VEGETATION DISTRIBUTION AND SITE RELATIONSHIPS IN AN APPALACHIAN OAK FOREST IN SOUTHWEST VIRGINIA

by

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INTRODUCTION

Studies of forest systems have focused on various aspects of ecosystem dynamics. One important aspect is the investigation of the relationship between site and species composition, aimed at understanding community relationships within a limited geographic area. An understanding of the environmental factors which influence species distribution patterns yields information that is applicable for community classification systems and silvicultural planning.

It is generally agreed that climate is the major environmental factor affecting worldwide distribution of vegetation. Within a given region, however, local variations in environment caused by geology and soils, topography and stand history become more important in determining the distribution of plants (Braun 1950; Ricklefs 1976; Spurr and Barnes 1980). The Appalachian region offers a wide range of environments due to the great variability in these site factors. Many studies conducted in the region have recognized species patterns which are repeated under similar habitat conditions (Racine 1971; Mueller-Dombois and Ellenberg 1974).

Although emphasis on particular vegetation-site relationships differs with forest situation, the discussions typically center around the influence of various site factors on soil moisture availability and aeration, temperature regimes, and nutrient levels. A few studies have actually measured the environmental parameters of moisture and temperature (Cantlon 1953; Buell et al. 1966; Keever 1973; Stephenson 1982) or levels of available nutrients (Stephenson 1982) associated with differences in landscape and stand conditions. More often, these relationships are assumed from easily measured site factors such as elevation or topographic features which are then related to vegetation patterns. Characteristics which have, in different studies, been correlated with species distributions in the Appalachians include elevation, soil depth and texture, lithology, landform, and slope exposure, position and steepness (Whittaker 1956; Hack and Goodlett 1960; Thor et al. 1969; Racine 1971; Keever 1973).

The present study presents the distribution patterns of forest vegetation in a Ridge and Valley landscape of southwestern Virginia. Braun (1950) included this portion of the Ridge and Valley Physiographic Province in the

Oak-Chestnut Region[1] of the Eastern Deciduous Forest Formation. She described the general topography as a longitudinal arrangement of ridges rising above the lowland belts. Her studies, conducted in the 1930's and 40's, and later investigations (Hack and Goodlett 1960; Strahler 1972), suggested that these forests closely reflect local geologic and topographic conditions. Braun's studies were largely based on a few select stands of the most prevalent climax associations with little emphasis on second growth forests. Although her extensive work on the Eastern Deciduous Forest remains an authoritative reference, considerable time has elapsed since she conducted her studies, requiring an analysis of current vegetation-site relationships. Of particular interest is the degree to which composition of existing second growth forests and their relationship to site approaches that described by Braun for primary forests in the region.

Few studies have quantitatively examined vegetation distribution in the Ridge and Valley Province of Virginia. Hack and Goodlett (1960) surveyed the geology and forest vegetation of the Shenandoah Valley in north-central Virginia. They distinguished community types based on the presence or absence of a few key species. Much of the

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[1]The Region is now referred to as Appalachian Oak Forest due to the disappearance of American chestnut (Castanea dentata) from the overstory (Kuchler 1964).

variation in species distribution patterns was attributed to differences in site moisture conditions as inferred from topographic form. Strahler (1972) resurveyed the vegetation along a 122 km transect from northcentral Virginia to southwestern Maryland known as the Fairfax Line. From comparisons with the original survey data of 1746, Strahler concluded that the distribution patterns of common woody species had not changed significantly. Other studies of a smaller magnitude are those of Adams (1974) and Stephenson (1976) conducted in southwestern Virginia's Giles County. Adams (1974) analyzed tree species distribution and abundance on south-facing slopes of Peters Mountain. He recognized three community types, each characterized primarily by species of oak. Stephenson (1976) conducted a quantitative study of 25 stands from which he described the community types of the Salt Pond Mountain area in relation to elevation, topography, and soils.

The present study, a quantitative analysis of current forest community relationships, contributes to existing knowledge of the forests of southwestern Virginia. The study utilizes information generated on surficial geology (Harza Engineering Co. 1978) and soils (Jurney et al. 1945; Wilhelm et al. 1980) to aid in the evaluation of relationships of soil and geology to the distribution and abundance of individual tree species and communities.

The objectives of this study were to:

1. Determine the abundance and distribution patterns of tree species in a Ridge and Valley landscape in southwestern Virginia;

2. Describe community relationships from the joint occurrences of individual species; and

3. Examine the relationship between distribution of individual forest tree species and communities, and site factors.

DESCRIPTION OF STUDY AREA

The Brumley Gap study area is located in Washington County, Virginia, approximately 10 miles northwest of Abingdon (Fig. 1). The area covers approximately 6880 ha, entirely within the Ridge and Valley Physiographic Province. Approximately 90 percent of the land (6188 ha) is in second growth forests with the remainder (692 ha) consisting of open land (fields, roads, transmission lines and other open areas). Elevation ranges from 487 to 1280m above sea level. The area is characterized by steep mountainous ridges of sandstone and shale separated by parallel valleys of mainly limestone, shale or dolomite.

The climate of the region is continental. The winters are mild with mean temperatures normally 1 to 2 C. Summers are relatively short with warm days and cool nights. The frost-free season averages 167 days, extending from April 28 to October 12. Annual precipitation is about 1143 mm, with most of the rainfall received during the spring and summer (Hoffman 1969).

Clinch Mountain is the dominant topographic feature in the region. Located in the northwest portion of Washington

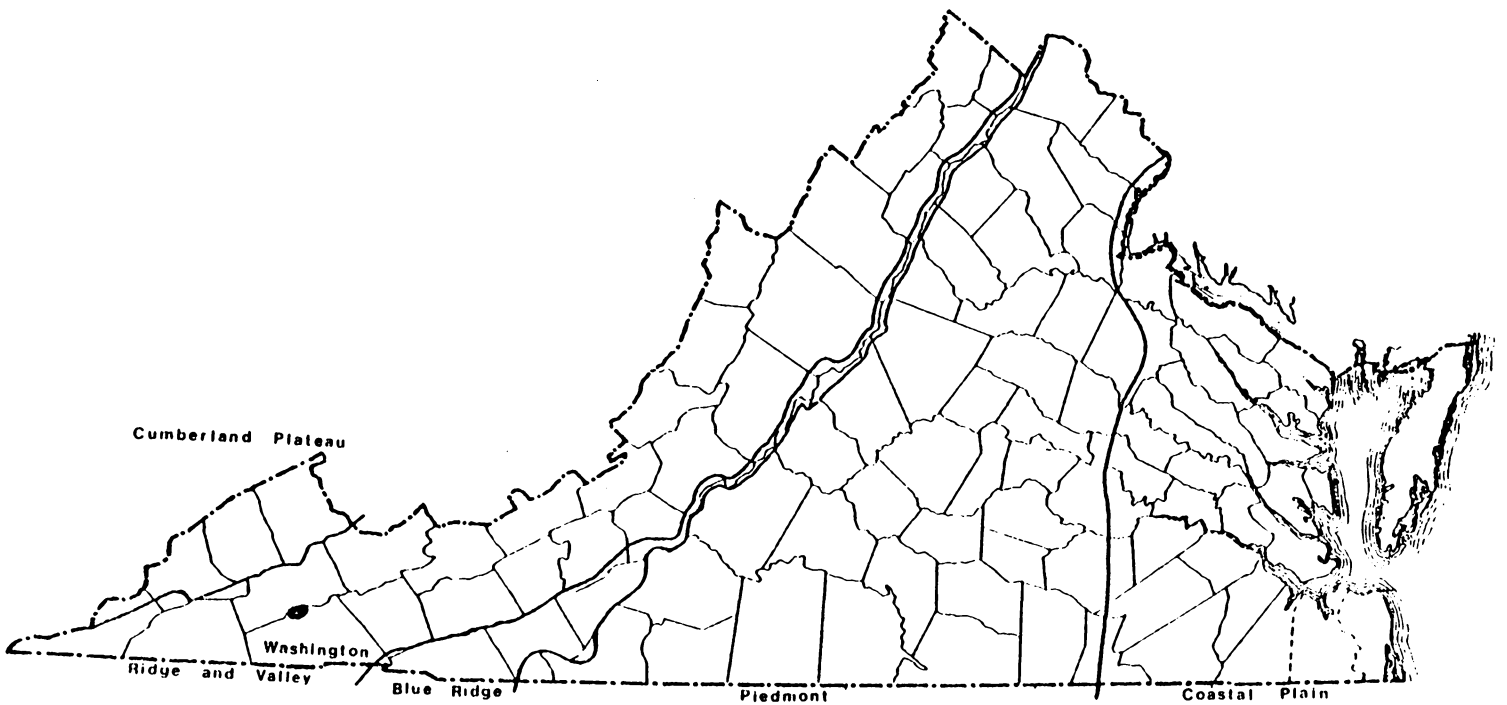


Figure 1. Location of the Brumley Gap study area in Washington County, southwest Virginia.

County, it also formed the northwest boundary of the study area (Fig. 2). An extension of Clinch Mountain rim, known locally as Brumley Mountain, forms the northern, southern and western sides of a shallow upper valley known as Hidden Valley. The study area is drained by Brumley Creek, which has its origin on Brumley Mountain at an elevation of 1237m. Elevation of Clinch-Brumley Mountain ranges from 1100 to 1280m along the rim.

Poor Valley extends along the foot of Brumley Mountain in a northeast-southwest direction. One of the major valleys in the region, it lies 760m below the crest of Brumley Mountain. The study area was bounded on the southeast by Little Mountain, a steeply inclined ridge of Missippian sandstone and shales ranging from 600 to 760m in elevation. Little Mountain separates Poor Valley from the North Fork of the Holston River. Brumley Gap, a 274m deep water gap in Little Mountain, was formed by the erosive action of Brumley Creek (Fig. 2).

The study area is underlain by sedimentary strata ranging in age from Ordovician through Missippian (Fig. 3). Many of the stratigraphic units are widespread in the Appalachians (Harza Engineering Co. 1978). Some show considerable uniformity in thickness, lithology and physical properties that may be continuous for great distances. A number of streams (mostly tributaries of Brumley Creek) have cut narrow valleys in Brumley Mountain, creating many coves.

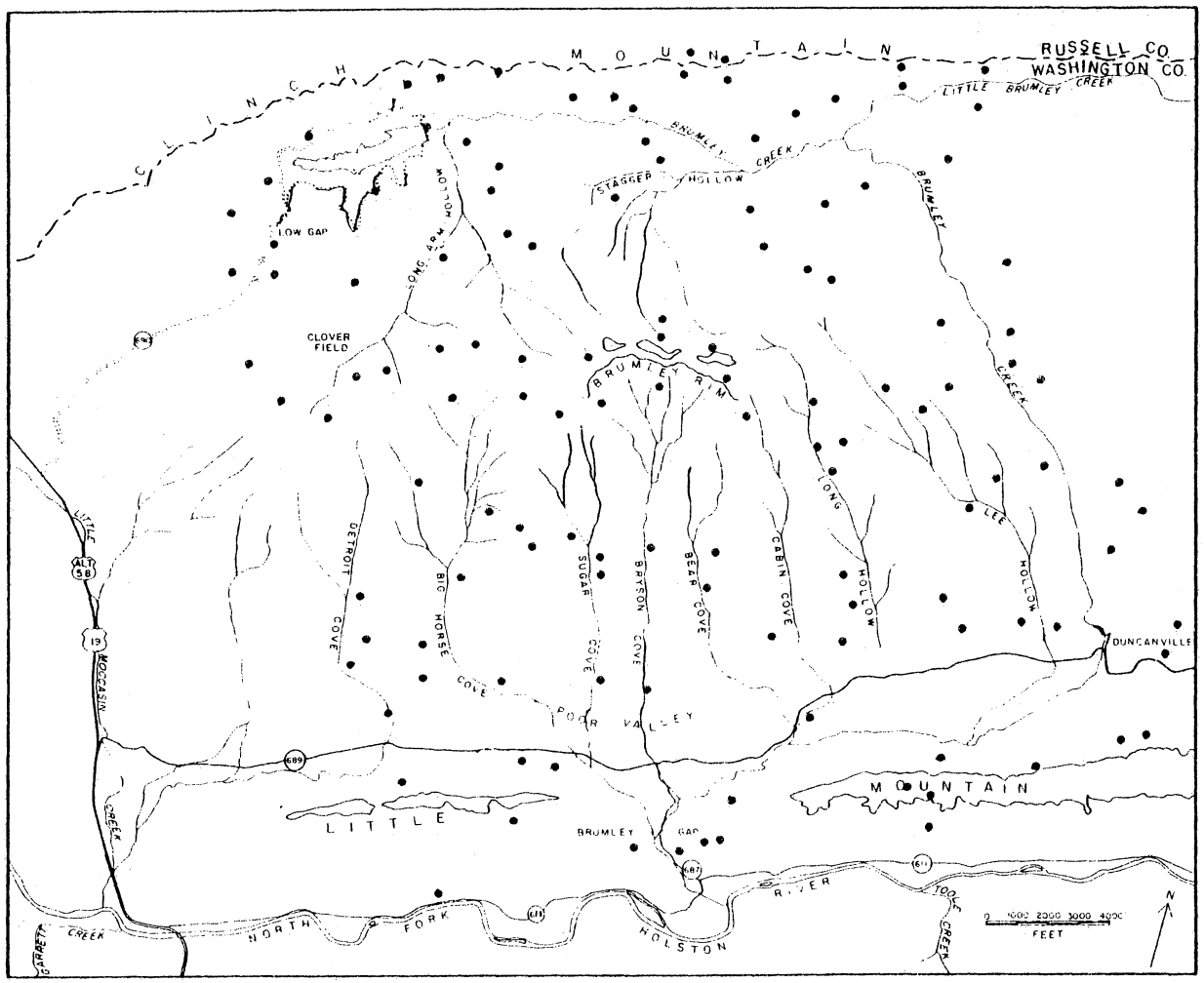


Figure 2. Simplified map of the Brumley Gap, VA study area showing the major drainages and approximate locations of the sample plots.

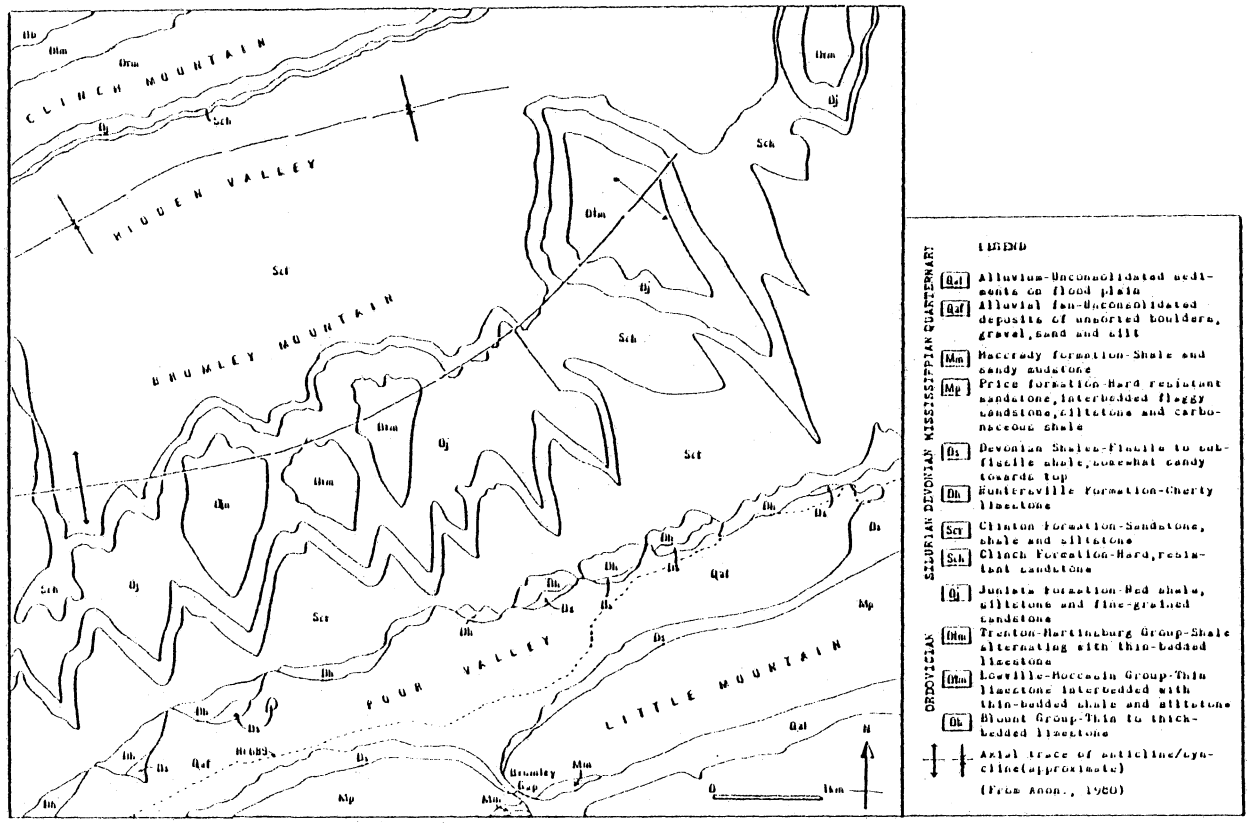


Figure 3. Surface geology of the Brumley Gap, VA study area.

These cove areas are excellent examples of geologic inliers where a regular sequence of young to old beds are exposed. Bryson Cove, Sugar Cove, and Brumley Cove are of particular interest in this respect.

The Trenton-Martinsburg unit (Middle Ordovician), which consists mostly of grey-green shales and thin argillaceous limestone interbeds, is the oldest exposed stratum in the study area. It appears at the surface on the south side of Brumley Mountain (Fig. 3). The Juniata Formation (Upper Ordovician) overlies the Trenton-Martinsburg unit. It is composed mostly of red shale and mudstone, and beds of brown to brick-red fine grained sandstone (Harza Engineering Co. 1978). It crops out in the coves and hollows on the southern flank of Brumley Mountain. Overlying the Juniata is the Tuscarora Formation (also called Clinch) of Silurian age. It consists of thick-bedded, resistant orthoquartzite which usually is well-cemented, but locally may be friable. The Tuscarora Formation is prominent throughout the Appalachians as a high ridge former (Butts 1940; Stephenson 1976; Harza Engineering Co. 1978). Within the project area, it crops out as steep slopes and cliffs on the Clinch-Brumley Mountain rim and on the spur ridges that separate the coves.

Resting upon the Tuscarora Formation is the Rose Hill (or Clinton) Formation. The second most important ridge

former (Stephenson 1976), it occupies much of the rim area of Clinch-Brumley Mountain and also the lower slopes on the south side of Brumley Mountain (Fig. 3). The upper portion of the Rose Hill Formation, consisting predominantly of shale and thin interbedded sandstone, is probably present on the western portion of the rim area (Harza Engineering Co. 1978). On the eastern part of the rim, where erosion has been extensive, the lower thick-bedded, fine-grained sandstones are encountered with occasional siltstones and shales. The sandstone is typically well cemented with iron and silica.

Except for the Huntersville Formation, which is an easily recognized cherty limestone, the formations of Devonian age are not readily distinguished from one another, being predominantly dark grey to black shale and siltstones. The Huntersville Formation crops out in a narrow band along the lower south slopes of Brumley Mountain. The Devonian shales underlie Poor Valley and may extend up the valley between 35 and 65 m. The shales are easily eroded and weather to form a thick, clayey, impermeable soil (Harza Engineering Co. 1978).

The Missippian units are the Price (which forms Little Mountain) and the Maccrady Shale Formations. The Price Formation is composed of sandstone, siltstone, and shale with a fine-grained sandstone predominating. The Maccrady

shale directly overlies the Price Formation and comprises a very small portion of the project area on Little Mountain. Its lithology is coarse-grained red shale, sandy mudstone, and a few thin sandstone beds (Harza Engineering Co. 1978).

Quaternary depcsits consist of all the unconsclidated overburden and include alluvium, colluvium and alluvial fan deposits. Alluvium is found in all the stream beds. Colluvial material, which includes the residual soils, slope wash and talus, is common on slopes throughout the study area. Large alluvial fan deposits are distributed at the base of the coves along the northern side of Poor Valley. The unsorted deposits consist of soil cobbles and large boulders that have eroded from the flank of Brumley Mountain and overlie the Devonian shale of the valley. Big Horse Cove and Bryson Cove (Fig. 2) have well defined alluvial fans.

The soils within the study area are represented by four soil orders and 16 soil series. Their classification according to the U. S. Comprehensive Soil Classification System, 7th Approximation (USDA 1975) and their relationship to the geologic units in the study area are given in Table 1. The soil series are in turn placed in five broad landscape groups: (1) mountain uplands (2) valley uplands (3) colluvial lands (4) terraces and (5) bottomlands (Fig. 4). The upland soils have formed from residuum and accumulations

Table 1. Key to soils in the Brumley Gap study area.

Landscape Class	Soil Mapping Unit	% of Study Area Covered	Present Classification 7th Approximation	Geology	Parent Material
Mountain Upland Soils	Montevallo*	1.5	Typic Dystrocrepts, loamy-skeletal, mixed, thermic, shallow	Devonian shales	black shale, green shale and some sandstone
	Muskingham*	46.8	Typic Dystrocrepts, fine-loamy, mixed, mesic	Mississippian Price Formation and Silurian Rose Hill and Tuscarora Formations	sandstone with some interbedded shale in places
	Rough Stony Land*	25.9	--	same as above	same as above
Valley Upland Soils	Bland*	1.3	Typic Hapludalfs, fine-mixed mesic	Ordovician Trenton-Martinsburg group	limestone and mudstone
	Clarksville	0.1	Typic Paleudults, loamy-skeletal, siliceous, mesic	Devonian Huntersville Formation	cherty limestone
	Leadvale	0.2	Typic Fragiudults, fine-silty, siliceous, thermic	Quaternary deposits - alluvium, Devonian shales, Silurian sandstones - Rose Hill and Tuscarora Formations, Ordovician Juniata Formation	Montevallo, Muskingham and Ramsey soil materials
	Westmoreland*	1.4	Ultic Hapludalfs, fine-loamy, mixed, mesic	Ordovician Trenton-Martinsburg group	limestone and shale, interbedded
Colluvial Soils	Allen	0.3	Typic Paleudults, fine-loamy, siliceous, thermic	Quaternary deposits, alluvial fan colluvium from Rose Hill, Tuscarora and Juniata Formations	residual material derived from the weathering of sandstone fragments and other rock waste accumulated on the valley uplands near the foot of mountains
	Hayter*	14.5	Ultic Hapludalfs, fine-loamy, mixed, mesic	same as above	same as above

Table 1. Key to soils in the Brumley Gap study area (continued).

Landscape Class	Soil Mapping Unit	% of Study Area Covered	Present Classification 7th Approximation	Geology	Parent Material
Colluvial Soils	Jefferson*	4.6	Typic Hapludults, fine-loamy, siliceous, mesic	same as above	same as above
Terrace Soils	Holston	0.1	Typic Paleudults, fine-loamy, siliceous, thermic	Quarternary Deposits, old alluvium from Mississippian, Silurian and Ordovician rocks	sandstone, shale, and in places limestone
	Sequatchie	0.1	Humic Hapludults, fine-loamy, siliceous, thermic	same as above	same as above
Bottomland Soils	Atkins	0.9	Typic Fluvaquents, fine-loamy, mixed, acid, mesic	Quaternary Deposits, alluvium from Missippian, Silurian and Ordovician sandstone and shales	sandstone and shale
	Pope*	0.8	Fluventic Dystrocrepts, coarse-loamy, mixed, mesic	same as above	same as above

*Mapping unit known to have been sampled.

of colluvium and rock wash. They lie above the stream bottoms and terraces. Approximately 47 percent of the soils in the study area are Muskingham soils, which occur on the mountain uplands. These soils, derived from fine-grained grey sandstone and acid interbedded sandstone, siltstone and shale, occupy the ridgetops and upper slopes of Clinch-Brumley and Little Mountains. They tend to be shallow (depth to bedrock averages less than 50 cm) with low natural fertility. Their surface (A) horizon ranges from sandy loam to silt loam and may include stony types. Although these soils generally are well-drained and have low moisture holding capacity, a perched water table may exist below the solum in low areas of the Clinch-Brumley Rim due to the abundance of impermeable shale beds (Harza Engineering Co. 1978). Rough Stony Land is the designation given to some of the upland sites where predominant features are rock outcrops and ledges that cover 10 to 60 percent of the land surface. This land type includes some of the steepest slopes and occupies 26 percent of the Brumley Gap study area. The soil that develops is quite droughty.

The soils that characterize lower slopes adjacent to valley floors occur on rolling to steeply rolling topography (Jurney et al. 1945; Wilhelm et al. 1980). They are prone to erosion and are mildly to strongly acid. Soil depth ranges from very shallow in some of the limestone and

shale derived Westmoreland soils, to deep (1.5 m) in the Clarksville series. The Clarksville soils contain a high chert and stone content (up to 35 percent in the A horizon). Bland soils are characterized by high percentages of shrink and swell clays, which adversely affect drainage.

Colluvial soils are located near the foot of slopes and in depression areas. Portions are under cultivation or pasture. In general, these soils are deep, well drained, and strongly acid. Permeability varies according to subsoil clay content. Hayter soils are mapped along many portions of Brumley Creek tributaries. They may be influenced by calcareous parent materials. Water availability is medium in all the colluvial soils (Hayter, Jefferson, Allen) as compared with the mountain upland soils where water avaliability is low to very low (Wilhelm et al. 1980).

The soils of the terraces and bottomlands have developed from water-deposited sandstone and shale (and in some places, limestone) parent materials. In addition, bottomlands are still subject to flooding while flooding of terraces is rare (Jurney et al. 1945). These water-deposited soils, comprising about two percent of the study area, occupy level to gently rolling landscape positions. Most are cleared for agriculture; the exceptions are some nearly level places with poor drainage and high seasonal water tables. These soils were not of significance in the present study.

METHODS

Field sampling began in September 1978 and was completed in September 1979. All understory vegetation was sampled from early July to mid-September 1979. A stratified random sampling design was employed. A grid comprised of 1000 x 1000m (100 ha) cells referenced to the Universal Trans Mercator (UTM) coordinate system was superimposed on the 6880 ha study area. Sampling points were located at the center of each of two one-ha areas randomly chosen within each 100 ha cell.

A total of 126 400m² forested plots were established (Fig. 2). Their combined area represented a 0.074 percent sample of the study area. This sampling intensity is approximately 1.8 times that employed in regional forest inventories (U.S. Forest Service 1977). The vegetation sampling scheme (Fig. 5) incorporated a nested plot design at each sampling point with three plots of varying size used to accommodate vegetation of varying dimensions (Mueller-Dombois and Ellenberg 1974). All woody stems with a diameter at breast height (DBH) equal to or greater than 2.54 cm were recorded by DBH and species in a 400m² circular plot (slope area) centered on the permanent plot marker.

