Bambi is Destroying our Forests: A Case Study in Vegetation Regeneration Following a Clear-cut

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Abstract

Deer overbrowsing in the northeastern hardwood forests has put pressure on the growth of vegetation for a number of years. This effect is especially dramatic following a clear-cut, where deer browsing has been known to slow down and sometimes stop succession altogether. Deer exclosures are instrumental in determining what effect, if any, is due exclusively to deer. I performed a case study of this effect in Black Rock Forest, which contains two deer exclosures on its grounds.

In this study, I analyzed the two exclosures and compared them with additional annual data from exclosures at West Point Military Academy. The results show that in the absence of deer overbrowsing, a clear-cut area is able to regenerate in a typical successional sequence. After 15 years, the 1988 exclosure displays an average height of 4.94 m, while in the areas exposed to deer, I found no tree species growing above the height of 1 foot, even after 28 years. This finding is supported by the Simpson diversity index. Plots inside the exclosure measured an average index value of 4.67, while the plot outside the exclosure measured an index value of 3.24.

This study found that in the absence of deer overbrowsing, Black Rock Forest has the ability to regenerate following a clear-cut. There is no significant difference in the soil quality, geographic location, or seed sources between the exclosures and the control plot. Therefore, a removal of browsing pressure should lead to a typical successional sequence.

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Introduction

Background

Deer overpopulation has been a problem in northeastern forests for the past 30 years (Danoff-Burg, 1997). The high population numbers are probably caused by a combination of the removal of natural predators and the availability of a larger habitat for deer in the region, due to reduced forestry and timber harvesting. Aside from the obvious impact on vegetation, overpopulation of deer may also lead to an increase in the incidence of Lyme disease, due to an increase in its vertebrate host (Van Buskirk and Ostfeld, 1995). Several studies have considered the effect of deer on vegetation and growth of the forest (Anderson 1994, Huntley and Birks 1979, Borcher et al. 1989, Ross et al 1970, Godman and Krefting 1960, Jacobson 1979). Many of these studies involve the use of exclosures, fenced areas that exclude deer. Researchers often use exclosures in conjunction with clear-cut areas, allowing them to study regeneration of the forest from the beginning of succession. The purpose of this study is to demonstrate the long-term effect of deer overpopulation on regeneration of a clear-cut area.

Deer Overbrowsing

Deer overpopulation has devastating effects on forest growth. In a study performed by Roger Anderson, results indicate that white-tailed deer (*Odocoileus virginianus*) browsing intensity has a direct effect on the height of white-flowered trillium (*Trillium grandiflorum*) (Anderson, 1994). This study made use of deer exclosures to single out the effect of deer browsing on vegetation. As deer browsing increased, not only did *Trillium* display shorter stem length in successive growing seasons, but deer also preferentially removed flowering individuals. Furthermore, agriculture and land development fragment today's eastern forests, so that overbrowsing may lead to local extinction of preferred species (Anderson, 1994).

Without surrounding forests, it is unlikely that species will have the ability to recolonize, even if deer populations are controlled due to the island effect. "Islands," or regions of isolated habitat, have much smaller populations of the same species found on a "mainland," making local extinction more likely to occur due to environmental fluctuations (Willis, 1974). Also, once local extinction has occurred, it is much harder to recolonize. In Anderson's study, the data do show, however, that removal of overbrowsing before local extinction of *Trillium* allows for recovery of *Trillium* (Anderson, 1994). Inside the exclosure, plants exhibited taller stems, and a denser reproductive unit. The increase in current plant growth and new plant regeneration is a direct result of the removal of deer herbivory.

Huntley and Birks (1979), suggest the use of exclosures to stimulate tree regeneration in areas where certain species were unable to recolonize. The browsing patterns of deer, as well as insects and the effects of fire, may affect entire communities. For example, in the Morrone Birkwoods National Nature Reserve in Scotland, there is an absence of birch regeneration as well as several currently unhealthy other species. This suggests that previous natural balances may be unable to re-establish themselves without the help of exclosures, which eliminate deer browsing.

Species of trees with large seeds have had significantly more trouble in starting new saplings, especially in areas with high deer populations. Large seeds are a problem under overbrowsing conditions because the trees produce less absolute numbers of seeds. Each acorn eaten means one less germinating sapling. Many oak species fall into this category, and have a history of low rates of natural regeneration (Borcher et al, 1989). In a study focused on acorn predation and seedling recruitment in California, the results showed that blue oak (*Quercas douglasii*) populations typically occur in monospecific older stands, indicating that new seedlings and saplings are not establishing themselves. A variety of mortality factors affect the seedling recruitment of these populations, including consumption of acorns by deer. Deer exclosures may help to protect the acorns during mast years and encourage new seedling germination.

In north central Minnesota, a study was performed to determine the effects of deer population management in a *Pinus resinosa* forest (Ross et al, 1970). Deer in this forest have been existing at starvation population densities for ten years, meaning that over the winter, a significant part of the population perished from starvation. An exclosure was established in 1937 to determine the effect of deer on vegetation. Inside of the exclosure, seedling and sapling occurrences increased dramatically and a typical successional pattern was observed (see

Table 1). Overbrowsing continued outside of the exclosure, virtually ceasing the reproduction of the forest, until a management policy in 1945 allowed hunting inside the forest. The hunting almost eliminated the deer population. After browsing pressures from deer were lifted by the decrease in population in 1945, saplings of *Betula papyrifera* and *P. resinosa* were found outside of the exclosure.

Deer Dietary Preferences

Deer prefer certain species of plants to others. Striped and red maple are the two most preferred species (New York Fish and Game Journal, 1978). Their second choice of species includes red oak, sugar maple, yellow birch, hickory, and blueberry. Also, seasonal changes may affect the eating patterns of deer. For example, in the spring, yellow birch and red oak are browsed most often, while in the winter, striped maple and red maple make up the majority of deer diets (Bramble and Goddard, 1951). During mast years, when mature oak trees release acorns, deer also feast on these large seeds.

Deer Population Control

In managed forests, methods are used to control deer populations in response to the available evidence showing the negative impact of deer on forest regeneration. One of the most widespread methods of management is the hunting of deer to eliminate the surplus population. Black Rock Forest is one such managed forest. Guidelines relating to the number of antlered bucks and does that can be killed keep the population near a desired target (Brady, 1994). The guidelines for the number of deer that can be shot change with the seasons, accounting for the natural fluctuations in the deer population (Severinghaus and Darrow, 1976).

Forest managers that choose not to interfere with deer populations are finding that their forests are not regenerating properly, as predicted by exclosure studies. For example, in the Fontanelle Forest near Omaha, the management policy states "The underlying philosophy for operating the reserve is one of no management, no interference by humans" (Diamond, 1992). In this forest, the hardwood trees are all mature trees. There are no seedlings or saplings of hardwood species that use large nuts for seeds, such as hickories or oaks. What is present are the saplings of ironwood and hackberries, which use small windblown seeds for reproduction, and which are known for their establishment in disturbed areas (Diamond, 1992).

Forest Management Techniques

Forest managers often clear-cut plots of land for stand regeneration or timber. While clear-cutting eliminates deer forage produced by the forest canopy, it also leads to growth of early successional species.

Table 1. (Fallows, 1965) Table of all woody species located inside plots at Black Rock Forest for this study categorized by most common successional stage.

Primary (pioneer)	Secondary (intermediate)	Tertiary (climax)
black birch	red maple	northern red oak
gray birch	sugar maple (also climax)	white oak
big-toothed aspen	american plum (also climax)	bitternut hickory
witch hazel	yellow birch (also climax)	
tulip-poplar (also secondary)	pin cherry	
white birch	chokecherry	

The result is an increase in the overall diversity of browse available for deer, which leads to an increase in the population of deer (Johnson, et al 1995). This increase in population leads to concentrated overbrowsing in the clear-cut area and has a negative impact on regeneration (Danoff-Burg, 1997). Exclosures surrounding a clear-cut area exclude deer and allow comparison of regeneration with and without deer. However, there is still the possibility that deer are not the only factor affecting stand regeneration. Inherent differences in the locations of the exclosures may also affect the regeneration ability of the land (Jordan, 1962). Other factors that may affect regeneration include availability of seed sources, nutrient cycle destruction, soil content, soil erosion, and the long-term history of the plot (Mladenoff and Stearns, 1993). Selective cutting of species creates canopy gaps and favors slower growing shade-tolerant species, while deer overbrowsing favors rapid-growing shade intolerant species (Whitney, 1990). Therefore, simply decreasing the deer population in the hopes of stimulating regeneration may not be effective.

Clear-cutting as a Management Tool

It has been suggested that management of timber has a close relationship with management of animals, especially in northern hardwood forests (Jordan, 1962). Practices that affect timber regeneration have a direct effect on animal populations, a side effect that is rarely considered. Clear-cutting areas of a forest is one such practice used to promote stand regeneration. Clear-cutting results in an increase of available deer browse, which may increase the population of deer.

When the population increases, overbrowsing may occur, allowing for the possibility that deer will have a severe negative effect on regeneration, reversing the very purpose of the clear-cut. To this end, it is important to consider all consequences when implementing a management plan.

The species most commonly affected by deer overbrowsing are those that deer prefer to eat: sugar maple, red maple, and yellow birch (Jordan, 1962). In order to show that overbrowsing by deer is the reason behind the poor growth, an exclosure is used, which isolates the effects due only to deer. Clear-cut area forage is browsed more intensely than uncut forest, as discussed previously, because of the increase of readily available browse (Johnson et al, 1995). Exclosures established after a clear-cut show more noticeable effects of regeneration.

As stand age increases, the availability of browse decreases (Johnson et al, 1995). Therefore, deer prefer to browse in newly clear-cut areas because of the high availability of sprout growth and primary successional species. However, clear-cutting eliminates the source of acorns for up to 40 years. In the fall, acorns are the most important part of deer diets where there are oak trees. This elimination of acorns can be detrimental to deer, but is most certainly disruptive to oak regeneration. Because clear-cutting poses a threat (especially to the regeneration of preferred species) and may increase deer populations, it is being replaced as a management practice and timber-harvesting tool. With the elimination of timber harvest, deer populations are more likely to stabilize and the negative effects of overbrowsing will be eliminated. One possible negative consequence of eliminating clear-cutting for timber management is heavier browsing throughout the forest. With clear-cutting, concentrated browsing in the clear-cut area is allowed before the population of deer stabilizes.

Successional sequence

Clear-cutting is often used as a management tool for experimental studies of its effect on plant biodiversity (Gilliam et al, 1995). Recent studies have focused more on the forest as a whole, as opposed to the older viewpoint of "indicator species" as examples of overall forest health. Observing stands of different ages allows the documentation of all species regardless of their occurrence in successional stages. Stands studied after a clear-cut may range from young (<20 years old), to mature (>70 years old) (Gilliam et al, 1995). The study performed by Gilliam found that stem density was higher in young stands, but the basal area of mature stands was twice that of young stands. In addition, young stands exhibited higher species richness on a per-plot basis. These results are consistent with the view that a clear-cut stand (lacking further disturbance) will display a successional sequence of competitive thinning and that less shade-tolerant species will be replaced by tolerant species. Immediately following cutting, a uniform stratum of plants develops, where competition for water and nutrients is most intense. Woody species that survive this level may grow and compete more for light, while herbaceous species are still limited by water and nutrients. Establishment of an overstory limits the light available for young saplings, and favors shade-tolerant, or secondary species.

The initial phase of growth following a clear-cut is also known as the reorganization phase, which can last upwards of 20 years (Reiners, 1992). The plant growth documented by Reiners in a study in New Hampshire obtained results similar to that collected at Black Rock during its reorganization phase. Similar species present include striped maple (*Acer saccharum*), hay-scented fern (*Dennstaedtia punctilobula*), solomon's seal (*Smilacina racemosa*), raspberry (*Rubus idaeus*), american plum (*Prunus pennsylvanica*), red maple (*Acer rubrum*), and black birch (*Betula lutea*). Annual productivity increased exponentially in the first few years, then linearly. As the area matures, species richness can be expected to decline for a period of up to 100 years, followed by a steady state. This same sequence is expected for the 1988 exclosure in Black Rock Forest. Data from the reorganization phase is not available for the 1971 exclosure, but at the 28 year mark in 1999, the exclosure does exhibit less species richness than the newer clear-cut areas.

Effect of Clear-cutting on Soil Composition

The storage of organic matter and nutrients in the forest soil has an important role in the recovery of an area after a disturbance such as a clear-cut (Covington, 1981). The balance of decomposition, throughfall, and stream flow is disrupted by clear-cutting, leaving the stored soil nutrients as the only means of recovery. Organic matter levels show a decrease following clear-cutting as plants use the reserves available from the soil. This phase lasts for approximately 20 years, after which the organic nutrients increase because the balance in the forest nutrient cycle is restored.

The carbon-nutrient hypothesis states that under nutrient-poor conditions, woody plants suffer from slow growth rates that restrict their ability to replace tissue lost to herbivores and to grow beyond the reach of herbivores (Bryant et al, 1983.) If clear-cutting leads to nutrient poor conditions in the soil, regeneration of woody species may never occur under a threat of overbrowsing. However, if succession is allowed to proceed, the carbon : nutrient ratio is expected to decrease (Iason and Hester, 1993.) This means that more nutrients will be available for all species in the ecosystem. According to Iason and Hester, growth is more strongly affected by stress from lack of nutrients (nitrogen, phosphorus, potassium, calcium, and magnesium) than other factors, such as sunlight or water availability. Therefore, if succession is halted, the carbon : nutrient ratio will not decrease and woody plants will not be able to grow.

Study Site

The site for this study is located in the Hudson Highlands of New York State (see Figures 1, 2, and 3). In this region, West Point Military Academy grounds and the Black Rock Forest form a contiguous span of mixed oak-hickory hardwoods that cover almost 18,000 acres (7.84×10^8 ft^2). Within the two reserves of forest, there are fourteen deer exclosures, two in Black Rock Forest (established in 1971 and 1988, see Figure 4) and twelve in West Point (established

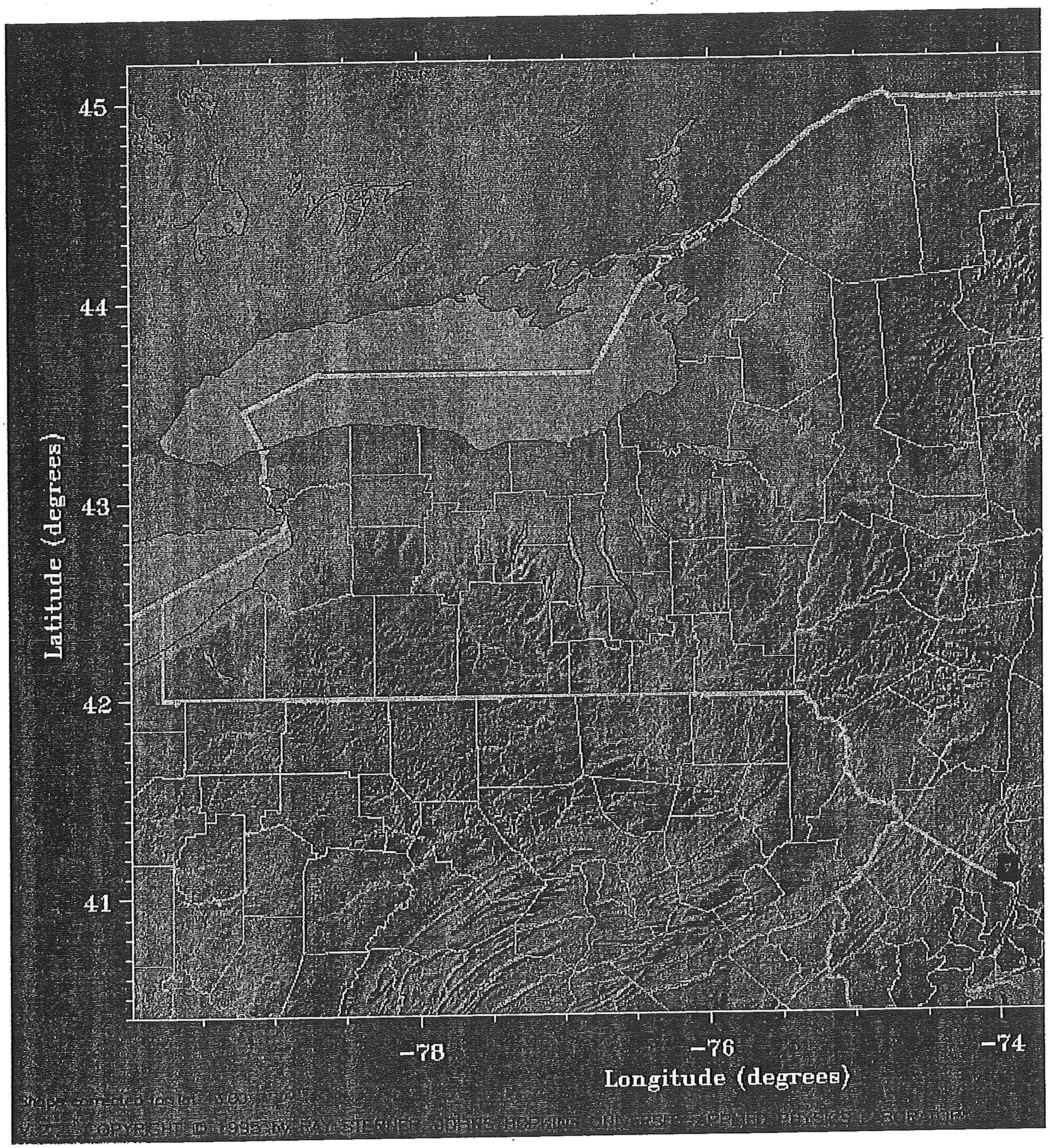

Figure 1. New York State. A map of New York, showing the location of Black Rock Forest.

