering nutrient status and physical properties of individual soil horizons.

LITERATURE CITED

Ballard, R. and W. L. Pritchett. 1974. Phosphorus retention in coastal plain forest soils: II. Significance to forest fertilization. Soil Sci. Soc. Am. Proc. 38: 363-366.

Bray, R. H. and L. T. Kurtz. 1945. Determination of total organic and available forms of phosphorus in soils. Soil Sci. 59: 39-45.

Carmean, W. H. 1975. Forest site quality evaluation in the United States. In Adv. in Agron. Ed. by N. C. Brady. 27: 209-269.

Jackson, M. L. 1958. Soil Chemical Analysis. Prentice Hall, Inc.

MacCarthy, R. and C. B. Davey, 1976. Nutritional problems of *Pinus taeda* (Loblolly Pine) growing on Pocosin soil. Soil Sci. Soc. Am. J.40: 582-585.