To the Graduate Council:

I am authorizing herewith a thesis written by Daniel Thomas Rutledge entitled "GIS Modeling of Forest Cover Distributions in a Southern Appalachian Watershed." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Ecology.

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Associate Vice Chancellor and
Dean of the Graduate School

GIS MODELING OF FOREST COVER DISTRIBUTIONS IN A SOUTHERN APPALACHIAN WATERSHED

A Thesis

Presented for the

Master of Science

Degree

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Daniel Thomas Rutledge

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ABSTRACT

This study develops a method to model forest cover distributions in the Little Tennessee River Watershed in Macon County, North Carolina using a geographic information system (GIS). The model employs common environmental variables, e.g. elevation, aspect, and slope, and a newly developed metric called a topographic index. The topographic index quantifies landscape form to reflect the degree of site convexity or concavity. To generate index values, the GIS sums relative aspect differences between all adjacent cells and the center cell in a neighborhood analysis. To determine predominant community types and their environmental ranges in the study area, I surveyed canopy trees, small trees, and saplings on 216 10 x 10 m plots located throughout the watershed.

TWINSPAN identified eight community types: Birch-Hemlock, Basswood-Birch, Tuliptree, Red Oak-Hickory, White Oak-Black Oak, Chestnut Oak, Chestnut Oak-Red Oak, and Chestnut Oak-Black Oak. All communities showed strong association with the topographic index. Most showed strong association with elevation and a general preference for either N/NE/E or S/SW/W aspects. No overall relationship with slope was apparent. Field and GIS values for elevation and aspect correlated well, but slope data differed markedly. A discriminant analysis identified topographic

index, elevation, and aspect as significant predictive variables of forest cover types. Classification success depended on the number of forest cover types in the analysis. Two cover types produced a success rate of 84%; four produced 64.8%, six produced 48.8%, and eight produced 40.8%. Several factors could account for the decrease in successful classification including inadequacy of the topographic index, spatial resolution of the GIS data, the clusters produced by TWINSPAN, the need for additional significant predictor variables, or the failure to account for disturbance regimes. Overall the topographic index provides a quantitative, objective, and reliable measurement of landscape form. Further research should increase its usefulness and applicability to other studies.

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I. INTRODUCTION

Background

Concern about the gradual loss of habitat and species diversity due to human development has led to the realization that efforts to preserve single species would prove inadequate for protecting present and future levels of biodiversity (Franklin 1993). Consequently, land managers and scientists began focusing their research and management efforts towards ecosystems and landscapes (Slocombe 1993). This new approach, called ecosystem management, implies that conservation at broad scales will insure the continued existence of individual species and important ecological processes. The appeal of Ecosystem management is its potential ability to address objectively and quantitatively a broad spectrum of issues. Examples include preserving biodiversity while assuring sustainable product yields (Hanson et al. 1993, Kuusipalo and Kangas 1994), examining long-term trends such as impacts from global warming (Costanza et al. 1990), and answering questions about the linkages between economic, social, and ecological processes (Riebsame et al. 1994; Turner et al. in press; Wear et al. in press).

Successful implementation of ecosystem management will require the ability to monitor land use over time (Riebsame et al. 1994). Land use data provide a basis to address many other questions, the most important being the ability to analyze species viability based on spatial and temporal patterns of habitat availability (Probst and Weinrich 1993; Dunning et al. 1995; McIntyre 1995). Additionally, land use data can clarify important ecological processes that otherwise might be difficult to understand or reveal relationships that would not be apparent in a non-spatially explicit context (Kareiva and Wennergren 1995).

Ecosystem management would not be practical without the tremendous technological gains made over the past 10 to 15 years, especially the rapid development of geographic information systems (GIS) (Tomlinson 1990). These systems provide a mechanism for managing the large and complex data sets required for ecosystem-level research and the processing power to execute models at ecosystem scales. As these systems become more sophisticated, they permit the testing of more complex models that simultaneously simulate many ecosystem processes.

One such model is the Land Use Change Analysis System, or LUCAS (Flamm and Turner 1994). LUCAS was designed to integrate economic, social, and ecological processes into one model. LUCAS estimates land use change probabilities

based on underlying socioeconomic variables. These transition probabilities are then used to forecast possible land use changes under different management schemes and evaluate potential economic, social, and ecological effects. LUCAS allows for feedback among those three areas. For example, land use changes could cause habitat changes that threaten a particular species or community, resulting in modifications to the management scheme that would prevent certain land conversions from taking place.

For LUCAS or any similar ecosystem management tool, however, the analysis is only as good as the underlying data. Remotely sensed data can often provide large quantities of baseline data, including land cover types (Wickland 1991; Flamm and Turner 1994). However, the level of information provided for those land cover types may vary considerably, may prove costly for initial data expense and for personnel costs to convert and interpret the data, and may even vary in final outcome according to the experience of the interpreter (Hoffer 1994).

A different approach would involve using physical data to model the distribution of relatively undisturbed land. One focus of the LUCAS project is the Little Tennessee River watershed in Macon County, North Carolina. This area occurs in the southern Appalachian mountains where forest communities exhibit strong relationships with environmental

variables such as elevation, aspect, slope, landforms, and soils (Whittaker 1956; Pittillo and Smathers 1979). Theoretically one could develop a model that predicts the most likely forest cover type based on those physical variables. Advantages of a physically based model include data availability (e.g. digital elevation models) and the ability to predict forest cover types over a large region. The drawback of such a model is the initial cost of survey work to establish predictive relationships between forest cover types and environmental variables, if such information does not already exist.

Objectives

My goal is to generate a model to predict forest cover distributions using environmental variables readily available in a GIS, e.g. elevation, slope, aspect, and a new variable, a topographic index, generated from an analysis of aspect data. The study area is the Little Tennessee River watershed in Macon County, North Carolina. The model will relate forest cover types, determined from a field survey, to environmental variables using discriminant analysis. The resulting discriminant function can then assign forest cover types to cells within a GIS based on the associated environmental variables.

The motivation for the topographic index is Whittaker's (1956) work mapping vegetation in the Great Smoky Mountains. Whittaker identified dominant forest cover types and mapped them in a moisture complex-elevation matrix. The matrix predicts the forest cover type for any combination of moisture complex and elevation. However, Whittaker's "moisture complex" actually reflects moisture as measured in topographic variation. Mesic sites are characteristically more concave while xeric sites are more convex (see Whittaker 1956, Figs. 19 & 20, page 58). The new topographic index described in this study attempts to quantify the moisture complex and thereby provide a straightforward means for mapping forest cover types over large areas.

Following these procedures, my study attempts to answer three questions:

1) Does the topographic index successfully quantify the "moisture complex" (*sensu* Whittaker 1956)?
2) Do the observed forest communities show predictable relationships with environmental variables?
3) How well can the combined suite of environmental variables accurately predict forest cover distributions?

II. STUDY AREA

The study area consists of the Little Tennessee River watershed in western North Carolina. Almost all of the study area is located within Macon County, North Carolina, about 15 km south of Great Smoky Mountains National Park (Figure 1). The study area extends north to the point where the Little Tennessee River empties into Fontana Lake, approximately where it crosses U.S. Highway 19, and extends south to the North Carolina-Georgia border. The Nantahala Mountains, running north-south, define the western rim of the watershed while the Cowee Mountains, running slightly northwest-southeast, define the eastern rim. The Little Tennessee River flows south to north through the watershed, passing through the city of Franklin located near the center of the study area. The Cullasaja River flows northwest through the southeast part of the study area and joins the Little Tennessee River in Franklin.

The study area lies within the Blue Ridge physiographic province. The Blue Ridge province consists of a mixture of igneous, metamorphic, and sedimentary rocks that underwent repeated cycles of uplifting and erosion during the Paleozoic era. Today the area contains highly eroded, rugged terrain with many hills and mountains with deeply incised

valleys and drainages. Soils consist mostly of highly weathered and acidic Ultisols and younger coarse acidic Inceptisols (Stephenson et al. 1992). Elevations range from 500 m to 1675 m, but most fall between 760 and 1460 m. The topography is level along the Little Tennessee River and increases in steepness towards the surrounding mountains that define the watershed. The ridges and drainages show no predominate orientation, with aspects being fairly uniformly distributed. The overall slopes in the study area range from 0 to 64% (Thomas 1993). The predominant cover type in the area is forest (92.8% forested as of 1986), with the remaining area distributed among urban/industrial and agricultural land uses (Turner et al. in press).

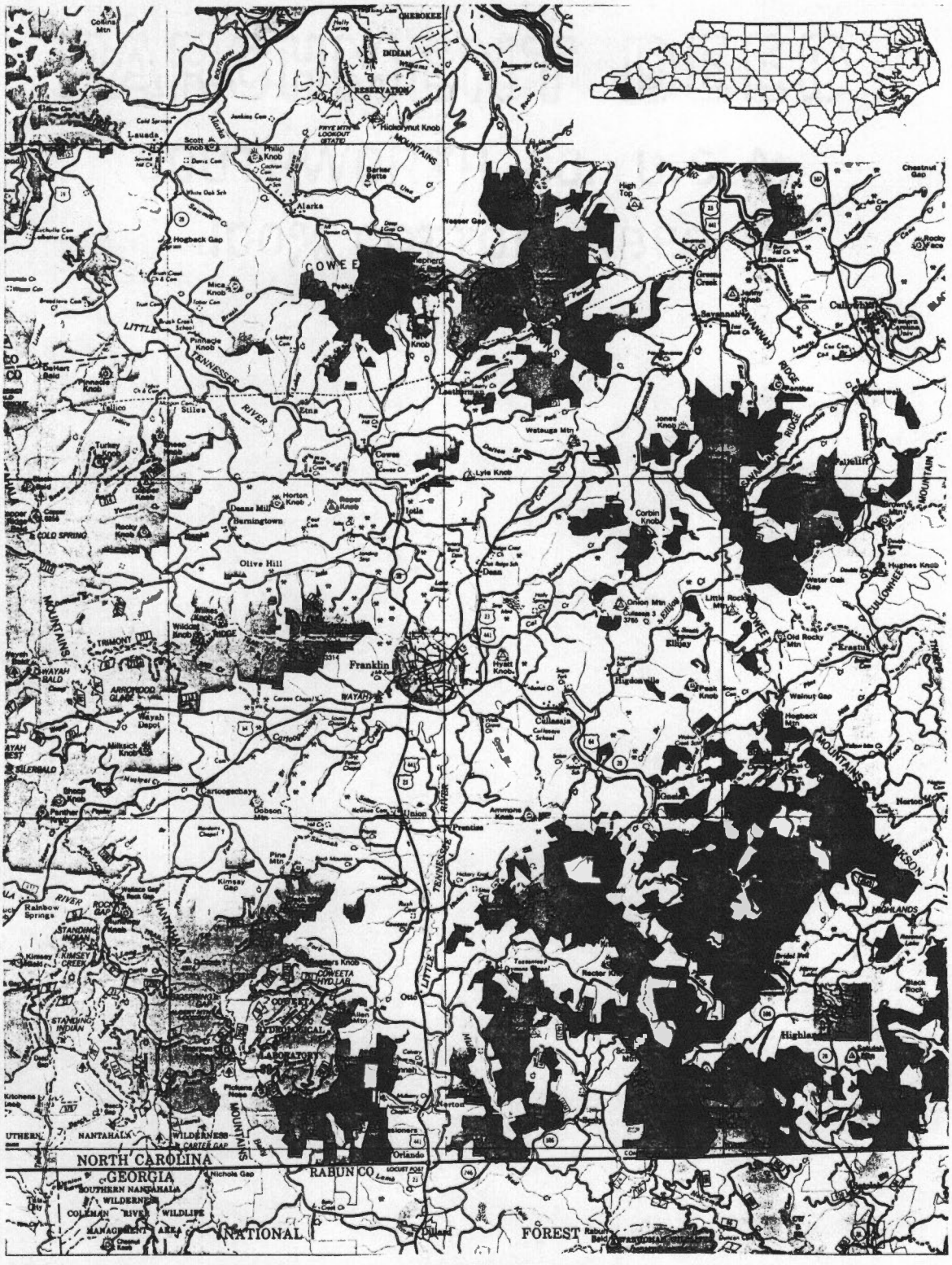


Figure 1: Location of study area in western North Carolina.

III. Methods

Predictive Forest Cover Model

Base Data Sources

Base maps for the Little Tennessee River watershed were stored as raster files in the Geographic Resources Analysis Support System (GRASS) (U.S. Army Corps of Engineers 1993) at the Environmental Sciences Division, Oak Ridge National Laboratory. Maps containing the following information at the indicated scale were used: 1) elevation (1 m increments); 2) aspect (15° increments); and 2) slope (1° increments). All data used a cell size of 90 x 90 m.

Topographic Index Model

The model generated a topographic index for a given cell by comparing the aspect of each neighboring cell to the cell of interest and summing the differences from the eight separate comparisons. The model then created a new GIS map layer with topographic index values by passing this 1-cell neighborhood filter across the entire aspect map layer. I only analyzed adjacent cells in the model because I wanted the index to reflect local or microscale topographic conditions. Given the cell size of 90 x 90 m, the model

analyzed an area of 270 x 270 m. Larger neighborhood filters may not necessarily improve the index considering the abrupt changes in topography in the study area.

A cell contributed a maximum value to the index if its aspect pointed directly toward the center cell; a cell contributed nothing if its aspect pointed directly away from the center cell. The amount contributed to the index decreased as the aspect of the adjacent cell pointed farther away from the center cell. Absolute aspect direction, i.e. N, S, E, or W, was not important; only the relative difference mattered. Cells with aspects pointing in different directions towards the center cell but with the same relative difference contributed the same amount to the index. Summing across all neighboring cells created an index for the local topography. For example, all surrounding cells with aspects pointing towards the center defined a local minimum (depression or concavity), whereas all surrounding cells with aspects pointing away from the center defined a local maximum (hill or convexity). Large numbers represented more concave sites while small numbers represented more convex sites.

Actual calculation of the topographic index proceeded in the following manner. First the aspect that would point from the center cell to the center of each neighboring cell was found. In the case of a grid, this was 0° for north, 45°

for northeast, etc. Second, these "pointer" aspects were converted to the appropriate aspect class found in the data set. Aspect class values ranged from 1 to 24, starting with east (1) and increasing in 15° increments counterclockwise to 15° south of east (24). Class 25 was no aspect. (Figure 2). Third, for each neighboring cell, the model found the relative aspect difference to the center cell by using the following formula:

$$\text{relative aspect difference} = 12 - \left| 12 - \left| \text{neighboring cell aspect class} - \text{pointer class} \right| \right|$$

The vertical bars in the formula signify absolute values. This formula gave a range of values from 12 for neighboring cells with an aspect pointing directly towards the center cell and 0 for neighboring cells with aspects pointing directly away from the center cell. As discussed above, neighboring cells with the same relative aspect difference contributed equally to the index. Fourth, the model converted the relative aspect difference to a new value based on one of five models discussed below, and finally summed the contributions from all eight neighboring cells to produce the topographic index.

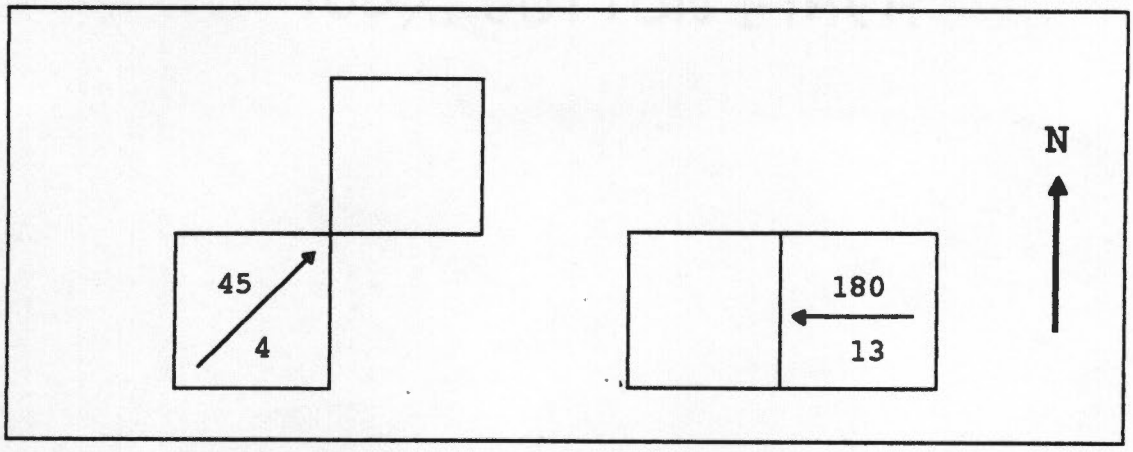


Figure 2: Examples of pointer aspects used in topographic index calculation. Number above arrow represents aspect in degrees; number below arrow represents aspect class value.

I used five different models to generate the topographic index. For each model, the maximum contribution from each neighboring cell was 12, corresponding to the aspect pointing directly at the center cell; conversely, the minimum was 0, corresponding to the aspect pointing away from the center cell. The models differed in calculating those cells with aspects pointing 15° to 165° from the center cell (Figure 3). The five models represented a range of conditions, with Model I generating the most "concave" values and Model V generating the most "convex" models. A conceptual interpretation would be that Model I indicated wetter sites, possibly with richer soils, while Model V

indicated drier sites, with thinner, poorer soils. The three remaining models span the range of conditions in between. With eight neighboring cells in the analysis, the index ranged in value from 0 to 96. However, because GRASS only used integers, the model multiplied the value from each pairwise comparison by 10 to retain the first decimal place

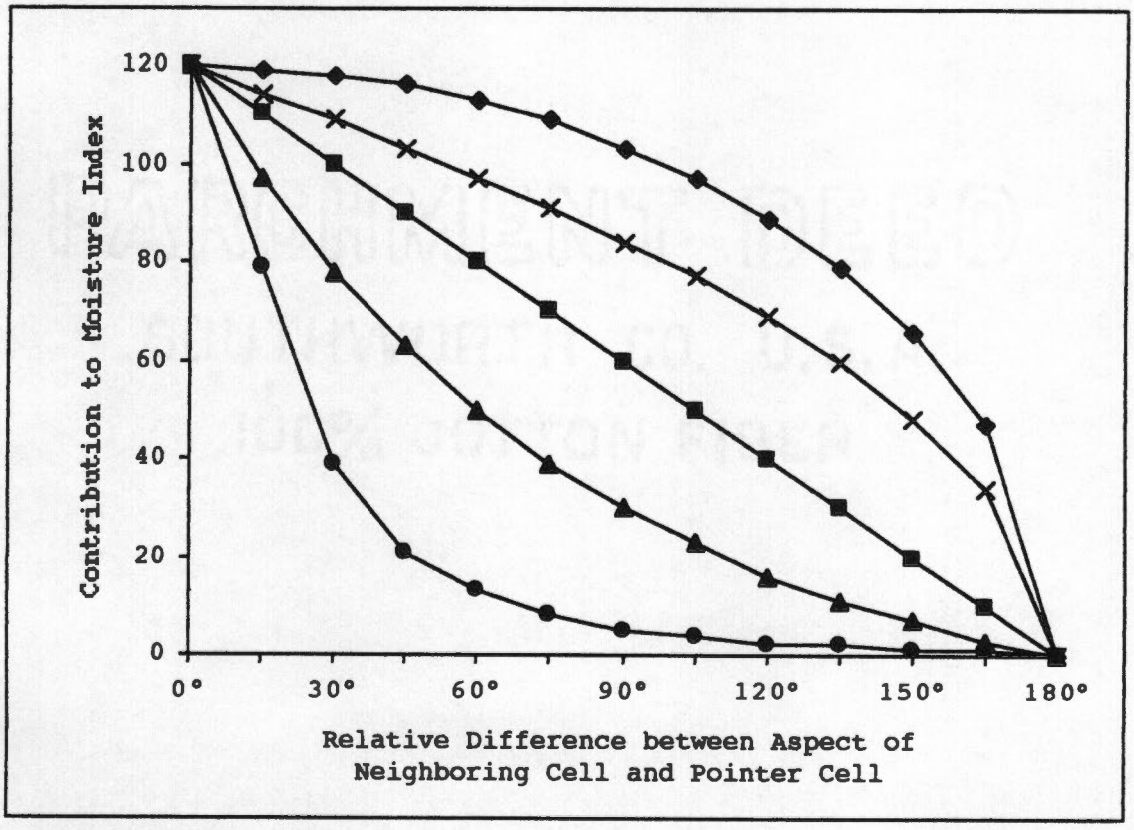


Figure 3: Relationships used to calculate topographic index values. ◆ = Model I; × = Model II; ■ = Model III; ▲ = Model VI; ● = Model V.

before being summed. Therefore, the map layer actually stored values from 0 to 960. I divided the map layer values by 10 for any further analyses. This analysis resulted in five new raster maps, one for each model, with topographic index values for each cell in the map.

The choice of final values for the index is somewhat arbitrary. One could scale the final index in whatever manner seems appropriate, i.e. 0-1, 0-100, +1 to -1 (e.g. McNab 1989). I chose 0-96 for two reasons. First, using relative aspect differences derived directly from aspect class values somewhat reflects the precision in the data. If aspect classes had been in 5° increments instead of 15° increments, there would have been 72 aspect classes, with a maximum relative aspect difference of 36. By not rescaling, one could directly compare a scale of 0-288 to a scale of 0-96, assuming the same methodology, and know that the former comes from a finer-scaled database. Second, the 0 to 96 is intuitively appealing in physical terms. If the number represents such factors as soil moisture, soil thickness or nutrient levels, humidity levels, etc., then larger values will indicate moist, rich, protected sites like coves while smaller values will indicate drier, sparse sites like ridge tops.

Data Collection

I collected data on 10 x 10 m plots in the Nantahala National Forest within the study area. I concentrated on three primary areas that together exhibited the full range of physical characteristics of elevation, slope, aspect, and landform found in the entire watershed. The first area extended from Trimont Ridge, northwest of Franklin, west to Wayah Bald and along the eastern facing slopes of the Nantahala Mountains. This area contained the highest elevations in the study. The second area included Fishhook, White, and Scaly mountains to the south/southeast of Franklin. The third area included the Cowee Mountains in the northeast part of Macon County.

I sampled plots at elevations ranging from 730 m (2400 ft) to 1465 m (4800 ft) in intervals of 90 m (~300 ft). For each elevation level, I selected plots in five topographic classes: cove/canyon, drainage/ravine, sheltered slope, open slope, and ridge/hilltop. These five classes conceptually represented the range of local topographic conditions within the area and corresponded to the "moisture complex" of Whittaker (1956). The 9 elevations and 5 topographic classes combined to form a matrix of 45 plot types. I attempted to survey 5 plots within each type for a total of 225 plots.

I inspected U.S.G.S. 7.5-minute topographic maps to select plots with the correct combination of elevation and topographic class. Because this research will determine whether a topographic index has any utility in predicting forest cover type, I had no *a priori* quantitatively-based criterion for selecting plots among topographic classes. Instead, I selected sites based on a set of guidelines describing what constituted each of the topographic classes (Table 1) and attempted to apply them in a non-biased manner when selecting plots. I did not systematically sample slopes and aspects within each combination, although I attempted to include all four cardinal directions in each topographic class-elevation combination.

I surveyed plots in groups of 3 to 8. I distributed the five plots in each combination as follows: three plots in the Nantahala mountains in the western part of the study area, one plot in the Fishhook, White, and Scaly mountains in the southeastern part of the study area, and one plot from the Cowee Mountains in the northeastern part of the study area. I followed existing roads or trails to a selected starting location and proceeded cross-country from that point. I typically followed topographic features, such as a drainage, and sampled at appropriate elevations. Occasional detours occurred due to unexpected conditions, e.g. an unmapped forest service road or dense undergrowth. I

Table 1: Guidelines for determining topographic class of field plots.

Topographic Class	Typical Features
Cove	Highly convex; well protected from exposure to sun and wind; level to moderately sloped
Drainage	Moderately concave; along watercourses with shallow drainages, either perennial or seasonal; often rocky and steeply sloped
Sheltered slope	Slightly concave to slightly convex surface; uniformly sloping; abrupt changes minimal; receives some protection from nearby landforms, most often open slopes
Open slope	Moderately convex; often an inflection along a hillside between two drainages; exposed; potential for steep slopes; often contained large rock outcrops
Ridge top	Highly convex; hilltops and ridge tops; exposed to all directions

attempted to maintain at least a 10-m buffer around roads, well-used trails, and other disturbances that could affect the species composition in a plot.

I ground-truthed plot locations by comparing surrounding topography to U.S.G.S. 7.5-minute topographic maps, approximate distance from my starting location on a road or trail, and elevation readings from an altimeter (Peet Brothers Co., Ocean, NJ, Model 80) with an accuracy of +/- 15 m. Although I always attempted to sample at the

prescribed 90 m elevation intervals, occasional deviations occurred to account for local site conditions. Also, I attempted to survey only plots with relatively well-developed canopies and more stable species compositions. I avoided plots that exhibited signs of relatively recent disturbance, such as small, short canopy species; large numbers of sapling species; or obvious signs of disturbance such as old forest roads or evidence of timber cutting.

If the plot was suitable, I selected a large canopy tree to serve as one corner of a 10 x 10 m sampling plot. From the selected tree, I defined the plot boundaries, oriented north-south and east-west, with a hip chain. Standing at the center of the plot, I determined aspect to within 5° using a compass, and I estimated the average slope of the plot to within 5°.

Within each plot, I identified and counted all plants ≥1 cm diameter breast height (dbh) whose stems fell inside plot boundaries (~1 m high) (Shanks and Sharp 1963; Little 1980; Petrides 1988; Kemp and Voohris 1993; Swanson 1994). I considered two plants as distinct if their bases emerged separately from the ground. I classified individuals measuring ≥ 1 and < 3 cm dbh as saplings and individuals ≥ 3 cm dbh as small trees or canopy trees. Small trees had crowns extending to approximately 1/3 of the total canopy height. Canopy trees had crowns in the upper 2/3 of the overstory. The canopy trees represented the dominant species

within a plot. The small trees and saplings reflected the potential the plot's potential regeneration conditions. I identified trees by species. I could not identify a total of 28 saplings on 8 plots and 3 small trees on one plot and did not count them. After being counted, I marked each individual with a push pin to prevent double counting. I recorded information on a sampling data sheet. Appendix 1 includes a copy of a sampling sheet.

Data analysis

I converted all species count data for each plot to relative density values (relative density = # of species *i* / total # of individuals of all species) for each size class (sapling, small tree, canopy) and expressed as a percentage. Therefore abundance values for saplings, small trees, and canopy trees summed to 100%, unless no individuals occurred at all in that size class on a plot. I used relative density because it reduces the variability associated with total number of individuals per plot, a possible artifact of sampling (Causton 1988), but retains the relative ranking and importance of each species.

Cluster Analysis

I identified forest cover types by clustering the plots using two-way species indicator analysis (TWINSPAN) (Hill

1979; Kent and Coker 1992). TWINSPAN is a polythetic divisive method that follows a stepwise procedure for classifying vegetation types. It divides a group of plots into smaller clusters by first ordinating plots with correspondence analysis and then adjusting the first division using an indicator score ordination based on preferential species. Preferential species are those species occurring mostly in one group or the other and can be simply the species or different abundance levels of the species, such as *Quercus rubra* 30% (relative density in this study). TWINSPAN repeats this process for each group until the desired level of division is achieved.

I used the relative density data for the TWINSPAN analysis. The program allows the user to set a number of variables at the start of the program. Appendix 4 contains the complete list of variables and the settings that I used. In particular I required all final clusters or cover types to have 15 or more plots to assure sufficient data exits for each type in the discriminant analysis.

Discriminant Analysis

I performed a discriminant analysis (SAS 1989, SAS 1995) to determine the feasibility of predicting forest cover types based on physical variables for each level of division produced by the TWINSPAN analysis. Clusters

developed in TWINSPAN served as class variables for the analysis. I included the following independent variables in the analysis: elevation, slope, aspect, and topographic index. Variable values came from field measurements or from GRASS map layers by selecting the value from each cell that contained a plot location. I determined plot locations within GRASS by reading latitude and longitude values from U.S.G.S. 7.5-minute topographic maps to the nearest 0.1 of a degree-second, converting degree-minute-second coordinates to UTM coordinates (GRASS *m.ll2u*), and creating a site map of all plots. GRASS then reported values from other maps at those sites.