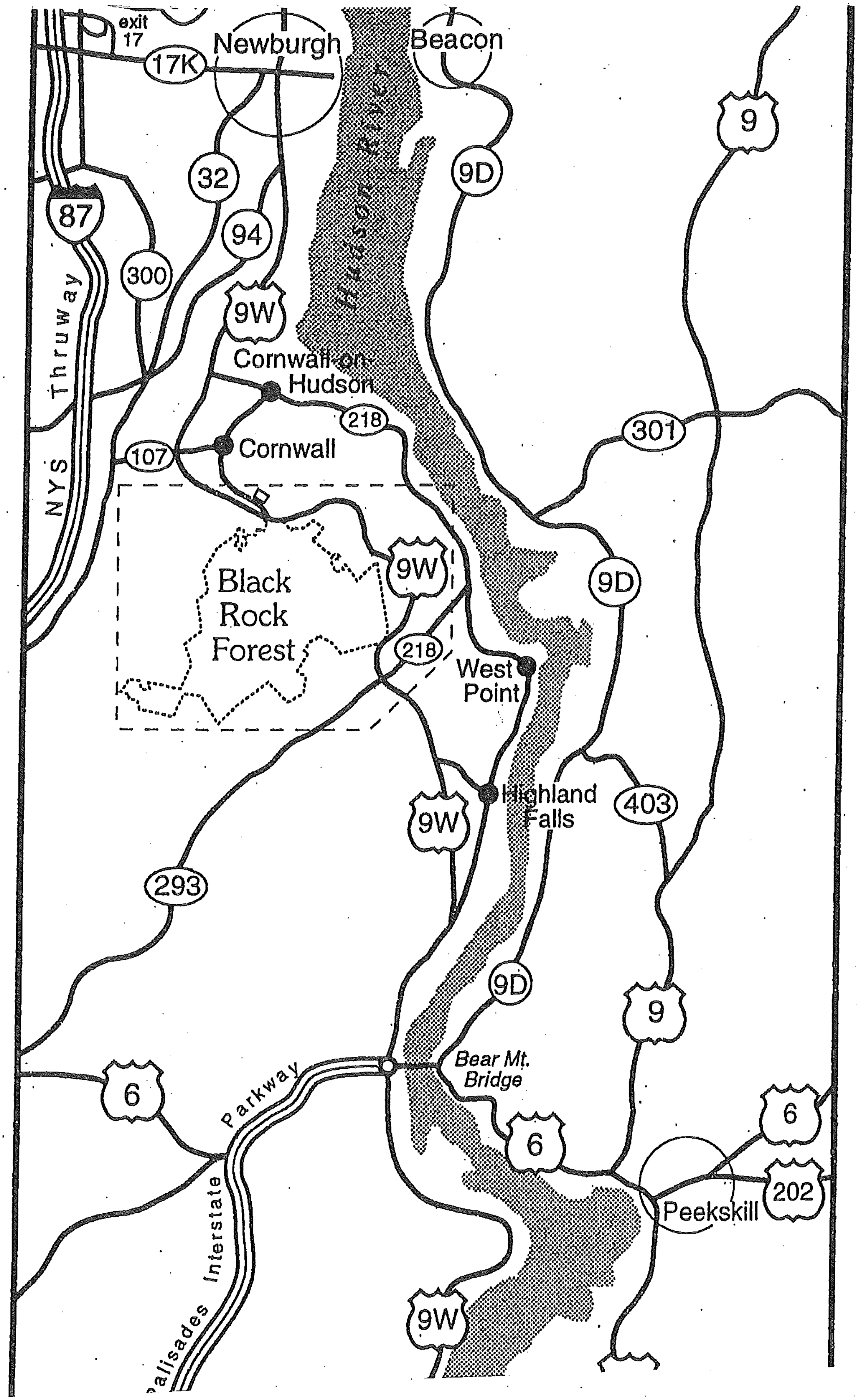

Figure 2. Southeastern New York State. A map of southeastern New York, showing the location of Black Rock Forest.

Cornwall, NY

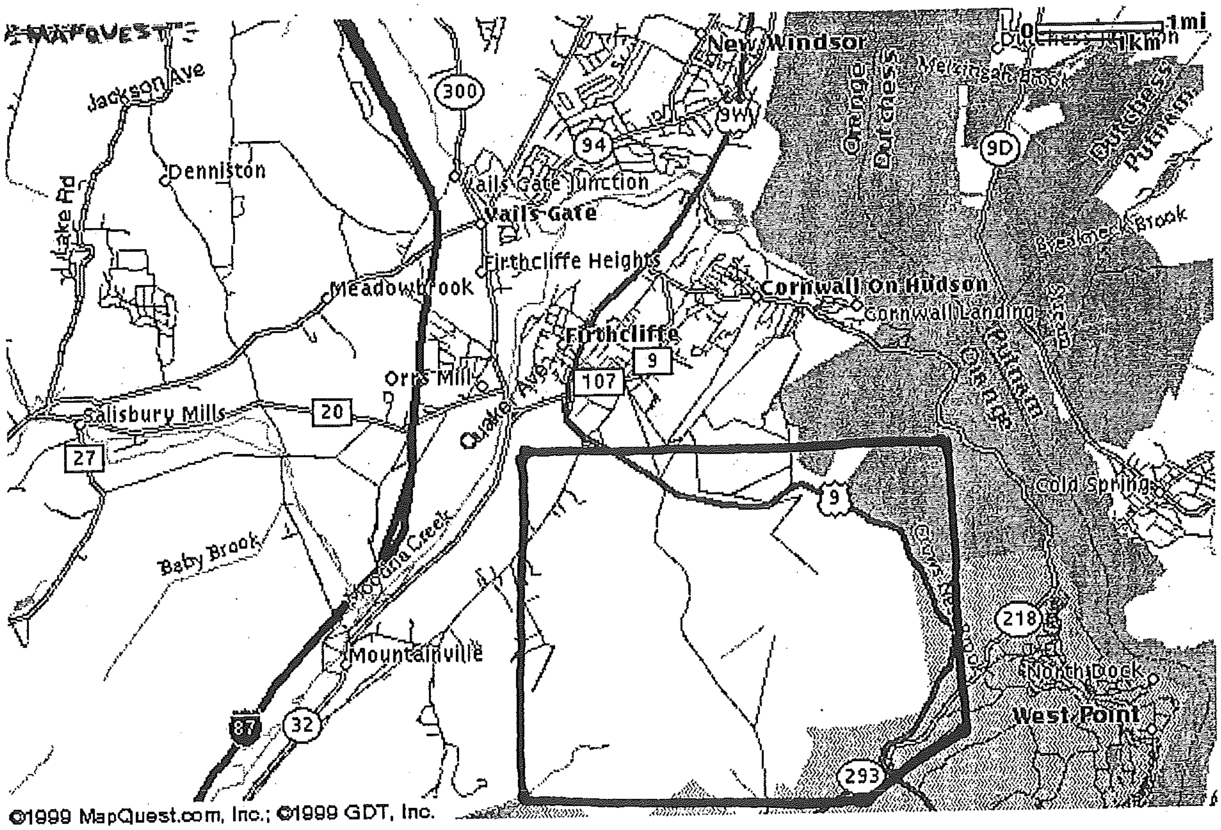

Figure 3. Cornwall, NY. A map of Cornwall, New York, showing the location of Black Rock Forest.

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in 1983, 1984, 1986, and 1987). The 1971 exclosure offers a unique perspective on secondary succession after 28 years, as all of the other exclosures are closer to 15 years old and still in the primary successional stage, otherwise known as reorganization (Reiners, 1992). The variety of exclosures available and the large area make this an ideal site for a study on the effect of deer exclosures on vegetation regeneration.

All of the studies mentioned previously concur that uninhibited regeneration is observed once browsing pressure is removed (Jordan 1962, Johnson et al 1995, Gilliam et al 1995, Reiners 1992, Anderson 1994, Huntley and Birks 1979, Borcher et al 1989, and Ross et al 1970). However, there may be other factors besides the population of deer that contribute to the lack of natural regeneration. For example, historical land use, climate, or other disturbances may have just as important a role (Mladenoff and Stearns, 1993). Clearly, overpopulation of white-tailed deer is a primary factor preventing regeneration of many species, especially late-successional and old-growth ecosystems. However, removal of these herbivores may not always result in natural regeneration if other factors are also involved, such as soil content and soil thickness. Changes observed in species content in an unprotected area may cause a change in the soil nutrients necessary for plant life. Heavy logging and fires may eliminate establishment sites for seedlings as well as seed sources. Selection for certain species creates pure stands that may alter soil properties and nutrient cycling to further encourage growth of that one species only. Large deer populations are simply one contributing factor in this positive feedback loop.

Because deer exclosure plots are usually chosen in known overpopulated areas, Mladenoff and Stearns (1993) state that these plots produce biased results by being established in areas where dramatic effects are expected. However, the research cited in this report provides overwhelming evidence of the impact of deer browsing. They suggest current conditions may no longer be ideal for the establishment of certain species. This combined with a decrease in seed bed capacity does not present an optimistic viewpoint about the regeneration of forests.

Black Rock Forest

Black Rock Forest's topography is formed by bedrock composed mainly of gneiss with a mantle of glacial till (Brady, 1994). Mountainous terrain covers much of the region. The forest spans approximately 3,800 acres ($1.7x10^8 ft^2$), and consists mainly of oak and other hardwood species. Black Rock has been managed for much of the past century for optimum growth and regeneration, while scientists have used the forest in more recent times to study the ecology of the region. Information is readily available on a variety of projects and long-term experimental plots (Berger, 1998).

The forest has fallen victim to both natural and man-caused events such as fire, silviculture, and clear-cutting. In the past, scientists have used these occurrences to implement experiments, as is the case with the deer exclosures.

Of the fourteen exclosures used for this study, two are currently in place in Black Rock, created after a clear-cut (see Figures 4 and 5). The first exclosure was established in 1971 and the second in 1988, both in a heavily wooded and relatively undisturbed area of the forest. The 1971 exclosure is an eight foot by twelve foot (8′ X 12′) rectangle (2.2×10^{-3} acres). The control area is located directly adjacent, and measures approximately 1/2 acre (2.18×10^{4} ft^2). The 1988 exclosure is approximately 26,000 $feet^2$ (5.97×10^{-1} acres) in area. There is no control for this exclosure. Therefore, the data from the 1988 plot will be compared to the 1971 control plot.

History of the 1971 Plot

Files for Black Rock Forest plots that contain limited management data are available back to the year 1932 (Compartment File #25, Black Rock Forest). For example, the area containing the 1971 exclosure and control was a farmstead before 1932. At that time, the farm had good quality soil. Intermittent timber harvests and plantings were done, mostly of red pine and yellow poplar. Red pine displayed excellent survivorship (85%), but yellow poplar showed a low (60%) survival rate. In 1940, when a report was filed on the progress of the yellow poplar, it stated that no individuals remained. Because white and red oak were able to grow, along with hickory and maple trees, the area is probably too dry for yellow poplar. Yellow poplar grows best in above-average moisture conditions (Cogliastro et al, 1997). The sweet fern observed may have also led to an acidic soil, causing the yellow poplars to die.

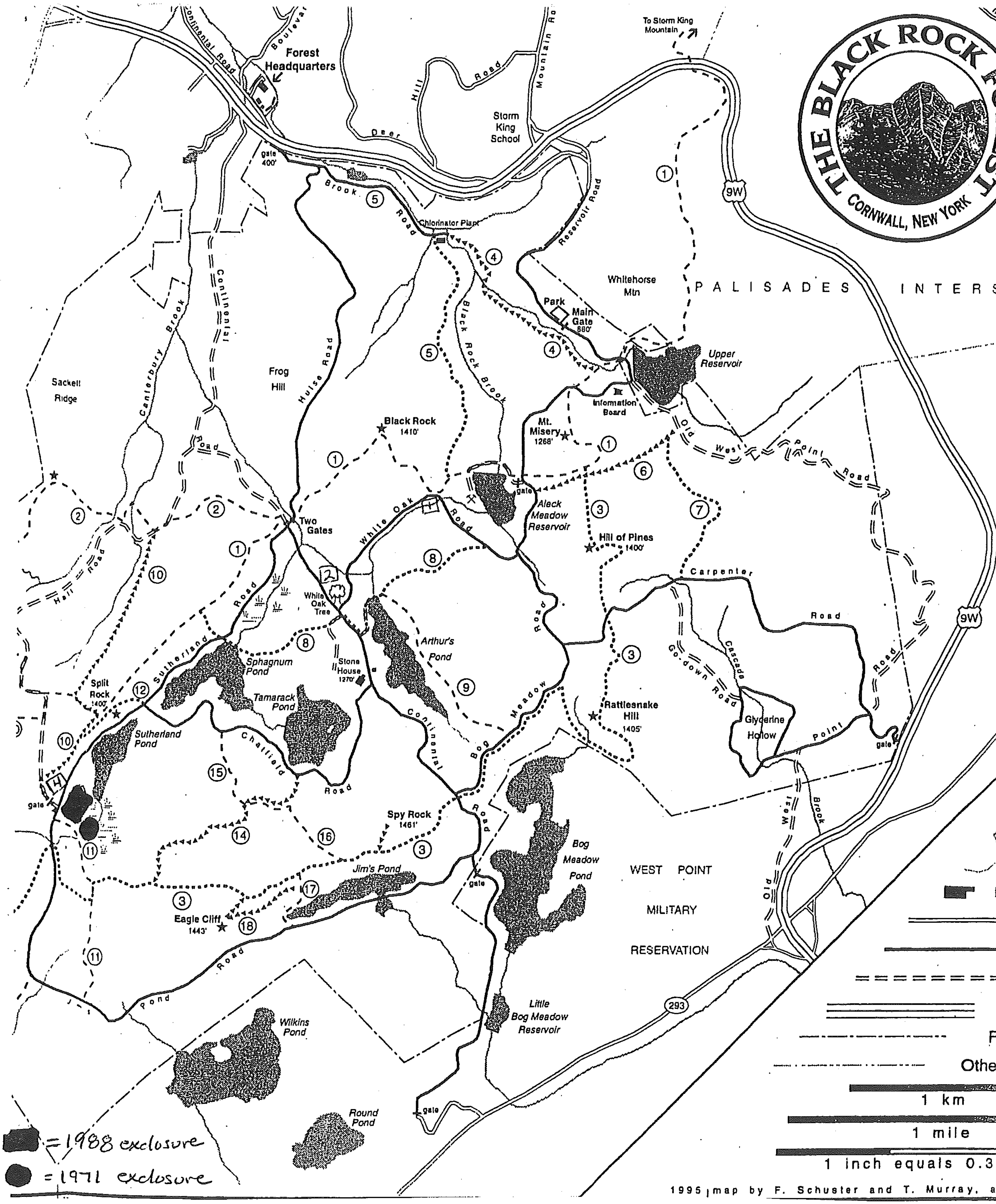

Figure 4. Black Rock Forest. A map of Black Rock Forest, showing the locations of the two exclosures.

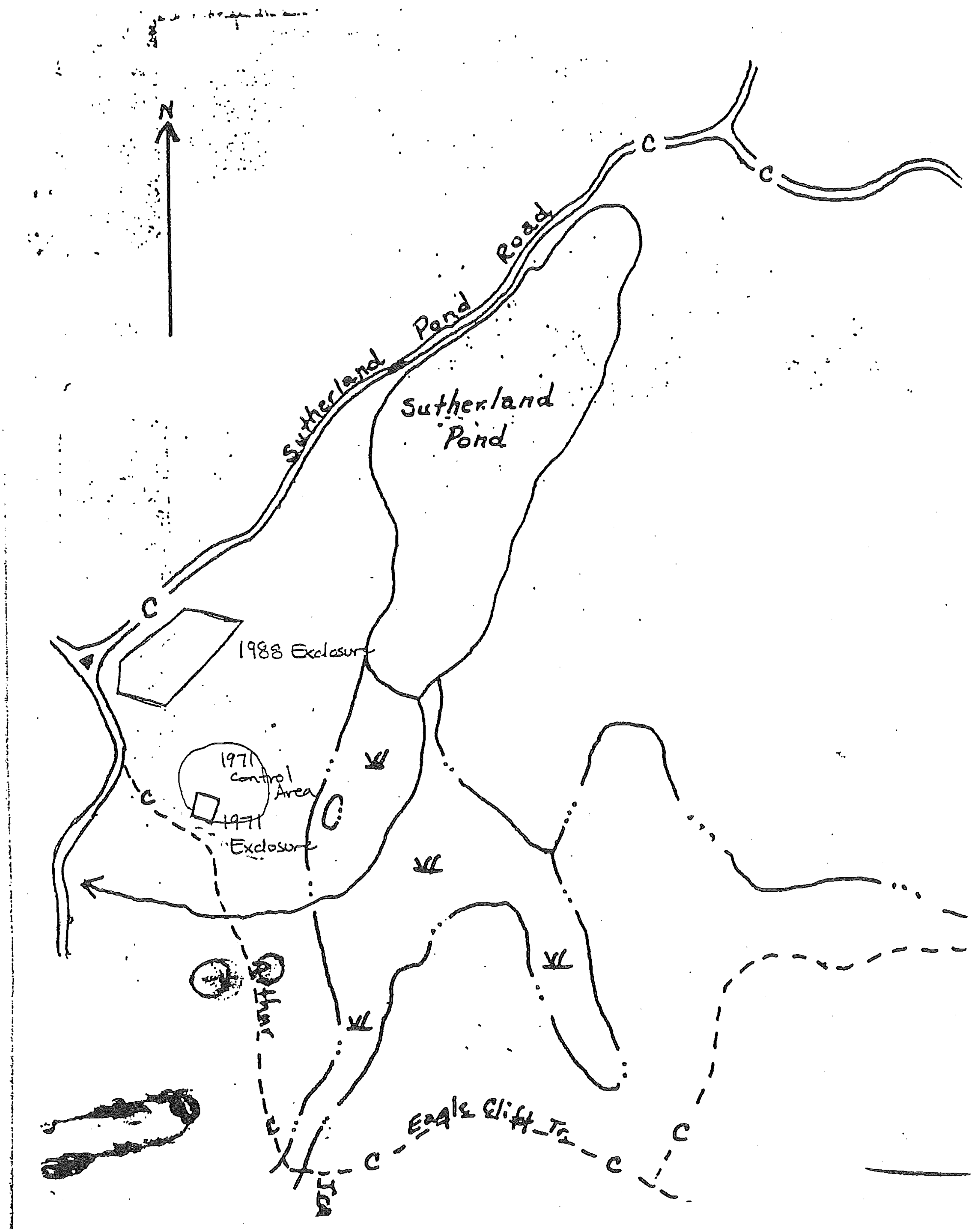

Figure 5. Black Rock Forest. A map of the Compartment #25 of Black Rock Forest, which contains both exclosures.

The next reported planting took place in 1976, inside of the 1971 clear-cut plot. The clear-cut was established to obtain wood and to study the effect of deer browsing on the rate of natural and artificial regeneration after a clear-cut. By the year 1976, it was reported that a visible difference could be seen between the fenced plot and the outside control. Black Rock management established the exclosure in 1971 to show the amount of forest regeneration without deer, while the control plot was used for planting treatments. Conifers (white pine, scotch pine, austrian pine, and white spruce) were planted in rows in 1976 to further test the impact of deer browsing. To protect it from deer, a fence surrounded the twelfth tree in each row. Unfortunately, no other reports were filed on the progress of these trees.

History of the 1988 Plot

Between the years of 1986 and 1987, gypsy moth defoliation killed several white oak trees in the area now known as the 1988 exclosure (Compartment File #25, Black Rock Forest). The area was fenced in during the year 1988 after the removal of these dead trees, along with other oaks and red maples. Seedlings were planted inside the fence to test their survival without the presence of deer. Unfortunately, the number of seedlings that were planted is not known. The first available data is from 1989, when an inventory of the living seedlings was taken. In 1989, there were 148 surviving seedlings of the species *Juglans nigra* and *J. cinera*, *Quercas rubra*, *Picea glauca*, *Quercas alba*, *Quercas montana*, and *Pinus sylvestris*. In addition, during this survey, a solution of Round-up was used on any seedling that needed release from nearby vegetation. It is reported that white sticks were placed at each seedling, but these markers were removed before any other report could be made on the seedling progress.

