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SOIL-SITE QUALITY RELATIONSHIPS ON THE UNIVERSITY OF IDAHO EXPERIMENTAL FOREST[1]

by

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INTRODUCTION

Few soil-site studies of forest land in Idaho exist despite a wealth of information for other areas of the U.S. and other countries. However, the forest industry is of great economic importance to the state and especially so in northern Idaho. With the ever increasing demand for lumber and paper products, it is essential that forest lands produce to the optimum. To get this optimum production, effective management must be practiced.

Investments in forest management are usually costly and must be based on fairly accurate estimates of expected future yields. Current methods of estimating forest site quality are based on site index. This requires well stocked stands of desired species. Many areas in northern Idaho have been cut-over or burned, or else are poorly stocked, stocked with undesirable species, or unstocked. In situations such as these, an indirect method of evaluation is needed so that the best land use can be obtained. Through the correlation of soil and topographic characteristics and site index, site quality may be estimated by measuring these characteristics.

This study was designed to find the relationships between certain soil and topographic characteristics and site quality for Douglas-fir (*Pseudotsuga menziesii* Franco), grand fir *(Abies grandis* (Dougl.) Lindl.) and western larch *(Larix occidentalis* Nutt.) within the University of Idaho Experimental Forest.

PREVIOUS WORK

Although soil-site studies have been performed throughout the United States and Canada, very little work has been completed in the intermountain area of eastern Washington, northern Idaho, and western Montana.

Cox, McConnell, and Matthew (1960) found that depth of soil in which tree roots might develop is the principal factor influencing growth of ponderosa pine *(Pinus ponderosa* Laws) in western Montana. Holtby (1947) discovered that soil texture 6 in. (15.24 cm) below the soil surface is a fairly reliable indicator of site quality in the ponderosa pine zone of eastern Washington.

For western white pine *(Pinus monticola* Dougl.) in the northern Rockies, Copeland (1956 and 1958) found that site index could be correlated with effective soil depth, depth to zone of reduced permeability, and the available water holding capacity of the top 3 ft. (.91 m) of soil.

Base and Fosberg (1971), in establishing prediction equations for site quality in northern Idaho for four conifers, found the following characteristics to be significant. In the prediction equation for ponderosa pine, soil family accounted for 45 percent of the variation in site index. Elevation and moist consistence of the most developed horizon in the upper 40 in. (101.6

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cm) accounted for 41 percent of the variation in site index of lodgepole pine *(Pinus contorta* Dougl.) in the prediction equation with elevation approximately 25 percent more important than moist consistence. In the equation selected to predict site index of western white pine, soil drainage and moist color of the upper 6 in. (15.2 cm) mineral horizon accounted for 64 percent of the variation in site index with soil drainage 33 percent more important than soil color. Elevation, soil subgroup, and soil family accounted for 26 percent of the variation in site index of western larch in the prediction, with soil family 25 percent more important than elevation and 75 percent more important than soil subgroup.

Wall and Loewenstein (1969) found that for estimating site quality of grand fir on volcanic ash soils in northern Idaho, the characteristics with significant effect are percent slope, elevation, aspect, and depth of ash deposit (effective soil depth, texture, and soil color).

The work that has been reviewed brings to light the many factors that have been used to try to determine site quality in the intermountain area. Given adequate precipitation and habitat for tree growth, the following characteristics could probably best be used to give some indication of site quality:

(1) elevation
(2) slope
(3) aspect
(4) soil depth
(5) effective soil depth
(6) water holding capacity
(7) texture

However, to produce a relatively precise estimate of production potential, a more intensive study of the soils in a particular area is required.

AREA DESCRIPTION

Location, Size, Access

The study area is designated as the Flat Creek Unit of the University of Idaho Experimental Forest. It is located 4 miles south along state highway 9 from the junction of state highway 9 and U.S. highway 95A in Latah County, Ida. It includes all of section 33 and portions of sections 28, 31, and 32 T41N, R3W and portions of sections 4, 5, 7, and 8, T40N, R3W. All legal descriptions are based on the Boise Meridian.

The area consists of 2,765 acres and is accessible from state highway 9, by a U.S. Forest Service road leading to Brown's Meadow and by an unnamed logging road.