I performed a separate analysis for each of the five index models combined with either field or GRASS data. I also tested the data with prior probability of group memberships being equal or being proportional to initial group frequencies. Therefore each level required 20 runs. Each run used the linear discriminant function, which assumes the data follow a multivariate normal distribution. Also each run tested for equality of variance-covariance matrices of the groups (PROC DISCRIM, test=yes, slpool=0.001). Finally I tested the effectiveness of each run in predicting forest cover types by performing a jackknife procedure within SAS (PROC DISCRIM, option CROSSVALIDATE). This procedure recalculated the discriminant

analysis while withholding one plot and then classified the withheld plot based on the recalculated analysis. The process repeated for each plot and procduced a matrix showing classification success rates for each group and for the overall analysis.

IV. RESULTS

Topographic Index Model

The five topographic index models performed as expected. Each produced a unimodal distribution of values that varied in a predictable manner (Figure 4). Model III, produced a normal distribution of index values; the remaining four models showed distributions skewed higher or lower according to the function used to calculate the index. Note that Figure 4c shows much higher frequency values because Model III only produces integer values. Table 2 shows the basic statistics for each of the five models.

Table 2: Summary statistics for topographic index models.

Model	Mean ± S.D.	Range
I	74.4 ± 10.66	14.1 - 95.4
II	63.1 ± 11.25	10.2 - 92.5
III	48.0 ± 13.46	3 - 90
IV	31.8 ± 12.49	0.9 - 83.4
V	16.0 ± 9.76	0.3 - 74.1

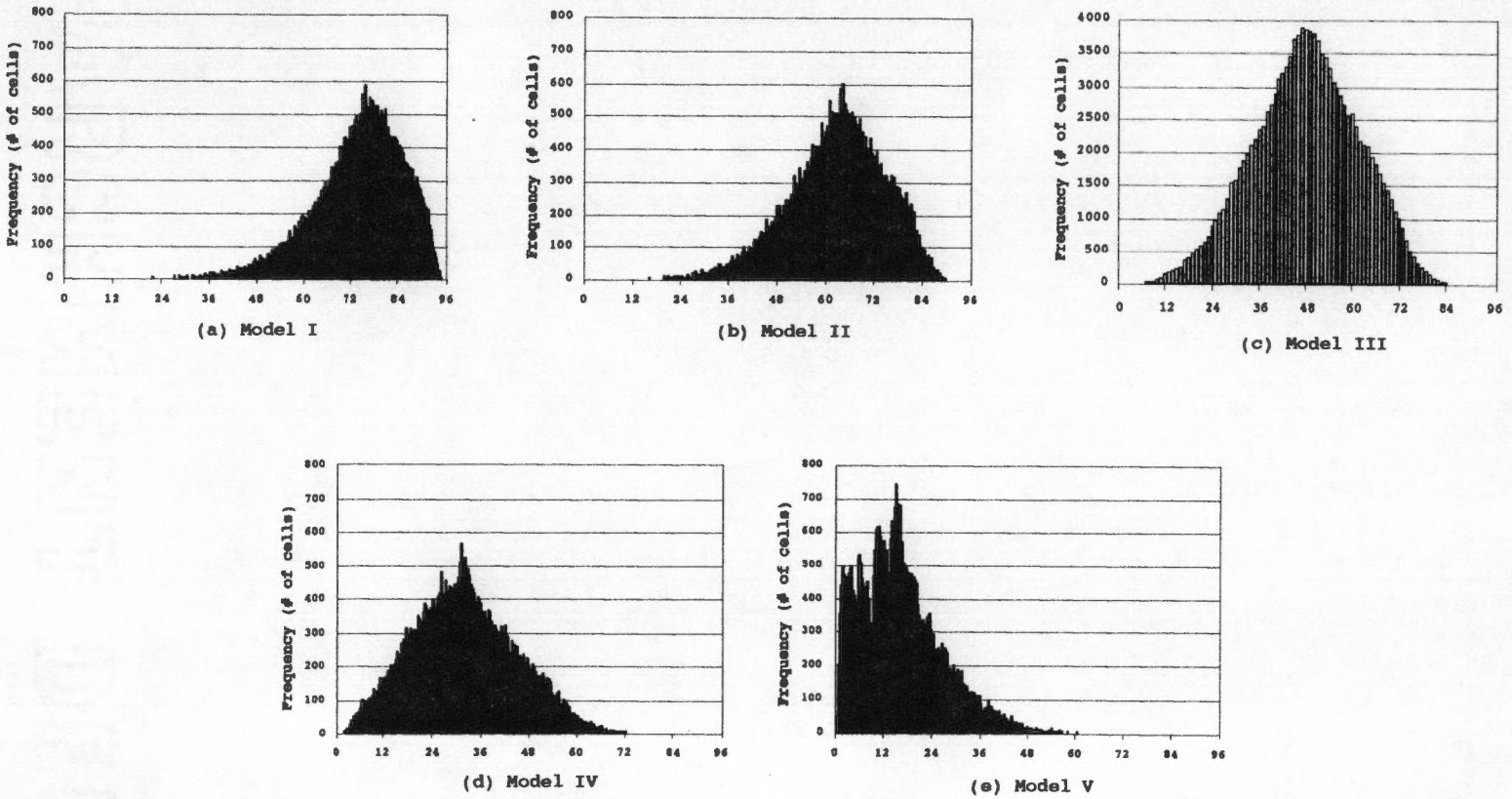


Figure 4: Distribution of topographic index values within the study area.

The five models represent the range of possible methods to characterize local landforms as more concave (Model I) to more convex (Model V). Increasing concavity could indicate more hydric or mesic conditions; deeper, more fertile soils; increased protection from wind resulting in more humid microclimates; and possibly increased shading. Conversely, increasing convexity could indicate more xeric conditions; shallower, less fertile soils; increased exposure to wind leading to drier microclimates, and more direct exposure to sunlight.

Field Study Results

I sampled 216 10 x 10 m plots throughout the study area, five plots from each of the 45 possible combinations of elevation (9 levels) and topographic class (5 levels) except as discussed below. I sampled three cove plots at 1370 m and no cove plots at 1465 m because most of the study area falls below 1525 m in elevation, making the conditions for coves rare to non-existent at higher elevations. Also, I sampled three plots on 730-m ridges. Three factors contributed to the paucity of these plots: a smaller number of highly convex landforms, a general lack of U.S. Forest Service land at lower elevations, and greater percentage of land harvested for timber. Appendix 1 contain both field and

GIS-based environmental data for each site. Appendix 2 contains all vegetation data for each plot.

Environmental Data

Analysis of the environmental data involved two primary questions. First, how well do field data agree with the GIS data for each plot? The level of agreement depended on three primary factors: 1) relative size of plots to GIS cell size; 2) method of calculation of environmental variables in the field; and 3) GIS cell size relative to landform complexity. Second, do systematic trends, either expected or unexpected, exist in the environmental data and how might they affect the ability to predict forest cover types? For example, topographic index values should show significant differences among the five topographic classes but not among the nine elevation levels surveyed.

Elevation values show a strong correlation between field values and GRASS values ($r = 0.996$, $p < 0.001$). The mean of the absolute value of differences between field and GRASS values is 17.6 m, which is close to the estimated margin of error in field measurements of 15 m. The differences range from -58 m to +57 m, with most falling between -30 m and +30 m (185 of 216 plots) which would not shift a plot to a higher or lower elevation class (Figure 5a). Sixteen GRASS plot elevation values were -30 m or lower

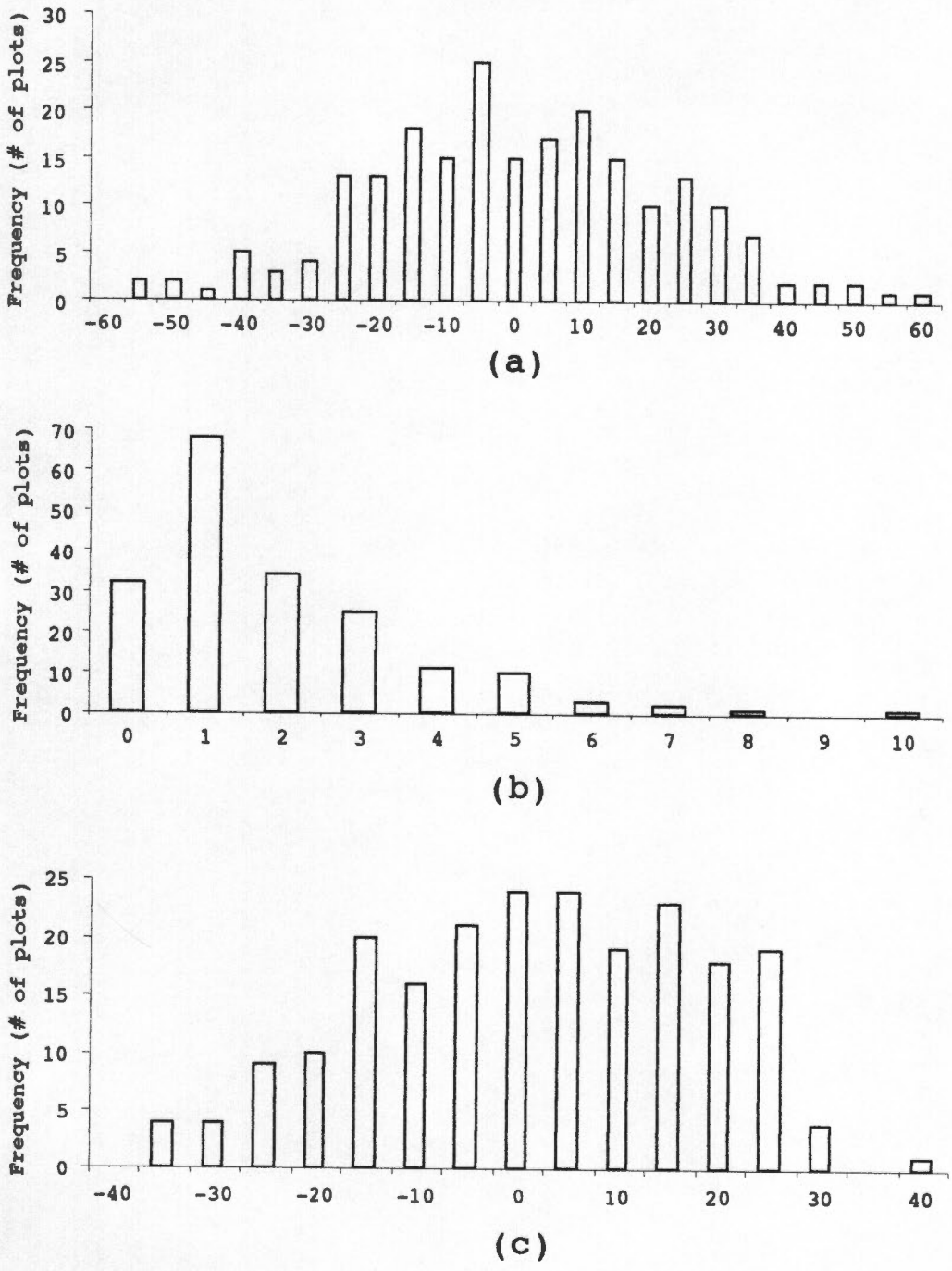


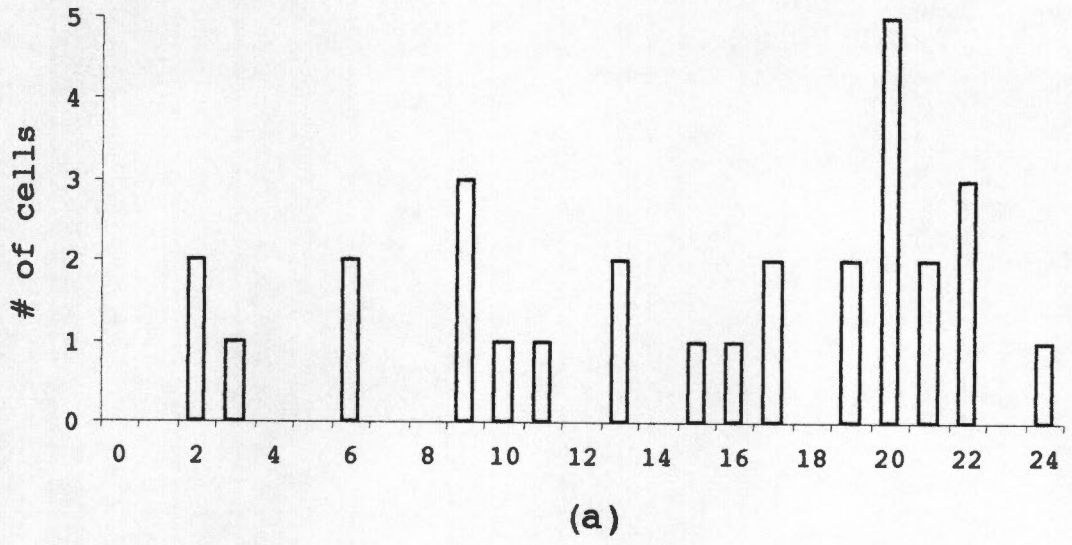
Figure 5: Differences between field and GRASS environmental variable values, (a) elevation differences in 5 meter increments; (b) aspect differences, each number represents the relative class difference (1 class = 15°); (c) slope differences in 5 degree increments

than field values; 15 values were +30 m or higher than field values. Examination of the topographic classes reveals a trend in the larger errors. Most low GRASS values come from plots along open slopes or ridges while most high GRASS values appear in plots in coves and ridges. These errors most likely result from the inability of the 90-m grid to accurately capture the abrupt changes in relief common to the southern Appalachians. These effects would be most pronounced on ridges or in coves/valleys where the tops or bottoms would be "flattened out", resulting in under and over estimations, respectively.

Aspect values between field values and GRASS values show agreement but not as strongly as elevation values. Of the 216 plots, 187 sloped enough to measure an aspect; the remaining 29 plots, mostly flat areas on ridge tops, had no real aspect. Figure 5b shows the frequency of absolute aspect differences between field and GRASS values for the plots with field values. A difference of 3 or greater indicates a difference of 45° or more between the value measured in the field and the GRASS derived value. Inspection of topographic maps revealed most large discrepancies between field and GRASS aspect values occur in areas with abrupt changes in topography, such as in narrow coves or ravines or along highly convex open slopes. For example, plot 35, showing the largest difference (10 classes or 150°), fell within a deep north facing cove. The plot was

sampled along the west side of the cove (facing east), while the GRASS cell appears centered on the eastern side of the cove that faces more northwest. Other large differences stem from similar situations where the plot fell along one side of a ravine or slope while the GRASS cell is centered on the other side. However, GRASS shows no bias in the direction of aspect shift, either counterclockwise or clockwise, for the 53 sites with an aspect class differential of 3 or more (32 clockwise, 21 counterclockwise, $\chi^2 = 1.89$, 1 d.f., $p = 0.17$) (Sokal and Rohlf, 1981, p. 711, Expression 17.6C). For the 29 plots with no recorded field aspect, GRASS also shows no bias towards any particular aspect (Figure 6a). The GRASS aspect values depend upon the cell location relative to the ridge top and surrounding slopes; again, map inspection showed that all values were consistent with the local topography near the plots.

Slope values show the least agreement between field and GRASS data (Figure 5c). The mean and standard deviation of the absolute value of all differences is 13.5° ± 8.9°. The discrepancies result from the difference in plot size versus GRASS cell size. Although the field slope estimated the average slope of the plot, the placement of the plot strongly influenced that value. For example, a plot may occur on a relatively flat area within a deep cove or ravine. Therefore, the plot would seem relatively level



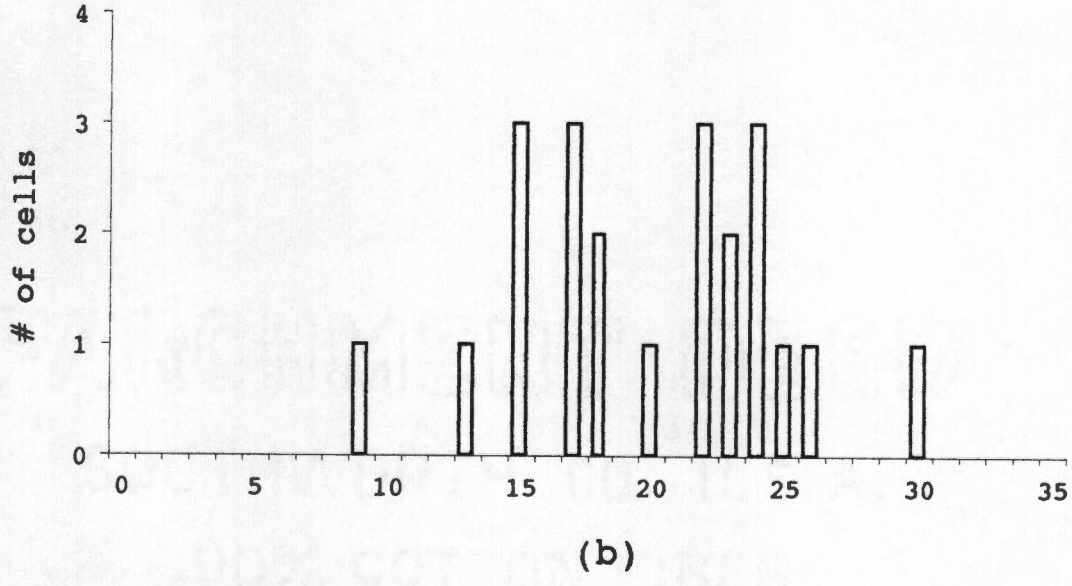


Figure 6: GRASS aspect class and slope values for plots with field values of 25 (no aspect) and 0° (no slope).

while the larger GRASS cell would approximate the slope of the larger surrounding area. The relative position of plot to cell also becomes important. This positioning is especially important for plots on ridge tops. These plots often had little or no slope, yet the associated GRASS cell always extended to an adjacent slope. Consequently, GRASS slope values differ from all 29 plots with no slopes located on ridge tops (Figure 6b).

All five topographic index models behaved as expected in assigning index values for the 216 plots. Within a model, mean index values decreased monotonically going from coves to ridge tops, and for each topographic class, mean index values decreased monotonically from Model I to Model V (Figure 7). Each model showed no significant difference for the elevation-topographic class interaction (ANOVA: 31, 172 d.f.; $F \leq 1.382$, $p \geq 0.10$ for all five models) or for elevation as a single factor ($F \leq 1.238$, $p \geq 0.28$). However all five models showed highly significant differences among topographic classes ($F \geq 61.952$, $p < 0.0001$ for all tests).

Vegetation Data

From the survey of the 216 plots, I counted a total of 6,397 individuals among 66 species. Following the field survey, I modified the data set as follows:

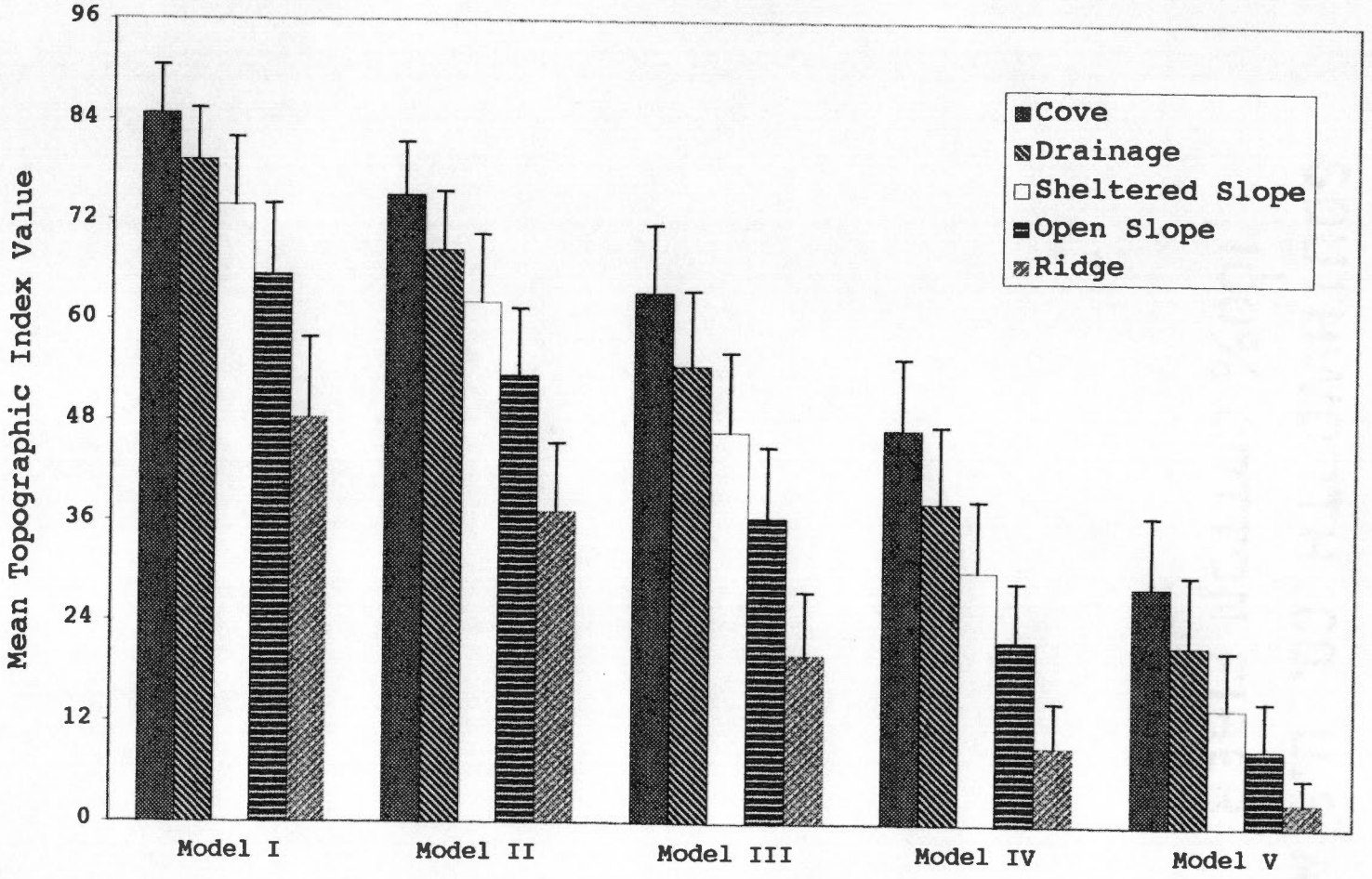


Figure 7: Mean topographic index values for survey plots by model and by topographic class.

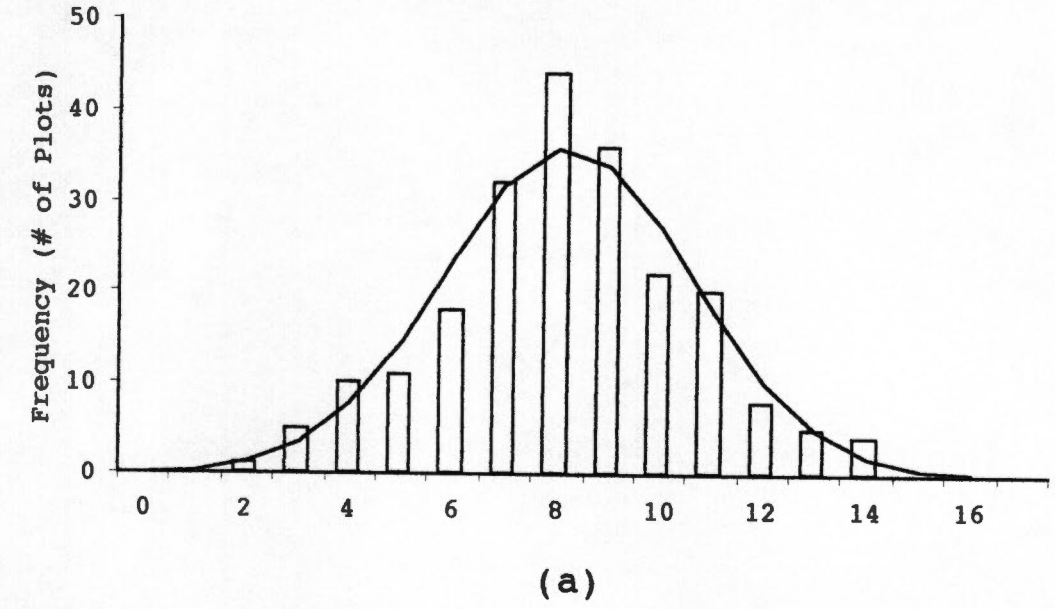
1) combined the occurrence of one *Fraxinus americana* var. *biltmoreana* with all other *Fraxinus americana*

2) combined 8 *Viburnum cassinoides*, 1 *V. prunifolium*, and 1 *V. rufidulum* into one *Viburnum* spp. category

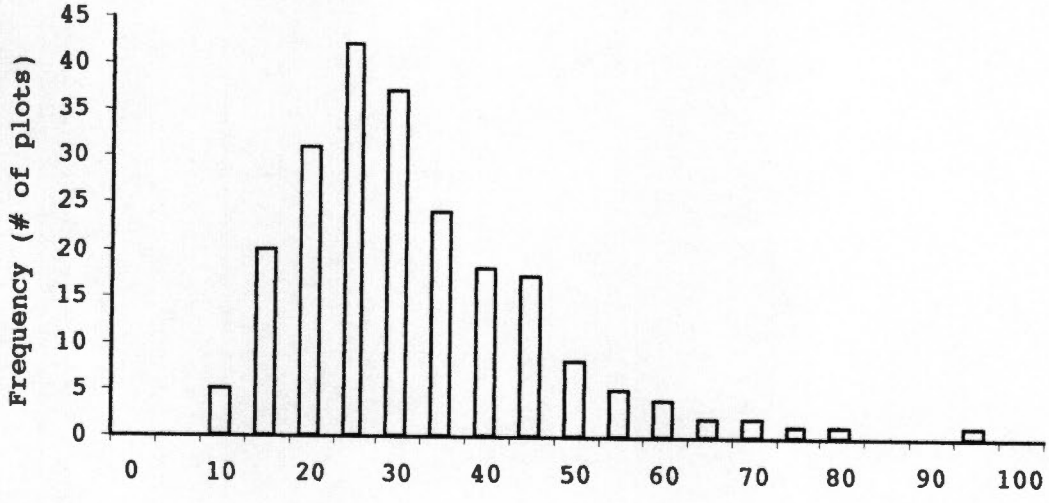
3) combined all *Carya* species into one category

These changes represent all possible cases of combining rare species with more numerous individuals of the same genus or more common varieties of the same species. The decision to combine all *Carya* species resulted from difficulty in field identification due to lack of suitable bud development and generally high phenotypic variability and hybridization among *Carya* species. Survey work occurred in spring and early summer before development of mature buds, which are one of the best field indicators. Therefore, I decided to sacrifice the additional information provided by species level data in favor of increased accuracy. The combined data set had 57 genus/species classes; all subsequent analyses used the revised classes.

Figure 8 shows the distributions for the number of species per plot and the number of individuals per plot. The



(a)



(b)

Figure 8: Distribution of (a) number of species per plot and (b) number of individuals per plot. The fitted line in (a) is the corresponding normal distribution. Individual numbers are reported in increments of 5.

number of species per plot follows a normal distribution (χ^2 = 7.35, 11 d.f., p = 0.17) but the number of individuals per plot does not (χ^2 = 56.65, 32 d.f., p = 0.005). Count data typically follows a Poisson distribution, which has a mean equal to the variance, and normally requires a square root transformation to separate the mean from the variance (Causton 1988). A square root transformation did normalize the vegetation data somewhat but not significantly (χ^2 = 49.86, 32 d.f., p = 0.02). Mean number of species per plot and mean number of individuals per plot increased as vegetation class size decreased (Table 3). These results are expected given that the survey plots would accommodate more individuals in progressively smaller size classes. Additionally, variation in number of species and individuals increased with smaller vegetation size class, as shown by their large range of values for both saplings and small trees. Understory development varied considerably among sites but generally showed higher density and development with increasing site convexity.

Analysis of species frequencies (# of plots containing the species/total # of plots) confirmed known environmental-vegetation relationships as described in previous studies (Braun 1950, Keever 1953, Whittaker 1956, Pitillo and

Table 3: Basic statistics for number of species and number of individuals per plot.