West Point Military Academy

West Point's deer exclosures are located in the forested uplands region of the forest. This area consists of both Appalachian oak-hickory forest and chestnut oak forest. Oaks are the dominant canopy feature of the former, with chestnut oak, sugar and red maple, and hophornbeam usually comprising the sub-canopy (Cackerback, unpublished data). Hickory species are found among older, undisturbed stands of Appalachian oak-hickory forest and produce a mast crop for deer. The mast crop occurs when the trees in the population coordinate release of their seeds over a several year period. This collection of trees is found in well-drained bottomlands, and on some dry upper edge slopes and rocky ridgetops. The chestnut oak forest is more typically found on the dry ridgetops and slopes of the region, as it thrives on well drained, thin soil. Chestnut and red oak, with white oak, black oak, and red maple dominate the canopy also in the community.

Due to the greater area of forest compared to Black Rock Forest, approximately 16,000 acres ($7x10^8 ft^2$), West Point offers a greater number of deer exclosures. All were created after clear-cuts. One was established in 1983, five in 1984, three in 1986, and three in 1987. Each of these exclosures has a control plot (clear-cut the same year) directly adjacent. The Natural Resource Division at

West Point has collected exclosure data semi-annually since the establishment of the exclosures.

Methods

Preliminary Work

At the West Point Military Academy sites, height and density data were collected for the separate exclosures and their control plots. Average height and height range for each species was recorded. Bob Cackerback provided the rest of the data from previous years and the 1999 data for nine other exclosures. The same data was collected for the Black Rock Forest sites. Average height and height range were recorded for these species as well.

Data Collection - West Point

Inside each of the West Point exclosures, wooden posts serve as markers to represent the center of each 1/100 acre (435.6 ft^2) area plot. Data was collected on an annual or semi-annual basis in the following fashion: A rope measured at 11.77 ft. with a loop at one end was placed around the post. This rope acted as the radius of a circle measuring 1/100 of an acre in area, inside of which all trees were counted. For each plot, the number of viable individuals of each species was recorded. The average height of those individuals and the range of heights were estimated for each species.

Outside the exclosure, in the control area, wooden posts were also used to mark the center of each plot. However, the control plot exhibited no substantial growth since being clear-cut, probably due to deer browsing. Any hardwood species present were no more than a few feet high. Therefore, a rope 1.177′ long with a loop at one end was placed around each post. This rope created the radius of a circle measuring 1/1000 of an acre (43.56 ft^2) in area, inside of which all individuals were counted. This smaller plot made it feasible to count all individuals under a foot high. We recorded the number of individuals and we measured the height of each species with a meter stick.

Plot Distribution - Vegetation
Black Rock

Inside the Black Rock forest, I used the same method of establishing plots. I used wooden posts as center plot markers and an 11.77′ long rope to sweep out an area 1/100 of an acre to collect data for each of the plots. There was one exception to this method: the 1971 exclosure. Measuring only 96 $feet^2$ (2.2×10^{-3} acres) in area, it is too small to use a post and rope. Instead, I considered the entire area inside of the fence as a plot.

Although the plot measurement method was the same as at West Point, additional data was collected at Black Rock Forest. For each species with a trunk larger than 1″ in diameter, I measured height and diameter. Species smaller than 1″ in diameter were counted as individuals, but no height was recorded.

I created a plot distribution for each of the exclosures in 1999. As previously stated, the 1971 exclosure counted as a plot in itself. For the control of the 1971 exclosure, I chose a location near the middle of the clear-cut to represent the area. Inside the 1988 exclosure, six evenly distributed plots were established, large enough to cover the area inside the exclosure with no overlap between plots.

Data Collection - Black Rock

For each plot, including the control, I took a complete inventory of all species present. For trees with a diameter larger than 1 inch, as measured by a diameter tape at breast height (DBH), height was taken in meters with a range pole. I counted trees with a diameter smaller than 1 inch as saplings and recorded their presence. I tallied herbaceous species by the number of individuals.

Plot Distribution - Soil
Black Rock

In an attempt to offer alternative hypotheses to the poor regeneration of forests following a clear-cut in an overpopulated deer area, I collected soil samples for each of the eight plots in Black Rock Forest. For each plot, using a spade, shallow soil samples were taken in five different spots inside the radius of the plot. These five samples were combined in a bag. The soil was air dried for two days at room temperature. A sieve was used to separate the particles smaller than 2mm. The particles smaller than 2 mm were sent to Cornell Nutrient Analysis Laboratory for analysis of nutrient and organic content.

Unfortunately, historical data on soil depth and nutrient content is not available at this time.

Implementation of Experiment

It became apparent that I needed two separate analyses to examine the 1988 exclosure. The first would involve the use of the 1971 exclosure, its control, and the exclosures from West Point in a comparison study to determine the effect of deer on initial regeneration of trees following a clear-cut. In another experiment, a control needed to be established for the 1988 plot. After sufficient data was collected for the first experiment, the fence for the 1988 exclosure was cut in half, creating a control plot consisting of approximately 10,000 $feet^2$ ($2.3x 10^{-1}$ acres) inside the fence, and a treatment plot of the same size newly outside of the fence. Although no results from this new experiment will be available for this study, this treatment should provide valuable data in years to come.

For the results of this study, the data from the 1988 Black Rock Forest exclosure will be compared to the controls at West Point and in the 1971 exclosure. However, the data collected from the six plots established in the 1988 Black Rock Forest exclosure will serve as data for an experiment that began in the summer of 1999. The plots inside the fence now serve as the control in an experiment measuring the effect of deer on secondary regeneration of an oak-hardwood forest.

Data Analysis - West Point

The data available for the exclosures at West Point include the number of individuals of woody plants, and the average height and range of height per species. These numbers can be directly compared to each other without the use of indices. In order to compare these plots to the Black Rock data, the Black Rock data must be reduced to calculate average height and range of height for each species. The exclosures must be compared on a relative basis for species content and growth.

Data Analysis - Vegetation, Black Rock

The Black Rock data is more thorough than that available from West Point, and therefore can be analyzed in a more detailed manner. The Shannon Index is utilized in order to display diversity in each plot. The equation is:

$$H'=-(\Sigma(p_i \ln p_i)$$

where H'= the Shannon Index

p_i = the proportional abundance of the i^{th} species

The Shannon Index is a measure of the degree of uncertainty in predicting to what species an individual chosen at random in a community will belong (Shannon and Weaver, 1949.)

The Simpson Index is also used to display the probability of choosing two individuals of the same species from one community. Its equation is:

$$D=(\Sigma(n_i(n_i - 1))/(N(N - 1))$$

Where D = the Simpson Index for finite or real communities

n_i = the number of individuals in the i^{th} species

N = the total number of individuals

The index is reported as 1/D, so that as diversity increases, the value of this index increases as well. The Simpson index is a dominance index, meaning that more weight is given to common or dominant species in the plot (Simpson, G.H., 1949.)

The Sorenson Index is used to show the similarity between plots. For two plots at a time, a value of C_N is calculated.

$$C_N = 2j_N / a_N + b_N$$

Where C_N = the Sorenson Index

j_N = the number of individuals common to both sites

a_N = the number of individuals in site A

b_N = the number of individuals in site B

N = the total number of individuals

The closer this value is to one, the more similar the two plots.

Results

Analysis showed a dramatic difference between the 1988 exclosure and the 1971 exclosure. The Simpson Index (see Figure 6), shows that most of the 1988 plots have higher diversity values relative to the 1971 plots. Plot 3 from the 1988 Exclosure shows a lower diversity value of 3.04, as opposed to Plot 71 C, the 1971 Control, which is 3.24. However, the average Simpson value for the six 1988 plots (Plot numbers 1-4, 6 and 7) at 4.67, is higher than the average for the two 1971 plots at 2.78. Plot 7, from the 1988 exclosure, displays the highest Simpson Index value, while Plot '71 Ex, the 1971 exclosure, displays the lowest Simpson Index value.

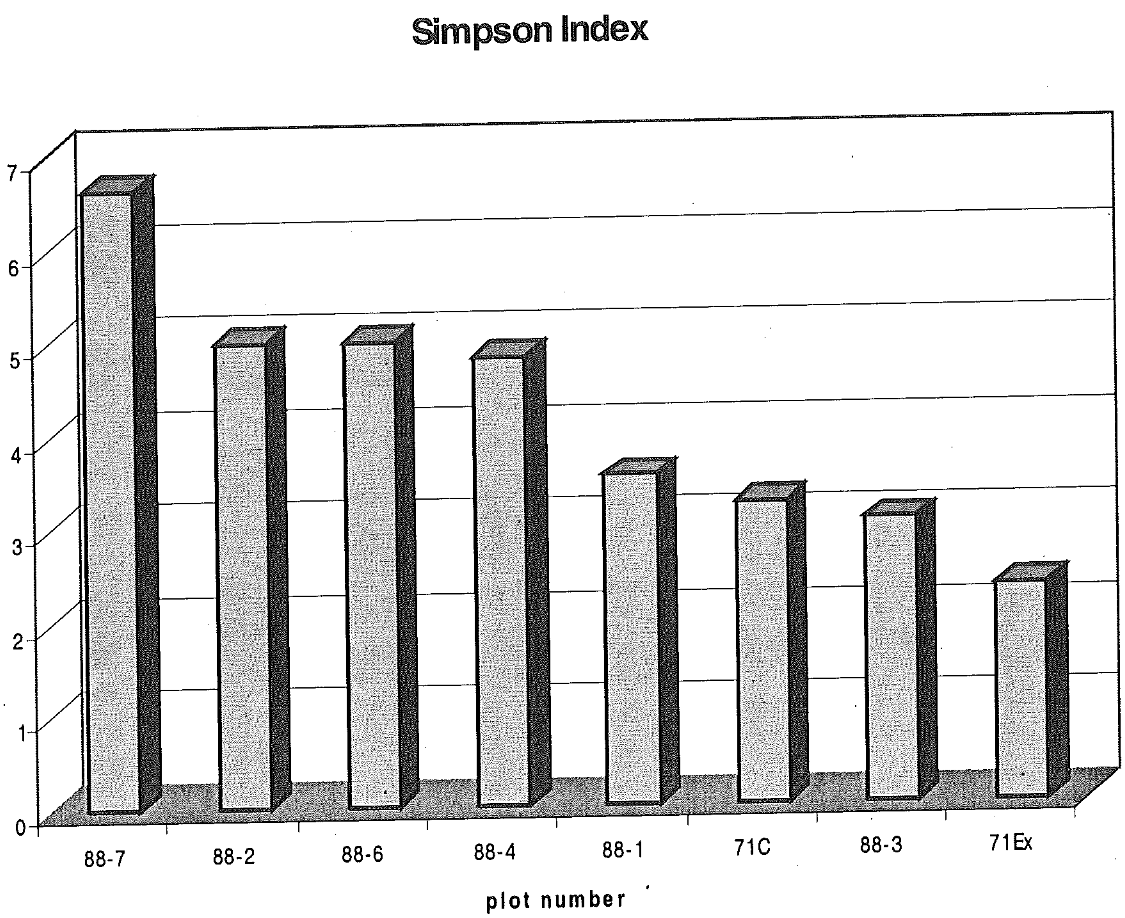

Figure 6. The Simpson Index. A measure of diversity on a per plot basis. A higher index value indicates higher diversity. All plots are from Black Rock Forest. 88- indicates inside the 1988 exclosure. 71C is the control plot. 71 Ex is the 1971 exclosure plot.

On average, the exclosure plots display a higher Simpson Index, and therefore a higher diversity, than the outside plots. Also, taken as an average, the 1988 plots show a higher diversity than the 1971 plots.

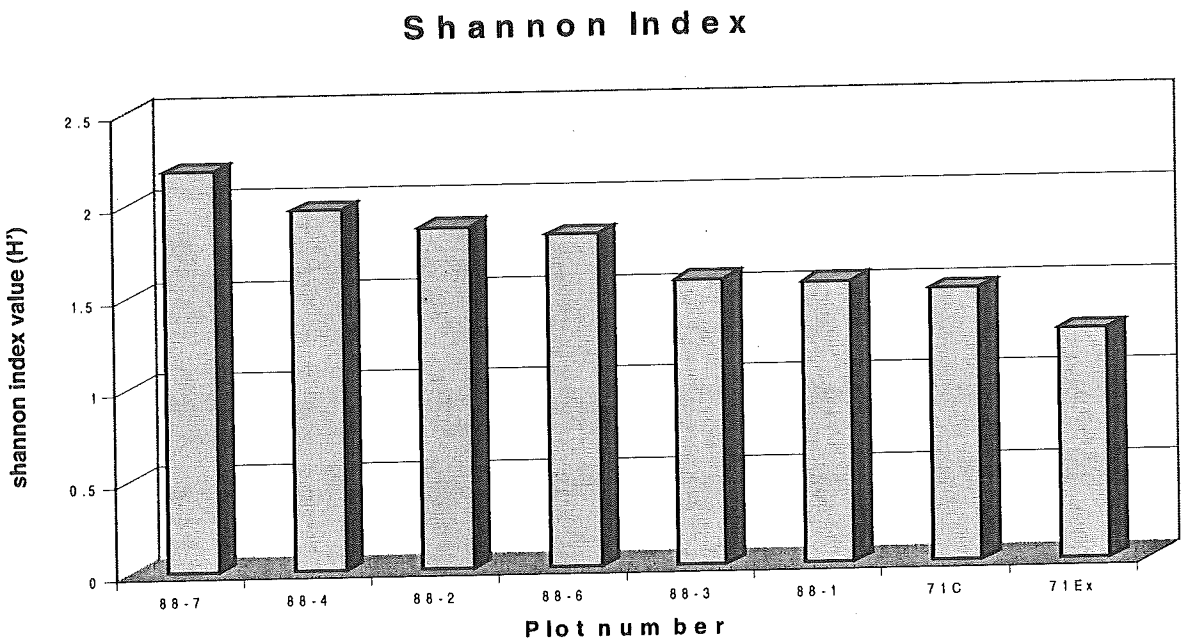

Figure 7. The Shannon Index. A measure of diversity on a per plot basis. A higher index value indicates higher diversity. All plots are from Black Rock Forest. 88- indicates inside the 1988 exclosure. 71C is the control plot. 71 Ex is the 1971 exclosure plot.

As expected, all of the 1988 plots, 1, 2, 3, 4, 6, and 7, show higher diversity individually and on average than the 1971 plots '71 C and '71 Ex. Again, Plot 7 of the 1988 exclosure displays the highest Shannon Index value, while Plot '71 Ex, the 1971 exclosure displays the lowest Shannon Index value.

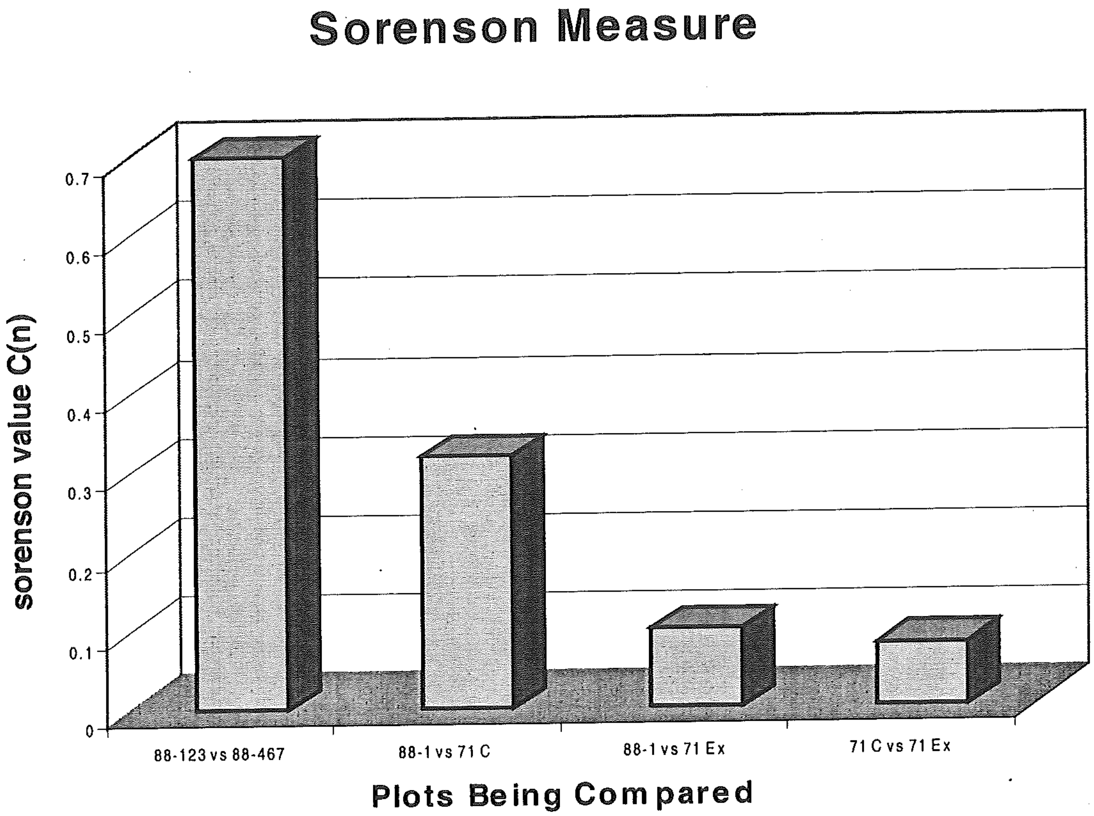

Figure 8. The Sorenson Measure. A measure of the similarity between two plots. All plots are from Black Rock Forest. 88-123 is a compilation of plots 88-1, 88-2, and 88-3 from inside the 1988 exclosure, as is 88-467. 71C is the control plot for the 1971 exclosure. 71 Ex is the 1971 exclosure plot.

As can be seen from Figure 8, the six plots of the 1988 exclosure have a higher value when compared to each other than when compared to either of the 1971 plots. In addition, the lowest Sorenson value occurs between the 1971 exclosure plot and the 1971 control plot. The second lowest value is given by the comparison of Plot 1 of the 1988 exclosure and the 1971 exclosure.

