MODELING THE PLANT COMMUNITIES OF LONG BRANCH ENVIRONMENTAL EDUCATION CENTER

By

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Abstract

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The study of environmental gradients that affect plant community composition can lead to useful information about what shapes a community. Modeling these relationships can provide a tool for management and environmental education. This study examined environmental characteristics and species composition of understory plant communities at Long Branch Environmental Education Center in western Buncombe County, NC, USA. This information was used to test the reliability of using environmental factors to distinguish among plant communities. The study also tested if stands with different topography differ in their recovery from disturbance. Soil characteristics, aspect, elevation, and light influenced the composition of both spring and summer communities. Some communities from both seasons differed in soil properties and aspect. Some summer communities also differed in elevation. Surprisingly, these environmental factors failed to distinguish among all of the communities. For example, dispersal may have had an overriding influence on the composition of summer communities. Also, an interaction between elevation and age affected the total richness of plant communities, suggesting that stands that differ in topography also differ in their response to logging. Overall, the study suggests that some environmental factors may reliably distinguish among communities that are defined at a coarse scale. It also suggests that management practices, especially aggressive management such as logging, should be carefully implemented based on topographic characteristics of sites.

Introduction

The effects of environmental factors on plant species have been widely studied throughout the history of ecology. The importance of understanding these relationships has increased in the face of development that leads to habitat fragmentation and climate change. Quantitative description of these relationships is a first step toward understanding them. This study combines a natural experiment with such description to examine whether community composition in stands classified by landscape features can be reliably predicted from vegetation-environment relationships and whether these communities differ in response to disturbance.

Species distributions and community composition

Species composition and diversity change across landscapes due in part to changes in environmental factors that affect plant success. These changes in environmental factors are referred to as environmental gradients. Variation in factors such as light, nutrients, and water—variables that directly affect plant growth—are characterized as direct environmental gradients. Environmental factors like elevation, aspect, and slope do not directly affect plant growth, but they do influence direct gradients. Changes in these factors are described as indirect environmental gradients. Shifts in composition along environmental gradients reflect the fact that species differ in the environmental conditions they can tolerate.

Although many plant species have distributions that span a range of environments, the abundance of a species typically changes along environmental gradients according to variation in the capacity of individuals to grow and reproduce (Huston 1994). Individuals of a species rarely have equal fitness across an entire environmental gradient. Rather, individual fitness is typically higher in regions of a gradient where physiological performance is maximized (MacArthur 1960; Mueller-Dumbois and Ellenberg 1974). The abundance of a species will often correspond to this pattern in individual fitness, with a species reaching maximum abundance where environmental conditions are optimal (MacArthur 1960; Whittaker et al. 1973; Austin 2002; Austin and Smith 1989). Abundance tends to decline toward lower ends of resource and productivity gradients due to stress from abiotic limitation; it also often declines toward higher ends of such gradients due to competition (Grime 1979; Huston 1994). Consequently, most species have a unimodal distribution with respect to resource and productivity gradients, albeit they are often asymmetric (Austin 2002).

Changes in species' abundance patterns across landscapes are, like the underlying environmental gradients, usually gradual; therefore abrupt lines of demarcation rarely occur between different communities. The gradual nature of shifts in species composition is due to a variety of gradients changing independently of one another across the landscape (Whittaker 1956). Plant communities, then, are not the result of some random assortment of species; rather, they are changing mosaics of individual species with similar responses to environmental conditions.

Environmental gradients

Variables such as aspect, elevation, and slope curvature influence species diversity and community composition because they create gradients in variables that directly influence growth and reproduction. For example, species composition typically shifts from drought-tolerant species to shade-tolerant species when moving from south-facing to north-facing slopes because of changes in light, moisture, and soil nutrients (Whittaker 1956; Melillo et al. 1982; Hicks and Frank 1984; Lipscomb and Nilsen 1990; Olivero and Hix 1998; Hutchinson et al. 1999). Similarly, a shift from shade-tolerant to drought-tolerant species typically coincides with increased elevation in mesic regions characteristic of the eastern United States (Whittaker 1956). Not surprisingly, aspect and elevation also interact to affect species' abundances. Ginseng (*Panax quinquefolius*), for instance, is found at different elevations depending on aspect due to the effects these factors have on moisture and temperature (McGraw et al. 2003). Slope curvature also causes changes in species composition between noses and hollows due to movement of water and soil nutrients (Stephenson and Mills 1999; White et al. 2001). Like aspect, slope curvature interacts with elevation. For example, the presence of heath balds can be directly related to the interaction between slope position and elevation (White et al. 2001). Local topography can also cause shading of lower elevations, creating an environment that selects against species that lack shade tolerance (McNab 1992). All of these vegetation-environment patterns found in relation to landscape features lead us to believe that we can predict environmental conditions and community composition or at least community dominants from landscape features.

other environmental factors. After initial disturbance, diversity increases with time as more species immigrate to an area (Huston 1979, 1994). The increase in diversity is limited, however, tending to reach a maximum and then decline due to sequestering of resources by dominant individuals. Disturbance like natural treefalls, if gradual and constant, can increase species diversity by opening new niches and reducing competitive suppression by dominant species (Huston 1994). Large, intense, and sudden disturbance events generally tend to cause an initial decrease in diversity due to inability of sensitive species to survive the event. Plants that specialize to endure such disturbance are often short-lived perennials that can colonize and reproduce after disturbance events (Grime 1977). In western North Carolina this type of disturbance often causes heath dominated understories (White et al. 2001).

Timber harvesting activities disturb many aspects of natural herbaceous communities. Removal of trees increases erosion and leaching of nutrients from the soil, reducing resources for herbaceous plants. Compaction of soil from roads and heavy equipment used for logging reduces porosity and may increase erosion by reducing infiltration during rains (Huang et al. 1996; Xu et al. 2002). These changes in soil quality affect the ability of herbaceous plants to grow and reproduce. Timber harvest also reduces canopy cover, increasing light intensity on the forest floor. Once the successional understory is established, light is subsequently reduced below pre-harvest levels. This sudden change in light intensity decreases survival of many herbaceous species by affecting germination, seed production, and growth rates (Small and McCarthy 2002).

levels. This sudden change in light intensity decreases survival of many herbaceous species by affecting germination, seed production, and growth rates (Small and McCarthy 2002).

Modeling

Statistical descriptions of changes in the abundance of individual species across environmental gradients are commonly combined to describe shifts in community composition (Guissan and Zimmerman 2000). Such descriptions have been used as predictive models that have effectively been applied to questions about the impacts of development and conservation of biologically important areas (Chiarucci et al. 2001), distributions and requirements of threatened species (McGraw et al. 2003), and site characteristics of vegetation types (White et al. 2001; McNab 1992; Cawsey et al. 2002). Predictive models possibly can be used for education about environmental requirements for specific types of plant communities. Predictive models can also be used as a tool for biologists to evaluate plant communities for ecological restoration. Such models are also applied as GIS applications for mapping plant communities (Austin 2002).

How can responses of individual species to gradients be used to create a statistical description of plant communities? It is important to consider fundamental concepts of plant ecology when using modeling as a tool (Austin 2002). There are three important components to any predictive model (Austin 2002). First, the "ecological model" consists of the biological concepts to be used or tested. It often represents the biological question being asked or assumptions about ecological relationships. For example, assumptions about the shape of species' distributions could be part of the ecological model on which a predictive model is based. Second, the "data model" consists of ideas about how data are collected. Third, the "statistical model" consists of tools like the analytical methods, error functions, and significance tests used to evaluate species responses. A wide variety of statistical tools are used to evaluate data sets including generalized linear models and generalized additive models (Bio et al. 1998). The results consist of correlations between species and gradients.

Plants are affected by a host of environmental variables simultaneously (Austin and Gaywood 1994). All gradients that may possibly affect the plant community need to be considered for accurate analysis. However, a complete evaluation of every gradient at a site is an impossible task. Often, only obvious gradients are examined. In other cases, gradients are collapsed into fewer variables to make models more manageable (Grime 1979). For example, moisture and temperature gradients might be collapsed into a single gradient of elevation. These considerations will guide the model building and determine which environmental variables to measure as well as sampling strategies.

Statistical modeling is not without limitations. First, correlation does not tell us why a species occurs where it does; it only tells us that there is a relationship between location and plant composition (Austin 2002). Another limitation is that statistical models express data that are snapshots of conditions, yet plant communities are in a constant condition of being changed by their environment (Austin 2002). A third limitation arises from the trade-off between a model's generality, its precision, and its reflection of reality (Guissan and Zimmerman, 2000). Despite the shortcomings, statistical modeling can be a valuable tool for description and prediction of plant species responses to environmental changes.

Objectives

The overall objective of this research was to identify environmental gradients associated with community composition in the Sandy Mush/ Newfound Mountain region of western North Carolina. A related goal was to use the relationships found in the study to predict vegetation types from environmental factors in the region. However, this application assumes that community composition is reliably predicted from landscape features and associated environmental characteristics. Therefore, the study will also test the effectiveness of predicting community type from landform indices and landscape-based stand classifications. If landscape features accurately predict community type, then stands that are classified as the same type of community should be more similar in landscape features and other environmental variables than stands classified as different communities.

The tracts studied differed in age but included sites that were topographically similar. This combination creates an opportunity to also test whether recovery of vegetation from disturbance is linked to topography and other landscape features. If recovery of vegetation from disturbance varies with topography, then the effect of age on community composition will differ among sites that differ in landscape classification. No effect would suggest that communities do not vary in response to disturbance based on topography.

Methods

Study area

The study was carried out on Long Branch Environmental Education center and its associated wildlife conservation lands. The 643 ha area is part of the Sandy Mush Basin in Buncombe and Haywood Counties of western North Carolina, incorporating areas on Newfound Mountain and Sandy Mush Bald. It is in the part of the southern Appalachians that Braun (1950) classified as oak-chestnut forest. Elevations range from 829 to 1570 m (the highest point in Buncombe County). Annual precipitation for the region is around 200 cm. Mean regional temperatures range from -2 to 22 °C (White et al. 2001). The area has been geologically uplifted and is comprised of a variety of soil types underlain by metamorphic sedimentary rock. Soils at the site are acidic, deep, and well drained in nature. Most of the study area was logged in the early to mid 1900s; however, Big Sandy Mush Bald was selectively logged 20 years ago. This tract will be considered to be young portion of the study area while the other two plots will be considered of old age. The study area primarily contains late to mid successional hardwood forests with ericaceous understory that includes rhododendron and azaleas.

Three tracts were sampled: Big Sandy Mush Bald (BSMB), the Big Sandy Mush Creek watershed (BSMC), and the Willow Creek watershed (WC). BSMB is a 243 ha watershed defined by high elevation ridges. It ranges in elevation from 853 m to 1570 m and opens to the southeast. BSMB contains the complete headwaters for Bald Fork Creek. BSMC is a 59 ha cove running north to south with primarily southern aspects. The elevation ranges from 927 m to 1292 m. This area experienced selective logging in the 1950s, but has received relatively little disturbance since. WC spans 172 ha with elevation ranging from 829 m to 1480 m and opens to the northeast. This area has not been logged since the early 1900s.

Sampling

Each tract was stratified into sites with respect to aspect and elevation. Elevation was divided into three zones that each span roughly 305 m (1000 feet): 823-1067 m, 1067-1372 m, and 1372-1585 m. Aspects were divided into south, north, east, and west. These combinations of elevation and aspect resulted in 12 possible types of sampling sites. Some site combinations are absent from each tract. When possible, six randomly placed 100 m^2 plots were established in each sample site. Plot locations were identified by randomly selecting grid coordinates on topographic maps of the study area. Random compass directions and random distances between zero and 30 m were then generated using Microsoft Excel for each coordinate which identified the top right corner of each plot. This procedure ensured the possibility of placing plots at any location between gridlines.

Plots were surveyed for a variety of environmental variables (Appendices B and C). Light levels were measured as percent open sky from canopy photographs taken parallel to the hillside. Photographs were taken in August at a height of 1 m with a 16mm lens from the center of each plot. The images were analyzed with Scion Image (version 4.02, Scion Corporation, Frederick, MD, USA). Aspect was recorded, as was degrees departure from S-SW (202.5°), typically the most xeric aspect in the region (Whittaker et al 1979). Plots were classified according to slope curvature as convex, concave, or linear/uncurved. Water tends to spread off of convex slopes and linear slopes, whereas it tends to collect on slopes with concave curvature. Percent slope from bottom right corner to top right corner of each plot was measured with a clinometer. A relative landform index was calculated by averaging measures of the angle of inclination to the horizon in four directions, generally north, south east, and west (McNab 1992). A positive index value indicates the overall concave nature of the land with flat land being zero and the number increasing towards one for the most convex land forms.

Five 1-m^2 quadrats were randomly placed within the 100 m^2 plots. Locations for the quadrats were identified by placing a grid pattern over the plot and randomly selecting points of intersection along the grid. Points that could have fallen on the upper and left boundary of each plot were excluded from consideration due to disturbance of the understory during plot setup. The herbaceous vegetation was surveyed within these quadrats in the spring (April-May) and again in summer (June-July). Species identification followed Wofford (1989). Abundance of each species was estimated as percent cover. Species richness was also measured. Soil samples were collected to a depth of 10 cm when possible during the period from July 14 to August 24. Rocky soil required the use of a hand trowel rather than a hand held soil corer. The samples were placed in freezer bags in the field and kept in a cooler until August 25. They were transferred to paper bags dried to a constant weight at about 65 °C, and then ground buffering capacity, total N, and percent carbon by the Soil Testing Laboratory at the University of Kentucky's Division of Regulatory Services.

Data analysis

Data taken in quadrats (understory cover values, species richness, and soil variables) were averaged over quadrats for each plot. Plant data from spring (late April – late May) and summer (June – late July) were analyzed separately. Cover of some plants was measured more than once during each season. The repeated measures were averaged.

Species richness was measured as average richness over quadrats, total richness over quadrats, as well as total species richness for the plot. A series of simple linear regressions and stepwise multiple regressions were used to examine the relationship between species richness and measured environmental variables. Species richness was measured for each plot by counting the number of species in each quadrat, and then averaging over the five quadrats in a plot. It was also measured simply as the total number of species identified in the plot. The multiple regression was used to determine the model that best predicts species richness from the measured environmental factors.

Detrended correspondence analysis (DCA) was used to help identify the environmental gradients that underlie species' distributions. Detrending was done by segments. This ordination technique is an indirect gradient analysis that sorts species scores (estimate of a species' optimum based on abundance) and sample scores (weighted average of the abundance of species in the sample) in one or more dimensions by maximizing the correspondence between species and samples. Mean percent cover within a plot served as the measure of a species' abundance. A series of Pearson correlations was used to examine environmental variation along the first two axes from the DCA. Ward's minimum variance method of cluster analysis (Ward 1963) was used together with the ordination results to classify plots in to community types based on species' average cover. Distance between plot pairs was measured as relative Euclidian distance. PC-Ord (version 4.25, MjM Software Design, Gleneden Beach, OR, USA) was used for the ordinations and cluster analyses. SAS for Windows (release 9.0, SAS Institute Inc., NC, USA) was used for all other analyses.

ANOVA was used to test for the effects of stand age and topography on vegetation structure, species richness in particular, with both stand age and topography as fixed effects. Plots with the same age and topography served as replicates. Categories of age and topography were additionally compared with a series of two-sample t-tests. The sequential Bonferroni procedure was used to maintain an experiment-wise, type-one error rate of 0.05 (Graffen and Hails 2002). Pairwise comparisons were used to examine differences among means within factors identified as significant in the ANOVA. Factorial ANOVA was also used to evaluate any interaction between topography and age. The interaction term was used to evaluate the hypothesis that stands with different topography differ in their recovery from disturbance.

Community types identified from cluster analysis were compared with respect to landscape associated environmental variables using ANOVA, with community type as a fixed effect. Plots classified as the same community type served as replicates. Communities were compared with a series of two-sample t-tests with community type as the dependent variable. The sequential Bonferroni procedure was used to maintain an experiment-wise, type-one error rate of 0.05. Significant differences among community types were interpreted as evidence that landscape variables and indices using them effectively predict stand composition. Community types generated through vegetation data in the cluster analysis were also compared with respect to additional cluster analysis with environmental variables used for the generation of the groups. The community types generated via vegetation and the two other cluster dendrograms, direct and indirect/topographic variables, were compared for similarity of plot placement in the dendrogram by evaluating the degree to which community types remained together in the new dendrograms.

Results

Overstory vegetation was not quantified, but low elevation plots seemed to be dominated by *Liriodendron tulipifera* and *Tilia americana*, whereas middle and high elevation plots seemed to be dominated by *Quercus* species, primarily *Q. montana* in middle elevations and *Q. rubra* at high elevations. There also seemed to be a distinct shift from deciduous midstory of *Hydrangea arborescens, Acer pennsylvanicum*, and *Halesia tetraptera* to more ericaceous shrubs as elevation increased.

A total of 147 understory herbaceous species were observed during spring sampling and 137 species in summer sampling in the study area. Among the most frequently encountered were *Polystichum acrostichoides, Aster divaricatum, Impatiens pallida, Stellaria pubera, Smilacina racemosa, Viola sororia, Sedum ternatum*, and *Arisaema triphyllum*. Dominant species in various plots included *Galax aphylla, Cimicifuga racemosa, Laportea canadensis, Toxicodendron radicans*, and *Dennstaedtia punctilobula* (Table 1). *Toxicodendron radicans*, as well as other woody vines, were included in the study due to their direct competition with herbs on the forest floor. Several rare and locally infrequent species were also encountered, including *Phacelia fimbriata, Cypripedium calceolus, Prenanthes trifoliolata, Solidago caesia*, and *Solidago lancifolia*.

Table 1. Twenty most common species encountered in Long Branch sampling quadrats, their average cover over all plots (in decimal equivalents), standard deviation of this average cover, and number of plots the species occurred in during the study.

Species	Average cover	Standard deviation	Frequency
Polystichum acrostichoides	0.12	0.8	29
Polygonatum biflorum	0.04	0.04	24
Aster divaricatum	0.07	0.09	44
Impatiens pallida	0.07	0.07	25
Stellaria pubera	0.06	0.11	24
Smilacina racemosa	0.06	0.07	28
Eupatorium rugosum	0.04	0.03	26
Potentilla simplex	0.03	0.03	18
Viola sororia	0.06	0.10	34
Sedum ternatum	0.07	0.05	29
Arisaema triphyllum	0.03	0.25	40
Galax aphylla	0.17	0.12	4
Asarum canadense	0.10	0.18	12
Laportea canadensis	0.28	0.26	8
Disporum lanuginosum	0.12	0.08	8
Geranium maculatum	0.11	0.11	6
Cimicifuga racemosa	0.17	0.12	18
Toxicodendron radicans	0.14	0.16	6
Caulophyllum thalictroides	0.12	0.09	7
Dennstaedtia punctilobula	0.17	0.11	6

Environmental gradient

DCA of spring vegetation and DCA of summer vegetation each defined two gradients with moderate to high correspondence between species and sample scores (Figures 1 and 2). The first axis from both ordinations (spring DCA1 and summer DCA1) reflects a nutrient gradient. N, P, K, Ca, Mg, soil pH, and buffering capacity decrease along spring DCA1 (Figure 3). The same nutrients and soil pH increase along summer DCA1 (Figure 4). The reversal of the gradient is simply an artifact of the analyses. Average species cover also decreased along spring DCA1 and increased along summer DCA1 (Figures 3 and 4). The association between topography and the order of plots along spring DCA1 suggests an additional relationship with moisture. For example, plots in coves and low hillsides occur at the low end of the axis, and plots on ridges and high hillsides occur at the high end of the axis. However, other variables related to moisture, such as aspect, were not correlated with spring DCA1. Instead, they were correlated with the second axis from the DCA of spring vegetation (spring DCA2), that appears to reflect a gradient of increasing solar radiation and decreasing moisture, with an increase in the axis corresponding to more southerly aspects and less concave curvature (Figure 5).

This relationship with solar radiation and moisture was not a component of the gradient defined by the second axis from the DCA of summer vegetation (summer DCA2). Like summer DCA1, the second axis reflected an increase in nutrients (Figure 6). Summer DCA2 also reflected a slight increase in soil buffering capacity and a slight trend toward less concave curvature. In addition, summer DCA2 reflected a decrease in age. Plots from BSMS clustered together in the ordination of summer vegetation. Plots from the other tracts spread out over the axes, as did plots from all tracts in the ordination of spring vegetation. Plots that were near each other in the landscape tended to be clustered in the ordination of summer vegetation.

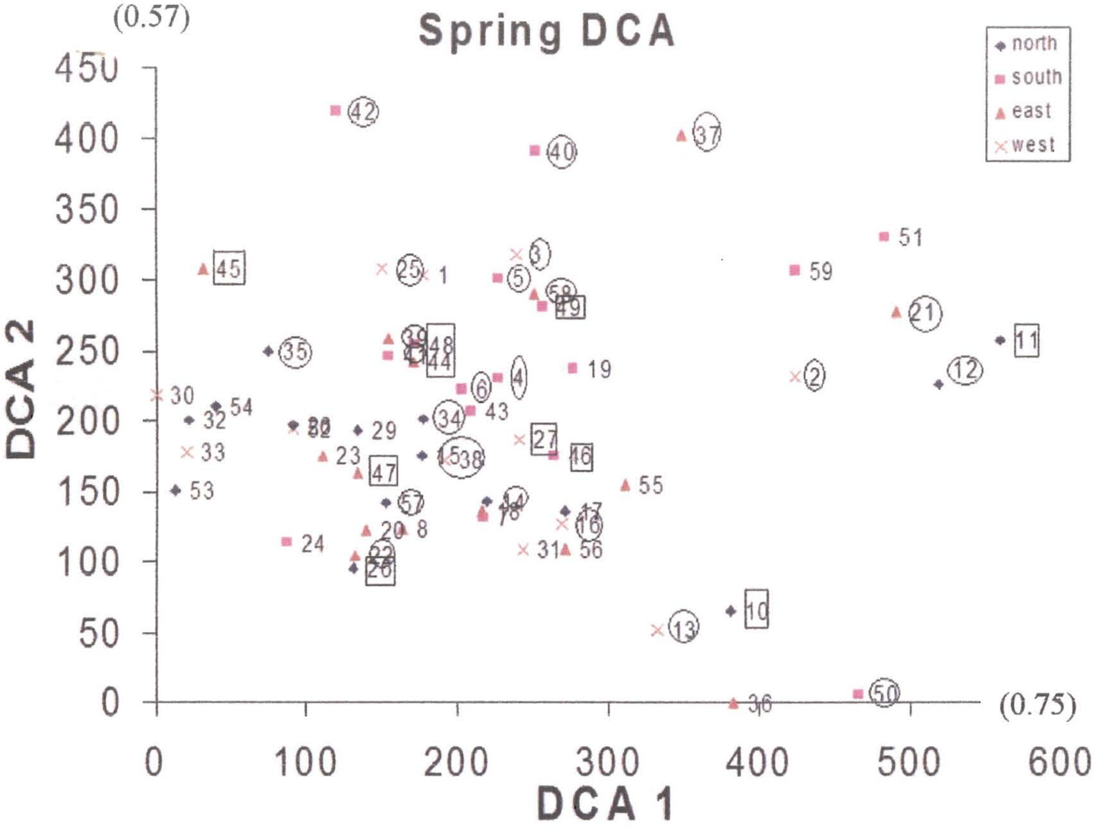


Figure 1. Plot scores from DCA of spring vegetation. Eigenvalues for DCA1 and DCA2 given in parentheses. Circled numbers represent middle elevation plots, squares represent high elevation plots. Numbers without symbols around them are low elevation plots.

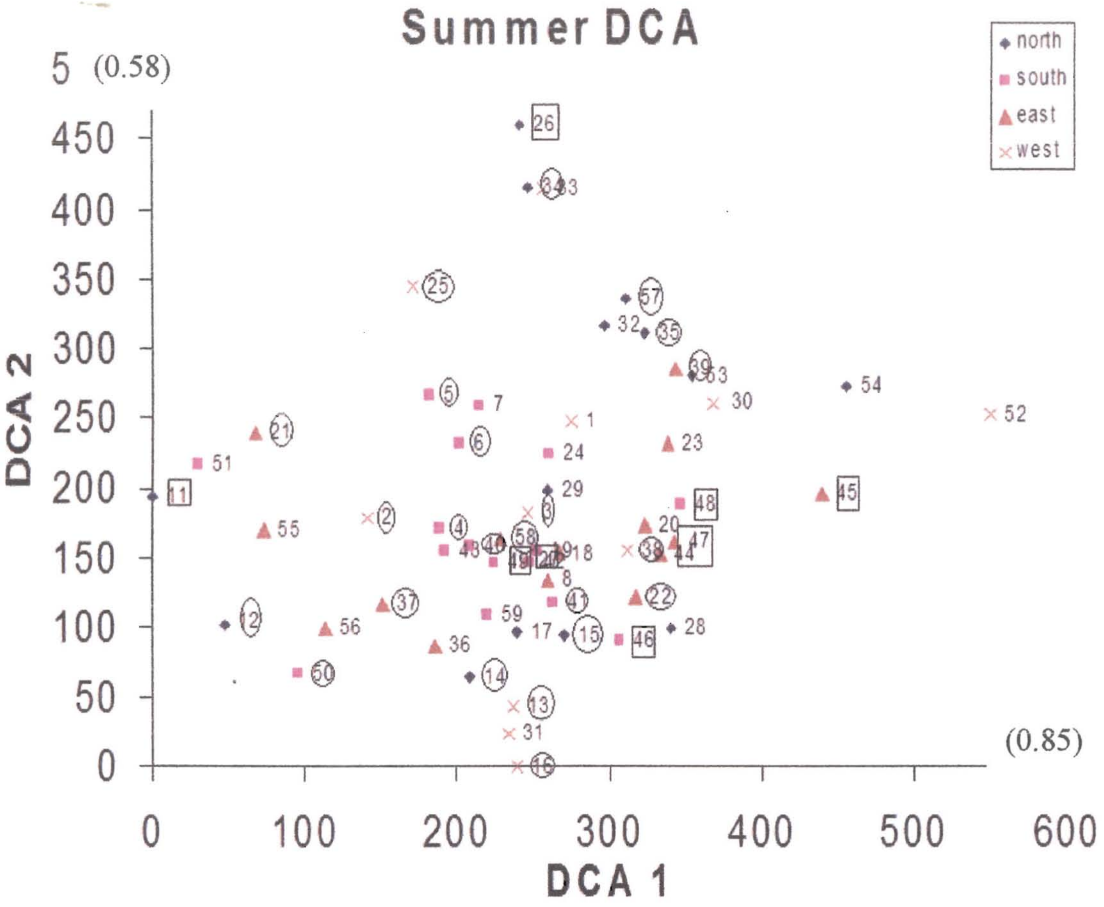


Figure 2. Plot scores from DCA of summer vegetation. Eigenvalues for DCA1 and DCA2 given in parentheses. Circled numbers represent middle elevation plots, squares represent high elevation plots. Numbers without symbols around them are low elevation plots.