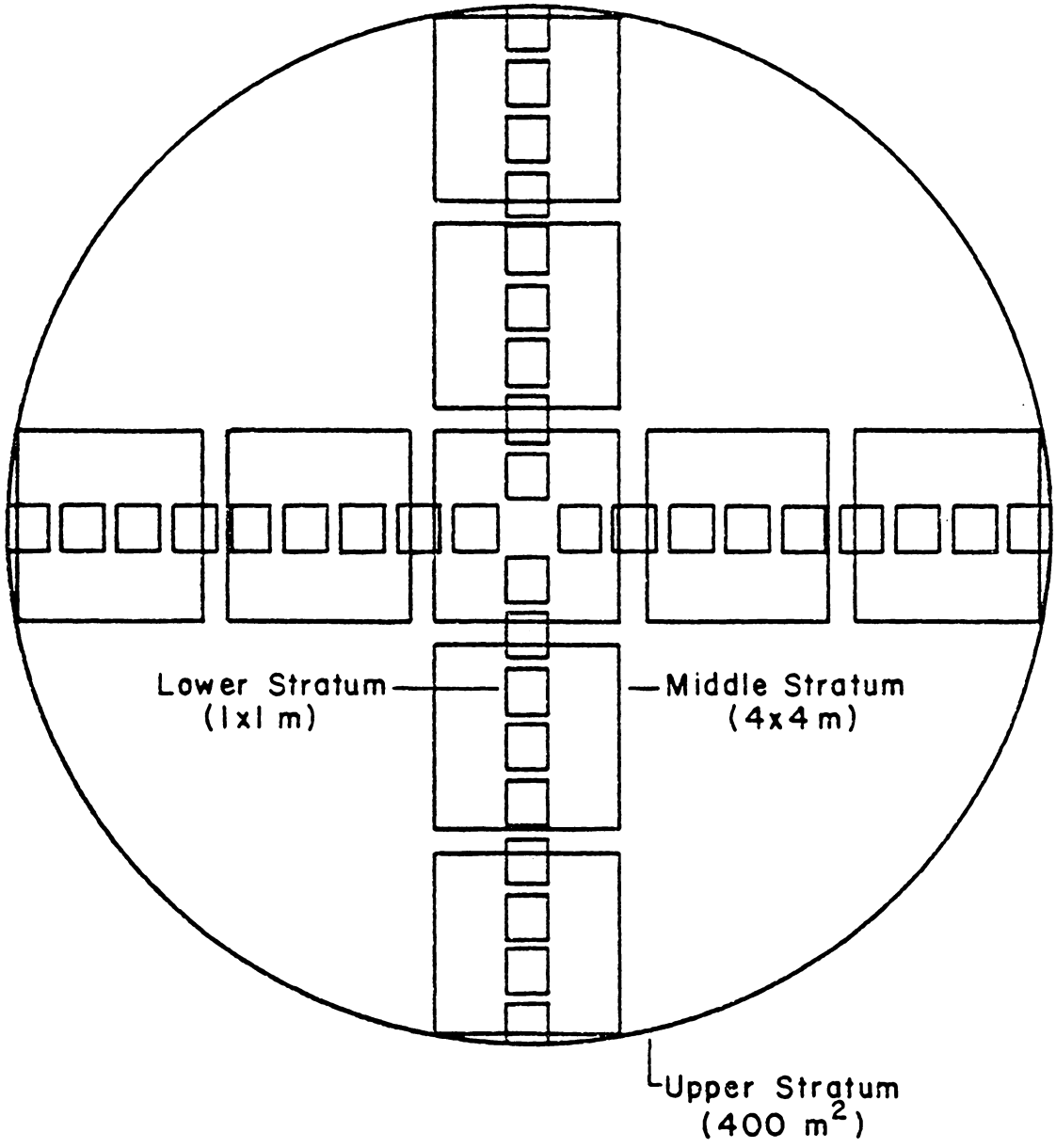


Figure 5. Nested plot design for sampling different vegetation strata in the Brumley Gap, VA study area.

Stem counts were used to generate density values (no. stems/ha) for tree species. Diameter measurements were converted to basal area (m^2/ha). All woody vegetation with stems less than 2.54 cm dbh and equal to or greater than 1 m tall were inventoried in nine discrete 4 x 4m plots nested within the 400m^2 circular plot (Fig. 5). Plots were situated along two transects passing through the central reference point, perpendicular and parallel to the slope contour. Individual stems were recorded for tree species only. Percent cover was determined for all species as a measure of dominance. Woody stems less than 1m tall were sampled in 36 1 x 1m plots nested within the 400m^2 circular plot in the manner described for the 4 x 4m plots. All herbaceous vascular plants were tallied on the basis of their abundance in the 400m^2 plot according to a scale developed by Daubenmire (1968).

Plants that could not be positively identified in the field were numbered and collected for subsequent identification and verification in the laboratory. Verification of all materials was conducted by personnel at the Virginia Polytechnic Institute and State University Herbarium. Nomenclature followed Gleason (1963) except where authors names are given.

The topographic setting of each plot was described on the basis of elevation, degree of slope, aspect, slope

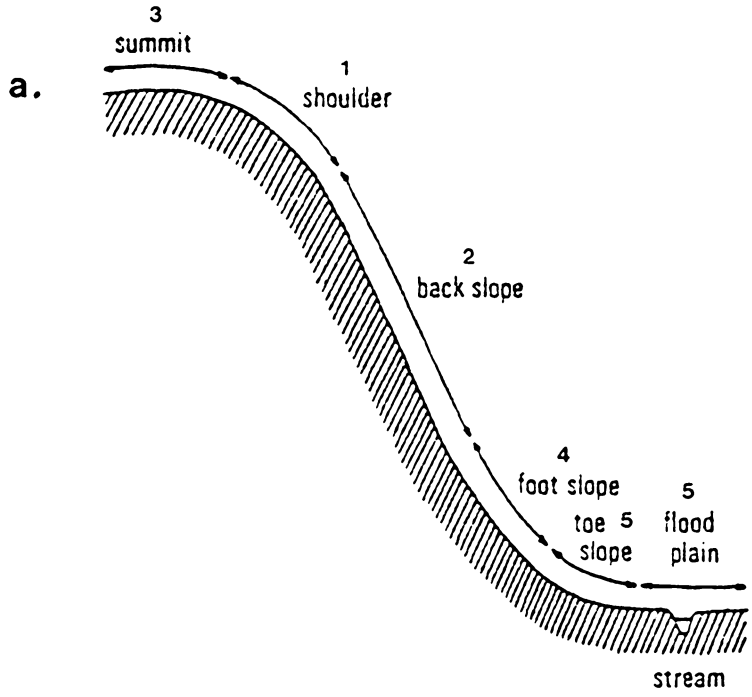
position, landform and slope shape. Aspect (Table 2) and slope position (Fig. 6a) were classified acccrding to the methods of Wathen et al. (1977). The assigned values were based on the effect these variables were thought to have on water available for plant growth, with the higher scale values indicating greater moisture availability. More recent work by Meiners (1982) has verified this relationship.

Landform classification (Fig. 6b) was based on the immediate characteristics of the site as they affect stand composition. For example, a nose slope which had a wide, flat surface in the immediate area of the plot site was classified as a side slope. To further characterize the site, special features such as rock outcrops, depressions or sinks, standing water, and extent of soil erosion were noted. Tree increment cores were extracted from two or three dominant or co-dominant trees and used for determinations of stand age. Thirteen stands contained stems from several age classes in the overstory, as evidenced by 20 or more years difference in extracted tree cores. A single stand age was not calculated for these stands or for 14 other stands which had only one or no cores collected.

Soil samples were taken in most stands at the time of vegetation sampling. Samples were collected close to the

Table 2. Azimuth range and associated aspect values.

Azimuth Range (deg.)	Aspect Values
196-260	1
166-195 and 261-280	2
146-165 and 281-340	3
000-020 and 341-360	4
081-145	5
021-080	6



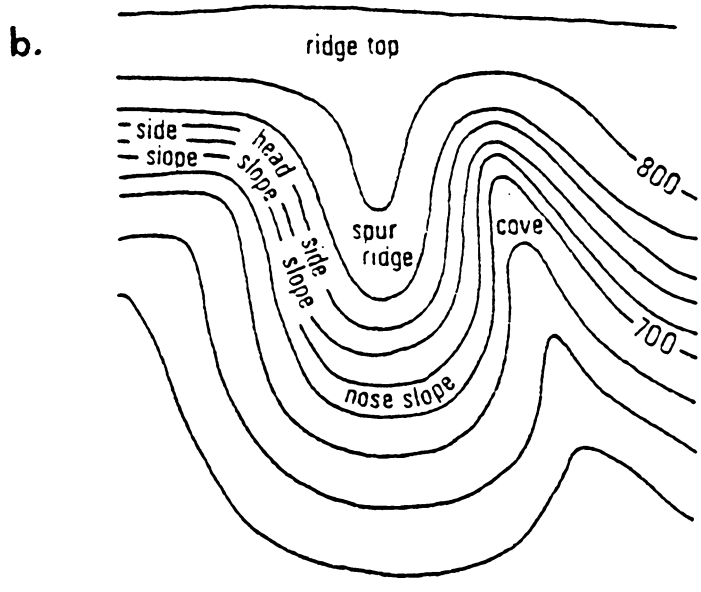


Figure 6. Classification of a) slope position and b) landforms in the Brumley Gap, VA study area. The numbers for slope position follow Wathen (1977). Higher scale values indicate greater moisture availability.

plot center with depth determinations and textural descriptions noted for the major horizons.

Data Analysis

The vegetation data presented in this thesis deal primarily with the upper stratum, consisting of stems greater than 2.54cm DBH. Information on subordinate strata is largely limited to presence and stratal dominance. Calculation of abundance estimates for each 400m² plot included total density, total basal area, and absolute density and basal area for each species. Shrub data were excluded because of the problem of inflated density estimates associated with multiple stemmed individuals. Relative values of density and basal area were averaged to give an importance value (IV; max=100) for each species.

Stand Ordinations

Vegetation patterns and site relationships were investigated using polar ordination, an indirect gradient analysis technique (Bray and Curtis 1957). This ordination technique arranges samples along axes of compositional variation which may or may not correspond to environmental gradients (Whittaker 1967). The method is relatively simple

and free from distortion as compared with more sophisticated methods (Gauch and Whittaker 1972; Beals 1973). Although ordination permits an alternative to classification into discrete groups, it may serve to identify clusters or trends in the vegetation (Mueller-Dombois and Ellenberg 1974). In the present study, similar stands, as determined from the ordination placement, overall vegetation composition, and physical environment, were grouped into community types and are described as a unit.

Ordination analyses were conducted with importance values of trees from the upper stratum and excluded those species which were present in less than five percent of the stands. Initially, all 126 stands were used. Ordinations were conducted both with and without double standardization and with percentage similarity (PS) and coefficient of community (CC) similarity indices (Gauch 1977). Results with sample standardization, following deletion of rare species, and stand comparisons with PS are reported here. The relative positions of stands were projected on a 2 axis graph using the Cornell Ecology Program CEP-25A (ORDIFLEX) (Gauch 1977).

Selection of reference stands presents a problem in polar ordination. In the original Bray-Curtis (1957) method, those samples which were the most dissimilar were chosen as endpoints. That method allows the ordination of

samples without prior assumptions about environmental gradients but creates the possibility of selecting an outlier stand (one that is extreme in relation to most others) as a reference stand (Cottam et al. 1978). Endpoints may also be subjectively selected on the basis of suspected environmental gradients.

For the initial ordination, both subjective selection and high dissimilarities (max=100) were used as the basis for determination of X axis endpoints. Y axis endpoints were chosen automatically by the ORDIFLEX program which uses a procedure similar to that of Bray and Curtis (1957) for axes of higher order. Problems of distortion (or sample displacement) were encountered when using all stands due to high beta diversity (differences between samples), partial disjunction, and presence of extreme samples. Partial disjunction refers to the situation where groups of samples which share many species are related by a few species to other groups (Whittaker and Gauch 1978). Polar ordination does not distinguish between samples that do not belong to the endpoint groups, which may lead to erroneous interpretation of the axes of variation.

To limit the wide range of vegetation composition which may lead to distortion in the full ordinations, an ordination was also conducted of a subset of the stands. Subset content was based on species comprising the first and

second leading dominant of each stand and on stand placement in the full ordination. Five stands which appeared to represent unique vegetation types were designated as outliers and thus were excluded from the subset ordination.

Regressions of the abundance of vegetation and tree species on site factors

The relationship of the abundance of vegetation and of individual tree species to site factors was investigated with multiple regression analysis. Basal area was used as the dependent variable as it takes size into account and thus seems to indicate better than density the species' degree of utilization of the site (Oosting 1956; Keever 1953). Relative values were used for individual species regressions instead of absolute values because, 1) the relationship of absolute basal area of a particular species with a site factor may be misconstrued by the relationship of total basal area to that same factor (eg., total basal area in the project area increases with stand age, but a particular species' basal area may increase or decrease with stand age), and 2) use of relative values indirectly considers competition from other species.

Criticism of the use of relative rather than actual measurements stems from the fact that both densely and sparsely vegetated sites can have the same relative values

of density, basal area, cover, etc., and therefore the relative values give little indication of actual species biomass or cover (Daubenmire 1968). In addition, light, temperature, moisture and competition effects are altered in sparsely stocked stands. To reduce the objection to the use of relative values, only stands which had at least 11.5m² of basal area per hectare (50ft²/acre), an estimate of the minimum stocking level needed for full utilization of the site (Roach and Gingrich 1968), were used in the regressions. This resulted in the deletion of eight stands.

Equations were derived for the relative basal area of the six most important tree species in the study area with site factors as independent variables which have been found to be of ecological importance in the distribution of woody plants in the Appalachians (Read 1952; Whittaker 1956; Hack and Goodlett 1960; Bormann et al 1970; Keever 1973; Day and Monk 1974; Ricklefs 1976). Quantitative variables included elevation, aspect class, percent slope, slope position, thickness of the A and B horizons, age, and six interaction terms: 1) elevation x aspect, 2) elevation x percent slope, 3) elevation x slope position, 4) aspect x percent slope, 5) aspect x slope position, and 6) percent slope x slope position. Qualitative or character variables were the underlying geology, texture of the A and B horizons, and landform.

Initially, a general model containing the same set of independent variables was proposed for all six species to see if a relatively simple model could adequately account for the variation in species' abundances. Individual models were then developed for each species by examining all possible regressions using the RSQUARE procedure provided by SAS (Helwig and Council 1979). Stepwise regression, though chosen in other studies (Bormann et al. 1970; Martin 1971; Day and Monk 1974) to search for a good model, was not selected here due to the possibility of arriving at an unreasonable "best model" when the independent variables are very highly correlated (Neter and Wasserman 1974; Weisburg 1980). Accordingly, all quantitative variables and their interaction terms were included in the RSQUARE procedure. Age was deleted initially because data were not available from all stands. Several good models were chosen according to the criteria of a high coefficient of determination (R^2) and low Cp (Neter and Wasserman 1974). At the expense of omitting some of the stands where the species occurred, age was added if it improved the model.

R^2 is a measure of the proportion of the variability in Y (relative basal area) accounted for by the model (Weisburg 1980). However, it is an inadequate criterion for model selection if used alone since as the number of X variables increases, R^2 will also increase. Models based on subsets

of the full regression model were in fact more desirable because independent variables which were correlated to one or more other variables sometimes added little to R^2 but lowered the precision of regression coefficients. Mallow's Cp statistic was used to find several subset models. It is an estimator of the total mean squared error (MSE) of the regression model, which consists of a variance component (or mean squared error of prediction) and a bias component (due to the omission of one or more important independent variables from the full model). There are always points where a subset model will have a lower mean squared error of prediction than the full model, but it may also eliminate too many of the independent variables. The objective was to identify a set of independent variables that gives a small or negative Cp (which indicates small total mean squared error) but to also include enough independent variables so that the model is not substantially biased (Neter and Wasserman 1974; Weisberg 1980). The RSQUARE procedure was also employed with arcsin transformations of the dependent variable, which are often applied to proportional data to stabilize the variances of the error terms (Neter and Wasserman 1974). However, these transformations did not improve the models.

Following the RSQUARE screening procedure, the models were examined for multicollinearity (correlation among the

independent variables) with PROC REG (SAS 1981). Possible damaging effects of multicollinearity include unstable regression coefficients and inability to ascribe a specific portion of the explained variation to a particular independent variable.

Accepted regression models were chosen on the basis of a combination of highest coefficient of determination (R^2), relative stability of regression coefficients, biological rationale, and overall model significance at the .05 level or better. Coefficients of determination for the equations varied from .13 to .52. Individual independent variables included in the models were significant at least at the .15 level and usually at the .05 level. Significance refers to the additional extent to which the variable contributes towards reducing the remaining variation in Y after allowance is made for the contributions of the other independent variables in the model.

Since in the field it was apparent that the distribution of a species was not random, it seemed that the relationship of basal area to the site factors had not been adequately described by the regression models utilized. Thus, further regression analysis was conducted for two of the species, Liriodendron tulipifera and Quercus rubra. Regression with class variables (or indicators) tested whether there was an additional portion of variance from the

original models which could be explained by consideration of different landforms, geologic substrates or soil textures.

An approach called piecewise linear regression or spline regression was used to modify the original model. With this technique, the relationship between the Y and X variable is separated into pieces and a different function is applied to each segment. The pieces are joined at knots (the breaking points). The basis for spline regression stems from the idea that the relationship between two variables Y and X may follow one particular pattern in some range of X but assume a different relationship elsewhere (Neter and Wasserman 1974; Wold 1980). Spline functions can represent any variation of Y with X over wide intervals of X (Wold 1980). For simplicity, only one variable, elevation, was treated as a spline of three pieces. However, the procedure may be extended to other variables (Wold 1980 from Greville 1969).

The choice of knot placement (point at which the slope changes) was based on the suggestion of Wold (1980) that the knots should be positioned to take into consideration the overall behavior of the data points (total number, high and low points, etc.). In the present study, the data set for the two species was partitioned into three elevation ranges, each containing approximately equal numbers of observations.

A final approach of examining the relationship of species with site factors was a splitting of the data into two diameter classes (2.54 - 10.2 cm and >10.2cm), to see if regression models differed for large and small individuals of the same species.

RESULTS AND DISCUSSION

A large body of data collected over a broad area and on a variety of sites is necessary in order to present an integrated picture of the forest. The present study involved such a set of data which reflects the existing conditions in a Ridge and Valley landscape and its history of high-grading in the early part of this century, which resulted in the removal of the best quality trees of the most desirable species. Many stands contained scattered older individuals (which were remnants from earlier forests) but most of the forest overstory consisted of trees between 35 and 75 years old. Evidence of recent cutting (past 20 years) or conversion from agricultural operations was observed in 11 stands.

Stand basal area averaged 22.2 m^2/ha and ranged from a high of 47.0 m^2/ha to a low of 2.2 m^2/ha. Average density was 1411 stems/ha and ranged from 173 stems/ha to 4176 stems/ha (Table 3). These averages do not differ appreciably from results obtained by Day and Monk (1974) at Coweeta Hydrologic Laboratory in the Blue Ridge Province in North Carolina (22.4m^2/ha and 1266 stems/ha excluding

Table 3. Averages and ranges of density and basal area within the six dominance types and over all stands (n=126) in the Brumley Gap, Va. study area.

Dominance Type	Number of stands	Density (stems/ha)	Basal area (m^2/ha)
All stands	126	1411 (173 - 4176)	22.2 (2.2 - 47.0)
Sugar maple mixed-hardwoods	22	1089 (519 - 1804)	24.1 (13.7 - 39.5)
Yellow-poplar	17	1301 (321 - 1853)	18.3 (5.13 - 31.3)
Hemlock	4	896 (544 - 1631)	35.3 (29.6 - 47.0)
Oak-mixed hardwoods	27	1631 (593 - 4176)	23.9 (12.3 - 36.2)
Chestnut oak-red oak-hickory	17	1685 (964 - 3039)	22.6 (14.7 - 34.2)
Scarlet oak-chestnut oak	12	1892 (1310 - 3138)	21.3 (12.5 - 31.5)

Rhododendron and Kalmia) and by the U. S. Forest Service for Washington County, Virginia (23.2m²/ha). In Giles County, to the east of the study area, Adams (1974) reported considerably higher values (basal area of 31m²/ha and density of 2714 stems/ha) on open south slopes dominated by oaks, hickory and pines, while Stephenson (1976) estimated 26.3m²/ha and 600 stems/ha for large trees (>10cm DBH) alone. The lower basal area and density in the present study may have been due to the inclusion of both young and poorly stocked cutover stands.

No attempt was made to avoid young and poorly stocked stands as cutover areas and areas converted from agriculture are quite widespread. There are those who would object to this approach, arguing that disturbed forests have poorly interpretable species patterns in relation to the environment. It is true that the inclusion of disturbed stands added another dimension to the study, i.e., difference in stand history, and that the dominant species in disturbed stands may not be a result of a particular environmental factor (Damman 1964; Whittaker 1978). However, in many parts of the Appalachians, the effort to avoid disturbed areas may result in a selection of stands that are not representative of the area being studied. Since few forests exist in the undisturbed condition, patterns of vegetation should be recognized as they exist.

The composition of the 126 stands indicate in general, a present forest composition distribution approximating that of the original landscape as described by Braun (1950), with the exception that the demise of Castanea dentata has led to increased importance by species already present in the original forest (Oosterhuis et al. 1982). The 51 tree species recorded were all mentioned by Braun (1950) as components of the Ridge and Valley Section (Table 4). In addition, 36 shrubs and over 500 herbaceous species were recorded. The most important species (in order of decreasing importance value (IV)) were Acer rubrum (red maple), Quercus rubra L. (northern red oak), Liriodendron tulipifera (yellow-poplar), Quercus prinus (chestnut oak), Acer saccharum (sugar maple), and Quercus coccinea (scarlet oak). Each was a leading dominant in at least 11 stands (Table 4).

The six most important species, Acer rubrum, Quercus rubra, Q. prinus, Liriodendron tulipifera and Quercus coccinea have been mentioned as dominants in other studies of Appalachian Oak forests (Appendix A). The first four species are also reported as commonly replacing Castanea dentata (Keever 1953; Woods and Shanks 1959; Day and Monk 1974). The high importance of Liriodendron in this study may be partially attributed to its localized importance in

Table 4. Frequency of occurrence (%) and importance of tree species (>2.54cm DBH) in the Brumley Gap, Va. study area.

Species	# Stands present[1]	# Stands leading dominant[2]	Average IV 126 stands	Average IV occupied stands
Acer pensylvanicum	31	-	1.3	5.3
Acer rubrum	110	18	13.3	15.2
Acer saccharum	37	13	5.9	20.1
Amelanchier arborea	49	-	1.6	5.4
Betula alleghaniensis	13	-	0.7	7.1
Betula lenta	46	4	2.1	9.4
Carya glabra	31	1	1.7	7.1
Carya tomentosa	17	1	0.8	5.8
Castanea dentata	10	-	+	1.3
Cornus florida	50	1	2.1	7.1
Fagus grandifolia	10	1	+	7.5
Fraxinus americana	18	1	+	7.0
Fraxinus pennsylvanica	11	-	+	9.1
Hamamelis virginiana	35	-	2.1	7.7
Ilex montana	26	-	1.2	6.0
Liriodendron tulipifera	50	17	8.8	22.2
Magnolia acuminata	44	3	2.6	7.5
Magnolia fraseri	38	3	2.6	8.5
Nyssa sylvatica	44	-	2.0	5.7
Oxydendrum arboreum	62	4	5.5	11.2
Pinus virginiana	8	4	1.5	23.8
Prunus pensylvanica	16	1	+	5.4
Prunus serotina	24	-	1.1	5.7
Quercus alba	31	1	2.5	10.2

[1] total number of stands=126
[2] leading dominant refers to the species with the highest IV

Table 4. Frequency of occurrence (%) and importance of trees (>2.54cm DBH) in the Brumley Gap, Va. study area (cont.).

Species	# Stands present	# Stands leading dominant	Average IV 126 stands	Average IV occupied stands
Quercus coccinea	41	11	5.7	17.7
Quercus prinus	58	16	7.8	16.9
Quercus rubra	82	16	10.1	15.5
Quercus velutina	18	-	1.2	8.1
Robinia pseudoacacia	51	3	3.7	9.2
Sassafras albidum	32	-	[4]	3.2
Tilia spp.[3]	15	1	1.0	8.3
Tsuga canadensis	16	3	1.6	12.2
Acer negundo[4]	1	-	0.08	9.8
Aesculus octandra	1	-	0.03	3.4
Carpinus caroliniana	6	-	0.1	2.5
Carya cordiformis	4	-	0.1	3.0
Carya ovata	5	-	0.5	11.9
Celtis occidentalis	2	-	0.03	1.9
Diospyros virginiana	3	-	0.05	2.2
Ilex opaca	1	-	0.07	8.7
Juglans cinerea	1	-	0.02	3.1
Juglans nigra	5	-	0.3	7.7
Juniperus virginiana	3	-	0.04	1.6
Malus sp.	2	-	0.04	2.8

[3] Tilia spp. includes all individuals regardless of degree of leaf pubescense or morphology of fruits, and thus may encompass individuals traditionally assigned to the taxon T. americana as well as the more abundant T. heterophylla

[4] species below this point were not included in the ordinations

Table 4. Frequency of occurrence (%) and importance of trees (>2.54cm DBH) in the Brumley Gap, Va. study area (cont.).

Species	# Stands present	# Stands leading dominant	Average IV 126 stands	Average IV occupied stands
Ostrya virginiana	6	-	0.4	8.8
Pinus echinata	5	1	0.5	12.4
Pinus rigida	1	-	0.05	6.0
Platanus occidentalis	2	-	0.1	7.0
Populus grandidentata	1	-	0.1	13.3
Ulmus americana	5	-	0.2	5.3
Ulmus rubra	4	-	0.05	1.5

disturbed areas. In some locations, the species had become almost the sole overstory species. The abundance of Acer saccharum may be a reflection of the large number of stands sampled at high elevations and of the study area's proximity to the Mixed Mesophytic region to the west.

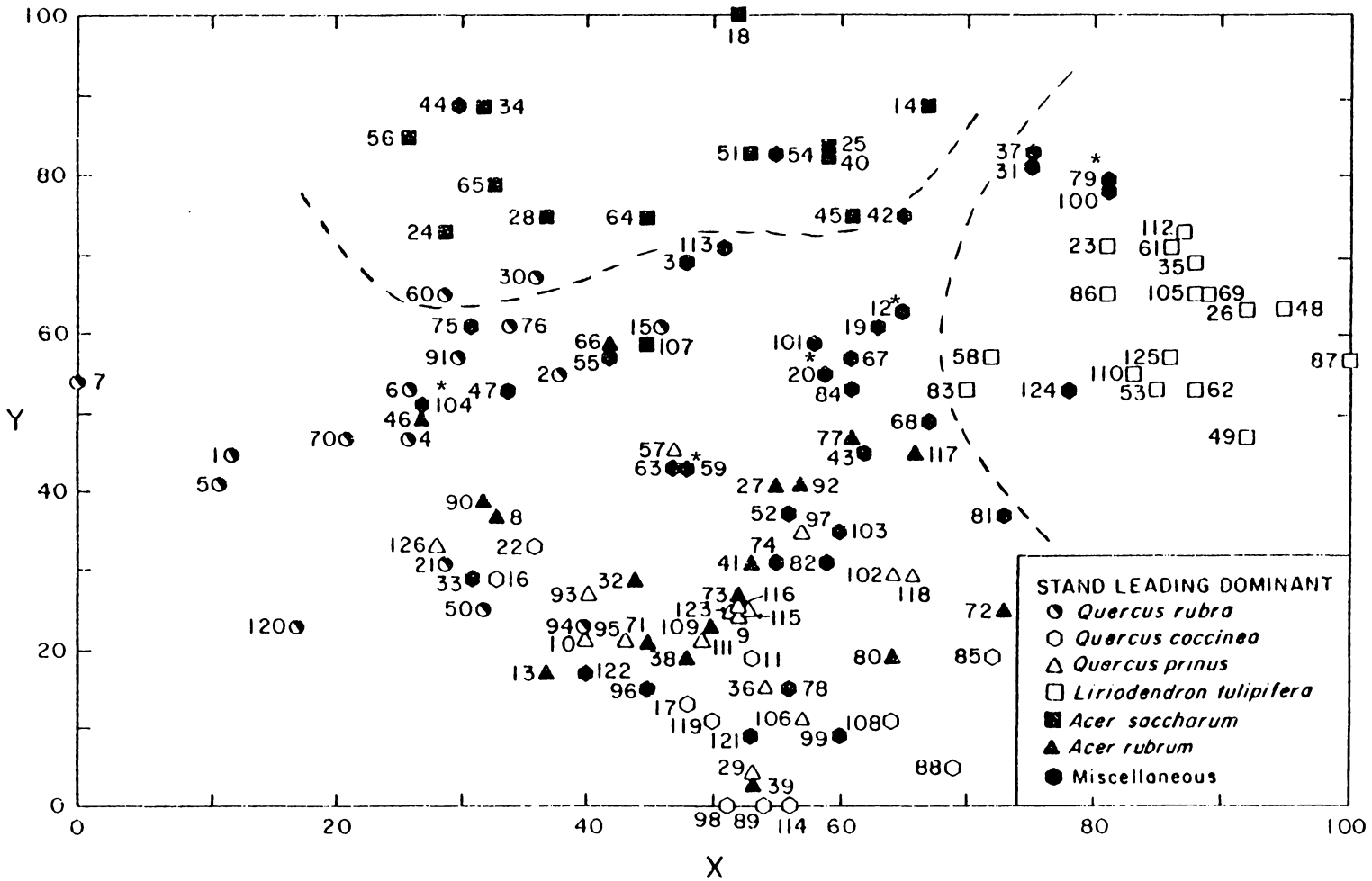
Stand Ordinations

Vegetation patterns in the Brumley Gap study area were summarized with the aid of polar ordination. Importance values (IVs) for the 32 species used in the ordinations are presented in Appendix B.