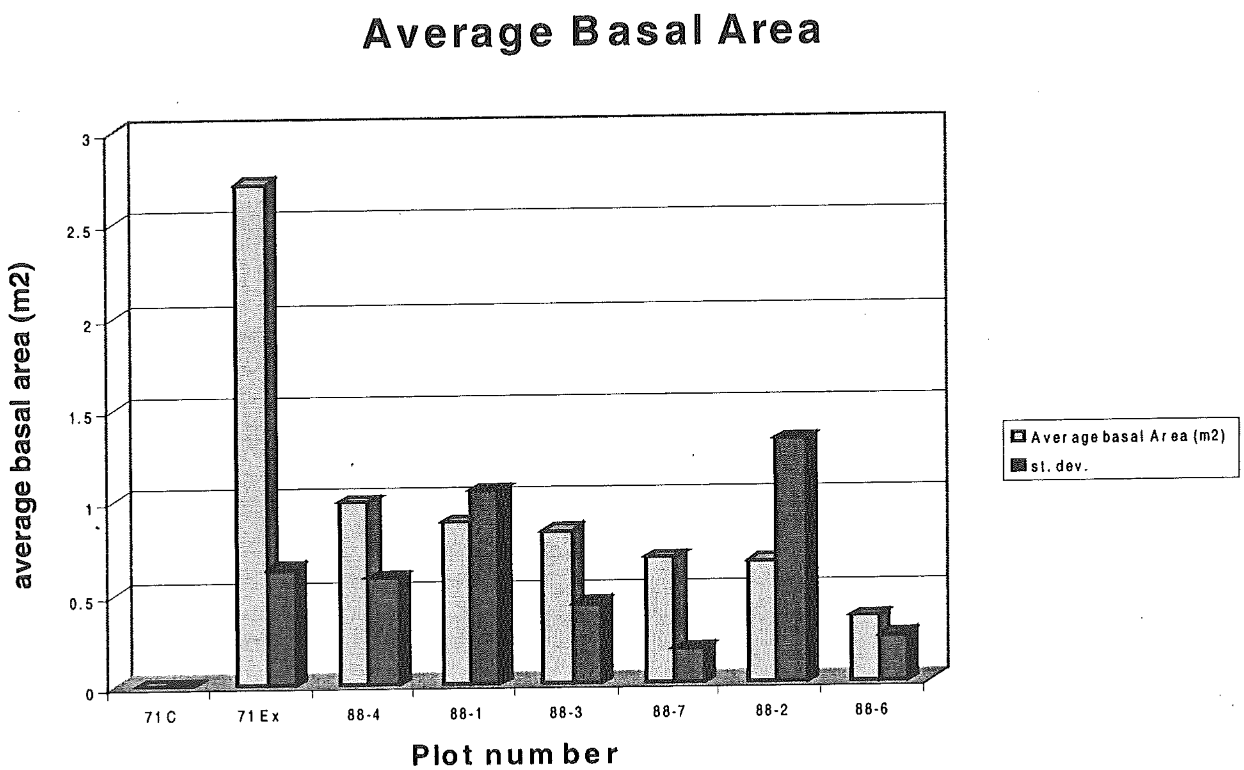

Figure 9. Average Basal Area. The average diameter at breast height (DBH) multiplied by the height gives the basal area for all species within a plot. All plots are from Black Rock Forest. Standard deviation was calculated based on the average standard deviation of the basal areas of individual species within a plot.

Unfortunately, no basal area for Plot 5 is available because only herbaceous plants and saplings were growing at the time of the survey. The 1971 exclosure displays the highest basal area, taking standard deviation into account.

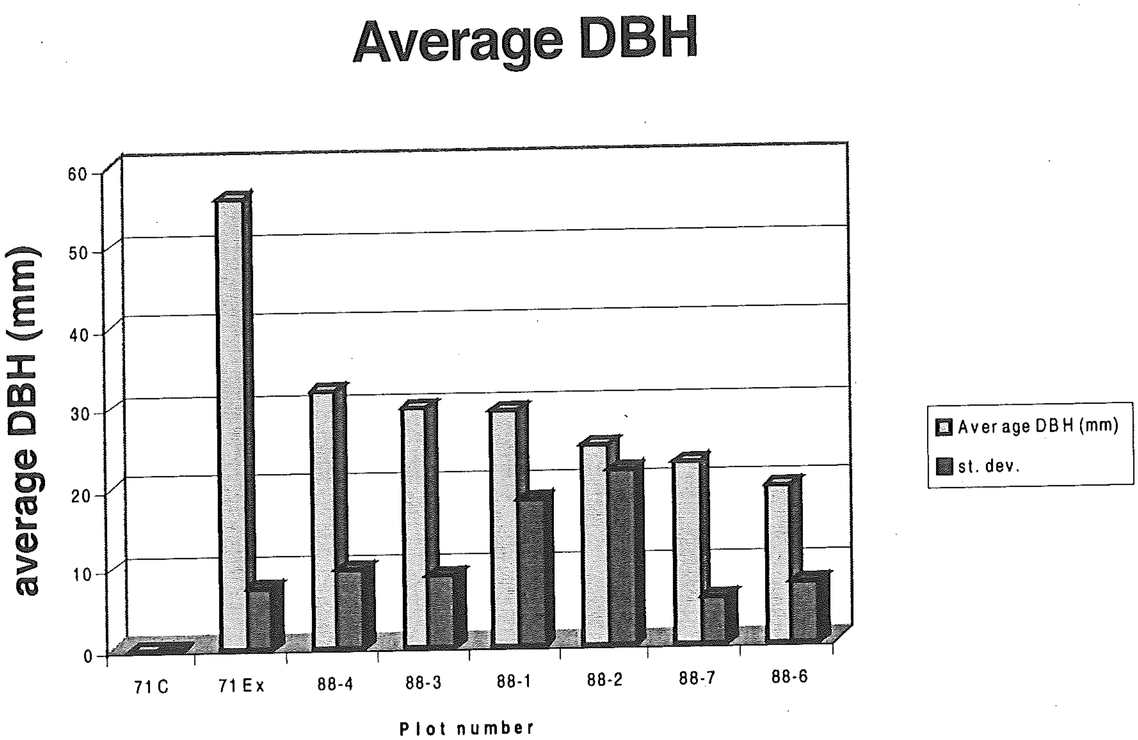

Figure 10. Average diameter at breast height (DBH). The average diameter at breast height (DBH) for all species within a plot. All plots are from Black Rock Forest. Standard deviation was calculated based on the average standard deviation of the diameters of individual species within a plot.

Again, no figures for Plot 5 could be calculated, and the 1971 exclosure displays the highest average DBH.

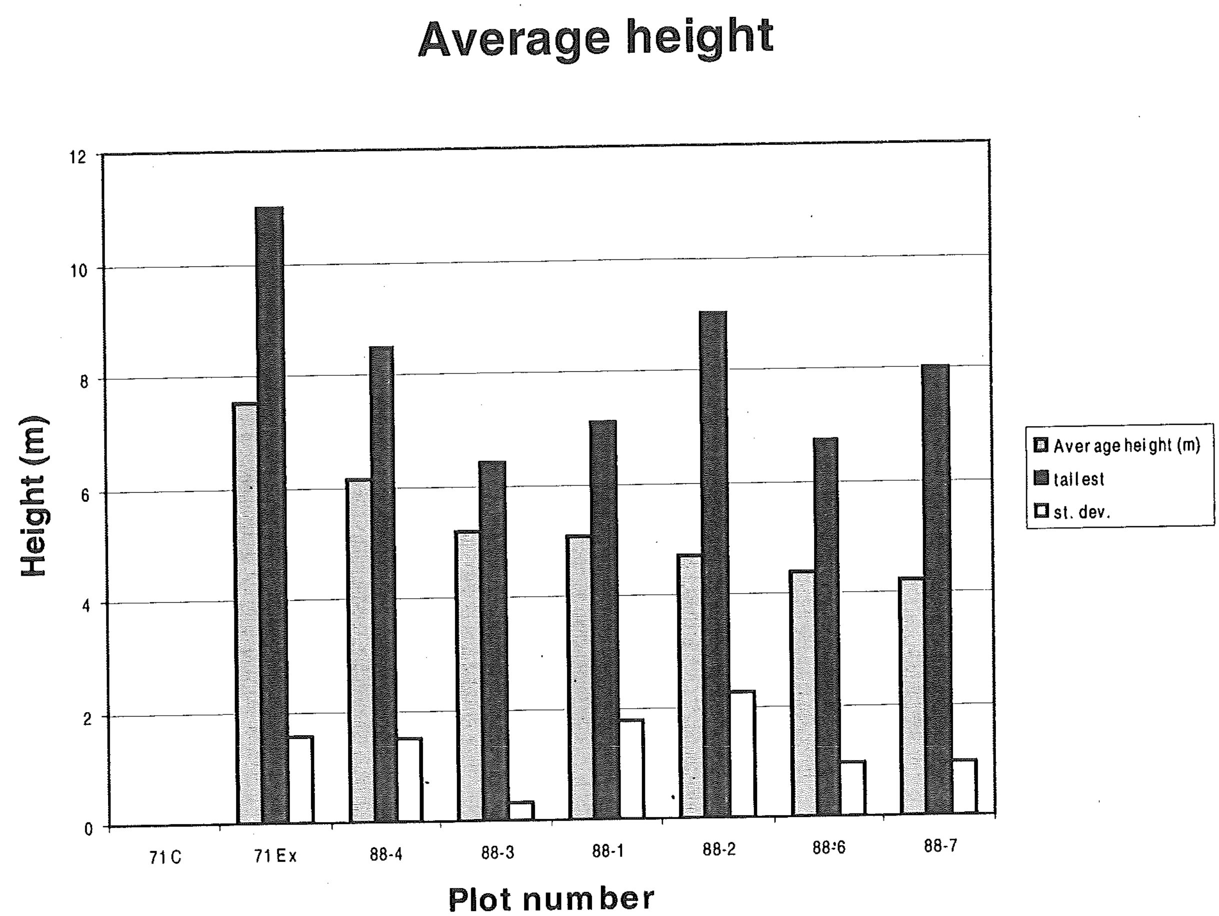

Figure 11. Average height. The average height of woody species per plot inside of Black Rock Forest, including tallest tree and standard deviation. Standard deviation was calculated by averaging the standard deviation of the heights of each species within a plot.

The 1971 exclosure has the highest average height and the tallest individual of the study.

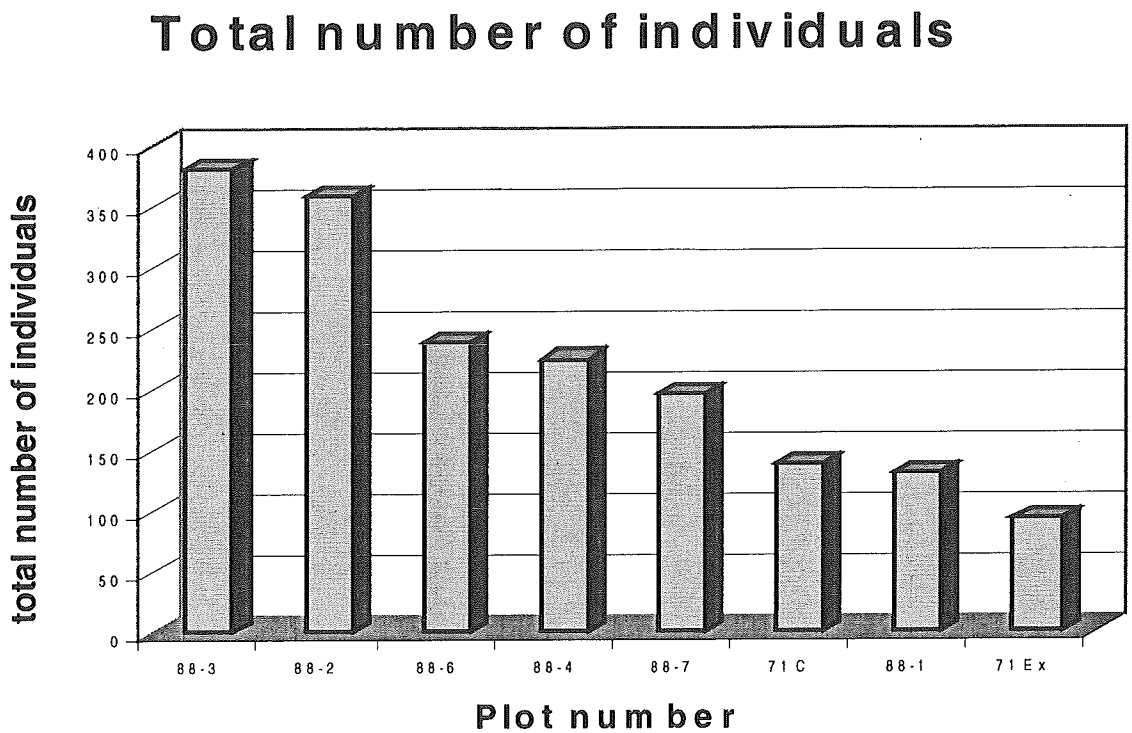

Figure 12. Total number of individuals. The total number of individuals per plot inside of Black Rock Forest. Includes all species (woody and herbaceous) located inside of each plot.

For the most part, the 1988 plots have a higher number of individuals, except Plot 1. The 1971 exclosure plot displays a much lower number of individuals than any other plot. The 1971 control plot displays a surprisingly high number of individuals, but this is mainly due to blueberry bushes.

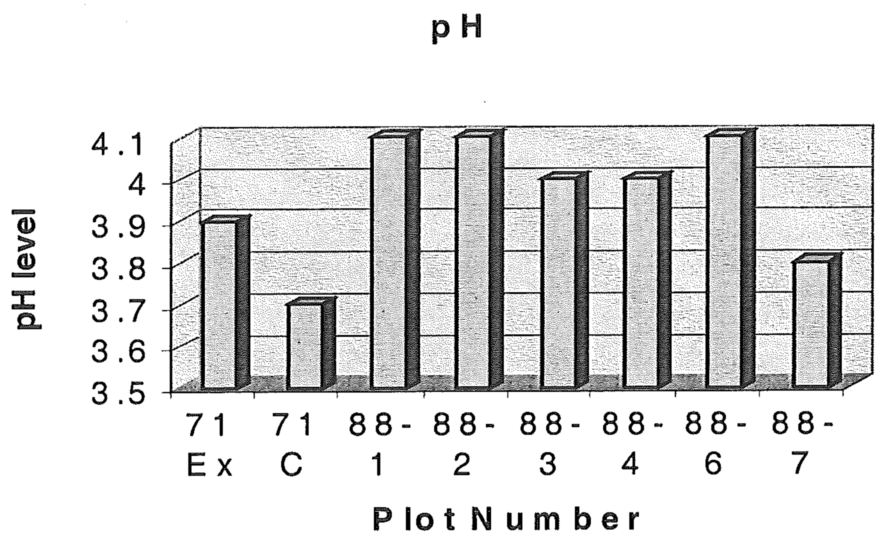

Figure 13. pH level. pH of soil sample from each Black Rock Forest plot. 88- refers to plots inside of the 1988 exclosure. 71C is the control plot for the 1971 exclosure. 71 Ex is the 1971 exclosure.

The 1971 control plot has the lowest pH of all of the plots. The dominating species in the 1971 control plot is blueberry. The pH value for the 1988 plots and the 1971 exclosure plot are very close in value.

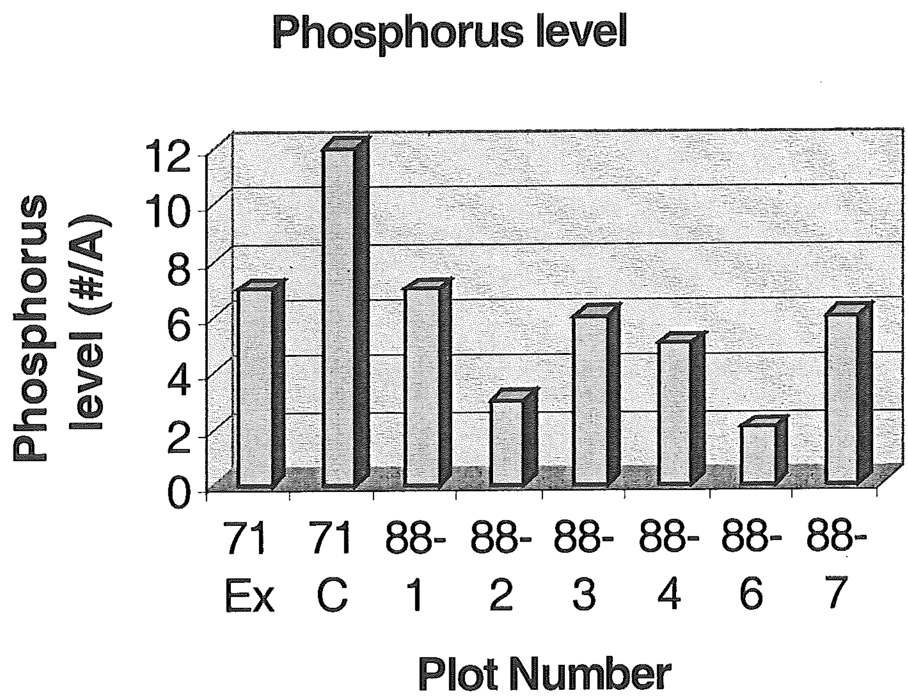

Figure 14. Phosphorus level. Phosphorus level of the soil samples taken for each Black Rock Forest plot. 88- refers to plots inside of the 1988 exclosure. 71C is the control plot for the 1971 exclosure. 71 Ex is the 1971 exclosure. The level of phosphorus is given in pounds per acre (#/A).

Surprisingly, the 1971 control plot contains the most phosphorus, known to be a bio-limiting nutrient, yet it has the lowest diversity value, and one of the lowest total number of individual counts. Phosphorus levels are much more varied among the 1988 plots.

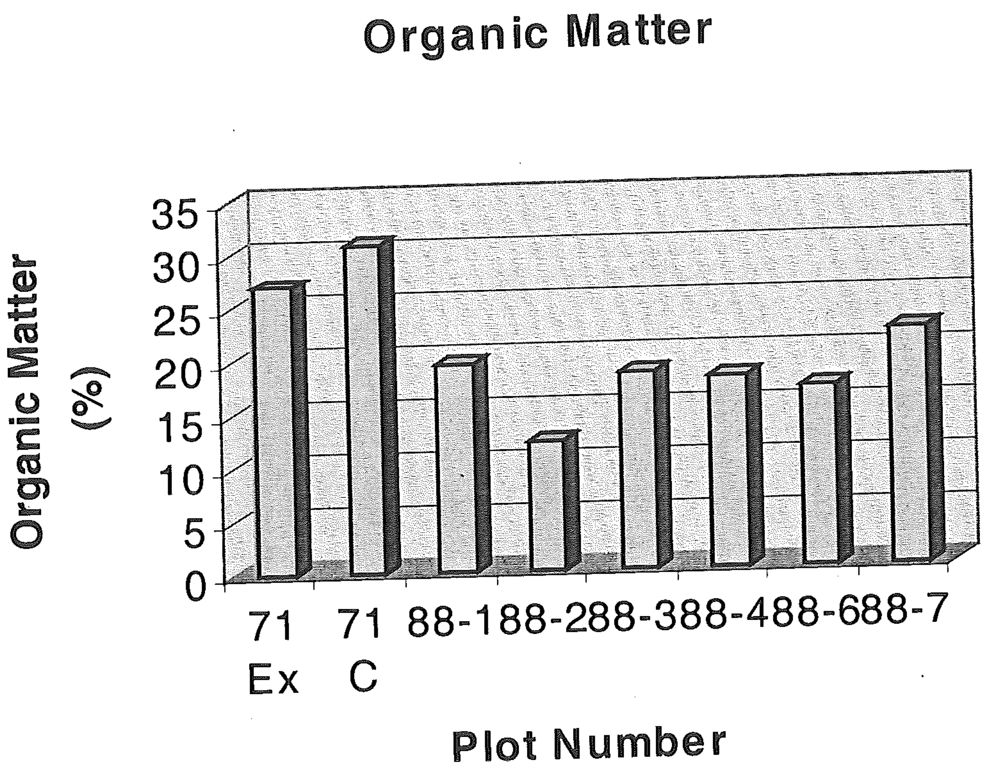

Figure 15. Organic Matter level. Organic matter level of the soil samples taken for each Black Rock Forest plot. 88- refers to plots inside of the 1988 exclosure. 71C is the control plot for the 1971 exclosure. 71 Ex is the 1971 exclosure.