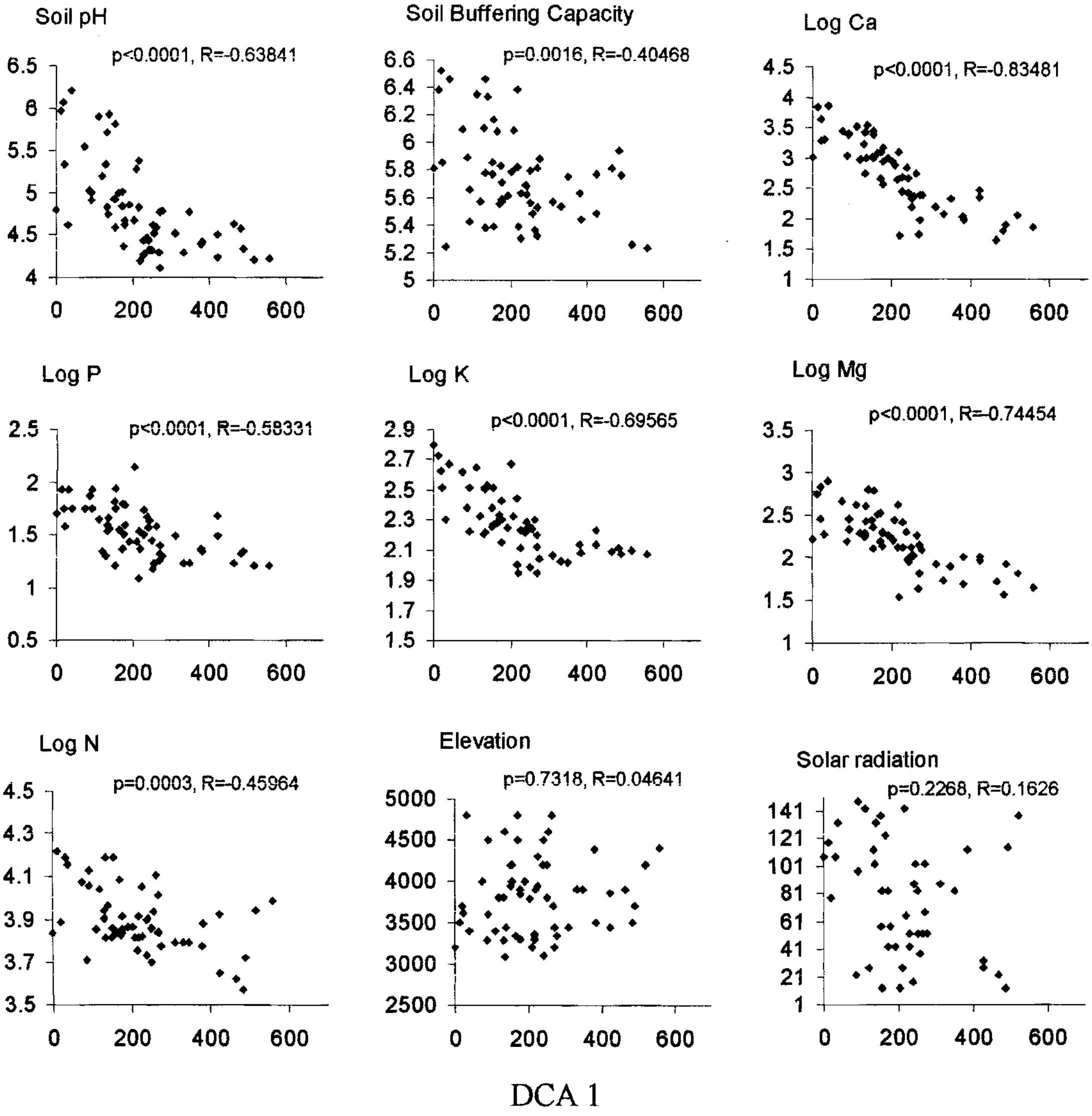


Figure 3. Environmental properties along the gradient defined by DCA1 from analysis of spring vegetation. Each graph and associated analysis is based on 59 data points. Nutrients are reported in lb/acre and solar radiation is in degrees departure from south southwest. Elevation is reported in feet.

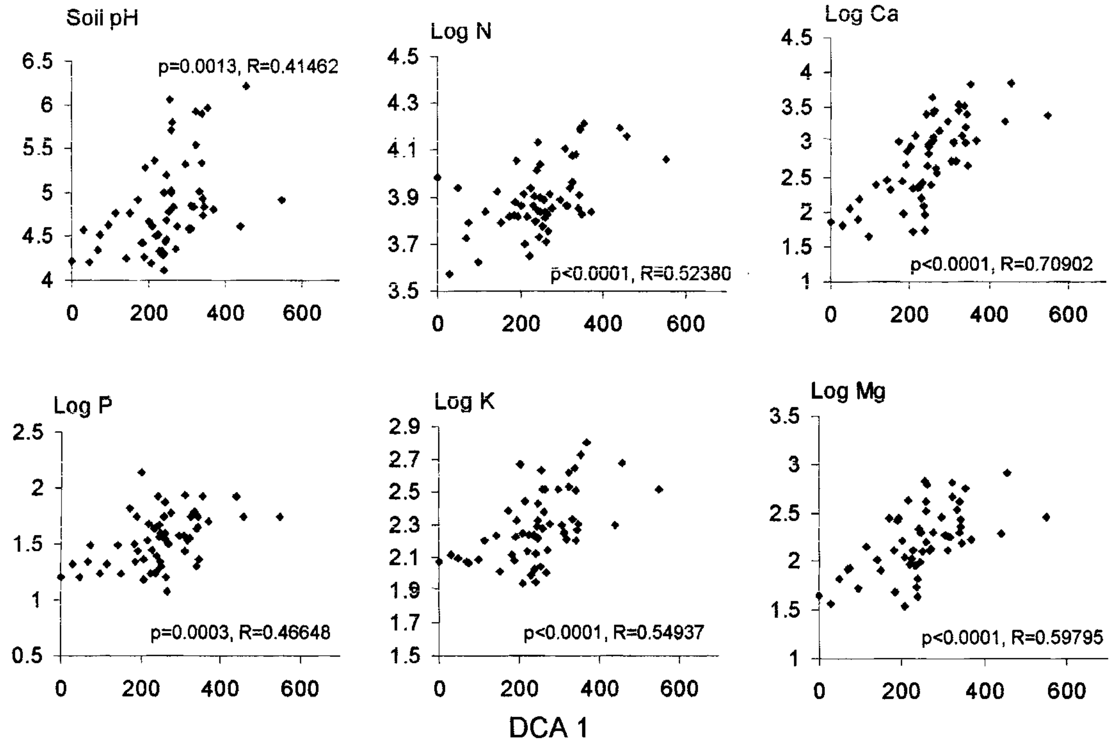


Figure 4. Environmental properties along the gradient defined by DCA1 from analysis of summer vegetation. Each graph and associated analysis is based on 59 data points. Nutrients are reported in lb/acre .

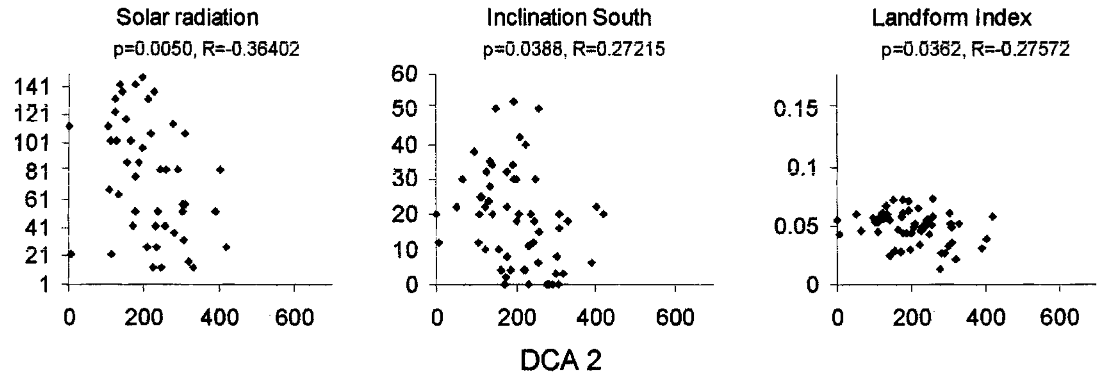


Figure 5. Environmental properties along the gradient defined by DCA2 from analysis of spring vegetation. Inclination to South reflects the increasing slope to the southern horizon line and therefore reflects a decrease in solar insolation. Each graph and associated analysis is based on 59 data points. Solar radiation is reported in degrees departure from south-southwest and inclination is in degrees.

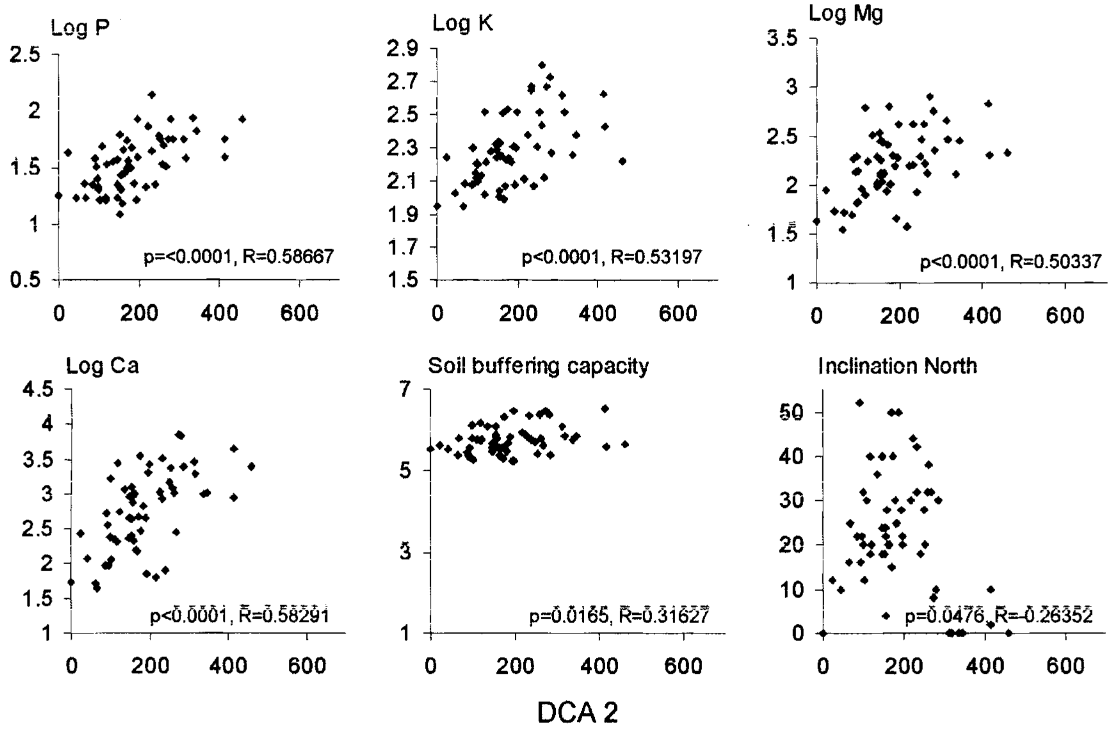


Figure 6. Environmental properties along the gradient defined by DCA2 from analysis of summer vegetation. Inclination to North reflects the increasing slope to the northern horizon line and therefore reflects an increase in shading. Each graph and associated analysis is based on 59 data points. Inclination is given in degrees and nutrients in lb/acre.

Classification of plots

Plots sampled in the spring clustered into nine relatively distinct vegetation types (Figure 7). *Smilacina racemosa* and *Toxicodendron radicans* dominated community type A (Table 2). *Aster divaricatum* and *Cimicifuga racemosa* dominated type B. *Galax aphylla* and *Pyrularia pubera* dominated C. Community type D was dominated by *Viola sororia* and *Impatiens pallida*. *Prenanthes serpentaria* and *Parthenocissus quinquefolius* dominated type E. Type F was dominated by *Cimicifuga racemosa* and *Stellaria pubera*.

Type G was dominated by *Polystichum acrostichoides* and *Prenanthes serpentaria*. Community H was dominated by *Geranium macrophyllum* and *Polystichum acrostichoides*.

Table 2. Average species cover values in spring classes for dominant species.

Spring Class	Species	Average Cover in Spring Class
A	*Smilacina racemosa*	0.13
A	*Toxicodendron radicans*	0.20
B	*Aster divaricatum*	0.10
B	*Cimifuga racemosa*	0.14
C	*Galax aphylla*	0.21
C	*Pyrularia pubera*	0.20
D	*Viola sororia*	0.15
D	*Impatiens pallida*	0.11
E	*Prenanthes serpentaria*	0.20
E	*Parthenocissus quinquefolius*	0.23
F	*Cimicifuga racemosa*	0.27
F	*Stellaria Pubera*	0.23
G	*Polystichum acrostichoides*	0.20
G	*Prenanthes serpentaria*	0.07
H	*Geranium macrophyllum*	0.15
H	*Polystichum acrostichoides*	0.14

Summer plots clustered into 10 vegetation types (Figure 8). Class I was dominated by *Aster divaricatum* and *Smilacina racemosa* (Table 3). Type J was dominated by *Prenanthes serpentaria* and *Pyrularia pubera*. *Parthenocissus quinquefolius* and *Toxicodendron radicans* dominated type K. Community type L was dominated by *Galax aphylla* and *Thylepteris novebranceous*. Type M was dominated by *Galax aphylla* and *Clitoria mariana*. Type N was dominated by *Viola canadensis* and

Viola sororia. Laportea canadensis and *Aster divaricatum* dominated type O. *Polystichum acrostichoides* and *Stellaria pubera* dominated type P. *Cimicifuga racemosa* and *Sedum ternatum* dominated type Q. Type R was dominated by *Solidago caesia* and *Viola rotundifolia.*

Table 3. Average species cover values in summer classes for dominant species.

Summer Class	Species	Average Cover in Summer Classes
I	*Aster divaricatum*	0.10
I	*Smilacina racemosa*	0.11
J	*Prenanthes serpentaria*	0.69
J	*Pyrularia pubera*	0.34
K	*Parthenocissus quinquefolius*	0.31
K	*Toxicodendron radicans*	0.30
L	*Galax aphylla*	0.26
L	*Thylepteris novebranceous*	0.11
M	*Galax aphylla*	0.12
M	*Clitoria mariana*	0.07
N	*Viola canadensis*	0.36
N	*Viola sororia*	0.16
O	*Laportea canadensis*	0.43
O	*Aster divaricatum*	0.20
P	*Polystichum acrostichoides*	0.14
P	*Stellaria pubera*	0.08
Q	*Cimicifuga racemosa*	0.25
Q	*Sedum ternatum*	0.11
R	*Solidago caesia*	0.05
R	*Viola rotundifolia*	0.05

Some plots that were classified together by the cluster analysis of spring vegetation were also classified together in the analysis of summer vegetation. Eight plots were common to spring group A and summer group I. Spring group D and summer group N shared all plots. Summer group P shared five plots with spring group F and three plots with both spring groups B and D.

Clusters identified by analysis of plots based on environmental variables differed from clusters identified by analysis of plots based on species' abundances. Classes identified in the cluster analysis of vegetation data were more similar to the classes identified in cluster analysis of large-scale topographic/indirect environmental data than classes identified in cluster analysis of soil data alone (Figures 9 and 10). Both analyses yielded four groups based on the environmental variables. Spring groups A, B, C, D, and F and summer groups J and L were conserved in the soil groups. Spring groups, A, E, F, and G, and summer groups I, J, N, P, and Q were conserved in the topographic clusters. Spring groups A and F and summer groups I and P were very closely linked in the topographic gradients dendrogram. These results support the frequent observation that indirect gradients ultimately determine the factors that directly affect plant growth and community composition.

Comparison of communities

Communities identified in both seasons separated widely along the gradients defined by DCA1 of the respective ordinations (Figure 11). According to the DCA axes communities D, H, F, N, and Q were at positions with high nutrients. A, G, E, B, K, I, P, O, and J were at moderate nutrient levels while C, M, and L were low nutrient communities. ANOVA and pairwise comparisons confirmed differences among communities. Spring community types differed in degrees departure from S-SW, degrees inclination to eastern horizon line, Mg, Ca, K, P, and soil pH (Figure 9). Summer communities differed among age, elevation class, Ca, N, soil organic matter, and degrees departure from S-SW (Figure 10).

Soil nutrients varied most between communities. Spring communities were very different, whereas summer communities had fewer significant differences in environmental variables between classification groups (Figures 12 and 13). Communities D and H were nutrient rich, while C was nutrient poor. Community L was higher in soil organic matter than communities K and O. Communities O and K were older than J and Q, and O had higher calcium levels that L. Communities N and Q also had more nitrogen than M.

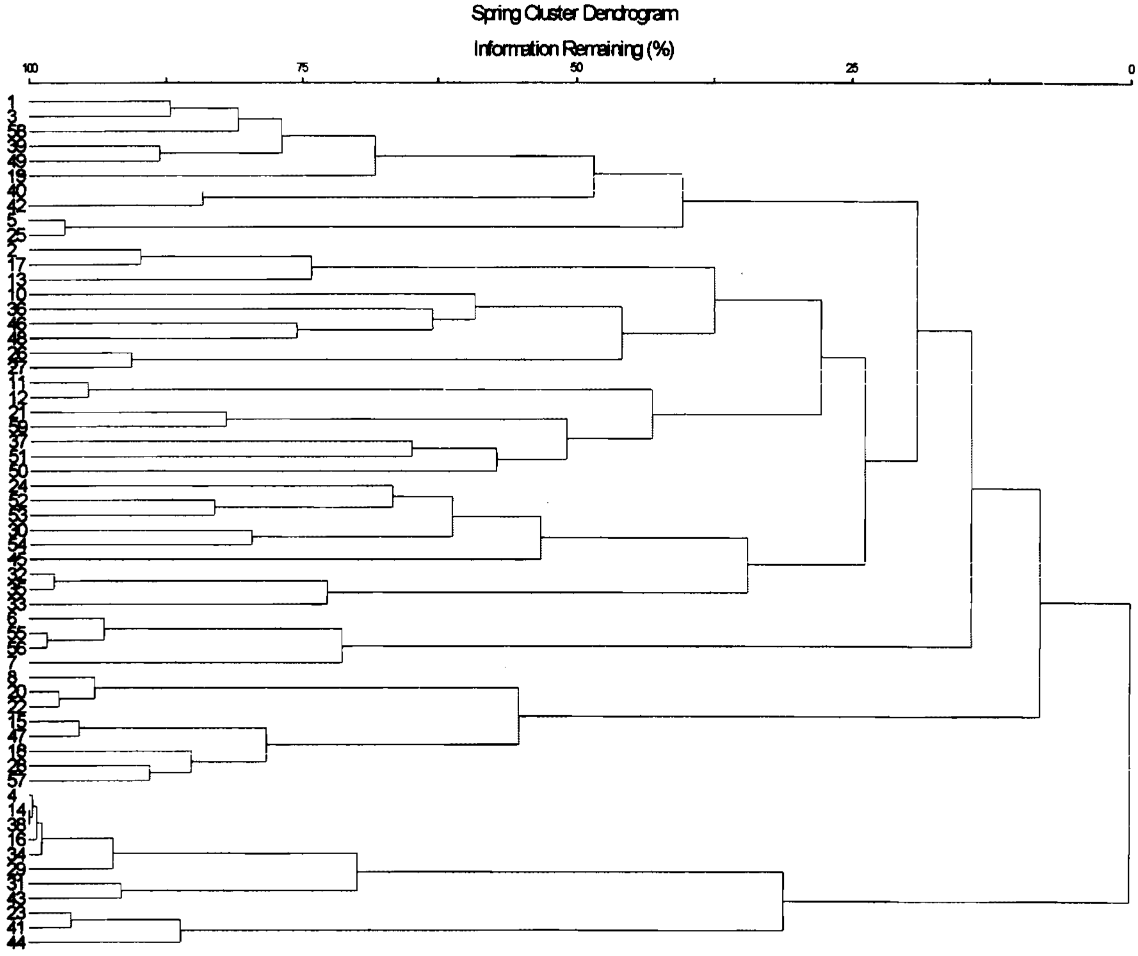
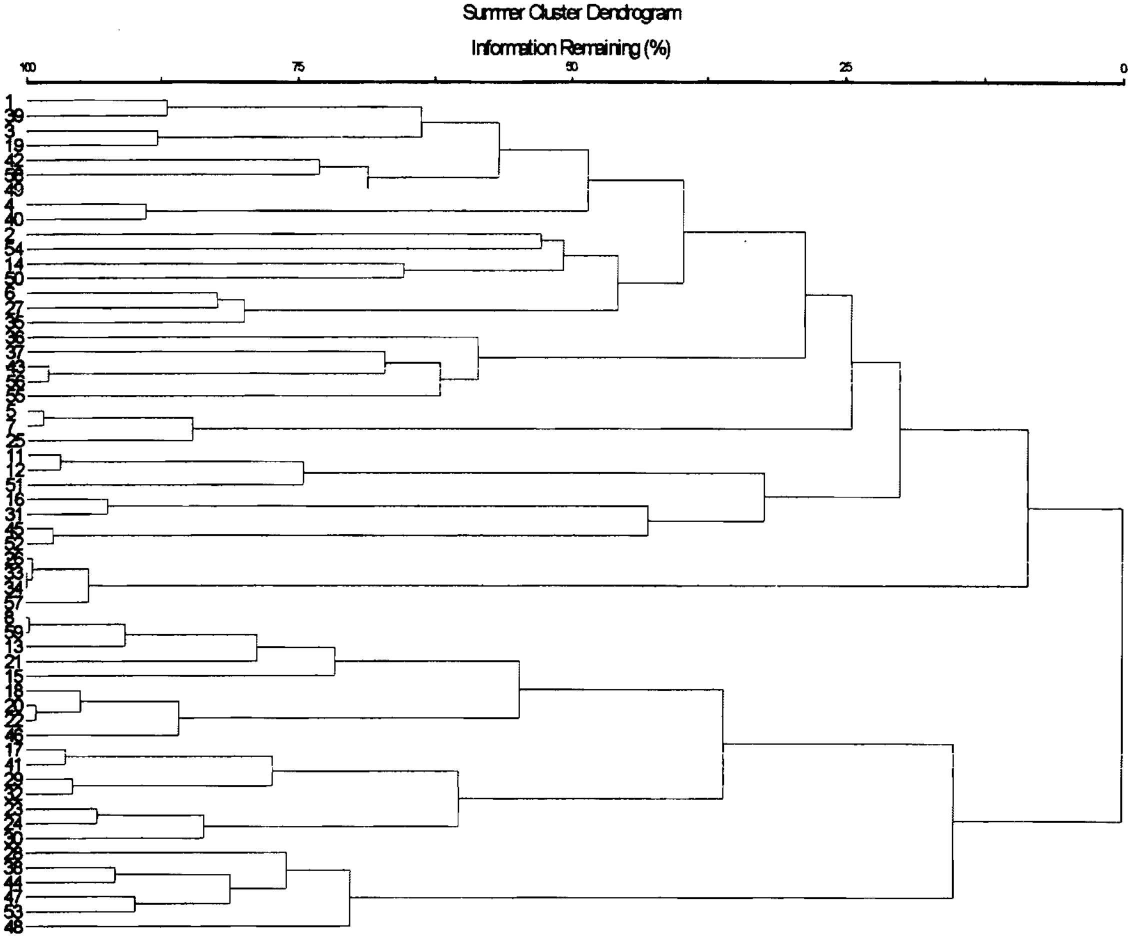


Figure 7. Cluster analysis of plots using species abundance data from spring survey. Information remaining scale can be interpreted as the inverse of the proportion of plots that have been grouped. No plots are grouped at 100% information remaining. All plots are grouped into one cluster at 0% information remaining. Plots clustered together with 42.5% information remaining were considered the same community type.