Full Ordinations

Figure 7 depicts the distribution of stands in the full ordination (126 stands) with respect to the X and Y axes. Because of the great elevation range in the study area (793m), the most dissimilar stands near elevational extremes were used to define the poles of the X axis. The percent dissimilarity value for the two reference stands (7 and 87) was 94.2. The only species in common was Acer rubrum. Y reference stands chosen by ORDIFLEX were 100 percent dissimilar. Stands were placed in one of three groups based

Figure 7. Polar ordination of all 126 stands in the Brumley Gap, VA study area using compositionally dissimilar stands near elevational extremes to define the endpoints of the X axis. Individual stands are indicated by numbers and by symbols according to the leading dominant in the upper stratum. Groups of stands representing community types are outlined with dashed lines. An asterisk indicates extreme samples. Miscellaneous species include Betula lenta (stands 42, 43, 74, 100); Oxydendrum arboreum (stands 82, 96, 99, 122); Pinus virginiana (stands 31, 59, 121, 124); Magnolia acuminata (stands 33, 55, 84); Robinia pseudoacacia (stands 37, 54, 101); Tsuga canadensis (stands 19, 67, 68); Hamamelis virginiana (stands 3, 63); Magnolia fraseri (stands 79, 113); Carya glabra (stand 103); Carya tomentosa (stand 47); Cornus florida (stand 75); Fagus grandifolia (stand 20); Fraxinus americana (stand 104); Pinus echinata (stand 52); Prunus pensylvanica (stand 12); Quercus alba (stand 78); Tilia heterophylla (stand 44).


STAND LEADING DOMINANT
Quercus rubra
Quercus coccinea
Quercus prinus
Liriodendron tulipifera
Acer saccharum
Acer rubrum
Miscellaneous
Y
X
0
20
40
60
80
100

on positions with respect to the X and Y axes and on species comprising the first and second leading dominants, as follows. The first group, consisting of 22 stands occupying the right side of the ordination, contained Liriodendron tulipifera as the first or second leading dominant. This species contributed greater than 35 percent of the importance value in 14 of the 21 stands. The tight grouping reflects the abrupt decline in importance for yellow-poplar in other stands and was due in part to the contribution of the secondary species Robinia pseudoacacia (black locust) and Acer rubrum.

The second group consisted of 16 stands at the top of the ordination (Fig. 7) with Acer saccharum as the first or second leading dominant. Most of these stands, although not intermingled with other stands, were not as closely grouped as the Liriodendron tulipifera stands. Acer saccharum accounted for greater than 35 percent of the IV in seven of the stands. The 16 stands exhibited little separation along the Y axis but were spread across the X axis due to a change in secondary species composition rather than to a decline in the importance of sugar maple. Liriodendron tulipifera and Robinia pseudoacacia were important associates in stands on the right side of the X axis (14, 45, and 54) while stands on the left (44, 56, 24, 65, 34, 30) exhibited higher IVs for Quercus rubra.

The third group consisted of the remaining 89 stands in the center and left of the ordination which were not readily segregated into smaller groups. Quercus coccinea, Q. prinus, Q. rubra, Acer rubrum and occasional other species were leading dominants. The lack of a clear separation of stands containing the same leading dominant was due in part to the decreased importance of the leading dominant in relation to the importance of other species. There was also a more gradual transition between the decline of some species and the increase in others when compared to stands in the first two groups.

Inspection of the center of the ordination in Figure 7 indicated that another axis would have been useful for further separation of dissimilar stands. However, this option was not available with the ORDIFLEX program. There were a number of stands which were as different from each other in composition as they were from the reference stands. For example, stand 57 (Quercus prinus - dominated), 63 (Hamamelis virginiana - Acer rubrum), and 59 (Pinus virginiana - Amelanchier arborea) were nearly equidistant from the four reference stands, yet their relationship to each other was: stands 57 and 59, 0 percent similarity; stands 57 and 63, 10.8 percent similarity; stands 59 and 63, 7.9 percent similarity.

Other examples of stands not effectively ordinated by comparison with the terminal stands in Figure 7 were those which contained abundances of species not common to any endpoint. Included were four stands (19, 42, 67, 68) which contained an abundance of Tsuga canadensis (eastern hemlock), and five additional stands, 59, 12, 20, 79, and 104. These last five stands appeared to represent sole occurrences of distinct vegetation types and thus were not included in subsequent analyses of community types. Polar ordination ignores species not contained in a reference stand and ordinates only on the basis of similarity. For this reason, high beta diversity can lead to distortions, as stands which are floristically different may appear close in the ordination based on species they have in common.

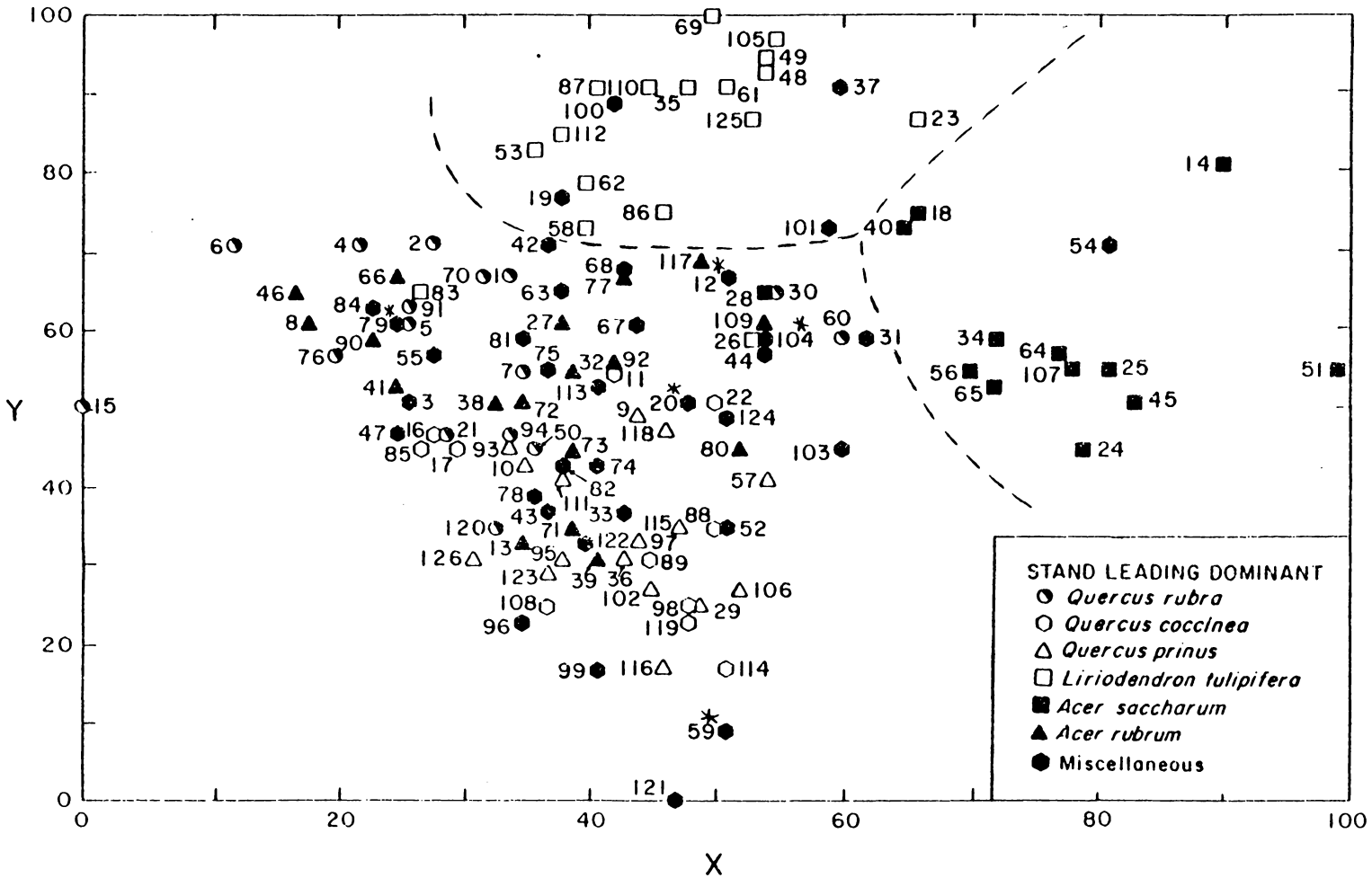
Stands dominated by hemlock were somewhat dispersed in the ordination, occupying a position next to the Liriodendron tulipifera - dominated group. They shared an average similarity of 52.7; however, in the ordination, the nearest samples were more distantly related than this. For example, stands 42 and 45 share similarity of only 8.2 (Fig. 7).

In general, the full ordination based on X axis endpoints of elevational and compositional extremes did not appear to provide an accurate representation of the

interstand distance matrix provided by ORDIFLEX. Because of the complexity of species mixtures and the wide variation in the composition of individual stands (Fig. 7), the choice of reference stands may have significantly affected the plot positions relative to one another. To test this, alternative reference pairs were chosen for a second ordination (Fig. 8). The X axis endpoints (stands 15 and 51) were objectively chosen on the basis of 100 percent dissimilarity and the fact that they were not outliers or poles of suspected gradients. The Y axis stands selected by ORDIFLEX were stands 69 and 59, also 100 percent dissimilar. Stand 59 was rejected as an outlier and the second most dissimilar stand, 121, was chosen instead.

The most obvious difference between the two full ordinations in Figures 7 and 8 was the reversed location of the Acer saccharum and Liriodendron tulipifera-dominated groups of stands. The stands appearing in these two groups were in general consistent with the the first ordination. However, in the second ordination, the Liriodendron tulipifera group, with stands still relatively tightly clustered, was situated at the top of the ordination field, closer to Quercus rubra dominated stands while Acer saccharum dominated stands occupied the right side of the ordination. In addition, positions of the outlier sample

Figure 8. Polar ordination of all 126 stands in the Brumley Gap, VA study area using alternate reference stands. X axis reference stands were objectively chosen on the basis of 100 percent dissimilarity, and did not represent poles of suspected environmental gradients. Individual stands are indicated by numbers and by symbols according to the leading dominant in the upper stratum. Groups of stands representing community types are circled with dashed lines. An asterisk indicates extreme samples. Miscellaneous leading dominants are as in Fig. 7.


STAND LEADING DOMINANT
Quercus rubra
Quercus coccinea
Quercus prinus
Liriodendron tulipifera
Acer saccharum
Acer rubrum
Miscellaneous
X
Y
0
20
40
60
80
100

stands (12, 20, 59, 79, 104) and those which surrounded them were different. Another major difference was that the third group of stands, consisting of primarily Quercus rubra, Q. prinus, Q. coccinea and Acer rubrum as leading dominants, was more congested in the second ordination than in the first. Stands with different leading dominants were still intermingled but in general, the closest stands were not the same as in the first ordination.

A certain amount of distortion was expected since the ordination graphs represent a two-dimensional portrayal of multidimensional relationships (Mueller-Dombois and Ellenburg 1974; Orloci 1978). However, the first and second full ordinations in the present study produced a major distortion probably attributable to high overall sample dissimilarity and partial disjunction. The nearness of Acer saccharum-dominated and Quercus rubra-dominated stands in the initial ordination, based on all 126 stands and subjectively selected X axis endpoints, suggested that the two groups were more similar in species composition than were Q. rubra and Liriodendron tulipifera-dominated stands. In contrast, the second ordination projection based on alternative endpoint selection by ORDIFLEX, placed Q. rubra and Acer saccharum-dominated stands at the most distant poles. The discrepancy is probably due to partial

disjunction, where some of the stands in a group of similar samples are related by a few species to another group (Whittaker and Gauch 1978) and may be placed near each other, while other stands from the different groups are not related at all.

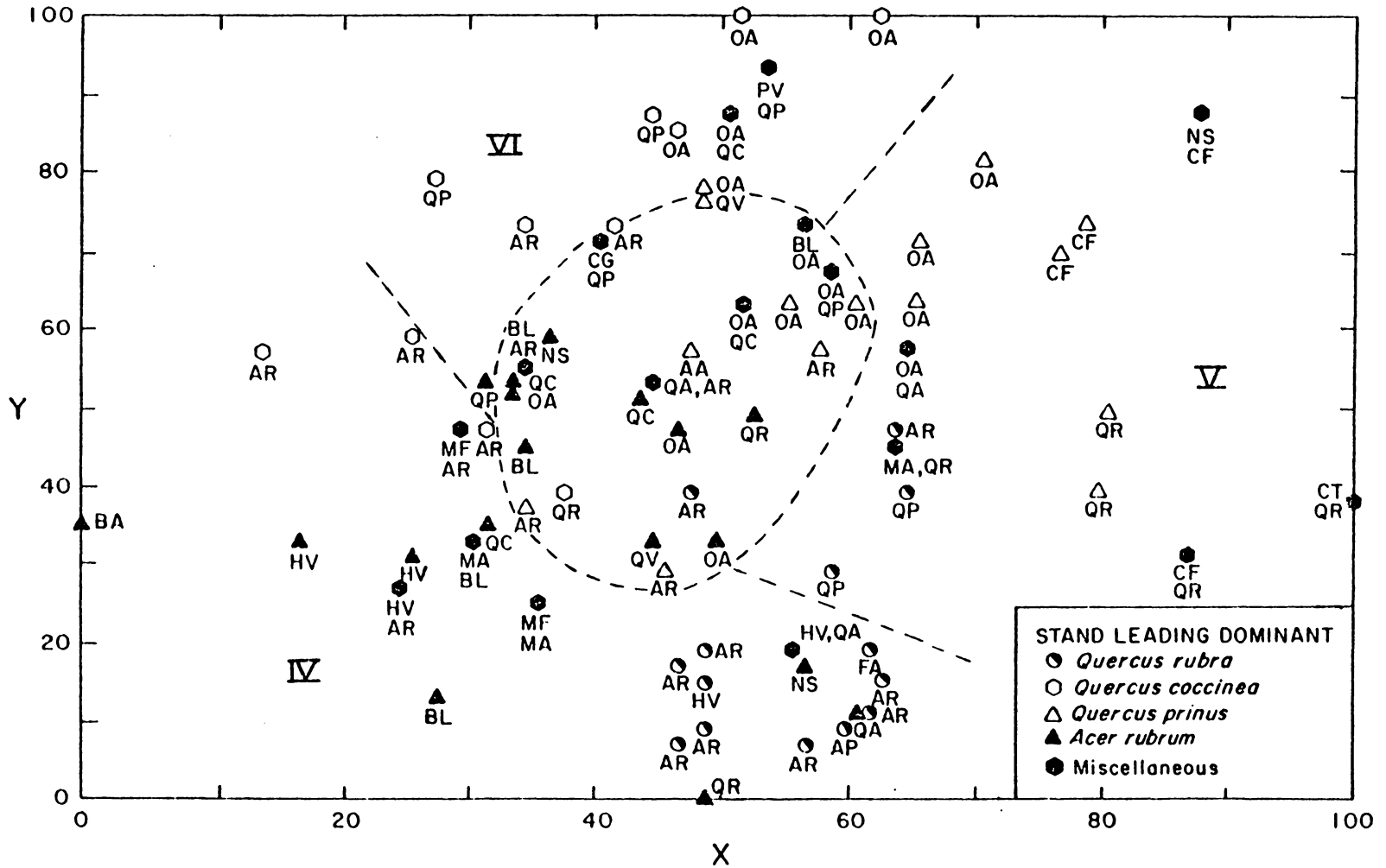
Because of these inconsistencies in the full ordination with changing reference stands, it was concluded that an interpretation of compositional trends and environmental patterns between the stand groups may not be realistic. For example, although the greatest separation of stands along the X axis of the first ordination represented near extremes in the elevation gradient, not all stands were ordered along this gradient. Thus, from the full ordinations, only the more distinct groupings, the stands dominated by Acer saccharum and Liriodendron tulipifera, were recognized as composing the bulk of community types I and II respectively. The stands dominated by Tsuga canadensis were also distinctive enough to be recognized as a type (III) although their relatedness was not seen in the ordinations for the reasons discussed earlier. The remaining stands were analyzed separately as a subset to more clearly define groups.

Subset Ordination

Figure 9 shows the distribution of seventy seven stands along the X and Y axes of the subset ordination, with stands near elevational extremes used to define the poles of the X axis. There appeared to be a gradient from stands with large quantities of Betula lenta, Magnolia acuminata, M. fraseri, Hamamelis virginiana, Ilex montana, and Amelanchier arborea at the lower left of the ordination to stands with abundant Oxydendrum arboreum, Cornus florida, Nyssa sylvatica and Carya spp. at the upper right. In addition, while similar to the pattern in the full ordinations, the subset ordination resulted in a separation among stands containing various proportions of the three major oak species, Quercus rubra, Q. prinus, and Q. coccinea. This separation was most evident among the Quercus prinus-Quercus rubra and Quercus prinus-Quercus coccinea dominated stands. There were still no well defined groupings, rather the stands formed a continuum.

The greater effectiveness of the subset ordination, in displaying compositional gradients (with no major distortions), was attributed to lower heterogeneity of the data set (predominantly mixed oak stands) and the exclusion of extreme stands. The vegetation continuum exhibited a general but not strict arrangement with the elevation

Figure 9. Subset polar ordination of 77 stands in the Brumley Gap,VA study area using stands near elevational extremes to define the endpoints of the X axis. Individual stands are indicated by symbols according to the leading dominant. Groups of stands representing community types IV-VI are outlined with dashed lines. Roman numerals represent the community types explained in the text. Letters accompanying each symbol refer to the second leading dominanat in the stand. Where a miscellaneous symbol ( ) appears, letters indicate the first (upper) and second (lower) leading dominant. (AA, Amelanchier arborea AP, Acer pensylvanicum AR, Acer rubrum BA, Betula alleghaniensis BL, Betula lenta CG, Carya glabra CT, Carya tomentosa CF, Cornus florida FA, Fraxinus americana HV, Hamamelis virginiana MA, Magnolia acuminata MF, Magnolia fraseri NS, Nyssa sylvatica OA, Oxydendrum arboreum PV, Pinus virginiana QA, Quercus alba QC, Quercus coccinea QP, Quercus prinus QR, Quercus rubra QV, Quercus velutina).


Y
X
0
20
40
60
80
100
VI
V
IV
STAND LEADING DOMINANT
Quercus rubra
Quercus coccinea
Quercus prinus
Acer rubrum
Miscellaneous

gradient (Fig. 9). However, the effects of elevation were modified by other factors (i.e. landform, aspect) and species assemblages appeared to be influenced not by any one overriding site factor but by a combination of site factors, including the interaction of elevation and other factors. For the purposes of discussion the stands were separated into three intergrading community types (IV, V, and VI, Fig. 9) characterized by certain assemblages of species and site conditions.

Stands placed in community type IV occupied the bottom and left portions of the ordination (Fig. 9). Within this group, the dominant oaks were Quercus coccinea in stands on the left, a combination of Q. coccinea and Q. rubra in stands in the center, and Q. rubra and Q. alba in the bottom stands (centered at X55 - Y10). One stand, which contained a higher IV for Quercus prinus was outside the designated type boundary at X64 - Y46.

The right-hand portion of the ordination contained stands placed in community type V (Fig. 9). The major species were Quercus prinus in combination with Q. rubra, Acer rubrum, Carya glabra, C. tomentosa (mockernut hickory), Cornus florida and Oxydendrum arboreum. The stands exhibited a gradient from more red oak and red maple in the lower portion of figure 9, to more dogwood and sourwood at

the top, but no obvious environmental differences were evident within the type.

Twelve stands classified in community type VI were positioned at the top of the ordination field (Fig. 9). The species with the highest importance values were Quercus coccinea and Q. prinus. Pinus virginiana and P. rigida (pitch pine) were leading dominants in one plot each. The plot with pitch pine was outside the designated type boundary at X87 - Y86.

Stands which occupied the center of the subset ordination in Figure 9 were not considered distinct enough to describe as a separate type. They were essentially intermediate in composition between the other two or three types and were thus considered transitional. They exemplified the gradual rather than abrupt changes in community composition.

Descriptions of Community Types

The recognition of community types was mainly for the purpose of describing charcteristics of stands strongly dominated by combinations of species, thus reducing the amount of individual stand description. They are named for

the principal species which were usually dominant or codominant. It should be emphasized that boundaries drawn in distinguishing types were to allow for comparison between dissimilar groups and may not represent an abrupt discontinuity in vegetation types in the field.

Type I. Sugar maple - mixed hardwoods

Twenty-two of the 126 sampled stands were placed in the Sugar maple - mixed hardwoods community type. Included were all stands with sugar maple as first or second leading dominant in the ordinations (Fig. 7 and 8), plus four additional stands (62, 83, 112, 113). Stands of the Sugar maple - mixed hardwood type were observed in the major coves (particularly at the heads and in the smaller connecting draws) on the south side of Clinch-Brumley Mountain where mudstone and sandstone of the Juniata Formation and shale and limestone of the Trenton-Martinsburg group comprise the substrata (Fig. 3 and Appendix C). Aspect varied but was often southwest. The type was also found on gentle slopes and flats at higher elevations (above 1100m) within Hidden Valley on mostly northeast exposures (Fig. 10).

The dominant species occurred in various combinations. Next to Acer saccharum, the most important associates were Quercus rubra or Liriodendron tulipifera. These three

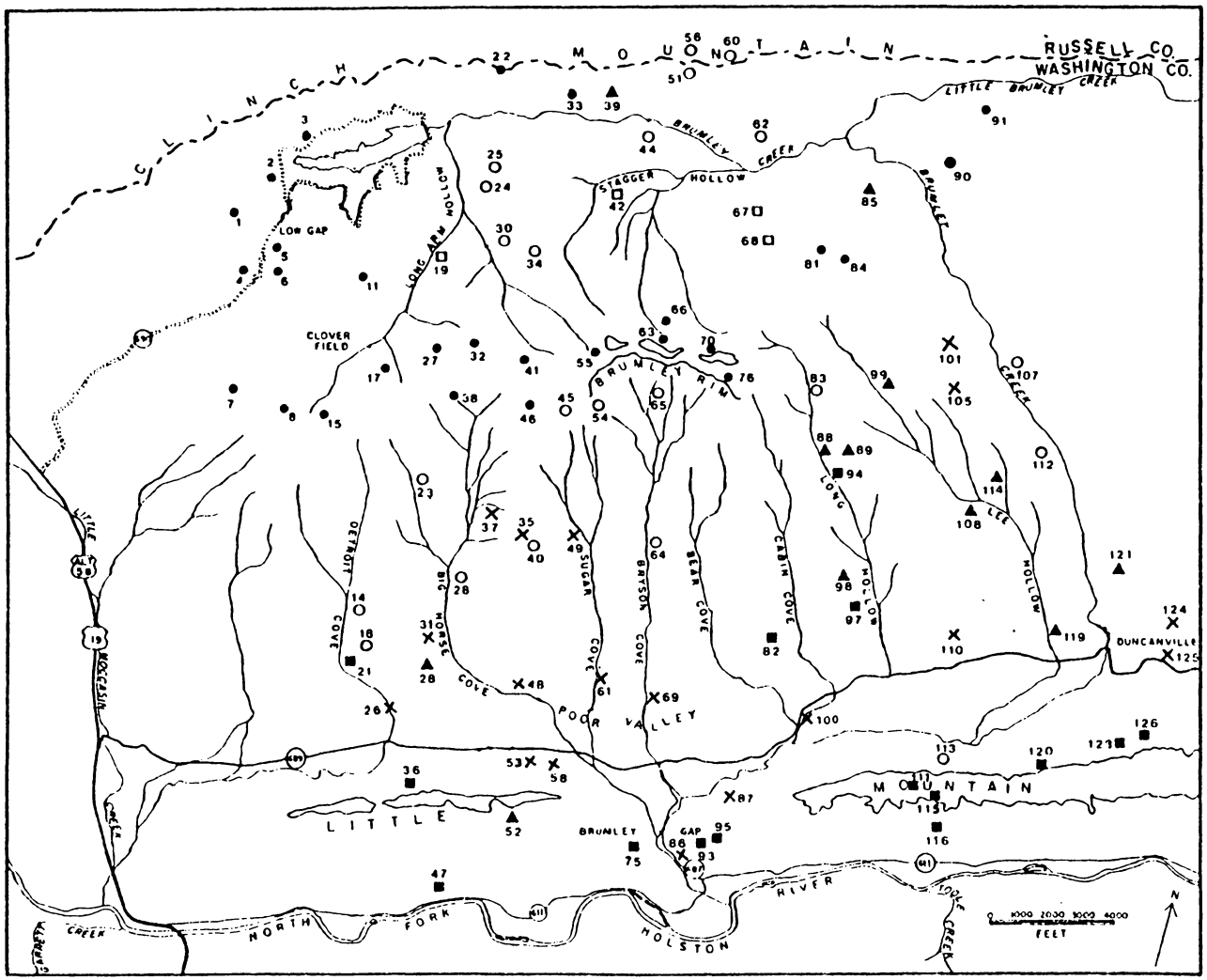


Figure 10. Approximate locations of stands in community types I-VI in the Brumley Gap, VA study area. Stand numbers are indicated. Symbols are =I. Sugar maple - mixed hardwoods; =II. Yellow-poplar; =III. Hemlock; =IV. Oak - mixed hardwoods; =V. Chestnut oak - red oak - hickory; =VI. Scarlet oak - chestnut oak.

species contributed half the basal area, which averaged 24.1m²/ha (Table 3). Other important but less frequent species were Tilia spp. (basswood), Prunus serotina (black cherry), Robinia pseudoacacia, Carya glabra (pignut hickory), Fraxinus americana (white ash) and Magnolia acuminata. The largest individuals sampled of many of these species were recorded in this community type. Among the woody understory species, Acer saccharum was the most important, comprising half of the stems between 2.54 and 10.2cm DBH (Table 5). The only other well represented understory species occurring also in the canopy were Liriodendron tulipifera and Tilia spp.. Acer rubrum, A. pensylvanicum (striped maple), Hamamelis virginiana, Fraxinus pennsylvanica (green ash), and Cornus florida were also found as small trees in many stands. The proportion of woody shrubs was low except for a few sites which contained an abundance of Rhododendron maximum. Herbaceous cover was generally high with several species in each stand covering five percent or more of the area. The most important taxa in this respect were Impatiens pallida, Urtica dioica, Viola rotundifolia and Cimicifuga racemosa. Other frequently occurring species were Disporum lanuginosum, Arisaema triphyllum, Aster divaricatus, Smilacina racemosa, Geranium maculatum, Polystichum acrostichoides and Dioscorea villosa.