Again, the 1971 control plot shows the greatest amount, while the 1988 plots vary within 10% of each other.

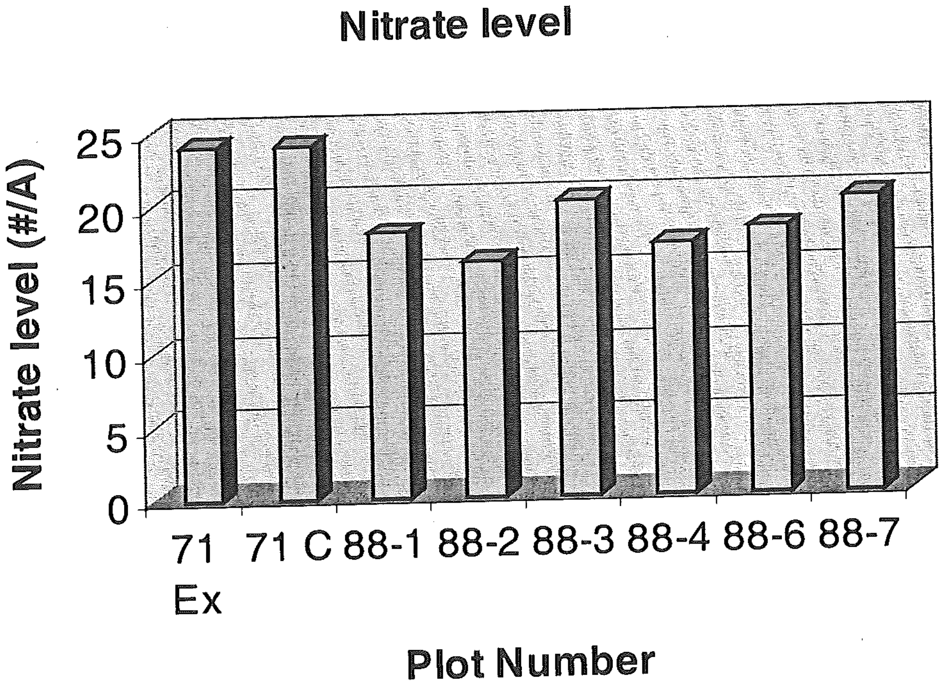

Figure 16. Nitrate level. Nitrate level of the soil samples taken for each Black Rock Forest plot. 88- refers to plots inside of the 1988 exclosure. 71C is the control plot for the 1971 exclosure. 71 Ex is the 1971 exclosure. The level of nitrate is given in pounds per acre (#/A).

The 1971 control plot shows the greatest amount of nitrate among all of the plots at Black Rock Forest. It is followed closely behind by the 1971 exclosure plot, and the 1988 plots vary slightly.

Plot number	pH	phosphorus (#/A)	Nitrate (#/A)	Organic Matter %
71 Ex	3.9	7	24	27
71 C	3.7	12	24	30.8
88- 1	4.1	7	18	19.6
88- 2	4.1	3	16	12.1
88- 3	4	6	20	18.5
88- 4	4	5	17	17.9
88- 6	4.1	2	18	16.8
88- 7	3.8	6	20	22.2
average 88=	4.016667	4.833333333	18.1666667	17.85
st. dev. 88=	0.116905	1.940790217	1.60208198	3.363778

Table 2. Soil composition of the Black Rock Forest plots. Data provided by Cornell Nutrient Analysis Lab. 88- refers to the 1988 exclosure inside Black Rock Forest. Average 88 is the average of all six 1988 exclosure plots. St. dev. 88 is the standard deviation of the six 1988 exclosure plots.

As can be seen from the table, both of the 1971 plots (exclosure and control) show a lower pH, but a higher level of phosphorus, nitrate, and organic matter.

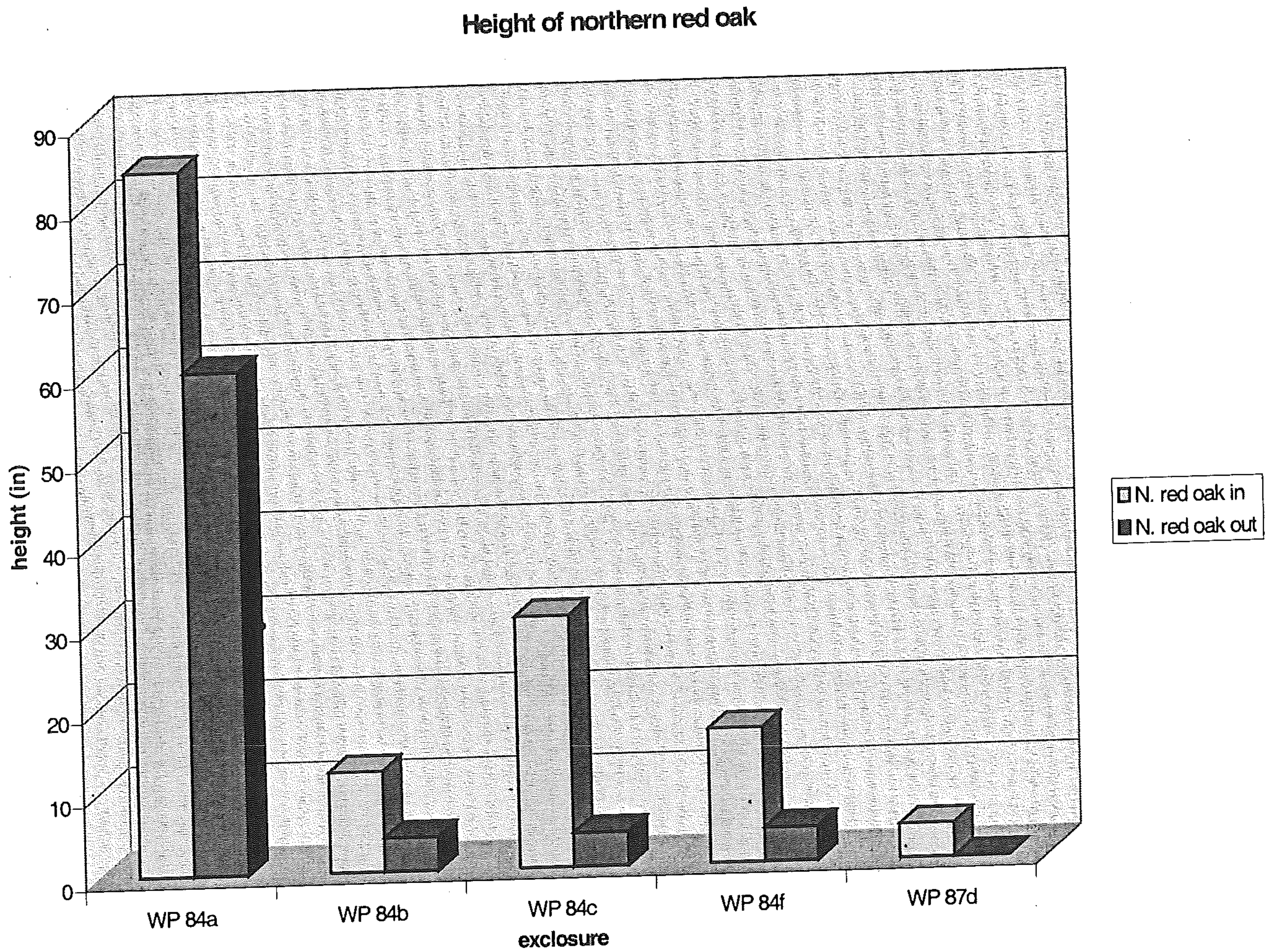

Figure 17. Average height of northern red oak. From West Point Military Academy data of 5 different exclosures where northern red oak is found. N. red oak = northern red oak. Shown for comparison of inside the exclosure and outside in the control plot. WP84a = West Point exclosure #84a, established 1984. WP84b = West Point exclosure 84b, established 1984, etc.

In each exclosure, plotted on the x-axis, it can be seen that the height of the northern red oak tree is larger inside of the exclosure than outside the exclosure.

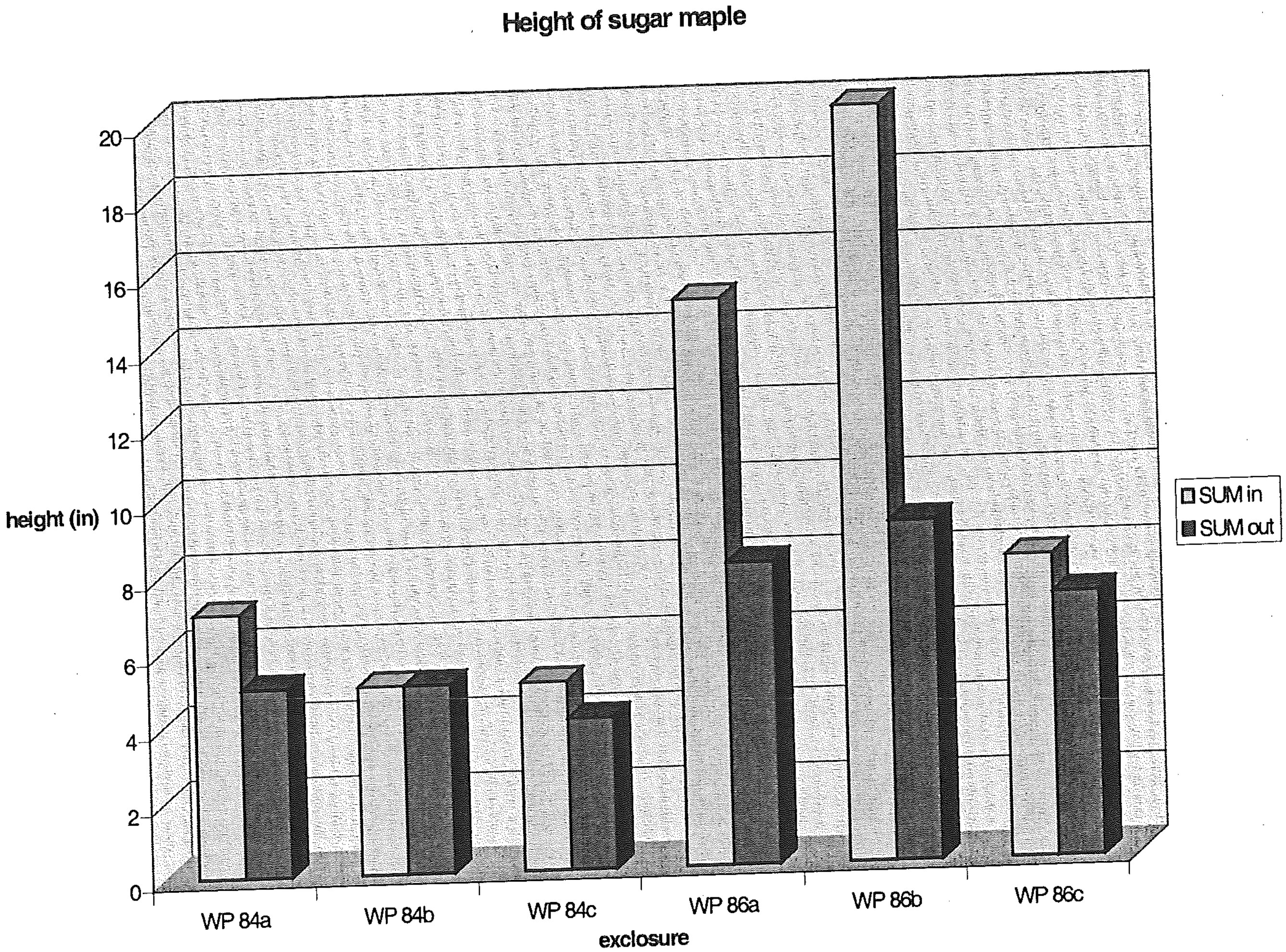

Figure 18. Average height of sugar maple. From West Point Military Academy data of 6 different exclosures where sugar maple is found. SUM = sugar maple. Shown for comparison of inside the exclosure and outside in the control plot. WP84a = West Point exclosure #84a, established 1984. WP84b = West Point exclosure 84b, established 1984, etc.

In each case, the height of the protected tree (inside the exclosure) is taller, or at an equivalent height.

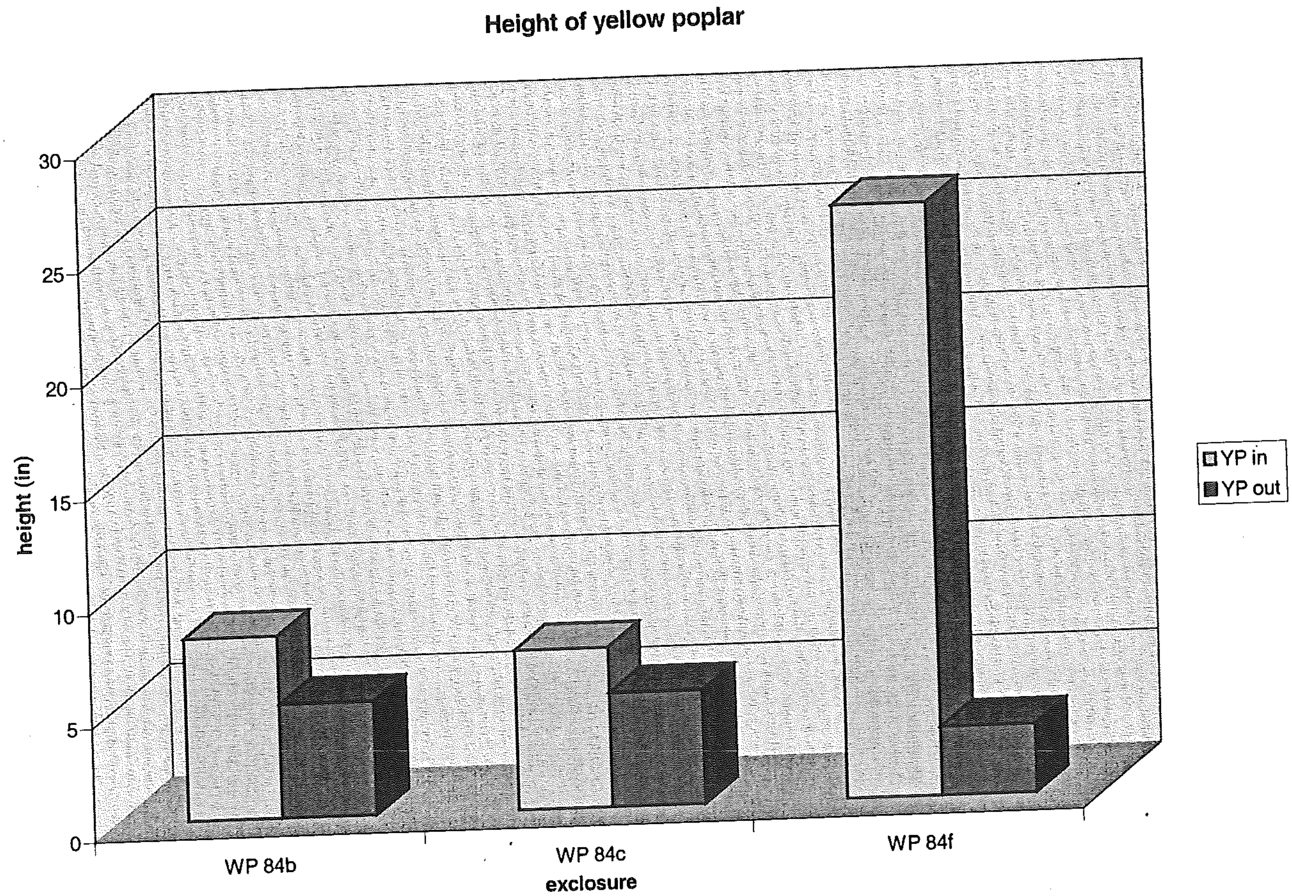

Figure 19. Average height of yellow poplar. From West Point Military Academy data of 3 different exclosures where yellow poplar is found. YP = yellow poplar. Shown for comparison of inside the exclosure and outside in the control plot. WP84b = West Point exclosure #84b, established 1984. WP84c = West Point exclosure 84c, established 1984, etc.

For each exclosure, the protected tree shows an increased average height when compared with the control plot that is exposed to browsing by deer.