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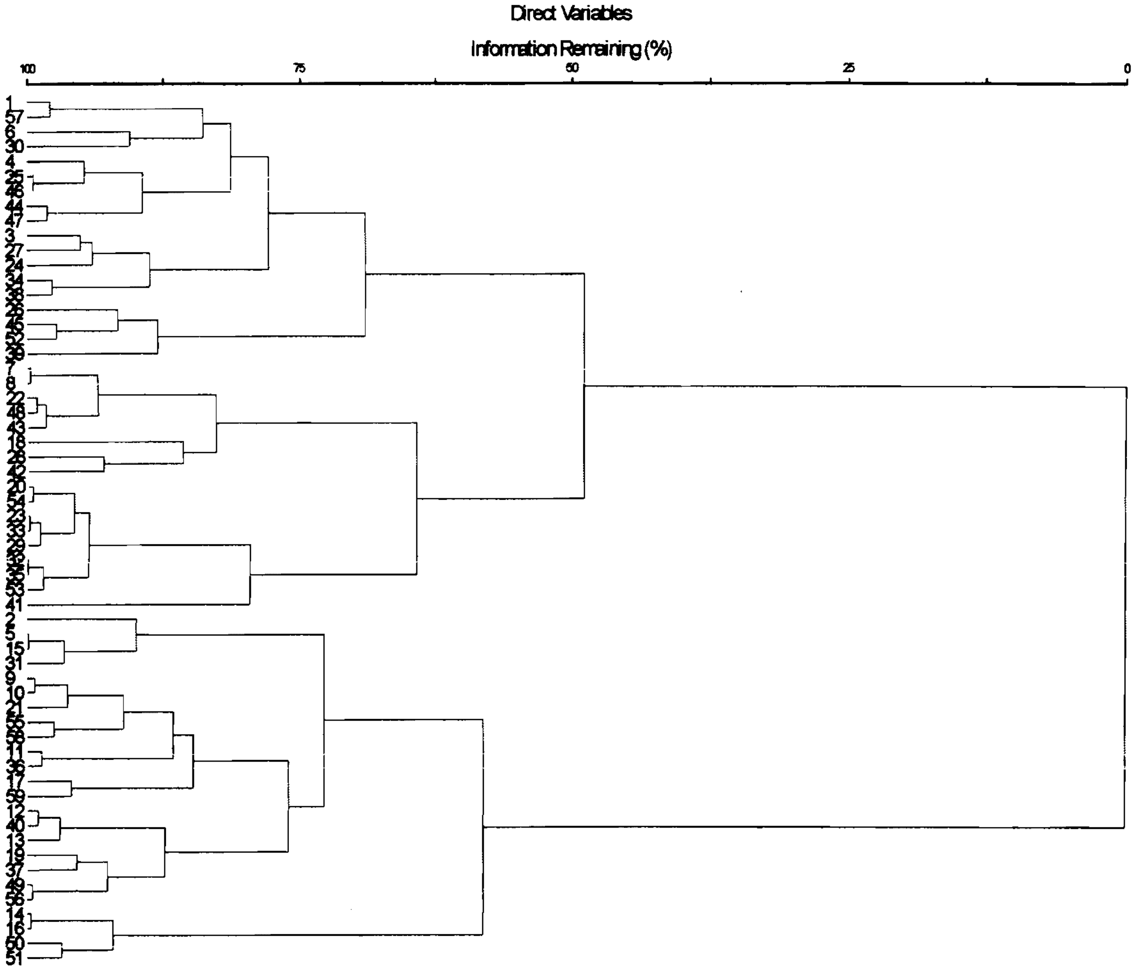

Figure 9. Cluster analysis of plots based on values of direct/soil variables. Information remaining scale can be interpreted as the inverse of the proportion of plots that have been grouped. No plots are grouped at 100% information remaining. All plots are grouped into one cluster at 0% information remaining. Plots clustered together with 60% information remaining were considered the same community type.

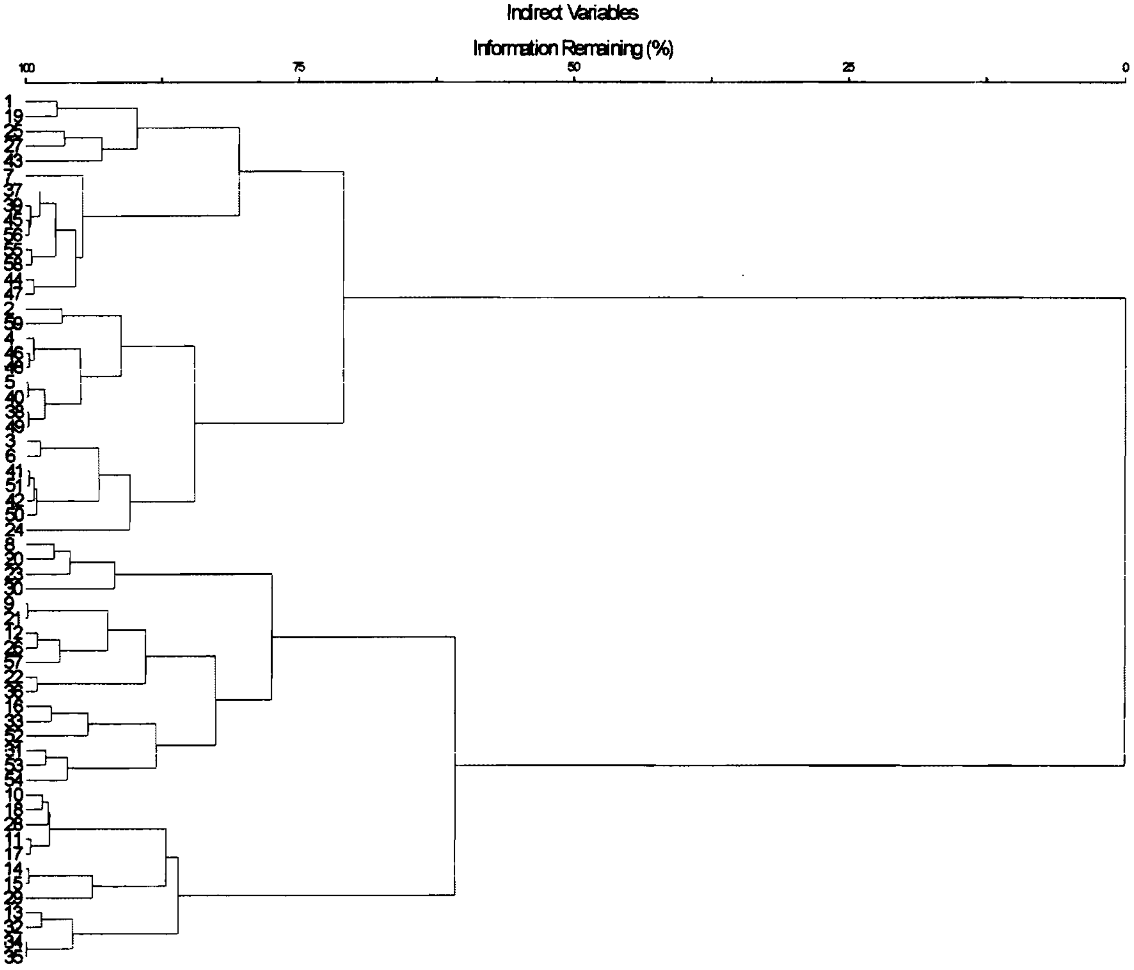

Figure 10. Cluster analysis of plots based on values of indirect environmental variables. Information remaining scale can be interpreted as the inverse of the proportion of plots that have been grouped. No plots are grouped at 100% information remaining. All plots are grouped into one cluster at 0% information remaining. Plots clustered together with 60% information remaining were considered the same community type.

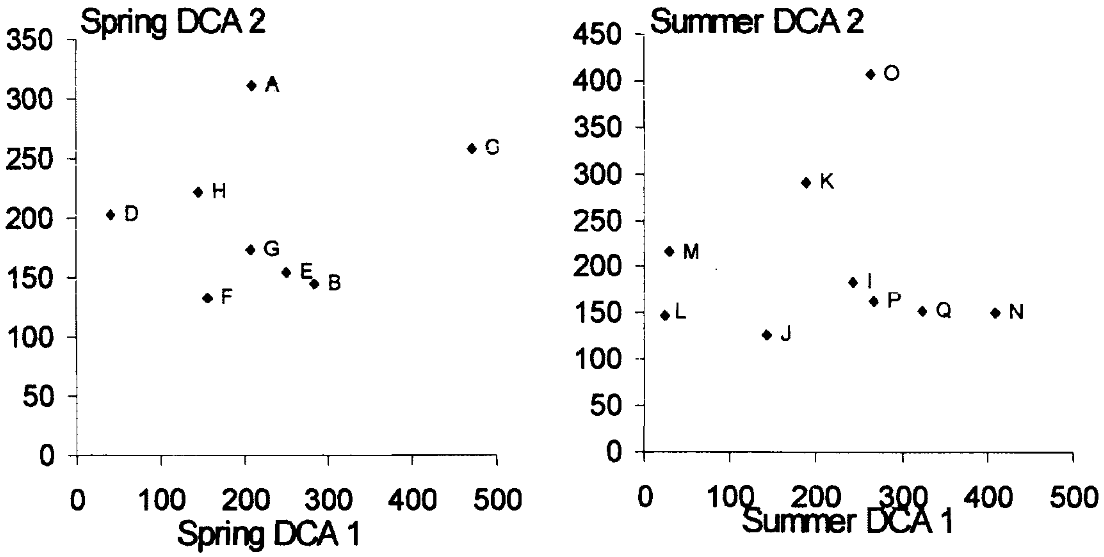

Figure 11. Scores from DCA of spring and summer vegetation. A community's score was calculated by averaging the DCA scores of all plots classified as the community type.

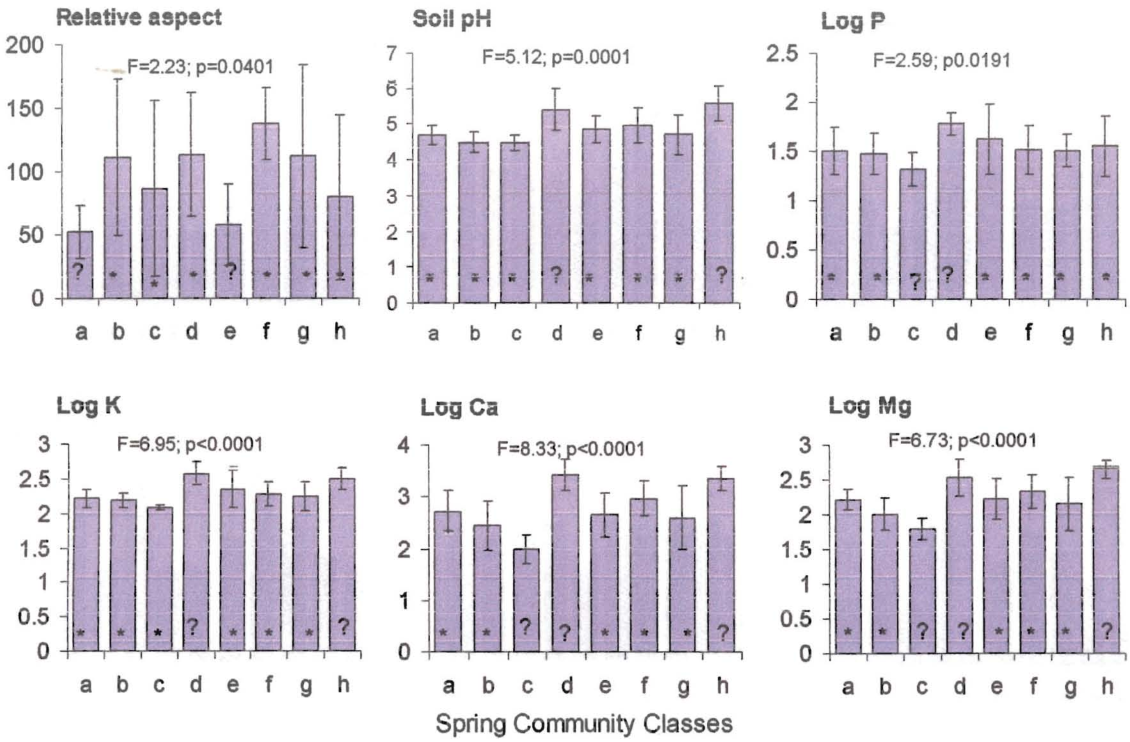

Figure 12. Mean (+/- SD) environmental conditions in vegetation types that were identified by cluster analysis of spring data. Community types that were not distinguished by pairwise comparison are identified with asterisks and question marks. Results from ANOVA are included in each graph. Df=9, 49. Nutrients are given in lb/acre and relative aspect in degrees departure from south-southwest.

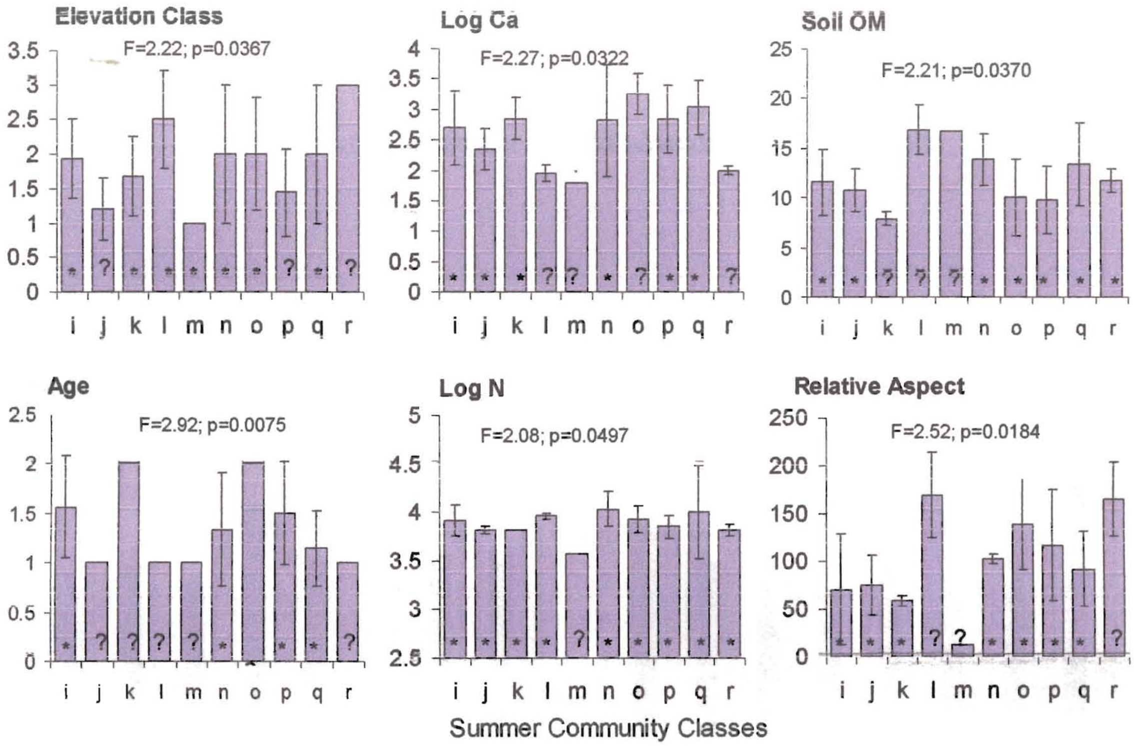

Figure 13. Mean (+/- SD) environmental conditions in vegetation types that were identified by cluster analysis of summer data. Community types that were not distinguished by pairwise comparison are identified with asterisks and question marks. Results from ANOVA are included in each graph. Df= 8, 50. Nutrients are given in lb/acre and relative aspect in degrees departure from south-southwest. Soil organic matter (OM) is given in percent of total weight. Elevation classes are as follows 1=low,2=medium,3=high elevation. Age classes are 1=young and 2=old.

Environmental differences were also detected among stands of different ages within different community types (Figures 14 and 15). Soil nutrients (Mg, Ca, K, and P), soil pH, and degrees inclination to the southern horizon line varied with age among plots sampled during the spring (Figure 14). Soil nutrients (K, P, Ca, Mg) and inclination to southern horizon differed with age among plots sampled during the summer (Figure 15). A student's T-test revealed soil nutrients varied with age, with old locations having higher concentrations of nutrients than young ones (phosphorus, p=<0.0001, T=-5.53; potassium, p=0.0023, T=-3.19; calcium, p=0.0005, T=-3.70; magnesium, p=0.0004, T=-3.76; df=57). This variation between ages could have caused these results.

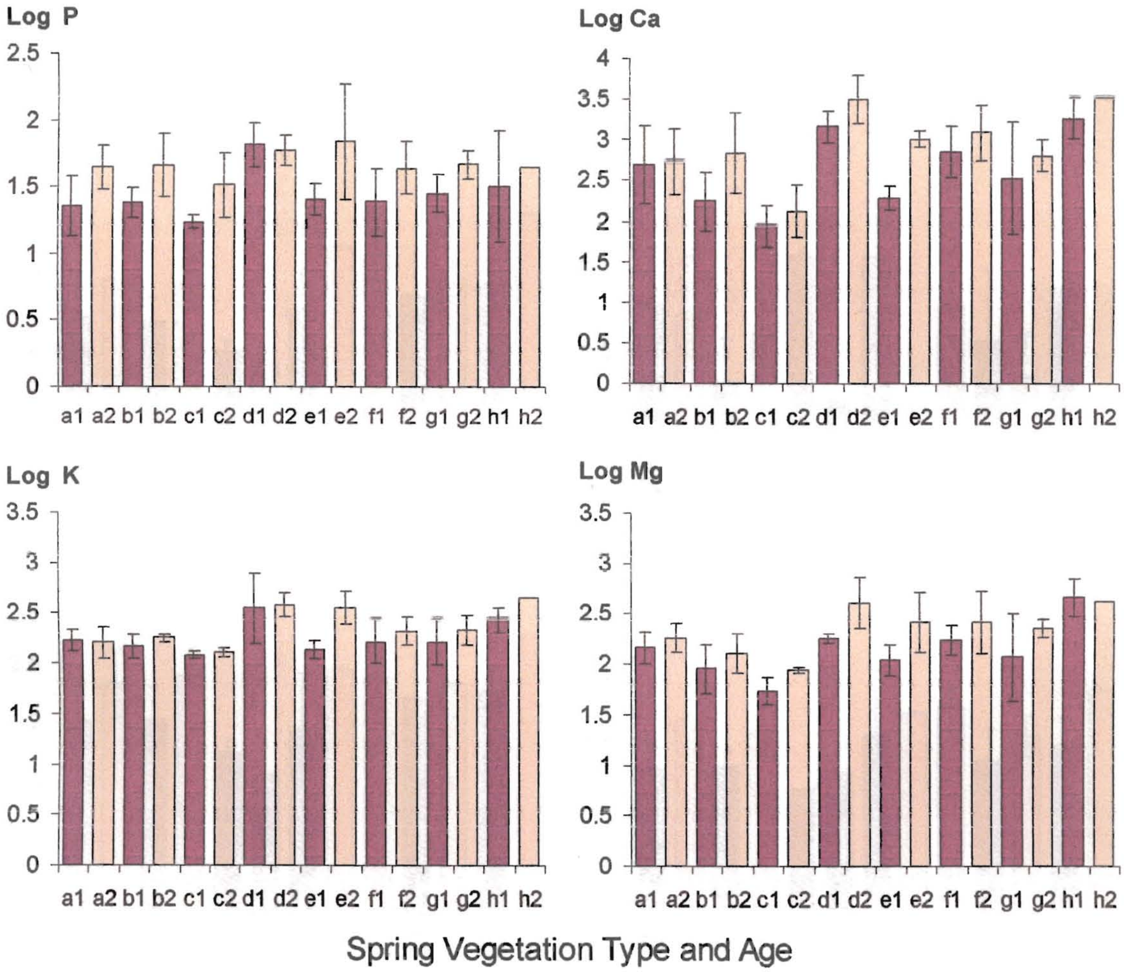

Figure 14. Mean (+/- SD) environmental conditions of vegetation types that were identified by cluster analysis of spring data and age. The one and dark bars indicate young plots while the two and light bars indicate old plots. Nutrients are given n lb/acre.

Table 4. A set of two-factor ANOVAs examining differences in soil conditions with age and spring community type as fixed effects. Only age effects reported here, degrees of freedom 9 and 49, respectively.

Variable	MSerror	F	p
Log of phosphorus	0.03304	21.04	<0.0001
Log of calcium	0.14939	7.89	0.0071
Log of magnesium	0.53160	9.58	0.0033
Log of potassium	0.22578	4.71	0.0350
Soil buffering capacity	0.09317	4.14	0.0472

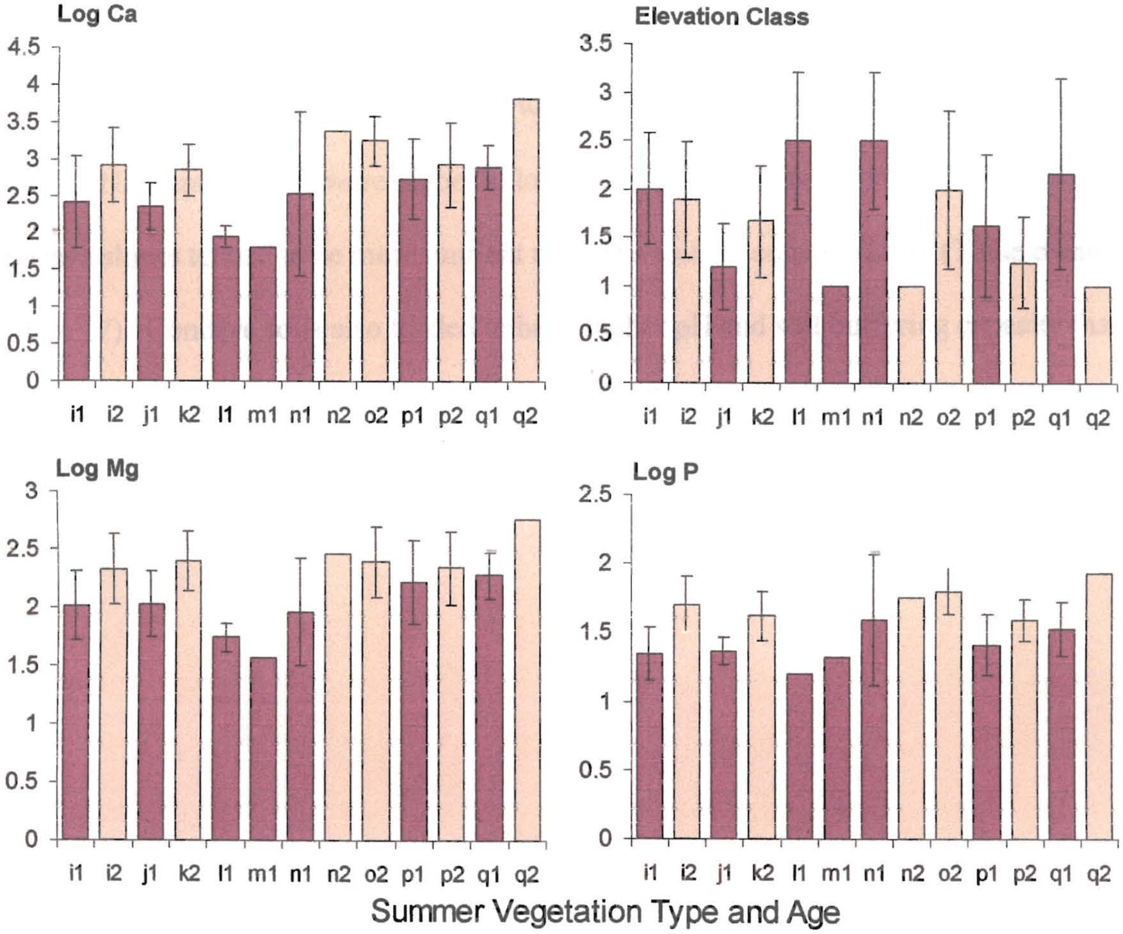

Figure 15. Mean (+/- SD) environmental conditions of vegetation types that were identified by cluster analysis of summer data and age. The one and dark bars indicate young plots while the two and light bars indicate old plots. Nutrients are given in lb/acre.

Table 5. A set of two-factor ANOVAs examining differences in soil conditions with age and summer community type as fixed effects. Only age effects reported here, degrees of freedom 10 and 48, respectively.

Variable	MSerror	F	p
Log of phosphorus	0.036046	19.93	<0.0001
Log of calcium	2038662	9.58	0.0107
Log of magnesium	0.086816	7.60	0.0082
Elevation Class	1.638664	3.71	0.0600

Topography and recovery from disturbance

Soil characteristic varied with topography and age (Table 6). No significant interactions between topography and age were detected with respect to environmental factors. Nutrients and pH were higher at low elevation (Table 6 and Figure 16). Soils on concave slopes tended to be more nutrient rich than soils in convex slopes (Table 6 and Figure 17). Concave soils also tended to have higher pH and soil buffering capacity than convex soils. Plots at northern aspects were generally more nutrient rich than plots at southern aspects (Table 6 and Figure 18).

Table 6. Three sets of two-factor ANOVAs examining differences in soil conditions with age and topography as fixed effects. One set is for stands classified by elevation. The other two are for stands classified by either aspect or slope curvature. Only topographic effects are reported here.