Table 5. Relative density of trees ≤ 10.2cm and > 10.2cm over all stands and in each of the six community types in the Brumley Gap study area. Sample sizes are n=22, 18, 4, 27, 17 and 12 for community types I, II, III, IV, V, and VI, respectively.

	All stands[a] (n=126)		Community Type											
			I. Sugar maple-mixed hardwoods		II. Yellow-poplar		III. Hemlock		IV. Oak-mixed hardwoods		V. Chestnut oak-red oak-hickory		VI. Scarlet oak-chestnut oak	
Species	≤10.2	>10.2	≤10.2	>10.2	≤10.2	>10.2	≤10.4	>10.2	≤10.2	>10.2	≤10.2	>10.2	≤10.2	>10.2
Acer pensylvanicum	2	+	4	+	-	-	4	-	5	2	3	4	3	-
Acer rubrum	21	11	7	2	14	7	30	12	30	18	17	4	23	5
Acer saccharum	8	4	52	23	3	+	-	-	1	1	+	+	-	-
Amelanchier arborea	5	+	3	+	-	-	3	-	8	2	6	+	2	-
Betula alleghaniensis	+	+	+	-	-	-	3	3	+	2	-	-	-	-
Betula lenta	3	5	+	3	4	6	11	16	4	4	+	-	+	-
Carya glabra	1	1	2	5	+	+	-	-	+	-	4	2	+	-
Carya tomentosa	+	+	+	1	1	+	-	-	+	+	2	5	+	1
Castanea dentata	+	-	-	-	-	-	-	-	+	-	-	-	+	-
Cornus florida	7	+	3	-	12	2	-	-	+	+	26	+	6	-
Fagus grandifolia	+	+	+	-	2	+	9	7	+	-	+	-	-	-
Fraxinus americana	1	+	1	2	1	+	-	2	+	2	-	-	-	-
Fraxinus pennsylvanica	+	+	2	3	2	-	-	-	-	-	-	-	-	-
Hamamelis virginiana	6	+	7	-	+	-	2	-	14	+	2	-	1	-
Ilex montana	4	-	+	-	+	-	-	-	13	-	+	-	-	-
Liriodendron tulipifera	4	9	4	10	23	49	4	17	+	1	+	1	-	+
Magnolia acuminata	1	4	1	5	+	+	-	5	3	7	-	+	2	+
Magnolia fraseri	2	4	2	2	2	2	2	5	3	5	-	+	2	5
Nyssa sylvatica	4	1	-	+	3	-	-	-	1	+	4	+	14	4
Oxydendrum arboreum	10	4	1	+	2	+	-	3	+	1	18	7	30	5
Pinus virginiana	+	2	-	-	1	9	-	-	-	-	-	2	+	5
Prunus pensylvanica	+	+	+	+	+	-	-	-	+	2	-	-	-	-
Prunus serotina	+	1	+	4	+	+	-	1	+	1	-	-	-	-
Quercus alba	+	3	+	+	1	3	-	-	+	8	+	2	1	3
Quercus coccinea	+	9	-	2	-	+	-	-	2	9	+	4	3	39
Quercus prinus	3	12	+	2	-	+	-	2	+	2	7	38	8	23
Quercus rubra	5	13	+	13	+	3	6	2	7	28	5	20	+	2
Quercus velutina	+	1	+	-	1	+	-	1	+	-	+	3	-	-
Robinia pseudoacacia	2	4	1	8	10	7	-	-	+	2	+	2	-	+
Sassafras albidum	2	+	+	+	6	+	-	-	+	+	2	-	2	+
Tilia heterophylla	+	+	3	5	+	-	-	-	-	-	-	-	-	-
Tsuga canadensis	1	+	+	+	+	2	26	26	+	-	-	-	+	-
Other	2	2	3	4	6	5	-	-	+	+	+	+	+	4

[a]includes 26 stands which did not fall within the six major dominance types.

+ present, < 1%

- absent

The Sugar maple - mixed hardwoods type was further characterized by medium-textured soils. The upper elevation sites had deep A horizons while some of the cove sites were highly eroded, had shallow surfaces, and often exposed colluvial boulders (Appendix C). Six of the stands were in the immediate vicinity of a stream.

Type II. Yellow-poplar

The vegetation characteristics of the 22 stands containing Liriodendron tulipifera as first or second dominant (Fig. 7 and 8) fell into two main types. Four stands (23, 62, 83, and 112), although exhibiting high importance values for Liriodendron tulipifera, were included in the Sugar maple - mixed hardwoods community type (I) as they contained associate species more characteristic of this type. The remaining group (18 stands) was classified in the Yellow-poplar community type and contained such species as Pinus virginiana, in some of the younger stands, and Robinia pseudoacacia as asscciates.

The average age of stands in the yellow-poplar community type was 24 years, much lower than in all other community types. The stands were generally found at lower elevations (av. 668m, Appendix C) near roads or major

drainages which are easily accessible, but were not confined to any particular aspect, slope position or landform (Fig. 10). There was, however, a predominance of the type on the less resistant lithologic units -- Trenton-Martinsburg (Ctm) and Devonian shales (Ds) (Table 6). Liriodendron contributed half the basal area, 18.3m²/ha (Tables 3 and 7). Five stands (35, 37, 86, 105, and 124), all younger than 20 years, contained less than 11.5m²/ha.

Cornus florida, Sassafras albidum (sassafras) and Acer rubrum were present as small trees >2.54cm DBH (Table 5). Common species in the lower and middle strata were Sassafras albidum, Cornus florida, Rubus argutus and Lindera benzoin (spicebush). Yellow-poplar saplings were present in some younger stands. Woody lianas were abundant and included Rhus radicans, Parthenocissus quinquefolia, and Smilax rotundifolia. The herbaceous layer was characterized by high diversity, which averaged 60 species in the stands sampled. The most frequent taxa were Asplenium platyneuron, Polystichum acrostichoides, Clematis virginiana, Smilacina racemosa and Geum canadense. Impatiens pallida and Verbesina alternifolia were prominent in stands located near water.

Table 6. Frequency of occurrence (%) of community types with respect to elevation, aspect, slope position, percent slope, landform, surface geology, and depth and texture of the A and B soil horizons.

	All stands	Community Type					
		I. Sugar maple-mixed hardwoods	II. Yellow-poplar	III. Hemlock	IV. Oak-mixed hardwoods	V. Chestnut oak-red oak-hickory	VI. Scarlet oak-chestnut oak
	(n=126)	(n=22)	(n=18)	(n=4)	(n=27)	(n=17)	(n=12)
ELEVATION (m)							
480-780	28	9	72	-	-	88	25
781-1080	35	64	28	-	7	12	58
1081-1272	37	27	-	100	93	-	17
ASPECT CLASS[a]							
1	28	32	22	-	30	18	42
2	14	4	17	-	7	24	16
3	18	14	6	75	15	41	17
4	9	18	6	-	15	6	-
5	18	9	39	-	15	12	25
6	13	23	11	25	18	-	-
SLOPE POSITION							
shoulder (1)	36	32	17	50	26	82	25
backslope (2)	32	27	28	25	30	12	58
summit (3)	11	14	6	-	18	6	17
footslope (4)	14	23	33	25	18	-	-
toeslope (5)	7	4	17	-	7	-	-
PERCENT SLOPE							
0-14	15	9	28	-	33	-	8
15-29	38	23	28	50	63	6	42
30-44	14	36	17	50	-	-	17
45-59	11	9	11	-	-	18	25
≥ 60	22	23	17	-	4	76	8

Table 6. Frequency of occurrence (%) of community types with respect to elevation, aspect, slope position, percent slope, landform, surface geology, and depth and texture of the A and B soil horizons (continued).

	All stands	Community Type					
		I. Sugar maple-mixed hardwoods	II. Yellow-poplar	III. Hemlock	IV. Oak-mixed hardwoods	V. Chestnut oak-red oak-hickory	VI. Scarlet oak-chestnut oak
	(n=126)	(n=22)	(n=18)	(n=4)	(n=27)	(n=17)	(n=12)
LANDFORM							
ridge	12	14	6	-	30	-	8
spurridge	24	23	11	25	7	12	67
sideslope	32	9	33	50	37	76	25
headslope	3	4	-	-	4	-	-
noseslope	5	-	11	-	4	-	-
cove	23	50	28	25	18	12	-
floodplain	2	-	11	-	-	-	-
GEOLOGY[b]							
Otm	8	18	28	-	-	-	-
Oj	13	36	6	-	-	12	8
Sch	10	14	-	-	4	6	33
Sct	51	27	22	100	96	12	50
Dh	2	-	6	-	-	6	-
Ds	4	-	22	-	-	6	-
Mp	10	5	6	-	-	59	8
Qaf	2	-	11	-	-	-	-
A HORIZON DEPTH							
≤ 15cm	61	56	62	25	33	93	50
> 15cm	39	44	38	75	67	7	50
B HORIZON DEPTH							
≤ 32cm	52	67	62	25	46	53	50
> 32cm	48	33	38	75	54	47	50

Table 6. Frequency of occurrence (%) of community types with respect to elevation, aspect, slope position, percent slope, landform, surface geology, and depth and texture of the A and B soil horizons (continued).

	All stands	Community Type					
		I. Sugar maple-mixed hardwoods	II. Yellow-poplar	III. Hemlock	IV. Oak-mixed hardwoods	V. Chestnut oak-red oak-hickory	VI. Scarlet oak-chestnut oak
	(n=126)	(n=22)	(n=18)	(n=4)	(n=27)	(n=17)	(n=12)
A HORIZON TEXTURE[c]							
fsl, sl	27	12	31	25	29	40	33
l, sil	40	47	31	50	63	20	17
scl, sicl, cl	27	29	25	25	8	33	50
sc, sic, c	5	12	13	-	-	7	-
B HORIZON TEXTURE[c]							
fsl, sl	10	-	19	-	8	20	17
scl, sicl, cl	45	47	44	50	58	40	25
sc, sic, c	45	53	37	50	33	40	58

[a]ASPECT CLASS 1 = 196-260°; 2 = 166-195 and 261-280°; 3 = 146-165 and 281-340°; 4 = 000-020 and 341-360°; 5= 081-145°; 6 = 021-080°.

[b]GEOLOGY: Otm = Trenton-Martinsburg; Oj = Juniata; Sch = Tuscarora; Sct = Rose Hill; Dh = Huntersville; Ds = Devonian shale; Mp = Price; Qaf = Quaternary deposits.

[c]HORIZON TEXTURES: fsl = fine sandy loam; sl = sandy loam; l = loam; sil = silt loam; scl = sandy clay loam; sicl = silty clay loam; cl = clay loam; sc = sandy clay; sic = silty clay; c = clay.

Table 7. Relative basal area of trees over all stands and in each of the six community types in the Brumley Gap study area. Sample sizes are n=22, 18, 4, 27, 17 and 12 for community types I, II, III, IV, V, VI, respectively.

Species	All stands[a] (n=126)	Community Type I. Sugar maple-mixed hardwoods	II. Yellow-poplar	III. Hemlock	IV. Oak-mixed hardwoods	V. Chestnut oak-red oak-hickory	VI. Scarlet oak-chestnut oak
Acer pensylvanicum	+	+	-	+	2	1	+
Acer rubrum	10	2	6	7	16	6	8
Acer saccharum	4	20	1	-	+	+	-
Amelanchier arborea	+	+	-	+	2	1	+
Betula alleghaniensis	+	+	-	+	2	-	-
Betula lenta	4	3	4	17	4	+	+
Carya glabra	2	6	+	-	+	2	+
Carya tomentosa	+	+	+	-	+	4	+
Castanea dentata	+	-	-	-	+	-	+
Cornus florida	+	+	2	-	+	3	+
Fagus grandifolia	+	+	+	4	+	+	-
Fraxinus americana	+	2	+	+	1	-	-
Fraxinus pennsylvanica	+	4	+	-	-	-	-
Hamamelis virginiana	+	+	+	+	3	+	+
Ilex montana	+	+	+	-	+	+	-
Liriodendron tulipifera	10	14	52	11	1	+	+
Magnolia acuminata	3	4	+	2	7	1	+
Magnolia fraseri	2	2	+	2	5	+	4
Nyssa sylvatica	2	+	+	-	2	1	4
Oxydendrum arborea	4	+	+	2	1	6	9
Pinus virginiana	1	-	7	-	-	1	4
Prunus pensylvanica	+	+	+	-	1	-	-
Prunus serotina	2	5	+	2	1	-	-
Quercus alba	4	+	3	-	9	4	2
Quercus coccinea	8	2	+	-	9	3	36
Quercus prinus	10	2	+	2	2	34	21
Quercus rubra	14	16	3	1	28	21	1
Quercus velutina	2	+	+	+	+	5	-
Robinia pseudoacacia	3	6	7	-	1	2	1
Sassafras albidum	+	+	1	-	+	+	+
Tilia heterophylla	1	5	+	-	-	-	-
Tsuga canadensis	2	+	2	46	+	-	+
Other	2	4	4	-	+	+	7

[a] includes 26 stands which did not fall within the six major dominance types.

+ present, < 1%

- absent

Type III. Hemlock

The Hemlock type occurred at high elevations in the bottom of draws, within steep ravines, and on the lower portions of slopes adjacent to Brumley Creek and its tributaries (Fig. 10). The exposure of sites occupied by the four sample stands representing this type varied from slightly northwest to northeast and slopes were moderately steep (av. 32 percent, Appendix C). Soils were moist when sampled and had variable textures (Table 6). The A horizon in one stand was quite dark, indicating a high organic matter content. The Hemlock community type was characterized by high basal area of Tsuga canadensis in the canopy (uppermost layer). Large tree associates were Liriodendron tulipifera and Betula lenta in that order of frequency. Prunus serotina, Fagus grandifolia and Magnolia acuminata were associates in one stand each. Acer rubrum, Betula lenta, Fagus grandifolia (American beech) and Tsuga canadensis were important as smaller trees (Table 5).

The average basal area (35.3m²/ha) was much higher in this type than in any other community type, with Tsuga canadensis contributing close to half the total (Tables 3 and 7). Individual hemlocks reached 65cm in diameter and 30m in height, although many were much shorter. The 896 stems/ha represented the lowest density of all the types (Table 3).

Rhododendron maximum was present in all four stands of the Hemlock community type, densely covering all of one and part of another. The ground cover was sparse, especially in the stands with abundant rhododendron, but some species were present in all stands. The constant members in subordinate strata were Tsuga canadensis, Acer rubrum, Prunus serotina, Ilex montana and the herbaceous species Maianthemum canadense, Monotropa uniflora and Dryopteris intermedia. Betula alleghaniensis, Liriodendron tulipifera, Magnolia fraseri, Acer saccharum, Fagus grandifolia and Hamamelis virginiana were less frequent, as were the herbaceous species Galax aphylla, Clintonia umbellulata, Lycopodium lucidulum and Oxalis montana.

Other stands were encountered, though not randomly sampled, which had vegetation and site characteristics similar to the four stands included here as belonging to the Hemlock type. Abundant hemlock was also observed in floodplain positions on boggy ground along Brumley Creek in combination with Betula alleghaniensis, Liriodendron tulipifera and Magnolia fraseri. In addition, a hemlock-rhododendron stand was observed on a 76 percent north-facing spur ridge of Little Mountain (elevation 594m) where codominant trees were Quercus prinus and Q. coccinea.

Type IV. Oak - mixed hardwoods

The Oak - mixed hardwoods community type occurred at higher elevations (av. 1192m) along Clinch-Brumley rim and extended into upland areas of Hidden Valley (Fig. 10). The sites were characterized by mostly gentle slopes (av. 17 percent) and variable aspects and slope positions. Twenty-six of the 27 sample stands included in this type occurred on the Rose Hill formation, characterized by interbedded impermeable shales and sandstones (Table 6). In some of the stands, the soil was quite moist and larger trees had heartrot. The most common overstory dominants were Quercus rubra and Acer rubrum but Betula lenta, Magnolia acuminata, Quercus coccinea and Betula alleghaniensis were the most important species in some stands. Quercus alba and Amelanchier arborea tended to be important associates in Q. rubra-dominated stands on shoulders and spur ridges with low aspect values (south-southwest through west-northwest exposures), while Prunus serotina and Acer saccharum were of some importance in stands with north to southeast aspects. Small trees present in this community type included those found in the canopy, together with Acer pensylvanicum, Hamamelis virginiana, Ilex montana and Amelanchier arborea. These last three species sometimes attained high IVs due to high densities rather than to positions in the canopy layer

(Table 5). The average number of trees >2.54 cm DBH was 1597 stems/ha. Average basal area was 23.6m²/ha (Table 3). The most common herbs were Clintonia umbellulata, Aralia nudicaulis, Medeola virginiana, Smilacina racemosa, Eupatorium rugosum, Smilax herbacea, Aster acuminatus and Solidago caesia.

Type V. Chestnut oak - red oak - hickory

The Chestnut oak - red oak - hickory type, represented by 17 stands, occurred at lower elevations (mostly below 800m), on dissected upland slopes, steep side slopes adjacent to drainageways, and on broad, less steep, open slopes (Fig. 10 and Appendix C). Some of the oldest stands were included in this type, which was characterized by Quercus prinus as the dominant overstory tree, followed by Quercus rubra. Other associates of some importance were Carya glabra, C. tomentosa, Quercus coccinea, and Q. velutina. Oxydendrum arboreum and Acer rubrum were of major importance in the lower canopy.

Most stands contained an abundance of woody plants in the understory. Cornus florida and Oxydendrum arboreum occurred most frequently and abundantly, obtaining relative densities of 26 and 18 percent (339 and 257 stems/ha in the

2.54 - 10.2cm size class, respectively (Table 5). Other frequent but less abundant species were Amelanchier arborea, Acer rubrum, A. pensylvanicum, Carya glabra and C. tomentosa. Average stand density was 1685 stems/ha; basal area was 22.6m²/ha (Table 3). The herb layer was not particularly dense but an average of 59 species occurred in a 400m² sample area. This was second only to the Yellow-poplar type. The most common species were Smilacina racemosa, Polygonatum biflorum, Potentilla canadensis, and Prenanthes altissima.

The sites were characterized by steep (av. 61 percent), usually convex slopes and shallow soils (av. 37 cm, Table 6 and Appendix C). About two-thirds of the stands occurred on Little Mountain over the Mississippian Price Formation (Fig. 10) and on Muskingham soil units. The Muskingham mapping units are highly variable but in general, the soils are subject to drought and are low in natural fertility (Wilhelm et al. 1980). The sites were in general less exposed due to some protection afforded by surrounding landforms than were the open slope sites typically occupied by the Scarlet oak - chestnut oak community type.

Type VI. Scarlet oak - chestnut oak

The 12 stands placed in the scarlet oak - chestnut oak community type were located at intermediate elevations (av. 917m) on mostly southwest and northwest exposures, and spur ridges or sideslope landforms (Table 6 and Appendix C). The slope position was most often the backslope (Table 6). The soils contained more sand and clay and less silt than those sites supporting other community types. Profiles were often well developed and the average solum was deeper (53cm) than in all other types except the Hemlock type. Rough Stony Land was the mapping unit in 58 percent of the stands.

Quercus coccinea and Q. prinus were usually the dominant canopy species but Pinus virginiana and P. echinata were locally important. Associated trees which occupied all other layers and occasionally entered the canopy were Nyssa sylvatica, Acer rubrum and Oxydendrum arboreum. Although the stands were comparable in age (average 44 years, Appendix C) to other stands in the Brumley Gap study area, the trees were generally smaller, rarely exceeding 30 cm DBH. The basal area (av. 21.3m^2/ha, Table 3) was not substantially low in comparison with other types due to the large number of stems. Average density was 1871 stems/ha, the highest of the community types (Table 3). Seventy percent of the trees were between 2.54 and 10.4cm DBH, with Oxydendrum arboreum the most abundant at 389 stems/ha.

Many of the stands in the scarlet oak - chestnut oak type were situated on the spur ridge that separates Lee and Long Hollow (Fig. 10 and Appendix D). This ridge, as compared with some of the others, is broader, and the distance to an opposing landform is greater. The geologic substrate is Tuscarora sandstone (Fig. 3). The stands sampled on this ridge and one other stand (39) supported dense, shrubby subordinate vegetation consisting of Kalmia latifolia, Lyonia ligustrina and Vaccinium vacillans. Acer rubrum, Castanea dentata, Nyssa sylvatica and Sassafras albidum were usually present, increasing in importance where the heath coverage was less dense (stands 29, 52, and 85). The most frequently occurring herbaceous species in this community type were Galax aphylla, Chimaphila maculata, Epigaea repens, Smilax glauca, S. rotundifolia and Cypripedium acaule. Of these species, Galax was the only one to reach coverage of more than one percent.

Transition Stands

Contained in the lower part of the center group in the subset ordination (Fig. 9) were 4 stands which were similar to the Oak - mixed hardwoods community type (IV), but the dominant oak was Quercus prinus rather than Q. rubra or Q. coccinea. Environmental differences were not readily

discernible. These transition stands all occupied upper slopes or ridges of south and southwest exposures as did some of the stands classified in community type IV. There were also several transition stands which possessed properties of community type V, chestnut oak - red oak - hickory, but contained Quercus velutina in place of Q. prinus or Q. rubra as the dominant species.

Intermittent streams were associated with some transition stands approaching community type VI (Fig. 9). Compositional differences were largely with respect to small trees, the transition stands containing such species as Ilex montana, Rhododendron maximum, or Betula lenta, which were rare or absent from community type VI.

More pronounced vegetation changes occurred between community types other than those dominated by oaks. For example, the transition of stands dominated by hemlock with those dominated by other species represented one of the more distinct discontinuities in which several species diminish in importance almost simultaneously. These more abrupt changes appeared to coincide with proximity to drainageways or with abrupt changes in topography. But even in this instance, vegetation boundaries were not discrete. Small individuals of Tsuga canadensis extended into less steep depressional areas in Hidden Valley or into gentler slopes at the heads of drainageways where they gradually decreased in abundance.

Unique Stands

Five stands were considered unique to the study area as each was substantially different from all other stands encompassed by the community types recognized above (Appendices B and C). Stand 12 was dominated by Prunus pensylvanica (fire cherry) and Ulmus americana (American elm), with the latter not included in the ordination. The site was located in Hidden Valley next to a road, and had obviously been disturbed. Ample light was entering the stand from the side; basal area was a low 8.1m²/ha.

Stand 20 was designated as unique due to the large proportion of beech (IV 36.2). It was one of two stands in which Fagus grandifolia contributed more than 10 percent of the importance value. The other stand was included in the hemlock type. Prunus serotina (black cherry) was the second leading dominant (IV 15.9). Less important species were Liriodendron tulipifera, Magnolia acuminata and Oxydendrum arboreum. The site showed no evidence of disturbance. It was at an elevation of 1122m on a steep (64 percent) northeast-facing slope.

The lowest stand density (173 stems/ha) and basal area (2.2m²/ha) of all stands sampled was recorded in Pinus virginiana dominated stand 59, located on a rock outcrop of Tuscarora sandstone. The other component species were

Oxydendrum arboreum, Amelanchier arborea, Kalmia latifolia and Vaccinium vacillans.

Stand 79, dominated by Magnolia fraseri, Betula alleghaniensis, and Betula lenta, was located near the head of a Brumley Creek tributary in Hidden Valley, at an elevation of 1024m (Appendix D). It had an intermittent stream running through it and large boulders had created a very uneven surface. The understory was dominated by Rhododendron maximum Rhododendron maximum (138 stems occurred on the 400m² plot) and little else. Betula alleghaniensis was rarely a dominant in the other stands sampled, but it was observed as a major overstory component along the Hidden Valley portion of Brumley Creek.

Stand 104, located near a main road, had an average dissimilarity of 95.7 percent with all other stands sampled, and consisted of, in order of decreasing importance, Fraxinus americana, Carya glabra, C. ovata, Juglans nigra, Carya cordiformis, Robinia pseudoacacia and Celtis occidentalis. The basal area was only 6.6m²/ha. The lack of trees and proximity to a main road suggested that the site had been disturbed recently.

Vegetation-Site Relationships

The relationship of forest communities with site in the Brumley Gap study area appears to be associated with modifications of site moisture and temperature. Whittaker (1956) is credited with first expressing the concept of variation in vegetation with a "complex moisture and elevation gradient". More recent investigations have corroborated his views (Rochow 1972; Strahler 1972), some emphasizing additional effects on vegetation due to differences in soil parent materials (Erush et al. 1980). Hack and Goodlett (1960) related changes in species composition to changes in topography and lithology, which in turn, influenced and were influenced by moisture regimes. Community types of the present study and their relationships to certain environments as affected by site, are discussed below. A diagram was developed (after Whittaker 1956) which displays the distribution of community types in relation to elevation and topography (Fig. 11). The axis for topography was based on the combined variables of aspect, landform, slope position and slope shape and is arranged in order of decreasing moisture conditions.

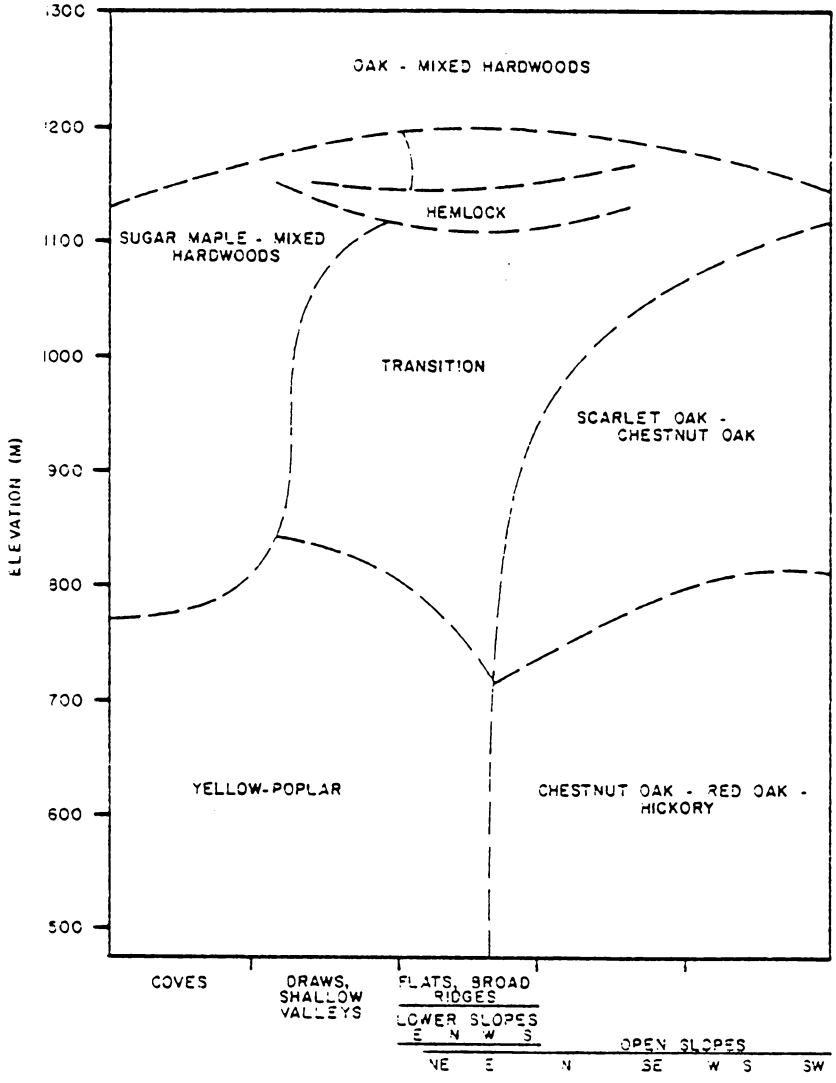


Figure 11. Distribution of community types in the Brumley Gap, VA study area in relation to elevation and topography. Community type boundaries were determined by plotting the stands on the diagram and drawing lines around the majority of stands in a particular community type. About 15 stands are outside the line drawn for their types. Lines are projected across draws and shallow valleys where sample coverage was low.