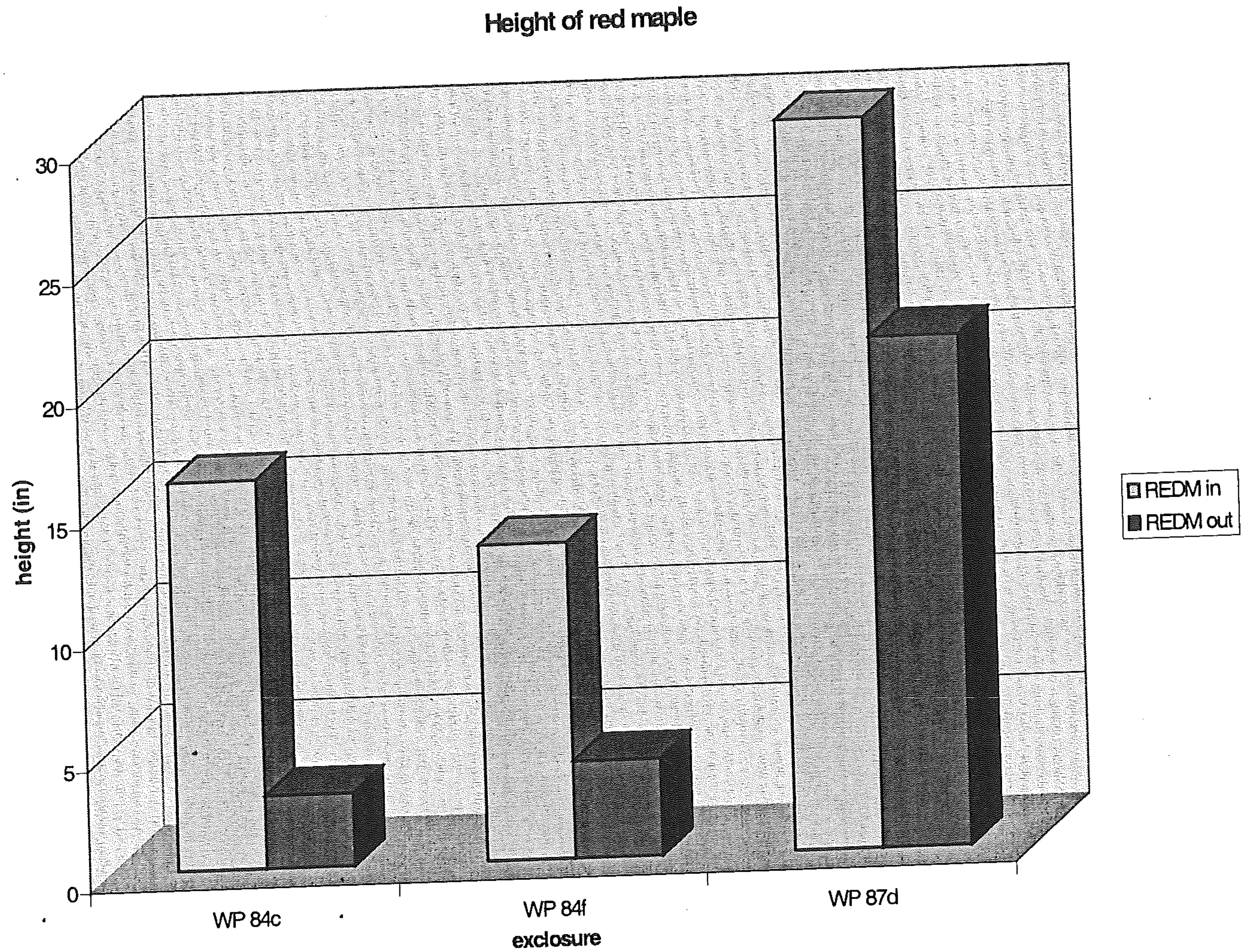

Figure 20. Average height of red maple. From West Point Military Academy data of 3 different exclosures where red maple is found. REDM = red maple. Shown for comparison of inside the exclosure and outside in the control plot. WP84c = West Point exclosure #84c, established 1984. WP84f = West Point exclosure 84f, established 1984, etc.

In each case, the exclosure trees are taller than the control plot trees.

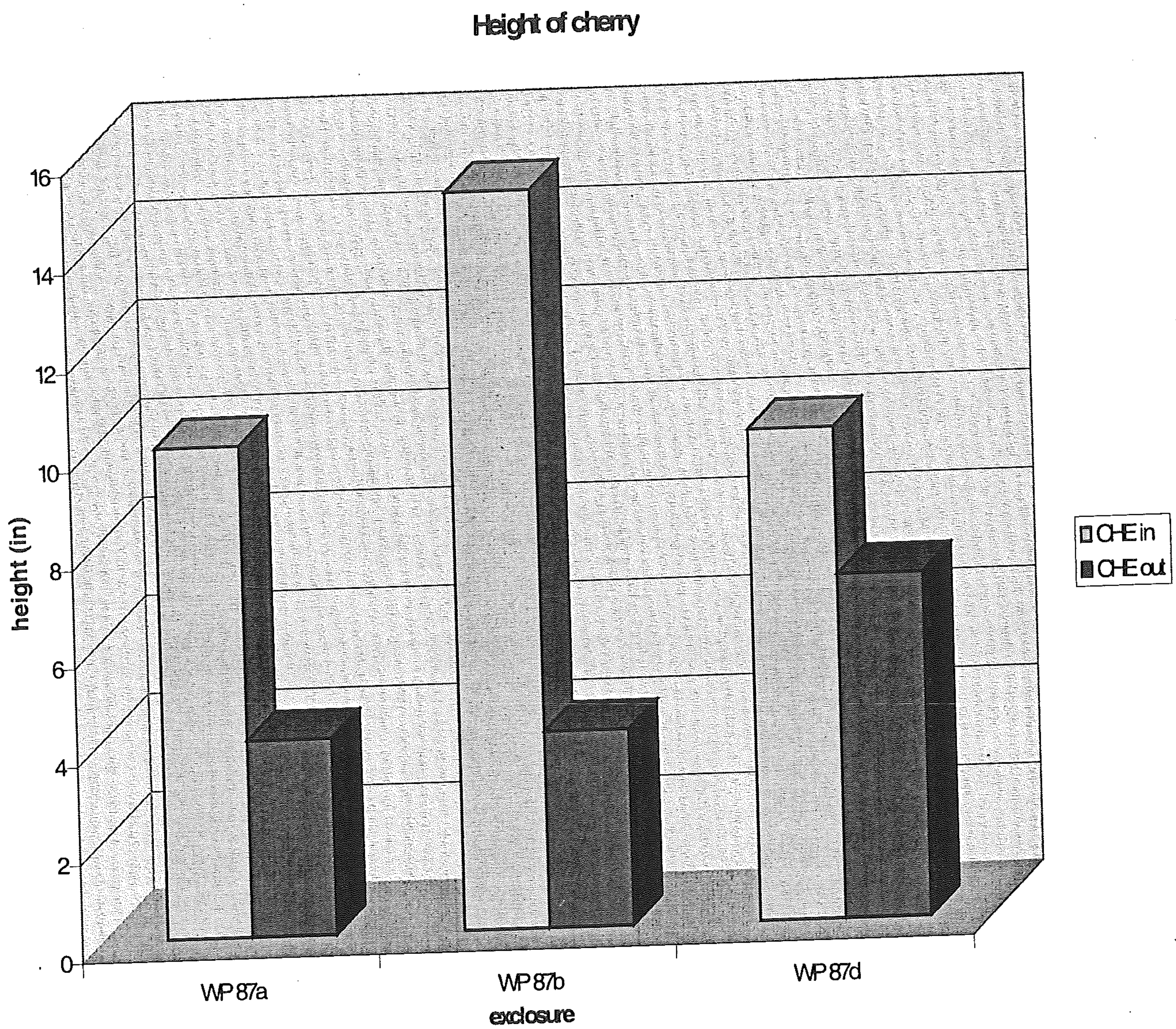

Figure 21. Average height of cherry. From West Point Military Academy data of 3 different exclosures where cherry is found. CHE = cherry. Shown for comparison of inside the exclosure and outside in the control plot. WP87a = West Point exclosure #87a, established 1987. WP87b = West Point exclosure 87b, established 1987, etc.

For each exclosure, the height inside is greater than the height outside.

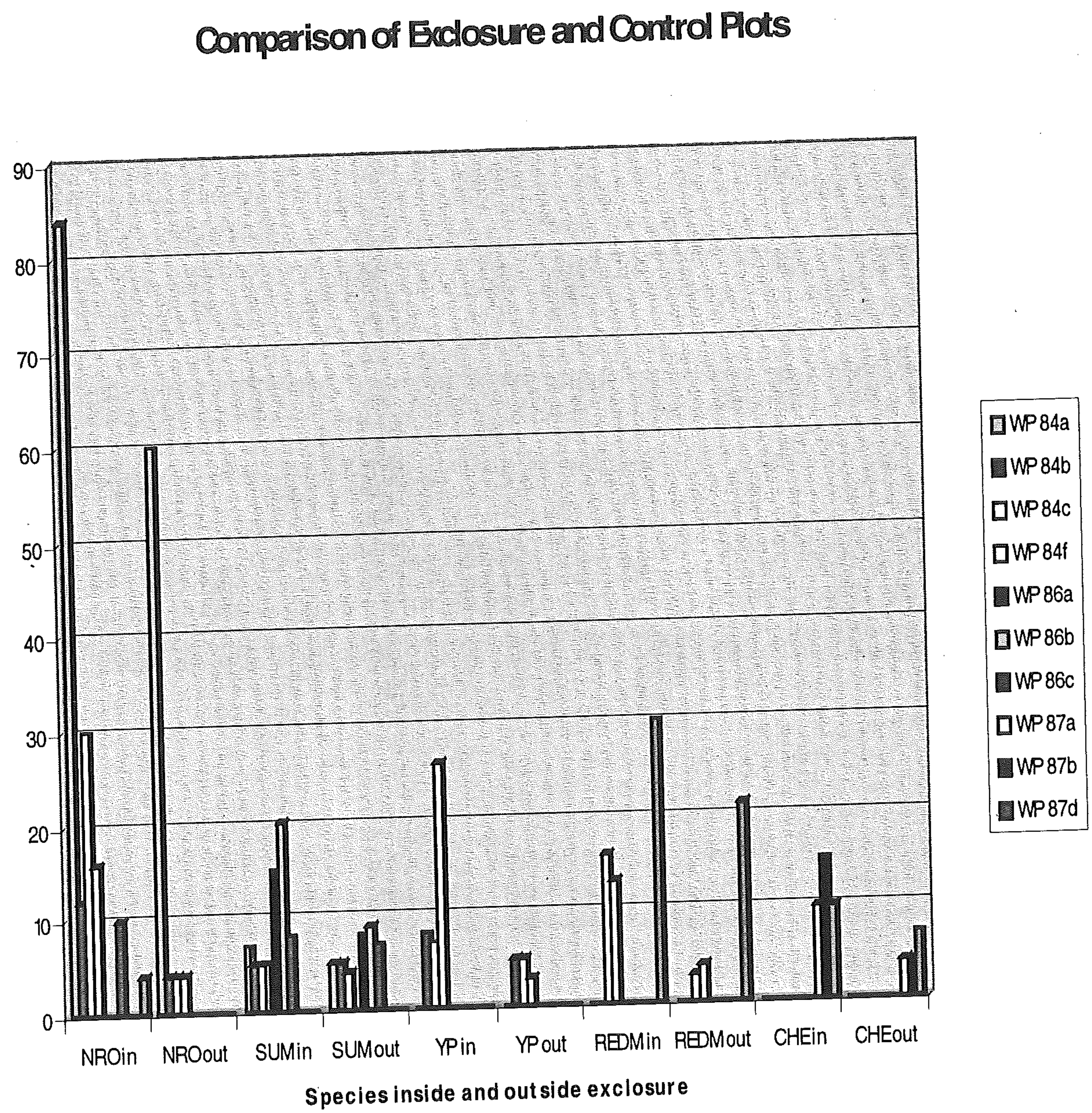

Figure 22. A summary chart of figures 17-21. Species is indicated on the x-axis, average height is indicated on the y-axis. Each bar represents one exclosure or control plot.

It can be seen that for each of the exclosures, the species found inside measure a greater average height than the species outside.

The wood pie charts (Figures 23-29) are included in the appendices as an indication of the approximate frequency of each species in each plot. It can be seen that in the 1988 exclosure, every plot is dominated by birch species, while the 1971 exclosure, seventeen years older, is dominated by red maple. Figures 30-37 are included to show the herbaceous covering of each plot. Again, there are similarities between all of the plots of the 1988 exclosure, mostly dominated by raspberry, while the 1971 exclosure is dominated by canada mayflower inside, and blueberry outside.

Discussion

Vegetation Analysis - 1988 Plots of Black Rock Forest

The six plots from the 1988 exclosure are similar in diversity (Figures 6 and 7), species composition (Figures 23-37), and growth rates (Figures 9, 10, and 11). In an undisturbed plot aged 11 years, we would expect to see an abundance of early successional species, and the beginning of a shift in the species of plants that are growing. As discussed by Reiners (1992), the reorganization phase may last up to 20 years, with species such as black birch, raspberry, and red maple being the dominant vegetation. After this time, species richness declines and late successional species take over, such as oak and hickory trees. This is precisely the case in the Black Rock Forest 1988 exclosure. Although at the present time, the exclosure is dominated by birch species, oak trees are beginning to establish a population, while the red maples continue to grow (see Figures 23-37).

The data used for the results of this study were collected before the exclosure fence was taken down. Therefore, the six plots of the 1988 exclosure were given the same treatment in this study. However, for the purpose of the experiment implemented this summer, it is important to mention the differences seen when comparing Plots 1, 2, and 3, still inside the 1988 exclosure plot, and Plots 4, 6, and 7, now outside and open to browsing. From the histograms dealing with diversity and similarity (Figures 6-8), no appreciable difference can be seen at this time between the two groups of plots. In fact, the Sorenson measure of similarity performed for the groups of plots 123 vs. 467 resulted in a value of approximately 0.7 out of a possible 1.0. This is a high value, indicating the great amount of likeness between these six plots.

In terms of growth rates (Figures 9-11), again the plots show no systematic differences when comparing 1, 2, and 3 with 4, 6, and 7. At the time the exclosure fence was reduced in size by half, there was no difference in the plots located inside, still protected from deer browsing, and the plots now outside.

Vegetation Analysis - 1971 Plots of Black Rock Forest

The 1971 exclosure is also a prime example of an undisturbed community after 28 years of succession following a clear-cut. Both the exclosure ('71 Ex) and the control ('71 C) display lower relative diversity when compared with the plots of the 1988 exclosure (Figures 6 and 7). This is to be expected, since older stands exhibit a lower species richness on a per-plot basis (Gilliam et al, 1995). The '71 Ex plot shows the lowest of all the plots inside of Black Rock Forest in the tally for diversity in both the Simpson measure (Figure 6) and the Shannon measure (Figure 7).

The '71 C (control plot) scores higher in terms of diversity than its protected counterpart. This can be explained by the fact that both of the diversity measures consider all species, both woody and herbaceous, when measuring diversity. The control plot ('71 C) may have more kinds of herbaceous species, but when considering woody plants only, the exclosure is far more dominant. In fact, the control plot contains no saplings whatsoever of woody species above 7 inches high. This result is especially striking when considering that the only difference between the 1971 exclosure and the 1971 control plot is the affect of deer over the past 28 years. This result is supported by the studies of Anderson (1994), and Huntley and Birks (1979). It was Anderson's argument that deer overbrowsing has a direct affect on the height of certain species, and also the removal of flowering (reproducing) plants. Huntley and Birks suggest that deer may prevent regeneration of certain species of trees completely.

Something is preventing the young seedlings of oak and maple from growing into saplings and trees. Perhaps it is the abundance of blueberry bushes that provide protection from deer looking for their preferred species of red maple and red oak (Bramble and Goddard, 1951). The blueberries are able to thrive in a disturbed community, thus providing a relatively complete camouflage. If seedlings grow past the cover provided by the blueberries, they may be browsed, thus preventing the growth of trees. There have been documented cases of low-growing species, such as blueberries, increasing the survival of woody seedlings, especially in disturbed communities (Berkowitz et al, 1995). Also, species that produce large seeds, such as oaks, typically have a lessened ability to regenerate (Borcher et al, 1989).

The Sorenson measure (Figure 8), shows that a comparison of the 1971 exclosure and the 1971 control plot results in the lowest value of all of the comparisons made between plots inside of Black Rock Forest. The value for this comparison is less than 0.1 out of a possible 1.0. The only difference between these two plots for the past 28 years has been the presence of deer overbrowsing. This result is consistent with the fact that deer overbrowsing has devastating effects on forest growth (Anderson, 1994).

The 1971 exclosure holds the highest value of average basal area, diameter at breast height (DBH), and average height of all the plots of Black Rock Forest in this study (Figures 9, 10, and 11), while the control plot ('71 C) has no measurable trees and therefore a relative average basal area, DBH, and height of zero. No trees were able to regenerate in the exposed control area. This is consistent with the fact that clear-cut areas are browsed more intensely than uncut forest, because of the increase in readily available food (Johnson et al, 1995).

In the total number of individuals graph (Figure 12), it is the control plot ('71 C) that contains more individuals than the exclosure plot ('71 Ex). This is again due to the fact that this figure was created using all species present in the plots, including both herbaceous and woody. The 1971 control plot may have more herbaceous species, but it is the 1971 exclosure that is clearly dominant in terms of woody plant regeneration.

Comparison of 1971 and 1988 Plots of Black Rock Forest

Figures 6 and 7 show that the 1988 plots are more diverse in species types than either of the two 1971 plots. This is expected considering that the 1971 plots are in a later successional stage (Gilliam et al, 1995). However, the 1971 exclosure shows a much higher average height, DBH, and basal area than any of the 1988 plots (Figures 9, 10, and 11). The trees inside of the 1971 exclosure are 19 years older than any trees growing in the 1988 exclosure, and are therefore larger. When comparing stands of different ages, it is expected that the younger stand will have a higher stem density, but the older stand will dominate in terms of basal area (Gilliam et al, 1995). This is due to the fact that following a clear-cut, there will be a stage of competitive thinning of the species of trees, where the less shade-tolerant species (early successional species) will be replaced by shade tolerant species (secondary species).

When comparing the similarity between two plots (the Sorenson measure), the plots of the 1988 exclosure are the most similar (Figure 8). This is to be expected because these six plots were subjected to the same environmental conditions. They were all clear-cut in 1988 and protected from deer browsing by an exclosure. The Index value for the '88-1 plot versus the 1971 control plot is higher than that of the '88-1 vs. the 1971 exclosure plot. This is probably due to the fact that in terms of herbaceous species, the 1988 exclosure is more similar to the control plot than to the exclosure. However, this value should not be interpreted to mean that the 1971 control plot and the 1988 exclosure plots are similar, because the value is still low at 0.3.

The index value for the 1988 exclosure plots vs. the 1971 exclosure plot is very low, at less than 0.1. This is to be expected since both plots were protected from browsing pressure and allowed to follow a successional sequence consistent with a northeastern hardwood forest. They are different because of their age discrepancy (19 years), indicating they are in different successional stages and therefore contain different species (Reiners, 1992).

Soil Analysis-Black Rock Forest

Figure 13 shows the pH levels of all of the plots inside Black Rock Forest. It is the 1971 control plot that has the lowest pH value. However, all of the plots have what would be considered relatively acidic soil, all below 4.1. There appears to be no difference between the pH value of the plots 88-1, 88-2, and 88-3 vs. 88-4, 88-6, and 88-7. This is an important note for the follow up of this experiment in the years to come when inspecting the result of deer browsing on the newly exposed 1988 plots.

The phosphorus level (Figure 14) seems to tell the same story in terms of the six 1988 exclosure plots. There appears to be no significant difference in comparing 1, 2, and 3 with 4, 6, and 7. Interestingly, it is the 1971 control plot that contains the most phosphorus, which is known to be a bio-limiting nutrient.

Hypothetically, without the presence of deer overbrowsing, this plot should be thriving in terms of regeneration.

The storage of organic matter is disrupted by clear-cutting, and should decrease until the stand is approximately 20 years old, when the forest nutrient cycle is restored (Covington, 1981). Considering this, there should be a decreased level of organic matter in the 1988 exclosure plots when compared to the 1971 exclosure. This is precisely the case in Figure 15. All six of the 1988 plots show a smaller percentage of organic matter in their soils. The 1971 control plot, in which it seems that equilibrium has not been restored, still shows the highest level of organic matter compared to all of the other Black Rock Forest plots.