Vegetation Class	Species		Individuals	
	Mean	Range	Mean	Range
Total	8.2 ± 2.4	2 - 14	29.8 ± 13.6	8 - 93
Canopy	3.8 ± 1.4	1 - 8	7.3 ± 2.9	2 - 19
Small Tree	4.0 ± 1.8	0 - 10	9.9 ± 6.4	0 - 41
Sapling	4.2 ± 2.3	0 - 11	12.5 ± 10.0	0 - 78

Significant differences exist among vegetation classes for both species (ANOVA: $F = 3.375$; 2, 645 d.f.; $p = 0.0348$) and individuals (ANOVA: $F = 28.944$; 2, 645 d.f.; $p < 0.0001$).

Smathers 1963, Gattis et al. 1992, McNab and Browning 1992, Stephenson et al. 1993, Yoke 1994). *Acer rubrum*, ubiquitous throughout the Appalachian mountains, had the highest frequency of 0.648 (141 plots). Two species, *Calycanthus fertilis* and *Ulmus rubra*, occurred on only one plot (frequency = 0.005). Out of the 58 genus/species found in the study, 56 occurred as saplings, 49 as small trees, and 32 as canopy trees. Among the canopy trees, most frequent were *Acer rubrum*, *Carya* species, *Liriodendron tulipfera*, and *Quercus* species. *Acer rubrum*, *Carya species*, *Cornus*

florida, *Kalmia latifolia*, and *Nyssa sylvatica* occurred most frequently in the small tree and sapling samples. *Rhododendron maximum* also appeared often in the small tree layer while *R. calendulaceum* ranked high in the sapling layer. American chestnut (*Castanea dentata*) was common despite the chestnut blight but only in both the small tree (0.231) and sapling (0.435) layers.

Further trends appear when analyzing species frequencies relative to the environmental variables. Most species are distributed as expected relative to the five topographic classes studied. *Acer spicatum*, *Carpinus caroliniana*, *Halesia caroliniana*, *Hamamelis virginiana*, *Ilex opaca*, *Tilia heterophylla*, and *Tsuga canadensis*, species favoring mesic conditions, primarily occur in coves and drainages. Conversely, species favoring more xeric sites, including *Castanea pumila*, *Pinus* species, *Quercus coccinea*, and *Q. velutina* primarily occur on open slopes and ridges. Less distinct elevation relationships are apparent, although several species do show preferences. *Acer saccharum* only occurred above 1100 m. *Cornus florida*, with frequencies as high as 0.80 in the lower elevations, disappeared above 1190 m. *Carya* species showed a strong overall decline with increasing elevation, from 0.74 at 730 m to 0.35 at 1460 m, but still remained abundant. Several species appeared more

frequently only in certain aspects, including *Acer spicatum* (NW to E), *Carpinus carolinana* (NE to SE), various *Pinus* species (SE to W), and *Quercus velutina* (SE to NW). No apparent trends emerged from a corresponding analysis of slope data. Appendix 3 contains a complete list of species frequencies relative to vegetation class, topographic class, field elevation, field aspect, and field slope.

Cluster Analysis

The TWINSPAN analysis produced eight distinct community types (Figure 9). They represent subtypes of either the Mixed Mesophytic Forest or the Appalachian Oak Forest of Küchler (Stephenson et al. 1993). Based on the abundance of *Castanea dentata* saplings and small trees, the oak-dominated types may also fall within the Oak-Chestnut forest type described by Braun (1950). Table 4 lists the major community types and their positions along the topographic and elevation gradients. Appendix 4 provides complete species information for all eight community types. Appendix 5 provides information on how those communities are distributed relative to environmental variables.

Three Mixed Mesophytic community types occur: Basswood-Birch, Birch-Hemlock, and Tuliptree. The first two represent the classic cove communities of Whittaker (1956), differing primarily in the dominance of *Tsuga* in the canopy and

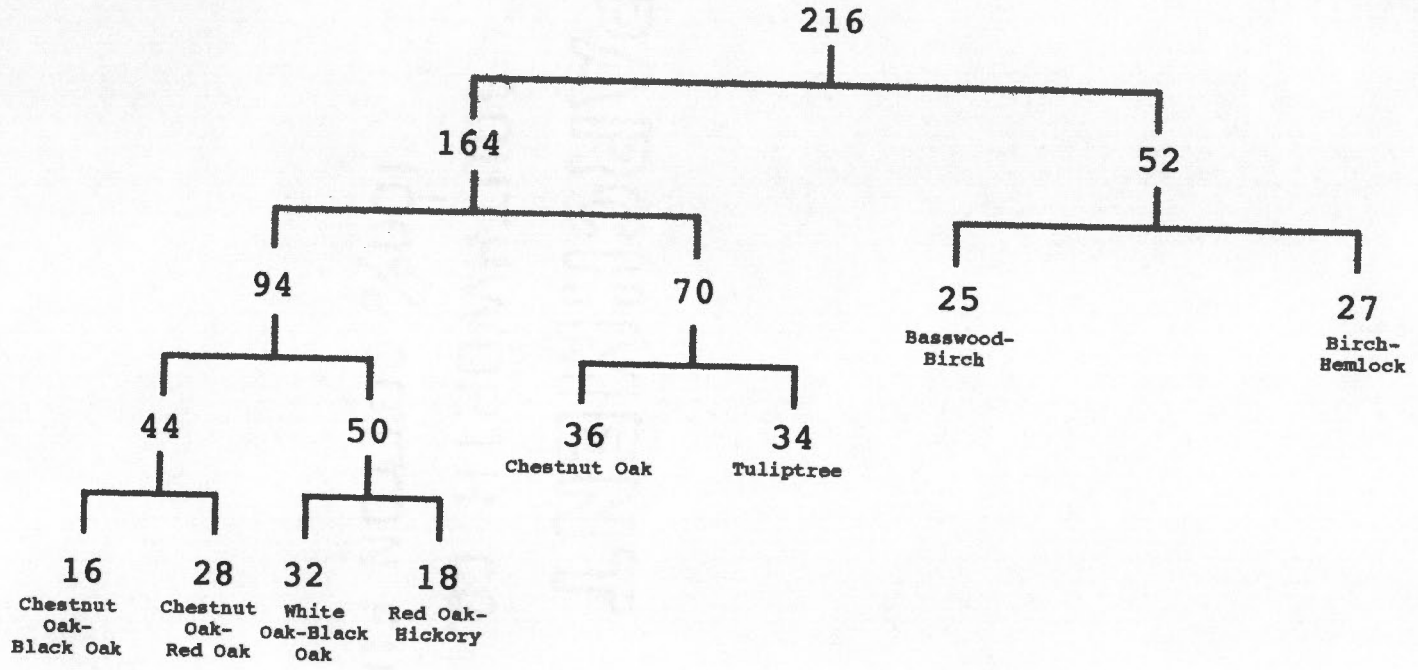


Figure 9: Classification hierarchy from TWINSPAN analysis.

Table 4: Forest community types and environmental ranges[1].

COMMUNITY	ELEVATION [2]	TOPOGRAPHY [2,3]
Mixed Mesophytic		
Basswood-Birch *Tilia heterophylla, Betula lenta, Liriodendron tulipfera, Aesculus octandra* [4]	1156 732 - 1463	58.2 32 - 76
Birch-Hemlock *Betula lenta, Tsuga canadensis, Rhododendron maximum* [4]	1133 820 - 1463	59.3 29 - 74
Tuliptree *Liriodendron tulipfera, Carya* spp., *Cornus florida* [4]	981 719 - 1189	53.0 21 - 76
Appalachian Oak		
Red oak-Hickory *Quercus rubra, Acer rubrum, Carya* spp.	1271 1097 - 1469	46.6 30 - 61
Chestnut oak-Red oak *Quercus prinus, Quercus rubra, Acer rubrum, Oxydendron arboreum*	1010 732 - 1372	29.9 12 - 52
Chestnut oak *Quercus prinus, Cornus florida* [4]	888 725 - 1097	40.2 8 - 67
Chestnut oak-Black Oak *Quercus prinus, Quercus velutina Quercus alba, Kalmia latifolia* [4]	1061 707 - 1463	32.2 12 - 57
White oak-Black Oak *Quercus alba, Quercus velutina Acer rubrum, Carya* spp., *Castanea dentata* [4], *Rhododendron calendulaceum* [4]	1332 1103 - 1494	30.8 9 - 63

1. Ranges with outliers removed. See text pg. 44.
2. Top number is mean; bottom numbers are range.
3. Model III scores.
4. Dominant in small tree or sapling class.

Rhododendron maximum in the small tree and sapling layers. They span the entire elevation range in the study area but are confined to mesic areas in drainages and coves. Although very similar in distribution, I found Birch-Hemlock more often along perennial streams in narrow ravines and gullies with steeper (e.g. 20°+) slopes.

Tuliptree forests are found at lower elevations (below 1200 m), primarily in drainages and along sheltered slopes. *L. tulipfera* shows strong dominance, making up on average 44% of the canopy. *Carya* spp. follow in importance, especially as saplings (27%). The less important species in all three vegetation classes represent a broad ecological spectrum, from *T. heterophylla* to *Q. velutina*. Although this community initially clustered with the other Appalachian Oak communities, I classified it as Mixed Mesophytic based on the composition of the associated species and its range relative to the environmental gradients. Also, this community may more correctly represent a transitional stage, both physiographically and temporally. As stated before, lower elevation areas generally have gentler slopes and provide better logging opportunities. Therefore, these communities may reflect forest management practices that favor early colonizing and fast growing species like *L. tulipfera* (Phillips and Shure 1990).

Five Appalachian oak forest types occur in the study area: Red Oak-Hickory, White Oak-Black Oak, Chestnut Oak-Red Oak, Chestnut Oak, and Chestnut Oak-Black Oak. They can be separated into two groups based on elevation, with Red Oak-Hickory and White Oak-Black Oak restricted to high elevations (above 1050 m) while the Chestnut Oak communities mostly occupy mid and low elevations (below 1100 m). The Red Oak-Hickory and White Oak-Black Oak communities span the topographic gradient at high elevations. The Red Oak-Hickory forest generally occurs in open drainages and on sheltered slopes and persists somewhat on open slopes. When conditions become too xeric, the White Oak-Black Oak community begins to dominate and eventually becomes the primary community type on very dry slopes and ridge tops. Their ranges overlap considerably during the transition, which probably reflects their similar understory composition. Although dominant canopy species change, *Carya* spp. and *A. rubrum* remain important canopy species, and understory species remain fairly constant with *R. calendulaceum* and *C. dentata* being most abundant and *Kalmia latifolia* increasing in abundance as conditions become more xeric.

The remaining three communities form a plausible Chestnut Oak complex, with *Q. prinus* either dominant or codominant in the canopy. These three types therefore exhibit much overlap both in species composition and

environmental range. *Q. prinus* on average comprises 21-23% of the canopy, so distinctions among the three types rest on associated canopy and understory species. Understory composition may also explain the early split of Chestnut Oak forests in the TWINSPAN analysis. Chestnut Oak forest has no clear associated canopy species, with *Q. alba*, *Q. rubra*, and *Q. velutina* averaging 8-9% relative density along with *Carya* spp. and *A. rubrum*. Instead, its distinguishing feature is a dense *Cornus florida* small tree layer. Of the three Chestnut Oak community types, this one shows the strongest association with environmental gradients, occurring exclusively below 1100 meters from slightly mesic to xeric conditions.

Chestnut Oak-Red Oak and Chestnut Oak-Black Oak forests present the largest challenge for classification. Their canopy compositions are quite similar, with only a moderate rearrangement of the dominant species. In the Chestnut Oak Forest, the order of canopy species with >10% average R.D. is *Q. prinus*.-*A. rubrum*.-*Oxydendron arboreum*-*Q. rubra*; for Chestnut Oak-Black Oak, the order changes to *Q. prinus*-*Q. velutina*-*Q. alba*. They share a number of species with lower relative densities such as *Pinus rigida* and *Nyssa sylvatica*. The primary difference occurs in the understory. Chestnut Oak-Red Oak has a diverse understory with important species including *A. rubrum*, *N. sylvatica*, *C. florida*, and *C.*

dentata. However, *K. latifolia* clearly dominates Chestnut Oak-Black Oak understory, with ~62% R.D. in both small tree and understory layers. Indeed, TWINSPAN used this attribute as the basis for dividing these two groups. Further, Chestnut Oak-Red Oak shows a strong association with elevation and topographic components, occurring in xeric conditions centered around 1050 m. Conversely, Chestnut Oak-Black Oak-White Oak ranges widely both topographically and elevationally and, unlike all other forest types, shows no distributional trends.

Finally, the study and TWINSPAN analysis demonstrates the paucity of pine in the study area. I did not observe any natural pure pine stands. According to Braun (1950), increased moisture and richer soils account for the rarity of pine stands south of the Great Smokey Mountains. In almost every case, pine encountered on plots was in decline, with large individuals showing signs of aging and decay and very few if any pine seedlings apparent, albeit from a very casual inspection.

Based on these results, I excluded three outliers prior to the discriminant analyze. They are Plot 47, the only White Oak-Black Oak site to occur below 1050 m, Plot 160 the only Red Oak-Hickory site to occur below 1050 m, and Plot 196, the only Tuliptree site above 1250 m.

Discriminant Analysis Results

The discriminant analysis consistently identified topographic index as the most important variable in distinguishing among the forest cover types. In almost all cases the topographic index correlated well ($r \geq 0.9$) with the first canonical axis, which explained a majority of the variation among the community types. Elevation and aspect also were significant in almost every case and usually correlated most strongly with the second and third canonical axes, respectively. Initially, aspect was more important than elevation in the analysis of the first level of the TWINSPAN classification. However, as more community types were added, elevation became the second most important variable for classifying forest cover sites. Slope did not contribute significantly to the analysis and typically did not correlate well with any axis or correlated with a non-significant axis.

Based on the jackknife results in the discriminant analysis, the environmental variables classified forest community types with an 84.5% accuracy with only two forest cover types but declined in predictive ability as more types were added (Table 5). However, in all cases the model performed better than random, as much as 3 times higher in the case of the Level IV division. GRASS data proved slightly better than field data at classification. More

Table 5: Discriminant analysis classification success based on jackknife results. The entries below each success rate represent the topographic index model (I - V) and data (F: Field or G: GRASS) combination that produced that success rate.

TWINSPAN Division	Random Success Rate[2]	Classification Success			
		Priors Equal[3]		Priors Proportional[4]	
		Minimum	Maximum	Minimum	Maximum
Level I	50%	77.4%	84.5%	82.6%	85.4%
(2)[1]		II-F/III-G	III-G	II-F/V-G	II - G
Level II	25%	44.7%	53.9%	55.9%	64.8%
(4)[1]		II-F	II-G	V-F	III-G
Level III	16.7%	36.7%	45.6%	40.8%	48.8%
(6)[1]		I-G	IV-G	I-G	IV-G
Level IV	12.5%	29.5%	35.0%	32.9%	40.8%
(8)[1]		III-F	II-G	I-G	V-G

[1] Number of forest community types in the analysis.
[2] Expected success rate if model had no discriminatory ability.
[3] Prior probability of group membership based on number of forest community types.
[4] Prior probability of group membership based on proportion of plots in each forest community type.

often the analyses with GRASS data passed the test for equal variance-covariance matrices among community types, allowing the use of the pooled matrix in the discriminant analysis. Field data more often failed that test, requiring the use of the within-class matrices and reducing the power of the analysis. Using proportional prior probabilities always increased classification success. No topographic index consistently provided the highest rate of successful classification.

Examination of distances between group centroids indicated that the discriminant function had the most difficulty distinguishing between Birch-Hemlock and Basswood-Birch communities and between Chestnut Oak-Black Oak and Chestnut Oak-Red Oak. Although distinct vegetationally, both pairs overlap considerably in environmental range. Of all the community types, the Chestnut Oak-Black Oak forest showed little association with the environmental gradients.

V. DISCUSSION

Topographic Index Model Effectiveness

The topographic index appears to serve as an objective, quantitative measure of landscape structure. It accurately modeled the variation in landforms throughout the study area. Plot index values corresponded well with conditions observed in the field; higher values of the index characterized areas with mesic conditions, often along temporary or permanent drainages, while lower values of the index characterized areas with xeric conditions, most often on open exposed slopes or on ridge tops. The five different models shifted the overall index distribution but preserved the relative rankings of areas according to the pattern described above. Consequently the topographic index could serve as a viable metric of Whittaker's "moisture complex", which in turn represents a more complex mixture of site hydrology, soils, and mircoclimate.

Forest Community Types

Relation to Other Studies

The eight forest community types identified in the field study strongly agree with other studies performed in

the southern Appalachians. At the broadest level, the communities fit well within the Mixed Mesophytic and Appalachian Oak communities of Küchler (Stephenson et al. 1993). The oak forests also represent the replacement of the Oak-Chestnut forest of Braun (1950) based on the abundance of *C. dentata* saplings and small trees encountered in the study. The forest types also fall within Vankat's (1990) classification system of North American forest types and represent subtypes of the Beech-Maple and Oak-Hickory forests of Monk et al. (1989).

The results remain consistent at lower levels within these associations. The Mixed Mesophytic forests subdivide along traditional lines into mixed hardwoods dominated by *T. heterophylla*, *Betula* spp., *Aesculus octandra*, and *A. saccharum*. and a *T. canadensis-Betula-Rhododendron* community type. McNab and Browning (1992) in a study of the Wine Spring watershed in the Nantahala National Forest also found these types, although they saw a greater elevation separation between them than I observed. Gattis et al. (1992) in a study of forest types on the Highlands Range District, which includes a portion of the present study area, identified mid-elevation, mesic forests dominated by *Q. rubra*, *T. canadensis*, and *Betula* spp. and an upper elevation mesic forest dominated by *T. canadensis*, *Q. rubra*, *A. rubrum*, and *Q. prinus*. They did not observe a mixed

Mesophytic forest with a strong *T. heterophylla* presence. Finally, the Tuliptree community found in this study was not present in these other studies.

In the present study, the oak forests organized in the following manner:

1) White Oak-Black Oak
2) Red Oak-Hickory
3) Chestnut Oak-Mixed Oak
    a) Chestnut Oak
    b) Chestnut Oak-Red Oak
    c) Chestnut Oak-Black Oak

These results agree less strongly with other studies. Gattis et al. (1992) identified four oak communities: mid elevation oak-hickory, mid-elevation scarlet oak, high elevation red oak-white-oak hickory, and high elevation scarlet oak-white oak-heath. However, chestnut oak is a codominant of both mid-elevation forests. Therefore the types identified in their study may merely represent localized subgroups of the overall chestnut oak dominated forest found in this study. Additionally, their high elevation communities may represent local subgroups of this study's white oak-black oak forest. Pittillo and Smathers (1979), in their study of the Balsam Mountains and Pisgah Ridge north of the study area, found similar vegetation types, with red oak dominated communities situated on more

mesic sites grading to chestnut oak- and white oak-dominated communities on more xeric sites.

Relation to Environmental Gradients

Overall forest community types delineated by the TWINSPAN analysis correlate strongly with topographic index, elevation, and aspect. They exhibit typical behavior relative to the topographic and elevation gradients; communities rise, peak, and decline in abundance at different locations along the gradients with overlapping areas representing transition zones (Causton, 1988). The discriminant analysis demonstrated that topographic index, elevation, and aspect are important environmental variables contributing to community variation, although this variation undoubtedly stems mostly from environmental tolerances of individual species.

Topographic index has the strongest relationship, with all eight community types being normally distributed along this gradient (see Appendix 5). Larger sample sizes could increase normality related to this parameter. The oak forests, except chestnut oak-black oak, and tuliptree forests correlate similarly with elevation, although the white oak-black oak forest shows a truncated distribution implying that the highest elevations in the study area only fall in the middle of its distribution (see also Table 4, p. 41). The chestnut-oak forest, birch-hemlock, and basswood-

birch forests occur more uniformly along elevations, although the basswood-birch forest shows a peak near 1190 m.

Aspect and slope proved less capable factors in discriminating forest cover types. Generally, most types showed an overall preference between N-NE directions, usually mesic sites, and S-SW facing directions, usually xeric sites. The exceptions to this general rule were birch-hemlock, chestnut oak-red oak, and tuliptree. Birch-hemlock and chestnut oak-black oak had a more uniform distribution while tuliptree forests, found on more mesic site, favored southern instead of northern aspects.

Forest Distribution Model

The discriminant analysis proved highly successful at predicting two forest cover types. The addition of additional cover types caused a steady decline in the predictive power of the analysis. Several factors or combination of factors may account this trend including the nature of the process under study, deficiencies in experimental design, and inadequate statistical tests. The following discussion will highlight some of the major difficulties encountered during this work, which point to potential problem areas in trying to generate a simple model to predict something as highly complex as forest community distribution. The order of the topics follows the order in

which they appeared throughout the thesis to provide conceptual continuity to the reader.

The topographic index model could be improved in two specific manners. First modifying the shape of the generating model for the topographic index could alter the range of values generated. For example, a negative sigmoid function would tend to flatten out the normal distribution given by the linear function. Second, the model could include relative slope differences between cells. As the model exists now, a cell with a maximum index value could be nearly flat to a steeply side depression. This modification would make the model closer to the terrain shape index of McNab (1989). The primary purpose would be to increase potential differences among plots, i.e. use as much of the index gradient as possible to help distinguish among community types.

Data resolution may also have affected the results. Because field plots cover just 1.2% (100 m^2 of 8100 m^2) of the cell size used in the analysis, recorded values and GIS values of environmental variables differ. These differences between field data and GIS data will depend on how the plot falls within the cell. Closer agreement could be expected if the plot falls closer to the center of the cell, where the data approximated by GIS algorithms might better reflect field data. Additionally, a resolution of 90 x 90 m may be too small to capture the marked changes in topography common

to the southern Appalachian mountains. This will be compounded even further when calculating the topographic index as the area of analysis increases. Not only will the relative plot/cell errors be compounded but aspect errors, which could be significant in GIS data (Bolstad and Stowe 1994), will also be compounded.

The field study methods may have been inadequate. The 10 x 10 m plot size and relative density data may not fully represent canopy composition. A larger plot size may increase the proportional representation of dominant species, particularly canopy individuals, thereby increasing their importance during classification and assuring more coherent groups. Measuring basal areas, a common field measurement, may provide similar effects. However, more extensive field measurements requires more time in the field. I designed the study with the goal of rapidly surveying a large watershed and made tradeoffs between time and quality/quantify of data gathered. Despite the potential drawbacks mentioned, the method successfully produced an ecologically viable set of community types.

The community classification represents a critical step in the process because the community types identified become 1) the focus of the discriminant analysis and 2) the ecological units assigned to the GIS database. Although TWINSPAN objectively classifies major community types, it permits adjustment of several parameters that does not

affect the overall classification but will affect the final placement of transitional plots (Hill 1979). This problem will increase as the number of plots increases because more transitional and therefore difficult to classify sites will be represented. This may explain the lack of success in the present study compared to those of Gattis et al. (1992) and McNab and Browning (1992). They used a small set of physical variables to classify sites and had much higher success rates, even up to 90%. However, they typically only surveyed 40-60 sites. Consequently their groups generally had 8-10 members and may have underrepresented transitional sites.

The model may lack enough variables to successfully distinguish among forest cover types. Although four variables are used, only three contribute significantly to the discriminant function. Three variables may not provide enough variation to discriminate among the eight community types. The model may require additional variables to increase classification success rates above 60% for more than 2 cover types. For example, the model had a difficult time distinguishing Basswood-Birch from Birch-Hemlock and Chestnut Oak-Red Oak from Chestnut Oak-Black Oak. These two pairs of communities overlapped strongly along environmental gradients related to the variables used in this study. Other variables (e.g., soils, other landform variables, disturbance regime) could provide a means for further

separating these pairs and increasing classification success.

Soil characteristics seem likely candidates to improve model success. For example, Gattis et al (1992) and Yoke (1994) identified certain soil characteristics as important predictors of forest composition. However, reliable plot soil information generally is not readily available. In one study McNab (1991) included variables from digitized soils maps and found that they did not contribute significantly to forest prediction. He attributed their failure to the highly complex soils in the Appalachian Mountains. Most soil map units consisted of complexes of soil types which makes it difficult, if not impossible, to assign specific edaphic conditions to a given location.

McNab (1993) has developed another potentially useful measure, a landform index, that forms an important component in land cover classification in several studies (Gattis et al. 1992, McNab and Browning 1992, Yoke, 1994). Basically, the landform index quantifies the degree of protection from direct sun, wind, etc. that an area receives from surrounding land masses. A GIS could readily calculate this measure.

One major deficiency of the model is that it currently does not consider disturbance regimes. Disturbance patterns could affect forest composition in several ways including preventing development of slow-growing but dominant species;

maintaining higher abundance of early successional species linked more to successional processes than environmental gradients; or altering environmental conditions so severely that they can no longer support the natural community. In the study area, timber harvesting is the dominant disturbance regime affecting forest communities. Information on stand age, serving as a surrogate for successional stage, could provide further information for clarifying differences and similarities among plots. I did not gain access to that data until late in the study and therefore could not include it.

A final consideration, also related to disturbance, is the scale at which the model attempts to operate. The large success in predicting two cover types reflects the broad scale across which those cover types apply. Reducing cover type specificity will mask the underlying variability in disturbance, soils, and other site specific conditions because by definition a larger set of species is represented. Broad scale relationships, like those with elevation and topography, become more important. Conversely, increasing specificity of community types reduces the number of species represented and increases the number of factors that influence local composition. Finer scale processes, like soils, light availability, proximity to seed sources, invasion sequence, etc. increase in importance. These often prove difficult to measure over

broad scales and may effectively limit the resolution of cover type data to four or six cover types.

The topographic index represents a quick, effective, and objective means for describing a complex environmental feature important to forest community composition. While the index may represent a necessary component for predicting forest cover distributions, it is by no means sufficient. Additional measures must be developed before GIS modeling of forest cover distributions becomes reliable enough to successfully contribute to ecosystem management.

I will finish by presenting a conceptual map of forest cover types for the Little Tennessee River watershed (Figure 10). This map highlights both the successes and the failures of this research. It shows the effectiveness of the topographic index in actually modeling the subjective "moisture complex". I drew this map by locating lines around the major concentrations of forest cover types. The very fact that some coherent picture of forest distribution can be made using the index is promising. It also points to *Q. prinus* as the primary successor to chestnut in this area. The topographic index could serve as another parameter in quantitatively assessing whether *Q. prinus* is the primary successor to *C. dentata*.