High Elevation Sites

Increasing basal area in the Brumley Gap study area appeared to be related to site factors which favor moisture and cooler temperatures (high elevations and more northerly and easterly aspects). These two factors were characteristic of mainly Sugar maple - mixed hardwoods, Hemlock, and Oak - mixed hardwoods stands, which had the three highest basal areas out of the six community types (Fig. 11). An increase in elevation within a given region is associated with a decrease in air temperature, reduced evapotranspiration, and more precipitation due to uplifting of air masses at higher elevations as well as more precipitation in the form of snow, resulting in a cooler, more moist environment. However, increased moisture may not be due to elevation alone. Specific effects of single factors were difficult to assess because of the association among factors. For example, high elevation sites had less steep slopes which would reduce runoff. In turn, the gentler slopes had thicker A horizons which are associated with higher moisture absorption and retention.

A regression model containing elevation, aspect and age accounted for 39 percent of the variation in stand basal area and was of the form:

$$\text{Stand basal area} = 1.398 + .0075\ \text{elevation} + 1.220\ \text{aspect} + .210\ \text{age} \qquad (R^2=.39)$$

The positive relationship between basal area and age indicated that younger stands (mostly at lower elevations) were probably not fully occupying the sites. Although the high elevation forests have also been influenced by disturbance, many may have already established full occupancy because of the generally more favorable growing conditions here. In addition, as the original stands which occupied these sites undoubtedly had better quality trees, harvesting was probably more complete and resulted in more abundant regeneration.

Muller (1981) compared second growth and virgin mixed-mesophytic stands from adjacent watersheds in eastern Kentucky. The results support the idea of rapid recovery on moist sites. He found similar total basal areas in the two watersheds, with a greater part of the second growth stand in the smaller diameter classes. In contrast to the present study, Bormann et al. (1970) found that basal area decreased with elevation in northcentral New Hampshire. The authors attributed this relationship to shallower soils and shorter growing seasons at higher elevations leading to a lower primary productivity.

All of the high elevation stands in the Brumley Gap study area except one occurred on the Rose Hill Formation. Although the associated soil units, Muskingham and 'Rough Stony Land', are considered well-drained, the Rose Hill

Formation may form reservoirs for groundwater where the impermeable shale and siltstone units occur beneath various thicknesses of overburden. These upper beds are thought to occur in the western half of the Clinch-Brumley Rim (Harza Engineering Co. 1978). Many of the Oak - mixed hardwood sites sampled on the south and west portion of the Rim were on boggy ground and standing water was often present in topographic depressions. It seems quite plausible that a perched water table may exist, although actual subsurface data were not obtained. If this is indeed the case, the abundant moisture in these sites may actually be detrimental, leading to restricted aeration in the rooting zone, and perhaps explaining the basal rot observed in many of the live trees.

High elevation sites in the Brumley Gap study area dominated by Sugar maple - mixed hardwoods were considered more favorable for tree growth than the adjacent Oak - mixed hardwoods sites. They often occupied some of the same shoulder and backslope positions as the Oak stands but tended to occur further into Hidden Valley, away from the exposed Rim (Fig. 10 and Appendix D). In comparison with the Oak forest sites, they had deeper A horizons and were more frequently associated with higher aspect values (north through southeast).

The Hemlock type is more difficult to characterize completely since only four stands were sampled. It appears to occupy similar sites in terms of moisture and temperature as adjacent Sugar maple - mixed hardwood stands. Others (Braun 1950; Whittaker 1956; Keever 1973) also noted the similarities in sites occupied by Tsuga canadensis and moist site hardwoods but said that hemlock stands were on somewhat less mesic sites. It has been suggested by Braun (1950) and others that Tsuga canadensis was much more widespread in presettlement forests than it is today. Rogers (1978) suggested that the decline of hemlock in the northeast is due to its inferior ability to recapture a site after disturbance, including fire, when compared with associated species. Tsuga canadensis is ill-adapted to germination on heavy leaf litter (Fowells 1965; Keever 1973) and the slow growing seedlings are dependent upon a constant supply of moisture. In the Brumley Gap study area, the hemlock stands are near streams on moderate slopes where surface runoff may have been rapid enough to carry away litter. In established stands, continued survival of Tsuga seedlings and saplings is favored due to the modification of the environment by the mature hemlocks. The sparseness of the understory is probably due to the dense layers of hemlock foliage and the acid leachate of the hemlock litter (Whittaker 1956; Rogers 1978).

The similarity of Hemlock, Oak - mixed hardwoods, and Suger maple - mixed hardwoods stands, in at least some aspects of environment, is indicated by the overlap of species between the different community types. For example, Quercus rubra was important in both Sugar Maple and Oak - mixed hardwoods stands while Liriodendron tulipifera was important in Sugar maple and Hemlock stands. Magnolia acuminata, M. fraseri, and Acer pensylvanicum were of similar importance in all three community types.

Forests of Slopes and Lower Elevations

Stands which occur primarily outside of the Rim area on the south slopes of Brumley Mountain and on Little Mountain are in the Sugar maple - mixed hardwoods, Yellow-poplar, Chestnut oak - red oak - hickory, and Scarlet oak - chestnut oak community types (Fig. 11). The Sugar maple - mixed hardwoods stands occurring on slopes are again asscciated with cool, moist conditions as they were inside the Rim area. An abundance of the type in the deeply dissected drainageways on Brumley Mountain is the first indication of moist conditions. These concavities are places of moisture convergence. In addition, the narrow "V" shape of the coves would tend to offer protection from winds and to decrease the amount of direct sunlight received. The effects of aspect were probably masked in these cove sites. Southwest-

facing slopes, which tend to be more open and warmer than north and northeast slopes, and normally tend to retain less moisture for the growth of plants, did not appear to restrict the occurrence of the Sugar maple - mixed hardwood type in the southwest slopes of coves (Appendix C, stands 18, 45, 64, 65, 83, 107). The erosion of the A horizons would seem to have a detrimental effect on moisture and perhaps nutrient relationships (Appendix C, stands 23, 40, 64, 65). However, the medium textured silt loams to sandy clay soils have higher water-holding capacities than sandy soils (Jenny 1941) and the water is held at lower tensions than in the soils having a higher percentage of clay. In addition, a clay soil on slopes suffers from lateral movement of water before infiltration can occur.

The Sugar maple - mixed hardwoods stands of coves could have been separated from sugar maple stands at higher elevations on the basis of topography, but the environments and species seemed quite similar. In comparison, stands at upper elevations contained more Prunus serotina or Magnolia acuminata and may have been somewhat cooler.

The Yellow-poplar community type is considered a temporary one, resulting from large-scale disturbances related to farming and subsequent abandonment and timber harvesting. The importance of intolerant species (Robinia pseudoacacia, Sassafras albidum, Liriodendron tulipifera,

and in some cases Pinus virginiana) suggests the existence of large openings at some time in the past. The understory species Rhus radicans, Rubus argutus, Parthenocissus quinquefolia, Geum canadense and Clematis virginiana are also species common in disturbed areas. Dominance by Liriodendron tulipifera is usually associated with moist well-drained sites (Auten 1945; Fowells 1965). Although there was a general lack of site preferences, an association of the Yellow-poplar-dominated stands with a combination of factors suggests mesic sites, with a deficiency in one factor being compensated for by a surplus in another. For example, stand 69, with an aspect value of 1 (southwest), was on a toeslope with only a 14 percent gradient (Appendix C).

The association of Yellow-poplar stands with low elevations was seen as a reflection of man's influence rather than of site affiliation. It is not clear whether the correlation with geologic substrates is of the same nature. Cleared areas on slopes may have been marginal for farming, but may consitute some of the better substrates for forestry (Smith and Linnartz 1980). The Yellow-poplar type occurred more often than other types on the calcareous Trenton-Martinsburg Formation and on Devonian shales and was the only type sampled on Quaternary deposits. These substrates are encountered within and adjacent to the populated Poor Valley.

Some of the younger stands in the Yellow-poplar community type (31, 49, 26, 110) contained associated pioneer species (Pinus virginiana and Sassafras albidum) which are characteristic of drier sites. It is well known that factors of moisture, temperature, light and competition are altered in young stands (Smith 1962; Marks 1980); thus, there may not as yet be equilibrium with the environment on these sites. These sites were especially difficult to characterize since Acer saccharum and Fraxinus pennsylvanica, species typically associated with moist conditions, were present as well.

The Chestnut oak - red oak - hickory (Type V) and Scarlet oak - chestnut oak (Type VI) community types also occurred on the slopes of South Brumley Mountain and Little Mountain, but on more open and on drier sites in comparison with the Yellow-poplar and Sugar-maple mixed hardwoods stands (Fig. 11). The Chestnut oak - red oak - hickory and Scarlet oak - chestnut oak types occurred more often on drier exposures and on upland topography; they were not associated with footslopes or toeslopes. Association of the Chestnut oak - red oak - hickory type with comparatively steeper slopes and shallower soils than the Scarlet oak - chestnut oak type would seem to point towards its occupying the driest sites in the study area but the species comprising this type are not those typically associated with

extremely xeric sites. Quercus prinus is generally considered intermediate between Q. rubra and Q. coccinea in terms of distribution in relation to moisture (Whittaker 1956; Hack and Goodlett 1960; Racine 1971). Although there was considerable overlap of species between the Chestnut oak - red oak - hickory and Scarlet oak - chestnut oak community types, Quercus prinus and Q. rubra were more important in the Chestnut oak - red oak - hickory type while Quercus coccinea and Pinus virginiana, (the latter also typically associated with more xeric sites, Whittaker 1956) were more important in the Scarlet oak - chestnut oak type. In addition, the subordinate strata of Chestnut oak - red oak - hickory stands consisted mostly of species classified by Whittaker (1956) as submesics, including Acer rubrum, Cornus florida, Amelanchier arborea and Acer pensylvanicum, while Scarlet oak - chestnut oak stands contained more taxa normally associated with xeric and subxeric conditions, i.e. Kalmia latifolia, Nyssa sylvatica, Lyonia ligustrina and Vaccinium vacillans.

The reason for the apparently more moist conditions on sites occupied by the Chestnut oak - red oak - hickory type compared to the Scarlet oak - chestnut oak type as indicated by species composition, is unclear. It may be that the degree of protection from direct solar radiation afforded by adjacent landforms is an important factor which was not

quantitatively included in this study. The Scarlet oak - chestnut oak stands generally occurred on open slopes that presumably receive more sun than a similar sheltered site on any given exposure. In addition, Scarlet oak - chestnut oak stands were, more often than any other community type, associated with the resistant Tuscarora sandstone, which in turn was often characterized by 'Rough stony land' (Table 6). That the associated soils were deep was not expected in light of the fact that deeper soils indicate a potentially deeper rooting zone. However, studies have shown that soils on warm, dry slopes often have a more highly weathered and deeper profile (Finney et al. 1962 Losche et al. 1970) than soils on adjacent cooler slopes. Thus, there may not be a general lack of water (which is a factor in chemical weathering) on these warm, dry sites but just a critical drought period.

Comparison of Community Types With Others in Appalachian Oak Forests

The present study of community relationships in the Appalachian Oak region revealed patterns similar to those reported in earlier studies. Some of the differences can be attributed to man-induced disturbances and to the low sampling intensity in the present study. For instance, the

Sugar maple - mixed hardwoods community type (I) is comparable to Braun's (1950) mixed mesophytic communities, which are limited to the most mesic areas in the Ridge and Valley section. The shifting dominance of component species, which in the present study included Acer saccharum, Liriodendron tulipifera, Tilia spp., Prunus serotina, Quercus rubra, and Robinia pseudoacacia is well recognized (Whittaker 1956; Martin 1971). The diversity of the type in the Ridge and Valley is lower than that in the Southern Appalachians.

Aesculus octandra and Fagus grandifolia, indicator species of mixed mesophytic communities, were scarcely encountered in the present study. Both are adversely affected by fire due to their relatively thin bark. However, according to Braun (1950), scattered areas of beech woods with occasional buckeyes occurred on Clinch Mountain. In the present study, the one beech stand sampled (stand 20) indicates that such areas still exist. The trend towards dominance by Acer saccharum was partly due to its abundant reproduction. The higher importance of Robinia pseudoacacia in comparison to other mixed mesophytic communities (Martin 1971, 1975) may be attributed to the combined disturbances of logging and chestnut blight. Woods and Shanks (1959) reported an increase in the species following death of Castanea but noted that it had since declined due to attacks by locust borers.

Communities dominated by Liriodendron tulipifera have been described in other studies as in the present one, as indicators of disturbance. Braun (1950) reported an abundance of Liriodendron tulipifera in secondary forests of lower slopes and coves in the Ridge and Valley and Northern Blue Ridge Provinces. These stands were considered developmental following repeated logging of commercially important dominants such as Quercus alba. Brush et al. (1980) noted the occurrence of Liriodendron tulipifera associations in Maryland which contained many of the same associate species common in the present study -- Acer rubrum, Cornus florida, and Sassafras albidum. The irregular distribution of the association in the Appalachian Province of Maryland could not be explained in terms of elevation and lithology as could the other associations described by Brush et al. 1980). Descriptions of Liriodendron tulipifera-dominated stands in the Great Valley of Tennessee also indicated a lack of site restriction of these communities to aspect, slope shape, position, and geologic substrate (Martin 1971). The sites were characterized by low overstory density and basal area, thus pointing towards past disturbance.

Oak communities in the present study have a close resemblance to Whittaker's (1956) vegetation types in the Great Smoky Mountains. The Oak - mixed hardwoods (Type IV)

of the present investigation is comparable to his red oak - chestnut forest. Both are described as high altitude submesic forests. Braun, in 1932, described a community on Salt Pond Mountain (about 200 km northeast of the Brumley Gap study area) with remarkably similar composition to the Oak - mixed hardwoods type, with the exception that Castanea dentata was the dominant species (Braun 1950). She suggested that the most important associate, Quercus rubra, would be the future dominant, and indeed that has been the case here, and also on Salt Pond Mountain in the same stand 38 years later (Stephenson 1976).

Neither of the above authors mentioned Prunus pensylvanica or Quercus coccinea as components. The former did occur here and is a successional species dependent on disturbance (Marks 1980). Quercus coccinea is normally considered a more xeric site species and there is some doubt as to whether the species as reported here was confused with Q. rubra which may often assume poor form on ridge sites or perhaps hybridize with Q. coccinea on these sites.

The Chestnut oak - red oak - hickory type (V) compares with a poorly developed phase of the red oak-pignut hickory forest described by Whittaker (1956, p49) as comprised of mixed oaks and chestnut and some hickory. In agreement with the present study, he described these forests as occurring at lower elevations. In contrast, a well-developed phase of

this forest would have included dominance by Quercus rubra, Q. alba, Carya glabra and C. tomentosa. The dense tree understory compares with his Chestnut oak - chestnut forest where he attributes the large numbers of Cornus florida, Oxydendrum arboreum and Acer rubrum stems to release resulting from the death of chestnut.

Castanea dentata is nowhere abundant in the Brumley Gap study area, but it occurs in the understory of all oak forests, and is most common in Scarlet oak - chestnut oak communities. Woods and Shanks (1959) have noted that the replacement of Castanea is slower on drier sites. The Scarlet oak - chestnut oak type is similar to the extremely dry sites reported by others to contain an admixture of pine and oak (usually Quercus coccinea and Q. prinus) and a well developed heath layer (Braun 1950; Whittaker 1956; Hack and Goodlett 1960; McEvoy et al. 1980). These communities are often described as occurring on convex ridges and crests that disperse runoff, and on steep, southwest-facing slopes. The stands in the present study appear to be related more to slope position and geology, than to aspect. The high stem densities in this type which were also noted by McEvoy et al. (1980) in mixed oak-pine vegetation in Craig County, Virginia, and by Martin (1971) on xeric sites in the Great Valley of Tennessee, may be due to less inter-specific competition on poor sites.

Species-site Relationships

The recognition of community types avoided descriptions of similar stands which varied slightly in species composition. Individual species, however, are not completely confined to any particular type, and no two species have exactly the same pattern of distribution (see also Gleason 1926 and Whittaker 1967). This was verified by regressing the relative basal area of six of the more abundant tree species in the Brumley Gap study area on several site factors.

The general model relating the relative basal area of the most important tree species (*Acer rubrum*, *A. saccharum*, *Liriodendron tulipifera*, *Quercus coccinea*, *Quercus prinus* and *Quercus rubra*) to site factors was proposed for its relative simplicity as well as for the presumed importance of the included variables in affecting species distributions. It was of the form:

$$\text{Species relative basal area} = a + b\,(\text{elevation}) + b\,(\text{slope position}) + b\,(\text{percent slope}) + b\,(\text{aspect value})$$

With this general model, all the variables were never significant for a single species. Neither were the same

variables important across different species (Table 8), which lends support to the theory of independent distribution. Individually developed models using PRCC RSQUARE (Helwig and Council 1979) and PRCC REG (SAS 1981) appeared to be species specific. However, the low R^2 in the individual species models indicates failure of the site factors as expressed to account for a large proportion of variation in relative basal area.

The accuracy of the final regression models was not ascertained by observing their predictive power on a new set of data, since all available data were used in developing the equations. Instead, a simulated cross validation was done, by examining the residuals to determine the nature of the lack of fit, outliers and influential stands for Liriodendron tulipifera and Quercus rubra models. With this procedure, single stand deletion (called case analysis) did not reveal any single stand to be an influential point (one that would bend the regression line in its direction).

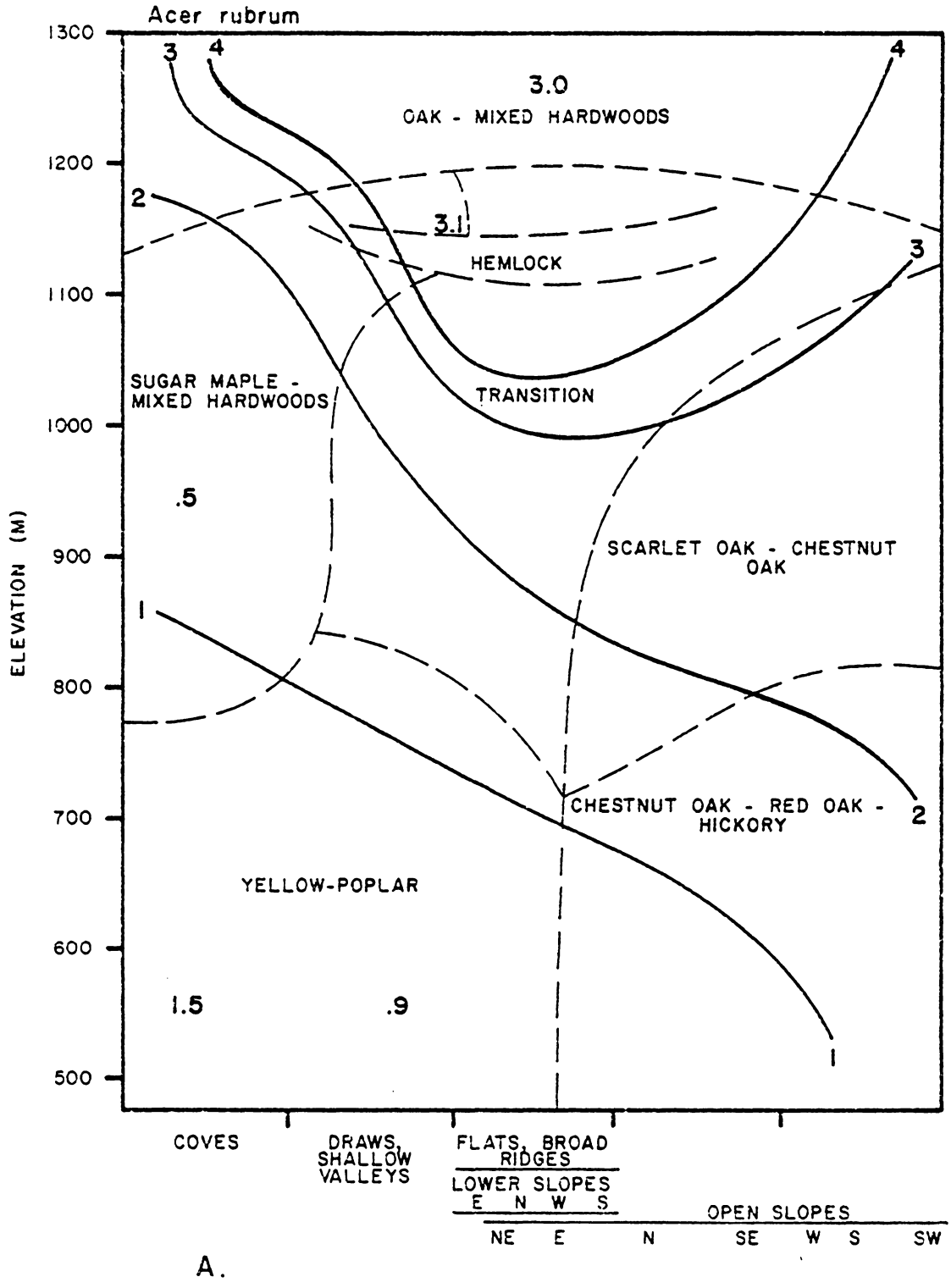
Species distribution diagrams were developed to identify species modes and limits, which follow the pattern for the community type diagram and portray relationships expressed by the regression models (Fig. 12, A-E).

Table 8. Single proposed multiple linear regression model for predicting the relative basal area of the six most important species in the Brumley Gap study area. The form of the model is $y = a + b_1$ (aspect) $+ b_2$ (elevation) $+ b_3$ (percent slope) $+ b_4$ (slope position).

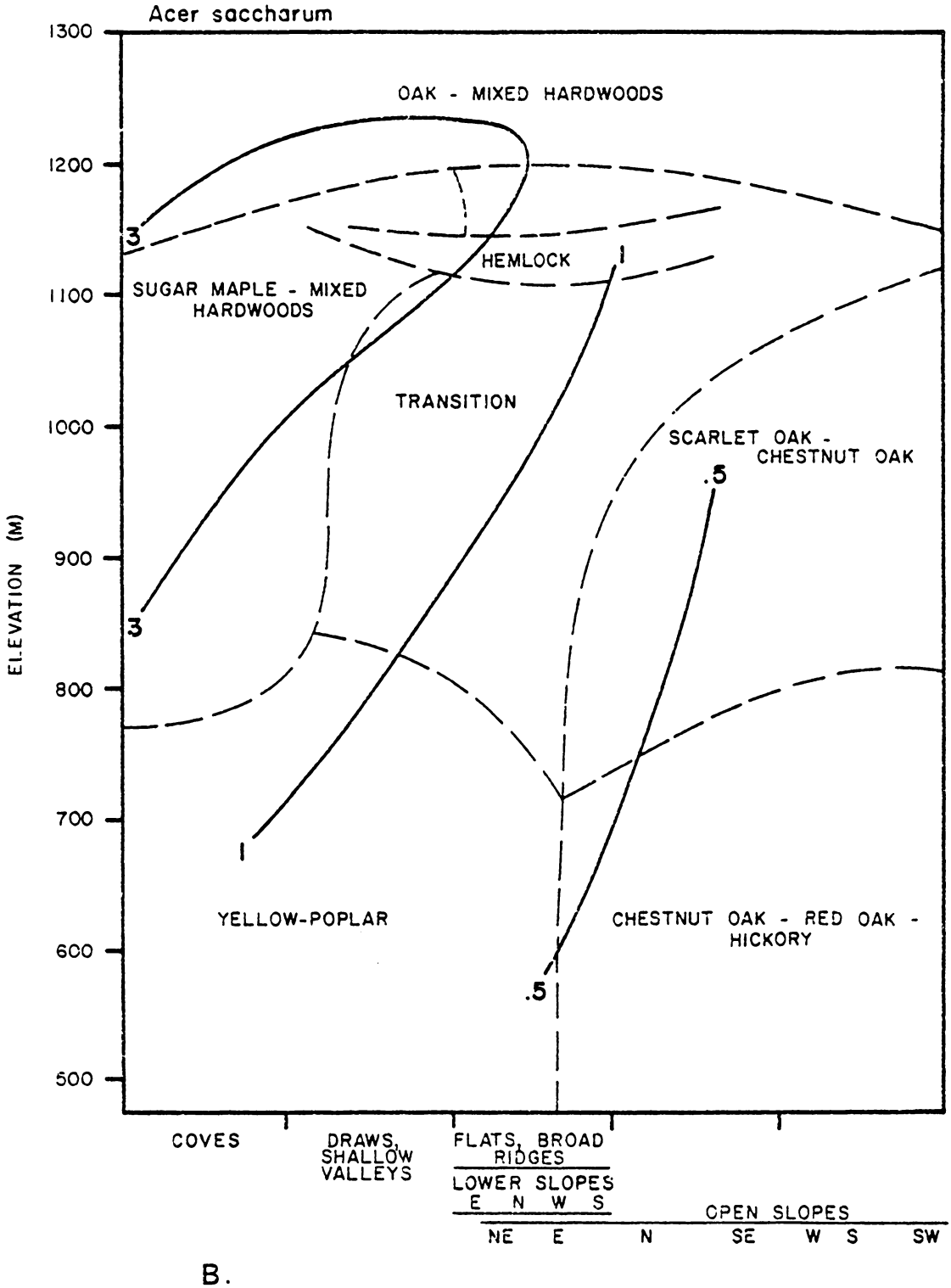
Species	Independent Variable[a]			
	aspect	elevation	percent slope	position
Acer rubrum			✓	
Acer saccharum				
Liriodendron tulipifera		✓		
Quercus coccinea				
Quercus prinus	✓			✓
Quercus rubra		✓		

[a] ✓ = 5 percent significance or better

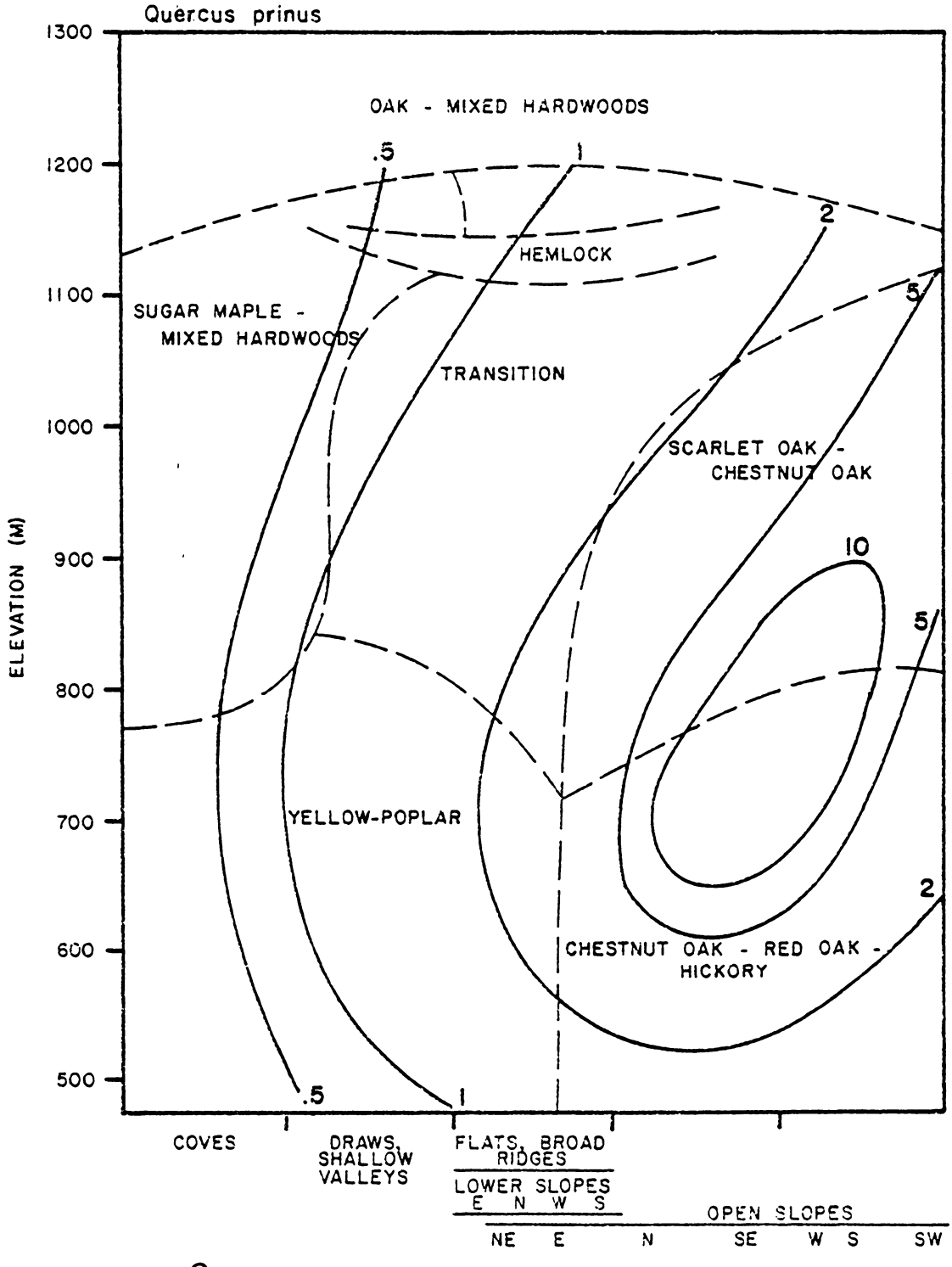
Figure 12. (A-E) Distribution of dominant species in the Brumley Gap, VA study area in relation to elevation and topography. Isclines of basal area (m^2/ha) are drawn to indicate the degree of abundance in a particular area. Average basal area was determined by sectioning the diagram into cells for each topographic unit and 200m of elevation, and dividing the basal area of each species over the total number of stands in each cell. The topographic gradient is arranged in order of decreasing moisture avail ability from left to right. Open slopes are upper positions, generally convex, which are not shaded by nearby landforms. A, *Acer rubrum*. B, *Acer saccharum*. C, *Quercus prinus*. D, *Liriodendron tulipifera*. E, *Quercus rubra*.