The nitrate level (Figure 16) appears to be stand-age specific. Both of the 1971 plots (control and exclosure) have higher levels of nitrate in their soils than any of the 1988 plots. Again, the 1971 control plot shows the highest level of nitrate, another bio-limiting nutrient, indicating that without browsing or other disturbance, the vegetation should be thriving.

In an attempt to find a trend in the soil analysis data, averages for each of these measures of the soil were calculated (see Table 2). When the differences in the 1988 plots are smoothed by the average, there appears to be an age-specific trend in the soil quality of Black Rock Forest. Within error (standard deviation), the average pH value of the 1971 plots (Ex and C) is lower than the average pH value of the 1988 plots. The phosphorus, nitrate, and organic matter levels are higher in the 1971 plots versus the 1988 plots. This indicates that the longer a stand has been regenerating after a clear-cut, the better quality soil that stand will have. The variation in soil seems to be determined by the age of the stand, rather than its protection from deer.

West Point Military Academy Exclosures

Figures 17-22 are histograms of the heights of several species of trees found growing inside the West Point exclosure and control plots. As can be seen clearly by the summary chart (Figure 22), the trees found inside of the exclosure are able to grow much faster, displaying a higher average height in all cases.

The control plots of West Point display some regeneration of hardwood species, unlike that of Black Rock Forest, which contain only a few seedlings. However, it can still be noted that in most cases, the height of the seedlings does not exceed two feet outside of the exclosures, and in fact, the majority of seedlings are under one foot tall (see Figure 22). A reasonable explanation for the greater regeneration is that when considering 12 control plots, regeneration can be noted on a limited basis. In Black Rock Forest, there is only one control plot. Perhaps if there were more, regeneration would be easier to find.

Conclusions

This study is consistent with the theory that deer overbrowsing has a significant impact on vegetation in the northeastern hardwood forests. Using fourteen different deer exclosures from varied years, this study demonstrates the impact that deer have on regeneration of vegetation following a clear-cut.

However, it appears that the changes in vegetation caused by overbrowsing are not related to a change in soil composition. There was no consistent correlation between soil composition or thickness and vegetation type. Therefore, it should be possible for hardwood forests to regenerate if browsing pressure is removed, as long as adequate seed sources are still available.

Black Rock Forest and West Point Military Academy continue to have a deer overpopulation problem, as shown by the lack of regeneration in their control clear-cut plots. The current management plan for preserving forest health and diversity must be improved.

Recommendations

Continued monitoring of both of the exclosures at Black Rock Forest is necessary to provide adequate data for a full analysis, including growth patterns as associated with soil composition and age following a clear-cut. An annual record of growth and species composition would be valuable to both researchers at Black Rock Forest and as a resource for other experiments involving regrowth of a hardwood clear-cut area. A new exclosure built inside of the 1971 control plot may help to prove the hypothesis that removing the pressure of deer overbrowsing will allow succession of a typical hardwood forest to take over in an area with a history of frequent disturbance.

Monitoring the experiment that began in mid-summer of 1999 would be instrumental in determining if there is a negative impact on deer browse associated with an established deer exclosure. Now that half of the vegetation previously unavailable to deer can be eaten, it would be interesting to monitor effects of future browsing. Perhaps findings will suggest that temporary exclosures are all that is needed to help the regeneration of hardwood forests. After a certain time period, in this case 11 years, the fence may be taken down and succession may continue until a climax community is reached.

On the other hand, it may be determined that the vegetation previously protected is being browsed to the point where no new seedlings are being established, in which case it would be necessary to manage the deer population, and perhaps re-build the exclosure.

Acknowledgements

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Appendices

Plot 71 C

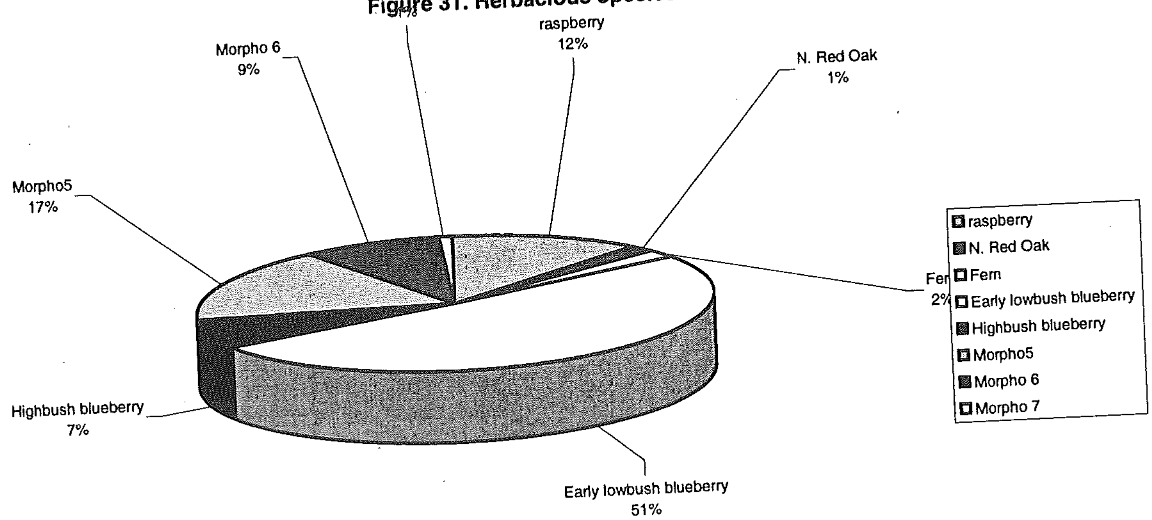
71 C Species	Common Name	# Individuals		Freq.
Rubus idaeus	raspberry		17	0.123188
Quercas rubra	N. Red Oak		2	0.014493
Dennstaedtia punctilobula	Fern		3	0.021739
Vaccinium vacillans	Early lowbush blueberry		70	0.507246
Vaccinium corymbosum	Highbush blueberry		10	0.072464
Morpho 5	Morpho5		23	0.166667
Morpho 6	Morpho 6		12	0.086957
Morpho 7	Morpho 7		1	0.007246
Total Individuals		138		

SIMPSON	n(i)*(n(i)-1)		(N(N-1)	(ni(ni-1))/(N(N-1))
raspberry	17	272	18906	0.014387
N. Red Oak	2	2	18906	0.000106
Fern	3	6	18906	0.000317
Early lowbush blueberry	70	4830	18906	0.255474
Highbush blueberry	10	90	18906	0.00476
Morpho5	23	506	18906	0.026764
Morpho 6	12	132	18906	0.006982
Morpho 7	1	0	18906	0
			D=	0.308791
			1/D=	3.238438

Shannon	pi=ni/N		pi ln pi
raspberry	17	0.123188406	-0.257961
N. Red Oak	2	0.014492754	-0.061364
Fern	3	0.02173913	-0.083231
Early lowbush blueberry	70	0.507246377	-0.344298
Highbush blueberry	10	0.072463768	-0.190193
Morpho5	23	0.166666667	-0.298627
Morpho 6	12	0.086956522	-0.212378
Morpho 7	1	0.007246377	-0.035705
			-1.483757
	H'=		1.48376

Sorenson	71 Ex			lowest of both
Plot 5				
Early lowbush blueberry	70	early lowbush blueberry	0	0
Fern	3	fern	0	0
Highbush blueberry	10	highbush blueberry	0	0
Morpho 6	12	morpho6	0	0
Morpho 7	1	morpho7	0	0
Morpho5	23	morpho5	0	0
N. Red Oak	2	N. red oak	2	2
raspberry	17	raspberry	7	7
american plum	0	American plum	1	0
lily-of-the-valley	0	lily-of-the-valley	60	0
lisimachia	0	lisimachia	8	0
red maple	0	red maple	11	0
solomon's seal	0	Solomon's-seal	4	0
white oak	0	white oak	1	0
	138		94	9
				0.077586

Figure 31. Herbacious species 71C



Plot 71 Ex

71 Species	Common Name	Height (m)	circumference (in)	DBH (in)
Acer rubrum	Red maple	7.5	8.3	2.643312102
Acer rubrum	Red maple	9	8.5	2.707006369
Acer rubrum	Red maple	7	7.5	2.388535032
Acer rubrum	Red maple	9	8	2.547770701
Acer rubrum	Red maple	6.3	7	2.229299363
Acer rubrum	Red maple	9	8.5	2.707006369
Acer rubrum	Red maple	7.5	7.7	2.452229299
Acer rubrum	Red maple	11	10.2	3.248407643
Quercas rubra	N. Red Oak	8	5.2	1.656050955
Quercas rubra	N. Red Oak	5.75	4	1.27388535
Quercas alba	White Oak	2.7	1.4	0.445859873
Prunus americana	American plum	7.5	6.5	2.070063694
	average=	7.520833333		

Herbacious plants Species	Common name	# of individuals
Maianthemum canadense	Lily-of-the-Valley	covers ground
Lisimachia trifolia		8
Smilacina racemosa	Solomon's-Seal	4
Rubus idaeus	raspberry	7
Acer rubrum	Red maple	3

lily-of-the-valley
lisimachia
Solomon's-seal
raspberry
red maple
Total

Shannon		pi=ni/N	pi ln pi
American plum	1	0.010638298	-0.048332923
red maple	11	0.117021277	-0.251057389
N. red oak	2	0.021276596	-0.081918034
white oak	1	0.010638298	-0.048332923
lily-of-the-valley	60	0.638297872	-0.28656397
lisimachia	8	0.085106383	-0.209689637
Solomon's-seal	4	0.042553191	-0.134340443
raspberry	7	0.074468085	-0.19342226
	94		-1.253657581
			H'=1.25366

simpson		n(i)*(n(i)-1)	(N(N-1)	(ni(ni-1))/(N(N-1))
American plum	1	0	8742	0
red maple	11	110	8742	0.012582933
N. red oak	2	2	8742	0.000228781
white oak	1	0	8742	0
lily-of-the-valley	60	3540	8742	0.404941661
lisimachia	8	56	8742	0.006405857
Solomon's-seal	4	12	8742	0.001372684
raspberry	7	42	8742	0.004804393
	94		D=	0.430336307
			1/D=	2.323763955

Importance Value (IV) Species	Density	Rel. Density	Frequency	Rel. Frequency

American plum	1	0.010638298	1	1
red maple	11	0.117021277	1	1
N. red oak	2	0.021276596	1	1
white oak	1	0.010638298	1	1
lily-of-the-valley	60	0.638297872	1	1
lisimachia	8	0.085106383	1	1
Solomon's-seal	4	0.042553191	1	1
raspberry	7	0.074468085	1	1
	94			

DBH (mm)	Basal Area (mm^2)	(x-avgx)^2	var
67.14012739	3.538620414	0.685765	22.55579
68.75796178	3.711210987	1.001401	stdev
60.66878981	2.889351115	0.031984	4.749294
64.7133758	3.28743949	0.332847	
56.62420382	2.51694586	0.037467	
68.75796178	3.711210987	1.001401	
62.2866242	3.04550449	0.112221	
82.50955414	5.344143822	6.936022	
42.06369427	1.388943185	1.746541	
32.3566879	0.821859873	3.567003	
11.32484076	0.100677834	6.811229	
52.57961783	2.170223726	0.29191	
55.81528662	2.710510982		

stdev	redmap	n. red oak	average
height	1.498988	1.59099	1.544989
DBH	7.740013	6.86389	7.301952
area	0.852087	0.400988	0.626538

			Average Basal Area
American p	1	0.083333	2.170224
red maple	8	0.666667	3.505553
N. red oak	2	0.166667	1.105402
white oak	1	0.083333	0.100678
Total	12		

60	0.731707317
8	0.097560976
4	0.048780488
7	0.085365854
3	0.036585366
82	

total samples=94

Basal Area	Rel. Basal Area	IV	*100

2.170223726	0.276628303	0.287267	28.72666
3.505553396	0.446836552	0.563858	56.38578
1.105401529	0.140900381	0.162177	16.2177
0.100677834	0.012832934	0.023471	2.347123
0.731707	0.093267281	0.731565	73.15652
0.097561	0.012435646	0.097542	9.754203
0.04878	0.006217759	0.048771	4.877095
0.085366	0.010881206	0.085349	8.534929
7.845270485			

Figure 30. '71Ex Herbacious plants and saplings

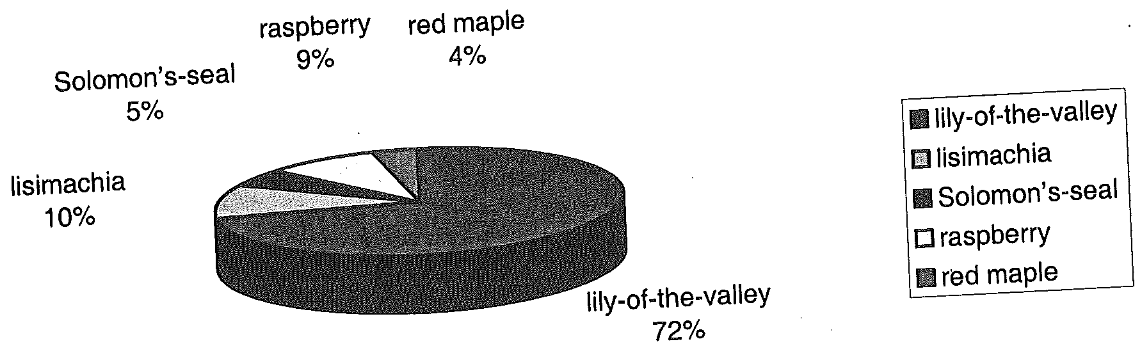
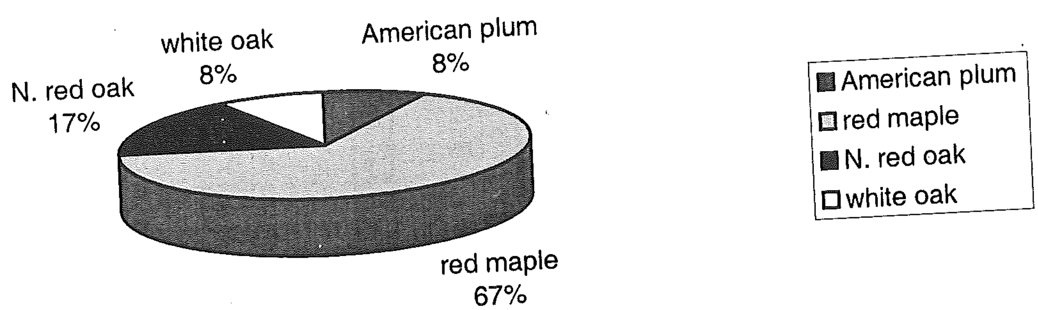


Figure 23. '71 Ex Woody plants



Plot 88-1

P1 Species	Common Name	Height (m)	circumference (in)	DBH (in)	DBH (mm)	Basal Area
Betula lenta	black birch	5.74	3.4	1.082803	27.50318	0.593794
Betula lenta	black birch	8	8	2.547771	64.71338	3.287439
Betula lenta	black birch	3.4	1.5	0.477707	12.13376	0.115574
Betula lenta	black birch	8	2.2	0.700637	17.79618	0.248613
Betula lenta	black birch	8	8.1	2.579618	65.52229	3.370139
Betula lenta	black birch	6	6.3	2.006369	50.96178	2.038726
Betula lenta	black birch	3.3	1.8	0.573248	14.56051	0.166427
Betula lenta	black birch	2.9	1	0.318471	8.089172	0.051366
Betula lenta	black birch	7.1	7.4	2.356688	59.85987	2.812815
Betula lenta	black birch	4	2	0.636943	16.17834	0.205465
Betula lenta	black birch	3.7	2	0.636943	16.17834	0.205465
Betula lenta	black birch	2.6	1.6	0.509554	12.94268	0.131498
Betula lenta	black birch	4.1	3.1	0.987261	25.07643	0.49363
Betula lenta	black birch	3.9	2	0.636943	16.17834	0.205465
Betula lenta	black birch	6.6	6.5	2.070064	52.57962	2.170224
Betula lenta	black birch	4.9	2.8	0.89172	22.64968	0.402711
Betula lenta	black birch	4.2	2.8	0.89172	22.64968	0.402711
Betula lenta	black birch	4.5	2.6	0.828025	21.03185	0.347236
Betula lenta	black birch	3.7	2	0.636943	16.17834	0.205465
Betula lenta	black birch	3.7	2	0.636943	16.17834	0.205465
Betula lenta	black birch	3.05	1.8	0.573248	14.56051	0.166427
Betula lenta	black birch	5.3	3.4	1.082803	27.50318	0.593794
Betula lenta	black birch	7.1	6.2	1.974522	50.15287	1.974518
Betula lenta	black birch	7.1	4	1.273885	32.35669	0.82186
Betula lenta	black birch	5.4	4.6	1.464968	37.21019	1.08691
Quercas rubra	Northern Red Oak	6.1	4.5	1.433121	36.40127	1.040166
Betula alleghanie	Yellow birch	4.9	4.7	1.496815	38.01911	1.13468
Betula populifolia	Gray birch	4.55	2.2	0.700637	17.79618	0.248613
		5.065714	Average DBH=	1.143085	29.03435	0.883114

Herbacious Species

Species	Common name	# individuals
Vaccinium vacilla	Early lowbush blueb	22
Rubus idaeus	Raspberry	61
Dennstaedtia pu	Fern	16
Smilacina racem	False Solomon's-sea	1
Acer rubrum	Red Maple	1
Quercas rubra	N. Red Oak	2
Betula lenta	Black birch	2

Total samples 132

		Freq	n(i)*(n(i)-1)	(N(N-1)	(ni(ni-1))/(N(N-1))
Black birch	25	0.892857	600	756	0.793651
N. Red Oak	1	0.035714	0	756	0
Yellow birch	1	0.035714	0	756	0
Gray birch	1	0.035714	0	756	0
Total	28			D=	0.793651
				1/D=	1.26
Blueberry	22	0.209524	462	10920	0.042308
Raspberry	61	0.580952	3660	10920	0.335165

Fern	16	0.152381	240	10920	0.021978
False Solomon's	1	0.009524	0	10920	0
red maple saplin	1	0.009524	0	10920	0
n. red oak saplin	2	0.019048	2	10920	0.000183
black birch	2	0.019048	2	10920	0.000183
Total	105				

SIMPSON		n(i)*(n(i)-1)	(N(N-1)		(ni(ni-1))/(N(N-1))
Black birch	25	600		17556	0.034176
N. Red Oak	1	0		17556	0
Yellow birch	1	0		17556	0
Gray birch	1	0		17556	0
Blueberry	22	462		17556	0.026316
Raspberry	61	3660		17556	0.208476
Fern	16	240		17556	0.013671
False Solomon's	1	0		17556	0
red maple saplin	1	0		17556	0
n. red oak saplin	2	2		17556	0.000114
black birch	2	2		17556	0.000114
	133		D=		0.282866
			1/D=		3.53524

