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USE OF SOIL/SITE DATA WITH A GEOGRAPHIC INFORMATION SYSTEM – A BETTER WAY TO PREDICT SITE PRODUCTIVITY

Background:

The purpose of soil/site studies by NRCS is to develop a database from which productivity and species composition can be predicted for each soil series on which forest is a prevalent land use. While the NRCS forest/soil database has been well developed during the past 40+ years (more than 2000 soil/site plots in North Carolina alone), it is recognized that budget and personnel constraints will probably never allow enough data collection to accurately make productivity predictions for all soils and species. Doolittle (1958) recognized that this method of developing site index data requires "…as many studies of soil-site relationships as there are species, and …each study requires considerable time and effort…"

In fact, it should be recognized that soil type is only one variable that determines forest productivity. Other site variables include aspect and slope type (McNab 1987), thickness of the A horizon and proportion of sand (Doolittle 1957), elevation, drainage, landform position, and land history (Harrington 1990).

Modern soil survey techniques used in Major Land Resource Area 130 take into account, to some extent, all of these variables with the exception of past management. For example, some soils are "elevation specific" while others are "aspect specific". Problems arise, however, when soil series are mapped over a wide range of elevation and topographic positions.

Recognizing that landform is related to environmental factors that affect site productivity in mountain terrain, McNab (1993) devised a simple index of landform to use as a predictor of site index. His landform index (LFI) is the mean of eight slope gradients from plot center to the skyline and represents a measure of mesoscale landform – ridge, slope, and valley. McNab (1989) also devised a terrain shape index (TSI), a quantitative expression of the geometric shape of the proximate land surface. It is the mean relative difference in elevation between the center of a plot and its boundary. It represents a measure of microscale landform – convex, linear, or concave. Both LFI and TSI can be determined by field measurement or computed using digital elevation models within a geographic information system (GIS). McNab (1993) found that the site index of yellow-poplar was significantly correlated with both landform index (LFI) and terrain shape index (TSI). McNab (1993) also recognized that much of the variation in site index remained to be accounted for by other site variables, such as soil and climate.

The Study:

In an effort to combine a known variable (soils) with landform and terrain shape, W. Henry McNab, Research Forester, USDA Forest Service, Southern Research Station at

Bent Creek Experimental Forest, and Albert Coffey, Forester, USDA Natural Resources Conservation Service (NRCS) analyzed a group of 54 soil/site sample plots. The plots represented a total of 63 site index computations for nine different tree species. Plots from eight western North Carolina counties were selected from upper and lower slope positions and a few mid-slope positions that contained colluvial soils. Coordinates for each soil/site plot were examined using 30m digital elevation models. Analysis was made using SAS (Cary, NC) statistical analysis software.

Results:

Species for which enough plots were available to make an analysis were yellow-poplar, white pine, scarlet oak, and northern red oak. An analysis of the data for three field-measured topographic variables, LFI, TSI, precipitation, and depth of soil >60 inches gave the following results:

TABLE 1 – TOPOGRAPHIC VARIABLES WITH ANNUAL PRECIPITATION AND SOLUM DEPTH

SPEC.	NO. PLOTS	R-SQ%	FIELD ELEV.	FIELD ASP.	FIELD SLOPE	GIS LFI	GIS TSI	PCP ANN.	DEPTH >60
ACSA3	1	-							
LITU	14	77			X	XXX	XX		XX
PIEC2	1	-							
PIST	11	33		X	X				
PRSE2	3	-							
QUAL	4	-							
QUCO2	8	26						X	
QUPR2	4	-							
QURU	17	60				XX			XX
TOTAL	63								

Note: 54 total plots; Multiple species were present on some plots.

X – somewhat related – $P \leq 0.05$ level of significance (5 times in 100 wrong).

XX – quite confident of true effect – $P \leq 0.01$ level of significance (1 time in 100 wrong).

XXX – very confident of true effect – $P \leq 0.001$ level of significance (1 time in 1000 wrong).

R-SQ% is the amount of variation in site index accounted for by the variables in columns with the “Xs.” Of the four species represented by adequate data, the analysis showed a “good” (R-SQ>60%) estimate of site index for only two species (northern red oak and yellow-poplar). For these two species, soil and landform variables most affected site index.

An analysis of the above tables may explain differences in site index which are not expected based on soil information alone. For example, Porters is a deep soil with a thick, dark surface. It is found on cool aspects and the expected site index for northern red oak is relatively high. Two such plots in the study sample are located at high elevations (4280 and 4360 feet) and have a correspondingly low LFI (0.044 and 0.013). On the other hand, Edneyville is a very deep soil, which has a thin, light colored surface and is normally found on warm aspects. Based on surface soil characteristics and aspect, one may expect Edneyville to have a somewhat lower site index than Porters. However, one plot of Edneyville in the study at elevation 3400 has an LFI of 0.100, and a site index of 92. The site indices for the two Porters plots are 71 and 66. So the impacts of soil depth and high elevation (and corresponding low LFI) explain more of the difference in productivity than soil surface characteristics alone would indicate.

Conclusions:

The use of soil survey information and GIS-computed or field-computed indices for landform and terrain shape provide a better prediction of productivity than any variable used alone. Soils, landform, and terrain shape account for most variables that influence site productivity. USFS and NRCS foresters, soil scientists, and planners would benefit from using current soil survey information in combination with knowledge of LFI and TSI. Computer-generated computations would be valuable, especially when overlaid with soil survey information in a GIS format. Potential exists to subdivide soil map units by predicted productivity based on LFI or TSI levels.

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