Acer rubrum
1300
1200
1100
1000
900
800
700
600
500
ELEVATION (M)
3
4
3.0
OAK - MIXED HARDWOODS
2
3.1
HEMLOCK
4
3
SUGAR MAPLE -
MIXED HARDWOODS
TRANSITION
.5
SCARLET OAK - CHESTNUT
OAK
1
CHESTNUT OAK - RED OAK -
HICKORY
2
YELLOW-POPLAR
1.5
.9
1
COVES
DRAWS,
SHALLOW
VALLEYS
FLATS, BROAD
RIDGES
LOWER SLOPES
E N W S
OPEN SLOPES
NE E N SE W S SW

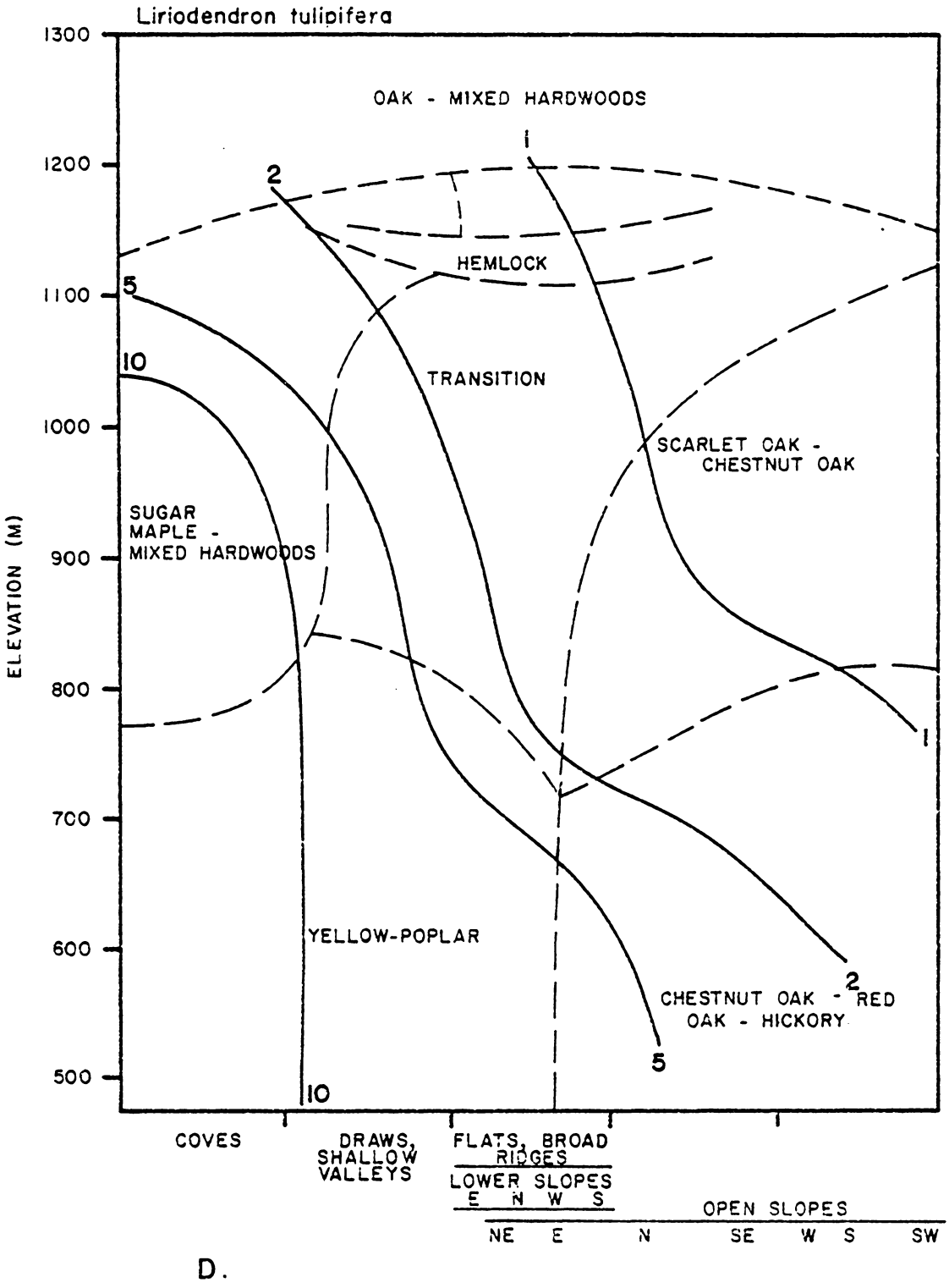
A.


Acer saccharum
1300
1200
1100
1000
900
800
700
600
500
ELEVATION (M)
OAK - MIXED HARDWOODS
HEMLOCK
SUGAR MAPLE - MIXED HARDWOODS
TRANSITION
SCARLET OAK - CHESTNUT OAK
YELLOW-POPLAR
CHESTNUT OAK - RED OAK - HICKORY
3
3
1
1
.5
.5
COVES
DRAWS, SHALLOW VALLEYS
FLATS, BROAD RIDGES
LOWER SLOPES
E N W S
OPEN SLOPES
NE E N SE W S SW

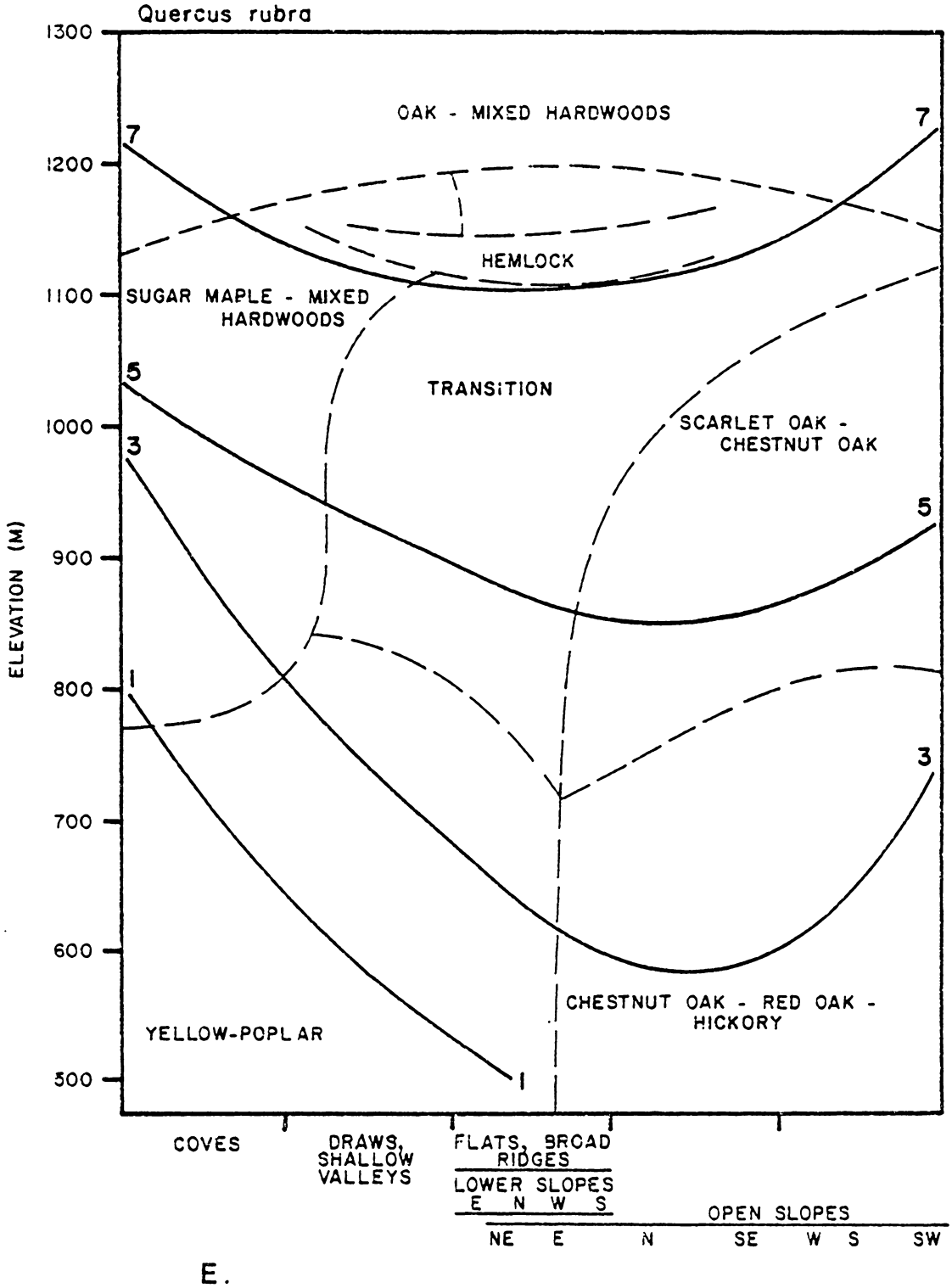
B.


Quercus prinus
1300
1200
1100
1000
900
800
700
600
500
ELEVATION (M)
OAK - MIXED HARDWOODS
.5
1
2
HEMLOCK
SUGAR MAPLE -
MIXED HARDWOODS
TRANSITION
5
SCARLET OAK -
CHESTNUT OAK
10
5
YELLOW-POPLAR
2
CHESTNUT OAK - RED OAK -
HICKORY
.5
1
COVES
DRAWS,
SHALLOW
VALLEYS
FLATS, BROAD
RIDGES
LOWER SLOPES
E N W S
OPEN SLOPES
NE E N SE W S SW

C.


Liriodendron tulipifera
1300
1200
1100
1000
900
800
700
600
500
ELEVATION (M)
OAK - MIXED HARDWOODS
HEMLOCK
TRANSITION
SCARLET OAK - CHESTNUT OAK
SUGAR MAPLE - MIXED HARDWOODS
YELLOW-POPLAR
CHESTNUT OAK - RED OAK - HICKORY
1
2
5
10
COVES
DRAWS, SHALLOW VALLEYS
FLATS, BROAD RIDGES
LOWER SLOPES
E N W S
OPEN SLOPES
NE E N SE W S SW

D.


Quercus rubra
1300
1200
1100
1000
900
800
700
600
500
ELEVATION (M)
OAK - MIXED HARDWOODS
HEMLOCK
SUGAR MAPLE - MIXED HARDWOODS
TRANSITION
SCARLET OAK - CHESTNUT OAK
CHESTNUT OAK - RED OAK - HICKORY
YELLOW-POPLAR
7
5
3
1
COVES
DRAWS, SHALLOW VALLEYS
FLATS, BROAD RIDGES
LOWER SLOPES
E N W S
OPEN SLOPES
NE E N SE W S SW

E.

Acer rubrum.

Acer rubrum was the most widely distributed woody species in the Brumley Gap study area, occurring in 110 out of 126 stands. The only place its occurrence was conspicuously restricted was in coves at middle elevations. The near ubiquity of this species has been noted by others (Whittaker 1956; Mowbray and Costing 1968; Thor et al. 1969; Day and Monk 1974). Best prediction equations for Acer rubrum were significant ($p<.05$) but explained less than 15 percent of the variation in relative basal area. Two similar equations are reported in Table 9 and Appendix E. The greatest abundance of Acer rubrum was associated with upper elevations (>1000m) on relatively gentle slopes and may have been due to high-grading, as many of the maples found here were large diameter cull trees or stump sprouts (Fig. 12-A). Both regression equations indicated a positive relationship of relative basal area with elevation, positive relationship with aspect, and a negative relationship with elevation x aspect. The inclusion of percent slope in equation 1b increased the R^2 only slightly (Table 9). There was some collinearity present among the variables, especially between aspect and elevation x aspect, causing instability in parameter estimates and thus making it difficult to assess with certainty, separate effects of each of the independent variables on the dependent variable. The

Table 9. Individually developed predictive multiple regression models for the relative basal area of the six most important tree species in the Brumley Gap study area.

Species	Independent variables in model	n	R^2
Acer rubrum	1a) +aspect, +elevation, -elevation x aspect	107	.11
	1b) +aspect, +elevation, -percent slope -elevation x aspect	107	.14
Acer saccharum	2a) -age	29	.13
Quercus coccinea	3a) -age, +aspect -slope position, -percent slope x aspect	33	.25
	3b) -age, +aspect, -slope position, -percent slope x aspect, -B thickness, +slope position x percent slope	32	.43
Quercus prinus	4a) -aspect, -elevation, -slope position	58	.19
	4b) -aspect, -A thickness, +B thickness -slope position	55	.19
Liriodendron tulipifera	5a) -age, +aspect, -elevation	38	.37
	5b) spline model (5a) with 3 elevation classes	38	.39
	5c) trees > 10.2cm DBH -age, +aspect, -elevation	34	.32
	5d) trees ≤ 10.2cm DBH -age	24	.18
Quercus rubra	6a) +aspect, +elevation, +percent slope -elevation x aspect, -elevation x percent slope	79	.23
	6b) +aspect, -B thickness, +elevation, -slope position	70	.22
	6c) spline model (6b) with three elevation classes	70	.24
	6d) trees > 10.2cm DBH +aspect, -B thickness, +elevation, -slope position	63	.22
	6e) trees ≤ 10.2cm DBH -age, -slope position	30	.13

magnitudes and even the sign of the coefficients were different if one of these variables were left out of the model. Percent slope did not appear to enter into the collinearity problem; its negative relationship with relative basal area of Acer rubrum in model 1b could be seen in the data set. Acer rubrum is often considered a subcanopy species more important in terms of numbers than in size. The magnitude of the maple isolines does not differ appreciably across Figure 12-A. Its increase in relative basal area in the area mentioned may actually be more a result of its seedling and sprouting success after disturbance than of any particular environmental affinity (Woods and Shanks 1959).

Acer saccharum.

The regression model for Acer saccharum, which contained a positive relationship of relative basal area with age (R^2=.13) as the only variable was possibly biased in terms of its deleting other important site variables (2a, Table 9). However, other included variables added little to the R^2. The reason for this is evident upon examination of stands containing Acer saccharum. In general, Acer saccharum appeared to dominate stands growing under relatively moist, cool conditions. It was rarely found on open slopes at any elevation. Figure 12-B indicates that

the species was most abundant in coves at mid elevations and extended to shallow valleys and flats at upper elevations, therefore negating simple relationships of Acer saccharum to percent slope and elevation in a regression model. In addition, exposure direction in cove sites varied considerably and substantial erosion of the A horizon was common. High elevation sites had favorable aspects (north-northwest through east-southeast) and fairly deep A horizons (>25 cm).

The relationship of the relative basal area of Acer saccharum with increasing age in the regression model, suggesting that it is a dominant in older stands, is consistent with earlier studies. The species is very tolerant and is considered a component of well established and relatively stable forest types (Braun 1950; Fowells 1965). Furthermore, 40 to 60 year old trees produce very light seed crops, while mature dominants produce more heavily. Buell et al. (1966) estimated that elimination of disturbances such as fire and cutting would lead to an increase in sugar maple in northern New Jersey.

Quercus coccinea.

Two regression models (3a and 3b) are reported for Quercus coccinea, explaining 26 and 45 percent of the variation in relative basal area respectively (Table 9 and

Appendix E). Both models indicated positive relationships of relative basal area with aspect and negative relationships with age, slope position, and percent slope x aspect. Additionally, one model containing the variables B horizon thickness and slope position x percent slope, showed an increasing relationship with basal area given the other variables already in the model.

Based on examination of the data, the highest stand representation of Quercus coccinea (20 to 65 percent of the basal area) seemed to be divided into two types of situations. The first was on ridges and upper slopes at mid elevations, in association with Quercus prinus and Oxydendrum arboreum. Slope gradients varied from 10 to greater than 60 percent. The A horizons were shallower and the B horizons were deeper than the average for all stands, which may explain the inclusion of the B horizon thickness in one of the regression models (3b, Table 9). The second situation of the high basal area representation for Quercus coccinea was on gentle to moderate slopes (8 to 32 percent) at high elevations in association with Acer rubrum, Magnolia acuminata, Quercus alba and occasionally Quercus rubra. Soils were deeper than the average and had loamy A horizons and clay to clay loam B horizons. However, the existence of Quercus coccinea as a dominant with the Oak-mixed hardwoods (community type IV) stands at high elevations was questioned

earlier in this paper, since Quercus coccinea is usually considered a xeric site species. (Whittaker 1956; Hack and Goodlett 1960). Because of the possible confusion of species, curves for the distribution of Quercus coccinea with elevation and topography were not plotted.

The variables which appear in the two regression equations for Quercus coccinea provided an example of the possible effects of collinearity on regression coefficient stability. As an example, both models possessed a positive slope coefficient for aspect, but the magnitude of the numbers varied greatly for the two regressions (Appendix D). Individual parameter estimates were nonetheless significant, indicating a further reduction in the variation in Y in spite of the fact that some of the information had already been accounted for by related variables. Model 3a, containing aspect (+), age (-), slope position (-), and percent slope x aspect (-), did not exhibit as severe collinearity as the other model, 3b, which contained the additional variables B horizon thickness (+) and slope position x percent slope (+), but neither did it account for as much of the variation in relative basal area (Table 9).

Data were surveyed in order to ascertain whether the indicated type of relationship between X and Y variables was plausible. There was no obvious trend with aspect, nor with percent slope x aspect; however, the slope position

relationship (-) was quite evident. The highest proportions of Quercus coccinea tended to be found on upper slope positions -- summit, shoulder, and backslope.

The inverse relationship of relative basal area with age may be due to the relative intolerance of Quercus coccinea (Fowells 1965). Its dominance with Pinus echinata, which was an associate in many of the mid-elevation stands on upper slopes, suggests the past occurrence of wildfire or other disturbance (Smith and Linnartz 1980).

Quercus prinus.

Two selected regression equations for Quercus prinus exhibited low multicollinearity and contained negative coefficients for aspect and slope position (Table 9), indicating that this species was abundant on upper slopes and on south-southeast through northwest exposures (Fig. 12-C). Inclusion of a third variable, elevation, in regression model 4a further reduced the variation in relative basal area by only three percent and was significant at the .13 level. Examination of the data further revealed some weakness of this negative relationship to relative basal area. Although the distribution of Quercus prinus was centered at low elevations, it also occurred abundantly in several upper elevation (>1100m) stands. Dominance at high elevations appeared to coincide

with slightly drier (south to west) aspects. At lower elevations, exposures were most often southeast and west-northwest (values 2 and 3) (Fig. 12-C). Slope positions were almost exclusively the shoulder and backslope (values 1 and 2). These site relationships indicate dry environments. However, Keever (1973) reported Quercus prinus as a dominant on the same types of sites (upper slopes and ridge tops) but maintained that in southeastern Pennsylvania the habitats were not xeric.

Regression model 4b indicated an inverse relationship of relative basal area in Quercus prinus to A horizon thickness and a direct relationship to B horizon thickness (Table 9). Slight collinearity was evident between the B horizon thickness and slope position variables. In addition, coefficients for slope position and aspect were less precise than in model 4a; however the direction of relationship (negative) remained the same. Field observations support the indicated soil relationships. Quercus prinus was a dominant species on soils with shallow A horizons which tended to possess deep B horizons.

Liriodendron tulipifera.

The greatest development of Liriodendron tulipifera as indicated by basal area, was in coves from low to mid elevations (Fig. 12-D). Its importance decreased on drier

substrates and at upper elevations. Because it is an intolerant species often present after disturbance, its occurrence extended to topographically drier sites in young stands at low elevations where full competition for the moisture resource had not been reached. Although absolute basal area of Liriodendron was similar at both high and low elevations, its relative proportion was greater at low elevations where total stand basal area was less.

Liriodendron tulipifera was by far the dominant species in most of the lower elevation stands less than 30-years-old in the study area which accounts for the negative relationship with age and elevation in the preferred regression model (Table 9). These young stands were also characterized by mostly high aspect values (5 and 6), which range from east-northeast through east-southeast, and considerable variation in soil depth.

The "best" regression model for Liriodendron tulipifera did not exhibit collinearity and indicated the trend towards reduction in relative basal area with increasing elevation and age, and drier exposures. These three variables accounted for 37 percent of the variation in relative basal area (Table 9 and Appendix E).

Quercus rubra.

The regression models for Quercus rubra indicate direct relationships of relative basal area with favorable aspects and increasing elevation (6a and 6b in Table 9, and Appendix E). Model 6a, which contained five variables, explained 23 percent of the variation in relative basal area. The variables included were selected on the basis of their high statistical significance, but percent slope, elevation, and elevation x percent slope were interrelated and separate effects of these variables were difficult to ascertain. As an example, the relationship of increasing relative basal area with steeper slopes was not substantiated by examination of the data. The trend appeared to be that greater amounts of Quercus rubra were found on gentle slopes at upper elevations (Fig. 12-E). Distribution curves appear similar to those for Acer rubrum but basal area values for the isolines are higher.

Regression model 6b (Table 9) for Quercus rubra was preferred to 6a due to its comparable R^2 value and lower collinearity. The included variables of elevation, aspect, slope position, and B horizon thickness indicated that Quercus rubra attained highest relative dominance on upper slopes (ridges and spur ridges) at high elevations and on relatively moist aspects. Exposures were variable but were most often north to east which places it in an intermediate

position along the topographic gradient (Fig. 12-E). Smaller amounts of red oak were associated with deeper B horizons.

Regressions With Qualitative Variables

The regressions for Liriodendron tulipifera and Quercus rubra which utilized a qualitative variable were in some cases helpful in accounting for an additional part of the variation in relative basal area with site (Table 10). In particular, inclusion of geologic substrate accounted for the greatest extra reduction for both Liriodendron and Quercus rubra. Others (Buell et al. 1966; Brush et al. 1980) have noted that elevation and geology are not independent since the highest elevations are underlain by the most resistant rocks. However, in the Brumley Gap study area, different lithologic units span some of the same elevations and seem to provide additional information not explained by elevation.

Liriodendron tulipifera was shown to occur in higher proportions on shale and limestone formations and on Quaternary deposits than on sandstone (Fig. 13), indicating a possible connection with greater water and nutrient

Table 10. Regression models for Liriodendron tulipifera and Quercus rubra with inclusion of qualitative variables.