Topographic variable	Environmental correlate	F value	P value
Elevation class	Soil pH	5.26	0.0005
	Soil buffering capacity	11.25	<0.0001
	Log of phosphorus	12.18	<0.0001
	Log of potassium	5.67	0.0019
	Log of calcium	6.66	0.0006
	Log of magnesium	6.36	0.0009
	Soil organic matter	7.11	0.0018
Aspect class	Log of phosphorus	7.98	<0.0001
	Log of magnesium	3.67	0.0102
Slope curvature	Soil pH	4.58	0.0062
	Soil buffering capacity	3.41	0.0236
	Log of phosphorus	10.55	<0.0001
	Log of potassium	6.72	0.0006
	Log of calcium	6.81	0.0006
	Log of magnesium	7.72	0.0002

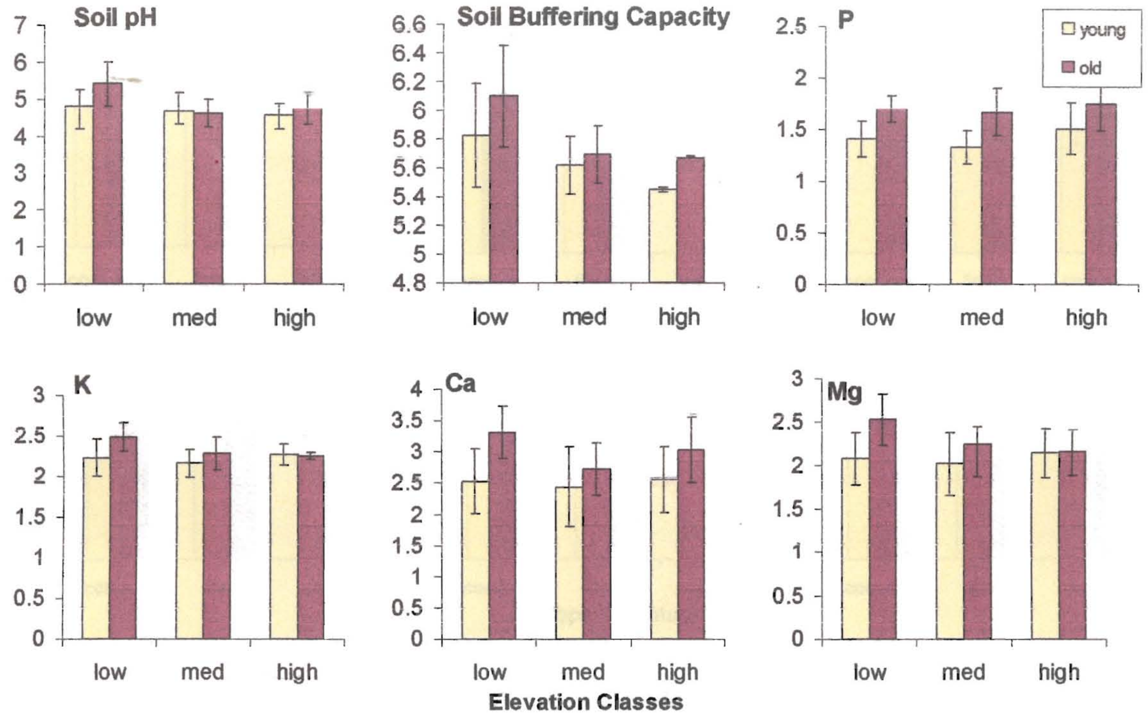

Figure 16. Mean (± SD) soil conditions in young and old stands at different elevations N=59. Nutrients are given in lb/acre.

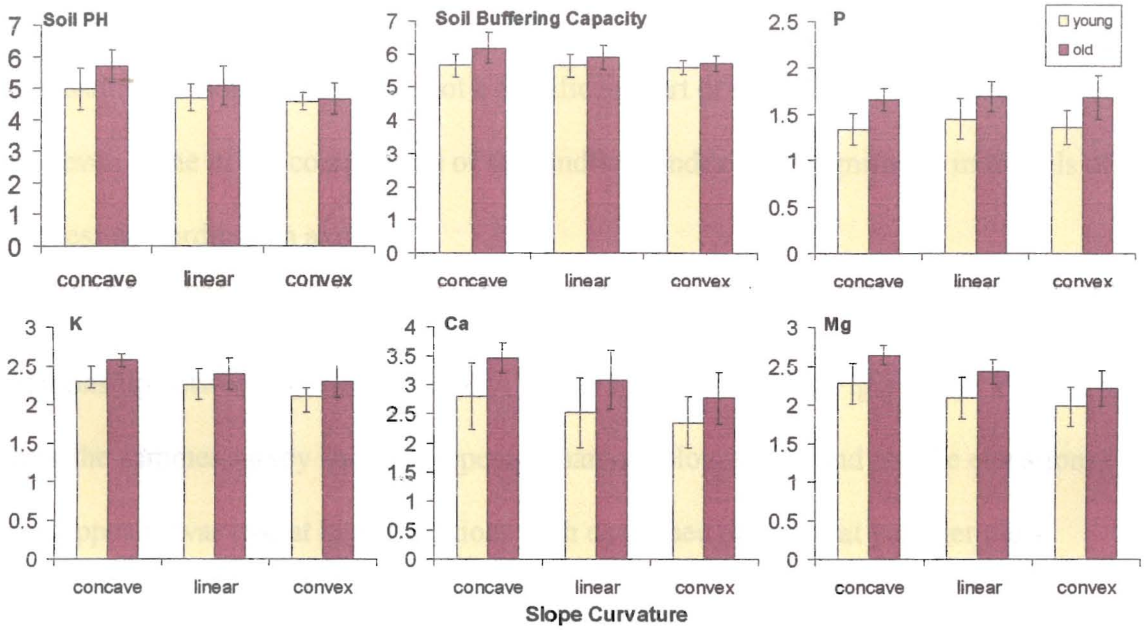

Figure 17. Mean (± SD) soil conditions in young and old stands at different slope curvatures N=59. Nutrients are given in lb/acre.

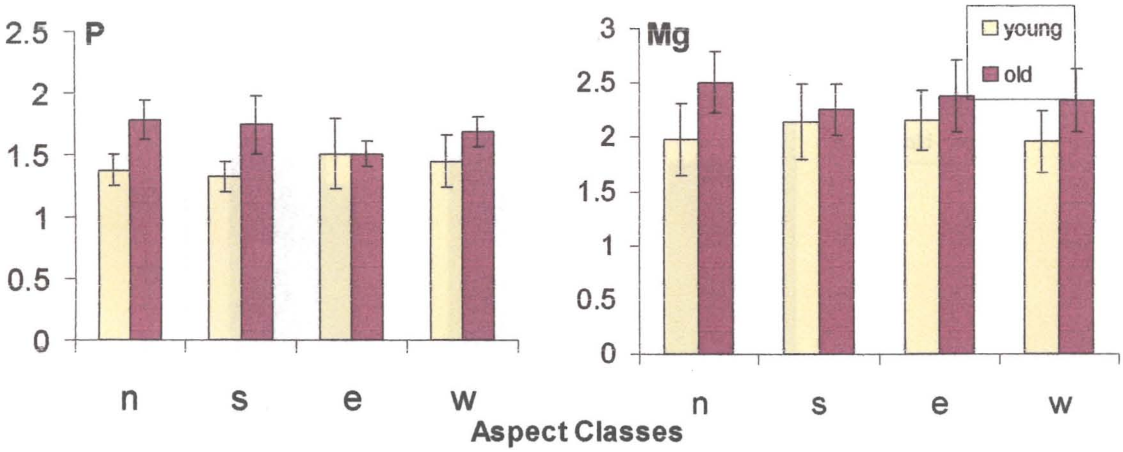

Figure 18. Mean (± SD) soil conditions in young and old stands at different aspects N=59. Nutrients are given in lb/acre.

Landform index was related to very few of the measured environmental variables (potassium and soil pH) and was not a significant part of any models constructed. However, some of the components of the landform index were significant in models of richness and ordination axes.

The only significant interaction between topography and age indicated a relationship between age and elevation class in species richness (Figure 19). Young plots from the summer survey had more species than old plots at low and middle elevations. The opposite was true at high elevations with decreased diversity at younger plots.

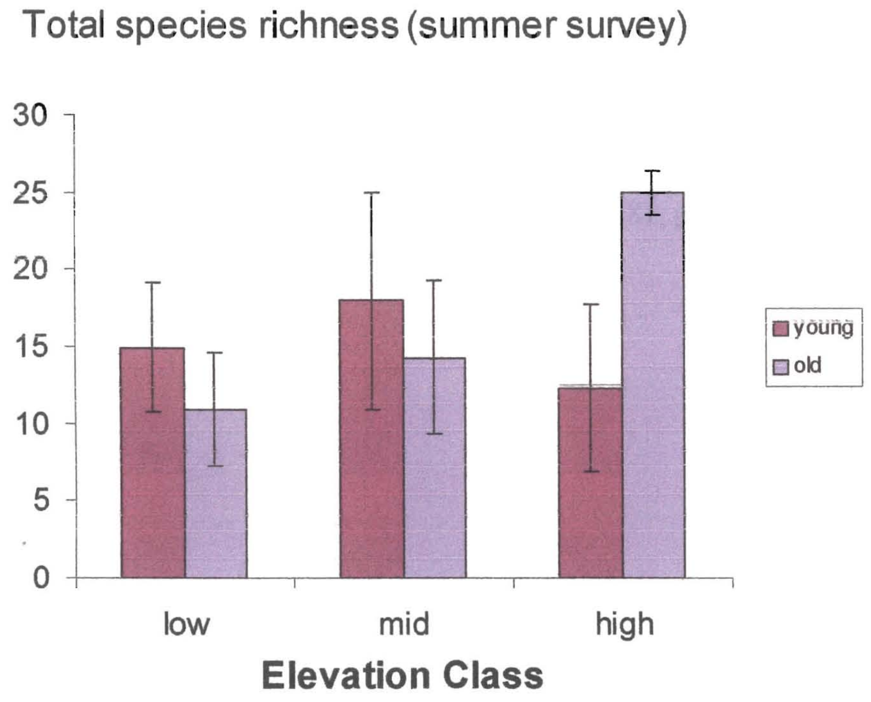

Figure 19. Mean (± SD) total species richness from spring surveys in young and old stands in different elevation classes. N=59

Modeling species' richness and species' distributions

Average species richness (the mean number of species in a plot calculated by averaging over all quadrats in the plot) in the spring decreased along DCA1 and increased with pH, N, P, K, Ca, and Mg (Figure 20 and 21). Average species richness in the summer increased with DCA1, pH, K, and Mg (Figure 20 and 22). Total species richness (the total number of species summed over all quadrats in a plot) in the spring was best predicted by degrees departure from S-SW, soil buffering capacity, and Zn (Table 7; full model r^2= 0.2281, F=4.73, p=0.0057, DF=3,51). Average species richness in the spring was best determined by elevation class, Ca, and Zn (Table 7; full model r^2=0.5416, F=13.59, p<0.0001, DF= 3,50). There was not a best fitting model of total species richness for summer. The best fitting model for average species richness for summer included age and Ca (Table 7; full model r^2=0.3866 F=14.81, p<0.0001, DF=2,49).

Table 7. Partial coefficients of factors related to species richness. Two different measures of species richness were used; the total number of species in a plot (total species richness) and the mean number of species in a plot averaged over five subsamples (average species richness). Measures of richness made in the spring and summer were separately analyzed.

Measure of Richness (season) Factor	Coefficient	Coefficient MS	F	p
Total Sp. Richness (spring)				
° Departure S-SW	-0.0449	0.0186	5.85	0.0195
Soil buffering capacity	8.3050	3.1159	7.10	0.0104
Log of zinc	-13.871	5.8197	5.68	0.0212
Avg. Sp. Richness (spring)				
Elevation class	-0.3171	0.1777	3.85	0.0557
Age	-1.0468	0.3304	10.04	0.0027
Log of calcium	1.7284	0.2817	40.46	<0.0001
Log of zinc	-1.7169	0.7269	6.70	0.0225
Avg. Sp. Richness (summer)				
Age	-0.9856	0.2918	11.41	0.0015
Log of calcium	1.2434	0.2307	29.06	<0.0001

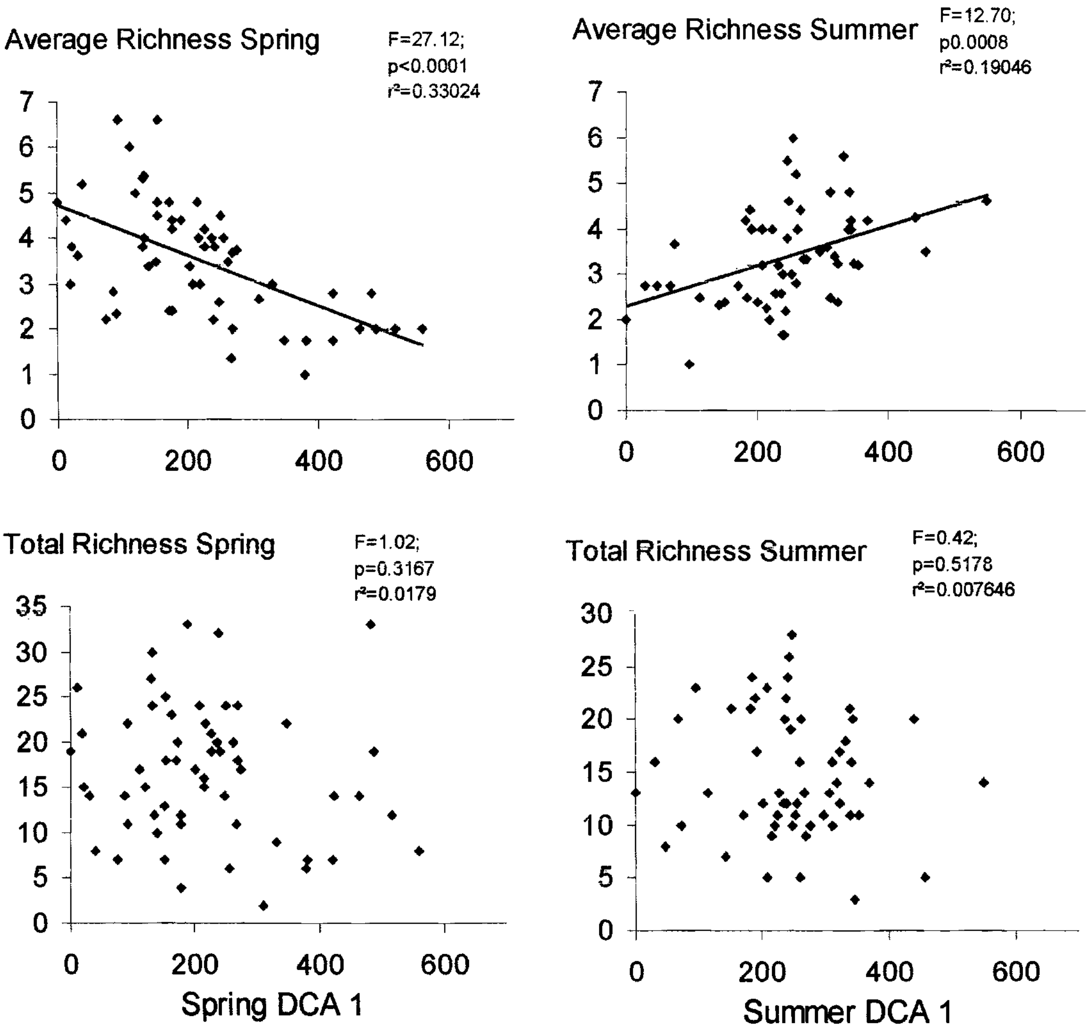

Figure 20. Species richness across the gradients defined by DCA analysis. Spring richness compared to DCA1 for spring and summer richness compared to DCA1 for summer data. Average richness is richness averaged by quads, while total richness is richness summed for all quads in a plot. Regression lines, when significant, were generated through simple linear regression.

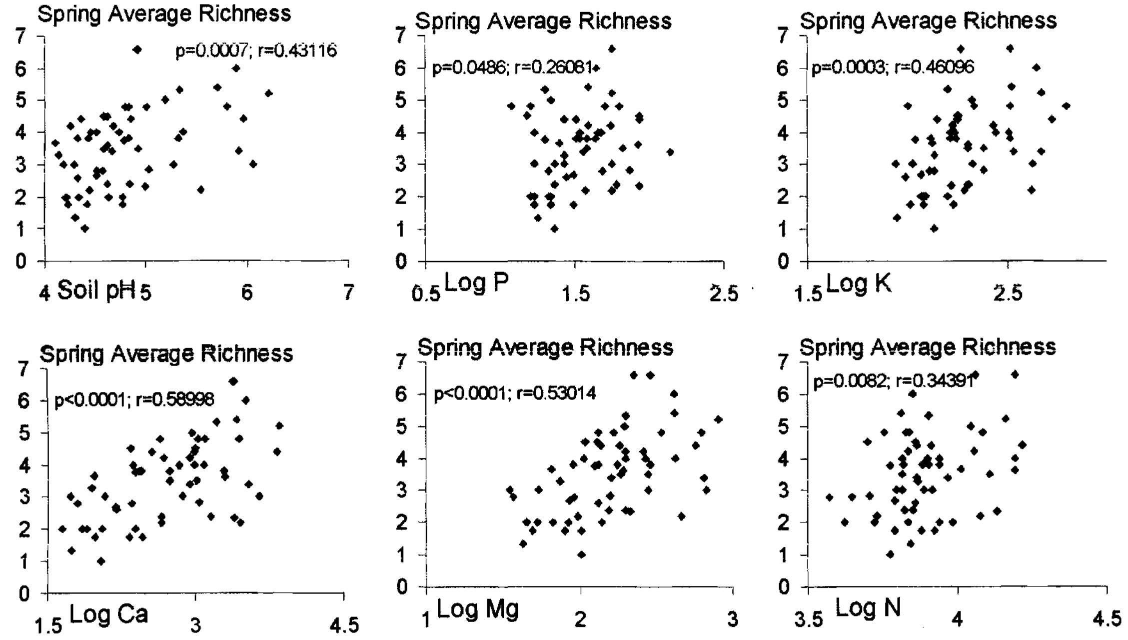

Figure 21. Variation in spring average species richness with soil characteristics. Nutrients are given in lb/acre.

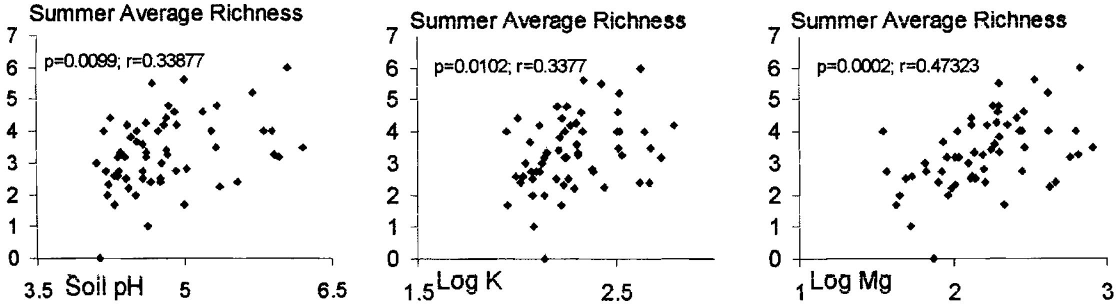

Figure 22. Variation in summer average species richness with soil characteristics. Nutrients are given in lb/acre.

Most species had an optimum in moderate nutrient and moisture levels (Figure 23). *Impatiens pallida* had a low score for spring DCA indicating its preference for high nutrients and moisture early in the growing season. *Polygonatum biflorum* had a high spring score, indicating its optimum in a drier and less nutrient rich environment at the start of the growing season. Summer scores were more leptokurtotic than spring scores for most species (Figure 24).

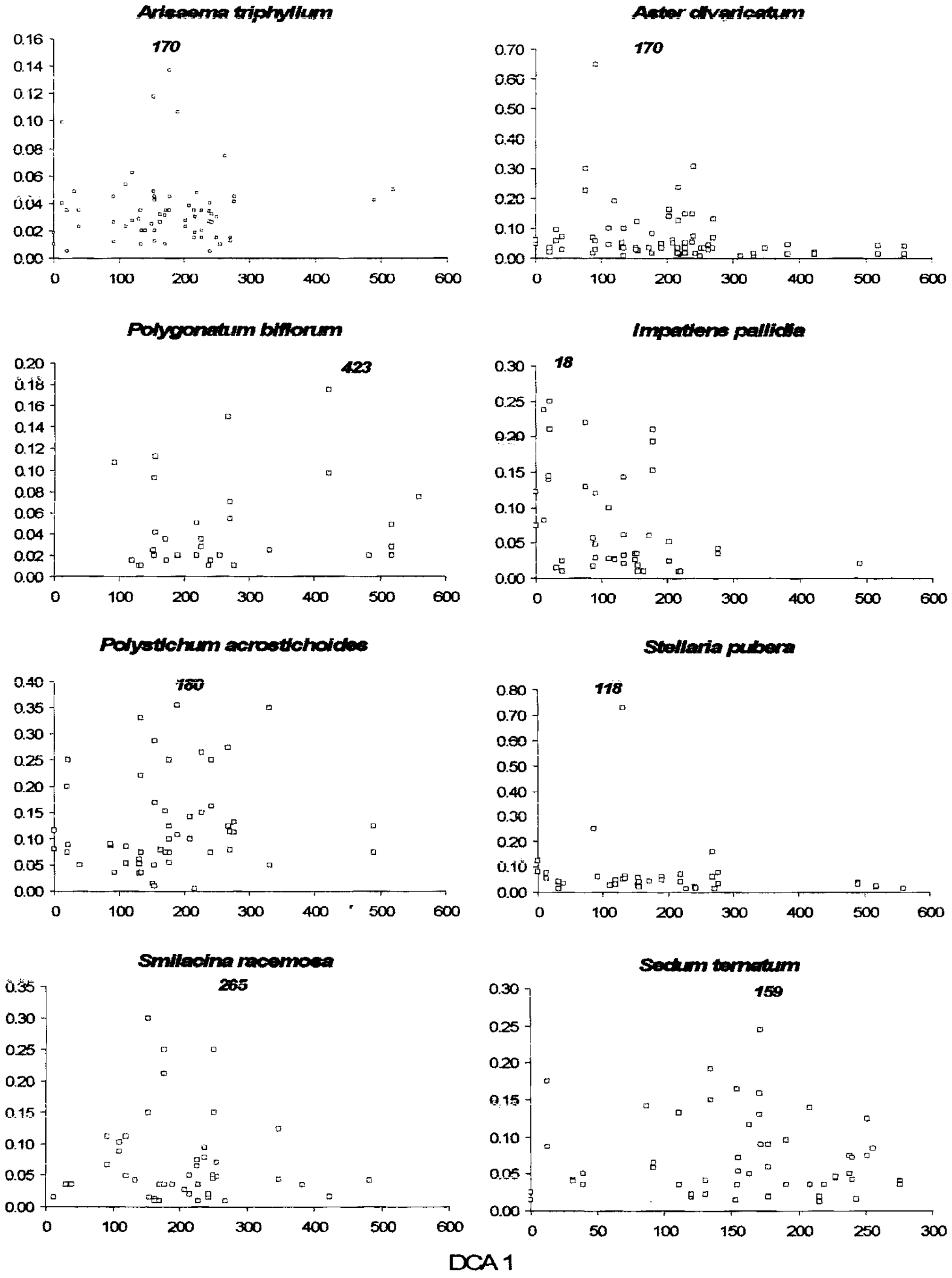

Figure 23. Distributions of common species along gradient defined by DCA1 from spring vegetation analysis. The Y axis represents average cover values. Values in bold indicate species' optima along the gradient.

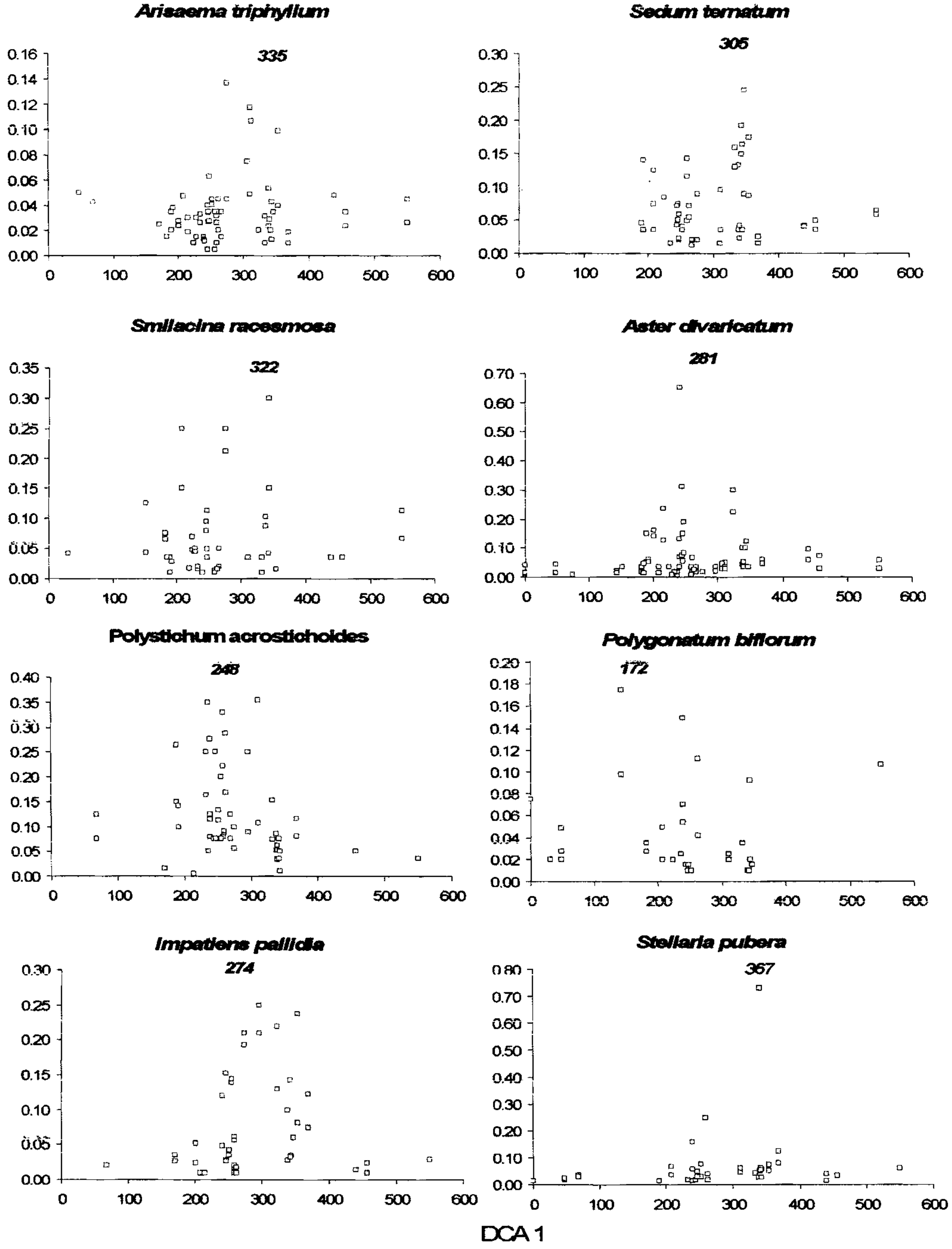

Figure 24. Distributions of common species along gradient defined by DCA1 from summer vegetation analysis. The Y axis represents average cover values. Values in bold indicate species' optima along the gradient.