The problems encountered in the study are also evident in the this map. First the map purposefully avoids clearly

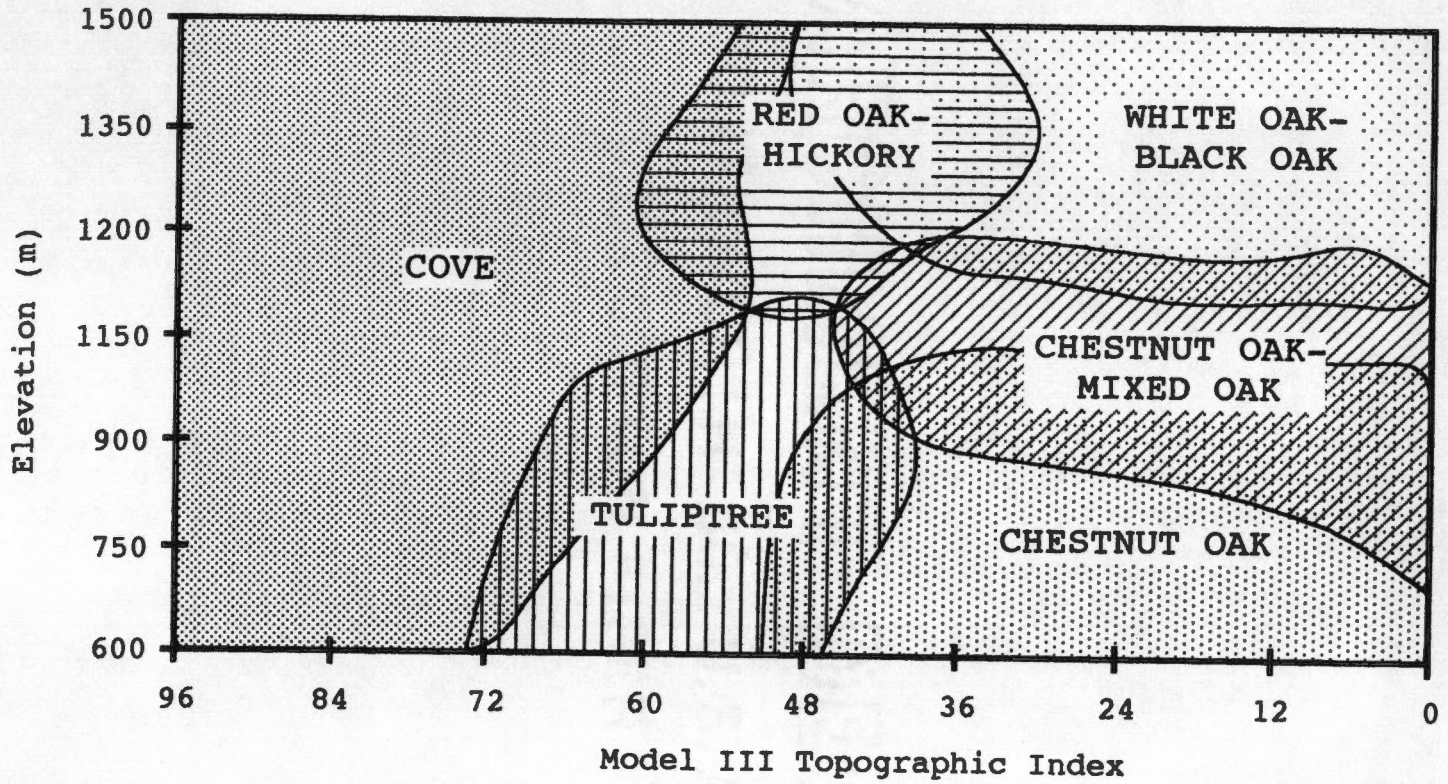


Figure 10: Conceptual forest community map for the Little Tennessee River watershed, western North Carolina.

separating community types. The overlap exists on the map because it exists in the field. We must use any GIS derived measure of forest cover distribution with caution because ultimately we merely approximate a very complex situation. Managers and researchers must understand to what extent they trade accuracy for ease of use and how subsequent results are affected. Second the map shows that the topographic index needs further development. In the particular model used, large areas to either end go unused. As discussed above, modifications to the index that could further separate the data may prove more fruitful for predictive purposes. As it looks now, a veritable "forest jam" exists near the center of the map.

Lastly there are many potential benefits to performing ecosystem management if the index and classificatory procedure can be improved satisfactorily. This process would allow quick and rapid classification of large tracts of land, which would prove extremely beneficial in areas with many landowners with small landholdings, as occurs in the study area (Flamm and Turner 1994). Potential habitat maps could be developed for a wide variety of plant and animal species and methods developed to identify common factors needed to manage many species simultaneously. Experimental manipulation of the topographic index could provide a method to model coarse-scale processes, e.g. global warming, affecting the entire watershed. Distributions of present

forest cover types, such as defined by this study, could be compared to expected or more natural conditions to examine what less obvious changes may be taking place and what their consequences might be. Overall, the index could provide an objective new tool for asking quantitative questions about coarse scale processes and problems.

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APPENDICES

APPENDIX 1: ENVIRONMENTAL DATA FOR SURVEYED PLOTS AND SAMPLING DATA SHEET

Plot #	Longitude	Latitude	Quad Sheet	Elevation (meters)		Aspect Class		Slope (degrees)		Community Type*	Topographic Index				
				Field	GRASS	Field	GRASS	Field	GRASS		I	II	III	IV	V
1	83:26:33.50	35:11:13.80	Franklin	823	797	22	22	45	9	4	67.4	52.3	30	12.4	2.4
2	83:30:21.50	35:11:08.70	Wayah Bald	1082	1064	25	2	5	26	7	44.6	34.1	17	8.0	2.1
3	83:30:13.50	35:10:38.50	Wayah Bald	1006	973	1	1	35	17	7	68.1	56.2	40	23.4	10.7
4	83:29:55.90	35:11:09.80	Franklin	1006	983	19	18	45	18	7	79.4	67.5	52	34.0	16.0
5	83:29:56.10	35:11:02.25	Franklin	930	924	19	19	5	18	3	92.0	84.3	76	60.6	39.8
6	83:26:08.25	35:10:55.70	Franklin	739	743	20	21	45	23	4	78.2	63.8	45	24.4	6.0
7	83:30:50.20	35:11:16.80	Wayah Bald	1173	1132	25	21	5	25	6	30.5	22.4	9	3.1	0.8
8	83:30:58.20	35:11:18.10	Wayah Bald	1091	1085	8	9	45	8	3	81.6	69.4	54	34.7	13.0
9	83:30:11.10	35:11:16.10	Wayah Bald	914	923	7	7	15	25	2	83.7	74.4	63	47.9	31.9
11	83:30:49.00	35:10:04.30	Wayah Bald	725	737	22	2	45	11	4	87.3	78.2	67	52.1	36.8
12	83:30:55.75	35:10:00.80	Wayah Bald	829	801	25	24	5	18	7	49.8	40.2	26	14.9	5.5
13	83:26:15.50	35:11:02.90	Franklin	829	797	25	20	5	9	4	57.5	44.7	25	12.5	3.5
14	83:26:12.25	35:11:15.60	Franklin	823	813	13	15	40	12	4	58.7	48.7	34	22.7	14.3
15	83:26:36.90	35:11:26.60	Franklin	914	894	20	21	45	20	4	57.2	45.4	28	15.0	5.5
16	83:27:04.80	35:11:22.70	Franklin	1013	969	25	21	0	24	4	25.2	18.8	8	2.8	0.6
17	83:26:56.50	35:11:19.20	Franklin	914	869	21	22	40	24	3	69.7	58.0	43	25.4	7.9
18	83:26:51.00	35:10:54.20	Franklin	823	819	24	1	20	11	3	79.9	68.7	54	37.2	20.3
19	83:26:57.00	35:10:46.70	Franklin	914	890	25	6	5	25	7	49.2	37.3	19	8.0	1.8
20	83:26:51.90	35:10:41.80	Franklin	823	824	22	22	30	15	3	84.4	73.4	60	41.7	20.2
21	83:26:27.10	35:11:31.25	Franklin	917	877	22	21	40	29	4	75.0	64.4	50	34.2	15.0
22	83:25:33.70	35:11:05.00	Franklin	1010	972	25	3	5	29	4	50.5	37.9	18	6.6	1.4
23	83:25:39.80	35:11:32.75	Franklin	914	925	3	5	30	19	3	82.9	72.1	58	41.8	25.6
24	83:26:11.10	35:11:29.30	Franklin	914	891	20	23	10	13	3	68.7	59.3	47	33.1	19.3
25	83:26:23.60	35:11:43.80	Franklin	823	834	6	6	10	22	1	86.2	74.8	61	42.1	20.8
26	83:26:48.30	35:11:29.60	Franklin	823	828	10	11	10	21	3	80.8	70.5	57	41.1	23.5
27	83:27:12.80	35:11:17.75	Franklin	914	911	15	15	45	24	4	73.1	61.0	46	26.6	7.0
28	83:27:18.50	35:11:12.70	Franklin	823	814	16	16	25	16	4	83.6	74.4	63	47.9	32.2
29	83:27:26.70	35:11:01.90	Franklin	732	740	16	17	40	22	2	92.8	84.6	76	59.6	36.4
30	83:27:12.60	35:10:54.75	Franklin	823	809	13	10	10	20	7	68.6	56.8	40	25.3	12.1
31	83:27:46.10	35:11:31.90	Franklin	1103	1045	25	22	0	26	3	57.3	43.4	22	8.9	2.0
32	83:28:00.50	35:11:49.50	Franklin	991	961	1	1	45	9	7	69.7	59.8	47	32.1	17.2
33	83:27:55.70	35:11:57.20	Franklin	920	898	6	1	35	15	7	69.3	59.5	47	31.7	14.4
34	83:27:43.00	35:12:02.25	Franklin	826	820	21	3	40	20	1	88.1	78.0	66	48.6	28.9
35	83:27:33.20	35:12:11.10	Franklin	732	750	24	10	10	22	3	79.9	72.3	64	49.4	29.9
36	83:26:08.00	35:12:04.25	Franklin	732	739	7	5	30	12	4	71.6	57.2	37	18.3	3.9
37	83:26:21.60	35:11:45.40	Franklin	823	817	5	5	30	26	2	76.5	63.9	47	28.7	9.8
38	83:26:35.70	35:12:06.75	Franklin	844	826	7	2	40	27	4	68.8	54.7	35	17.7	4.0
39	83:29:49.00	35:11:11.00	Franklin	1006	988	2	2	30	22	4	64.2	52.4	36	20.0	6.4
40	83:29:09.90	35:11:13.80	Franklin	1091	1050	13	17	15	25	7	41.8	30.6	12	4.1	1.1

Plot #	Longitude	Latitude	Quad Sheet	Elevation (meters)		Aspect Class		Slope (degrees)		Community Type*	Topographic Index				
				Field	GRASS	Field	GRASS	Field	GRASS		I	II	III	IV	V
41	83:29:02.90	35:11:27.10	Franklin	1006	986	21	22	20	15	3	84.4	75.6	65	49.5	31.4
42	83:29:14.75	35:11:23.10	Franklin	1006	1013	14	13	15	12	4	76.6	63.4	46	27.4	8.9
43	83:25:59.10	35:12:19.70	Franklin	716	726	16	15	10	19	6	84.8	73.9	60	42.6	23.8
44	83:28:42.10	35:10:43.60	Franklin	719	744	20	19	10	9	3	80.7	73.6	66	51.6	32.0
45	83:28:53.10	35:10:55.00	Franklin	808	835	19	13	5	22	3	76.3	63.8	47	28.9	9.9
46	83:29:06.30	35:10:59.80	Franklin	914	895	13	16	25	24	7	56.6	45.7	28	18.5	13.5
47	83:30:45.70	35:11:14.25	Wayah Bald	1097	1094	21	20	40	25	4	70.9	57.7	39	22.6	10.6
48	83:31:10.00	35:11:10.75	Wayah Bald	1085	1103	20	21	30	23	3	78.0	66.6	51	35.4	21.6
49	83:31:08.60	35:11:03.10	Wayah Bald	1000	1014	22	21	15	19	4	81.7	69.4	54	34.9	14.8
50	83:30:33.10	35:11:06.70	Wayah Bald	1009	994	17	18	35	17	4	84.7	72.7	58	38.2	16.2
51	83:28:03.10	35:10:52.00	Franklin	732	728	17	17	15	17	8	64.9	54.2	40	26.1	12.6
52	83:28:00.90	35:11:15.25	Franklin	908	875	25	13	0	23	7	40.3	30.9	17	7.1	1.5
53	83:27:53.40	35:11:18.00	Franklin	914	893	11	18	25	23	4	73.7	61.0	43	26.9	14.9
54	83:28:05.00	35:11:07.60	Franklin	817	832	18	15	35	28	4	64.0	51.5	33	19.5	10.1
55	83:27:55.60	35:10:50.25	Franklin	732	757	14	16	10	8	4	80.2	66.4	49	28.2	7.1
56	83:32:34.90	35:10:21.25	Wayah Bald	920	970	24	20	40	27	1	88.3	80.7	72	58.5	42.3
57	83:32:37.50	35:10:33.20	Wayah Bald	1000	1024	24	1	10	2	1	91.0	82.5	73	57.5	38.7
58	83:32:20.60	35:10:46.70	Wayah Bald	1189	1175	21	19	20	17	6	62.0	49.3	30	17.2	9.6
59	83:32:08.30	35:10:46.90	Wayah Bald	1097	1074	24	23	35	19	4	79.9	66.4	49	29.0	9.3
60	83:31:26.80	35:11:08.75	Wayah Bald	1195	1144	25	10	5	17	8	66.5	52.6	33	16.8	3.9
61	83:31:52.90	35:11:24.50	Wayah Bald	1006	1020	22	3	10	11	3	85.2	72.9	58	37.4	12.6
62	83:31:36.90	35:11:40.00	Wayah Bald	930	933	1	3	10	7	3	88.4	78.0	66	47.4	25.4
63	83:32:52.20	35:08:55.90	Wayah Bald	914	956	5	2	15	16	1	86.0	75.1	62	43.6	22.8
64	83:32:52.80	35:08:39.20	Wayah Bald	1006	1022	25	6	0	23	3	84.5	74.0	61	44.4	27.3
65	83:33:01.70	35:09:15.50	Wayah Bald	1097	1092	7	2	50	31	7	48.6	36.6	18	7.3	1.6
66	83:33:39.60	35:08:48.00	Wayah Bald	1097	1131	24	5	50	32	2	92.4	83.9	75	58.1	35.9
68	83:33:38.90	35:08:30.80	Wayah Bald	1372	1376	7	4	40	25	6	70.6	58.8	42	28.0	16.2
69	83:33:27.60	35:08:36.40	Wayah Bald	1280	1286	6	2	15	10	7	66.5	53.9	36	20.0	5.2
70	83:33:25.40	35:08:45.40	Wayah Bald	1189	1201	6	4	35	29	7	63.7	50.4	31	16.1	4.2
71	83:34:14.10	35:09:17.10	Wayah Bald	1097	1109	10	5	40	21	2	74.7	62.1	45	27.4	10.4
72	83:34:16.50	35:09:09.90	Wayah Bald	1189	1207	8	6	20	34	2	80.3	69.7	56	41.0	25.6
73	83:34:16.70	35:09:04.75	Wayah Bald	1280	1305	8	7	50	30	2	73.8	64.2	52	37.4	23.6
74	83:30:04.10	35:04:40.75	Rainbow Spgs	1189	1220	3	4	35	29	2	75.8	63.2	46	28.0	10.5
75	83:30:08.90	35:04:59.00	Rainbow Spgs	1097	1119	4	4	40	29	5	66.5	54.1	36	21.5	10.5
76	83:31:44.60	35:08:19.60	Wayah Bald	1113	1134	21	21	10	17	2	73.2	62.5	49	31.5	12.0
77	83:31:51.90	35:07:57.80	Wayah Bald	1091	1087	19	20	40	29	7	60.6	49.6	33	20.7	13.7
78	83:31:55.10	35:08:09.70	Wayah Bald	1170	1163	16	16	35	16	3	56.9	47.5	34	22.4	14.3
79	83:32:11.20	35:08:10.40	Wayah Bald	1180	1205	17	20	25	26	3	78.2	66.7	52	34.5	16.1
80	83:32:54.50	35:08:06.20	Wayah Bald	1280	1296	5	6	15	19	5	77.5	69.1	59	43.9	25.7

Plot #	Longitude	Latitude	Quad Sheet	Elevation (meters)		Aspect Class		Slope (degrees)		Community Type*	Topographic Index				
				Field	GRASS	Field	GRASS	Field	GRASS		I	II	III	IV	V
81	83:32:50.40	35:08:12.10	Wayah Bald	1280	1271	11	12	15	20	5	76.6	67.7	57	42.1	25.7
82	83:32:47.75	35:08:20.40	Wayah Bald	1280	1282	9	11	10	16	5	53.0	43.4	30	17.7	6.3
83	83:32:26.50	35:08:36.00	Wayah Bald	1268	1239	10	12	5	19	7	46.6	35.9	20	8.8	1.9
84	83:34:18.90	35:08:53.10	Wayah Bald	1448	1435	20	21	5	14	6	48.3	37.3	21	9.0	1.7
85	83:34:29.25	35:08:40.30	Wayah Bald	1463	1477	4	3	25	25	6	73.5	60.6	43	25.4	8.4
86	83:34:41.00	35:08:49.00	Wayah Bald	1463	1467	5	4	20	22	2	81.5	70.3	56	38.7	19.3
87	83:34:36.00	35:08:55.60	Wayah Bald	1372	1393	4	5	5	19	1	86.0	74.8	61	42.9	25.3
88	83:33:54.20	35:08:54.25	Wayah Bald	1372	1377	2	23	40	27	6	75.4	63.4	47	30.3	13.8
89	83:33:34.40	35:10:29.25	Wayah Bald	1463	1471	24	22	30	31	6	49.7	40.0	26	14.8	5.5
90	83:33:23.50	35:10:14.00	Wayah Bald	1378	1367	4	4	5	15	6	50.2	37.6	18	6.7	1.5
91	83:33:20.50	35:10:36.60	Wayah Bald	1280	1281	20	21	50	20	8	81.3	70.6	57	39.5	19.7
92	83:33:24.50	35:10:39.60	Wayah Bald	1372	1359	19	21	55	30	8	77.0	64.6	48	29.8	11.1
93	83:33:29.00	35:10:42.90	Wayah Bald	1463	1486	19	21	40	31	8	70.2	58.4	42	26.9	12.6
94	83:33:45.60	35:10:05.75	Wayah Bald	1097	1126	17	21	15	22	3	87.3	79.2	69	56.1	43.3
95	83:33:51.30	35:10:13.80	Wayah Bald	1189	1219	2	23	50	12	2	86.3	78.8	70	56.2	38.2
96	83:33:59.40	35:10:16.40	Wayah Bald	1280	1304	3	24	45	27	2	81.3	70.3	56	40.1	24.8
97	83:34:13.80	35:10:09.75	Wayah Bald	1372	1403	2	22	40	36	1	79.3	67.1	51	33.4	16.0
98	83:34:11.25	35:10:01.80	Wayah Bald	1189	1177	22	21	25	17	3	85.0	74.6	62	44.3	22.6
99	83:33:36.60	35:11:05.80	Wayah Bald	1463	1491	6	8	10	16	1	80.5	68.8	54	35.6	16.2
100	83:33:37.50	35:11:16.70	Wayah Bald	1359	1397	9	8	55	24	1	83.0	71.9	58	40.7	23.0
101	83:32:57.00	35:11:05.50	Wayah Bald	1283	1310	10	5	40	16	5	82.4	70.4	55	36.3	16.8
102	83:32:20.90	35:11:17.30	Wayah Bald	1268	1249	7	7	5	28	6	51.8	39.1	19	7.0	1.4
103	83:32:18.50	35:11:27.25	Wayah Bald	1204	1193	6	6	5	27	6	63.0	50.6	32	18.8	10.0
104	83:32:50.50	35:11:28.25	Wayah Bald	1213	1177	8	5	5	27	8	44.5	34.4	19	8.4	1.8
105	83:32:55.80	35:11:27.50	Wayah Bald	1183	1180	7	7	35	17	1	59.5	47.1	29	14.1	3.1
106	83:33:07.80	35:11:24.25	Wayah Bald	1277	1272	3	6	5	19	7	57.0	46.0	30	18.3	9.9
107	83:33:31.80	35:13:47.75	Wayah Bald	1463	1449	1	1	30	32	6	81.7	71.3	58	41.4	23.1
108	83:33:24.90	35:13:48.20	Wayah Bald	1372	1354	20	23	45	21	6	85.9	75.7	63	46.3	28.2
109	83:33:09.20	35:13:56.70	Wayah Bald	1372	1358	23	23	25	12	6	63.0	51.6	36	22.1	10.9
110	83:33:15.60	35:14:02.25	Wayah Bald	1463	1475	23	22	20	29	6	69.2	56.6	39	22.6	7.4
111	83:32:59.60	35:14:20.80	Wayah Bald	1448	1440	25	9	0	24	6	38.1	28.1	12	4.3	1.1
112	83:32:28.90	35:14:27.50	Wayah Bald	1372	1386	8	5	35	31	7	64.3	51.1	32	16.8	4.4
113	83:32:28.40	35:14:00.50	Wayah Bald	1280	1258	25	22	0	25	8	54.6	42.7	25	11.8	2.5
114	83:32:23.50	35:13:52.70	Wayah Bald	1225	1182	25	19	0	18	8	58.7	45.4	25	11.2	2.4
115	83:20:14.70	35:05:04.30	Scaly Mtn	823	818	13	15	35	24	3	74.3	61.4	44	26.1	8.6
116	83:20:15.00	35:05:13.80	Scaly Mtn	823	823	16	13	5	29	3	76.4	67.2	56	40.4	22.8
117	83:20:08.20	35:05:03.60	Scaly Mtn	914	897	15	16	40	28	4	69.7	57.5	40	26.0	15.2
118	83:20:03.20	35:05:11.25	Scaly Mtn	1006	980	20	21	20	21	4	49.4	40.6	27	18.2	13.3
119	83:19:44.50	35:06:03.50	Scaly Mtn	1189	1162	9	17	5	24	3	65.6	51.1	30	13.6	2.8

Plot #	Longitude	Latitude	Quad Sheet	Elevation (meters)		Aspect Class		Slope (degrees)		Community Type*	Topographic Index				
				Field	GRASS	Field	GRASS	Field	GRASS		I	II	III	IV	V
120	83:19:25.25	35:06:33.25	Scaly Mtn	1280	1271	20	16	2	16	6	46.4	34.8	16	5.9	1.3
121	83:19:36.10	35:06:42.00	Scaly Mtn	1192	1184	8	13	15	20	5	65.4	52.2	33	18.2	6.3
122	83:19:27.00	35:06:22.40	Scaly Mtn	1189	1188	16	15	20	19	6	76.8	65.8	51	36.2	23.2
123	83:19:25.20	35:06:17.20	Scaly Mtn	1189	1199	13	14	20	25	3	80.4	70.3	57	41.9	26.8
124	83:20:58.10	35:05:24.60	Scaly Mtn	1103	1084	4	23	2	30	6	48.1	36.1	17	6.5	1.4
125	83:21:28.20	35:05:20.25	Scaly Mtn	1018	992	18	20	2	24	4	42.2	31.3	13	4.6	1.1
126	83:21:59.90	35:05:04.25	Scaly Mtn	732	752	15	15	10	19	4	86.9	77.5	66	49.4	29.3
127	83:21:25.10	35:05:15.40	Scaly Mtn	908	908	15	17	40	21	4	79.3	68.6	54	39.3	26.0
128	83:21:22.10	35:05:17.00	Scaly Mtn	914	954	18	17	15	26	3	70.3	60.7	47	34.1	21.5
129	83:19:54.40	35:04:37.80	Scaly Mtn	732	727	20	21	35	10	7	66.5	55.1	40	23.6	6.6
130	83:19:55.60	35:04:46.70	Scaly Mtn	838	811	20	22	20	25	4	62.6	50.2	33	17.7	4.7
131	83:19:58.30	35:05:00.60	Scaly Mtn	920	913	25	20	0	22	7	56.1	45.2	30	15.6	3.9
132	83:19:32.80	35:05:37.75	Scaly Mtn	1094	1079	17	17	10	21	7	48.4	38.0	23	11.3	2.7
133	83:19:30.20	35:05:46.20	Scaly Mtn	1097	1094	15	13	20	15	3	66.8	55.3	40	23.2	7.4
134	83:19:36.30	35:05:49.90	Scaly Mtn	1097	1079	13	16	35	17	3	78.5	67.6	53	37.1	20.6
135	83:19:47.50	35:06:03.50	Scaly Mtn	1006	1002	18	15	50	16	3	85.2	75.1	63	46.4	28.6
136	83:19:44.30	35:05:24.40	Scaly Mtn	1006	1009	18	21	10	22	4	79.7	66.8	50	30.9	11.3
137	83:19:42.60	35:04:51.25	Scaly Mtn	732	735	16	15	1	20	2	90.5	81.8	72	56.2	39.3
138	83:19:33.40	35:05:11.30	Scaly Mtn	829	835	17	14	5	25	1	86.7	77.7	67	52.4	36.7
139	83:19:22.40	35:05:21.60	Scaly Mtn	914	940	15	15	50	22	1	85.7	77.1	67	50.9	29.7
140	83:19:38.80	35:05:28.00	Scaly Mtn	1006	1024	16	18	5	22	3	68.5	58.9	46	32.2	18.8
141	83:18:23.40	35:12:18.40	Corbin Knob	914	900	25	16	0	17	4	39.9	29.2	11	3.7	1.0
142	83:15:55.80	35:02:51.40	Scaly Mtn	1381	1379	25	17	0	22	6	29.9	22.2	9	3.1	0.7
143	83:16:10.75	35:02:53.20	Scaly Mtn	1280	1284	10	10	25	20	5	68.9	55.7	37	20.9	7.0
144	83:16:10.75	35:02:42.90	Scaly Mtn	1280	1290	12	13	20	18	5	71.2	60.2	46	29.2	13.0
145	83:16:13.50	35:02:33.30	Scaly Mtn	1280	1285	7	9	10	6	1	70.5	57.4	39	22.4	6.5
146	83:12:24.30	35:07:35.20	Glenville	1109	1116	11	17	7	8	1	92.0	83.3	74	57.0	36.2
147	83:12:26.80	35:07:52.90	Glenville	1189	1189	14	15	2	10	1	84.8	74.2	61	43.5	24.1
148	83:12:13.60	35:08:27.20	Glenville	1280	1292	22	20	15	12	5	85.2	74.0	60	42.2	25.2
149	83:12:11.80	35:08:36.60	Glenville	1372	1384	22	19	40	24	5	72.1	62.4	50	35.3	20.0
150	83:12:16.80	35:08:41.50	Glenville	1463	1435	21	20	25	21	6	74.9	62.3	45	27.7	12.4
151	83:12:04.50	35:06:47.20	Highlands	1372	1363	10	11	40	11	5	62.4	49.4	31	15.0	3.3
152	83:10:46.40	35:06:34.40	Highlands	1463	1495	9	8	30	18	5	66.5	52.8	33	17.3	4.7
153	83:10:57.80	35:06:39.00	Highlands	1372	1382	9	7	25	27	1	74.2	64.4	52	36.4	20.1
154	83:11:06.75	35:06:27.10	Highlands	1469	1453	14	15	30	34	5	70.8	56.7	37	19.2	4.6
155	83:11:13.10	35:06:35.40	Highlands	1494	1475	25	2	0	9	6	45.5	35.9	21	11.7	4.9
156	83:21:22.00	35:16:40.50	Greens Creek	823	816	25	17	0	20	7	49.4	39.3	23	14.0	9.0
157	83:21:12.70	35:16:52.80	Greens Creek	823	827	17	16	25	21	4	84.9	74.9	62	46.8	31.5
158	83:21:15.30	35:16:41.70	Greens Creek	732	761	1	24	40	12	3	88.3	77.1	64	44.0	20.5

