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NUTRIENT PROPERTIES OF FIVE WEST VIRGINIA FOREST SOILS

Abstract.—Nutrient levels in five well-drained forest soils of the northern mountain section of West Virginia were generally associated with the type of parent rocks from which the soils had formed. But in some instances, different rock types yielded soils of similar nutrient composition. Soils formed from limestone and calcareous shale were usually higher in fertility than soils formed from acid sandstone, siltstone, or shale. However, considerable variation in nutrient levels occurred within as well as among most of the different soil series.

Most of the upland forest soils in the northern mountain section of West Virginia (fig. 1) have developed in residuum from several different geological rock formations. Consequently the chemical properties of these soils could be influenced considerably by the mineral content of the rocks from which they developed. To gain an understanding of these relationships, we compared soil nutrient levels within and between modal soil series derived from five geologically different parent materials important in this section of the State. Although several additional geologic formations also occur in this area, they are thin and inconsistent in occurrence and therefore were not considered in this study.

The soils selected for study were well drained, were derived from the most extensively occurring geologic formations in the area, and represented the soil series normally developing from each of the individual formations. These soils occur on about 60 percent of the study area. The parent rocks, each of sedimentary origin, belonged to either the Devonian, Mississippian, or Pennsylvanian systems. Collectively, they included: (1) acid red and gray sandstone, siltstone, and shale; (2) limestone; and (3) calcareous red and gray shales (table 1).

The geology of the area is such that the formations that were studied generally occurred in a definite topographic sequence between elevations of 1,500 and 3,500 feet. The Chemung formation, located at lowest elevations, is capped by the slightly higher Catskill formation. Next in elevation is the Greenbrier, then the Mauch Chunk; and the Pottsville formation occupies the highest topographic positions. Greater precipitation and cooler temperatures are associated with higher elevations.

Although fertility of agricultural soils in West Virginia is reasonably well documented *(1, 2, 3, 4, 9)*, there is only limited information about the virgin forest soils in this part of the State *(5, 6)*. In this study we learned that nutrient concentrations in five locally important forest soils were related in general to the type of rocks from which the soils had developed. It is possible, therefore, to roughly characterize soil-nutrient levels in the field by identifying the soil series and its underlying geologic formation. Such prediction may ultimately prove useful in evaluating and as-

Figure 1.—The location of the study area in West Virginia.

signing research treatments that might be influenced by varying levels of soil fertility.

Methods

A total of 75 soil samples were collected from five well-drained upland soil series in Tucker and Randolph Counties, West Virginia. Each soil was sampled at five independent locations that were well distributed over the two-county area. At each sampling location, three soil samples were randomly taken from a topographically uniform ¼-acre plot. Each sample was drawn from a thoroughly mixed volume of soil obtained from an 8-inch section of the profile located just beneath the A_1 horizon. All samples were analyzed separately in the laboratory.

Differences in soil fertility due to variation in local climate and to species composition were minimized by limiting sampling to southern exposures and to stands containing a high proportion of red oak (*Quercus rubra*, L.), chestnut oak (*Q. prinus* L.), or scarlet oak (*Q. coccinea* Muenchh.). However, other less important factors that also influence soil fertility, such as position on slope, slope gradient, land form, and elevation were allowed to vary among the different sampling sites.

Chemical analyses were made on the fraction of oven-dry soil smaller than 2 millimeters. Total nitrogen (N) was determined by the macro-Kjeldahl method; phosphorus (P) was determined colorimetrically after extraction with 0.002 *N* H_2SO_4; and exchangeable potassium (K), calcium (Ca), magnesium (Mg), and manganese (Mn) were measured by atomic absorption following extraction with NH_4OA_c.

Results and Discussion

A wide range in nutrient concentrations occurred within and between the different soil series (table 2). Except for N, where there were no clearly defined differences between the soils, the data suggest that levels of other nutrients are generally associated with the various types of rocks from which the soils formed. However, it cannot be stressed too strongly that variation in nutrient concentrations between different sites on the same soil series can be considerable. For the six elements examined in this study, N and K consistently had the smallest coefficients of variation within the five soils, whereas Ca had the largest (fig. 2).

Table 1.—*Characteristics of soils and their geologic parent materials*

Geologic system[1]	Geologic formation	Soil series	Parent material composition	Subsurface soil texture	Soil color
Devonian	Chemung	Gilpin	Acid, gray sandstone and shale	Silt loam	Yellowish-brown
Devonian	Catskill[2]	Calvin	Acid, red sandstone and shale	Silt loam	Reddish-brown
Mississippian	Greenbrier	Belmont	Calcareous shale, sandstone and limestone	Silty clay loam	Dark reddish-brown
Mississippian	Mauch Chunk	Teas	Slightly calcareous red shale, and sandstone	Silt loam	Reddish-brown
Pennsylvanian	Pottsville	Dekalb	Acid, gray sandstone and siltstone	Loam	Yellowish-brown

[1] Geologic classification according to Reger *(7, 8)*.
[2] Currently classified as Hampshire formation.