Discussion

This study attempted to identify the environmental gradients that affect community composition at the Long Branch Environmental Education Center (LBEEC) land and to address whether these gradients can be used to predict vegetation types. Detrended correspondence analysis suggested that species in the LBEEC property respond to several environmental gradients. Spring and summer analyses were consistent with other existing research by identifying relationships between soil nutrients and species composition in an area (Austin 2002; Myers et al. 2004). Gilliam and Turrill (1993) also found calcium to hold the strongest correlation to vegetation composition. According to Nault and Gagnon (1988) many spring ephemerals, including *Allium tricoccum*, sequester large amounts of calcium and magnesium levels in the leaves and reproductive tissues. These nutrients are important in cells division and growth, and therefore are essential to plants. The spring vegetation classifications and DCA axes may have been related to these cations because they were released back into the soil that was then sampled in August. Relationships between vegetation and moisture and solar radiation were also confirmed by other research (Wiser et al. 1998). However, Collins and Pickett (1988) found that the amount of open sky above a plot did not influence understory cover or richness.

The use of landscape variables to determine vegetation type seems quite possible from the data generated in this study. A key based on the relationship between vegetation type and environmental variables has been generated for use on the LBEEC lands (Tables 8 and 9). Not all communities were able to be separated based on the measured environmental factors. This may be due to the vegetation responding to unmeasured variables. This may also be due to the alteration of successional patterns by immigrating species that makes the habitat more or less suitable to other species due to the their presence (Huston 1979).

Table 8. A key to spring communities based upon measured environmental variables. Types D and H can be differentiated based on D being at higher elevations and H at lower ones (Inclination to Western horizon <30=D, >30=H). Type C is on more southerly ridges that type B, but they are hard to differentiate with the measured variables.

Solar Radiation/Aspect	pH	P, K, and Mg	Ca	Class	Dominants
High-Southerly	Low	Low	Low	A	*Prenanthes* and *Smilacina*
High-Southerly	Moderate	Moderate	Low	E	*Galax* and *Clitoria*
Moderate-E/W	Low	Low	Low	B	*Polystichum* and *Stellaria*
Moderate-E/W	Low	Low	Low	C	*Parthenocissus* and *Toxicodendron*
Moderate-E/W	Moderate	Moderate	Low	G	*Viola sororia* and *canadensis*
Moderate-E/W	High	High	High	D	*Aster divaricatum* and *Smilacina*
Moderate-E/W	High	High	High	H	*Cimifuga* and *Sedum*
Low-Northerly	Low	Moderate	Low	F	*Laportea* and *Aster divaricatum*

Table 9. A key to summer communities based upon measured environmental variables. Either age refers to a mix of both young and old pots in that community type. Types L and R can be differentiated as type R is at the top of ridges and type L is not. Community types I and Q can not be differentiated based on these variables.

Elevation	Age	Solar Radiation/Aspect	Nitrogen	Class	Dominants
Low	Young	High-southerly	Medium	J	*Smilacina* and *Toxicodendron*
Low	Young	High-southerly	Low	M	*Prenanthes* and *Parthenocissus*
Low	Either	Moderate-E/W	Medium	P	*Aster divaricatum* and *Cimifuga*
Medium	Old	High-southerly	Medium	K	*Galax* and *Pyrularia*
Medium	Either	Moderate-E/W	High	N	*Polystichum* and *Prenanthes*
Medium	Either	Moderate-E/W	Medium	I	*Viola sororia* and *Impatiens*
Medium	Either	Moderate-E/W	Medium	Q	*Geranium* and *Polystichum*
Medium	Old	Moderate-E/W	Medium	O	*Smilacina* and *Toxicodendron*
High	Young	Low-Northerly	High	L	*Prenanthes* and *Parthenocissus*
High	Young	Low-Northerly	High	R	*Cimifuga* and *Stellaria*

Summer vegetation did not display an extremely strong relationship between environmental factors and summer communities. This discrepancy may be due to the higher sensitivity of spring ephemerals to environmental conditions, these ephemerals had senesced before summer analysis. Although spring communities were dominated by summer species, ephemerals did contribute to classification through their presence in spring data. Spring ephemerals have been found to be strongly competitive for soil nutrients, more so than summer flowering species, that may be responding to a wider variety of factors in effect later in the season (Meier et al. 1995; McKenna and Hole 2000). This trend, compounded by the fact that many spring ephemerals have limited dispersal, creates dense patches of these herbs (McLachlan and Bazely 2001). McKenna and Hole (2000) also found that it is rare that two species are alike in resources requirements, and therefore two individuals of the same species may be fit in different habitat types. Summer species may be more varied in requirements and responses than spring ephemerals that primarily respond to nutrients and light. The added correlation to soil in the spring by these spring ephemerals may also be due to the vernal dam effect in that spring ephemerals sequester large amounts of nutrient resources in a time of great turnover and loss of these nutrients (Eickmeier and Schussler 1993). The senescence of these plants later in the season nourishes summer herbs and may contribute greatly to the summer community composition.

The low correlation coefficients with environmental measures generated by this study could indicate that other factors play a larger role in community composition than previously believed. The strong relationship between total cover or biomass and the DCA axes reflects that increased nutrients allow for increased biomass, compounding the relationship between composition and nutrient gradients, however richness also increases linearly along the axis. Competition driven communities would show a decrease or saturation of species richness that coincided with increased biomass. Stevens and Carson (1999) stated that as nutrients increase, biomass responds and most species grow in size and fitness. While this prevents dominants from displacing all species, it does cause the gradual loss of already rare species. The absence of any reduction of richness seems to indicate that competition may play a minor role on the LBEEC land. Such findings agree with Muller (1990) who found competition to be a minor player in the composition of herbaceous understory in the Hubbard Brook experimental forest in New Hampshire.

Dispersal may be a large determinant of species richness and vegetation competition in the area. Dispersal due to historical distribution and migration is considered one of the two pillars of the ecological explanation of plant distributions by Nekola and White (2002). This is displayed by the close placement of plots to neighboring plots in summer DCA analysis. This could be due to a "homesite advantage" in that plants grow and reproduce more successfully close to the origins of their genetic heritage (Bennington and McGraw 1995). The greatest contributor to this assumption is the fact that many forest herbs produce low numbers of seed and have very specialized dispersal methods (Gilliam and Turrill 1993; McLachlan and Bazely 2001). Therefore, many herbs would be located primarily in areas near their source, for example a population of the species that survived the logging disturbance. Damman and Cain (1998) found that disturbance greatly affected composition because it disrupted plants that reproduce clonally, causing the need for recolonization and a great shift in the community composition. This is demonstrated in the BSMB area where herbs were highly clustered in areas that were not damaged during harvest; such as areas by cliffs and areas near steep stream banks (unpublished results).

The lack of correlation between some of the measured environmental gradients and the DCA axes could indicate that plants are responding to unmeasured environmental gradients. The depth and lignin composition of leaf litter can greatly affect species composition (Melillo et al. 1982; Xiong and Nilsson 1999; Tillman 1993). Further study could be done on canopy composition and the resultant leaf litter for the LBEEC land to determine its effects on understory composition and nutrient cycling. The lack of correlation between nitrogen and the DCA axes was unexpected as many studies have shown the opposite to be true (Gilliam and Turrill 1993; Hutchinson et al. 1999). However, this study recorded total nitrogen levels rather than available nitrogen. This may have affected the results of this study and could account for the discrepancy. Hicks (1980) found vegetation in the Great Smoky Mountains to be best predicted by soil depth, microtopography, dominance of hemlock, and soil moisture. These variables were not measured by this study. It has also been found that two areas that seem similar do not always have the same influences on communities (McCay et al. 1997) and therefore the results for this study may not be widely applicable and should be further tested.

While there is a long held belief that environmental factors are the main determinant of community composition, the relationship between measured environmental factors and summer DCA axes in this study suggests that this may not be the case for summer dominants or that perhaps they respond to less obvious gradients. These results suggest that it is better to do indirect ordination and allow the plant communities to reveal the gradients they experience with a posteriori testing of environmental factors than to impose the measured factors and restrict the axes of the ordination in a direct analysis. The direct gradient ordination such as CCA may be creating inadequate evaluations of communities by imposing only the commonly measured environmental variables on the identified correspondence axes and not evaluating the actual gradient to which the species are responding.

Reliability of distinguishing between communities using landscape variables

Stands classified as different communities differed primarily in soil nutrients and several topographic factors including aspect and elevation. Spring vegetation types seemed to have more meaningful relationships with measured environmental factors than summer vegetation types because more communities varied from each other in the spring. This was particularly interesting as the soil samples should have been more highly related to summer vegetation due to timing of collection. It is also interesting because summer communities were no less separated across the DCA axes when the mean values of communities were found for the axes. Age was very important to summer types with four groups having either all old or young plots, D and E only young and C and G only old plots. When comparing the average DCA1 scores from the appropriate correspondence analysis, spring types had tighter associations between the dominant species' scores, but this may be due to the inclusion of spring ephemerals into the spring analysis.

There were often common species with wide tolerances as the dominants in the summer vegetation types. This skewed the dominants' average away from the community average despite the most dominant species having a comparable score to the community score. Olivero and Hix (1998) found that species with adaptations to broad ranges of environmental conditions often indicated communities that did not coincide with their optima on a DCA axis. These facts may suggest that all data should be analyzed rather than dividing it into categories of spring and summer, thereby including the important contribution of spring ephemerals to the vegetation typing. It also leads me to believe that despite the absence of some summer species, the spring models generated in this study are far more meaningful than those for summer data. This would also explain how summer communities J and O could have different topographic situations and the same community dominants.

There were many species that had fidelity to specific summer vegetation types, giving added meaning to these classifications and highlighting the importance of dispersal and colonization in community composition. Some rarely encountered species were in vegetation type I including *Silene virginica, Houstonia longifolia, Penstemon laevigatus, Pilea pumila*, and *Heuchera parviflora*. *Cypripedium calceolus* and *Polygonatum pubescence* were only found in type L. *Phacelia fimbriata* was only located in one plot in community type L as well. *Lillium superbum* was entirely in type P and type J contained all of the *Lysimachia cilliata*. However, many species did not share community types, but were occurring in plots with close proximity including *Corallorhiza maculata* in 7 and 8, *Hypeircum hypercoides* in 3 and 4 and *Hypericum ellipticum* in 3 and 5, as well as *Monarda didyma* in plots 33, 34 and 35. This fact highlights the importance of dispersal to community composition.

The poor relationship between community types generated by vegetation data and environmental data independently verifies the interpretation of ordination results that these vegetation types are not responding solely to obvious environmental stimuli. If similar dendrograms can not be generated using environmental data, determination of communities from environmental factors alone in order to make land management decisions should not be done hastily. Further study should be devoted to these discrepancies between community composition and environmental gradients to determine if this phenomenon is widespread.

Answering the question about topography and recovery from disturbance

This study concurred with many others on the fact that disturbance affects soil nutrients and measures of species richness (Small and McCarthy 2002; Damman and Cain 1998; Mclachlan and Bazley 2001; Meier et al. 1995; Gilliam and Turrill 1993). Out of a list of soil calcium, magnesium, potassium, phosphorus, bulk density, pH, organic carbon, total nitrogen, and cation exchange capacity, Allen (1985) found that only bulk density and soil phosphorus would return to pre-harvest levels. How the interaction of disturbance and topography can affect community composition, however, has not been studied to a great degree. This was the secondary question asked by this study; "Is there a significant interaction between topography and community age with respect to community structure"?

The interaction in richness between elevation class and age demonstrates that high elevation areas have more difficulty in recovering from disturbance. High elevation areas are rich with rare species that will likely not recover from logging due to sensitivity and shear loss of small and widely spaced reproducing individuals from direct destruction (White and Miller 1988; Miller 1986). Another factor could be the erosion of high elevation soils down to middle and low elevations, increasing their nutrients and total richness after the disturbance. Meier et al. (1995) found an age-elevation interaction affected distributions of *Trillium sp.* in the Appalachian Mountains. Gilliam and Turrill (1993) also found a similar interaction in central Appalachia. These facts have implications for forest management as middle and low elevation, as well as south facing plots can recover from disturbance faster that other areas and should be considered for harvest instead of other more sensitive areas. Rich north coves and high elevation areas should not be disturbed if at all possible to insure their integrity as forest communities.

The McNab landform index was tested for herbaceous communities. Its irrelevance to most of the data analysis indicates that herbaceous communities may not be as sensitive to landform as the canopy species. However, components of the landform index, including degree of inclination to the south, were important to several analyses indicating the herbs do respond to the amount of light they receive. Therefore the idea of how landforms shade plant communities does apply to herbaceous communities, just not the actual index itself. The index's power to determine stands has not been contested because canopy species were not surveyed; however, it is not as useful in small scale evaluation of understory communities.

Species richness and species responses

Multiple regression analysis supported many ideas about the effectors of species richness including age, nutrients, aspect, and elevation (White and Miller 1988; Miller 1986; Wiser et al. 1998; McEwan et al. 2005; Meier et al. 1995; Gilliam and Turrill

1993). White and Miller (1988) also found that species richness was best modeled by simple linear regressions.

Average richness was strongly related to the DCA1 for both spring and summer; however, total richness for plots was not. This may be due to the inclusion of rare species with increasing area that may be responding to different factors than what the DCA axes represent. White and Miller's (1988) findings of increased area as the best predictor of rare species richness would support this idea; however this could also be due to the fact that richness only represents a number. Both studies by McLachlan and Bazely (2001) and Gilliam and Turrill (1993) found no significant differences in species richness, but extremely different species composition within their study areas. Total richness may stay relatively stable, while species composition changes between different species best suited to the area. This may be driven by environmental factors, dispersal, flowering time, or especially age of the area in reference to disturbances.

Individual species' responses to the gradient defined by the DCA's are important in evaluating an individual species' tolerance, as well as its optimum environmental conditions. The applications of this knowledge can allow for the identification of habitats that would be suitable for species reintroduction within the property, as well as location of the species based on the environment. The somewhat abstract relationship between topography and soil nutrients does not make this task easy. The DCA gradients are primarily nutrient driven and the relative location of the species must be evaluated using results that show how soil conditions respond to topographic variation. However the additional correlations to moisture, light, and possible competition and dispersal can allow the land manager to make assumptions about unknown locations of species, or of additional individuals if a location is already discovered.

Literature Cited

Literature Cited

Allen JC. 1985. Soil response to forest clearing in the US and the tropics: geological and biological factors. Biotropica 17: 15-27.

Austin MP. 1985. Continuum Concept, ordination methods and niche theory. Annual Review of Ecology and Systematics 16: 39-61.

Austin MP. 2002. Spatial predictions of species distribution: an interface between ecological theory and statistical modeling. Ecological Modeling 157:101-118.

Austin MP, Gaywood MJ. 1994. Current problems of environmental gradients and species response curves in relation to continuum theory. Journal of Vegetation Science 5: 473-482.

Austin MP, Smith TM. 1989. A new model for the continuum concept. Vegetatio 83: 35-47.

Bennington CC, McGraw JB. 1995. Natural selection and ecotypic differentiation on *Impatiens pallida*. Ecological Monographs 65:303-323.

Bio AMF, Alkemade R, Barendregt A. 1998. Determining alternative models for vegetation response analysis: a non-parametric approach. Journal of Vegetation Science 9:5-16.

Braun L. 1950. Deciduous Forests of Eastern North America. New York: Hafner Publishing Company.

Cawsey EM, Austin MP, Baker BL. 2002. Regional vegetation mapping in Australia: a case study in the practical use of statistical modeling. Biodiversity and Conservation 11:2239-2274.

Chiarucci A, Rocchini D, Leonzio C, De Domingicis V. 2001. A test of vegetation-environment relationships in serpentine soils of Tuscany, Italy. Ecological Research 16: 627-639.

Collins BS, Pickett STA. 1988. Demographic responses of herb layer species to experimental canopy gaps in a northern hardwood forest. Journal of Ecology 76: 437-450.

Damman H, Cain ML. 1998. Population growth and viability analyses of the clonal woodland herb, *Asarum Canadense*. Journal of Ecology 86: 13-26.

Duffy DC, Miller AJ. 1992. Do Appalachian herbaceous understories ever recover from clearcutting? Conservation Biology 6: 196-201.

Eickmeier WG, Schussler EE. 1993. Responses of the spring ephemeral *Claytonia virginica* to light and nutrient manipulations and the implications of the "vernal dam" hypothesis. Bulletin of the Torrey Botanical Club 120: 157-165.

Gilliam FS, Turrill NL. 1993. Herbaceous layer cover and biomass in a young versus a mature stand of a central Appalachian hardwood forest. Bulletin of the Torrey Botanical Society 120: 445-450.

Graffen A, Hails R. 2002. Modern statistics for the life sciences. Oxford Press, New York.

Grime JP. 1977. Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. American Naturalist. 111: 1169-1194.

Grime JP. 1979. Plant strategies and vegetational processes. John Wiley and Sons, New York.

Guissan A, Harrell FE. 2000. Ordinal response models in ecology. Journal of Vegetation Science 11:617-626.

Guissan A, Zimmerman NE. 2000. Predictive habitat distribution models in ecology. Ecological Modeling 35: 147-186.

Hicks DJ. 1980. Intrastand distribution patterns of southern Appalachian cove forest herbaceous species. The American Midland Naturalist 104: 209-223.

Hicks RR, Frank P S. 1984. Relationship of aspect to soil nutrients, species importance and biomass in a forested watershed in West Virginia. Forest Ecology and management 8:281-291.

Huang J, Lacy ST, Ryan PJ. 1996. Impacts of forest harvesting on the hydraulic properties of surface soil. Soil Science 161: 79-86.

Huston MA 1979. A general hypothesis of species diversity. American Naturalist 113: 81-101.

Huston MA 1994. Biological diversity; The coexistence of species on a changing landscape. Cambridge University Press, New York.

Hutchison TF, Boerner RE, Iverson LR, Sutherland S and ES. 1999. Landscape patterns of understory composition and richness across a moisture and nitrogen mineralization gradient in Ohio (U.S.A.) *Quercus* forests. Plant Ecology 144: 177-189.

Lipscomb MV, Nilsen ET. 1990. Environmental and physiological factors influencing the natural distribution of evergreen and deciduous ericaceous shrubs on northeast and southwest facing slopes of the southern Appalachian Mountains. II. Water relations. American Journal of Botany 77: 517-526.

MacArthur R. 1960. On the relative abundance of species. The American Naturalist 94: 25-36.

McCay DH, Abrams MD, DeMeo TE. 1997. Gradient analysis of secondary forests of eastern West Virginia. Journal of the Torrey Botanical Society 124: 160-173.

McEwan RW, Muller RN, McCarthy BC. 2005. Vegetation-environment relationships among woody species in four canopy-layers in an old-growth mixed mesophytic forest. Castanea 70: 32-46.

McGraw JB, Sanders SM, Van Der Voot M. 2003. Distribution and abundance of *Hydrastis Canadensis L. (Ranunculaceae)* and *Panax quinquifoleous L. (Araliaceae)* in the central Appalachian region. Journal of the Torrey Botanical Society 130: 62-69.

McKenna MF, Hole G. 2000. Why are annual plants rarely spring herbs? New Phytologist 48: 295-302.

McLachlan, S.M. and D.R. Bazely. 2001. Recovery patterns of understory herbs and their use as indicators of deciduous forest regeneration. Conservation Biology 15: 98-110.

McNab WH. 1992. A topographic index to quantify the effect of mesoscale landform on site productivity. Canadian Journal for Res. 23: 1100-1107.

Meier AJ, Bratton SP, Duffy DC. 1995. Possible ecological mechanisms for loss of vernal-herb diversity in logged eastern deciduous forests. Ecological Applications 5: 935-946.

Melillo JM, Aber JD, Muratore JF. 1982. Nitrogen and lignin control of hardwood leaf litter decomposition dynamics. Ecology 63: 621-626.

Miller RI. 1986. Predicting rare plant distribution patterns in the southern Appalachians of the southeastern U.S.A. Journal of Biogeography 13: 293-311.

Muller RN. 1990. Spatial interrelationships of deciduous forest herbs. Bulletin of the Torrey Botanical Club 117: 101-105.

Muller-Dumbois D, Ellenburg H. 1974. Aims and Methods of Vegetation Ecology. New Jersey: Blackburn Press.

Myers BR, Colbert JJ, Rentch JS, Gottschalk KW. 2004. Aspect induced differences in vegetation, soil, and microclimatic characteristics of an Appalachian watershed. Castanea 69:92-108.

Nault A, Gagnon D. 1988. Seasonal biomass and nutrient allocation patterns in wild leek (*Allium tricoccum Ait.*), a spring geophyte. Bulletin of the Torrey Botanical Club 115:45-54.

Nekola JC, White PS. 2002. Conservation, the two pillars of ecological explanation and the paradigm of distance. Natural Areas Journal 22: 305-310.

Olivero AM, Hix DM. 1998. Influence of aspect and stand age on ground flora of southeastern Ohio forest ecosystems. Plant Ecology 139: 177-187.

Small CJ, McCarthy.BJ 2002. Effects of simulated post-harvest light availability and soil compaction on deciduous forest herbs. Canadian Journal of Forest Research. 32: 1753-1762.

Stephenson SL, Mills HH. 1999. Contrasting vegetation of noses and hollows in the Valley and Ridge province, southwestern Virginia. Journal of the Torrey Botanical Society 126: 197-212.

Stevens MHM, Carson WP. 1999. Plant diversity determines species richness along an experimental fertility gradient. Ecology 80: 455-465.

Tilman D. 1993. Species richness of experimental productivity gradients: how important is colonization limitation? Ecology 74: 2179-2191.

Ward JH 1963. Hierarchical grouping to optimize an objective function. Journal of the American Statistical Society 58: 236-244.

White P, Wilds SP, Stratton DA. 2001. The distribution of heath balds in the Great Smoky Mountains, North Carolina and Tennessee. Journal of Vegetation Science 12: 453-466.

White PS, Miller RI. 1988. Topographic models of vascular plant richness in the southern Appalachian high peaks. The Journal of Ecology 76: 192-199.

Whittaker RH. 1956. Vegetation of the Smoky Mountains. Ecological Monographs 26: 1-80.

Whittaker RH, Levin SA, Root RB. 1979. Niche, habitat and ecotype. The American Naturalist 107: 321-338.

Wiser SK, Peet RK, White PS. 1998. Prediction of rare-plant occurrence: a southern Appalachian example. Ecological Applications 8: 909-920.

Wofford BE. 1989. Guide to the Vascular Plants of the Blue Ridge. University of Georgia Press; Athens.

Wolda H. 1981. Similarity indices, sample size, and diversity. Oecologia 50: 296-302.

Xiong S, Nilsson C. 1999. The effects of plant litter on vegetation: a meta-analysis. Journal of Ecology 87:984-994.

Xu YJ, Burger JA, Aust WM, Patterson SC, Miwa M, Preston DP. 2002. Changes in surface water table depth and soil physical properties after harvest and establishment of loblolly pine (*Pinus taeda* L.) in Atlantic costal plain wetlands of South Carolina. Soil and Tillage Research 63:109-121.

Yee TW, Mitchell ND. 1991. Generalized additive models in plant ecology. Journal of Vegetation Science 2: 587-602.

Appendices

Appendix A

Original Data Set

Table 10. Original data set for vegetation cover of Long Branch Environmental Education center. Cover data is an average from spring and summer.

Plot	*Species*	Spring Cover	Summer Cover
1	*Polygonatum biflorum*	0.0100	
1	*Aster divaricatum*	0.0163	
1	*Heuchera villosa*	0.0200	
1	*Uvularia grandiflora*	0.0200	
1	*Ipomea sp*	0.0350	
1	*Polystichum acrostichoides*	0.0550	0.1000
1	*Eupatorium rugosum*	0.0750	
1	*Sedum ternatum*	0.0900	0.0200
1	*Arisaema triphyllum*	0.1367	0.0450
1	*Impatiens pallida*	0.1930	0.2100
1	*Smilacina racesmosa*	0.2500	0.2125
1	*Toxicodendron radicans*	0.2500	0.0400
1	*Aster cordifolius*		0.0350
1	*Solidago caesia*		0.0350
1	*Clematis virginiana*		0.0500
1	*Pycnacanthemum tenuifolium*		0.0550
2	*Potentilla simplex*	0.0113	0.0125
2	*Aster divaricatum*	0.0150	0.0200
2	*Conopholis americana*	0.0150	0.0150
2	*Smilax glauca*	0.0200	0.0200
2	*Solidago curtisii*	0.0325	0.0500
2	*Kalmia latifolia*	0.0425	0.0500
2	*Polygonatum biflorum*	0.0975	0.1750
3	*Polygonatum biflorum*	0.0100	
3	*Eupatorium rugosum*	0.0150	0.0175
3	*Lysimachia quadrifolia*	0.0150	0.0200
3	*Viola sororia*	0.0150	0.0150
3	*Tradescantia subaspera*	0.0158	0.0133
3	*Galium latifolium*	0.0200	
3	*Satureja vulgaris*	0.0200	
3	*Silene virginica*	0.0250	0.0200
3	*Penstemon laevigatus*	0.0300	0.0100
3	*Arisaema triphyllum*	0.0343	0.0270
3	*Conopholis americana*	0.0350	
3	*Galium triflorum*	0.0350	0.0350
3	*Hypericum ellipticum*	0.0350	
3	*Heuchera parviflora*	0.0367	0.0300
3	*Sedum ternatum*	0.0508	0.0750

Table 10 continued. Original data set for vegetation cover of LBEEC.