Plot #	Longitude	Latitude	Quad Sheet	Elevation (meters)		Aspect Class		Slope (degrees)		Community Type*	Topographic Index				
				Field	GRASS	Field	GRASS	Field	GRASS		I	II	III	IV	V
159	83:21:16.00	35:16:32.50	Greens Creek	744	725	21	22	15	15	8	64.5	54.1	40	25.5	9.3
160	83:21:28.20	35:16:52.20	Greens Creek	829	821	15	17	35	22	5	80.9	69.8	55	39.4	25.9
161	83:32:40.50	35:14:43.75	Wayah Bald	1103	1122	4	7	20	33	2	87.2	77.8	67	50.4	31.1
162	83:32:54.70	35:14:36.20	Wayah Bald	1192	1202	1	1	20	29	2	87.6	78.9	69	53.6	35.9
163	83:33:18.80	35:14:25.75	Wayah Bald	1280	1322	3	4	15	29	2	87.4	77.7	66	49.8	32.8
164	83:33:19.25	35:14:20.60	Wayah Bald	1372	1394	24	7	35	26	2	85.0	76.4	66	51.4	33.4
165	83:33:26.40	35:14:13.70	Wayah Bald	1463	1497	5	4	20	23	2	82.4	72.5	60	43.8	24.4
166	83:33:19.10	35:14:38.80	Wayah Bald	1463	1444	3	23	30	32	6	59.8	47.8	30	15.8	5.5
167	83:33:06.50	35:14:48.80	Wayah Bald	1408	1401	25	9	0	24	6	50.2	37.6	18	6.7	1.5
168	83:21:32.90	35:18:10.50	Greens Creek	756	750	25	19	0	18	3	85.9	76.5	66	48.6	25.0
169	83:21:09.00	35:18:31.75	Greens Creek	820	830	15	13	5	4	1	89.2	78.3	66	46.2	23.3
170	83:21:05.50	35:10:16.00	Greens Creek	914	920	15	18	10	22	1	87.3	78.3	68	51.9	32.2
171	83:20:44.50	35:19:08.50	Greens Creek	1003	1021	15	10	20	27	1	85.0	73.9	60	42.6	25.2
172	83:20:30.00	35:19:10.70	Greens Creek	1097	1111	12	13	25	32	2	79.9	69.1	55	38.5	20.9
173	83:20:47.80	35:18:56.60	Greens Creek	1097	1059	15	17	15	34	7	70.5	56.2	36	18.8	4.9
174	83:20:56.60	35:18:49.80	Greens Creek	1006	981	22	18	40	24	7	55.6	43.3	24	12.1	3.4
175	83:25:18.10	35:17:46.60	Alarka	914	917	13	11	45	23	4	77.8	65.0	48	29.9	13.2
176	83:25:12.00	35:17:49.00	Alarka	1006	997	14	13	45	16	8	64.0	51.8	35	19.3	6.4
177	83:25:01.80	35:18:08.40	Alarka	1024	1004	25	20	0	22	8	37.0	27.5	12	4.6	1.1
178	83:25:31.30	35:17:29.20	Alarka	914	904	17	15	25	16	7	76.3	64.5	49	32.8	16.1
179	83:25:39.50	35:17:25.75	Alarka	823	808	15	14	45	22	8	74.9	62.1	45	27.0	9.0
180	83:20:17.50	35:19:42.75	Greens Creek	1463	1469	13	14	30	19	6	75.7	62.6	45	27.5	12.5
181	83:20:22.90	35:19:41.90	Greens Creek	1372	1374	16	16	45	38	5	80.9	70.0	56	39.2	21.0
182	83:20:25.60	35:19:38.50	Greens Creek	1280	1287	13	15	45	32	5	82.7	73.1	61	45.7	28.3
183	83:20:33.40	35:19:35.40	Greens Creek	1189	1207	18	19	5	31	2	84.1	73.0	59	40.7	19.9
184	83:20:25.70	35:19:16.30	Greens Creek	1189	1168	12	12	25	31	6	67.1	55.6	39	24.7	11.9
185	83:20:18.50	35:19:14.40	Greens Creek	1280	1253	12	13	20	10	6	66.1	54.8	39	24.8	14.6
186	83:20:09.75	35:19:18.50	Greens Creek	1372	1345	18	15	20	11	6	64.9	52.8	36	20.1	6.5
187	83:19:12.90	35:17:23.00	Greens Creek	1280	1274	12	12	20	19	5	82.1	72.4	60	44.6	27.9
188	83:19:38.60	35:17:24.30	Greens Creek	1177	1162	25	13	0	30	6	49.5	38.1	21	8.6	1.7
189	83:19:59.80	35:17:26.60	Greens Creek	1113	1099	14	11	2	25	7	52.6	40.0	20	8.6	2.0
190	83:19:27.20	35:17:16.50	Greens Creek	1103	1137	16	15	15	32	3	73.7	62.2	48	29.2	9.4
191	83:19:18.00	35:17:15.40	Greens Creek	1189	1184	14	17	45	36	5	72.3	60.2	43	28.2	16.1
192	83:19:18.60	35:17:24.60	Greens Creek	1189	1200	11	10	10	30	2	83.4	73.1	60	44.3	27.8
193	83:19:27.00	35:17:28.60	Greens Creek	1097	1130	10	11	40	16	1	84.8	75.0	63	47.0	30.1
194	83:19:36.00	35:17:32.10	Greens Creek	1006	1016	9	8	30	31	1	85.3	75.3	63	47.2	30.4
195	83:17:54.60	35:05:03.50	Scaly Mtn	1305	1301	25	15	0	15	6	39.9	32.0	20	11.5	4.8
196	83:18:19.00	35:05:07.50	Scaly Mtn	1372	1350	21	20	2	39	3	50.7	39.1	21	9.1	1.9
197	83:18:42.50	35:05:52.40	Scaly Mtn	1445	1430	21	22	8	23	6	36.5	27.0	11	3.8	0.9

Plot #	Longitude	Latitude	Quad Sheet	Elevation (meters)		Aspect Class		Slope (degrees)		Community Type*	Topographic Index				
				Field	GRASS	Field	GRASS	Field	GRASS		I	II	III	IV	V
198	83:26:25.25	35:05:56.60	Prentiss	930	901	8	5	2	11	4	55.6	44.3	27	14.5	5.3
199	83:25:50.60	35:06:05.40	Prentiss	811	803	25	11	0	17	7	51.0	40.6	24	16.2	13.1
200	83:17:33.20	35:02:04.50	Scaly Mtn	1451	1428	25	9	0	15	6	46.0	34.1	15	5.4	1.3
201	83:11:49.40	35:06:23.50	Highlands	1384	1378	25	20	0	13	8	44.1	32.7	14	5.0	1.2
202	83:29:27.20	35:04:15.50	Prentiss	1451	1395	7	3	35	33	1	77.1	64.6	48	30.8	15.0
203	83:29:01.10	35:03:54.20	Prentiss	1457	1421	6	4	30	25	1	69.6	57.9	43	25.4	7.1
204	83:28:58.50	35:03:57.70	Prentiss	1372	1318	4	4	40	23	2	76.8	67.8	57	41.5	23.3
205	83:29:06.90	35:04:28.25	Prentiss	1204	1227	3	3	8	26	2	59.6	48.2	32	17.4	4.4
206	83:29:12.40	35:04:09.90	Prentiss	1280	1286	6	7	2	21	2	79.6	69.7	57	42.2	25.9
207	83:33:51.50	35:15:07.20	Wesser	1372	1361	1	2	30	28	1	82.3	72.9	61	46.3	31.6
208	83:33:43.50	35:15:07.70	Wesser	1280	1288	3	3	2	26	2	85.5	75.6	63	46.9	29.9
209	83:30:20.70	35:16:12.00	Wesser	732	762	11	11	25	22	2	73.9	62.2	46	30.9	17.0
210	83:30:33.30	35:15:56.40	Wesser	732	735	14	15	15	16	4	74.5	61.9	45	27.2	9.1
211	83:30:38.10	35:16:04.00	Wesser	707	706	13	12	2	23	8	67.1	56.3	42	26.0	8.8
212	83:34:17.10	35:08:38.90	Wayah Bald	1372	1399	3	5	25	27	2	78.4	68.1	54	39.4	26.0
213	83:34:09.30	35:08:41.50	Wayah Bald	1280	1330	24	2	15	26	1	80.5	72.6	64	48.2	26.9
214	83:29:05.40	35:13:44.60	Franklin	768	741	25	20	0	15	8	48.2	36.5	18	7.1	1.5
215	83:29:26.00	35:13:43.90	Franklin	732	757	13	9	35	24	7	54.8	41.7	22	8.9	1.9
216	83:28:41.50	35:15:35.20	Alarka	768	756	25	22	0	17	8	46.3	36.2	21	10.7	3.1
217	83:18:24.10	35:08:56.80	Corbin Knob	732	758	20	18	30	22	4	65.9	52.1	32	16.4	4.2
218	83:22:42.10	35:14:55.10	Franklin	732	789	9	11	25	21	4	70.4	59.5	45	28.9	14.2

* 1 - Birch-Hemlock
2 - Basswood-Birch
3 - Tuliptree
4 - Chestnut Oak
5 - Red Oak-Hickory
6 - White Oak-Black Oak
7 - Chestnut Oak-Red Oak
8 - Chestnut Oak-Black Oak

Plot #:	Elevation:		Date:	
Lat/Lon:	Aspect:		Roll:	
Moisture Class:	Slope:		Neg. #:	
Acer pennsylvanicum (Mt. Maple)				
Acer rubrum (Red maple)				
Acer saccharum (Sugar maple)				
Aesculus octandra (Yellow buckeye)				
Betula allegheniensis (Yellow birch)				
Betula lenta (Sweet birch)				
Carya cordiformis (Bitternut hickory)				
Carya glabra (Pignut hickory)				
Carya ovalis (Red hickory)				
Carya tomentosa (Mockernut hickory)				
Castanea dentata (Chestnut)				
Clethra acuminata (White alder)				
Cornus florida (Dogwood)				
Fagus grandifolia (Amer. beech)				
Fraxinus americana (White ash)				
F. penna. v. subintegerrima (Green ash)				
Halesia carolina (Silverbell)				
Halesia monticola				
Hamamelis virginiana (Witch hazel)				
Ilex opaca (American holly)				
Kalmia latifolia (Mountain laurel)				
Lindera benzoin (Spicebush)				
Liriodendron tulipfera (Yellow poplar)				
Magnolia acuminata (Cucumber tree)				
Magnolia fraseri (Mt. magnolia)				
Nyssa sylvatica (Black gum)				
Ostrya virginiana (Hophornbeam)				
Oxydendron arboreum (Sourwood)				
Pinus pungens (Table mt. pine)				
Pinus rigida (Pitch pine)				
Pinus strobus (Eastern white pine)				
Pinus virginiana (Virginia pine)				
Prunus serotina (Wild black cherry)				
Quercus alba (White oak)				
Quercus coccinea (Scarlet oak)				
Quercus marilandica (Blackjack oak)				
Quercus prinus (Chestnut oak)				
Quercus rubra (Red oak)				
Quercus velutina (Black oak)				
Rhododendron catawbiense (Rose bay)				
Rhododendron maximum (Great laurel)				
Robinia pseudoacacia (Black locust)				
Sassafras albidum (Sassafras)				
Tilia heterophylla (White basswood)				
Tsuga canadensis (Eastern hemlock)				
Vaccinium arboreum (Farkleberry)				
Viburnum nudum (Possum-haw)				
Viburnum rufidulum (Blue haw)				

APPENDIX 2: VEGETATION DATA FOR SURVEYED PLOTS

Plot #	Acer pennsylvanicum			Acer rubrum			Acer saccharum			Acer spicatum			Aesculus octandra			Amelancher arborea			Amelancher laevis		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
1				1																	
2				1	3	1															
3				2	5	3															
4				2	3	1															
5				1	1	1															
6																					
7																	2			2	
8																					
9																					
11						2															
12				8																	
13				1																	
14																					
15						1															
16					1																
17						2														1	
18																					
19				1	1	1															
20						1															
21				1	2																
22						2															
23				2	1																
24																					
25																					
26					1																
27																					
28				4	1	1															
29					1	3															
30				5	6	3															
31					1	2															
32				2																	
33						3															
34	1					1															
35				3	1								2								
36				3	1	5										1					
37				1		2															
38																1					
39	2	2		5													1				
40				2	2	1															
41				1												1					

Plot #	Betula alleghaniensis			Betula lenta			Calycanthus fertilis			Carpinus caroliniana			Carya spp.			Castanea dentata			Castanea pumila		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
1												1	1		1						
2																5					
3															1	9	2				
4													1			5					
5													1		1						
6														3	1						
7														2	2	4					
8					1	2									1	8					
9				1																	
11														1	1						
12																1					
13													3	1	1						
14													1		1						
15																					
16					1								1	3	2						
17													1	1							
18														3							
19													1	2		10	3				
20													4		1	1	1				
21													1	4							
22				2									1	1		1					
23		1	2																		
24													4	10	1						
25						4							1								
26										1					1						
27														2							
28				2	1											1					
29				1	1	2															
30													2	1							
31													2	2	3	1					
32															1	3					
33														1		7	2				
34			1			2				1											
35										1			9								
36					1									3	1					1	
37						1							1								
38													2			1					
39													1								
40													1				1				
41													6			1					

Plot #	Clethra acuminata			Cornus florida			Corylus americana			Crataegus spp.			Fagus grandifolia			Fraxinus americana			pennsylvanica		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
1					12																
2																					
3																					
4				1																	
5					3																
6					4	2															
7					1								1		3						
8																					
9																1		1			
11					3								1								
12					2																
13				3	3																
14				3	11																
15					12																
16					3																
17					3																
18					3																
19				1	3	1															
20				5	5																
21				4	8											1					
22					1																
23					1													1			
24																					
25				1	2								3								
26					3																
27				1	3																
28				12	5												1				
29																					
30				2									2	2							
31																					
32					2											2	1				
33																					
34					4																
35					3																
36				3	8											4	3				
37					1									1							
38				3	2																
39				1																	
40				5	5	1															
41				1																	

Plot #	Halesia carolinana			Hamamelis virginiana			Ilex montana			opaca			Juniperus virginiana			Kalmia latifolia			Lindera benzoin		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
1																					
2																	12				
3																					
4																					
5																					
6																					
7																					
8																					
9																					
11	1	2								1	1										
12																					
13																1	2				
14																					
15													2			2	3				
16																					
17																1					
18																					
19																					
20																					
21																					
22																					
23																					
24																					
25	1																				
26				15																	
27																					
28																					
29					2																
30																					
31																10					
32																					
33																					
34																	3				
35										1											
36																					
37																					
38																					
39																	3				
40																					
41																					

Plot #	Liriodendron tulipfera			Leucothe recurva			Magnolia acuminata			fraseri			Nyssa sylvatica			Oxydendron arboreum			Pinus rigida		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
1			2																		
2													4	3							
3													1	1							
4	1												2	2	2						
5		2	1					1													
6																					
7		2																			
8	2	3	1								1										
9		2	3							1			6								
11														1							
12														3	2						
13													4	2		1		2			
14		1	2											1			1	2			
15														2			3				
16																					
17	1														1						
18			4																		
19													3	1			1	3			
20	1		4										1								
21													1	3							
22														1	1						
23		1	3														1	1			
24			5																		
25			1																		
26			4																		
27															2						
28	2	1	2										7				2	3			
29			3							1		1	1								
30													2			2		1		2	8
31																					
32													2	3		1	1				
33													1								
34		1																1			
35			10																		
36		1	4										1	1			1	2			
37			2																		
38																		1			
39			1																		
40																					
41			6																		

Plot #	Pinus strobus Sap	SmT	Can	virginiana Sap	SmT	Can	Prunus serotina Sap	SmT	Can	Pyrularia pubera Sap	SmT	Can	Quercus alba Sap	SmT	Can	coccinea Sap	SmT	Can	imbricaria Sap	SmT	Can
1																					
2																					
3																					
4																					
5													1								
6							1														
7															4						
8														1	1			1			
9																					
11						1															
12																					
13																					
14																		1			
15																					
16																					
17														2	2						
18															2						
19																					
20															1						
21																					
22														2	1						
23																					
24																					
25																					
26																					
27																					
28															1						
29															1						
30						2									1						
31													1								
32														3	1						
33																					
34																					
35																					
36													1								
37																					
38																					
39																					
40																					
41																					

Plot #	Quercus marilandica			prinus			rubra			velutina			Rhododendron calendalaceum			maximum			Robinia pseudoacacia		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
1						3															
2				3			2	1	2	2		1									1
3				1	1	5															1
4				1								3									
5									1												
6							1														
7									2												
8							3	2			1	1									
9									1												
11							2														
12					1	2															
13						2				1	1	2									
14					3							2									
15						1							1			1					
16												1									
17							1	1				1									
18																					
19																					
20							1	1	2												
21						1															
22						2	1	1				2									
23						1															
24																					
25						1															
26																1	3				
27						1															
28						1			1			2									1
29																				2	
30				3	1	2	4	1	1	1											2
31										1	1	1									
32					2	4	1		2											1	2
33					2	2			1			2									
34									3												
35																5	1				
36					3	3										1					
37																					2
38				3	3	5						1									
39									4												
40					3	2	2				3	2									1
41																					

Plot #	Sassafras albidum			Stewartia ovata			Tilia heterophylla			Tsuga canadensis			Ulmus rubra			Vaccinium arboreum			Vaccinium constablaei		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
1			1																		
2	5	1	1																		
3																					
4																					
5							1														
6																					
7	1	1	1																		
8			1																		
9																					
11							2	2	6		1					9				3	
12	3																				
13																					
14																					
15			1																		
16																					
17																					
18																					
19																					
20																					
21								1													
22																					
23																					
24																					
25																					
26																					
27																					
28																					
29																9					
30																					
31																					
32										1											
33	1																				
34																					
35																					
36																					
37							1		1												
38																					
39																2					
40																					
41										1						2					

Plot #	Viburnum cassinoides Sap	SmT	Can	Total Numbers of Individuals	Saplings	Small Trees	Canopy Trees	Species
1				36	2	24	10	8
2				35	22	8	5	10
3				34	13	9	12	6
4				23	14	5	4	9
5				14	4	7	3	8
6				21	2	7	12	7
7				28	8	14	6	11
8				23	11	5	7	9
9				25	12	4	9	6
11				16	3	9	4	11
12				29	14	9	6	9
13	1			27	13	6	8	10
14				39	13	20	6	13
15				20	0	17	3	7
16				19	3	11	5	8
17				12	2	5	5	8
18				10	0	6	4	3
19				37	17	12	8	9
20				26	13	7	6	10
21				30	7	19	4	9
22				15	5	4	6	11
23				14	2	5	7	7
24				20	4	10	6	4
25				18	7	5	6	9
26				25	16	4	5	6
27				15	1	6	8	10
28				57	37	12	8	11
29				23	5	6	12	9
30				60	32	11	17	13
31				24	6	9	9	9
32				24	9	8	7	8
33				26	10	8	8	10
34				21	7	6	8	11
35				39	22	7	10	13
36				46	8	21	17	14
37				10	3	1	6	7
38				27	12	8	7	9
39				18	9	3	6	8
40				32	12	14	6	8
41				17	11	0	6	8

Plot #	Acer pennsylvanicum			Acer rubrum			Acer saccharum			Acer spicatum			Aesculus octandra			Amelancher arborea			Amelancher laevis		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
42				3	1																
43				1																	
44				3		1											1				
45						1															
46				9	4	2															
47					1											1					
48																	1				
49				1	1	1															
50				2																	
51				1	3	1											1				
52				10	7	1													1	1	
53				7	1											1	1	1			
54																1					
55																1					
56				1																	
57																					
58				1	1	2											1				
59					3	2															
60																					
61						3											1				
62					1	1															
63																					
64	2													1							
65	1			4	1	4															
66							1	1	3												
68	1	1		2		3															
69					2											3					
70					4	5															
71		3			3																
72	1		1	1						1				3							
73			2	1		1							4	2							
74							1	2													
75							1		1					1	1						
76					1																
77				2	4	2															
78																					
79					1																
80	2																				
81	1				1																
82					1				4								1				
																	2				

Plot #	Betula alleghaniensis			lenta			Calycanthus fertilis			Carpinus caroliniana			Carya spp.			Castanea dentata			pumila		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
42													1			1					
43															1	3	7				
44		1	1										1								
45	2	3	1										2		1	1					
46													1			2	1				
47													2	1		1					
48													3			4					
49																1					
50														1	2						
51					1																
52														2		9	3				
53													6	3		2					
54													7	2							
55															1	1					
56					2	2															
57		1	1												2	12					
58														4	2						
59																1					
60				1	1										2	2					
61											1				1						
62			1							1											
63			2																		
64			2							1	1					1					
65													1			5					
66										1											
68				1												2	4	1			
69																2	1				
70																10					
71					1	1															
72	2			2	1																
73	1			2	3	3															
74						1															
75				1											1						
76						5								1	1	1					
77													1	2	5	1					
78													3	3	1						
79					2	1								1		1	1				
80																2	1				
81															1	5	1				
82																					

Plot #	Clethra acuminata			Cornus florida			Corylus americana			Crataegus spp.			Fagus grandifolia			Fraxinus americana			Fraxinus pennsylvanica		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
42					4											1					
43																					
44					1																
45															1	1					
46				1		1															
47				2									1								
48					3											3					
49					3											1					
50				3	8																
51					2											1					
52					1								2	3							
53				4	6																
54				1	7																
55				4	9																
56																2					
57																					
58																					
59					1																
60																					
61					1																
62																					
63													1								
64					1																
65					2																
66																					
68																		1			
69																					
70																					
71																					
72																1					
73																1	1				
74																					
75				1	1																
76																1					
77					2																
78																					
79																					
80																					
81																	1	2			
82																					

Plot #	Halesia carolinana			Hamamelis virginiana			Ilex montana			opaca			Juniperus virginiana			Kalmia latifolia			Lindera benzoin		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
42																					
43																					
44																					
45				4	3											2	1				
46																5	2				
47																					
48																					
49																					
50																					
51																11	9				
52																					
53																					
54																	1				
55																					
56				2	3																
57				3																	
58																	2				
59																	2				
60																6	1				
61				2																	
62										1											
63				4	1																
64				1																	
65																1	2				
66	1			2																	
68					1																
69																					
70				2																	
71				3	2																
72																			2		
73																					
74																					
75																					
76																					
77																2	1				
78																					
79																					
80																					
81																					
82																					

Plot #	Liriodendron tulipfera			Leucothe recurva			Magnolia acuminata			fraseri			Nyssa sylvatica			Oxydendron arboreum			Pinus rigida		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
42	1		1										1								
43			1															1			
44		1	1							1	2		4								
45	1	2	4										2			1					
46													4	4		1	1			1	3
47	3		1										1	1							
48		1	3																		
49																					
50		1											2	2			1	1			
51	1												1	1	1	2	3	1			
52																		1			1
53	1	1												1	1						
54													1	2							
55													6				1				
56		1	3																		
57			5						1		1	2									
58																					
59			2										3	2	4						
60																					
61		1	2								1										
62			4				3								1						
63			1																		
64			4													9	2				
65														4							
66																					
68													1								
69														7		1	1	3			
70														1	1	2	5	2			
71										2	1										
72																					
73																					
74																					
75							2	1													
76			5																		
77													1	2		1	1	3			
78	9	1																			
79	4	1	1																		
80																					
81														1							
82																					

Plot #	Pinus strobus			Pinus virginiana			Prunus serotina			Pyrularia pubera			Quercus alba			Quercus coccinea			Quercus imbricaria		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
42															1						
43															1						
44															1						
45															2						
46																					
47																					
48																					
49															1						
50																					
51															5						
52																					
53																					
54					1																
55															6						
56																					
57																					
58	2	1												1							
59																		1			
60															1						
61																					
62																					
63																					
64																					
65																					
66								1													
68																					
69															1						
70																					
71																					
72								5													
73																					
74																					
75																					
76																					
77																		1			
78																					
79																					
80						1															
81																					
82																					

Plot #	Quercus marilandica Sap	SmT	Can	prinus Sap	SmT	Can	rubra Sap	SmT	Can	velutina Sap	SmT	Can	Rhododendron calendalaceum Sap	SmT	Can	maximum Sap	SmT	Can	Robinia pseudoacacia Sap	SmT	Can
42												1									
43						1		1													2
44																					
45																					
46				1		2			1			1									
47						2			1												
48												1							2		
49						1			1										2		
50						1						1									
51																					
52						2															
53				2	1	3			1												
54					1	1		1	1										1		
55																					
56						1															
57																	6				
58								1				2				2	2				
59					1	1															
60				2	2	9	2														
61																	1				1
62									3												
63																					
64						1										2					
65									1												1
66																					1
68							2		1												
69						2			1			1									1
70						3	1		2								2				
71						1															
72																					
73									1												
74																					1
75								1	1												
76													3	1						1	
77						1															
78													12								
79												1									
80									1												
81				1		1		1	1			1	15	5							
82									4				4	2							

Plot #	Sassafras albidum			Stewartia ovata			Tilia heterophylla			Tsuga canadensis			Ulmus rubra			Vaccinium arboreum			Vaccinium constablaei		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
42																					
43		1																			
44							1		3												
45											1										
46																					
47																3	1				
48																16					
49																					
50																					
51																					
52																					
53																					
54	1															6					
55																2	1				
56							1		1	1		1									
57										1	9										
58																					
59																					
60																1					
61				1																	
62											3	1									
63									1		6	1									
64																					
65																					
66									2												
68																					
69																4					
70																1					
71							1		1												
72							2														
73				4	1																
74							2	1	3												
75																					
76																					
77																					
78																					
79																					
80			1																		
81	2	1																			
82																					

Plot #	Viburnum cassinoides Sap	SmT	Can	Total Numbers of Individuals	Saplings	Small Trees	Canopy Trees	Species
42				18	8	5	5	10
43				19	4	10	5	10
44				24	11	5	8	12
45				34	15	10	9	12
46				53	29	14	10	14
47				38	30	4	4	13
48				18	10	4	4	9
49				10	2	4	4	6
50				27	8	14	5	13
51				50	19	23	8	11
52				40	20	14	6	8
53				48	30	13	5	12
54				31	13	16	2	11
55				30	13	10	7	7
56				25	5	12	8	9
57				29	6	14	9	8
58				27	15	6	6	8
59				29	4	13	12	9
60				27	12	5	10	7
61				17	5	4	8	10
62				21	3	6	12	10
63				20	7	8	5	8
64				25	14	4	7	9
65				27	12	9	6	9
66				14	5	1	8	8
68				27	16	6	5	11
69				24	4	11	9	10
70				40	15	12	13	9
71				25	9	13	3	10
72				24	14	4	6	9
73				20	8	4	8	7
74				12	3	4	5	4
75				17	9	5	3	9
76				11	0	1	10	3
77				38	19	11	8	11
78				19	11	3	5	5
79				15	7	5	3	5
80				14	3	5	6	9
81				35	21	11	3	11
82				24	9	6	9	7

Plot #	Acer pennsylvanicum			Acer rubrum			Acer saccharum			Acer spicatum			Aesculus octandra			Amelancher arborea			Amelancher laevis		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
83				7	3																
84	1			1		1											1				
85																	2	3			
86									1								2	2			
87																					
88	1	2				1															
89																	2				
90																					
91						1															
92		1																			
93						2															
94							1										1				
95				1											1						
96					1	1															
97						3							1	1							
98					1	1															
99													1		2						
100																	2	3			
101	2	2		1	1	1				1											
102				1		2															
103				3	1	2															
104					1	2															
105					1	3															
106				4	1	3															
107				2		3															
108				1		1															
109						3															
110																					
111				5	1																
112				1		3															
113					1	1															
114					1																
115																					
116																					
117																					
118																					
119					1																
120																					
121	1	2	1	1	1											2	6	1			
122		1	3														3				

Plot #	Betula allegheniensis			lenta			Calycanthus fertilis			Carpinus caroliniana			Carya spp.			Castanea dentata			pumila		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
83				1																	
84																5	3				
85		2												1		20	4				
86			2											1							
87						2															
88																					
89														1	2	4	1				
90													1	4			1				
91																					
92																					
93																					
94				1	2								2	2		4					
95				2	1	1															
96				3	2	2											1				
97					2	3								1	1						
98				1									7	1	1	3					
99																					
100																					
101																3	1				
102															1	10	8				
103														2	1	12	4				
104															1	2					
105																					
106														1		2	5				
107														2		3	1				
108																3	1				
109														1		2					
110																1					
111																4	2				
112																	2				
113																	2				
114																2	2				
115				3	1								2								
116													2	1							
117													4	4	3						
118													1			3	1				
119														2	1	1	1				
120																7	1				
121					1	1							1	3	4	4	2				
122																					

Plot #	Clethra acuminata			Cornus florida			Corylus americana			Crataegus spp.			Fagus grandifolia			Fraxinus americana			Fraxinus pennsylvanica		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
83																					
84																					
85																					
86																					
87																	1				
88																					
89																					
90																					
91																					
92																					
93																					
94																					
95																					
96																					
97																					
98																					
99																2					
100																					
101																					
102																					
103																					
104																					
105																					
106																					
107																					
108																					
109																					
110																					
111														1							
112																					
113																					
114																					
115					5																
116					6																
117					4																
118																					
119				4																	
120																					
121																1					
122																					

Plot #	Halesia carolinana			Hamamelis virginiana			Ilex montana			Ilex opaca			Juniperus virginiana			Kalmia latifolia			Lindera benzoin		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
83																					
84																					
85																					
86																					
87				2	9																
88																					
89																					
90																5	4				
91				1												2	10				
92																5	15				
93																10	15				
94																18	10				
95					2		1														
96																1					
97				3																	
98																					
99							1														
100																					
101							1														
102																1	1				
103																	1				
104																					
105																15	15				
106																					
107																9	2				
108																1	2				
109																1	3				
110																6	8				
111																2	9				
112																					
113																					
114																11	17				
115																25	20				
116																					
117																					
118													1								
119																					
120																					
121																				1	
122																	1				