For the metallic elements, lowest nutrient levels were generally associated with the loamy Dekalb series of the Pottsville formation, whereas highest nutrient levels were usually associated with Belmont soils, which formed from limestone and calcareous shales. Although there is little information about critical soil nutrient concentrations for satisfactory growth of the various hardwoods, this study suggests that the Dekalb soils formed from Pottsville material are the most likely to be nutrient-deficient.

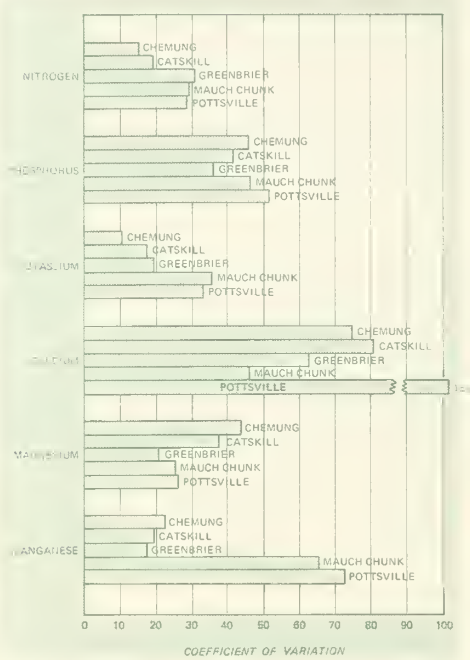
Gilpin and Calvin soils from the acid sandstones and shales of the Devonian system had similar nutrient levels except for P, which was significantly lower in the Gilpin series. K concentrations in these soils compared favorably with those of the Belmont series, but

Table 2.—Average nutrient values and standard deviations of soils derived from different geological parent materials[1]

Item	Parent Material				
TOTAL NITROGEN (percent)					
Formation	Chemung	Catskill	Mauch Chunk	Greenbrier	Pottsville
Soil	Gilpin	Calvin	Teas	Belmont	Dekalb
Mean	0.088	0.096	0.124	0.137	0.148
Standard deviation	0.013	0.018	0.036	0.043	0.043
PHOSPHORUS (ppm.)					
Formation	Chemung	Pottsville	Catskill	Mauch Chunk	Greenbrier
Soil	Gilpin	Dekalb	Calvin	Teas	Belmont
Mean	3.4	5.8	7.0	9.6	12.4
Standard deviation	1.6	3.0	2.9	4.4	4.5
POTASSIUM (ppm.)					
Formation	Pottsville	Mauch Chunk	Catskill	Greenbrier	Chemung
Soil	Dekalb	Teas	Calvin	Belmont	Gilpin
Mean	26	48	66	73	74
Standard deviation	9	17	12	14	8
CALCIUM (ppm.)					
Formation	Pottsville	Catskill	Chemung	Mauch Chunk	Greenbrier
Soil	Dekalb	Calvin	Gilpin	Teas	Belmont
Mean	10	42	50	218	356
Standard deviation	19	34	38	101	225
MAGNESIUM (ppm.)					
Formation	Pottsville	Mauch Chunk	Catskill	Chemung	Greenbrier
Soil	Dekalb	Teas	Calvin	Gilpin	Belmont
Mean	4	14	26	30	45
Standard deviation	1	4	10	13	9
MANGANESE (ppm.)					
Formation	Pottsville	Catskill	Chemung	Greenbrier	Mauch Chunk
Soil	Dekalb	Calvin	Gilpin	Belmont	Teas
Mean	19	37	39	51	79
Standard deviation	14	7	9	9	52

[1] Mean values are the average of 15 observations. Means not underscored by the same line are significantly different [Hartley test, 5-percent level (*10*, p. 253)]. Standard deviations calculated from means of the three samples obtained at each sampling location.

Figure 2.—Relative dispersion of nutrients in soil developed from different parent materials.



Ca and Mg levels were significantly lower than those associated with the fertile Belmonts.

Teas soils had significantly lower K concentrations than Gilpin, Calvin, or Belmont; but these levels were significantly higher than in the infertile Dekalb. P and Ca concentrations in Teas soils were comparable to those in the Belmont series, but Mg levels were significantly lower than in the Gilpin, Calvin, or Belmont series. Rather high Mn levels were also associated with Teas soils, but these levels were not statistically higher than concentrations in either the Gilpin, Calvin, or Belmont series.

Total N is not synonymous with available N, but has been used extensively as an indicator, along with other soil characteristics, of a soil's ability to provide N for plant growth.

Unlike the other nutrients, N was not significantly affected by soil series or parent materials, but indicated a strong positive trend with increasing elevation. Samples from high elevations consistently had higher total N values than samples from lower elevations. This trend may be the result of slower decomposition rates of organic matter caused by higher precipitation and cooler temperatures associated with rises in topography.

Significant differences in nutrient levels between these soils indicate the importance of parent material for delineating soil series in this vicinity. However, because these observations apply only to southern exposures and to soils supporting stands predominately of oak they should not, without confirming study, be used to estimate fertility levels on other exposures or for areas with different species compositions.

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