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The Relationship Of Certain Soil And Topographic Properties To Site Quality Of Grand Fir In Northern Idaho

by

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INTRODUCTION

Very limited information is available concerning the relationship of soils to forest site quality in Idaho. Yet more than two-fifths of the State is forested (Wilson, 1962), with the forest industry second only to agriculture in economic importance. Successful management of this resource will require among other things an ability to predict, for a given species and area, the volume of timber available at future dates.

Investments in forest management are usually costly and must be based on rather accurate figures o. expected future yields. Current methods of forest site quality evaluation require well-stocked stands of the desired species to be present on the site. In situations where land is poorly stocked, stocked with undesirable species or without trees present to indicate the quality of the land, an appraisal is difficult, not only for purposes of timber production but also for taxes, land sale and choosing the best land use.

A technique for evaluating forest land quality founded on the characteristics of soil and site is needed in Idaho. The relationship of soil to productivity can be more clearly understood if a specific investigation is confined to a particular species as it grows on soil derived from only one kind of parent material. The current study involves just such an investigation, grand fir (**Abies grandis** (Dougl.) Lindl.) productivity being related to topographic factors and certain properties of soils having a spodic horizon heavily influenced by volcanic ash. The spodic horizon is defined by the Soil Survey Staff (1967) as

> ". . . one in which active amorphous materials composed of organic matter and aluminum, with or without iron, have precipitated. The term "active" is used here to describe material having high exchange capacity, large surface area, and high water retention."

Plots and information concerning grand fir productivity were supplied by Albert Stage, Principal Mensurationist, U.S. Forest Service, Intermountain Forest and Range Experiment Station. This information provided two measures of site quality: (1) site index (Stage, 1959) which is the relationship of tree height to age of the dominant trees in a stand and is expressed as total height at an index age of fifty years, and (2) a productivity rating, q, which Stage (1966) expressed as the current annual increment divided by an expression that adjusts current annual increment for the varying growth po-

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tential of stands of different stages of development and levels of stocking. A q value of 1.0 would indicate average site quality,while a q of 1.4 means the site is capable of producing 40 percent more wood than the average site. Also a q of 0.5 means that the site is 50 percent less productive than the average site. The q value was considered by Stage to be superior to site index in its ability for predicting growth for several reasons. First, q accounts for the influence of site quality on height growth and stocking, while site index represents only the factors that affect height growth of individual trees. Secondly, the productivity rating procedure allows purposeful selection of plots to cover a range of sizes, ages, and densities. Lastly, q measures the site potential directly in physical units of wood production. By taking each of these measures of site quality as dependent variables and the soil and topographic variables as independent variables the relationships between them was studied with the aid of multiple regression analysis.

LOCATION AND SOILS OF STUDY AREA

The center of the study area lies approximately fifteen miles northeast of Moscow, Idaho and is bounded by the towns of Harvard, Emida, Clarkia, Elk River and Bovill. The area is within the Northern Rocky Mountain Province bordering on the Tri-state Uplands Section of the Columbia Plateau Province as based on the map of Ross and Forrester (1958). The mountains are in a youthful stage with V shaped slopes and rounded ridge tops.

Volcanic ash was deposited on top of pre-existing soils in the study area approximately 6600 years ago (Fryxell, 1965) and has been retained because of the protective influence of the coniferous forest. The depth of this deposit varied from twelve to thirty inches. As a consequence a new soil profile developed with the majority of plant roots concentrated in the ash horizon. The following soil profile description from Plot No. 159, T42N, R1W, Section 15, Boise Meridian is representative of the soils in this study:

Horizon	Depth	Description
01	1/8-1/2 in.	Undecomposed conifer needles and twigs.
02	0-1/8 in.	Partially decomposed organic material.
B21ir	0-7 in.	Dark Brown (10YR3.0/3.0) when moist; Yellowish brown (10YR5.0/4.0) when dry; silt loam; weak very fine crumb structure; very soft and very friable, non-sticky and nonplastic; few small concretions; abundant roots of all sizes; pH 6.6 (paste) gradual wavy boundary. There are some small gravel and pieces of charcoal in this horizon.
B22ir	7-12 in.	Dark yellowish brown (10YR3.5/4.0) when moist. Light yellowish brown (10YR6.0/4.0) when dry; silt loam; weak very fine crumb structure; nonsticky and nonplastic; few small concretions medium to large roots, pH 6.1 (paste); clear wavy boundary. There are some small gravel and pieces of charcoal in this horizon.
IIC1	12-36 in.	Yellowish brown (10YR4.6/3.8) when moist; Light yellowish brown (10YR6.5/3.5) when dry; loam; single grain structure; non-sticky and nonplastic, firm; very few medium size roots; pH 5.6 (paste); gradual irregular boundary.
		Yellowish brown (10YR4.7/3.8) when moist;
IIC2	36+ in.	Very pale brown (10YR7.2/3.0) when dry; gravelly loam; single grain structure; weakly coherent, friable, nonsticky and nonplastic; no roots; pH 5.1 (paste); increasing gravel with depth.

The buried portion of these soils developed from Pre-Cambrian meta-sedimentary rocks of the Belt Series. The Belt Series is of marine origin, distributed over 65,000 square miles in Montana, Idaho, and eastern Washington and constitutes a thick unit composed mainly of argillaceous and quartzitic rocks with subordinate amounts of calcareous rocks (Ross and Forrester, 1958).

METHODS

Field Study and Sampling

Thirty of the original plots used by Stage were relocated and a soil pit excavated to expose all soil horizons. Twenty-four of these plots had a spodic soil horizon and were used for this study.

The following variables were recorded on each plot: (1) native vegetation, according to Daubenmire's classification (Daubenmire, 1952); (2) microrelief; (3) slope, measured in percent with an abney; (4) aspect, recorded in eight quadrants; and (5) elevation to the nearest one hundred feet. The profile description, based on the standards in the Soil Survey Manual (1951), consisted of horizon designation and the depth, boundary characteristics, dry and moist color (using the Munsell notation), and structure of each horizon. When possible each horizon was sampled for bulk density using a core sampler. A sample from each mineral horizon in a profile was collected and air dried in a greenhouse. The samples were then sieved and the less than 2 mm fraction collected for laboratory analyses of various physical and chemical properties of the soils.

A multiple regression analysis was employed to evaluate the 38 variables involved in this study. Use of a computer greatly facilitated the multiple regression computations.

RESULTS AND DISCUSSION

Site index may be defined as the relationship of height to age of the dominant trees in a stand and is usually expressed as total height at an index age such as 50 or 100 years. The term is widely used to compare stands and site quality. Site index of the particular plots used in this study were determined by Stage and ranged from 36 to 74. The values encompassed the entire range of site indexes found on all 151 of his plots.

The relative productivity rating, q, proposed by Stage was obtained by dividing the current volume increase in cubic feet per acre per year of a stand by an expression that accounted for the varying growth potential of stands of differential levels of stocking and stage of development. The current study included plots encompassing the entire range of q, from 0.59 to 1.61, found by Stage.

The bisequum soil profiles sampled in this investigation developed from the deposition of volcanic ash over pre-existing soils. Horizon development within the ash deposit was weakly expressed, with only 2 horizons, B2lir and B22ir, observable in the field. Separation of these horizons was based on moist color, because there were no apparent differences in texture or structure.

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The difference in bulk density between the B2ir horizons and those of the pre-existing soils apparently was the reason that vegetation roots rarely penetrated deeper than the boundary between the ash deposit and pre-existing soils. Bulk density samples were collected on 14 of the 24 plots. Bulk density of the B2ir horizons averaged 0.753 with a range from 0.480 to 1.093, while that of pre-existing soils averaged 1.391 with a range from 1.261 to 1.548. While bulk density of the pre-existing soils was not unusually high, the difference in bulk density probably caused plant roots to remain within the less dense B2ir horizons above. The B2ir horizons would thus have the greatest effect upon tree growth, and the statistical analyses were limited to examination of the properties of these horizons and to the topographic data. Tables 1 and 2 present the range of values found for certain soil and topographic properties in this study.

Table 1. Range of Soil Properties.