Plot #	Liriodendron tulipfera			Leucothe recurva			Magnolia acuminata			fraseri			Nyssa sylvatica			Oxydendron arboreum			Pinus rigida		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
83	1																				
84													1			2		1			
85																					
86																					
87																					
88																					
89														3	2						
90																					
91																					
92														1							
93																					1
94	1		8																		
95			1																		
96																					
97																					
98	4	1																			
99																					
100																					
101																					
102																					
103																		1			
104																					
105																1	2	4			
106															1						
107																					
108																					
109																					
110												1									
111																					
112																					
113													2	4	3						
114														1							3
115	4		2										2		2			4			1
116			3																		
117													1			1					
118																					
119	1	1	2										1	3	2						
120														1							
121																					
122																	1	1			
													1								

Plot #	Pinus strobus Sap	SmT	Can	virginiana Sap	SmT	Can	Prunus serotina Sap	SmT	Can	Pyrularia pubera Sap	SmT	Can	Quercus alba Sap	SmT	Can	coccinea Sap	SmT	Can	imbricaria Sap	SmT	Can
83																					
84													2		2						
85															1						
86																					
87																					
88																					
89																					
90													2	2	5						
91														1	3						
92																					
93																					
94															6						
95																					
96																					
97																					
98									1												
99																				1	
100															1						
101																					
102															1						
103															2						
104															1						
105																		3			
106																					
107								2	1						1			1			
108														1	1						
109													1		1						
110															1						
111							1								2						
112															3						
113															1						
114																					
115																					
116															4						
117					3																
118																					
119								1	1												
120								1													
121													2	1	3						
122														1							

Plot #	Quercus marilandica			prinus			rubra			velutina			Rhododendron calendalaceum			maximum			Robinia pseudoacacia		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
83									1				2						1	1	
84										2		3	1								
85												2	4								1
86																					
87												1				1	1				
88												1	4								
89										4	2	1	4	1							1
90												1	5	4							
91					3	7	1		1												1
92						4		1	2												
93																	2				
94							1		1												
95																5	3				
96									1								3				1
97						1							6			1	5				
98							2														
99																1	2				
100																10	8				
101						1		1	4				15			3	1			1	
102										2		2									1
103												3									1
104					1	2					1										
105									1							7	23				
106					1	1			1								1				1
107												2					3				
108									1				25			2	7				
109													3	1			3				2
110												5	4	1		1	7				
111													2								
112						2						1	3			8	6				
113						1						4									
114						2			2												
115																					
116									1			1									
117					1	4															
118					3	4					1	2									
119									2												
120							3	1	1	2	1	2				3	1				
121								2	2			1									1
122					1		1					1	14								1

Plot #	Sassafras albidum			Stewartia ovata			Tilia heterophylla			Tsuga canadensis			Ulmus rubra			Vaccinium arboreum			Vaccinium constablaei		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
83	8	2																			
84	4																				
85																	2				
86																1	1				
87																					
88																					
89																					
90																					
91																					
92										1						2					
93																					
94												2									
95							2	2	5												
96																					
97											1										
98								1													
99									1												
100																					
101											2	3									
102											1										
103	1																				
104		3														1					
105																					
106																					
107																					
108																1					
109																2					
110																					
111																1					
112																3					
113																4	1				
114																					
115																					
116																					
117																					
118																					
119																8					
120																					
121							2	1								5					
122	1																				

Plot #	Viburnum cassinoides Sap	SmT	Can	Total Numbers of Individuals	Saplings	Small Trees	Canopy Trees	Species
83				43	30	9	4	11
84				42	29	8	5	10
85				17	5	6	6	7
86				8	0	3	5	4
87				16	3	10	3	5
88				22	9	7	6	8
89				39	16	16	7	8
90				26	7	15	4	4
91				38	10	19	9	8
92				35	10	17	8	6
93				41	18	13	10	6
94				24	10	4	10	7
95				26	11	8	7	7
96				18	5	8	5	8
97				27	10	9	8	9
98				30	20	5	5	12
99				11	2	4	5	5
100				24	11	10	3	3
101				42	26	9	7	12
102				31	13	9	9	8
103				33	18	7	8	10
104				53	18	23	12	10
105				36	7	24	5	4
106				34	15	11	8	11
107				25	7	11	7	10
108				49	35	11	3	9
109				31	11	13	7	10
110				34	9	18	7	8
111				21	15	3	3	7
112				41	18	13	10	9
113				41	11	21	9	8
114				63	29	23	11	9
115				15	4	5	6	3
116				19	7	7	5	8
117				16	3	9	4	5
118				35	13	11	11	6
119				19	9	5	5	8
120				42	19	15	8	11
121				28	11	11	6	9
122				42	22	10	10	14

Plot #	Acer pennsylvanicum			rubrum			saccharum			spicatum			Aesculus octandra			Amelancher arborea			laevis		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
123					1	1															
124																					
125				1																	
126				3	3	1															
127				1	1												1				
128																					
129				1	1																
130		1	3																		
131				2																	
132					2																
133																					
134																					
135	3	2																			
136																					
137																1					
138					1																
139					1									1							
140																					
141				1		1															
142																					
143				2																	
144				1	3	5															
145		1																			
146						2								1							
147						3			1												
148						1															
149		1			1	2															
150						2															
151						1											1				
152					1	3															
153	5	1				1											1				
154																					
155						1															
156				2												2					
157				3	1	1															
158					1	1															
159					2	2															
160				2	3																
161				3	1	2															
162		1		1	1	2							6	3	1	3	4				
														2							

Plot #	Betula allegheniensis			lenta			Calycanthus fertilis			Carpinus caroliniana			Carya spp.			Castanea dentata			pumila		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
123																					
124													2	4			1				
125														1	1						
126														3	4						
127														1		1					
128													1	2	1	1	1				
129													1	2							
130													1	2	1						
131													1	5							
132														1		2					
133																5					
134													2	1	1						
135													4	4	1						
136													2		3	2					
137						1							2		1	1					
138					1	2							4								
139					2	3															
140																					
141													9			1					
142													3	2	1						
143			1		1	1									1	2	1				
144																4					
145		1	1											1		4					
146	1	4																			
147			2																		
148			1			1															
149					3	2									1						
150														1	2	2	2				
151				1											1	3	1				
152																2	1				
153	2	2		1		2										1					
154																2					
155																	1				
156																1	2	4			
157															1						
158															1						
159													5			2					
160															1						
161													2								
162			1			3															

Plot #	Clethra acuminata			Cornus florida			Corylus americana			Crataegus spp.			Fagus grandifolia			Fraxinus americana			pennsylvanica		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
123																					
124							3									1	1	1			
125																					
126					4																
127				1	3								1								
128					2																
129				3	1																
130				2	4																
131				1	2																
132				3	3																
133																					
134																1	1				
135				1																	
136				1	5											3					
137				2	1		3			1											
138													1				2	1			
139					1									2	2						
140																					
141				5	4																
142																					
143																					
144																					
145																					
146																			3		
147																					
148																					
149																					
150										1							1				
151																					
152																					
153																					
154																					
155																					
156																					
157					3																
158					4																
159				1	2											1					
160					3																
161																					
162																					

Plot #	Halesia carolinana			Hamamelis virginiana			Ilex montana			opaca			Juniperus virginiana			Kalmia latifolia			Lindera benzoin		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
123																					
124																					
125																					
126																					
127																2					
128																					
129																					
130																1					
131																2					
132																	1				
133																					
134																					
135							1									3	2				
136																					
137				4	1																
138																					
139																2					
140																					
141																					
142																					
143							4	3								4	8				
144				8	2																
145				3	4																
146		1																			
147					1																
148							1														
149																					
150																					
151																1					
152				2	1		1	2													
153				2			1	1													
154				8	12																
155																3	3				
156																					
157																2	2				
158																4					
159																					
160																3	7				
161																2	3				
162				10	5																

Plot #	Liriodendron tulipfera			Leucothe recurva			Magnolia acuminata			fraseri			Nyssa sylvatica			Oxydendron arboreum			Pinus rigida		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
123	2	1																			
124													2				1	1			
125																					
126			1																		
127																	1				
128			4											1							
129			1												1						
130	2												4	3			4	3			2
131													1			1		1	1	4	1
132	1												6	4	1	2	5	7			
133	2	4	3										2	1			1				
134	1	2	4																		
135			1										3			1					
136			1																		
137			2										1	1							
138													2								
139			2						1												
140			7																		
141			1										7								
142													1		1	1	1	1			
143																					
144																					
145																					
146			2																		
147																					
148										3											
149																					
150																					
151				1														1			
152							1														
153										1	1										
154																					
155																1	7	1			
156																		1			
157			1										6			1		4			
158			2											1	4			1			
159																		1			
160													1	7	1					2	1
161	1		1											1				1			
162																					

Plot #	Pinus strobus Sap	SmT	Can	Pinus virginiana Sap	SmT	Can	Prunus serotina Sap	SmT	Can	Pyrularia pubera Sap	SmT	Can	Quercus alba Sap	SmT	Can	Quercus coccinea Sap	SmT	Can	Quercus imbricaria Sap	SmT	Can
123																					
124							2	4	1												
125									1												
126															1						
127																					
128															1						
129				1		3															
130															3						
131							1														
132																					
133																		1			
134													1		2						
135															1						
136																					
137																		3			
138															1						
139																					
140																					
141													1								
142													2		1						
143													2	1	4						
144															1					1	
145																					
146															1						
147																					
148															2						
149																					
150							2														
151													2	1	2						
152																					
153																					
154																					
155									1												
156													1		2						
157														1	4						
158																					
159				1		1															
160																2	1	3			
161							1														
162								1		2											

Plot #	Quercus marilandica			Quercus prinus			Quercus rubra			Quercus velutina			Rhododendron calendalaceum			Rhododendron maximum			Robinia pseudoacacia		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
123				1		1															
124					3	2	6	1	2				2				1				1
125					1	1		1													
126												1									2
127						3			1							8	3				
128																					
129							2	1		1			5								
130						2	1			2											
131				1	1	2	1				1								1	1	
132				2	3	5	1		2	1		1									
133									3												
134						1	3	1													
135									2				1	2							1
136									1								1				
137									1												
138																					
139																4	8				
140							1									5	5				
141							3	1	1	1	2	2									
142									1		1	2					1				
143					1	1					1										
144									1				6			1	1				
145									2				2			5	7				
146																16	13				
147																8	27				
148												1	8	1							
149						2						1									
150												1	18	5							
151									3				23	4							
152									1				26	1							
153									1				7	1							
154								2	6			2	5								
155									1	2	1	9									
156							3	1	1												
157						1							4						4	2	
158																					
159		1		3	1					1									1		
160					2	4			2				5	6							
161																					
162																					

Plot #	Sassafras albidum			Stewartia ovata			Tilia heterophylla			Tsuga canadensis			Ulmus rubra			Vaccinium arboreum			Vaccinium constablaei		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
123																					
124	2											1									
125																2					
126																					
127																					
128																					
129																					
130																					
131																					
132		2																			
133																					
134																					
135											3	1									
136																					
137								1													
138													5								
139																					
140		1									2	2									
141																					
142																					
143											1										
144											1										
145																1					
146										3	3	1									
147										4	1	4									
148												2									
149								1		1	1										
150																					
151																3					
152											2										
153											1										
154										3	5					1					
155																					
156																2					
157																					
158																					
159																					
160																					
161									1												
162							3		2												

Plot #	Viburnum cassinoides Sap	SmT	Can	Total Numbers of Individuals	Saplings	Small Trees	Canopy Trees	Species
123				26	10	10	6	15
124				30	15	9	6	8
125				15	1	5	9	9
126				31	15	13	3	11
127				18	4	8	6	8
128				10	1	4	5	5
129				44	19	15	10	13
130				35	14	14	7	12
131				42	16	16	10	11
132				36	15	12	9	11
133				21	6	6	9	6
134				32	15	9	8	10
135				28	13	8	7	13
136				18	6	6	6	9
137				33	22	5	6	14
138				23	6	12	5	6
139				24	5	11	8	7
140				27	19	1	7	8
141				36	17	10	9	10
142				28	8	12	8	7
143				22	11	7	4	10
144				35	21	8	6	9
145	1			39	17	16	6	11
146				48	21	19	8	6
147				46	8	28	10	7
148				21	13	3	5	10
149				21	3	9	9	11
150				44	29	8	7	11
151				38	27	7	4	7
152				43	30	9	4	10
153				40	25	11	4	12
154				51	17	25	9	7
155				30	8	3	19	9
156				34	18	6	10	8
157				25	11	5	9	9
158				18	9	5	4	9
159				44	12	24	8	11
160				36	11	18	7	9
161				27	14	8	5	6
162				34	16	10	8	9

Plot #	Acer pennsylvanicum			Acer rubrum			Acer saccharum			Acer spicatum			Aesculus octandra			Amelancher arborea			Amelancher laevis		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
163				4	1																
164				2	3	1								3	1		2				
165		1											3	2	1						
166	1				2	4									2						
167	2			3	6				1												
168				1		1										3	3				
169																					
170				1		1															
171					1																
172					1																
173					1	1															
174				1	4																
175				2	3	3															
176																					
177				3		2															
178				3	2											1	1				
179					1																
180					3												1				
181		1		2	2	1											1	2			
182																	1				
183																1					
184				1									5			1	2	-			
185				3																	
186																					
187			1	1												1	1	5			
188																2		1			
189																					
190																					
191						1															
192				2	1	2											1				
193																					
194																					
195					2	2								1							
196																					
197																					
198				3													1	1			
199				8	2	1										1					
200																					
201																					
202																					

Plot #	Betula allegheniensis			lenta			Calycanthus fertilis			Carpinus caroliniana			Carya spp.			Castanea dentata			pumila		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
163																					
164			2																		
165						2															
166																					
167																1					
168					1	1								1		1		1			
169													2	1							
170						1															
171						2									1						
172		1																			
173													1								
174																7					
175						1										4	3				
176													1								
177																					
178																	1				
179													4	1	1	1					
180																					
181																4					
182															1	1					
183													1		2						
184																					
185													1			1	6				
186						1										5	8				
187													1	6		2					
188													1		1	2	3				
189													1	2		1	1				
190																1				2	
191															2						
192					1	2								1	2	1					
193						4										1					
194						2															
195																					
196														1	1	6	1				
197													1		3						
198														2	4						
199															2	4	1				
200							3									7	2				
201													1	1	7						
202			2			2											4				

Plot #	Clethra acuminata			Cornus florida			Corylus americana			Crataegus spp.			Fagus grandifolia			Fraxinus americana			pennsylvanica		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
163																					
164																		2			
165																		1			
166	2	1											3	13	2						
167																					
168					2																
169															1						
170																					
171																					
172																					
173																1					
174		1																			
175				1	1																
176																					
177				4																	
178					1																
179				1	2																
180																					
181	1																				
182																3	4				
183																	2	1			
184																1	2	-			
185																					
186																					
187																					
188																1					
189																					
190																					
191																					
192																					
193																1	2	2			
194																					
195																		1			
196																					
197																					
198				2	7																
199				2	4																
200																					
201																					
202																					

Plot #	Halesia carolinana			Hamamelis virginiana			Ilex montana			opaca			Juniperus virginiana			Kalmia latifolia			Lindera benzoin		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
163					1																
164				1	1																
165																					
166																					
167							2	2													
168	1																				
169											2										
170					1																
171		1		3	1																
172	3																				
173																					
174																					
175																					
176																					
177																8	12				
178																4	12				
179																					
180																15	31				
181																1	1				
182																					
183																					
184																					
185																	2				
186																4					
187																					
188																					
189																					
190																	3				
191																					
192																					
193				5	1																
194	1																				
195																					
196																					
197																					
198																3	1				
199																					
200																4	1				
201																					
202																	6				

Plot #	Liriodendron tulipfera			Leucothe recurva			Magnolia acuminata			fraseri			Nyssa sylvatica			Oxydendron arboreum			Pinus rigida		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
163																					
164																					
165																					
166																					
167																					
168			2															1			
169			3										2					1			
170		2	1																		
171	1		6									1									
172	1		4										1								
173																					
174													4				1	2			
175													12	2							1
176																		1			
177			1										1								
178																					2
179													9	7	2			2			
180													1	3	1		2				
181																					
182																					
183			4																		
184																					
185																1					
186													1								
187																					
188																					
189																					
190	1	3	2										5	6							1
191																					
192																1					
193			5																		
194			3							1											
195																					
196									1												
197																					
198																					
199													16		1						
200													2			1		1			
201																					
202																					

Plot #	Pinus strobus Sap	SmT	Can	virginiana Sap	SmT	Can	Prunus serotina Sap	SmT	Can	Pyrularia pubera Sap	SmT	Can	Quercus alba Sap	SmT	Can	coccinea Sap	SmT	Can	imbricaria Sap	SmT	Can
163																					
164									1												
165																					
166																					
167							1														
168															1						
169														1							
170																					
171																					
172																					
173																					
174																		2			
175															1						
176																					
177																					
178														1							
179						1									1						
180															1						
181														1	4						
182																					
183																					
184								2													
185																					
186																					
187													5		6						
188																					
189															1						
190																					
191																					
192																					
193										2											
194										9	2										
195							1		1												
196							1								2						
197														4	4						
198														2	10						
199																					
200							1	1										1			
201													1	3	4						
202														1	1			4			

Plot #	Quercus marilandica			prinus			rubra			velutina			Rhododendron calendalaceum			maximum			Robinia pseudoacacia		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
163																	5				
164																					
165																					
166										2		4	8	1		3	1				
167					2	1				3		2	27	6							
168																	1				
169																3	7				
170									1								5				
171																6	7				
172																					
173					1	2						2	1								
174				4	1	4	6	1		1											
175						2			1								1				
176					1	3	1		4	1		2							1		
177				6	7	2						3								2	
178									1			2									
179									1			1	5			4					
180								1					35	19							
181								1	4				6	1							
182									2				2								
183																					
184					1	4	2	1		2		2	39								1
185				1	1	2	1	1			3		60								
186								2		1			20								5
187								1	4												
188				3	4	4	1	1			1		3								1
189				2	1	4						4									
190									2												
191						2			2											1	2
192																					
193																14	7				
194																	5				
195								1				3									
196							1		3		2	1									
197												1	8								
198					1	10															
199				1		5			2			2	6							1	
200							1			8		3									
201											1	2					3				
202									1							8	35				1

Plot #	Sassafras albidum			Stewartia ovata			Tilia heterophylla			Tsuga canadensis			Ulmus rubra			Vaccinium arboreum			Vaccinium constablaei		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
163							10	1	2												
164							3		1												
165																					
166																					
167																1					
168																1					
169										2	4	1									
170									3			1									
171										2	6	1									
172							1	1	1	2	1	2									
173	1																				
174	8																				
175																7					
176	1															1					
177																					
178		1																			
179		1														7					
180																					
181																					
182							2														
183							2	4	1												
184	1	1																			
185																1					
186																3					
187																					
188	4																				
189	1																				
190			1																		
191																					
192								1	2												
193										1	3										
194							1														
195																					
196																					
197																12					
198																1					
199	1	1																			
200																					
201																3					
202																					

Plot #	Viburnum cassinoides Sap	SmT	Can	Total Numbers of Individuals	Saplings	Small Trees	Canopy Trees	Species
163				27	14	8	5	6
164				27	9	11	7	8
165				23	3	14	6	4
166				35	20	7	8	9
167				66	41	18	7	12
168				27	8	12	7	13
169				18	3	8	7	5
170				23	3	13	7	8
171				34	13	11	10	8
172				15	7	3	5	7
173				25	13	3	9	9
174				61	43	12	6	11
175				18	5	5	8	9
176				35	13	13	9	7
177				52	18	24	10	11
178				45	24	12	9	12
179				72	26	41	5	13
180	4	4		80	44	30	6	8
181				29	13	10	6	9
182				13	6	2	5	7
183				25	9	10	6	7
184				66	49	11	6	11
185				93	78	13	2	9
186				56	30	9	17	9
187				18	7	4	7	7
188				28	13	9	6	10
189				30	11	10	9	8
190				11	1	3	7	4
191				14	2	3	9	8
192				17	4	5	8	5
193				43	22	12	9	7
194				25	11	8	6	8
195				22	7	5	10	8
196				20	3	6	11	7
197				45	23	6	16	7
198				49	27	9	13	8
199				58	35	11	12	14
200				31	12	5	14	6
201				25	3	15	7	7
202				49	8	35	6	5

Plot #	Acer pennsylvanicum Sap	SmT	Can	rubrum Sap	SmT	Can	saccharum Sap	SmT	Can	spicatum Sap	SmT	Can	Aesculus octandra Sap	SmT	Can	Amelancher arborea Sap	SmT	Can	laevis Sap	SmT	Can
203															1						
204									3					2							
205									1					2							
206							3	2							1						
207			1							5	5										
208								3					4								
209													3								
210					1	4															
211					3																
212					2										1						
213								1		1											
214				2	2	1								1	3	1					
215				1	4	1															
216				1	2	2											1				
217																					
218																					
Totals	27	23	12	189	160	160	7	9	15	8	5	0	29	24	17	29	53	19	1	4	0
	62			509			31			13			70			101			5		

Plot #	Betula allegheniensis			lenta			Calycanthus fertilis			Carpinus caroliniana			Carya spp.			Castanea dentata			pumila		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
203			3																		
204		5								3	3										
205				1		5															
206		1	1		1	2															
207	1	1			1	1															
208			2			8															
209						3															
210					1	2									1						
211																					
212						1															
213		1	2																		
214															1						
215															1	1					
216																					
217															1						
218																					
Totals	9	24	31	27	37	88	3	0	0	8	5	0	146	133	108	310	111	6	2	1	0
	64			152			3			13			387			427			3		

Plot #	Clethra acuminata			Cornus florida			Corylus americana			Crataegus spp.			Fagus grandifolia			Fraxinus americana			pennsylvanica		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
203													4	5							
204																					
205																					
206													4	2	2						
207																1		1			
208													1								
209																					
210					4																
211				1									1	1							
212														4	2						
213																					
214				4																	
215				1	1																
216																					
217				4	3																
218					2																
Totals	3	2	0	106	240	5	6	0	0	2	0	0	26	34	13	37	23	15	3	0	0
	5			351			6			2			73			75			3		

Plot #	Halesia carolinana			Hamamelis virginiana			Ilex montana			Ilex opaca			Juniperus virginiana			Kalmia latifolia			Lindera benzoin		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
203																					
204																					
205																					
206																					
207			1																		
208	3		2																		
209																					
210																					
211																					
212					1		1									5	10				
213				1	1																
214																					
215																9	4				
216																2	1				
217																10	32				
218							1									1					
Totals	11	4	3	91	56	0	15	8	0	2	4	0	3	0	0	249	307	0	2	1	0
	18			147			23			6			3			556			3		

Plot #	Liriodendron tulipfera			Leucothe recurva			Magnolia acuminata			fraseri			Nyssa sylvatica			Oxydendron arboreum			Pinus rigida		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
203																					
204																					
205			1																		
206																					
207																					
208																					
209		1	13																		
210			2											1			1				
211														2			4	2			
212																					
213																					
214	1													1			3	3			
215														2		3	2	1			
216																					
217			1										1	3				1			
218		1																5			
Totals	51	40	191	1	0	0	5	3	3	9	8	5	162	111	38	38	61	82	1	9	25
	282			1			11			22			311			181			35		

Plot #	Pinus strobus Sap	SmT	Can	virginiana Sap	SmT	Can	Prunus serotina Sap	SmT	Can	Pyrularia pubera Sap	SmT	Can	Quercus alba Sap	SmT	Can	coccinea Sap	SmT	Can	imbricaria Sap	SmT	Can
203																					
204																					
205																					
206																					
207																					
208																					
209																					
210		1								1											
211																					
212															1						
213																					
214																					
215																					
216																		2			
217														1	1						
218															1						
Totals	2	2	0	2	8	5	12	12	14	14	2	0	25	32	138	2	1	24	1	1	0
	4			15			38			16			195			27			2		

Plot #	Quercus marilandica Sap	SmT	Can	prinus Sap	SmT	Can	rubra Sap	SmT	Can	velutina Sap	SmT	Can	Rhododendron calendalaceum Sap	SmT	Can	maximum Sap	SmT	Can	Robinia pseudoacacia Sap	SmT	Can
203																					
204																	1				
205																					
206																					
207									1							1	1				
208																					3
209																					
210																					3
211									1			4									
212																1	6				
213																2	6				
214						1	1					7	1							1	
215									3				1								
216				1		1			1												
217							2		2			1									
218						1															
Totals	0	1	0	42	66	170	68	35	130	41	24	128	461	62	0	143	249	0	13	14	47
	1			278			233			193			523			392			74		

Plot #	Sassafras albidum			Stewartia ovata			Tilia heterophylla			Tsuga canadensis			Ulmus rubra			Vaccinium arboreum			Vaccinium constablaei		
	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can	Sap	SmT	Can
203									1			1									
204							3	1	2												
205							2	1													
206									1												
207																					
208							1	2	1												
209							1														
210																					
211	1										2										
212							1	2	7							1					
213									1			1									
214																1					
215											1										
216	1																				
217																1					
218																					
Totals	48	16	6	5	1	0	45	23	50	23	61	26	5	0	0	123	7	0	3	0	0
	70			6			118			110			5			130			3		

Plot #	Viburnum cassinoides Sap	SmT	Can	Total Numbers of Individuals	Saplings	Small Trees	Canopy Trees	Species
203				16	4	6	6	6
204				22	6	11	5	5
205				13	3	3	7	5
206				20	7	6	7	6
207				21	8	8	5	8
208				30	9	5	16	8
209				21	4	1	16	4
210				22	1	9	12	10
211				38	8	22	8	11
212				30	4	15	11	9
213				21	4	10	7	8
214				44	20	11	13	14
215				26	9	11	6	10
216				54	13	35	6	7
217				22	8	7	7	9
218				12	2	3	7	7
Totals	6 10	4	0	6397	2702	2121	1574	

APPENDIX 3: SPECIES FREQUENCIES RELATIVE TO ENVIRONMENTAL VARIABLES

Aspect Class Frequencies

Species		Aspect								
		NE	E	N	NW	SE	W	S	SW	None
Acer	pennsylvanicum	0.142	0.200	0.250	0.210	0.090	0.040	0.153	0.066	0.068
	rubrum	0.380	0.700	0.625	0.736	0.863	0.680	0.461	0.633	0.758
	saccharum	0.285	0.100	0.041	0.052	-	0.040	-	0.033	0.034
	spicatum	-	0.100	0.041	0.052	-	-	-	-	-
Aesculus	octandra	0.476	0.200	0.166	0.157	0.045	-	0.038	0.066	-
Amelancher	arborea	0.190	0.150	0.250	0.210	0.181	0.200	0.269	0.166	0.275
	laevis	-	-	-	-	0.045	-	-	0.033	0.034
Betula	allegheniensis	0.285	0.300	0.250	0.157	0.090	0.080	0.076	-	0.034
	lenta	0.476	0.250	0.375	0.473	0.227	0.080	0.038	0.366	0.137
Calycanthus	fertilis	-	-	-	-	-	-	-	-	0.034
Carpinus	caroliniana	0.047	0.150	-	0.052	0.090	-	-	-	0.034
Carya	spp.	0.285	0.600	0.416	0.210	0.772	0.680	0.769	0.666	0.586
Castanea	dentata	0.190	0.300	0.541	0.578	0.545	0.560	0.384	0.400	0.724
	pumila	-	-	0.041	-	-	0.040	-	-	-
Clethra	acuminata	0.047	-	-	-	0.045	-	-	0.033	-
Cornus	florida	0.142	0.300	0.208	0.210	0.500	0.440	0.538	0.500	0.482
Corylus	americana	0.047	-	-	-	-	-	-	0.033	-
Crataegus	spp.	-	-	-	-	0.045	-	-	0.033	-
Fagus	grandifolia	0.190	-	0.166	-	0.090	0.080	0.076	0.166	0.034
Fraxinus	americana	0.190	0.250	0.083	0.157	0.181	0.240	0.192	0.166	0.068
	pennsylvanica	-	-	0.041	-	-	-	-	-	-
Halesia	carolinana	0.047	0.100	0.041	0.105	0.045	0.040	-	0.033	0.034
Hamamelis	virginiana	0.190	0.400	0.125	0.263	0.045	0.120	0.076	0.133	0.034
Ilex	montana	0.095	0.050	0.041	0.263	0.045	-	0.038	-	-
	opaca	-	0.100	-	-	0.045	-	-	-	0.034
Juniperus	virginiana	-	-	-	-	-	0.040	-	0.033	-
Kalmia	latifolia	0.142	0.150	0.250	0.105	0.318	0.480	0.346	0.233	0.448
Lindera	benzoin	-	-	-	0.052	-	-	0.038	-	-
Liriodendron	tulipfera	0.238	0.450	0.166	0.473	0.409	0.280	0.500	0.666	0.206
Leucothe	recurva	-	-	-	0.052	-	-	-	-	-
Magnolia	acuminata	0.047	0.100	-	0.052	-	-	0.038	0.033	0.034
	fraseri	-	0.050	0.083	0.157	0.136	-	0.038	0.066	-
Nyssa	sylvatica	-	0.250	0.416	0.210	0.318	0.520	0.500	0.566	0.448
Oxydendron	arboreum	0.047	0.100	0.291	0.105	0.090	0.520	0.230	0.400	0.448
Pinus	rigida	-	-	-	-	0.090	0.120	0.115	-	0.137
	strobus	-	-	-	-	0.045	0.040	-	-	-
	virginiana	0.047	-	-	-	0.090	0.040	0.076	0.066	-
Prunus	serotina	0.095	0.200	0.041	0.052	0.135	-	0.192	-	0.172
Pyrularia	pubera	-	0.050	-	0.105	-	0.040	-	-	-