3	*Aster divaricatum*	0.0550	0.1500
3	*Clematis virginiana*	0.0575	0.0990
3	*Toxicodendron radicans*	0.0575	0.0350
3	*Smilacina racesmosa*	0.0790	0.0950
3	*Potentilla simplex*	0.1000	0.1400
3	*Solidago curtisii*		0.0100
3	*Viola hastata*		0.0100
3	*Hypericum hypericoides*		0.0300
3	*Solidago rugosa*		0.0350
4	*Fragaria virginiana*	0.0075	0.0150
4	*Lysimachia quadrifolia*	0.0100	0.0150
4	*Silene virginica*	0.0100	0.0200
4	*Smilacina racesmosa*	0.0100	0.0350
4	*Viola blanda*	0.0100	
4	*Eupatorium rugosum*	0.0125	0.0350
4	*unidentifiables*	0.0125	
4	*Stellaria pubera*	0.0150	
4	*Tradescantia subaspera*	0.0150	0.0200
4	*Arisaema triphyllum*	0.0200	0.0350
4	*Houstonia tenuifolia*	0.0200	0.0200
4	*Galium latifolium*	0.0210	0.0550
4	*Clitoria mariana*	0.0275	0.1950
4	*Solidago curtisii*	0.0275	0.0388
4	*Penstemon laevigatus*	0.0288	0.1500
4	*Conopholis americana*	0.0350	0.0350
4	*Sedum ternatum*	0.0462	0.0450
4	*Aster divaricatum*	0.0514	0.1500
4	*Potentilla simplex*	0.0550	0.0533
4	*Pycnacanthemum verticillatum*	0.0806	0.1238
4	*Polystichum acrostichoides*	0.2642	0.1500
4	*Hypericum hypericoides*		0.0050
4	*Pilea pumila*		0.0100
4	*Viola sororia*		0.0100
4	*Aristolochia macrophylla*		0.0200
5	*Hypericum ellipticum*	0.0100	
5	*Viola blanda*	0.0100	0.0100
5	*Lysimachia quadrifolia*	0.0108	0.0233
5	*Arisaema triphyllum*	0.0150	
5	*Pteridium aquilinum*	0.0150	0.0350
5	*Aster divaricatum*	0.0179	0.0350
5	*Clematis virginiana*	0.0200	
5	*Viola sororia*	0.0200	0.0267
5	*Smilax glauca*	0.0225	0.0150
5	*Duchesnea indica*	0.0250	
5	*Galium latifolium*	0.0275	0.0350

Table 10 continued. Original data set for vegetation cover of LBEEC.

5	*Polygonatum biflorum*	0.0275	0.0350
5	*Pycnanthemum tenuifolium*	0.0275	0.0350
5	*Viola triloba*	0.0440	0.0313
5	*Potentilla simplex*	0.0604	0.1050
5	*Smilacina racesmosa*	0.0650	0.0750
5	*Eupatorium rugosum*	0.0750	
5	*Toxicodendron radicans*	0.1617	0.1425
5	*Parthenocissus quinquefolius*	0.1838	0.4500
5	*Cacalia atriplicifolia*		0.0100
5	*Eupatorium rugosum*		0.0100
5	*Viola hastata*		0.0100
5	*Fragaria virginica*		0.0350
5	*Solidago caesia*		0.0350
5	*Solidago curtisii*		0.0350
5	*Monarda clinopodia*		0.0750
6	*Ranunculus acris*	0.0050	
6	*Botrychium virginianum*	0.0100	
6	*Botrychium virginianum*	0.0100	
6	*Eupatorium rugosum*	0.0150	
6	*Hydrangea arborescence*	0.0175	0.0200
6	*Ranunculus recurvatus*	0.0175	
6	*Clematis virginiana*	0.0183	0.0250
6	*Viola sororia*	0.0200	0.0300
6	*Cacalia atriplicifolia*	0.0217	
6	*Arisaema triphyllum*	0.0233	0.0275
6	*Impatiens pallida*	0.0235	0.0520
6	*Trillium cernuum*	0.0260	0.0500
6	*Oxalis stricta*	0.0580	0.1688
6	*Parthenocissus quinquefolius*	0.0700	0.0350
6	*Silene virginica*	0.0750	
6	*Aster divaricatum*	0.1400	0.1625
6	*Prenanthes serpentaria*	0.2039	0.1613
6	*Alliaria petiolata*		0.0350
6	*Pilea pumila*		0.0350
7	*Corallorhiza maculata*	0.0050	
7	*Polystichum acrostichoides*	0.0050	
7	*Ranunculus acris*	0.0050	
7	*Impatiens pallida*	0.0100	0.0300
7	*Viola sororia*	0.0100	
7	*Potentilla simplex*	0.0150	0.0100
7	*Ranunculus recurvatus*	0.0150	0.0150
7	*Viola pubescens*	0.0150	
7	*Arisaema triphyllum*	0.0188	
7	*Eupatorium purpureum*	0.0350	0.0500
7	*Hepatica acutiloba*	0.0350	

Table 10 continued. Original data set for vegetation cover of LBEEC.

7	*Oxalis stricta*	0.0575	0.1125
7	*Aster divaricatum*	0.1270	0.2375
7	*Parthenocissus quinquefolius*	0.4167	0.4167
7	*Prenanthes serpentaria*	0.7500	
7	*Trillium cernuum*	1.5000	0.0350
7	*Viola hastata*		0.0050
8	*Impatiens pallida*	0.0100	0.0100
8	*Ranunculus acris*	0.0100	0.0050
8	*unidentifiables*	0.0100	
8	*Viola cucullata*	0.0100	0.0175
8	*Prenanthes trifoliolata*	0.0125	
8	*Smilacina racesmosa*	0.0125	0.0100
8	*Viola sororia*	0.0125	
8	*Hepatica acutiloba*	0.0150	
8	*Pycnanthemum tenuifolium*	0.0150	
8	*Smilax glauca*	0.0150	0.0100
8	*Botrychium virginianum*	0.0200	
8	*Corallorhiza maculata*	0.0200	
8	*Aplectrum hyemale*	0.0225	
8	*Potentilla simplex*	0.0250	0.0350
8	*Arisaema triphyllum*	0.0260	0.0317
8	*Asclepias amplexicaulis*	0.0350	0.0500
8	*Dentaria laciniata*	0.0350	
8	*Viola pubescens*	0.0350	0.0375
8	*Parthenocissus quinquefolius*	0.0775	0.1075
8	*Polystichum acrostichoides*	0.0783	0.0783
8	*Dentaria laciniata*	0.0925	
8	*Sedum ternatum*	0.1167	0.0500
8	*Hydrangea arborescence*	0.5188	0.6250
8	*Laportea canadensis*		0.0100
8	*Viola hastata*		0.0150
8	*Botrychium virginianum*		0.0200
10	*Solidago caesia*	0.0500	
10	*Viola rotundifolia*	0.0500	
11	*Aster divaricatum*	0.0050	0.0125
11	*Medeola virginiana*	0.0100	0.0350
11	*Viola rotundifolia*	0.0150	0.0350
11	*Hamamelis virginiana*	0.0350	
11	*Galax aphylla*	0.0750	0.3500
11	*Goodyera pubescens*	0.0750	0.0100
11	*Stellaria pubera*		0.0150
12	*unidentifiables*	0.0100	
12	*Aster divaricatum*	0.0133	0.0400
12	*Viola rotundifolia*	0.0250	0.1500
12	*Prenanthes trifoliolata*	0.0350	0.0275

Table 10 continued. Original data set for vegetation cover of LBEEC.

12	*Veratrum viride*	0.0500	
12	*Polygonatum biflorum*	0.0750	
12	*Polygonatum pubescence*	0.0750	0.0350
12	*Galax aphylla*	0.3500	0.2500
12	*Trillium grandiflorum*		0.0200
12	*Uvularia grandiflora*		0.0200
12	*Viburnum acerifolium*		0.0200
12	*Clintonia umbellulata*		0.0500
12	*Cypripedium calceolus*		0.0750
12	*Thelypteris noveboracensis*		0.1850
13	*Uvularia grandiflorum*	0.0100	0.0200
13	*Prenanthes trifoliolata*	0.0125	
13	*Aster divaricatum*	0.0133	0.0425
13	*Medeola virginiana*	0.0150	
13	*Prenanthes altissima*	0.0150	
13	*Solidago caesia*	0.0150	0.0750
13	*Stellaria pubera*	0.0200	0.0250
13	*Thelypteris noveboracensis*	0.0200	
13	*Viola rotundifolia*	0.0375	
13	*Polygonatum biflorum*	0.0488	0.0475
13	*Hydrangea arborescence*	0.0567	0.1583
13	*Thelypteris noveboracensis*	0.1250	
13	*Dennstaedtia punctilobula*		0.0350
13	*Disporum languinosum*		0.0350
13	*Medeola virginica*		0.0350
13	*Arisaema triphyllum*		0.0500
13	*Viola rotundifolia*		0.0567
13	*Viola blanda*		0.1000
14	*Aster divaricatum*	0.0100	0.0175
14	*unidentifiables*	0.0100	
14	*Viola rotundifolia*	0.0125	
14	*Medeola virginiana*	0.0175	0.0850
14	*Allium tricoccum*	0.0200	
14	*Polygonatum biflorum*	0.0250	
14	*Solidago caesia*	0.0250	0.1400
14	*Polystichum acrostichoides*	0.3500	0.0500
14	*Goodyera pubescens*		0.0100
14	*Viola blanda*		0.0200
14	*Uvularia grandiflora*		0.0475
14	*Dryopteris marginalis*		0.1510
15	*Claytonia caroliniana*	0.0100	
15	*Goodyera pubescens*	0.0100	
15	*Impatiens pallida*	0.0100	
15	*Oxalis stricta*	0.0100	0.0350
15	*Thalictrum dioicum*	0.0100	

Table 10 continued. Original data set for vegetation cover of LBEEC.

15	*Viola rotundifolia*	0.0100	0.1250
15	*Lysimachia quadrifolia*	0.0125	
15	*Aster divaricatum*	0.0150	
15	*Hydrangea arborescence*	0.0150	0.1675
15	*Parthenocissus quinquefolius*	0.0175	0.1338
15	*Allium tricoccum*	0.0188	
15	*Polygonatum biflorum*	0.0200	0.0500
15	*Prenanthes trifoliata*	0.0283	0.0500
15	*Dryopteris intermedia*	0.0350	
15	*Sedum ternatum*	0.0350	
15	*Viola pubescens*	0.0350	
15	*Stellaria pubera*	0.0388	0.0700
15	*Disporum languinosum*	0.0500	
15	*Sanguinaria canadensis*	0.0550	
15	*Lillium canadense*	0.0917	
15	*Trillium grandiflorum*	0.0950	
15	*Cimicifuga racesmosa*	0.1250	
15	*unidentifiables*		0.0100
15	*Viola sororia*		0.0150
15	*Trillium grandiflorum*		0.0200
15	*Uvularia grandiflorum*		0.0233
15	*Aristolochia macrophylla*		0.0350
15	*Caulophyllum thalictroides*		0.0350
15	*Dioscorea villosa*		0.0350
15	*Uvularia grandiflorum*		0.0350
15	*Lillium superbum*		0.0450
15	*Arisaema triphyllum*		0.0475
15	*Uvularia perfoliata*		0.0500
15	*Thelypteris noveboracensis*		0.0750
15	*Disporum languinosum*		0.2750
16	*Prenanthes serpentaria*	0.0100	
16	*Magnolia fraseri*	0.0500	0.0500
16	*Viola rotundifolia*	0.0700	0.2000
16	*Polystichum acrostichoides*	0.1250	0.0750
16	*Medeola virginica*		0.0150
16	*Dennstaedtia punctilobula*		0.1500
17	*Smilacina racesmosa*	0.0100	
17	*Viola blanda*	0.0100	
17	*Dentaria laciniata*	0.0150	
17	*Thelypteris noveboracensis*	0.0225	0.0750
17	*Viola rotundifolia*	0.0225	0.0350
17	*Aster divaricatum*	0.0350	
17	*Hydrangea arborescence*	0.0533	0.2667
17	*Prenanthes trifoliata*	0.0550	0.0350
17	*Stellaria pubera*	0.0590	0.1600

Table 10 continued. Original data set for vegetation cover of LBEEC.

17	*Polystichum acrostichoides*	0.1250	0.2750
17	*Polygonatum biflorum*	0.1500	
17	*Parthenocissus quinquefolius*		0.0050
17	*Dryopteris intermedia*		0.0350
17	*Uvularia puberula*		0.0750
18	*Dentaria laciniata*	0.0050	
18	*Duchesnea indica*	0.0050	
18	*Parthenocissus quinquefolius*	0.0100	0.200
18	*Potentilla simplex*	0.0100	0.0150
18	*Ranunculus acris*	0.0100	
18	*Thelypteris hexagonptera*	0.0100	0.0350
18	*Arisaema triphyllum*	0.0150	0.0125
18	*Dioscorea batatas*	0.0150	0.200
18	*Medeola virginica*	0.0150	
18	*Toxicodendron radicans*	0.0150	0.200
18	*Viola pubescens*	0.0150	0.0225
18	*Viola rotundifolia*	0.0150	0.0100
18	*Viola cucullata*	0.0186	0.0200
18	*Botrychium virginianum*	0.0200	0.0150
18	*Viola sp.*	0.0200	
18	*Prenanthes serpentaria*	0.0213	
18	*Polygonatum biflorum*	0.0543	0.0700
18	*Hydrangea arborescence*	0.0625	0.1875
18	*Aster divaricatum*	0.0690	0.1320
18	*Athyrium filix-femina asplenioides*	0.1050	0.1000
18	*Polystichum acrostichoides*	0.240	0.0783
18	*Rhododendron maximum*	0.1250	0.1500
18	*Cimicifuga racesmosa*	0.1950	0.1075
18	*Ranunculus recurvatus*		0.0050
18	*Uvularia grandiflora*		0.0100
18	*Fragaria virginiana*		0.0150
18	*Stellaria pubera*		0.0150
18	*Viola sororia*		0.0150
19	*Pycnacanthemum muticum*	0.0050	
19	*Smilax glauca*	0.0075	0.0200
19	*Asclepias exaltata*	0.0100	0.0500
19	*Botrychium biternatum*	0.0100	
19	*Sedum ternatum*	0.0125	0.0200
19	*Viola sororia*	0.0130	0.0267
19	*Aster divaricatum*	0.0167	0.0350
19	*Botrychium virginianum*	0.0200	
19	*Smilacina racesmosa*	0.0200	0.0500
19	*Solidago curtisii*	0.0200	0.0200
19	*Satureja vulgaris*	0.0275	
19	*Arisaema triphyllum*	0.0350	

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Table 10 continued. Original data set for vegetation cover of LBEEC.

22	*Viola cucullata*	0.0200	0.0200
22	*Thalictrum dioicum*	0.0286	0.0350
22	*Dentaria laciniata*	0.0325	
22	*Trillium grandiflorum*	0.0350	
22	*Eupatorium rugosum*	0.0367	0.0500
22	*Stellaria pubera*	0.0368	0.0310
22	*Asclepias exaltata*	0.0500	0.1000
22	*Sanguinaria canadensis*	0.0630	0.0350
22	*Disporum languinosum*	0.0675	0.0750
22	*Cimicifuga racesmosa*	0.1158	0.1925
22	*Polystichum acrostichoides*	0.1250	0.0750
22	*Trillium flexipes*	0.1250	0.0350
22	*Hydrangea arborescence*	0.2044	0.3150
22	*geranium maculatum*		0.0350
22	*Arisaema triphyllum*		0.0425
22	*Adiantum pedatum*		0.0500
22	*Dioscorea villosa*		0.0750
23	*Asplenium platyneuron*	0.0100	
23	*Viola rotundifolia*	0.0100	
23	*Viola affinis*	0.0125	
23	*Hydrophyllum virginianum*	0.0150	
23	*Viola sororia*	0.0157	0.0300
23	*Galium aparine*	0.0163	
23	*Polygonum sagittatum*	0.0200	
23	*Trillium rugelii*	0.0200	0.0200
23	*Viola canadensis*	0.0225	
23	*Arisaema triphyllum*	0.0233	0.0533
23	*claytonia caroliniana*	0.0236	
23	*Impatiens pallida*	0.0273	0.1000
23	*Stellaria pubera*	0.0275	
23	*Ranunculus recurvatus*	0.0325	0.0350
23	*Parthenocissus quinquefolius*	0.0350	0.0350
23	*Thalictrum dioicum*	0.0350	0.0925
23	*Trillium erectum*	0.0350	
23	*Viola pubescens*	0.0350	
23	*Euonymus elatus*	0.0375	0.0100
23	*Eupatorium rugosum*	0.0425	0.0517
23	*Aster divaricatum*	0.0444	0.1000
23	*Anemone thalictroides*	0.0483	
23	*Polystichum acrostichoides*	0.0850	0.0525
23	*Dentaria laciniata*	0.0854	
23	*Osmorhiza claytonia*	0.0881	0.0650
23	*Smilacina racesmosa*	0.1033	0.0875
23	*Hydrangea arborescence*	0.1290	0.1750
23	*Hydrophyllum virginianum*		0.0500

Table 10 continued. Original data set for vegetation cover of LBEEC.

23	*Sedum ternatum*	0.1333	0.0350
23	*Geranium maculatum*	0.2500	
23	*Arisaema dracontium*		0.0200
23	*Botrychium virginianum*		0.0200
23	*Clitoria mariana*		0.0275
23	*Hydrophyllum canadense*	0.1320	0.1250
24	*Ranunculus recurvatus*	0.0100	0.0150
24	*Osmorhiza claytonia*	0.0150	
24	*Smilax tamnoides*	0.0150	0.0350
24	*Aster divaricatum*	0.0167	0.0675
24	*Impatiens pallida*	0.0172	0.0567
24	*Viola sororia*	0.0175	0.0275
24	*Ranunculus acris*	0.0283	0.0500
24	*Eupatorium rugosum*	0.0350	0.0750
24	*Prenanthes trifoliolata*	0.0550	0.0350
24	*Hydrangea arborescence*	0.0775	0.1125
24	*Polystichum acrostichoides*	0.0900	0.0875
24	*unidentifiables*	0.1000	
24	*Cystopteris protrusa*	0.1188	0.0588
24	*Hydrophyllum virginianum*	0.1269	0.0100
24	*Sedum ternatum*	0.1425	
24	*Stellaria media*	0.2050	
24	*Stellaria pubera*	0.2500	
24	*Clitoria mariana*		0.0200
24	*Clematis virginiana*		0.0750
25	*Ranunculus acris*	0.0125	0.0350
25	*Polystichum acrostichoides*	0.0150	
25	*Ranunculus recurvatus*	0.0150	0.0150
25	*Botrychium virginianum*	0.0163	
25	*Asarum canadense*	0.0175	
25	*Clematis virginiana*	0.0200	0.0200
25	*Impatiens pallida*	0.0267	0.0350
25	*Asplenium platyneuron*	0.0350	
25	*Fragaria virginiana*	0.0350	
25	*Viola sororia*	0.0383	0.0325
25	*Sanguinaria canadensis*	0.0475	0.0150
25	*Tradescantia subaspera*	0.0800	0.0175
25	*Parthenocissus quinquefolius*	0.1258	0.2750
25	*Toxicodendron radicans*	0.3742	0.5100
25	*Arisaema triphyllum*		0.0250
25	*Monarda clinopodia*		0.0350
26	*Osmorhiza claytonia*	0.0100	0.0500
26	*Arisaema triphyllum*	0.0117	
26	*Galium aparine*	0.0275	
26	*Impatiens pallida*	0.0475	0.1200

Table 10 continued. Original data set for vegetation cover of LBEEC.

26	*Dentaria laciniata*	0.1500	
26	*Cystopteris protrusa*	0.3350	0.0313
26	*Aster divaricatum*	0.6500	
26	*Dryopteris intermedia*		0.0750
26	*Laportea canadensis*		0.8100
27	*Arisaema triphyllum*	0.0050	0.0400
27	*Ranunculus recurvatus*	0.0100	
27	*Cimicifuga racesmosa*	0.0125	
27	*Heuchera villosa*	0.0150	0.0350
27	*Polygonatum biflorum*	0.0150	
27	*Dentaria laciniata*	0.0238	
27	*Houstonia longifolia*	0.0350	
27	*Prenanthes trifoliolata*	0.0350	0.0250
27	*Sedum ternatum*	0.0425	0.0725
27	*Solidago curtisii*	0.0510	0.2200
27	*Aster divaricatum*	0.0738	0.3100
27	*Uvularia grandiflora*		0.0100
27	*Stellaria pubera*		0.0200
27	*Uvularia puberula*		0.0300
27	*Anemone quinquefolia*		0.0350
27	*Polystichum acrostichoides*		0.0750
28	*Adiantum pedatum*	0.0100	
28	*Medeola virginiana*	0.0100	
28	*Polygonatum biflorum*	0.0100	
28	*Uvularia grandiflora*	0.0117	
28	*claytonia caroliniana*	0.0150	
28	*Pteridium aquilinum*	0.0150	
28	*unidentifiables*	0.0150	
28	*Heuchera villosa*	0.0175	0.0500
28	*Prenanthes serpentaria*	0.0183	
28	*Asarum canadense*	0.0233	
28	*Eupatorium rugosum*	0.0233	
28	*Sedum ternatum*	0.0233	0.0417
28	*Viola blanda*	0.0250	
28	*geranium maculatum*	0.0267	0.1583
28	*Polystichum acrostichoides*	0.0333	
28	*Prenanthes trifoliolata*	0.0350	0.0200
28	*Trillium cernuum*	0.0400	0.0175
28	*Anenome thalictroides*	0.0410	0.0275
28	*Osmorhiza claytonia*	0.0425	
28	*Aster cordifolius*	0.0475	0.0425
28	*Dennstaedtia punctilobula*	0.0500	0.1250
28	*Dentaria laciniata*	0.0500	
28	*Aster divaricatum*	0.0506	0.0350
28	*Stellaria pubera*	0.0517	0.7310

Table 10 continued. Original data set for vegetation cover of LBEEC.

28	*Polystichum acrostichoides*	0.0520	0.0617
28	*Tiarella cordifolia*	0.0690	0.0670
28	*Dentaria diphyllum*	0.0800	
28	*Osmorhiza longistylis*	0.0833	0.0350
28	*Ranunculus recurvatus*	0.0850	0.0500
28	*Cimicifuga racesmosa*	0.1533	0.3500
28	*Hydrangea arborescence*	0.2000	0.0838
28	*Disporum languinosum*	0.2125	0.1375
28	*Goodyera pubescens*		0.0100
28	*Arisaema triphyllum*		0.0288
28	*Dioscorea villosa*		0.0350
28	*Thelypteris hexagonptera*		0.0350
28	*Viola rotundifolia*		0.0350
28	*Anemone quinquefolia*		0.0500
28	*Conopholis americana*		0.0500
29	*Aster divaricatum*	0.0075	0.0350
29	*Arisaema triphyllum*	0.0100	0.0350
29	*Solidago caesia*	0.0100	
29	*Botrychium virginianum*	0.0117	0.0225
29	*Cimicifuga racesmosa*	0.0150	
29	*Galium aparine*	0.0150	
29	*Lactuca biennis*	0.0150	
29	*Tiarella cordifolia*	0.0150	
29	*unidentifiables*	0.0150	
29	*Clematis virginiana*	0.0188	0.0225
29	*Prenanthes altissima*	0.0200	0.0350
29	*Impatiens pallida*	0.0207	0.0613
29	*Galium triflorum*	0.0217	0.0175
29	*Pycnacanthemum muticum*	0.0217	0.0100
29	*Asplenium platyneuron*	0.0225	0.0125
29	*Ranunculus recurvatus*	0.0240	0.0183
29	*Parthenocissus quinquefolius*	0.0333	0.0550
29	*Claytonia caroliniana*	0.0350	
29	*Erigeron pulchellus*	0.0350	
29	*Ranunculus hispida*	0.0350	
29	*Viola sororia*	0.0350	0.0150
29	*Osmorhiza claytonia*	0.0365	0.0325
29	*Ranunculus acris*	0.0450	0.0425
29	*Dentaria laciniata*	0.0560	
29	*Prenanthes serpentaria*	0.0750	0.0150
29	*Podophyllum peltatum*	0.1250	0.0500
29	*Polystichum acrostichoides*	0.2211	0.3300
29	*Anemone quinquefolia*		0.0100
29	*Sanicula canadensis*		0.0138
29	*Silene virginica*		0.0150

Table 10 continued. Original data set for vegetation cover of LBEEC.

29	*Clitoria mariana*		0.0300
29	*Adiantum pedatum*		0.0350
29	*Prenanthes trifoliata*		0.0350
29	*Aster praealtus*		0.0567
29	*Hydrangea arborescence*		0.0588
29	*Eupatorium rugosum*		0.0750
30	*Anemone quinquefolia*	0.0100	
30	*Arisaema triphyllum*	0.0100	0.0188
30	*Galium aparine*	0.0100	
30	*Osmunda caroliniana*	0.0100	
30	*Viola sororia*	0.0100	0.0100
30	*Dentaria laciniata*	0.0110	
30	*Ranunculus recurvatus*	0.0113	0.0100
30	*Eupatorium rugosum*	0.0125	0.1250
30	*Sedum ternatum*	0.0150	0.0250
30	*Stellaria media*	0.0200	
30	*Asarum canadense*	0.0350	
30	*Parthenocissus quinquefolius*	0.0350	0.0217
30	*unidentifiables*	0.0350	
30	*Hydrophyllum maculatum*	0.0400	
30	*Aster divaricatum*	0.0594	0.0475
30	*Hydrophyllum canadense*	0.0733	0.0700
30	*Osmorhiza claytonia*	0.0740	0.2120
30	*Impatiens pallida*	0.0744	0.1220
30	*Sanguinaria canadensis*	0.1117	0.1300
30	*Polystichum acrostichoides*	0.1167	0.0800
30	*Stellaria pubera*	0.1238	0.0800
30	*Claytonia caroliniana*	0.2250	0.2500
30	*Osmorhiza longistylis*	0.2900	
30	*Caulophyllum thalictroides*	0.3000	0.1750
30	*Ranunculus acris*		0.0100
30	*Clitoria mariana*		0.0150
30	*Polygonum sagittatum*		0.0200
30	*Chelone lyonii*		0.0350
30	*Sanicula canadensis*		0.0200
30	*Hydrangea arborescence*		0.1750
31	*Eupatorium rugosum*	0.0050	
31	*Viola pennsylvanica*	0.0100	
31	*Asarum canadense*	0.0150	
31	*Asplenium platyneuron*	0.0150	
31	*Smilacina racesmosa*	0.0150	0.0200
31	*Stellaria media*	0.0150	
31	*unidentifiables*	0.0150	
31	*Sedum ternatum*	0.0157	
31	*Solidago caesia*	0.0175	0.0200

Table 10 continued. Original data set for vegetation cover of LBEEC.