Species	Independent variables	Qualitative variables, levels ( )	Largest and smallest significant adjusted mean	R^2
Liriodendron tulipifera	elevation, age, aspect			.37
		A texture (3)	sl, cl[a]	.40
		Landform (6)	nose slope, spur ridge	.46
		Geology (7)	Ds, Otm[b]	.49
Quercus rubra	elevation, aspect, slope position B thickness			.22
		Geology (7)	Otm, Sch[b]	.31

[a] sl = sandy loam; cl = clay loam

[b] Ds = Devonian shale; Otm = Trenton-Martinsburg group; Sch = Tuscarora Formation

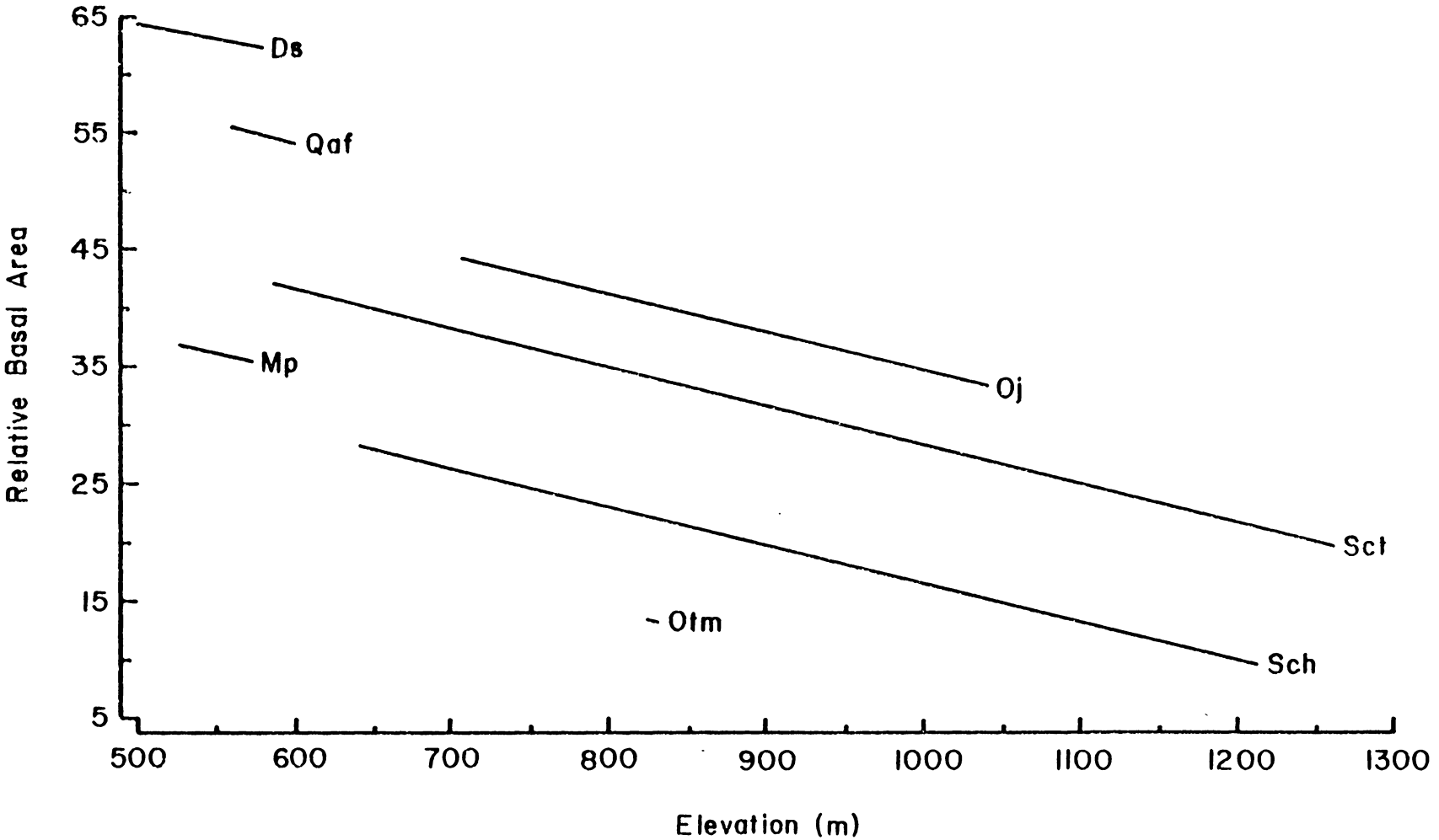


Figure 13. Effect of different geologic substrates on the regression model of relative basal area of Liriodendron tulipifera with elevation.

availability on these finer-textured, less resistant substrates. The one exception -- low relative basal area associated with the Trenton-Martinsburg Formation -- is misleading since there were several Liriodendron-dominated stands occurring on this substrate which were deleted from the regressions because of a low total basal area.

The relationship of Quercus rubra to lithology indicated significantly higher relative basal area on the Price and Trenton-Martinsburg Formations than on the Tuscarora Formation, but the significance tests are tenuous due to the model building process and lack of a preconceived hypothesis in regard to the different substrates. The species actually occurred most frequently on the Rose Hill formation, but in varying amounts.

Spline Regressions

The small additional reduction (about 2.5 percent) in variation of relative basal area of Quercus rubra and Liriodendron tulipifera in spline models 5b and 6c (Table 9) indicated that the spline regression did not represent a superior way of expressing the relationship of these two species with elevation. Species distribution across sufficiently wide gradients has been referred to as nonmonotonic (Whittaker and Gauch 1978), and although the spline models for Quercus rubra and Liriodendron tulipifera

allowed for possibly changing relationships of relative basal area with elevation, they did not account for simultaneous changes in other variables.

Separation of Data into Two Size classes

The regression models which separated the data sets for Liriodendron tulipifera and Quercus rubra into two size classes (<10.2cm and >10.2cm DBH) suggested that individuals in the understory were not responding to site conditions in the same fashion as individuals in the overstory. In addition, more variation was explained with the models for large size class (>10.2 cm DBH trees).

For Liriodendron tulipifera, the model for trees smaller than 10.2cm DBH (5d, Table 9) contained only the variable age and had an R^2 of .18. The model for the large size class (trees >10.2 cm DBH), accounted for 52 percent of the variation in relative basal area, compared to 37 percent explained by the combined data set although both equations contained the same variables. The regression equation for large stemmed individuals of Quercus rubra followed that of the combined data set (6c, Table 9). However, the model for small trees indicated entirely different relationships -- a high representation of small trees on footslopes of young stands (6d, Table 9).

Brush et al. (1980) indicated that spatial patterns of forest associations in Maryland were not evident when small trees were considered. They suggested that the presence of smaller trees was a reflection of seed dispersal and a favorable habitat for germination but not necessarily survival of the species. Cantlon's (1953) findings lend support to this idea. In his analysis of vegetation and microclimates of a north and south slope in the New Jersey piedmont, he found that more species were present on the opposing slopes as small trees than as larger trees.

The attractiveness of the regression analysis was that it allowed the study of the reaction of a species to a combination of many site factors simultaneously as opposed to just one at a time. A disadvantage was that because of collinearity and interaction, assessment of effects of single factors was often difficult. Other investigators utilizing regression analysis to reveal species-site relationships have suggested that certain site variables are biologically more important than others in affecting the distribution of species (Nowbray and Costing 1968; Bormann et al. 1970; Martin 1971; Wikum and Wali 1974). The weakness in this assessment is that even if all potentially important variables have been considered, the relationship of the predicted variable (Y) to other independent (X) variables may not have been accurately expressed. In

addition, the effects of single independent variables may be masked by their relationship to other factors (Draper and Smith 1966; Neter and Wasserman 1974). The present study revealed that site factors initially determined to be important based on their influence on moisture and temperature relations, such as elevation, were rendered unimportant in the regression analysis. It seems quite possible that one site factor can compensate for another in providing optimum conditions for establishment and maintenance of a species. For example, the cool, moist conditions preferred by Acer saccharum, seem to occur on both steep slopes of coves at moderate elevations and on gentle slopes at high elevations. However, the interaction terms in the regression analysis were not effective in accounting for the types of interaction among independent variables.

A better system of relating species distributions to environment might be the development of a class rating for each variable's effect on moisture. Mathen et al. (1977) designed such a system for use on a single substrate in the Ridge and Valley Province, which considered the effects of slope position, aspect, and slope steepness. In the present study, two variables, slope position and aspect, were coded in this manner, but were not added to produce a single ranking. The productivity index (as the combined ranking

for the three variables is referred to) was initially applied to the data set but was later rejected as it did not seem to account for elevational or landform differences. Another alternative to regression analysis would be the transformation of all quantitative variables, including relative basal area, into classes, (eg. high, medium, and low). Each variable then forms one dimension of a multi-way contingency table and the values in each cell represent the number of sites with a particular combination of variables (Fienberg 1980). Both of these suggested alternatives would necessitate sacrifice of some of the information contained in quantitative measurements. An additional alternative would be to utilize multivariate statistical procedures such as discriminant function analysis or principal component analysis to ascertain the contributions of individual site factors in n-dimensional space.

SUMMARY AND CONCLUSIONS

The low sampling intensity in the present study (.074 percent) was considered sufficient for obtaining a representative sample of the major forest vegetation types in the study area. Results indicate a similarity in species composition with original and present day forests of the Appalachian Oak region, with some differences in dominance by particular species.

The analysis of community type and individual species distributions with site factors indicated differences related to moisture and temperature, and in some cases, to stand history. However, effects of a specific site factor was often difficult to ascertain because all others could not be held constant. Other investigators have conducted studies of vegetation distribution with site, and have limited the scope of the study to a smaller area, for example: to opposing north and south slopes of similar gradient (Cantlon 1953; Mowbray and Oosting 1968; Racine 1971; Stephenson 1982) or to just one slope exposure (Adams 1974). They have thus been able to give more attention to other factors which were not held relatively constant. However, the projection of their results to other areas is also more limited.

The multiple regression analysis indicated some degree of relationship of species distributions with site variables (including aspect, elevation, percent slope, slope position, soil depth, and geologic substrate) but the relationships as expressed were not strong. Ideally, one should be able to predict abundance of species in areas that were not sampled. Although the models developed were not tested with a new set of data, the small amount of variation in relative basal area that was accounted for leads to a great difference in observed and predicted values of even the present data set so that projection to other data would not be reasonable. Alternative methods of analysis were suggested above, which would result in a sacrifice of quantitative information. In addition, further analysis could be directed towards understory-overstory relationships to gain a better understanding of the nature of the future forest.

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Appendix A. Dominant species in studies of Appalachian Oak forests.

Species	Importance Measure	Location	Elevation Range (m)	Source
Acer rubrum, Quercus rubra, Quercus prinus Liriodendron tulipifera, Acer saccharum, Quercus coccinea	Importance Value	Ridge and Valley Southwest Virginia	488-1280	Present Study
Quercus rubra, Quercus prinus, Carya glabra and Carya ovalis, Quercus alba	Relative Basal Area	Highlands North Carolina	853-1280	Keever 1953
Quercus prinus, Quercus rubra, Acerrubrum, Quercus alba, Nyssa sylvatica, Quercus coccinea	Importance Value	Ridge and Valley Southwest Virginia	640-1234	Adams 1974
Quercus prinus, Acer rubrum, Quercus coccinea, Quercus rubra, Liriodendron tulipifera, Carya glabra	Relative Basal Area	Coweeta Hydrologic Laboratory	726-993	Day and Monk 1974
Quercus prinus, Quercus rubra, Acer rubrum, Carya sp., Quercus velutina, Quercus alba	Importance Value	Ridge and Valley Southwest Virginia	775-1280	Stephenson 1976

Appendix B. Importance values for species used in the ordinations. Stand totals were relativized to equal 100 following removal of rare (< 5 percent occurrence) species.

Species	Stand															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Acer pensylvanicum		1.6		5.1	+	14.4									18.3	3.2
Acer rubrum	40.2	16.9	4.9	14.5	17.2	19.0	5.8	22.5	36.8	30.6	24.4	7.0	23.6			13.4
Acer saccharum		3.5	8.8	1.1			2.0				1.6			52.7		
Amelanchier arborea			7.3		3.7	2.2	2.7	10.6			2.2					10.4
Betula alleghaniensis		+													8.4	
Betula lenta			1.2	4.0	1.1	6.2			7.1						4.2	3.9
Carya glabra	2.3			1.2										6.5		
Carya tomentosa																
Castanea dentata										2.0	1.0					
Cornus florida			+					3.0	2.1					1.2		
Fagus grandifolia																
Fraxinus americana							22.4									
Fraxinus pennsylvanica				3.6												
Hamamelis virginiana		7.8	36.1					5.1							5.7	9.8
Ilex montana		1.4	10.1	3.9		5.8	1.4	3.6			2.9		1.9		16.4	+
Liriodendron tulipifera		16.8									4.6	11.5		12.8		
Magnolia acuminata		+		1.6	1.5					1.0		8.2	9.4	2.8		7.2
Magnolia fraseri		4.4	6.9									6.3	1.9		13.6	
Nyssa sylvatica				2.4	5.2			20.5					7.6			
Oxydendrum arboreum									2.7	1.0			14.9			
Pinus virginiana																
Prunus pensylvanica			+				4.4				1.4	46.0				14.1
Prunus serotina		+		1.4	1.0	15.1		1.2				5.6	1.0			
Quercus alba			9.2	13.9	11.1	8.8		14.1			7.3		2.4		15.0	5.0
Quercus coccinea		2.8									54.6					26.6
Quercus prinus					1.3				48.8	31.4			18.3			
Quercus rubra	57.5	42.5	9.0	39.4	57.3	28.6	61.4	19.3	2.4	19.7		5.2	19.0	3.5	18.4	15.5
Quercus velutina										14.3						
Robinia pseudoacacia			+	7.6								5.2		15.4		
Sassafras albidum			4.8									4.9				
Tilia heterophylla														5.1		
Tsuga canadensis																

+ present, < 1%.

Appendix B. Importance values for species used in the ordinations. Stand totals were relativized to equal 100 following removal of rare (< 5 percent occurrence) species (Continued).

Species	Stand															
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Acer pensylvanicum	1.0			2.2		1.0										
Acer rubrum	15.6	2.5	10.5	4.9	23.1	24.2	2.6	4.3	3.6	2.5	21.2		17.1	13.4		29.2
Acer saccharum		39.2		3.0		12.0	8.8	50.3	40.3			18.1		18.2	10.3	
Amelanchier arborea	10.2	2.3	2.1	3.2	1.2						10.6			12.5		2.0
Betula alleghaniensis	3.7		4.5	2.5												22.8
Betula lenta		21.8	2.5						3.3		9.0				8.4	
Carya glabra							7.5					15.4	+			
Carya tomentosa									14.0				+			
Castanea dentata						+										
Cornus florida		10.1			11.8					11.0		2.1			3.6	
Fagus grandifolia			7.4	36.2											1.7	
Fraxinus americana			3.4				1.6	10.7				4.9				8.4
Fraxinus pennsylvanica							4.1					8.1			5.3	
Hamamelis virginiana	4.5			4.9	7.6				1.4		19.5					1.9
Ilex montana	17.7										12.5					3.9
Liriodendron tulipifera		10.7	17.2	10.3			53.5		9.1	42.2				10.6	27.4	
Magnolia acuminata	3.4		6.7	7.0		12.0		1.7	22.3		6.3	1.0		11.6		12.8
Magnolia fraseri	2.2		5.6	1.7												4.4
Nyssa sylvatica					1.9					1.8			7.2			
Oxydendrum arboreum				5.1		+				4.5	5.6		21.6			
Pinus virginiana										29.6					32.7	
Prunus pensylvanica	5.2						7.7					1.0				3.8
Prunus serotina	3.4			15.9		3.6	8.4	13.5								
Quercus alba										1.3	6.6	16.6				
Quercus coccinea	33.1			3.0		27.8		9.4	6.0				7.3			10.8
Quercus prinus					25.8								43.4	5.0		
Quercus rubra		9.7	7.9		27.6	17.5		10.1			2.0	16.3	1.8	28.7	3.4	
Quercus velutina							1.1									
Robinia pseudoacacia							2.6			4.0	6.6	8.1			3.7	
Sassafras albidum		3.6			+					3.0						
Tilia heterophylla							2.0					8.4			3.4	
Tsuga canadensis			32.2													

+ present, < 1%.

Appendix B. Importance values for species used in the ordinations. Stand totals were relativized to equal 100 following removal of rare (< 5 percent occurrence) species (Continued).

Species	Stand															
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Acer pensylvanicum								2.9		5.2	+					
Acer rubrum	6.6	3.2		15.2		32.1	37.1	8.1	29.3	4.9	8.2			36.4	4.4	6.5
Acer saccharum		69.4	2.4		16.8			35.9				24.0	31.6			
Amelanchier arborea				17.6		16.2	+			1.6	3.4			9.2		
Betula alleghaniensis																
Betula lenta		6.6						1.9	6.0	27.8	41.1	8.9		2.6		
Carya glabra								1.6					17.3		+	
Carya tomentosa															21.8	3.7
Castanea dentata	2.1					+										
Cornus florida	3.2		5.9		3.0			2.2					1.5		20.2	4.6
Fagus grandifolia										17.6					1.4	+
Fraxinus americana		3.2														
Fraxinus pennsylvanica			6.3		2.2								14.6			
Hamamelis virginiana					1.5				22.3	3.5		3.0	1.5	5.0		
Ilex montana			9.4	1.1		+			11.3					3.7		
Liriodendron tulipifera			67.0		29.9			8.6		17.5			4.8		1.0	43.3
Magnolia acuminata																
Magnolia fraseri	30.4			1.9			+	2.7	3.4		11.6					
Nyssa sylvatica				4.2			2.5				6.6				1.0	+
Oxydendrum arboreum	7.7			8.5			2.9				18.4			+	14.3	
Pinus virginiana																
Prunus pensylvanica									1.4							
Prunus serotina		3.8					12.8					16.5				
Quercus alba			5.8			20.5	7.9		5.7					14.0	12.3	
Quercus coccinea				4.6		26.2	21.0		17.1							
Quercus prinus	18.6			32.8			26.0	2.7			8.5		13.2		+	
Quercus rubra	27.3	13.8		6.1	10.1	3.3	1.8	11.2		1.9		17.7	3.7	27.6	20.6	
Quercus velutina				4.6										+		5.3
Robinia pseudoacacia	4.1		3.3	1.0	35.6			9.3			1.5		6.1		+	18.9
Sassafras albidum				2.3	+								4.4		1.1	16.1
Tilia heterophylla									1.4			29.8	1.4			
Tsuga canadensis										20.0						

+ present, < 1%.

Appendix B. Importance values for species used in the ordinations. Stand totals were relativized to equal 100 following removal of rare (< 5 percent occurrence) species (Continued).

Species	Stand															
	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
Acer pensylvanicum							4.9	3.9						2.6	5.1	8.5
Acer rubrum	32.2	20.1		1.0	8.8	2.1	11.2	+	1.5	12.1		8.4		7.4	15.9	9.2
Acer saccharum		2.8	50.8			34.1		51.9	15.0			13.4	1.6			60.0
Amelanchier arborea		2.1					5.1	2.6			29.2				1.5	
Betula alleghaniensis							10.6									
Betula lenta							17.5			15.8			7.0	2.5		
Carya glabra						19.1				2.8						
Carya tomentosa				11.5	2.3							2.6				
Castanea dentata																
Cornus florida		1.4		17.9	8.8				4.6	7.0						
Fagus grandifolia					3.8					3.8						
Fraxinus americana						2.0			3.4				3.1			2.5
Fraxinus pennsylvanica			34.0			1.0						20.0				
Hamamelis virginiana							4.5							6.7	34.9	2.7
Ilex montana															9.0	
Liriodendron tulipifera	52.6				36.6					27.6			84.9	51.5		
Magnolia acuminata		9.3	6.0				26.0							17.4	14.3	
Magnolia fraseri		4.3					1.6					3.8		5.7		
Nyssa sylvatica		10.6		36.0	6.3		7.3	1.5								
Oxydendrum arboreum	1.2	2.1		17.2						+	18.0			4.2		
Pinus virginiana											52.8					
Prunus pensylvanica						1.0									5.1	
Prunus serotina	2.8				4.2	1.7						13.3				
Quercus alba		3.5			26.1											
Quercus coccinea										12.0						
Quercus prinus		17.5		7.6	3.0				34.2	6.0						
Quercus rubra		26.3					11.3	31.8	15.0	7.3		35.4		2.0	4.7	4.4
Quercus velutina									13.7							
Robinia pseudoacacia	11.2		3.8			39.0		6.1	12.6			3.1	3.4		4.5	
Sassafras albidum				8.8				1.3								
Tilia heterophylla			5.3													11.3
Tsuga canadensis										4.7					4.9	1.4

+ present, < 1%.

Appendix B. Importance values for species used in the ordinations. Stand totals were relativized to equal 100 following removal of rare (< 5 percent occurrence) species (Continued).

Species	Stand															
	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Acer pensylvanicum		12.9	+									3.2				
Acer rubrum		37.7	10.5	27.0	19.0	16.7	44.5	25.0	33.6	23.9	1.0	8.3	34.2	27.4		44.0
Acer saccharum	39.6															
Amelanchier arborea		1.1				15.3			+	1.5		7.4	2.5			
Betula alleghaniensis		1.5	2.2					3.9							23.8	
Betula lenta		14.1	15.8	10.0	7.7	1.0		7.2		26.9		11.4	1.7		19.2	1.0
Carya glabra					1.1				+		1.9		2.8	1.3		
Carya tomentosa	1.9										14.2					
Castanea dentata						2.0			+					+		
Cornus florida					8.4				1.6		27.7			+		
Fagus grandifolia		1.1														
Fraxinus americana					2.1											
Fraxinus pennsylvanica	7.9															
Hamamelis virginiana		2.6						3.3	6.1			11.5			4.1	
Ilex montana						1.0				7.7		9.0				
Liriodendron tulipifera				7.8	39.4	1.0	2.6	1.8	+		3.8		14.7		7.7	
Magnolia acuminata		4.3	2.3			6.1					10.7	8.9	2.7			
Magnolia fraseri		3.7	2.1	4.0		5.2		9.8				7.6		+	42.7	1.3
Nyssa sylvatica		1.3						15.1	8.7	8.2	2.0					1.5
Oxydendrum arboreum			2.6	4.2			15.2	12.3	17.8	5.1	3.3	3.2	17.8	17.0		28.8
Pinus virginiana																
Prunus pensylvanica		3.7														
Prunus serotina		1.5	4.7									2.9				
Quercus alba						3.2					3.4			31.0		
Quercus coccinea							17.0		8.0					20.5		13.4
Quercus primus	7.8			6.2			8.3	10.5	1.3	23.8	2.8		2.1			1.5
Quercus rubra	25.7	11.8			+	48.5	12.4		10.6		27.3	26.6	13.1			
Quercus velutina			3.8													
Robinia pseudoacacia	8.1				19.3			7.7	6.0	1.7			8.4			8.5
Sassafras albidum					1.1				1.3	1.2	1.9					
Tilia heterophylla	9.0				1.1											
Tsuga canadensis		2.6	55.1	40.8				3.4	1.6						2.5	

+ present, < 1%.

Appendix B. Importance values for species used in the ordinations. Stand totals werere lativized to equal 100 following removal of rare (< 5 percent occurrence) species (Continued).

Species	Stand															
	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
Acer pensylvanicum	1.2	+	2.2	+	12.5											
Acer rubrum	20.1	12.3	1.7	9.7	15.0		10.5	13.6	25.2	37.4	26.6	35.4	6.5	19.9	14.1	14.2
Acer saccharum																
Amelanchier arborea	2.6		3.5	7.8				2.0		1.0				2.1	+	1.9
Betula alleghaniensis			2.0									6.2				
Betula lenta	10.3			3.4	2.0	4.8					16.0	27.0		1.2		
Carya glabra		17.0											1.1	1.1	+	
Carya tomentosa						7.6				4.4	1.4		2.6		1.2	
Castanea dentata					1.7			1.0								
Cornus florida		7.9				28.8		2.3					12.3	3.5	6.3	1.0
Fagus grandifolia																
Fraxinus americana																
Fraxinus pennsylvanica																
Hamamelis virginiana			14.1					1.0			6.3			3.3		
Ilex montana	2.0		1.5	16.8								2.0				
Liriodendron tulipifera			33.2		7.1	30.9	47.8				5.3					1.1
Magnolia acuminata		2.0	5.3	27.9	2.6			9.3	1.1			1.5				
Magnolia fraseri	40.6		9.0	20.5	13.9		24.8	9.0				+				
Nyssa sylvatica		4.3						7.0	1.4	+		9.2	7.6	7.4	1.7	
Oxydendrum arboreum	5.8	22.3	6.1		6.7	12.8		5.1	14.1	4.9		15.4		11.2	19.1	24.0
Pinus virginiana															7.4	
Prunus pensylvanica	2.5															
Prunus serotina																
Quercus alba		19.4							7.1	28.9			4.6			8.4
Quercus coccinea	3.3	6.3			26.8			20.5	41.0				2.4		8.3	17.9
Quercus prinus	7.1		6.5		7.5			20.0	10.0		9.8		30.6	17.7	19.6	22.0
Quercus rubra			14.9	11.3	2.9					22.6	34.5		22.0	21.6	16.0	9.5
Quercus velutina		7.6					4.2								2.0	
Robinia pseudoacacia	4.5			1.7			8.4	9.2				2.7	10.3	11.0	2.6	
Sassafras albidum							4.3									
Tilia heterophylla																
Tsuga canadensis					1.3	15.2										

+ present, < 1%.

Appendix B. Importance values for species used in the ordinations. Stand totals were relativized to equal 100 following removal of rare (< 5 percent occurrence) species (Continued).

Species	Stand															
	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
Acer pensylvanicum							6.9								12.1	9.6
Acer rubrum	2.1	13.4	8.4	7.0	4.0	2.1	9.4		8.3	10.9	3.5	11.0	31.8	31.4	18.1	3.6
Acer saccharum					5.6		7.6				23.3				+	
Amelanchier arborea		+				9.5				2.0		4.0			9.0	
Betula alleghaniensis																
Betula lenta				33.0					7.8							11.7
Carya glabra	1.5			1.3			33.9	43.3			14.5		8.8		+	
Carya tomentosa																
Castanea dentata																
Cornus florida	17.7	1.8		11.4			2.5				1.5		15.7	1.9	9.3	
Fagus grandifolia										4.7						
Fraxinus americana					2.1			50.9	5.7		12.9		8.6			
Fraxinus pennsylvanica							1.3									
Hamamelis virginiana						10.6										9.6
Ilex montana																
Liriodendron tulipifera	7.4			28.5	2.5	1.4			46.2					57.4		42.5
Magnolia acuminata			2.1			6.1			4.6	2.0						
Magnolia fraseri			8.0			6.4						11.8				
Nyssa sylvatica		10.6	1.9							7.4		1.2			+	
Oxydendrum arboreum	12.9	8.0	35.4			20.2				10.2		21.8			13.1	
Pinus virginiana				2.4												
Prunus pensylvanica																
Prunus serotina							2.4									
Quercus alba			5.8	7.3												
Quercus coccinea	4.6	34.3	27.7				9.7			6.9	15.4	32.6	27.4			
Quercus prinus	34.8	28.1	10.7			25.4	11.9			28.2		9.3			34.1	
Quercus rubra	6.3	3.0		1.3		4.1						2.9		6.1	1.9	
Quercus velutina	12.6			+						27.8			4.5			
Robinia pseudoacacia				4.2	85.8	10.5	6.0	5.8	25.0		12.4					
Sassafras albidum				+		3.7	1.6		1.2			5.4		3.2		
Tilia heterophylla							6.8		1.2		16.5		3.1			22.9
Tsuga canadensis				2.0												

+ present, < 1%.

Appendix B. Importance values for species used in the ordinations. Stand totals were relativized to equal 100 following removal of rare (< 5 percent occurrence) species (Continued).

Species	Stand													
	113	114	115	116	117	118	119	120	121	122	123	124	125	126
Acer pensylvanicum					5.5						14.7			1.0
Acer rubrum	1.7	8.5	6.6		35.4	17.1	3.5	15.5	3.2	15.8	10.9	2.2	13.0	3.3
Acer saccharum	16.7										4.1		3.9	
Amelanchier arborea				+				6.9						11.0
Betula alleghaniensis														
Betula lenta						1.9								1.0
Carya glabra	14.5		14.4		4.8	4.4								
Carya tomentosa				3.3						3.6				7.8
Castanea dentata														
Cornus florida	3.7		29.5	12.2	12.3	1.0	6.7	+			4.3			5.4
Fagus grandifolia	1.7													
Fraxinus americana	1.9													
Fraxinus pennsylvanica														
Hamamelis virginiana								+	3.7					1.9
Ilex montana														
Liriodendron tulipifera					1.7	8.9						27.8	66.6	
Magnolia acuminata	3.0									11.7				
Magnolia fraseri	24.6													
Nyssa sylvatica		12.6	+		1.5		13.5		4.4			11.6	+	1.0
Oxydendrum arboreum	2.1	18.3	7.6	13.2	1.7	17.2	29.7	11.0	15.8	22.2	21.3	1.7		4.2
Pinus virginiana				5.6					34.0			33.6		
Prunus pensylvanica												6.0		
Prunus serotina					1.7									
Quercus alba							1.1			1.8				
Quercus coccinea		43.2		10.4			36.1		13.8	21.8				
Quercus primus	1.7	15.1	30.0	42.9	3.2	33.8	7.4	21.7	23.4	5.7	31.9			42.2
Quercus rubra	20.8		3.4	5.0		6.3	1.3	43.1		16.1	5.1	3.6	1.7	21.2
Quercus velutina			7.7	2.6	27.0						7.7			
Robinia pseudoacacia					3.6	7.1						10.2		
Sassafras albidum		2.3		3.9	1.7	2.3	+		1.6	1.3		3.9	13.9	
Tilia heterophylla														
Tsuga canadensis	7.7													

+ present, < 1%.