Geology

The study area is underlain by a granitic outlier of the Idaho Batholith called the Thatuna Batholith of the Mesozoic Era. Granodiorite is the chief rock type. This material has little affect on the soils developed within the study area, as the entire vicinity was covered with several blankets of loess in the middle to late Pleistocene (Ross and Savage, 1963). The depth of the loess ranges from 2 feet (.61 m) to greater than 10 feet (3.05 m). The variability in the depth is probably due to differential erosion and deposition (drifting affect).

Approximately 6,600 years ago the volcanic eruption of Mt. Mazama (Crater Lake, Ore.) resulted in an ash fall over the entire region (Fryxell, 1965). Most of the ash has been eroded away in the study area except on sites which are presently in western redcedar/pachistima (*Thuja plicata* Donn/*Pachistima myrsinites* Raf.) habitat type and grand fir/pachistima *(Abies grandis* (Dougl.) Lindl./*Pachistima myrsinites* Raf.) habitat type. Apparently the kind and amount of vegetation in these areas during the altithermal period was sufficient to prevent extensive erosion of the volcanic ash. Where the ash deposits are present they range in depth from 10 to 20 in. (25.4 to 50.8 cm).

The majority of the soil development within the study area has taken place in the loess and volcanic ash strata.

Vegetation

The Flat Creek Unit is predominantly coniferous forest with a few small open meadows. There are four habitat types (Daubenmire and Daubenmire, (1968) represented. The majority of the area is grand fir/pachistima *(Abies grandis* (Dougl.) Lindl./*Pachistima myrsinites* Raf.). The next most common habitat type is western redcedar/pachistima (*Thuja plicata* Donn/ *Pachistima myrsinites* Raf.). Douglas-fir/ ninebark (*Pseudotsuga menziesii* Franco/ *Physocarpus malvaceous* Camb.) habitat type is found on the drier, warmer slopes and ridgetops. The most restricted habitat type is the subalpine fir/pachistima *(Abies laziocarpa* (Hook.) Nutt./*Pachistima myrsinites* Raf.) which occurs only in stream bottoms which are "frost pockets."

The distribution of vegetative communities within this area seems to be goverened more by air drainage patterns and aspect than by elevation.

Much of the vegetation within the Flat Creek Unit has been disturbed by either logging, fire, insect damage, or grazing and is in varying stages of succession.

Climate

The climate within the study area is relatively mild. The mean annual temperature ranges from approximately 47° F (8.3° C) on the more open south and west facing slopes to several degrees cooler on the north slopes and in the frost pockets and cold air drainage ways.

The mean annual precipitation ranges from approximately 25 to 30 in. (63.5to 76.2 cm) with the majority coming during the winter.

Topography

The study area is dominated by round secondary ridges generally running to the north and east of the Palouse Range. The gross aspect is northeast. The slopes average about 16 percent with a few ranging up to over 35 percent in the southwest corner near the crest of the range.

There is about 700 ft. (213.4 m) of relief expressed in the study area with an average elevation of approximately 3,000 ft. (914.6 m).

METHODS

Field Work

In connection with a forest inventory project, 80 plots had been randomly selected within the study area for the purpose of collecting growth information (Allen, unpub.) From the data generated by this inventory project, height and age of the dominant trees on each plot were obtained and site index was determined using standard curves for this area (Cummings, 1937; Stage, 1959). The plots were then stratified and 21 were selected, based on the widest range of site index within the area.

For each plot the following information was recorded: (1) habitat type, based on Daubenmire's classification system (Daubenmire and Daubenmire, 1968); (2) elevation, to the nearest 50 ft. (15.2 m) using an altimeter; (3) soil parent material and geology; (4) land form; (5) slope position; (6) macrorelief; (7) microrelief; (8) slope, in percent measured with an abney level; (9) aspect, recorded in eight quadrants.

Within each plot one soil pit was dug to below the effective rooting zone to expose the soil horizons. The profile description of each pit, based on the Soil Survey Manual procedures (Soil Survey Staff, 1951), consisted of: (1) horizon designation and depth; (2) boundary characteristics; (3) dry and moist color according to Munsell notation; (4) texture; (5) structure; (6) dry, moist, and wet consistence; (7) clay films; (8) pores; and (9) roots. Each horizon in the profile was sampled for bulk density using a core sampler. A 500 gm sample was collected from each mineral horizon, air dried, and sieved so that the 2 mm and less size fraction could be used in the laboratory.