31	*Stellaria pubera*	0.0175	
31	*Viola rotundifolia*	0.0233	0.0350
31	*Viola blanda*	0.0263	0.1050
31	*Parthenocissus quinquefolius*	0.0283	0.0300
31	*Arisaema triphyllum*	0.0325	0.0263
31	*Dryopteris campyloptera*	0.0775	0.1375
31	*Prenanthes serpentaria*	0.1250	0.0483
31	*Prenanthes trifoliata*	0.1750	0.0750
31	*Prenanthes altissima*	0.2000	0.0400
31	*Polystichum acrostichoides*	0.2500	0.1625
31	*Hydrangea arborescence*		0.0150
31	*Aster divaricatum*	0.0167	0.0175
31	*Thelypteris noveboracensis*		0.1033
31	*Dennstaedtia punctilobula*		0.3000
32	*unidentifiables*	0.0050	
32	*Duchesnea indica*	0.0075	
32	*Asclepias amplexicaulis*	0.0100	
32	*Parthenocissus quinquefolius*	0.0150	0.0750
32	*Ranunculus aborvitus*	0.0150	
32	*Ranunculus recurvatus*	0.0183	
32	*Actinomeris alternifolia*	0.0200	0.0488
32	*Aster divaricatum*	0.0200	0.0350
32	*Clematis virginiana*	0.0200	
32	*Monarda didyma*	0.0200	0.0350
32	*Osmorhiza claytonia*	0.0238	0.0613
32	*Galium aparine*	0.0250	
32	*Ranunculus acris*	0.0425	0.0400
32	*Polystichum acrostichoides*	0.0883	0.2500
32	*Cystopteris protrusa*	0.1225	0.0500
32	*Stellaria media*	0.1564	
32	*Alliaria petiolata*	0.1625	0.0583
32	*Impatiens pallida*	0.2100	0.2500
32	*Viola sororia*	0.2900	0.1800
32	*Sanicula canadensis*		0.0275
32	*Clematis virginiana*		0.0350
32	*Polygonum sagittatum*		0.0350
33	*Arisaema triphyllum*	0.0050	0.0350
33	*Monarda didyma*	0.0200	0.0350
33	*Ranunculus aborvitus*	0.0200	
33	*Ranunculus acris*	0.0325	0.0350
33	*Asarum canadense*	0.0350	
33	*Eupatorium rugosum*	0.0350	0.0200
33	*Viola sororia*	0.0693	0.0517
33	*Dentaria diphyllum*	0.1017	
33	*Cystopteris protrusa*	0.1100	0.0350

Table 10 continued. Original data set for vegetation cover of LBEEC.

33	*Galium aparine*	0.1150	
33	*Impatiens pallida*	0.1390	0.1440
33	*Alliaria petiolata*	0.1463	0.1833
33	*Hydrophyllum macrophyllum*	0.1492	0.0483
33	*Polystichum acrostichoides*	0.2000	0.0750
33	*Laportea canadensis*	0.2167	
33	*Ranunculus recurvatus*		0.0275
33	*Laportea canadensis*		0.4833
34	*Osmorhiza claytonia*	0.0050	
34	*Viola rotundifolia*	0.0050	
34	*Asplenium platyneuron*	0.0100	0.0225
34	*Ranunculus aborvitus*	0.0100	
34	*Toxicodendron radicans*	0.0100	
34	*Viola sororia*	0.0140	
34	*Viola affinis*	0.0150	
34	*Clematis virginiana*	0.0200	
34	*Uvularia grandiflora*	0.0200	
34	*Ranunculus recurvatus*	0.0275	
34	*Botrychium biternatum*	0.0350	
34	*Lactuca biennis*	0.0350	
34	*Smilacina racesmosa*	0.0350	
34	*Solidago curtisii*	0.0350	
34	*Aristolochia macrophylla*	0.0425	
34	*Sedum ternatum*	0.0594	
34	*Asarum canadense*	0.0750	
34	*Parthenocissus quinquefolius*	0.0750	
34	*Aster divaricatum*	0.0829	
34	*Polystichum acrostichoides*	0.2500	0.0750
34	*Eupatorium rugosum*		0.0200
34	*Arisaema triphyllum*		0.0350
34	*Cystopteris protrusa*		0.0350
34	*Monarda didyma*		0.0350
34	*Ranunculus acris*		0.0350
34	*Hydrophyllum macrophyllum*		0.0483
34	*Viola cucullata*		0.0517
34	*Impatiens pallida*		0.1520
34	*Alliaria petiolata*		0.1833
34	*Laportea canadensis*		0.4833
35	*Parthenocissus quinquefolius*	0.0100	
35	*Eupatorium serotinum*	0.0200	
35	*Osmorhiza claytonia*	0.0325	0.0500
35	*Prenanthes altissima*	0.0350	0.0350
35	*Thalictrum dioicum*	0.0350	
35	*Ranunculus acris*	0.0388	0.0500
35	*Eupatorium rugosum*	0.0400	0.0875

Table 10 continued. Original data set for vegetation cover of LBEEC.

35	*Alliaria petiolata*	0.0950	0.0500
35	*Impatiens pallida*	0.1300	0.2200
35	*Aster divaricatum*	0.2250	0.3000
35	*Viola sororia*	0.5600	0.4150
35	*Solidago curtisii*		0.0200
35	*Monarda clinopodia*		0.0350
35	*Sanicula canadensis*		0.0500
35	*Actinomeris alternifolia*		0.1250
36	*Smilax glauca*	0.0050	0.0050
36	*Laportea canadensis*	0.0100	
36	*Aster divaricatum*	0.0150	
36	*Prenanthes trifoliolata*	0.0150	0.0350
36	*Prenanthes serpentaria*	0.0333	0.0650
36	*Athyrium filix-femina aspleniodes*	0.1125	0.1750
36	*Conopholis americana*	0.3350	
36	*Euonymus elatus*		0.0100
36	*Eupatorium purpureum*		0.0200
36	*Conopholis americana*		0.0350
36	*Prenanthes altissima*		0.0350
36	*Smilacina racesmosa*		0.0350
36	*Aster divaricatum*		0.0450
37	*gaultheria procumbens*	0.0050	0.0200
37	*Viola sororia*	0.0050	0.0050
37	*Lysimachia quadrifolia*	0.0175	0.0263
37	*Smilacina racesmosa*	0.0433	0.1250
37	*Prenanthes serpentaria*	0.0763	0.0500
37	*Solidago lancifolia*	0.0800	0.0550
37	*Pyrularia pubera*	0.2963	0.3750
37	*Potentilla simplex*		0.0050
37	*Smilax glauca*		0.0200
37	*Aster divaricatum*		0.0350
37	*Asclepias amplexicaulis*		0.1000
37	*Prenanthes trifoliata*		0.1675
38	*Viola cucullata*	0.0050	0.0675
38	*Galium aparine*	0.0075	
38	*Trillium grandiflorum*	0.0100	
38	*Asarum canadense*	0.0150	
38	*Botrychium virginianum*	0.0150	0.0500
38	*Eupatorium rugosum*	0.0200	0.0675
38	*Polygonatum biflorum*	0.0200	0.0200
38	*Thalictrum dioicum*	0.0200	0.0500
38	*Uvularia peltatum*	0.0200	
38	*Ranunculus recurvatus*	0.0333	
38	*Pycnanthemum tenuifolium*	0.0350	0.1500
38	*Solidago curtisii*	0.0350	0.1000

Table 10 continued. Original data set for vegetation cover of LBEEC.

38	*Viola sororia*	0.0350	0.0425
38	*Aster divaricatum*	0.0492	0.0350
38	*Prenanthes serpentaria*	0.0500	
38	*Viola rotundifolia*	0.0506	0.0700
38	*Disporum languinosum*	0.0533	0.1417
38	*Prenanthes serpentaria*	0.0550	0.0350
38	*Stellaria pubera*	0.0610	0.0480
38	*Sedum ternatum*	0.0963	0.0350
38	*Polystichum acrostichoides*	0.3550	0.1083
38	*Uvularia grandiflora*		0.0200
38	*Galium latifolium*		0.0250
38	*Pilea pumila*		0.0250
38	*Smilacina racesmosa*		0.0350
38	*Dioscorea villosa*		0.0750
38	*Arisaema triphyllum*		0.1067
38	*Aster cordifolius*		0.1250
38	*Cimicifuga racesmosa*		0.1500
39	*Aplectrum hyemale*	0.0100	
39	*Asarum canadense*	0.0100	
39	*Botrychium biternatum*	0.0100	
39	*Campsis radicans*	0.0100	
39	*Galium aparine*	0.0100	
39	*Polystichum acrostichoides*	0.0100	0.0500
39	*Ranunculus acris*	0.0100	
39	*Uvularia peltatum*	0.0100	
39	*Arisaema triphyllum*	0.0125	0.0425
39	*Galium latifolium*	0.0125	0.0125
39	*Parthenocissus quinquefolius*	0.0125	0.0500
39	*Potentilla simplex*	0.0150	
39	*Osmorhiza claytonia*	0.0183	
39	*Ranunculus recurvatus*	0.0183	
39	*Trillium flexipes*	0.0188	
39	*Dentaria laciniata*	0.0189	
39	*Polygonatum biflorum*	0.0200	0.0925
39	*Podophyllum peltatum*	0.0275	
39	*Cimicifuga racesmosa*	0.0300	0.0750
39	*Solidago*	0.0350	
39	*Caulophyllum thalictroides*	0.0350	0.1250
39	*Erigeron pulchellus*	0.0350	
39	*Pycnacanthemum muticum*	0.0350	0.0450
39	*Pycnanthemum tenuifolium*	0.0444	0.0350
39	*Aster cordifolius*	0.0475	0.2000
39	*Trillium grandiflorum*	0.0480	
39	*Viola rotundifolia*	0.0550	
39	*Stellaria pubera*	0.0579	0.0275

Table 10 continued. Original data set for vegetation cover of LBEEC.

39	*Viola sororia*	0.0983	0.2200
39	*Viola canadensis*	0.1230	0.0700
39	*Aster divaricatum*	0.1235	
39	*Smilacina racesmosa*	0.1500	0.3000
39	*Sedum ternatum*	0.1650	0.0350
39	*Viola hastata*		0.0200
39	*Sanicula canadensis*		0.0217
39	*Impatiens pallida*		0.0350
39	*Pilea pumila*		0.0500
39	*Monarda clinopodia*		0.0583
39	*Laportea canadensis*		0.2000
40	*Viola sororia*	0.0050	0.0100
40	*unidentifiables*	0.0063	
40	*Galium triflorum*	0.0125	0.0100
40	*Prenanthes serpentaria*	0.0138	
40	*Galium latifolium*	0.0200	
40	*Conopholis americana*	0.0250	
40	*Potentilla simplex*	0.0263	0.0350
40	*Solidago lancifolia*	0.0330	0.0725
40	*Aster divaricatum*	0.0350	0.0350
40	*Tradescantia subaspera*	0.0350	
40	*Lysimachia quadrifolia*	0.0433	0.0350
40	*Pycnacanthemum tenuifolium*	0.0867	0.0650
40	*Pyrularia pubera*	0.1167	0.1125
40	*Sedum ternatum*	0.1250	0.0750
40	*Clitoria mariana*	0.1875	0.2750
40	*Uvularia perfoliata*	0.2000	0.0500
40	*Smilacina racesmosa*	0.2500	0.1500
40	*Uvularia grandiflora*		0.0100
40	*Clematis virginiana*		0.0350
40	*Eupatorium rugosum*		0.0350
40	*Uvularia perfoliata*		0.0425
41	*Ranunculus recurvatus*	0.0050	
41	*Ranunculus hispidus*	0.0100	
41	*Pyrularia pubera*	0.0150	0.0550
41	*Smilacina racesmosa*	0.0150	
41	*Impatiens pallida*	0.0175	0.0100
41	*Stellaria pubera*	0.0192	0.0400
41	*Arisaema triphyllum*	0.0200	0.0450
41	*Clitoria mariana*	0.0200	0.0350
41	*Dioscorea batatas*	0.0200	
41	*Dioscorea villosa*	0.0200	0.0275
41	*Hydrangea arborescence*	0.0225	0.2000
41	*Aster divaricatum*	0.0250	
41	*Pycnacanthemum tenuifolium*	0.0325	0.0350

Table 10 continued. Original data set for vegetation cover of LBEEC.

41	*Anemone thalictroides*	0.0350	
41	*Asclepias*	0.0350	0.0475
41	*hepatica acutiloba*	0.0350	1
41	*Oxalis stricta*	0.0350	0.0350
41	*Trillium flexipes*	0.0400	0.0750
41	*Polygonatum biflorum*	0.0417	0.1125
41	*Trillium grandiflorum*	0.0500	0.0200
41	*Sedum ternatum*	0.0544	0.0717
41	*Tradescantia subaspera*	0.0550	0.1000
41	*Polystichum acrostichoides*	0.1688	0.2875
41	*Geranium maculatum*	0.4083	0.1583
41	*Potentilla simplex*		0.0150
41	*Thalictrum dioicum*		0.0200
41	*Aster cordifolius*		0.0950
42	*Botrychium virginianum*	0.0100	
42	*Caulophyllum thalictroides*	0.0150	
42	*Lysimachia quadrifolia*	0.0150	0.0200
42	*Polygonatum biflorum*	0.0150	
42	*Oxalis stricta*	0.0183	
42	*Sedum ternatum*	0.0225	0.0200
42	*Dentaria laciniata*	0.0238	
42	*Arisaema triphyllum*	0.0275	0.0625
42	*Impatiens pallida*	0.0275	0.0267
42	*Pyrularia pubera*	0.0283	0.0350
42	*Stellaria pubera*	0.0300	0.0483
42	*Thelypteris hexagonptera*	0.0317	0.0483
42	*Potentilla simplex*	0.0350	0.0200
42	*Sanguinaria canadensis*	0.0350	0.0350
42	*Asclepias amplexicaulis*	0.0417	0.0750
42	*Dryopteris intermedia*	0.0417	0.1117
42	*Tradescantia subaspera*	0.0417	0.0275
42	*Smilacina racesmosa*	0.0490	0.1125
42	*unknown*	0.0500	
42	*Dioscorea villosa*	0.0700	0.0600
42	*Viola sororia*	0.0775	0.0800
42	*Solidago flexicaulis*	0.0783	0.1733
42	*Geranium maculatum*	0.0800	0.1250
42	*Aster divaricatum*	0.1913	
42	*Uvularia perfoliata*	0.1500	0.0500
42	*Trillium*		0.0150
42	*Uvularia grandiflora*		0.0200
42	*Eupatorium rugosum*		0.0350
42	*Oxalis grandis*		0.0625
42	*Eupatorium purpureum*		0.1000
43	*Gaultheria procumbens*	0.0050	0.0050

Table 10 continued. Original data set for vegetation cover of LBEEC.

43	*Potentilla simplex*	0.0083	0.0350
43	*Eupatorium rugosum*	0.0100	
43	*Lysimachia quadrifolia*	0.0100	0.0283
43	*Aristolochia macrophylla*	0.0150	
43	*Hydrangea arborescence*	0.0150	0.0350
43	*Solidago flexicaulis*	0.0150	0.0275
43	*Asarum canadense*	0.0250	
43	*Galium latifolium*	0.0350	0.0600
43	*Prenanthes altissima*	0.0350	0.0500
43	*Pycnacanthemum muticum*	0.0350	
43	*Aster divaricatum*	0.0507	0.0613
43	*Sedum ternatum*	0.1400	0.0350
43	*Polystichum acrostichoides*	0.1417	0.1000
43	*Prenanthes serpentaria*	0.2000	0.0475
43	*Clitoria mariana*		0.0100
43	*Viola sororia*		0.0100
43	*Smilax glauca*		0.0183
43	*Laportea canadensis*		0.0200
43	*Smilacina racesmosa*		0.0275
43	*Parthenocissus quinquefolius*		0.0350
43	*Arisaema triphyllum*		0.0380
43	*Chelone lyonii*		0.0500
43	*Prenanthes trifoliata*		0.2125
44	*Anemone quinquefolia*	0.0100	0.0200
44	*Arisaema triphyllum*	0.0100	0.0313
44	*Botrychium virginianum*	0.0100	0.0200
44	*Smilacina racesmosa*	0.0100	0.0350
44	*Campsis radicans*	0.0150	
44	*Potentilla simplex*	0.0150	0.0200
44	*Pycnacanthemum tenuifolium*	0.0150	0.0350
44	*Trillium grandiflorum*	0.0150	0.0425
44	*Uvularia sessilifolia*	0.0150	
44	*Ranunculus hispida*	0.0300	
44	*Aster cordifolius*	0.0333	0.1438
44	*Cimicifuga racesmosa*	0.0350	0.2000
44	*Galearis spectabilis*	0.0350	0.0350
44	*Galium latifolium*	0.0350	0.0200
44	*Galium triflorum*	0.0350	0.0275
44	*Osmorhiza claytonia*	0.0350	
44	*Polygonatum biflorum*	0.0350	
44	*Viola sororia*	0.0350	0.0350
44	*Thalictrum dioicum*	0.0488	0.0713
44	*Geranium maculatum*	0.1580	0.0550
44	*Tradescantia subaspera*	0.0950	0.0500
44	*Polystichum acrostichoides*	0.1525	0.0738

Table 10 continued. Original data set for vegetation cover of LBEEC.

44	*Sedum ternatum*	0.1590	0.1300
44	*Campanula americana*		0.0200
44	*Clematis virginiana*		0.0200
44	*Dioscorea villosa*		0.0200
44	*Thelypteris hexagonptera*		0.0200
44	*Triosteum aurantiacum*		0.0200
44	*Geranium maculatum*		0.0350
44	*Stellaria pubera*		0.0425
44	*Eupatorium rugosum*		0.0613
44	*Uvularia perfoliata*		0.1750
44	*Solidago curtisii*		0.0200
45	*Aster cordifolius*	0.0100	0.0500
45	*Athyrium thelypterioides*	0.0100	
45	*Uvularia perfoliata*	0.0100	
45	*Anemone quinquefolia*	0.0117	
45	*Galium aparine*	0.0150	
45	*Stellaria pubera*	0.0150	0.0400
45	*Dentaria laciniata*	0.0217	
45	*Pycnacanthemum muticum*	0.0275	0.0250
45	*Ranunculus acris*	0.0350	
45	*Solidago lancifolia*	0.0350	0.0500
45	*Tradescantia subaspera*	0.0350	0.0500
45	*Sedum ternatum*	0.0417	0.0400
45	*Aster divaricatum*	0.0575	0.0950
45	*Ranunculus recurvatus*	0.0800	
45	*Phacelia fimbriata*	0.0820	
45	*Viola sororia*	0.1088	0.3000
45	*Podophyllum peltatum*	0.1750	
45	*Viola canadensis*	0.6500	0.5000
45	*Impatiens pallida*		0.0150
45	*Gillinia trifoliata*		0.0350
45	*Osmorhiza longistylis*		0.0350
45	*Smilacina racesmosa*		0.0350
45	*Triosteum aurantiacum*		0.0350
45	*Arisaema triphyllum*		0.0483
45	*Eupatorium rugosum*		0.0750
45	*Dennstaedtia punctilobula*		0.3000
46	*Erigeron pulchellus*	0.0100	0.0350
46	*Eupatorium rugosum*	0.0100	0.1150
46	*Uvularia perfoliata*	0.0100	0.0350
46	*Dryopteris*	0.0133	
46	*Aster cordifolius*	0.0150	
46	*Pycnanthemum tenuifolium*	0.0150	0.0488
46	*Satureja vulgaris*	0.0200	
46	*Cimicifuga racesmosa*	0.0225	0.1250

Table 10 continued. Original data set for vegetation cover of LBEEC.

46	*Aster divaricatum*	0.0275	0.0450
46	*Conopholis americana*	0.0300	
46	*Solidago caesia*	0.0333	0.0200
46	*Hydrangea arborescence*	0.0350	0.2500
46	*Thalictrum dioicum*	0.0350	0.2000
46	*Galium latifolium*	0.0450	0.0775
46	*Viola sp*		0.0350
46	*Arisaema triphyllum*		0.0750
46	*Lysimachia quadrifolia*		0.0750
46	*Silene stellata*		0.0750
46	*Campanula americana*		0.0783
46	*Dioscorea villosa*		0.1250
46	*Athyrium filix-femina aspleniodes*		0.1583
46	*Dennstaedtia punctilobula*		0.2000
47	*Anemone thalictroides*	0.0100	
47	*Galium aparine*	0.0100	
47	*Polygonatum biflorum*	0.0100	
47	*Uvularia peltatum*	0.0100	
47	*Aster cordifolius*	0.0200	0.0450
47	*Sanguinaria canadensis*	0.0200	
47	*Impatiens pallida*	0.0325	0.1425
47	*Viola sororia*	0.0325	0.0350
47	*Eupatorium rugosum*	0.0350	0.1375
47	*Pycnanthemum tenuifolium*	0.0350	0.1000
47	*Stellaria pubera*	0.0620	0.0550
47	*Polystichum acrostichoides*	0.0750	0.0350
47	*Dentaria laciniata*	0.0850	
47	*Tradescantia subaspera*	0.0875	0.1000
47	*Aster divaricatum*	0.1000	
47	*Trillium grandiflorum*	0.1033	0.0750
47	*Thalictrum dioicum*	0.1075	0.0533
47	*Sedum ternatum*	0.1500	0.1925
47	*Cimicifuga racesmosa*	0.2500	0.3000
47	*Disporum languinosum*	0.2500	0.2500
47	*Arisaema triphyllum*		0.0200
47	*Solidago lancifolia*		0.0200
47	*Viola hastata*		0.0350
47	*Smilacina racesmosa*		0.0425
47	*Eupatorium aromaticum*		0.1000
47	*Hydrangea arborescence*		0.2500
47	*Aruncus dioicus*		0.3000
48	*Viola sororia*	0.0100	
48	*Dioscorea villosa*	0.0125	0.0200
48	*Galium triflorum*	0.0150	
48	*Polygonatum biflorum*	0.0150	

Table 10 continued. Original data set for vegetation cover of LBEEC.

48	*Zizia trifoliata*	0.0217	0.0275
48	*Galium latifolium*	0.0250	0.0350
48	*Aster divaricatum*	0.0350	
48	*Thalictrum dioicum*	0.0350	0.1667
48	*Pycnanthemum tenuifolium*	0.1625	0.0988
48	*Sedum ternatum*	0.2450	0.0900
48	*Cimicifuga racesmosa*	0.2500	0.2500
48	*Aster cordifolius*	0.4000	0.0625
48	*Houstonia tenuifolia*		0.0100
48	*Arisaema triphyllum*		0.0350
48	*Impatiens pallida*		0.0600
48	*Clematis virginiana*		0.0750
48	*Solidago lancifolia*		0.4583
49	*Solidago caesia*	0.0050	0.0500
49	*unidentifiables*	0.0050	
49	*Viola rotundifolia*	0.0050	
49	*Arisaema triphyllum*	0.0100	
49	*Pycnanthemum tenuifolium*	0.0125	0.0200
49	*Satureja vulgaris*	0.0150	
49	*Uvularia perfoliata*	0.0150	
49	*Viola cucullata*	0.0150	0.0350
49	*Zizia trifoliata*	0.0150	0.0350
49	*Polygonatum biflorum*	0.0200	
49	*Viola sororia*	0.0238	0.0350
49	*Medeola virginica*	0.0275	0.0200
49	*Aster divaricatum*	0.0350	
49	*Potentilla simplex*	0.0375	0.0675
49	*Prenanthes trifoliolata*	0.0400	
49	*Smilacina racesmosa*	0.0700	0.0475
49	*Tradescantia subaspera*	0.0750	0.0750
49	*Eupatorium rugosum*	0.0788	0.0817
49	*Erigeron pulchellus*	0.0800	0.0750
49	*Sedum ternatum*	0.0850	
49	*Houstonia longifolia*		0.0175
49	*Galium latifolium*		0.0200
49	*Clitoria mariana*		0.0350
49	*Eupatorium purpureum*		0.0350
49	*Uvularia perfoliata*		0.0350
50	*Erigeron pulchellus*	0.0050	
50	*Smilax glauca*	0.0100	0.0100
50	*unidentifiables*	0.0100	
50	*Conopholis americana*	0.0150	
50	*Solidago curtisii*	0.0200	0.0350
50	*Uvularia grandiflora*	0.1750	0.1250
51	*Lillium canadense*	0.0050	

Table 10 continued. Original data set for vegetation cover of LBEEC.