Aspect Class Frequencies

Species		Aspect								
		NE	E	N	NW	SE	W	S	SW	None
Quercus	alba	0.095	0.150	0.250	0.210	0.454	0.320	0.461	0.400	0.586
	coccinea	0.047	0.050	0.041	-	0.045	-	0.076	0.066	0.172
	imbricaria	-	-	-	0.052	0.045	-	-	-	-
	marilandica	-	-	-	-	0.045	-	-	-	-
	prinus	0.142	0.250	0.375	0.315	0.318	0.480	0.346	0.366	0.551
	rubra	0.238	0.200	0.500	0.473	0.318	0.640	0.576	0.533	0.620
	velutina	0.190	0.200	0.333	0.105	0.500	0.400	0.346	0.333	0.655
Rhododendron	calendulaceum	0.190	0.150	0.083	0.368	0.227	0.360	0.230	0.200	0.172
	maximum	0.285	0.450	0.333	0.263	0.181	0.200	0.153	0.233	0.103
Robinia	pseudoacacia	0.238	0.200	0.333	0.157	0.181	0.240	0.192	0.133	0.275
Sassafras	albidum	0.095	-	0.166	0.105	0.090	0.200	0.076	0.266	0.206
Stewartia	ovata	-	-	0.041	-	0.045	-	-	-	-
Tilia	heterophylla	0.428	0.300	0.250	0.210	0.136	0.080	0.115	0.066	-
Tsuga	canadensis	0.047	0.250	0.125	0.421	0.136	0.200	0.153	0.133	0.034
Ulmus	rubra	-	-	-	-	-	-	-	0.033	-
Vaccinium	arboreum	0.190	0.100	0.250	0.157	0.227	0.240	0.269	0.066	0.172
	constablaei	-	-	-	-	-	0.040	-	-	-
Viburnum	spp.	-	-	0.041	-	-	0.040	-	-	0.034

Elevation Class Frequencies

Species		Elevation (m) 730	823	914	1006	1097	1189	1280	1372	1463
Acer	pennsylvanicum	-	0.080	-	0.120	0.080	0.160	0.240	0.304	0.200
	rubrum	0.739	0.640	0.760	0.680	0.520	0.720	0.720	0.565	0.450
	saccharum	-	-	-	-	0.120	0.120	0.160	0.086	0.050
	spicatum	-	-	-	-	-	0.040	0.040	0.086	-
Aesculus	octandra	0.086	0.040	0.040	0.040	0.120	0.240	0.240	0.130	0.100
Amelancher	arborea	0.217	0.120	0.160	0.240	0.120	0.160	0.240	0.217	0.500
	laevis	0.043	-	-	0.040	-	0.040	-	-	-
Betula	allegheniensis	0.043	0.080	0.120	0.080	0.080	0.120	0.280	0.173	0.200
	lenta	0.304	0.240	0.200	0.160	0.280	0.320	0.320	0.347	0.150
Calycanthus	fertilis	-	0.040	-	-	-	-	-	-	-
Carpinus	caroliniana	0.043	0.120	0.040	0.040	0.040	-	-	0.043	-
Carya	spp.	0.739	0.680	0.760	0.640	0.600	0.520	0.400	0.391	0.350
Castanea	dentata	0.217	0.240	0.360	0.600	0.480	0.640	0.640	0.565	0.550
	pumila	0.043	-	-	-	0.040	-	-	-	-
Clethra	acuminata	-	-	-	0.040	-	-	-	0.043	0.050
Cornus	florida	0.826	0.840	0.720	0.600	0.320	0.080	-	-	-
Corylus	americana	0.043	-	-	-	0.040	-	-	-	-
Crataegus	spp.	0.043	-	-	-	-	-	-	-	0.050
Fagus	grandifolia	0.434	0.080	0.080	-	-	-	0.080	0.043	0.150
Fraxinus	americana	0.217	0.040	0.040	0.200	0.360	0.200	0.200	0.130	0.100
	pennsylvanica	-	-	-	-	-	-	0.040	-	-
Halesia	carolinana	0.086	0.040	-	0.080	0.120	-	0.040	0.043	-
Hamamelis	virginiana	0.086	0.120	0.080	0.160	0.120	0.160	0.200	0.260	0.100
Ilex	montana	0.043	-	-	0.040	-	0.040	0.120	0.086	0.150
	opaca	0.130	-	0.040	-	-	-	-	-	-
Juniperus	virginiana	-	0.040	0.040	-	-	-	-	-	-
Kalmia	latifolia	0.391	0.560	0.120	0.120	0.240	0.240	0.280	0.304	0.350
Lindera	benzoin	-	-	-	-	0.040	-	0.040	-	-
Liriodendron	tulipfera	0.695	0.600	0.480	0.600	0.560	0.360	0.040	-	-
Leucothe	recurva	-	-	-	-	-	-	-	0.043	-
Magnolia	acuminata	-	-	0.120	0.040	0.040	-	0.040	-	0.050
	fraseri	0.086	-	0.080	0.080	0.120	-	0.040	0.086	-
Nyssa	sylvatica	0.652	0.600	0.600	0.560	0.320	0.240	0.240	0.130	-
Oxydendron	arboreum	0.608	0.560	0.360	0.120	0.160	0.280	0.120	0.086	0.100
Pinus	rigida	0.086	0.080	0.080	0.080	0.040	0.040	0.040	0.043	-
	strobus	0.043	-	-	-	-	0.040	-	-	-
	virginiana	0.190	0.120	0.040				0.040		
Prunus	serotina	0.043	0.040	-	0.040	0.120	0.200	0.080	0.173	0.200
Pyrularia	pubera	0.043	-	-	0.040	0.040	0.040	-	-	-

Elevation Class Frequencies

Species		Elevation (m)								
		730	823	914	1006	1097	1189	1280	1372	1463
Quercus	alba	0.565	0.240	0.240	0.360	0.160	0.240	0.360	0.434	0.550
	coccinea	0.086	0.080	-	0.040	0.160	0.080	0.040	0.043	-
	imbricaria	-	-	-	-	-	0.040	0.040	-	-
	marilandica	0.043	-	-	-	-	-	-	-	-
	prinus	0.260	0.520	0.560	0.520	0.440	0.320	0.320	0.173	0.050
	rubra	0.391	0.360	0.560	0.520	0.480	0.480	0.680	0.434	0.300
	velutina	0.260	0.360	0.320	0.360	0.240	0.360	0.360	0.434	0.550
Rhododendron	calendulaceum	0.130	0.200	-	0.040	0.120	0.160	0.360	0.521	0.500
	maximum	0.130	0.240	0.200	0.200	0.080	0.200	0.280	0.478	0.350
Robinia	pseudoacacia	0.217	0.160	0.120	0.280	0.280	0.280	0.320	0.130	0.150
Sassafras	albidum	0.130	0.240	0.080	0.160	0.240	0.240	0.120	-	0.050
Stewartia	ovata	-	-	-	0.040	-	-	0.040	-	-
Tilia	heterophylla	0.130	0.120	0.160	0.040	0.160	0.360	0.240	0.130	0.100
Tsuga	canadensis	0.173	0.080	0.240	0.160	0.080	0.080	0.280	0.173	0.150
Ulmus	rubra	0.043	-	-	-	-	-	-	-	-
Vaccinium	arboreum	0.086	0.120	0.200	0.080	0.160	0.080	0.200	0.347	0.450
	constablaei	-	0.040	-	-	-	-	-	-	-
Viburnum	spp.	-	0.040	-	-	-	-	0.040	-	0.050

Slope Frequencies

Species		Slope (degrees)				
		0 - 5	6 - 15	16 - 25	26 - 39	40 +
Acer	pennsylvanicum	0.052	0.097	0.194	0.090	0.224
	rubrum	0.649	0.609	0.666	0.606	0.693
	saccharum	0.070	0.097	0.027	0.030	0.061
	spicatum	-	0.024	0.027	0.030	0.020
Aesculus	octandra	0.070	0.170	0.194	0.121	0.061
Amelancher	arborea	0.210	0.243	0.250	0.212	0.163
	laevis	0.017	0.024	-	-	0.020
Betula	allegheniensis	0.087	0.195	0.194	0.151	0.061
	lenta	0.192	0.268	0.333	0.181	0.326
Calycanthus	fertilis	0.017	-	-	-	-
Carpinus	caroliniana	0.017	0.073	-	-	0.081
Carya	spp.	0.596	0.560	0.611	0.545	0.530
Castanea	dentata	0.578	0.414	0.527	0.424	0.408
	pumila	0.017	-	-	0.030	-
Clethra	acuminata	-	-	-	0.030	0.040
Cornus	florida	0.368	0.390	0.250	0.424	0.469
Corylus	americana	0.035	-	-	-	-
Crataegus	spp.	0.017	-	-	-	0.020
Fagus	grandifolia	0.105	0.121	0.111	0.060	0.061
Fraxinus	americana	0.087	0.170	0.194	0.181	0.224
	pennsylvanica	-	0.024	-	-	-
Halesia	carolinana	0.035	0.048	0.055	0.060	0.040
Hamamelis	virginiana	0.105	0.170	0.138	0.121	0.183
Ilex	montana	-	0.048	0.111	0.060	0.061
	opaca	0.017	0.048	-	-	0.020
Juniperus	virginiana	-	-	-	-	0.040
Kalmia	latifolia	0.403	0.097	0.305	0.333	0.265
Lindera	benzoin	0.017	-	-	-	0.020
Liriodendron	tulipfera	0.263	0.585	0.416	0.424	0.285
Leucothe	recurva	-	-	-	-	0.020
Magnolia	acuminata	0.035	0.048	-	0.030	0.040
	fraseri	-	0.146	0.055	-	0.081
Nyssa	sylvatica	0.403	0.341	0.305	0.454	0.387
Oxydendron	arboreum	0.350	0.219	0.250	0.303	0.204
Pinus	rigida	0.105	0.024	0.055	0.030	0.040
	strobus	-	0.024	0.027	-	-
	virginiana	0.017	0.048	-	0.060	0.061
Prunus	serotina	0.192	-	0.165	0.060	0.040
Pyrularia	pubera	-	0.024	0.027	0.030	0.020

Slope Frequencies

Species		Slope (degrees) 0 - 5	6 - 15	16 - 25	26 - 39	40 +
Quercus	alba	0.561	0.268	0.305	0.242	0.244
	coccinea	0.122	0.097	-	0.030	0.020
	imbricaria	-	-	0.055	-	-
	marilandica	-	0.024	-	-	-
	prinus	0.403	0.219	0.333	0.333	0.469
	rubra	0.543	0.390	0.388	0.454	0.530
	velutina	0.543	0.268	0.388	0.333	0.204
Rhododendron	calendulaceum	0.140	0.146	0.333	0.272	0.244
	maximum	0.157	0.268	0.166	0.303	0.306
Robinia	pseudoacacia	0.263	0.121	0.194	0.181	0.285
Sassafras	albidum	0.245	0.146	0.083	0.060	0.122
Stewartia	ovata	-	0.024	-	-	0.020
Tilia	heterophylla	0.105	0.243	0.194	0.181	0.122
Tsuga	canadensis	0.087	0.195	0.166	0.121	0.224
Ulmus	rubra	0.017	-	-	-	-
Vaccinium	arboreum	0.175	0.073	0.361	0.212	0.142
	constablaei	-	-	-	-	0.020
Viburnum	spp.	0.017	0.024	-	0.030	-

Topographic Class Frequencies

Species		Cove	Drainage	Sheltered Slope	Open Slope	Ridge
Acer	pennsylvanicum	0.105	0.178	0.200	0.111	0.047
	rubrum	0.605	0.511	0.644	0.756	0.721
	saccharum	0.184	0.067	0.022	0.022	0.023
	spicatum	0.053	0.044	-	-	-
Aesculus	octandra	0.368	0.222	0.022	-	-
Amelancher	arborea	0.105	0.156	0.289	0.244	0.256
	laevis	-	-	0.022	0.022	0.023
Betula	allegheniensis	0.421	0.200	0.022	0.044	-
	lenta	0.474	0.400	0.178	0.178	0.093
Calycanthus	fertilis	-	-	-	-	0.023
Carpinus	caroliniana	0.132	0.067	-	-	-
Carya	spp.	0.368	0.467	0.756	0.578	0.651
Castanea	dentata	0.132	0.311	0.489	0.711	0.698
	pumila	-	-	-	0.022	0.023
Clethra	acuminata	-	-	0.022	0.044	-
Cornus	florida	0.263	0.333	0.444	0.467	0.395
Corylus	americana	0.026	-	-	-	0.023
Crataegus	spp.	0.026	-	0.022	-	-
Fagus	grandifolia	0.263	0.089	-	0.111	0.023
Fraxinus	americana	0.263	0.244	0.267	-	0.070
	pennsylvanica	-	0.022	-	-	-
Halesia	carolinana	0.211	0.044	-	-	-
Hamamelis	virginiana	0.500	0.156	0.044	0.067	-
Ilex	montana	0.105	0.067	0.044	0.044	-
	opaca	0.079	0.022	-	-	-
Juniperus	virginiana	-	-	0.022	0.022	-
Kalmia	latifolia	0.053	0.111	0.333	0.444	0.465
Lindera	benzoin	-	0.022	-	-	0.023
Liriodendron	tulipfera	0.684	0.533	0.400	0.200	0.116
Leucothe	recurva	-	-	-	0.022	-
Magnolia	acuminata	0.079	0.044	0.022	-	0.023
	fraseri	0.158	0.089	0.022	0.022	-
Nyssa	sylvatica	0.184	0.200	0.467	0.600	0.419
Oxydendron	arboreum	0.079	0.200	0.244	0.422	0.372

Topographic Class Frequencies

Species		Cove	Drainage	Sheltered Slope	Open Slope	Ridge
Pinus	rigida	-	-	0.022	0.111	0.140
	strobus	-	-	0.022	0.022	-
	virginiana	-	0.044	-	0.111	0.023
Prunus	serotina	0.132	0.022	0.068	0.044	0.233
Pyrularia	pubera	0.026	0.044	0.022	-	-
Quercus	alba	0.184	0.156	0.356	0.400	0.605
	coccinea	-	-	0.022	0.133	0.140
	imbricaria	-	-	0.022	0.022	-
	marilandica	-	-	-	0.022	-
	prinus	0.079	0.200	0.422	0.578	0.488
	rubra	0.158	0.333	0.622	0.578	0.628
	velutina	0.026	0.156	0.311	0.578	0.674
Rhododendron	calendulaceum	0.053	0.156	0.311	0.333	0.209
	maximum	0.526	0.267	0.178	0.178	0.070
Robinia	pseudoacacia	0.132	0.178	0.267	0.267	0.233
Sassafras	albidum	-	0.089	0.156	0.178	0.279
Stewartia	ovata	0.026	0.022	-	-	-
Tilia	heterophylla	0.500	0.267	0.067	0.022	-
Tsuga	canadensis	0.395	0.222	0.111	0.044	0.047
Ulmus	rubra	0.026	-	-	-	-
Vaccinium	arboreum	0.026	0.044	0.222	0.378	0.233
	constablaei	-	-	0.022	-	-
Viburnum	spp.	-	0.022	0.022	-	0.023

Vegetation Class Frequencies

Species		Total	Canopy	Small Tree	Saplings
Acer	pennsylvanicum	0.130	0.032	0.074	0.074
	rubrum	0.648	0.398	0.398	0.366
	saccharum	0.060	0.037	0.023	0.023
	spicatum	0.019	-	0.005	0.019
Aesculus	octandra	0.116	0.060	0.060	0.042
Amelancher	arborea	0.213	0.042	0.153	0.093
	laevis	0.014	-	0.014	0.005
Betula	allegheniensis	0.130	0.093	0.060	0.028
	lenta	0.259	0.190	0.125	0.083
Calycanthus	fertilis	0.005	-	-	0.005
Carpinus	caroliniana	0.037	0.005	0.014	0.028
Carya	spp.	0.569	0.324	0.296	0.301
Castanea	dentata	0.477	0.014	0.231	0.435
	pumila	0.009	-	0.005	0.005
Clethra	acuminata	0.014	-	0.009	0.009
Cornus	florida	0.384	0.019	0.333	0.194
Corylus	americana	0.009	-	-	0.009
Crataegus	spp.	0.009	-	-	0.009
Fagus	grandifolia	0.093	0.032	0.046	0.065
Fraxinus	americana	0.167	0.056	0.065	0.116
	pennsylvanica	0.005	-	-	0.005
Halesia	carolinana	0.046	0.009	0.014	0.032
Hamamelis	virginiana	0.144	-	0.102	0.111
Ilex	montana	0.051	-	0.019	0.051
	opaca	0.019	-	0.014	0.009
Juniperus	virginiana	0.009	-	-	0.009
Kalmia	latifolia	0.287	-	0.231	0.231
Lindera	benzoin	0.009	-	0.005	0.005
Liriodendron	tulipfera	0.380	0.310	0.125	0.125
Leucothe	recurva	0.005	-	-	0.005
Magnolia	acuminata	0.032	0.014	0.014	0.009
	fraseri	0.056	0.019	0.032	0.028
Nyssa	sylvatica	0.380	0.106	0.222	0.259
Oxydendron	arboreum	0.269	0.204	0.139	0.106

Vegetation Class Frequencies

Species		Total	Canopy	Small Tree	Saplings
Pinus	rigida	0.056	0.056	0.019	0.005
	strobus	0.009	-	0.009	0.005
	virginiana	0.037	0.019	0.019	0.009
Prunus	serotina	0.098	0.046	0.032	0.046
Pyrularia	pubera	0.019	-	0.005	0.019
Quercus	alba	0.343	0.306	0.097	0.069
	coccinea	0.060	0.060	0.005	0.005
	imbricaria	0.009	-	0.005	0.005
	marilandica	0.005	-	0.005	-
	prinus	0.361	0.338	0.167	0.093
	rubra	0.472	0.352	0.144	0.167
	velutina	0.356	0.301	0.079	0.097
Rhododendron	calendulaceum	0.218	-	0.083	0.218
	maximum	0.236	-	0.218	0.153
Robinia	pseudoacacia	0.218	0.153	0.051	0.037
Sassafras	albidum	0.144	0.032	0.056	0.093
Stewartia	ovata	0.009	-	0.005	0.009
Tilia	heterophylla	0.162	0.111	0.074	0.102
Tsuga	canadensis	0.157	0.079	0.111	0.060
Ulmus	rubra	0.005	-	-	0.005
Vaccinium	arboreum	0.185	-	0.028	0.176
	constablaei	0.005	-	-	0.005
Viburnum	spp.	0.014	-	0.005	0.014

APPENDIX 4: SPECIES LIST FOR EIGHT FOREST COMMUNITIES

TWINSPAN Parameter Values

Number of Pseudospecies Cut Levels:	4
Cut Levels:	0 10 20 40
Minimum Group Size for Division:	30
Maximum Number of Indcators per Division:	15
Maximum Number of Species in Final Tabulation:	137
Maximum Level of Division:	15
Diagrams of Divisions Wanted:	No
Machine-Readable Output:	Yes
Pseudospecies Weights:	1 1 2 2
Indicator Potential for Cut Levels:	0 1 1 1
Species Omitted as Indicators:	*Acer Rubrum*
	Kalmia latifolia

PARCHMENT-DEED
SOUTHWORTH CO. U.S.A.
100% COTTON FIBER

Basswood-Birch
(N = 27)

Species		Canopy		Small Tree		Sapling	
		Average R.D.	Count	Average R.D.	Count	Average R.D.	Count
Tilia	heterophylla	20.7	17	11.9	12	18.4	16
Betula	lenta	19.2	17	7.4	8	6.6	7
Liriodendron	tulipfera	16.7	11	5.6	2	0.8	2
Acer	rubrum	7.2	8	10.4	11	7.1	9
Acer	saccharum	4.9	4	9.0	4	3.6	3
Aesculus	octandra	4.9	7	11.4	10	11.1	7
Prunus	serotina	4.1	3	1.1	2	0.3	1
Fraxinus	americana	4.0	5	5.9	5	2.5	5
Betula	allegheniensis	4.0	5	3.5	3	1.0	2
Robinia	pseudoacacia	3.6	6				
Fagus	grandifolia	3.0	3	6.9	4	7.9	5
Quercus	rubra	1.8	3			0.6	1
Acer	pennsylvanicum	1.5	2	1.5	3	0.3	1
Amelancher	arborea	1.5	1	6.0	4	1.2	2
Quercus	prinus	1.2	1				
Quercus	alba	0.9	2				
Halesia	carolinana	0.5	1			3.6	3
Magnolia	fraseri	0.3	1	0.3	1	1.9	3
Hamamelis	virginiana			6.4	8	6.1	5
Rhododendron	maximum			5.9	4	2.6	2
Cornus	florida			4.4	2	0.3	1
Carpinus	caroliniana			1.0	1	2.6	2
Stewartia	ovata			0.9	1	1.9	1
Castanea	dentata			0.5	1	0.9	1
Nyssa	sylvatica					2.9	3
Carya	spp.					2.4	3
Ilex	montana					1.3	2
Vaccinium	arboreum					0.9	1
Ulmus	rubra					0.8	1
Lindera	benzoin					0.8	1
Kalmia	latifolia					0.7	1
Corylus	americana					0.5	1
Pyrularia	pubera					0.5	1
Acer	spicatum					0.3	1
Crataegus	spp.					0.2	1

R.D. = Relative Density

Birch-Hemlock
(N = 25)

Species		Canopy		Small Tree		Sapling	
		Average R.D.	Count	Average R.D.	Count	Average R.D.	Count
Betula	lenta	20.5	14	3.1	5	0.2	1
Liriodendron	tulipfera	16.1	11	1.6	3	0.3	1
Tsuga	canadensis	12.9	12	13.5	11	6.9	8
Betula	allegheniensis	8.5	8	3.0	6	1.0	3
Acer	rubrum	8.2	7	1.2	4	2.1	2
Quercus	rubra	6.7	7				
Tilia	heterophylla	5.1	6			1.2	2
Aesculus	octandra	3.8	4	1.4	3		
Amelancher	arborea	2.4	1	2.3	2		
Quercus	alba	2.3	3				
Quercus	prinus	1.7	3				
Fagus	grandifolia	1.6	1	4.0	2	6.3	3
Fraxinus	americana	1.5	2			0.5	1
Magnolia	fraseri	1.5	2	1.0	3	0.2	1
Quercus	velutina	1.3	1				
Carya	spp.	1.1	2	0.4	1	0.6	1
Magnolia	acuminata	0.9	2				
Acer	pennsylvanicum	0.8	1	0.6	2	1.4	2
Halesia	carolinana	0.8	1	0.6	2	0.9	2
Nyssa	sylvatica	0.8	1			0.3	1
Robinia	pseudoacacia	0.7	1				
Oxydendron	arboreum	0.5	1				
Acer	saccharum	0.4	1	0.4	1		
Rhododendron	maximum			50.1	23	47.1	20
Hamamelis	virginiana			7.8	9	13.6	10
Cornus	florida			4.6	3	0.6	1
Acer	spicatum			2.5	1	3.9	3
Pyrularia	pubera			1.0	1	3.6	2
Rhododendron	calendalaceum			0.4	1	4.0	3
Ilex	montana			0.4	1	2.2	2
Kalmia	latifolia					1.3	1
Fraxinus	pennsylvanica					0.7	1
Carpinus	caroliniana					0.6	1
Castanea	dentata					0.3	1
Viburnum	spp.					0.2	1
Vaccinium	arboreum					0.2	1

R.D. = Relative Density

Chestnut Oak
(N = 36)

Species		Canopy		Small Tree		Sapling	
		Average R.D.	Count	Average R.D.	Count	Average R.D.	Count
Quercus	prinus	23.0	24	4.4	10	0.9	2
Carya	spp.	9.9	19	13.5	20	13.4	19
Acer	rubrum	9.1	12	7.2	14	15.5	17
Quercus	alba	8.9	13	1.2	3	0.3	1
Quercus	velutina	8.5	13	0.8	2	0.6	2
Quercus	rubra	8.4	12	2.0	5	2.9	5
Liriodendron	tulipfera	7.9	14	1.8	6	1.3	5
Oxydendron	arboreum	7.7	12	2.5	9	0.6	3
Nyssa	sylvatica	4.9	8	8.7	18	10.2	16
Robinia	pseudoacacia	3.8	7	0.5	1	0.3	2
Quercus	coccinea	2.0	3				
Acer	pennsylvanicum	1.2	1	2.1	2	0.6	1
Betula	lenta	0.8	2	0.9	4	1.3	2
Sassafras	albidum	0.7	2			0.2	1
Pinus	virginiana	0.7	1	1.1	2		
Fagus	grandifolia	0.7	1	0.1	1	2.6	3
Cornus	florida	0.5	1	42.8	32	16.2	20
Fraxinus	americana	0.5	1	0.5	1	1.4	4
Pinus	rigida	0.4	1	0.8	1	0.2	1
Prunus	serotina	0.3	1			1.6	2
Carpinus	caroliniana	0.3	1				
Kalmia	latifolia			3.4	5	4.6	6
Amelancher	arborea			2.0	4	1.5	6
Rhododendron	maximum			1.2	2	1.7	2
Castanea	dentata			0.7	2	5.0	12
Halesia	carolinana			0.6	1	1.0	1
Ilex	opaca			0.3	1	1.0	1
Pinus	strobus			0.3	1		
Tsuga	canadensis			0.3	1		
Vaccinium	arboreum			0.2	1	7.2	10
Castanea	pumila			0.1	1		
Pyrularia	pubera					2.9	1
Ilex	montana					1.4	1
Juniperus	virginiana					1.4	2
Rhododendron	calendulaceum					1.3	2
Vaccinium	constablaei					0.7	1
Viburnum	spp.					0.2	1

R.D. = Relative Density

Chestnut Oak-Black Oak
(N = 16)

Species		Canopy		Small Tree		Sapling	
		Average R.D.	Count	Average R.D.	Count	Average R.D.	Count
Quercus	prinus	21.3	10	6.3	6	5.2	4
Quercus	velutina	15.6	7	0.7	2	1.0	2
Quercus	alba	11.2	6	0.7	2		
Acer	rubrum	9.8	9	4.7	9	2.5	4
Quercus	coccinea	9.6	4	0.3	1	1.0	1
Quercus	rubra	9.2	7	0.4	1	2.5	4
Oxydendron	arboreum	8.1	5	4.5	5	1.0	2
Pinus	rigida	5.5	5	0.5	1		
Nyssa	sylvatica	3.9	4	4.3	7	2.0	5
Carya	spp.	1.8	3				
Tsuga	canadensis	1.3	1	0.6	1	0.6	1
Pinus	virginiana	1.3	1	0.3	1	0.5	1
Robinia	pseudoacacia	0.8	1	1.1	2	0.5	1
Liriodendron	tulipfera	0.6	1			0.6	2
Kalmia	latifolia			62.3	16	61.1	15
Castanea	dentata			3.1	4	1.6	3
Amelancher	arborea			2.3	5	0.7	2
Rhododendron	maximum			2.2	2	1.0	1
Betula	lenta			1.5	2	0.5	1
Cornus	florida			1.4	3	4.2	5
Fagus	grandifolia			1.1	2	1.4	2
Sassafras	albidum			1.0	2	1.7	3
Acer	pennsylvanicum			0.4	1		
Amelancher	laevis			0.3	1	0.3	1
Quercus	marilandica			0.3	1		
Vaccinium	arboreum					7.8	3
Rhododendron	calendulaceum					1.5	2
Hamamelis	virginiana					0.6	1