Analysis	Horizons B21 max.	B21 min.	B22 max.	B22 min.
·Sand	56.89	14.10	55.30	17.40
·Silt	66.00	25.49	64.40	33.60
·Clay	21.00	10.10	24.57	10.44
·Nitrogen	0.213	0.074	0.148	0.028
··Cation Exchange Capacity	22.61	12.76	17.89	7.99
··Ca	10.11	1.00	6.24	0.41
··Mg	2.46	0.37	2.28	0.11
··Na	0.50	0.07	0.40	0.11
··K	1.47	0.39	1.39	0.12
··H	14.28	2.27	10.22	2.21
···OM	13.56	3.02	5.91	1.26
pH	6.9	5.3	6.0	5.2
Thickness (in)	11	3	24	5
·H2O cap.	34.27	14.74	34.23	10.60
·Base Saturation	84.1	21.4	78.0	13.5

·%
··me/100g O.D. soil
···me/g O.D. soil

Table 2. Range of Topographic Properties.

	min.	max.
Elevation (ft)	2850	4450
%Slope	10.0	64.0
Aspect (Azimuth)	All except north	

Over a range of site index from 36 to 74, combinations of the following soil and topographic variables provided the best prediction equations: moist hue of the B2lir and B22ir; moist value of the B21ir; K of B21ir + B22ir; percent sand of the B21ir; percent silt of the B22ir; azimuth (sin and cos); elevation, percent slope, thickness of the ash deposit; and thickness of the B22ir. The first 5 variables formed a regression equation that accounted for 68.75 percent of the variability in site index with a standard error of estimate of 5.302. The addition of 5 more variables produced an equation which accounted for 77.63 percent of the variation in site index. However, there was no concurrent improvement in the standard error of estimate because the added variables had coefficients not significantly different from 0. Thus the equation formed by the first 5 variables was:

SI = 12.6780 - 7.9435 (moist hue B21ir) + 10.9778 (moist hue B22ir)
+ 10.5889 (moist value B21) + 4.0432 (K of B21ir + K of B22ir)
+ 0.2278 (% sand B21ir - 0.4081 (% silt B22ir).

Three other combinations of variables were found that would predict site index with slightly less efficiency but do not require laboratory analysis. The equations are as follows:

1. SI = 62.5307 - 4.6704 (sin azimuth) + 2.7372 (cos azimuth) -
0.0084 (elev.) + 0.3196 (% slope) + 0.0791 (thickness B21ir)
+ 0.6249 (thickness of B22ir).
$R^2 = 0.5582$
Standard error of estimate 6.305

2. = SI 62.6434 - 3.9573 (sin azimuth - 0.0089 (elev.) + 0.2829 (% slope) + 0.5506 (thickness of ash deposit).
$R^2 = 0.5148$
Standard error of estimate 6.429

3. SI = 63.3050 - 4.7523 (sin azimuth) + 2.7557 (cos azimuth) - 0.0085 (elev.) + 0.3198 (% slope) + 0.6262 (thickness B22ir).
$R^2 = 0.5578$
Standard error of estimate 6.130

The best regression fit of q was obtained with the equation:

q = -0.2029 + 0.0199 (thickness of ash deposit) + 0.1715 (dry value (B21ir) - 0.1710 (dry value B22ir) + 0.3307 (dry chroma B21ir) - 0.1436 (dry chorma B22ir) + 0.0326 (Ca of B21ir + Ca of B22ir).
$R^2 = 0.7041$
Standard error of estimate 0.1542

These combinations of variables were regarded as the best to be obtained at the present time. An effort was made to use variables that influence site quality. The effects of topography, depth, texture, and color of soil on site quality were strongly demonstrated by their appearance in every regression on site index and q. The appearance of Ca and K in the regressions should be interpreted with caution because the actual quantity of these cations required by trees has not been established. However, they should not be ignored because the level of exchangeable Ca and K in soil does give an indication of the nutrient status of the site.

The equations presented offer an investigator a wide choice of variables, many of which are easily observed in the field, for estimating site quality of grand fir on volcanic ash soils in northern Idaho.

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