51	*Potentilla simplex*	0.0050	
51	*Campanula divaricata*	0.0150	
51	*Galium latifolium*	0.0150	0.0350
51	*Erigeron pulchellus*	0.0175	0.0350
51	*Polygonatum biflorum*	0.0200	
51	*Uvularia grandiflora*	0.0217	0.0300
51	*Clitoria mariana*	0.0225	0.1175
51	*Prenanthes serpentaria*	0.0250	0.0200
51	*Pyrularia pubera*	0.0350	
51	*Smilax glauca*	0.0350	0.0375
51	*Smilacina racesmosa*	0.0425	
51	*Galax aphylla*	0.0950	0.1425
51	*Kalmia latifolia*	0.3500	0.2000
51	*Euonymus elatus*		0.0175
51	*campanula americana*		0.0338
51	*Hieracium paniculatum*		0.0350
52	*Claytonia caroliniana*	0.0050	
52	*Cystopteris protrusa*	0.0100	
52	*Galium triflorum*	0.0100	0.0200
52	*Ranunculus acris*	0.0125	0.0100
52	*Anemone quinquefolia*	0.0150	
52	*Botrychium virginianum*	0.0200	
52	*Trillium flexipes*	0.0200	
52	*Botrychium virginianum*	0.0225	0.0750
52	*Aster cordifolius*	0.0250	0.0275
52	*Arisaema triphyllum*	0.0263	0.0450
52	*Aster divaricatum*	0.0275	0.0583
52	*Impatiens pallida*	0.0283	
52	*Parthenocissus quinquefolius*	0.0300	0.0175
52	*Sanguinaria canadensis*	0.0350	0.0350
52	*Dentaria laciniata*	0.0400	
52	*Tradescantia subaspera*	0.0425	0.0200
52	*Trillium cernuum*	0.0500	
52	*Sedum ternatum*	0.0588	0.0650
52	*Hydrophyllum canadense*	0.0610	0.0750
52	*Stellaria pubera*	0.0610	0.0617
52	*Disporum languinosum*	0.0675	0.1500
52	*Hydrophyllum macrophyllum*	0.0725	0.0200
52	*Osmorhiza claytonia*	0.0738	0.0838
52	*Thalictrum dioicum*	0.0750	0.2425
52	*Dicentra canadensis*	0.0769	
52	*Asarum canadense*	0.0900	0.1117
52	*Caulophyllum thalictroides*	0.0920	0.1000
52	*Hydrophyllum virginianum*	0.0925	
52	*Cimicifuga racesmosa*	0.1050	0.2063

Table 10 continued. Original data set for vegetation cover of LBEEC.

52	*Polygonatum biflorum*	0.1070	
52	*Smilacina racesmosa*	0.1125	0.0667
52	*Viola canadensis*	0.1550	0.1250
52	*Polystichum acrostichoides*		0.0350
52	*Hydrangea arborescence*		0.0750
52	*Viola sororia*		0.0850
53	*Claytonia caroliniana*	0.0125	
53	*Botrychium multifidum*	0.0150	
53	*Dentaria laciniata*	0.0150	
53	*Galium aparine*	0.0150	
53	*Smilacina racesmosa*	0.0150	
53	*Osmorhiza claytonia*	0.0200	0.0350
53	*Alliaria petiolata*	0.0275	0.0200
53	*Caulophyllum thalictroides*	0.0350	
53	*Dryopteris marginalis*	0.0350	0.0350
53	*Arisaema triphyllum*	0.0400	0.0988
53	*Parthenocissus quinquefolius*	0.0500	0.0625
53	*Stellaria pubera*	0.0538	0.0744
53	*Hydrophyllum canadense*	0.0675	0.0740
53	*Hydrophyllum macrophyllum*	0.0750	0.0575
53	*Hydrophyllum virginianum*	0.0775	0.0200
53	*Impatiens pallida*	0.0813	0.2375
53	*Sedum ternatum*	0.0875	0.1750
53	*Trillium flexipes*	0.0925	
53	*Trillium rugelii*	0.1300	0.0750
53	*Cystopteris protrusa*	0.2093	
53	*Cimicifuga racesmosa*	0.2438	0.5167
53	*Dicentra canadensis*	0.2875	0.0720
53	*Aristolochia serpentaria*		0.0100
53	*Arisaema dracontium*		0.0200
54	*Claytonia caroliniana*	0.0050	
54	*Viola pubescens*	0.0083	0.0150
54	*Dentaria laciniata*	0.0088	
54	*Anemone quinquefolia*	0.0100	
54	*Disporum languinosum*	0.0150	
54	*Parthenocissus quinquefolius*	0.0150	0.0200
54	*Potentilla simplex*	0.0150	
54	*Viola sororia*	0.0150	
54	*Hydrophyllum canadense*	0.0200	
54	*Ranunculus acris*	0.0200	
54	*Viola canadensis*	0.0200	
54	*Arisaema triphyllum*	0.0233	0.0350
54	*Impatiens pallida*	0.0238	0.0100
54	*Trillium rugelii*	0.0275	
54	*Cystopteris protrusa*	0.0289	0.0350

Table 10 continued. Original data set for vegetation cover of LBEEC.

54	*Dicentra canadensis*	0.0300	
54	*Trillium erectum*	0.0317	
54	*Stellaria pubera*	0.0329	0.0350
54	*Smilacina racesmosa*	0.0350	
54	*Osmorhiza claytonia*	0.0380	0.0388
54	*Cimicifuga racesmosa*	0.0413	0.1000
54	*Polystichum acrostichoides*	0.0500	
54	*Sedum ternatum*	0.0500	0.0350
54	*Aster divaricatum*	0.0710	0.0300
54	*Caulophyllum thalictroides*	0.2120	0.2125
54	*Asarum canadense*	0.4650	0.6000
54	*Polygonum sagittatum*		0.0200
54	*Dryopteris marginalis*		0.1000
55	*Galium latifolium*	0.0050	
55	*Medeola virginiana*	0.0050	
55	*unidentifiables*	0.0050	
55	*Aster divaricatum*	0.0100	
55	*Unidentifiable- orchid/single leaf?*	0.0100	
55	*Zizia trifoliata*	0.0150	0.0200
55	*Solidago petiolaris*	0.0500	0.0100
55	*Prenanthes serpentaria*	0.1250	0.0200
55	*Smilax glauca*		0.0100
55	*Solidago lancifolia*		0.0100
55	*Hypericum sp*		0.0100
55	*Lysimachia quadrifolia*		0.0117
55	*Uvularia puberula*		0.0150
55	*Prenanthes trifoliata*		0.0200
55	*Euonymus elatus*		0.0350
55	*Lysimachia ciliata*		0.0425
56	*Prenanthes altissima*	0.0538	0.0313
56	*Prenanthes serpentaria*	0.0763	0.0480
56	*Campanula americana*		0.0100
56	*Smilax glauca*		0.0100
56	*Prenanthes trifoliata*		0.0750
57	*Asarum canadense*	0.0100	
57	*Thelypteris hexagonptera*	0.0100	0.0200
57	*Osmorhiza claytonia*	0.0125	
57	*Sedum ternatum*	0.0150	
57	*Viola canadensis*	0.0175	0.0350
57	*Parthenocissus quinquefolius*	0.0200	0.0350
57	*Sanguinaria canadensis*	0.0233	0.0350
57	*Polygonatum biflorum*	0.0250	
57	*Aster divaricatum*	0.0350	0.0300
57	*Aristolochia macrophylla*	0.0500	
57	*Viola sororia*	0.0500	

Table 10 continued. Original data set for vegetation cover of LBEEC.

57	*Ranunculus recurvatus*	0.0533	
57	*Dentaria laciniata*	0.0930	
57	*Arisaema triphyllum*	0.1175	0.0488
57	*Laportea canadensis*	0.1530	0.4240
57	*Prenanthes trifoliolata*	0.1717	
57	*Hydrangea arborescence*	0.2000	0.1000
57	*Cimicifuga racesmosa*	0.2500	0.3000
57	*Aristolochia serpentaria*		0.0350
58	*Parthenocissus quinquefolius*	0.0050	
58	*Aster divaricatum*	0.0100	
58	*Clematis virginiana*	0.0100	0.0350
58	*Dioscorea villosa*	0.0100	0.0500
58	*Arisaema triphyllum*	0.0150	0.0300
58	*Galium latifolium*	0.0150	
58	*Smilax glauca*	0.0150	0.0360
58	*Viola pubera*	0.0150	0.0350
58	*Viola sororia*	0.0150	0.0200
58	*Solidago curtisii*	0.0175	0.0350
58	*Botrychium biternatum*	0.0200	0.0100
58	*Eupatorium rugosum*	0.0350	0.0350
58	*Smilacina racesmosa*	0.0450	0.0500
58	*Euonymus elatus*		0.0200
58	*Cacalia atriplicifolia*		0.0350
58	*Smilax tamnoides*		0.0350
59	*Potentilla simplex*	0.0050	
59	*Viola cucullata*	0.0050	0.0150
59	*Uvularia sessilifolia*	0.0100	
59	*Stellaria pubera*	0.0125	
59	*Clematis virginiana*	0.0150	0.0200
59	*Viola sororia*	0.0150	
59	*Eupatorium rugosum*	0.0200	0.0200
59	*Medeola virginica*	0.0200	
59	*Pycnacanthemum tenuifolium*	0.0200	0.0350
59	*Solidago*	0.0250	0.0275
59	*Satureja vulgaris*	0.0350	
59	*Smilax glauca*	0.0350	0.0550
59	*Prenanthes trifoliata*	0.0483	0.0700
59	*Vaccinium stamineum*	0.2500	
59	*Smilacina racesmosa*		0.0167
59	*Lysimachia quadrifolia*		0.0425
59	*Hydrangea arborescence*		0.2500

Appendix B

Plot data

Table 11. Plot data for the Long Branch Environmental Education Center. Aspect classes are follows; 1=North, 2=South, 3=East, 4=West. Slope is the degrees of inclination from the bottom to the top corners of the plot. Direction is in degrees departure from south-southwest. Curve is slope curvature; 1=convex, 0=side slope, -1=concave. Age classes are 1 being young and two being old plots. LN is the degrees of inclination to the northern horizon line from the center of the plot, LS is south, LE is east, and LW is west.

plot	Elevation class	aspect	elevation (ft)	slope	Direction	curve	Age	LN	LS	LE	LW
1	Low	4	3300	42	57.5	1	2	28	8	22	40
2	Medium	4	3850	0	27.5	1	2	30	0	25	25
3	Medium	4	4200	38	17.5	0	2	25	3	3	4
4	Medium	2	4300	41	42.5	0	2	50	11	10	8
5	Medium	2	3940	?	52.5	1	2	32	3	0	18
6	Medium	2	3780	48	12.5	1	2	32	4	0	18
7	Low	2	3360	16	64.5	0	2	32	24	10	42
8	Low	3	3340	28	122.5	0	2	36	10	18	28
9	High	1	4480	20	137.5	0	1	20	3	0	12
10	High	1	4380	30	192.5	0	1	19	30	0	24
11	High	1	4400	40	200.5	0	1	28	50	18	22
12	Medium	1	4200	22	137.5	0	1	12	40	2	20
13	Medium	4	3900	30	172.5	-1	1	10	22	40	25
14	Medium	1	3900	22	202.5	1	1	16	34	18	20
15	Medium	1	3840	24	194.5	1	1	16	22	10	22
16	Medium	4	3700	28	102.5	0	1	0	32	30	28
17	Low	1	3450	25	162.5	1	1	22	28	22	20
18	Low	3	3300	18	142.5	1	1	24	35	10	28
19	Low	2	3340	45	52.5	1	1	24	20	16	18
20	Low	3	3450	50	132.5	1	2	40	22	8	28
21	Medium	3	3700	28	114.5	0	2	18	0	0	3
22	Medium	3	3800	38	112.5	0	2	20	12	8	45
23	Low	3	3400	35	142.5	0	2	42	8	18	48
24	Low	2	3280	60	22.5	0	2	44	25	0	22
25	Medium	4	3940	18	57.5	0	2	0	20	30	8
26	High	1	4500	42	147.5	0	2	0	30	2	15

Table 11 continued. Plot data for the Long Branch Environmental Education Center.

27	High	4	4500	40	87.5	0	2	18	4	40	8
28	Low	1	3280	30	152.5	0	1	32	38	0	22
29	Low	1	3080	28	182.5	0	1	22	34	22	24
30	Low	4	3200	38	107.5	0	1	38	4	42	20
31	Low	4	3100	26	102.5	0	1	12	25	30	18
32	Low	1	3620	8	162.5	-1	2	0	18	30	22
33	Low	4	3700	22	77.5	-1	2	10	32	35	22
34	Medium	1	3900	15	192.5	1	2	2	30	28	10
35	Medium	1	4000	18	192.5	0	2	0	30	28	10
36	Low	3	3500	20	112.5	1	1	22	20	8	38
37	Medium	3	3900	15	82.5	1	1	18	22	2	20
38	Medium	4	4000	18	42.5	0	1	22	0	10	12
39	Medium	3	4200	28	82.5	1	1	30	15	10	38
40	Medium	2	4200	20	52.5	1	1	28	6	0	15
41	Medium	2	4000	25	12.5	-1	1	40	18	0	32
42	Medium	2	3800	28	27.5	-1	1	40	20	6	28
43	Low	2	3200	30	27.5	0	1	4	20	32	22
44	High	3	4800	38	82.5	0	1	18	12	0	58
45	High	3	4800	25	107.5	0	1	20	16	0	42
46	High	2	4800	32	52.5	-1	1	52	2	18	22
47	High	3	4600	38	102.5	0	1	20	4	0	52
48	High	2	4500	30	42.5	0	1	50	6	2	24
49	High	2	4600	20	37.5	0	1	24	0	0	18
50	Medium	2	3900	22	22.5	0	1	25	12	2	30
51	Low	2	3500	32	12.5	0	1	30	18	6	30
52	Low	4	3600	42	97.5	0	2	20	52	32	10
53	Low	1	3500	38	117.5	0	2	10	50	32	24
54	Low	1	3400	25	132.5	0	2	8	42	18	16
55	Low	3	3440	20	87.5	1	1	15	10	0	20
56	Low	3	3200	18	67.5	1	1	20	20	0	32
57	Medium	1	4200	24	137.5	1	2	0	20	20	0
58	Medium	3	3800	22	82.5	1	2	20	0	0	22
59	Low	2	3450	26	32.5	1	2	30	0	32	22

Appendix C

Additional Plot Data

Table 12. Additional plot data for the Long Branch Environmental Education Center. LI is the landform index, an average of all 4 inclination measures to the horizons. Sky is the percent open canopy. pH is the soil pH. Buffering is the soil buffering capacity via the pH of soil after buffering agents are applied. Nutrients are log transformed values of lb/acre values. OM is percent carbon after soil combustion.

plot	LI	sky	pH	Buffering	P	K	Ca	Mg	Zn	N	OM
1	0.06	0.1587	4.62	5.71	1.78	2.31	3.16	2.30	0.62	3.85	8.76
2	0.05	0.1090	4.24	5.48	1.49	2.23	2.46	2.01	0.89	3.92	12.12
3	0.02	0.0976	4.46	5.69	1.67	2.21	2.83	2.30	0.38	3.90	10.34
4	0.05	0.0854	4.26	5.3	1.74	2.23	2.68	2.42	0.57	4.05	15.23
5	0.03	0.0923	4.43	5.63	1.51	2.12	2.45	2.12	0.51	3.82	8.72
6	0.03	0.7995	4.67	5.79	2.14	2.67	2.94	2.21	0.41	3.86	8.69
7	0.07	0.0832	5.37	6.38	1.53	2.44	3.09	2.63	0.58	3.81	7.38
8	0.06	0.0414	5	6.08	1.54	2.28	3.07	2.52	0.52	3.84	7.52
9	0.02	0.1067	4.14	5.35	1.43	2.14	1.94	1.88	0.45	3.87	12.59
10	0.05	0.0315	4.4	5.63	1.36	2.14	2.04	2.01	0.54	3.78	10.82
11	0.07	0.0385	4.22	5.23	1.20	2.08	1.85	1.65	0.38	3.99	18.56
12	0.05	0.1493	4.21	5.26	1.20	2.10	2.05	1.83	0.20	3.94	15.1
13	0.06	0.0750	4.29	5.54	1.23	2.03	2.08	1.73	0.28	3.80	8.63
14	0.06	0.1751	4.19	5.39	1.36	1.94	1.72	1.54	0.34	3.91	14.38
15	0.04	0.0857	4.36	5.57	1.51	2.15	2.56	2.13	0.51	3.91	11.36
16	0.06	0.0710	4.3	5.53	1.26	1.95	1.74	1.63	0.28	3.84	11.14
17	0.06	0.1359	4.11	5.32	1.40	2.12	1.97	1.82	0.20	4.01	15.57
18	0.06	0.2690	4.83	5.82	1.08	2.00	2.64	2.12	0.11	3.76	7.82
19	0.05	0.2140	4.78	5.88	1.30	2.04	2.39	2.10	0.28	3.78	8.59
20	0.06	0.1087	5.92	6.33	1.56	2.53	3.54	2.81	0.67	3.97	11.08
21	0.01	0.1286	4.34	5.76	1.34	2.07	1.90	1.92	0.59	3.72	10.02
22	0.05	0.0401	4.83	5.78	1.53	2.21	2.74	2.25	0.30	3.94	11.66
23	0.07	0.1166	5.9	6.35	1.64	2.65	3.51	2.62	0.51	3.85	8.28
24	0.06	0.1000	5.03	5.89	1.87	2.38	3.03	2.20	0.41	3.71	6.41
25	0.04	0.2076	4.92	5.86	1.82	2.38	3.01	2.45	0.57	3.82	7.61
26	0.03	0.1352	5	5.66	1.93	2.22	3.40	2.33	0.66	4.13	15.82
27	0.04	0.1352	4.44	5.68	1.57	2.29	2.66	1.99	0.28	3.73	7.29
28	0.06	0.0657	5.34	6.11	1.30	2.20	3.22	2.30	0.45	3.91	10.66
29	0.06	0.3431	5.71	6.46	1.59	2.52	3.42	2.62	0.58	3.81	7.32
30	0.07	0.3021	4.8	5.81	1.70	2.80	3.02	2.22	0.60	3.84	8.01
31	0.05	0.2146	4.33	5.62	1.63	2.24	2.43	1.95	0.58	3.91	10.94
32	0.04	0.1341	5.33	5.86	1.58	2.51	3.29	2.46	0.57	3.89	7.86
33	0.06	0.0752	6.06	6.52	1.75	2.63	3.65	2.83	0.54	3.89	8.25

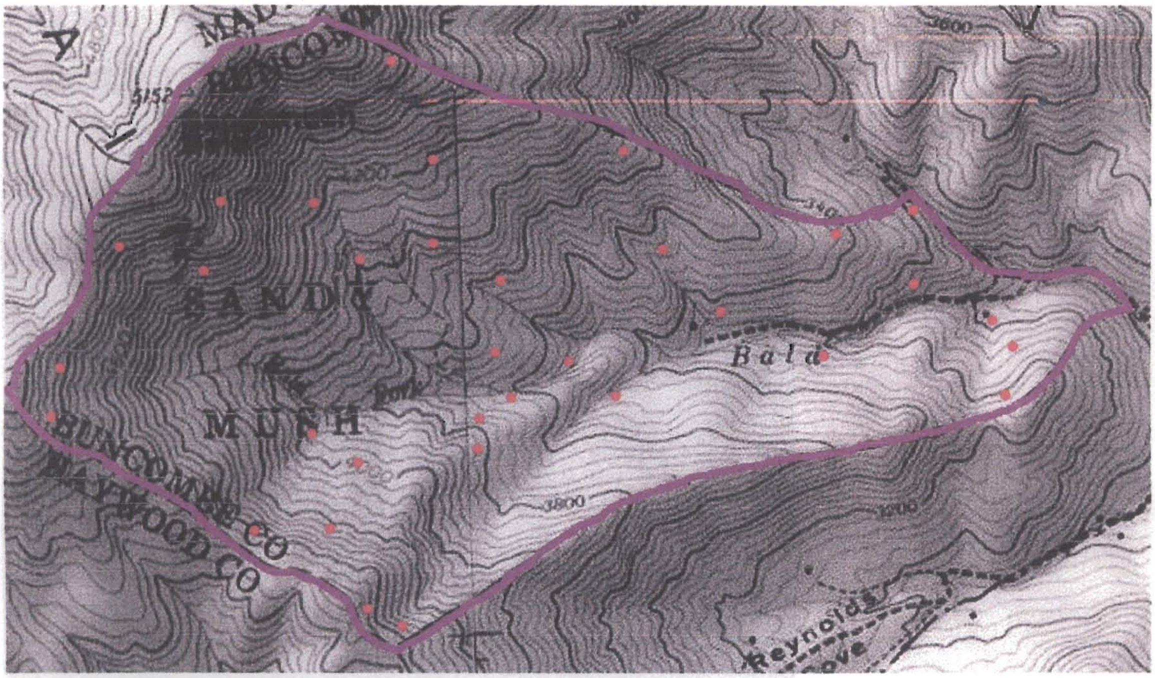
Table 12 continued. Additional plot data for the Long Branch Environmental Education Center.

34	0.04	0.1118	4.68	5.59	1.59	2.43	2.94	2.30	0.23	3.84	7.98
35	0.04	0.1910	5.55	6.1	1.75	2.62	3.45	2.66	0.59	4.08	12.83
36	0.06	0.0861	4.42	5.44	1.34	2.08	1.98	1.69	0.61	3.88	14.09
37	0.04	0.2374	4.77	5.75	1.23	2.02	2.32	1.90	0.57	3.79	10.33
38	0.03	0.1763	4.85	5.61	1.43	2.25	2.99	2.26	0.26	3.86	10.72
39	0.06	0.1253	4.93	5.39	1.75	2.27	3.39	2.36	0.08	4.19	18.01
40	0.03	0.2301	4.62	5.8	1.18	2.25	2.34	2.04	0.38	3.70	8.52
41	0.06	0.0737	5.81	6.17	1.20	2.52	3.45	2.79	1.13	3.83	10.1
42	0.06	0.0813	5.2	5.57	1.34	2.32	2.97	2.29	0.20	4.04	14.81
43	0.05	0.1419	5.28	6.09	1.43	2.33	2.87	2.45	0.45	3.82	8.18
44	0.06	0.0389	5.01	5.55	1.79	2.34	3.10	2.53	0.51	4.08	14.44
45	0.05	0.0841	4.62	5.24	1.92	2.30	3.30	2.28	0.41	4.19	16.27
46	0.06	0.2160	4.59	5.36	1.58	2.30	2.73	2.27	0.65	4.11	18.53
47	0.05	0.1208	4.74	5.38	1.65	2.51	2.99	2.43	0.41	4.19	20.78
48	0.05	0.0806	4.84	5.83	1.36	2.31	2.66	2.19	0.28	3.82	9.33
49	0.03	0.1124	4.52	5.48	1.23	2.24	2.36	2.03	0.57	3.94	12.76
50	0.04	0.2333	4.63	5.81	1.23	2.09	1.64	1.72	0.48	3.62	7.64
51	0.05	0.1171	4.58	5.94	1.32	2.11	1.80	1.57	0.64	3.57	6.7
52	0.07	0.0679	4.91	5.42	1.75	2.51	3.38	2.46	0.41	4.06	14.16
53	0.07	0.0755	5.97	6.38	1.93	2.73	3.83	2.76	0.48	4.22	16.64
54	0.05	0.3047	6.21	6.46	1.75	2.67	3.86	2.91	0.67	4.16	15.53
55	0.03	0.1069	4.52	5.57	1.49	2.07	2.18	1.93	0.57	3.79	11.05
56	0.05	0.2364	4.77	5.81	1.32	2.20	2.39	2.15	0.52	3.84	9.81
57	0.03	0.0214	4.59	5.77	1.93	2.26	3.00	2.11	0.66	3.86	8.16
58	0.03	na	4.33	5.56	1.45	1.99	2.19	2.12	0.46	3.86	9.71
59	0.05	na	4.51	5.77	1.68	2.14	2.35	1.97	0.32	3.65	6.39

Appendix D:

Map of Study Area- Big Sandy Mush Bald

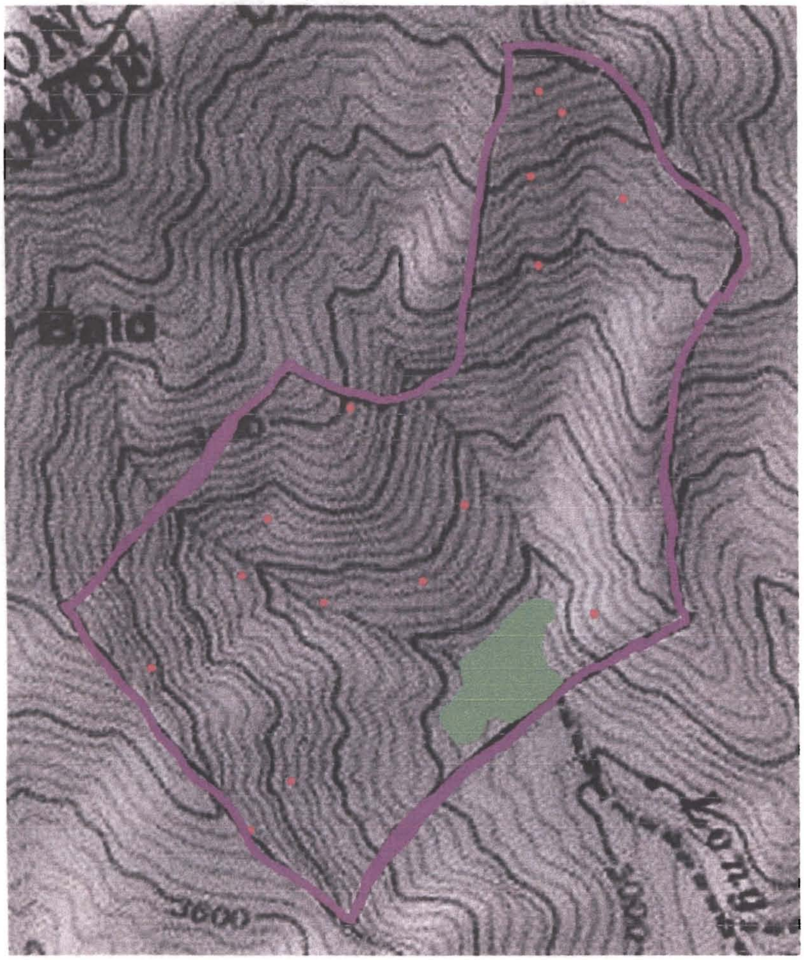
Figure 25. Map of study area including Big Sandy Mush Bald. Dots indicate plot locations and the heavy line indicates the property line.



Appendix E:

Map of Study Area- Big Sandy Mush Creek

Figure 26. Map of study area including Big Sandy Mush Creek watershed. Dots indicate plot locations and the heavy line indicates the property line. The large shaded in area indicates the environmental education center which was excluded from the study.



Appendix F:

Map of Study Area- Willow Creek

Figure 27. Map of study area including Big Sandy Mush Creek watershed. Dots indicate plot locations and the heavy line indicates the property line.