Laboratory and Computer Analysis

The laboratory work consisted of physical and chemical analysis of the soil following standard procedures.

Computer analysis of the data was done by stepwise multiple regression using a Statistical Analysis System (Barr and Goodnight, 1972) program.

RESULTS AND DISCUSSION

Grand fir site indices ranged from 30 to 60, Douglas-fir from 50 to 80, and western larch from 30 to 80.

A bisequm was found within the loess in most of the pits which expresses the fact that there has been more than one major deposition. The paleosols found in the lower sequm usually had a large increase in clay and high bulk densities. These bulk densities varied from 1.68 to 2.02 with the majority falling between 1.84 and 1.97. Since root penetration becomes seriously restricted at bulk densities this high, these levels were used as the criteria for determining effective rooting depth. The very few roots that did penetrate followed cracks and were flattened against the ped faces giving indication that this was a fragipan.

The first step in analyzing the data involved running the stepwise regressions on the horizons of each profile supporting a particular tree species. The variables in each linear model with the highest sums of squares and coefficients significantly different from zero were selected and used in future prediction equations for each species.

Douglas-fir

In the prediction of site index for Douglas-fir, effective rooting depth was the single most important factor accounting for 39.10 percent of the total variation in site index. The best regression equation for predicting site index for Douglas-fir follows:

Site index = 89.4507 + 0.4730 (eff. rooting depth in inches)
− 0.0994 (ppm of avail. P in surface horiz.)
− 0.4643 (% avail. H_2O in surface horiz.) — 72.3721 (meq./100gms of exch. Na in third horiz.)
+ 0.0360 (C:N of third horiz.) — 4.8469 (tex. of third horiz.)

$R^2 = 0.8339$

Standard error of estimate = 4.850

A slightly less efficient equation for predicting site index of Douglas-fir states:

Site index = 6.6033 + 1.9463 (elev. in feet) + 0.1774 (eff. rooting depth in inches) + 0.6026 (wet consis. of second horiz.) — 4.1907 (tex. of third horiz.)

$R^2 = 0.7542$

Standard error of estimate = 5.375

Although this equation accounts for slightly less of the total variation in site index than does the other equation (75.42 percent compared to 83.39 percent), the variables in this equation can be observed in the field. If the less precise prediction is adequate, expenses would be much lower, as no laboratory analysis would be required (if finger determination of texture and wet consistence is acceptable).

Western larch

There are only seven observations for western larch in this study. Therefore, models were limited to not more than three independent variables. The best three-variable equation is expressed as follows:

Site index = 252.4245 + 40.6077 (02 depth in inches) — 44.1904 (pH of fourth horiz.) + 0.2557 (ppm of P in fourth horiz.)

$R^2 = 0.9907$

Standard error of estimate = 2.479

The best two-variable model for western larch is listed below:

Site index = 291.3960 + 39.8304 (02 depth in inches) — 50.3588 (pH of fourth horiz.)

$R^2 + 0.8878$

Standard error of estimate = 7.462

The two-variable prediction model would prove useful as the depth of the 02 horizon and the pH of the fourth horizon in the profile would be easy and inexpensive to measure.

Grand fir

Any of the equations predicting site quality for this species with adequate accuracy contained variables that required laboratory analysis. Therefore the best prediction equation for grand fir is the only one presented:

Site index = 75834.5657 + 12.9801 (% O.M. of surface horiz.) − 329.8935 (% N of surface horiz.) + 0.0767 (dry color of surface horiz.) + 7.2530 (meq/100 gms Mg in second horiz.)

$R^2 = .9849$

Standard error of estimate = 1.706

This equation provides an excellent estimate of site index for grand fir as the standard error of estimate is quite low.

These prediction equations provide a land manager with a method of estimating the quality of sites that are poorly stocked, stocked with undesirable species, or unstocked. Even though this study was restricted to the University of Idaho Experimental Forest, these results are applicable to areas with similar parent materials, climate, and topography.

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