R.D. = Relative Density

Chestnut Oak-Red Oak
(N = 28)

Species		Canopy		Small Tree		Sapling	
		Average R.D.	Count	Average R.D.	Count	Average R.D.	Count
Quercus	prinus	21.3	19	7.0	12	3.3	10
Acer	rubrum	15.2	17	21.8	21	14.6	22
Oxydendron	arboreum	13.6	14	7.3	11	4.5	11
Quercus	rubra	12.1	17	2.2	6	4.1	11
Quercus	velutina	9.4	12	1.4	3	1.2	6
Quercus	alba	6.9	9	0.6	1	0.6	3
Nyssa	sylvatica	5.5	6	20.3	19	13.7	20
Pinus	rigida	5.1	6	0.9	2		
Carya	spp.	3.0	7	3.5	9	2.2	8
Quercus	coccinea	2.4	5				
Robinia	pseudoacacia	2.2	4	2.1	4	1.1	3
Cornus	florida	1.4	3	9.1	13	4.4	10
Sassafras	albidum	0.7	1	2.5	5	4.3	8
Amelancher	arborea	0.6	1	0.3	1	0.3	2
Pinus	virginiana	0.4	1	0.7	1	0.2	1
Liriodendron	tulipfera	0.4	1			0.6	3
Castanea	dentata			9.1	12	24.9	23
Kalmia	latifolia			7.5	11	6.6	10
Rhododendron	maximum			2.6	3	1.6	1
Vaccinium	arboreum			0.5	2	4.3	6
Tsuga	canadensis			0.3	1	0.4	1
Clethra	acuminata			0.3	1		
Rhododendron	calendulaceum					5.3	7
Castanea	pumila					0.6	1
Hamamelis	virginiana					0.5	1
Calycanthus	fertilis					0.3	1
Acer	pennsylvanicum					0.3	1
Fagus	grandifolia					0.1	1
Betula	lenta					0.1	1

R.D. = Relative Density

Red Oak-Hickory
(N = 18)

Species		Canopy		Small Tree		Sapling	
		Average R.D.	Count	Average R.D.	Count	Average R.D.	Count
Quercus	rubra	34.2	15	5.6	7		
Acer	rubrum	14.9	8	7.9	9	4.7	7
Carya	spp.	10.0	8	4.3	4	2.7	3
Quercus	prinus	9.7	6	1.4	2	0.3	1
Quercus	velutina	5.7	5	0.8	1		
Betula	lenta	4.7	4	4.9	3	0.8	2
Acer	saccharum	4.3	2			0.6	1
Fraxinus	americana	3.0	2	9.5	4	2.7	3
Betula	allegheniensis	2.5	2				
Oxydendron	arboreum	2.3	3	2.1	2	3.1	2
Quercus	alba	2.2	2				
Robinia	pseudoacacia	2.2	2	3.6	3		
Acer	pennsylvanicum	1.7	2	3.4	4	4.9	4
Sassafras	albidum	0.9	1	0.5	1	0.5	1
Pinus	virginiana	0.9	1				
Amelancher	arborea	0.8	1	6.9	6	2.5	2
Rhododendron	calendulaceum			13.5	8	34.6	12
Castanea	dentata			10.1	9	21.8	13
Tsuga	canadensis			6.2	6	0.4	1
Hamamelis	virginiana			4.7	3	5.1	3
Ilex	montana			3.6	2	2.8	4
Tilia	heterophylla			2.4	2	2.9	2
Kalmia	latifolia			2.2	3	2.2	3
Cornus	florida			2.0	2	0.6	1
Magnolia	acuminata			1.7	2	1.2	1
Rhododendron	maximum			1.3	2	0.9	2
Nyssa	sylvatica			0.8	2		
Vaccinium	arboreum			0.6	1	0.3	1
Crataegus	spp.					1.9	1
Magnolia	fraseri					1.3	1
Quercus	imbricaria					0.5	1
Clethra	acuminata					0.4	1
Leucothe	recurva					0.2	1

R.D. = Relative Density

White Oak-Black Oak
(N = 32)

Species		Canopy		Small Tree		Sapling	
		Average R.D.	Count	Average R.D.	Count	Average R.D.	Count
Quercus	alba	25.0	23	5.8	12	3.0	8
Quercus	velutina	20.3	22	3.2	7	5.4	10
Acer	rubrum	12.5	13	5.5	7	4.7	12
Carya	spp.	10.1	14	11.2	17	1.0	6
Quercus	prinus	9.4	6	3.6	6	0.8	2
Robinia	pseudoacacia	4.4	8				
Amelancher	arborea	4.1	1	5.7	11	2.0	5
Quercus	rubra	3.7	6	4.1	11	4.1	9
Oxydendron	arboreum	2.0	5			0.1	1
Castanea	dentata	1.7	3	21.9	19	24.3	26
Prunus	serotina	1.4	4	2.8	4	1.6	6
Nyssa	sylvatica	1.0	1	1.3	1	0.4	3
Acer	pennsylvanicum	0.9	1	1.7	3	1.0	5
Liriodendron	tulipfera	0.6	1	0.4	1		
Sassafras	albidum	0.5	1	0.8	3	2.6	7
Quercus	coccinea	0.5	1				
Betula	lenta	0.5	2	0.3	1	0.2	1
Acer	saccharum	0.4	1				
Magnolia	fraseri	0.4	1				
Magnolia	acuminata	0.3	1				
Kalmia	latifolia			12.7	13	7.3	12
Rhododendron	calendulaceum			6.9	8	30.4	19
Rhododendron	maximum			5.7	7	1.5	4
Vaccinium	arboreum			1.3	2	7.6	16
Betula	alleghenienses			1.0	1		
Ilex	montana			0.9	1	0.3	1
Pinus	strobus			0.5	1	0.4	1
Hamamelis	virginiana			0.5	1		
Clethra	acuminata			0.4	1	0.3	1
Amelancher	laevis			0.4	1		
Viburnum	spp.			0.4	1	0.3	1
Cornus	florida			0.2	1		
Lindera	benzoin			0.2	1		
Fagus	grandifolia			0.2	1		
Corylus	americana					0.6	1
Fraxinus	americana					0.2	1

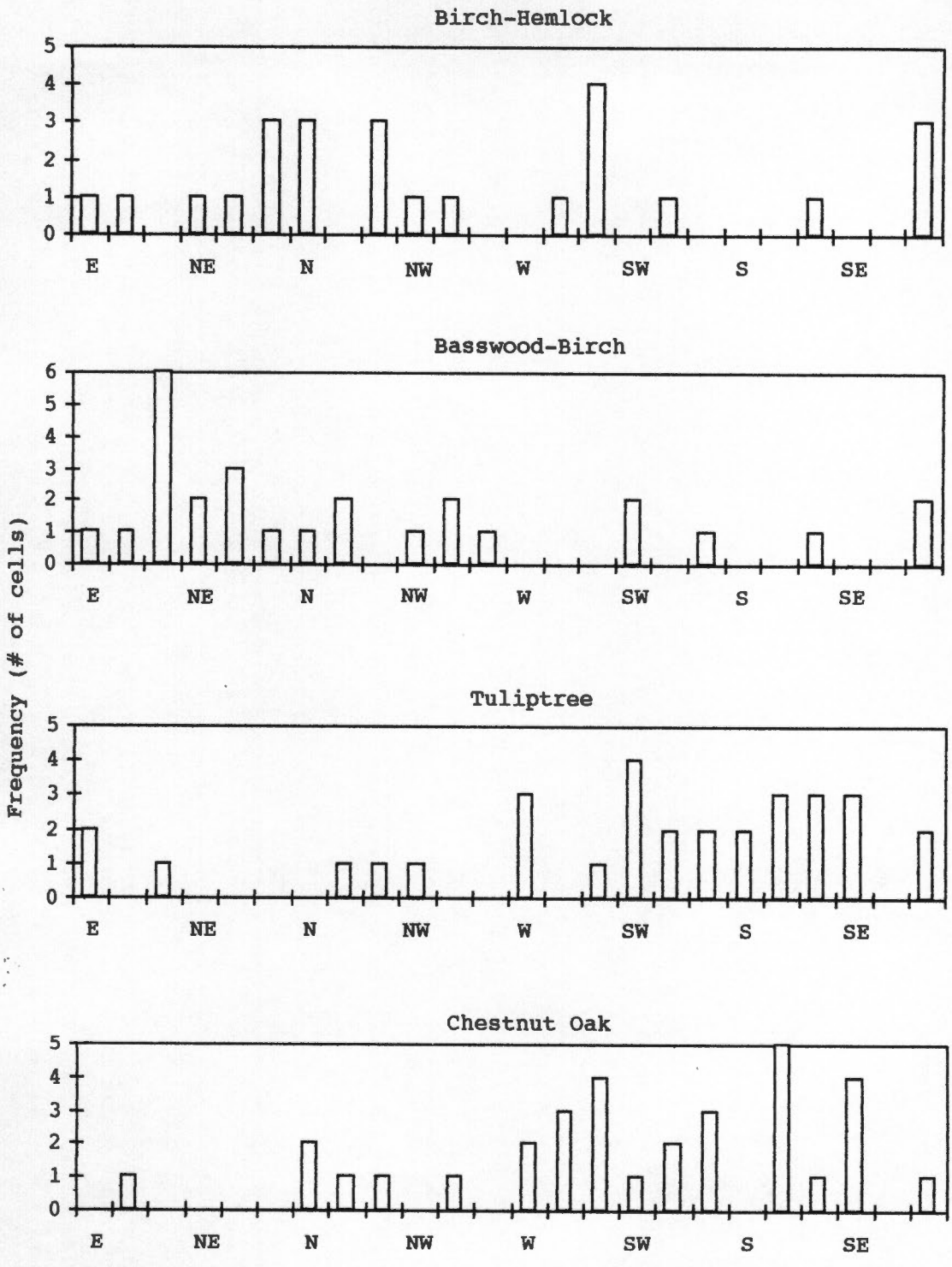
R.D. = Relative Density

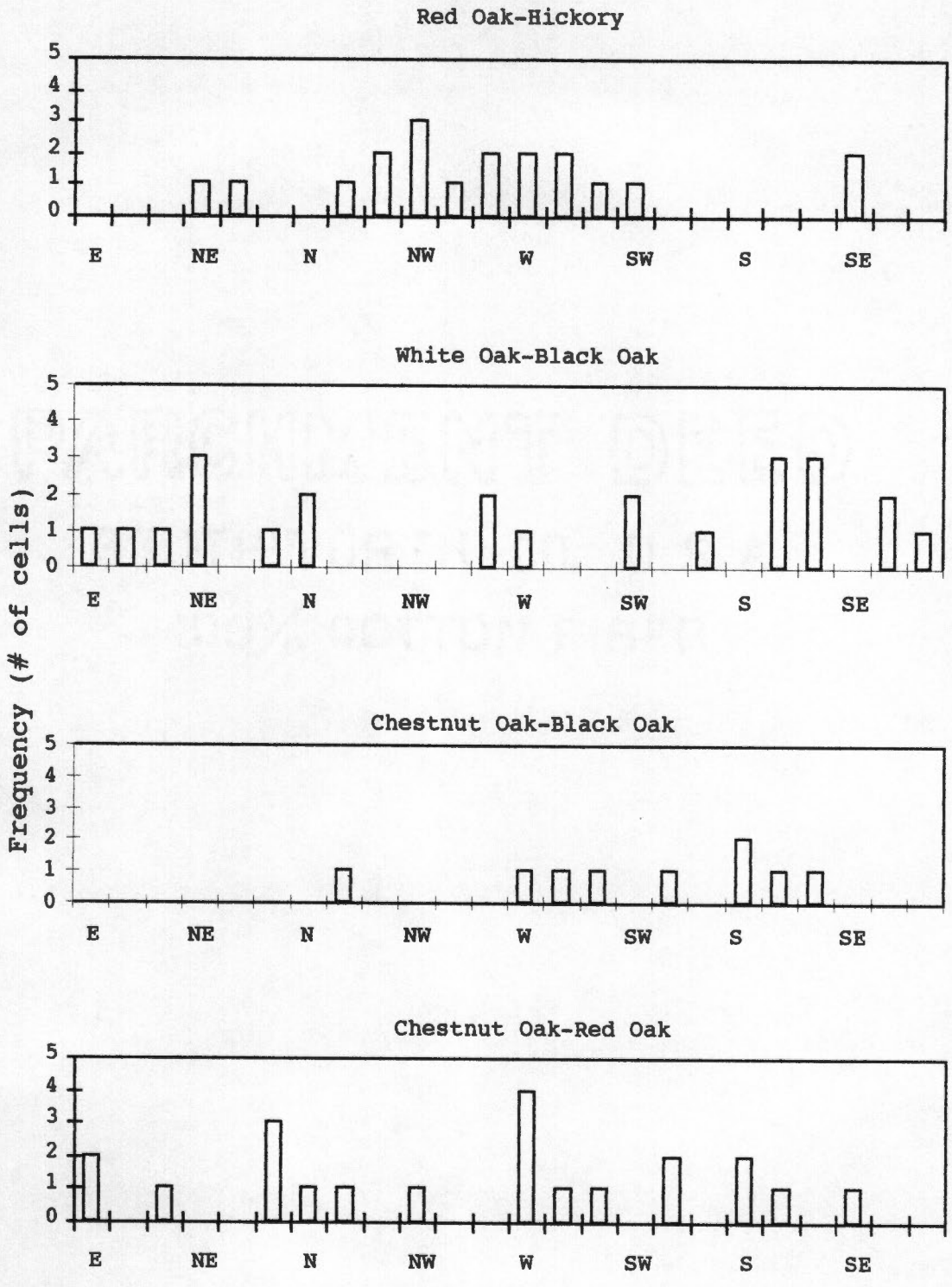
Tuliptree
(N = 34)

Species		Canopy		Small Tree		Sapling	
		Average R.D.	Count	Average R.D.	Count	Average R.D.	Count
Liriodendron	tulipfera	44.1	28	14.9	15	15.8	14
Carya	spp.	13.4	17	16.6	13	27.0	25
Acer	rubrum	7.6	12	5.8	11	5.7	6
Quercus	rubra	6.7	9	0.3	1	3.1	6
Quercus	alba	6.6	8	3.3	3	0.8	3
Quercus	velutina	2.9	5	1.3	2	0.5	1
Betula	allegheniensis	2.6	5	2.1	3	0.4	1
Oxydendron	arboreum	2.1	4	2.4	3	2.8	4
Robinia	pseudoacacia	1.9	4	0.3	1	0.9	2
Quercus	prinus	1.7	4			0.3	1
Tsuga	canadensis	1.6	4	4.0	4	1.0	2
Aesculus	octandra	1.5	2			0.4	2
Nyssa	sylvatica	1.4	3	0.6	1	5.3	8
Betula	lenta	1.3	2	2.8	4	1.8	3
Prunus	serotina	1.2	2	0.6	1	1.0	1
Tilia	heterophylla	1.1	1	1.0	2	1.0	2
Fraxinus	americana	0.9	2	2.4	4	4.8	11
Sassafras	albidum	0.8	2	3.0	1		
Fagus	grandifolia	0.8	2				
Cornus	florida			25.4	16	3.0	4
Magnolia	fraseri			2.6	3	0.3	1
Rhododendron	maximum			1.7	4	0.1	1
Castanea	dentata			1.3	3	10.3	15
Carpinus	caroliniana			1.3	2	0.5	3
Ilex	opaca			1.0	2	0.1	1
Kalmia	latifolia			1.0	2	1.0	2
Hamamelis	virginiana			0.9	1	5.1	4
Acer	pennsylvanicum			0.8	1	1.1	2
Rhododendron	calendulaceum			0.8	1	0.8	2
Amelancher	laevis			0.6	1		
Quercus	imbricaria			0.6	1		
Magnolia	acuminata			0.4	1	3.0	1
Stewartia	ovata					0.6	1
Halesia	carolinana					0.4	1
Acer	saccharum					0.3	1
Amelancher	arborea					0.3	1
Ilex	montana					0.2	1

R.D. = Relative Density

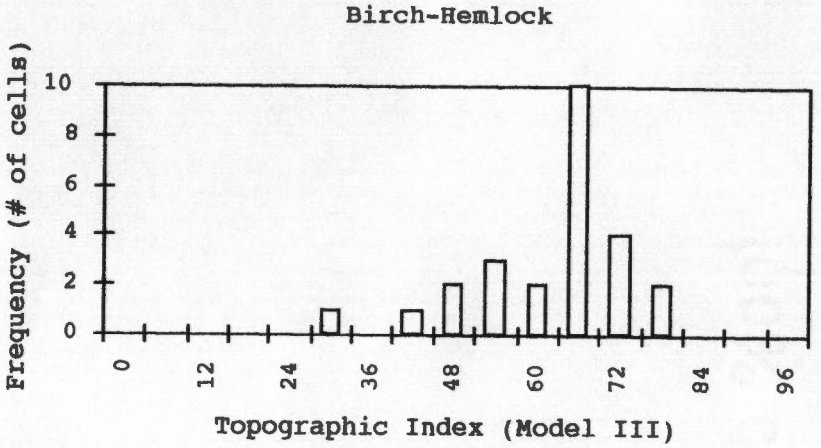
Appendix 5: Relation Between Forest Communities and Environmental Variables

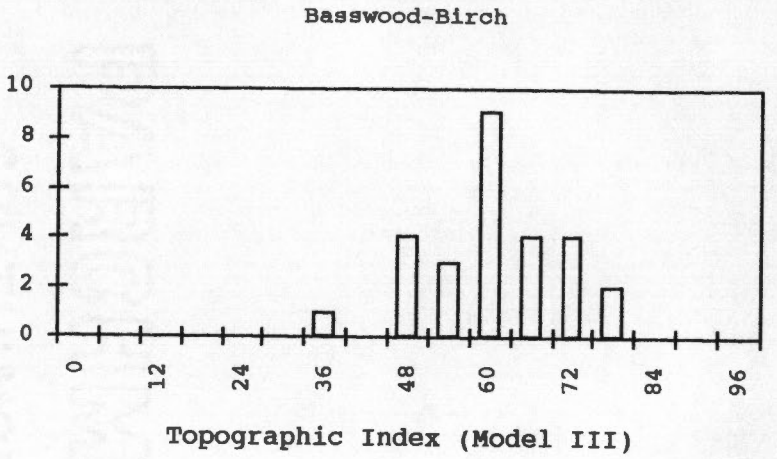

Birch-Hemlock
Basswood-Birch
Tuliptree
Chestnut Oak
Frequency (# of cells)
0
1
2
3
4
5
6
E
NE
N
NW
W
SW
S
SE
Aspect (15° Increments)

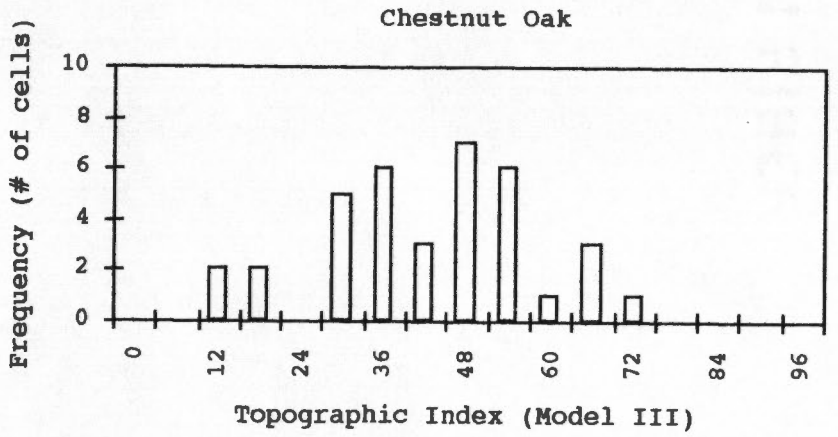

Red Oak-Hickory
White Oak-Black Oak
Chestnut Oak-Black Oak
Chestnut Oak-Red Oak
Frequency (# of cells)
0
1
2
3
4
5
E
NE
N
NW
W
SW
S
SE
Aspect (15° increments)

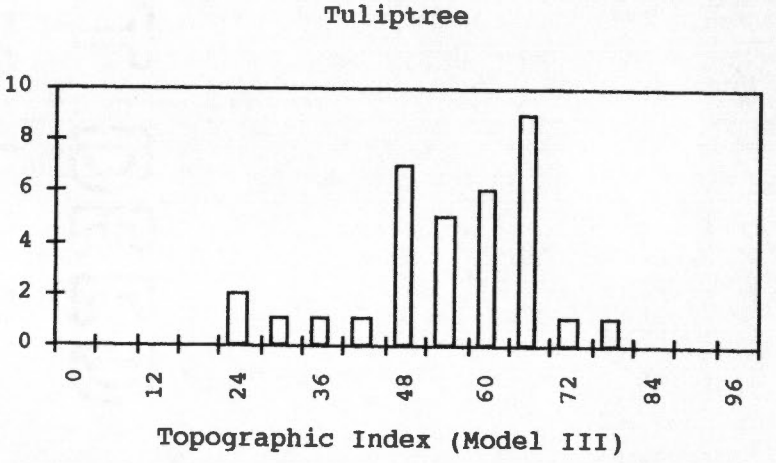
Frequency (# of cells)
0
2
4
6
8
10
12
730
823
914
1006
1097
1189
1280
1372
1463
Elevation (meters)
Chestnut Oak
Birch-Hemlock
Tuliptree
Basswood-Birch

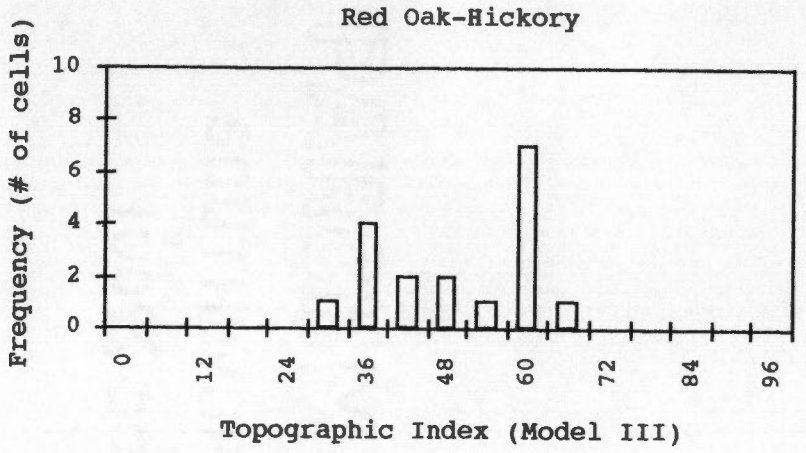
Frequency (# of cells)
Elevation (meters)
Red Oak-Hickory
Chestnut Oak-Black Oak
White Oak-Black Oak
Chestnut Oak-Red Oak
730
823
914
1006
1097
1189
1280
1372
1463
0
2
4
6
8
10
12

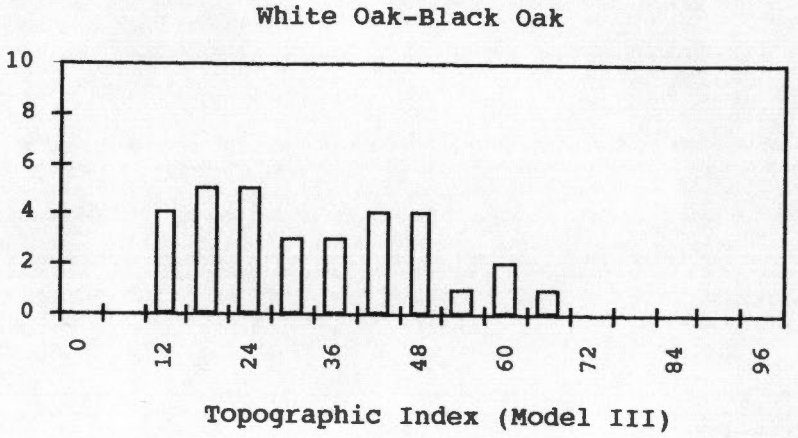

Birch-Hemlock
Frequency (# of cells)
0
2
4
6
8
10
0
12
24
36
48
60
72
84
96
Topographic Index (Model III)

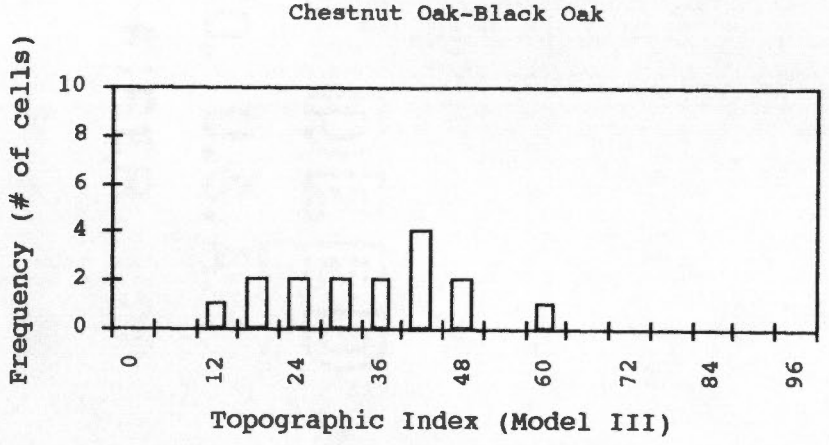

Basswood-Birch
0
2
4
6
8
10
0
12
24
36
48
60
72
84
96
Topographic Index (Model III)

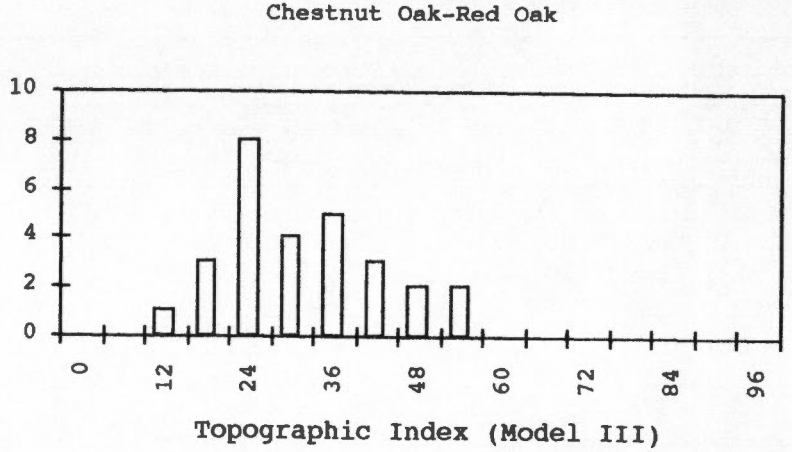

Chestnut Oak
Frequency (# of cells)
0
2
4
6
8
10
0
12
24
36
48
60
72
84
96
Topographic Index (Model III)


Tuliptree
0
2
4
6
8
10
0
12
24
36
48
60
72
84
96
Topographic Index (Model III)


Red Oak-Hickory
Frequency (# of cells)
0
2
4
6
8
10
0
12
24
36
48
60
72
84
96
Topographic Index (Model III)


White Oak-Black Oak
0
2
4
6
8
10
0
12
24
36
48
60
72
84
96
Topographic Index (Model III)


Chestnut Oak-Black Oak
Frequency (# of cells)
0
2
4
6
8
10
0
12
24
36
48
60
72
84
96
Topographic Index (Model III)


Chestnut Oak-Red Oak
0
2
4
6
8
10
0
12
24
36
48
60
72
84
96
Topographic Index (Model III)

VITA

Daniel T. Rutledge was born November 7, 1965 in Muskegon, Michigan. He spent the first three years of his life there, then 2 years in Duluth, MN, before moving to Greensburg, PA in 1973. He graduated from Hempfield Senior High School in 1984. He attended Northwestern University, majoring in the Integrated Science Program and Ecology and Evolutionary Biology, and received his B.A. in June 1988. After graduation, he worked for SRI International, a non-profit research and consulting firm in Menlo Park, CA, for almost five years. In 1993, he entered the University of Tennessee in the Ecology Program. He received his Master of Science Degree from UT in December 1995. Mr. Rutledge is currently a Ph.D. candidate at Michigan State University.