Appendix C. Site characteristics of sampled stands in the Brumley Gap study area.

STAND #	ELEV. (m)	% SLOPE	ASPECT VALUE[1]	SLOPE POSITION	SLOPE SHAPE[2]	LAND-FORM	AGE	GEOL-OGY[3]	HORIZON THICKNESS (CM) A	HORIZON THICKNESS (CM) B	HORIZON TEXTURE A	HORIZON TEXTURE B
						Type I. Sugar maple-mixed hardwoods						
14	1006	40	5	shoulder	3	spurridge	40	Oj				
18[4]	783	23	1	footslope	3	cove	46	Oj				
23	963	37	5	footslope	1	cove	46	Oj	9	42	sicl	sic
24	1201	16	6	shoulder	3	ridge	77	Sct	30	0	sl	
25[4]	1146	29	6	backslope	3	cove	50	Sct	46	18	sil	cl
28	853	34	3	footslope	4	cove		Otm	23	43	sicl	c
30	1186	4	4	summit	1	ridge	43	Sct	33	18	l	cl
34	1213	9	4	shoulder	3	spurridge	74	Sct	25	25	sic	hc[5]
40	933	65	2	shoulder	1	headslope	42	Sch	4	28	scl	sc
44	1122	34	3	backslope	3	cove	43	Sct	30	38	l	cl
45	1001	75	1	shoulder	3	sideslope	43	Oj	15	15	sicl	sicl
51	975	44	4	toeslope	2	cove	52	Sch				
54	1027	73	1	shoulder	1	spurridge	23	Oj	15	10	l	sic
56	951	55	3	summit	1	spurridge		Otm				
60	1109	20	6	backslope	2	draw		Sch				
62[4]	1036	40	6	backslope	1	cove	42	Sct	22	37	l	cl
64[4]	817	36	1	toeslope	4	cove	70	Oj	5	0	sil	
65	945	47	1	summit	1	spurridge	89	Otm	5	15	sil	cl
83[4]	1042	31	1	backslope	1	cove	46	Oj	13	23	scl	sc
107[4]	853	67	1	shoulder	2	cove	49	Otm	13	28	sil	sicl
112	707	22	6	footslope	1	cove	79	Oj	11	26	sl	sc
113	579	95	4	footslope	1	sideslope	42	Mp	11	14	sic	sic
Mean	975	41					52		1	24		

Appendix C. Site characteristics of sampled stands in the Brumley Gap study area (cont.).

STAND #	ELEV. (m)	% SLOPE	ASPECT VALUE	SLOPE POSITION	SLOPE SHAPE	LAND-FORM	AGE	GEOL-OGY	HORIZON THICKNESS (CM) A	HORIZON THICKNESS (CM) B	HORIZON TEXTURE A	HORIZON TEXTURE B
						Type II. Yellow-poplar						
26	646	35	1	shoulder	1	spurridge	25	Dh				
31	747	35	6	footslope	3	cove	20	Oj	23	69	sicl	sc
35[4]	817	38	1	footslope	1	cove	8	Otm	4	27	sic	sic
37	893	60	1	shoulder	1	spurridge	14	Otm	10	56	hsicl[5]	hcm[5]
48	585	8	5	toeslope	1	valley	22	Sct	13	58	l	c
49	826	25	5	backslope	4	cove	18	Otm	14	29	sl	sc
53[4]	558	10	5	floodplain	2	floodplain	35	Qaf				
58	570	68	3	backslope	1	sideslope	51	Ds	6	17	sicl	sic
61	671	12	5	footslope	3	cove	29	Sct	24	39	sl	scl
69	600	14	1	toeslope	3	sideslope	28	Qaf	15	20	l	cl
86	488	16	2	footslope	1	sideslope		Mp	5	fsl	sl	
87[4]	500	2	5	floodplain	4	floodplain	38	Ds	25	25	sl	sl
100	576	70	4	backslope	1	sideslope		Ds	6	26	fsl	sl
101	829	17	5	footslope	4	cove	21	Otm	23	8	sil	sicl
105	792	48	6	footslope	4	noseslope	28	Otm	18	28	l	cl
110	646	20	5	backslope	1	noseslope	42	Sct	10	41	l	cl
124	695	25	2	shoulder	3	sideslope	16	Sct	8	38	fsc	sc
125[4]	579	50	2	backslope	1	cove	28	Ds	18	5	sicl	sicl
Mean	667	31					24		14	32		

Appendix C. Site characteristics of sampled stands in the Brumley Gap study area (cont.).

STAND #	ELEV. (m)	% SLOPE	ASPECT VALUE	SLOPE POSITION		SLOPE SHAPE		LAND-FORM	AGE	GEOL-OGY	HORIZON THICKNESS (CM) A		HORIZON TEXTURE A		
												B		B	
								Type III. Hemlock							
19	1164	24	3	shoulder	1	sideslope	46	Sct	18	89	l	sc			
42	1116	37	3	footslope	3	sideslope	46	Sct	18	38	l	c			
67	1134	29	3	backslope	3	spurridge	38	Sct	18	15	sl	scl			
68	1164	40	6	shoulder	4	cove	63	Sct	11	47	sicl	scl			
Mean	1144	32							16	47					
								Type IV. Oak-mixed hardwoods							
1	1170	16	6	backslope	1	cove	45	Sct	22	37	sil	cl			
2	1128	25	4	backslope	1	noseslope		Sct	19	37	sil	c			
3	1120	9	1	footslope	2	sideslope	38	Sct	20	38	l	cl			
4	1173	64	1	backslope	3	sideslope	38	Sct	13	33	sl	scl			
5	1195	27	2	shoulder	1	sideslope	40	Sct	23	20	l	cl			
6	1216	20	6	footslope	2	cove		Sct	20	28	sl	sl			
7	1268	7	6	shoulder	1	ridge	20	Sct	16	34	l	sc			
8	1231	3	5	footslope	2	ridge		Sct	14	39	l	scl			
11	1207	16	3	shoulder	1	saddle	42	Sct	33	25	Cl	sc			
15	1219	19	5	summit	1	ridge	71	Sct	14	32	l	cl			
17	1192	23	6	footslope	4	sideslope	44	Sct	25	56	sil	c			
22	1146	8	4	summit	1	ridge		Sch	10	13	l	sl			
27*	1204	22	2	footslope	4	cove	36	Sct	20	25	l	sl			
32	1204	23	1	backslope	1	sideslope	43	Sct	13	18	sil	cl			

Appendix C. Site characteristics of sampled stands in the Brumley Gap study area (cont.).

STAND #	ELEV. (m)	% SLOPE	ASPECT VALUE	SLOPE POSITION	SLOPE SHAPE	LAND-FORM	AGE	GEOL-OGY	HORIZON THICKNESS (CM) A	HORIZON THICKNESS (CM) B	HORIZON TEXTURE A	HORIZON TEXTURE B
						Type IV. Oak-mixed hardwoods (cont.)						
33	1128	28	5	backslope	3	spurridge	47	Sct	18	38	sil	cl
38	1263	15	1	summit	1	ridge		Sct	18	18	l	cl
41	1207	15	1	shoulder	1	sideslope	45	Sct	15	41	l	cl
46	1268	15	1	shoulder	1	sideslope		Sct				
55	1244	22	1	toeslope	4	cove		Sct	28	0	sl	scl
63	1253	14	3	toeslope	3	cove		Sct	36	48	sl	scl
66	1272	5	5	shoulder	3	ridge		Sct	23	38	l	sc
70	1262	11	6	backslope	1	ridge		Sct	20	15	fsl	scl
76	1207	20	4	backslope	2	sideslope	77	Sct	13	79	sl	sc
81	1146	23	4	summit	1	headslope	46	Sct				
84	1164	13	3	shoulder	3	sideslope	47	Sct				
90	1067	11	1	summit	1	ridge	90	Sct	10	23	sl	sc
91	1036	24	3	backslope	2	draw	47	Sct	19	37	scl	sc
Mean	1192	18					48		19	32		
						Type V. Chestnut oak-red oak-hickory						
21	838	70	1	shoulder	1	sideslope	70	Sch				
36	701	75	3	shoulder	1	sideslope	43	Mp	4	27	sl	cl
47	527	65	3	shoulder	1	spurridge	81	Mp	10	36	sl	sl
75	573	60	1	shoulder	1	draw	84	Mp	10	11	sl	scl
82	646	68	2	backslope	1	sideslope	73	Dh	5	18	sl	sl

Appendix C. Site characteristics of sampled stands in the Brumley Gap study area. (cont.).

STAND #	ELEV. (m)	% SLOPE	ASPECT VALUE	SLOPE POSITION	SLOPE SHAPE	LAND-FORM	AGE	GECL-OGY	HORIZON THICKNESS (CM) A	HORIZON THICKNESS (CM) B	HORIZON TEXTURE A	HORIZON TEXTURE B
						Type V. Chestnut oak-red oak-hickory (cont.)						
93	549	68	5	shoulder	1	cove	39	Mp	10	36	sil	scl
94	948	70	2	backslope	1	sideslope	116	Oj	2	5	Cl	cl
95	579	75	5	shoulder	1	sideslope	36	Mp	6	8	scl	sc
96	643	35	2	shoulder	3	sideslope	48	Sct	20	25	sicl	sic
97	756	28	3	shoulder	1	sideslope	71	Sct	13	66	scl	sc
111	722	70	4	shoulder	1	sideslope	74	Mp	8	25	scl	sc
115	744	45	2	summit	1	sideslope		Mp	9	37	sl	sl
116	671	47	3	shoulder	1	spurridge	39	Mp	5	36	sc	hc[s]
118	762	63	1	shoulder	3	sideslope	42	Oj	9	39	l	cl
120	655	85	3	shoulder	1	sideslope		Mp	10	33	l	hsic
123	631	60	3	shoulder	1	sideslope	61	Ds	9	24	fsl	scl
126	628	70	3	shoulder	1	sideslope	42	Mp				
Mean	681	62					61		9	28		
						Type VI. Scarlet oak-chestnut oak						
29	853	45	3	shoulder	1	spurridge	46	Sch	25	69	fsl	sc
39	1140	40	1	shoulder	1	spurridge	40	Sct	10	18	scl	cl
52	731	28	5	backslope	1	spurridge		Mp	25	33	fscl	c
85	1018	26	3	summit	1	ridge	51	Sct	18	36	cl	c
88	984	59	1	backslope	3	sideslope	43	Cj	8	23	l	cl
89	1067	21	5	backslope	3	spurridge	41	Sch	15	50	l	sc

Appendix C. Site characteristics of sampled stands in the Brumley Gap study area (cont.).

STAND #	ELEV. (m)	% SLOPE	ASPECT VALUE	SLOPE POSITION	SLOPE SHAPE	LAND-FORM	AGE	GEOL-OGY	HORIZON THICKNESS (CM) A	HORIZON THICKNESS (CM) B	HORIZON TEXTURE A	HORIZON TEXTURE B
Type VI. Scarlet oak-chestnut oak (cont.)												
98	817	20	2	shoulder	3	spurridge	48	Sct	16	80	scl	sc
99	1091	14	1	backslope	1	sideslope		Sch	20	25	scl	sc
108	881	44	5	backslope	1	spurridge		Sch	15	20	scl	scl
114	841	58	1	backslope	1	spurridge	47	Sct	16	55	sl	sc
119	689	24	1	summit	1	spurridge		Sct	8	28	sl	sl
121	716	65	2	backslope	4	sideslope	44	Sct	8	30	fsl	sl
Mean	902	37					44		15	39		
Transition Stands												
9	1143	12	1	backslope	1	spurridge	70	Sct	4	29	cl	sic
10	1134	18	1	backslope	1	sideslope	44	Sct	25	0	fsl	scl
13	1128	15	1	backslope	2	draw		Sct	11	47	l	cl
16	1204	32	3	shoulder	1	sideslope	48	Sct	13	41	l	fscl
43	1097	50	5	backslope	1	noseslope	42	Sct	13	56	sl	scl
50	1122	18	2	shoulder	1	saddle	74	Sct	9	32	cl	sc
71	1012	10	5	summit	1	ridge	51	Sct	14	47	l	c
72	829	46	2	backslope	1	sideslope		Cj	33	0	s	
73	878	48	2	backslope	1	sideslope	47	Sch	3	18	cl	c
74	1000	18	2	footslope	2	noseslope	44	Sct	13	25	l	c
77	1213	17	5	shoulder	1	noseslope	48	Sch	25	33	sl	scl
78	1085	21	2	shoulder	1	ridge		Sct	6	19	l	cl

Appendix C. Site characteristics of sampled stands in the Brumley Gap study area (cont.).

STAND #	ELEV. (m)	% SLOPE	ASPECT VALUE	SLOPE POSITION	SLOPE SHAPE	LAND-FORM	AGE	GEOL-OGY	HORIZON THICKNESS (CM) A	HORIZON THICKNESS (CM) B	HORIZON TEXTURE A	HORIZON TEXTURE B
Transition Stands (cont.)												
80	1021	23	5	shoulder	3	headslope		Sct	11	39	l	c
92	1030	21	1	backslope	2	sideslope	41	Sct				
102	914	63	2	backslope	1	spurridge		Oj	10	15	sic	sic
103	1036	65	2	shoulder	1	draw	48	Cj	13	38	sil	cl
106♦	701	23	3	footslope	2	cove	46	Sct	14	50	l	c
109♦	869	65	3	shoulder	1	cove	47	Oj	13	25	l	cl
117	640	47	6	backslope	1	spurridge	64	Sch	9	72	scl	sc
118	762	63	1	shoulder	3	sideslope	42	Cj	9	39	l	cl
122	811	55	5	shoulder	1	spurridge	44	Sct	15	43	l	sc
Unique Stands												
12	1097	18	6	toeslope	4	sideslope		Sct				
20	1122	64	6	backslope	4	spurridge	47	Sct	8	15	sl	scl
59	911	24	1	backslope	4	spurridge	39	Sch	2		sl	
79	1024	30	4	footslope	1	cove	83	Sct	20	56	scl	c
104	829	25	1	backslope	4	ridge	34	Otm	18	74	scl	sc

[1] ASPECT VALUE: 1=196-260 ; 2=166-195 and 261-280 ; 3=146-165 and281-340; 4=000--020 and 341-360 ; 5=081-145 ; 6=021-080 .

[2] SLOPE SHAPE: 1=convex; 2=concave; 3=linear; 4=variable.

Appendix C. Site characteristics of sampled stands in the Brumley Gap study area (cont.).

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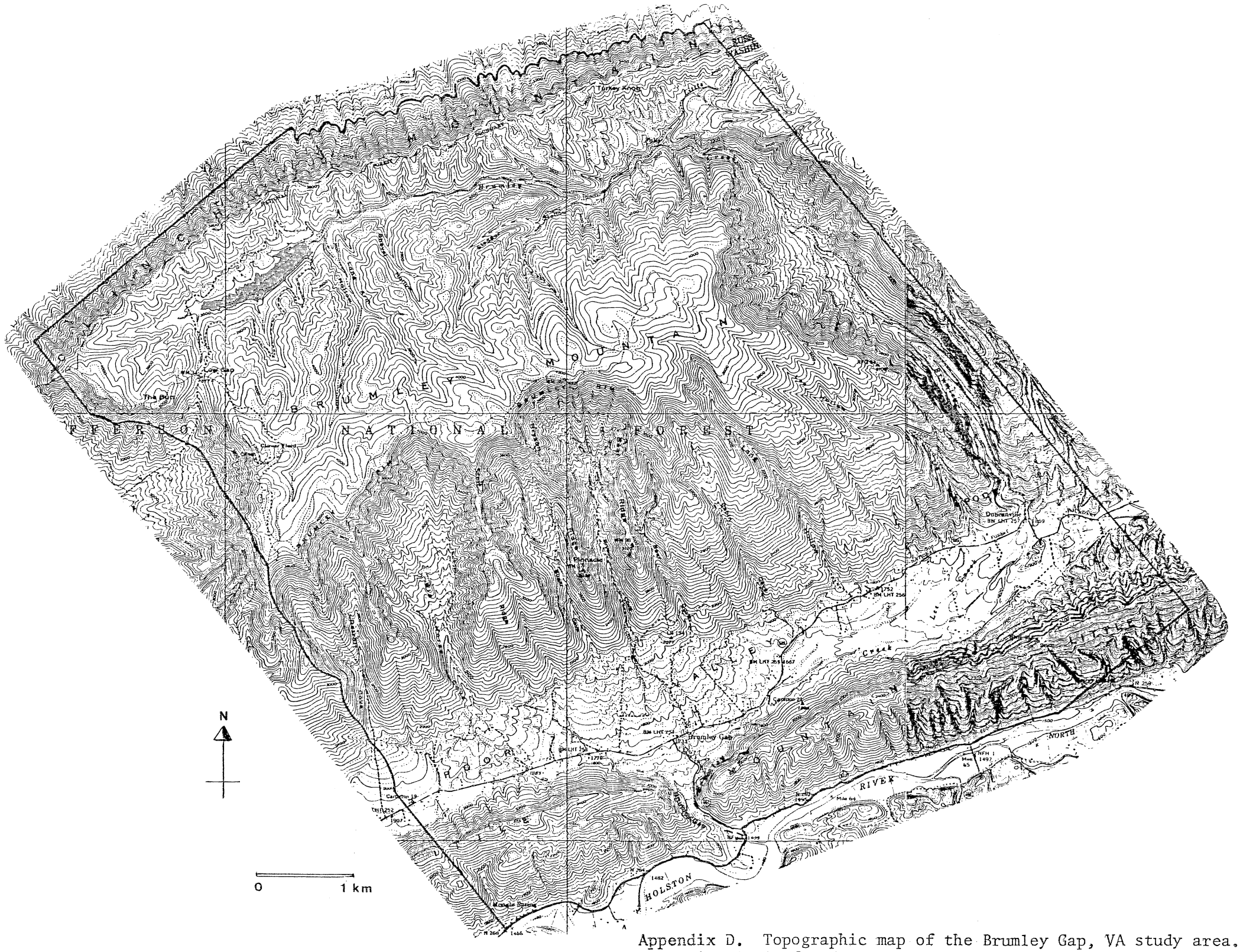
[3] GEOLOGY: Otm=Trenton-Martinsburg; Oj=Juniata; Sch=Tuscarora; Sct=RoseHill; Dh=Huntersville; Ds=Devonian shale; Mp=Price; Qaf=Quaternary deposits.

[4] Indicates that the stand was in the immediate vicinity of a stream.

[5] HORIZON TEXTURE: hc=shaly clay; hsicl= shaly clay loam; hcm=shalyclay matrix; hsic=shaly silty clay.



Appendix D. Topographic map of the Brumley Gap, VA study area. Elevation is in feet. Contour intervals are 20 and 40 feet.

Appendix E. Predictive multiple linear regression equations for selected species in the Brumley Gap study area. The dependent variable (Y) is relative basal area.

Species	Regression equations
Acer rubrum	Y = -18.352 + 5.110 aspect + .031 elevation - .005 elevasp[a] (R^2 = .113)
	Y = -8.092 + 4.351 aspect + .024 elevation - .093 percent slope - .005 elevasp[a] (R^2 = .141)
Acer saccharum	Y = -.185 + .317 age (R^2 = .131)
Quercus coccinea	Y = 65.870 - .679 age + 4.487 aspect - 5.229 slope position - .123 perasp[b] (R^2 = .264)
	Y = 62.827 - 15.369 slope position - 1.024 age + 11.649 aspect - .256 perasp[b] + .260 B thickness + .361 posper[c] (R^2 = .435)
Quercus prinus	Y = 57.328 - 3.104 aspect - .017 elevation - 5.90 slope position (R^2 = .189)
	Y = 38.312 - 2.893 aspect - 4.892 slope position - .543 A thickness - .240 B thickness (R^2 = .192)
Liriodendron tulipifera	Y = 75.484 - .593 age + 4.067 aspect - .042 elevation (R^2 = .37)
Spline model	Y = 117.654 - .107 elevation - .627 age + 4.02 aspect . . . for elevation $\leq$ 758 m
	Y = 32.0 + .006 elevation - .627 age + 4.02 aspect . . . for 758 m < elevation < 1025 m
	Y = 109.9 - .621 elevation - .627 age + 4.02 aspect . . . for elevation $\geq$ 1025 m (R^2 = .39)

Appendix E. Predictive multiple linear regression equations for selected species in the Brumley Gap study area. The dependent variable (Y) is relative basal area (continued).

Species	Regression equations
Quercus rubra	Y = - 58.561 + 3.049 aspect + .062 elevation + 1.368 percent slope - .001 elevper[d] - 0.121 perasp[b] (R^2 = .23)
	Y = .202 + .028 elevation + 2.584 aspect - .215 B thickness - 3.50 slope position (R^2 = .22)
Spline model	Y = 10.141 + .014 elevation + 2.439 aspect - .20 B thickness - 3.731 slope position . . . for elevation ≤ 850 m
	Y = - 20.459 + .050 elevation + 2.439 aspect - .20 B thickness - 3.731 slope position . . . for 850 m < elevation < 1140 m
	Y = - 133.319 + .149 elevation + 2.439 aspect - .20 B thickness - 3.731 slope position . . . for elevation ≥ 1140 m (R^2 = .24)

[a]elevasp = elevation × aspect

[b]perasp = percent slope × aspect

[c]posper = slope position × percent slope

[d]elevper = elevation × percent slope

Appendix F. Basal area and density of trees (>2.54cm DBH) for the 126 sampled stands in the Brumley Gap, VA study area.

Stand	Basal area (m^2/ha)	Density (stems/ha)	UTM #
1	23.5	593	026772
2	29.6	1927	029776
3	17.4	4176	031781
4	18.0	1137	032766
5	18.7	2644	032770
6	28.8	1359	034768
7	13.4	3015	037758
8	29.0	1878	039752
9	24.4	1186	039779
10	19.6	1408	039789
11	21.0	1359	042771
12	10.9	815	042786
13	21.2	1310	042791
14	22.8	1087	043745
15	21.6	1211	043756
16	23.6	1853	045765
17	23.9	1631	046766
18	17.0	667	047740
19	29.6	618	047773
20	26.3	914	047784
21	28.2	1384	048739
22	32.5	1433	048793
23	13.7	1804	049752
24	37.7	1532	050782
25	28.4	865	050784
26	19.5	1606	052731
27	23.7	2496	052767
28	19.8	1408	053749
29	19.9	2150	054739
30	27.4	1483	054778
31	17.2	964	055742
32	29.5	667	055770
33	22.9	1186	055793
34	39.5	865	056777
35	5.1	1087	057748
36	19.5	2422	058721
37	7.4	1829	058753
38	20.0	1680	058763

Appendix F. Basal area and density of trees (>2.54cm DBH) for the 126 sampled stands in the Brumley Gap, Va. study area (cont.).

Stand	Basal area (m^2/ha)	Density (stems/ha)	UTM #
39	22.6	3138	059794
40	18.8	1235	060747
41	18.3	1507	061771
42	31.5	791	061785
43	23.6	1903	061793
44	22.9	840	062790
45	14.3	988	064760
46	19.1	2076	064769
47	18.2	3039	065714
48	16.3	1853	066734
49	12.2	1038	066751
50	27.0	1235	066789
51	28.0	544	067802
52	31.5	1606	068722
53	27.9	1433	068727
54	14.1	1483	068759
55	27.4	1161	068773
56	25.1	1359	069804
57	22.7	1408	070750
58	31.3	1754	071727
59	2.2	173	071749
60	33.2	815	071801
61	25.9	865	072741
62	35.8	1161	073792
63	12.3	1235	074773
64	14.3	964	075753
65	29.7	1705	075762
66	18.5	1260	075777
67	33.2	1631	075784
68	47.0	544	076783
69	19.7	1705	078737
70	22.9	1260	078774
71	28.9	1977	078795
72	22.1	791	080751
73	16.9	1754	080752
74	26.7	1853	080798
75	25.6	1310	081721
76	32.8	1730	081773

Appendix F. Basal area and density of trees (>2.54cm DBH) for the 126 sampled stands in the Brumley Gap, VA study area (cont.).

Stand	Basal area (m^2/ha)	Density (stems/ha)	UTM #
77	23.7	1260	082770
78	14.7	1384	083804
79	20.7	618	084790
80	28.5	1310	084802
81	28.7	1260	085786
82	34.6	1458	086744
83	19.1	865	086768
84	29.6	1458	087786
85	21.9	1507	087792
86	7.7	815	089722
87	27.9	321	090733
88	18.2	1310	090763
89	13.0	1853	090765
90	36.2	1483	090797
91	26.0	1211	090802
92	17.7	2150	090804
93	16.2	1359	091725
94	26.9	1186	091762
95	19.3	1903	092726
96	20.3	1532	093747
97	27.8	1260	093751
98	24.5	1680	093754
99	23.6	1680	093772
100	26.8	1779	096734
101	13.4	939	097782
102	20.2	1433	098775
103	21.4	1087	098791
104	6.5	766	099784
105	11.1	1211	101776
106	18.0	865	102754
107	26.3	939	102783
108	22.4	2125	103765
109	15.1	420	104781
110	30.1	741	105752
111	16.8	2051	107736
112	26.0	519	107774
113	15.5	840	108738
114	12.5	1384	108765

Appendix F. Basal area and density of trees (>2.54cm DBH) for the 126 sampled stands in the Brumley Gap, VA study area (cont.).

Stand	Basal area (m^2/ha)	Density (stems/ha)	UTM #
115	22.8	2372	109736
116	21.4	1581	110734
117	24.1	988	112756
118	17.8	1532	113771
119	22.9	1952	114758
120	18.6	1433	117740
121	22.4	2323	117763
122	23.4	1137	117767
123	28.3	964	123744
124	9.4	1408	123761
125	16.3	1705	126756
126	14.7	1557	128746

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VEGETATION DISTRIBUTION AND SITE RELATIONSHIPS IN AN APPALACHIAN OAK FOREST IN SOUTHWEST VIRGINIA

by

Susanne Laura Travis

(ABSTRACT)

One hundred and twenty six stands were sampled using a stratified random design in a 6880 hectare Appalachian Oak Forest in southwest Virginia. The objective was to determine the present distribution patterns of tree species and community types and to relate their occurrence to site factors. Of the 52 tree species recorded, the dominants in order of decreasing importance were Acer rubrum, Quercus rubra, Liriodendron tulipifera, Quercus prinus, Acer saccharum and Quercus coccinea. Most site factors of importance, including elevation, lithology, landform, slope position, steepness, exposure, and soil depth appeared to influence the distribution of individual species and community types through their effect on local moisture and temperature conditions. Different site factors best explained the distribution of various species in a multiple regression analysis, thus suggesting that these species are distributed independently of each other. Stand history and interaction between site factors appeared to confound the species-site relationships examined and may explain the

large portion of variation unaccounted for by the regressions.

Stands were placed in one of six community types with the aid of polar ordination. Three community types were dominated by oak and showed considerable intergradation of species and site preferences. The dominant oaks shifted from Quercus rubra to Quercus prinus to Quercus coccinea on progressively drier sites. Sugar maple - mixed hardwoods, Yellow-poplar, and Hemlock community types were more discrete when compared to the oak community types. Stands dominated by Acer saccharum or Tsuga canadensis occurred mostly in relatively cool, moist conditions at mid to upper elevations, while most stands dominated by Liriodendron tulipifera were in moist locations at lower elevations. Results indicate that shifts in the composition of forest stands when compared to presettlement forests may be attributed to selective logging practices and to the demise of American chestnut.