SHANNON		pi=ni/N	pi ln pi
Black birch	25	0.18797	-0.314186711
N. Red Oak	1	0.007519	-0.036769542
Yellow birch	1	0.007519	-0.036769542
Gray birch	1	0.007519	-0.036769542
Blueberry	22	0.165414	-0.297629676
Raspberry	61	0.458647	-0.357503693
Fern	16	0.120301	-0.254768169
False Solomon's	1	0.007519	-0.036769542
red maple saplin	1	0.007519	-0.036769542
n. red oak saplin	2	0.015038	-0.063115819
black birch	2	0.015038	-0.063115819
	133		-1.534167597
			H'=1.534167597

SORENSON	1 vs 2			0.482758621	
Plot1			Plot 2		lowest of both
big-toothed aspe		0	Big-toothec	4	0
Black birch		27	Black birch	81	27
Blueberry		22	blueberry	15	15
False Solomon's		1	False Soloı	123	1
Fern		16	Fern	62	16
highland blueber		0	highland bl	1	0
Lisimachia		0	Lisimachia	3	0
morpho3		0	morpho3	1	0
N. Red Oak		3	N. Red Oal	1	1
pin cherry		0	Pin cherry	1	0
Raspberry		61	raspberry	58	58
red maple saplin		1	Red maple	6	1
witch-hazel		0	Witch-Haze	4	0
Yellow birch		1	yellow bircl	0	0
Gray birch		1	gray birch	0	0

	133		360	119
1 vs 3	0.462135922			
Plot1		Plot 3		lowest of both
big-toothed aspe	0	Big-toothec	0	0
Black birch	27	Black birch	19	19
Blueberry	22	blueberry	70	22
chokecherry	0	Chokecher	3	0
False Solomon's	1	False Soloı	0	0
Fern	16	fern	36	16
lily-of-the-valley	0	Lily-of-the-'	8	0
highland blueber	0	highland bl	0	0
Lisimachia	0	Lisimachia	28	0
morpho3	0	morpho3	0	0
N. Red Oak	3	N. Red Oal	0	0
pin cherry	0	Pin cherry	0	0
Raspberry	61	raspberry	202	61
red maple saplin	1	red maple	4	1
white birch	0	White birch	3	0
white oak	0	White oak	1	0
witch-hazel	0	Witch-haze	8	0
Yellow birch	1	yellow bircl	0	0
Gray birch	1	gray birch	0	0
	133		382	119

1 vs 4	0.603351955			
Plot1		Plot 4		lowest of both
bitternut hickory	0	Bitternut hi	1	0
Black birch	27	Black birch	22	22
Blueberry	22	blueberry	6	6
chokecherry	0	Chokecher	3	0
False Solomon's	1	false solom	54	1
Fern	16	fern	31	16
lily-of-the-valley	0	Lily-of-the-'	9	0
Lisimachia	0	lisimachia	3	0
Raspberry	61	raspberry	79	61
red maple saplin	1	red maple :	1	1
N. Red Oak	3	n. red oak	0	0
striped maple	0	Striped ma	3	0
sugar maple	0	sugar mapl	4	0
tulip	0	Tulip	3	0
white birch	0	White birch	1	0
witch-hazel	0	Witch-haze	4	0
Yellow birch	1	Yellow birc	1	1
Gray birch	1	gray birch	0	0
	133		225	108

1 vs '71 EX	0.0969163			
Plot1		Plot 5		lowest of both
american plum	0	American p	1	0
Black birch	27	Black birch	0	0
Blueberry	22	blueberry	0	0
False Solomon's	1	false Solon	4	1
Fern	16	fern	0	0

lily-of-the-valley	0	lily-of-the-v	60	0
Lisimachia	0	lisimachia	8	0
Raspberry	61	raspberry	7	7
red maple saplin	1	red maple	11	1
N. Red Oak	3	N. red oak	2	2
Yellow birch	1	Yellow birc	0	0
Gray birch	1	gray birch	0	0
white oak	0	white oak	1	0
	133		94	11
1 vs 6	0.532258065			
Plot1		Plot 6		lowest of both
Black birch	27	Black birch	56	27
Blueberry	22	blueberry	3	3
False Solomon's	1	false solom	2	1
Fern	16	fern	40	16
highbush bluebe	0	highbush b	3	0
lily-of-the-valley	0	lily-of-the-v	70	0
Lisimachia	0	lisimachia	5	0
Raspberry	61	raspberry	51	51
red maple saplin	1	Red maple	7	1
N. Red Oak	3	n. red oak	0	0
tulip	0	Tulip	1	0
Yellow birch	1	Yellow birc	0	0
Gray birch	1	gray birch	0	0
white oak	0	White Oak	1	0
	133		239	99
1 vs 7	0.668693009			
Plot1		Plot 7		lowest of both
Black birch	27	Black birch	23	23
Blueberry	22	blueberry	49	22
False Solomon's	1	False Solo	9	1
Fern	16	Fern	26	16
highbush bluebe	0	Highbush b	5	0
lily-of-the-valley	0	Lily-of-the-	9	0
morphobirch	0	morphobirc	1	0
Raspberry	61	Raspberry	46	46
red maple saplin	1	Red maple	20	1
N. Red Oak	3	N. Red Oa	1	1
tulip	0	Tulip-popla	2	0
Yellow birch	1	Yellow birc	0	0
Gray birch	1	gray birch	0	0
white oak	0	White oak	2	0
striped maple	0	Striped ma	1	0
sugar maple	0	Sugar map	2	0
	133		196	110

Plot1	1 vs 5=0.324723247	Plot 5		lowest of both	
Black birch	27	Black birch	0	0	pH
Blueberry	22	Early lowbı	70	22	phosphoru
False Solomon's	1	false solom	0	0	Potassium
Fern	16	Fern	3	3	Magnesiun
highbush bluebe	0	Highbush b	10	0	Calcium
Raspberry	61	raspberry	17	17	Ex Acidity (

red maple saplin	1	red maple :	0	0	Aluminum
morpho 6	0	Morpho 6	12	0	Iron
morpho 7	0	Morpho 7	1	0	Manganes
morpho 5	0	Morpho5	23	0	Zinc
N. Red Oak	3	N. Red Oal	2	2	Organic Ma
Yellow birch	1	Yellow birc	0	0	Nitrate
Gray birch	1	gray birch	0	0	
	133		138	44	
			0.324723247		

Plot123		Plot 467		lowest of both
bitternut hickory	0	Bitternut hi	1	0
Big-toothed aspe	4	bigtoothed	0	0
Black birch	127	Black birch	101	101
Blueberry	107	blueberry	58	58
Chokecherry	3	Chokecher	3	3
False Solomon's	124	False Solo	65	65
Fern	114	Fern	97	97
Gray birch	1	gray birch	0	0
highland blueber	1	Highbush b	8	1
Lily-of-the-valley	8	Lily-of-the-	88	8
Lisimachia	31	lisimachia	8	8
morphobirch	0	morphobirc	1	0
N. Red Oak	4	N. Red Oal	1	1
morpho3	1	morpho3	0	0
Raspberry	321	Raspberry	176	176
red maple	11	Red maple	28	11
Pin cherry	1	pin cherry	0	0
striped maple	0	Striped ma	4	0
sugar maple	0	Sugar map	6	0
tulip	0	Tulip	6	0
White birch	3	White birch	1	1
White oak	1	White oak	3	1
Witch-hazel	12	Witch-haze	4	4
Yellow birch	1	Yellow birc	1	1
	875		660	536
0.698371336				

(x-avgx)^2	var		
0.083706	27.04852	stdev bl birch	
5.780781	stdev	height	1.743243
0.589118	5.200819	DBH	17.83425
0.402592		area	1.051902
6.185293			
1.335439			
0.513641			
0.691805			
3.723747			
0.459208			
0.459208			
0.564927			
0.151698			
0.459208			
1.656651			
0.230787			
0.230787			
0.287166			
0.459208			
0.459208			
0.513641			
0.083706			
1.191163			
0.003752			
0.041533			
0.024665			
0.063286			
0.402592			

Plot 1

4.1
7
215
200
940
58

486
220
100
9.3
19.6
18

Figure 32. 88-1 Herbaceous plants and saplings

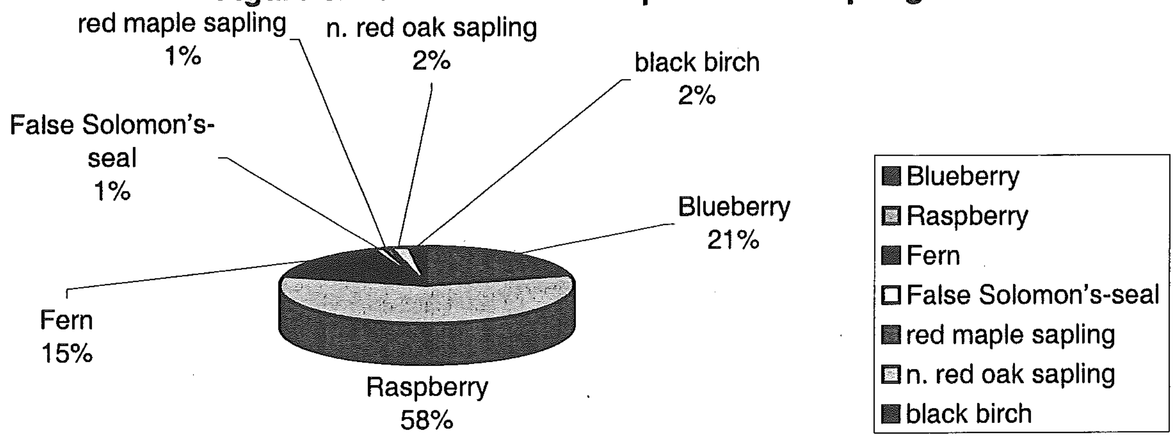
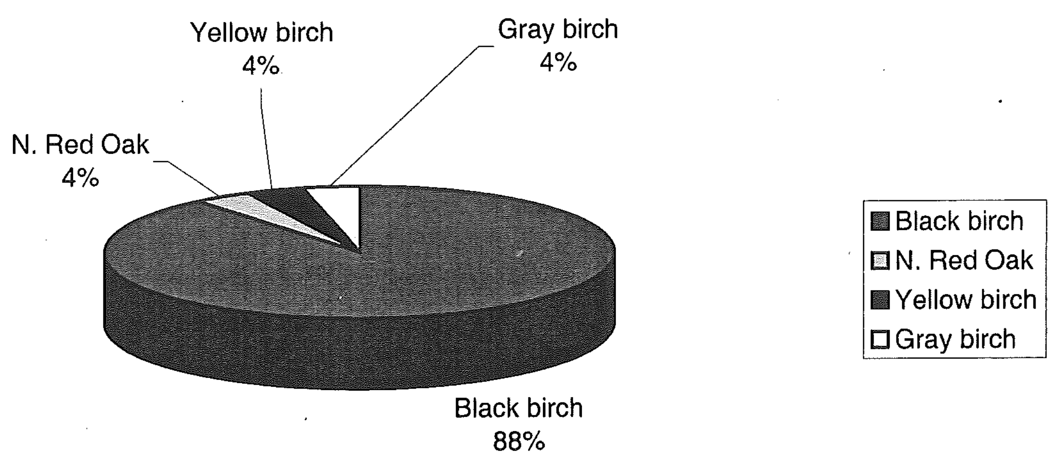


Figure 24. 88-1 Woody plants



Plot 88-2

P2 Species	Common Name	Height (m)	circumferei	DBH (in)	DBH (mm)	Basal Area	(x-avgx)^2	var
Betula lenta	black birch	6.65	4.1	1.305732	33.16561	0.863467	0.042834	40.46819
Betula lenta	black birch	3	1.5	0.477707	12.13376	0.115574	0.292605	stdev
Betula lenta	black birch	3.7	2.2	0.700637	17.79618	0.248613	0.166375	6.361461
Betula lenta	black birch	7.03	4.8	1.528662	38.82803	1.183478	0.277702	
Betula lenta	black birch	7.5	6	1.910828	48.53503	1.849185	1.422489	
Betula lenta	black birch	6.1	3.2	1.019108	25.88535	0.52599	0.017034	
Betula lenta	black birch	2.3	2	0.636943	16.17834	0.205465	0.203436	
Betula lenta	black birch	3.2	1.2	0.382166	9.707006	0.073967	0.339348	
Betula lenta	black birch	6.9	5.8	1.847134	46.9172	1.72796	1.14802	
Betula lenta	black birch	5.51	3.5	1.11465	28.3121	0.629236	0.000743	
Betula lenta	black birch	3	4	1.273885	32.35669	0.82186	0.027343	
Betula lenta	black birch	6.5	3.2	1.019108	25.88535	0.52599	0.017034	
Betula lenta	black birch	3.75	1.8	0.573248	14.56051	0.166427	0.240175	
Betula lenta	black birch	2.1	0.9	0.286624	7.280255	0.041607	0.378098	
Betula lenta	black birch	3.55	1.4	0.44586	11.32484	0.100678	0.308942	
Betula lenta	black birch	7.2	6.4	2.038217	51.7707	2.103961	2.095134	
Betula lenta	black birch	4.2	3.2	1.019108	25.88535	0.52599	0.017034	
Betula lenta	black birch	8.25	8	2.547771	64.71338	3.287439	6.921825	
Betula lenta	black birch	4.35	3.2	1.019108	25.88535	0.52599	0.017034	
Betula lenta	black birch	7.2	5.7	1.815287	46.10828	1.668889	1.024925	
Betula lenta	black birch	4.31	2	0.636943	16.17834	0.205465	0.203436	
Betula lenta	black birch	3.05	1.4	0.44586	11.32484	0.100678	0.308942	
Betula lenta	black birch	7.5	5.8	1.847134	46.9172	1.72796	1.14802	
Betula lenta	black birch	2.7	1.7	0.541401	13.75159	0.148448	0.25812	
Betula lenta	black birch	6.45	4.6	1.464968	37.21019	1.08691	0.18525	
Betula lenta	black birch	2.6	1	0.318471	8.089172	0.051366	0.366191	
Betula lenta	black birch	4	1.3	0.414013	10.51592	0.086809	0.324552	
Betula lenta	black birch	2.85	1.2	0.382166	9.707006	0.073967	0.339348	
Betula lenta	black birch	5	2.8	0.89172	22.64968	0.402711	0.06441	
Betula lenta	black birch	5.1	2.9	0.923567	23.4586	0.43199	0.050406	
Betula lenta	black birch	1.8	1.9	0.605096	15.36943	0.185432	0.221908	
Betula lenta	black birch	2.2	2.5	0.796178	20.22293	0.321039	0.112536	
Betula lenta	black birch	2.76	2	0.636943	16.17834	0.205465	0.203436	
Betula lenta	black birch	2.68	1.5	0.477707	12.13376	0.115574	0.292605	
Betula lenta	black birch	5.05	2.3	0.732484	18.6051	0.271727	0.148053	
Betula lenta	black birch	6.85	3.4	1.082803	27.50318	0.593794	0.003932	
Betula lenta	black birch	4.75	3.3	1.050955	26.69427	0.559378	0.009433	
Betula lenta	black birch	3.95	2	0.636943	16.17834	0.205465	0.203436	
Betula lenta	black birch	4.8	3	0.955414	24.26752	0.462296	0.037716	
Betula lenta	black birch	6.25	5.4	1.719745	43.68153	1.49784	0.707847	
Betula lenta	black birch	3.05	1.8	0.573248	14.56051	0.166427	0.240175	
Betula lenta	black birch	2.8	1.6	0.509554	12.94268	0.131498	0.275631	
Betula lenta	black birch	6.15	3.7	1.178344	29.92994	0.703204	0.002181	
Betula lenta	black birch	2.85	1.6	0.509554	12.94268	0.131498	0.275631	
Betula lenta	black birch	3.9	2.9	0.923567	23.4586	0.43199	0.050406	
Betula lenta	black birch	3.9	1	0.318471	8.089172	0.051366	0.366191	
Betula lenta	black birch	4.7	1.5	0.477707	12.13376	0.115574	0.292605	
Betula lenta	black birch	6.25	2	0.636943	16.17834	0.205465	0.203436	
Betula lenta	black birch	6.25	1.1	0.350318	8.898089	0.062153	0.353252	
Betula lenta	black birch	3.22	1	0.318471	8.089172	0.051366	0.366191	
Betula lenta	black birch	4.7	2.4	0.764331	19.41401	0.29587	0.130057	

Betula lenta	black birch	6.25	5.2	1.656051	42.06369	1.388943	0.536468
Betula lenta	black birch	5.7	3.1	0.987261	25.07643	0.49363	0.026528
Acer rubrum	Red maple	3	1.9	0.605096	15.36943	0.185432	0.221908
Populus gran	Big-toothed Aspe	9	8.9	2.834395	71.99363	4.06872	11.64322
Populus gran	Big-toothed Aspe	8.5	7.4	2.356688	59.85987	2.812815	4.649682
Populus gran	Big-toothed Aspe	4.04	2	0.636943	16.17834	0.205465	0.203436
morpho 3		2	1.4	0.44586	11.32484	0.100678	0.308942
Quercas rubr	Northern Red Oa	6.92	4.5	1.433121	36.40127	1.040166	0.147197
Prunus pens	Pin cherry	3	4	1.273885	32.35669	0.82186	0.027343
		4.713667		0.971868	24.68546	0.656503	

Herbacious Species

Species	Common Name	# individuals
Smilacina rac	False Solomon's	123
Dennstaedtia	fern	62
Hamamelis v	Witch-hazel	4
Lisimachia trifolia		3
Acer rubrum	Red Maple saplir	5
Vaccinium va	Early lowbush bl	15
Rubus idaeus	Raspberry	58
Betula lenta	black birch	28
Vaccinium cc	Highland bluebe	1
Populus gran	Big-toothed Aspe	1

total samples 360

		Freq
Black birch	53	0.883333
Red maple	1	0.016667
Big-toothed a	3	0.05
Pin cherry	1	0.016667
N. Red Oak	1	0.016667
morpho3	1	0.016667
Total	60	

False Solom	123	0.41
Fern	62	0.206667
Witch-Hazel	4	0.013333
Lisimachia	3	0.01
red maple sa	5	0.016667
blueberry	15	0.05
raspberry	58	0.193333
black birch	28	0.093333
highland blue	1	0.003333
big-toothed a	1	0.003333
Total	300	

SIMPSON		n(i)*(n(i)-1)	(N(N-1)	(ni(ni-1))/(N(N-1))
Black birch	53	2756	129240	0.021325
Red maple	1	0	129240	0

Big-toothed a	3	6	129240	4.64E-05
Pin cherry	1	0	129240	0
N. Red Oak	1	0	129240	0
morpho3	1	0	129240	0
False Solom(	123	15006	129240	0.11611
Fern	62	3782	129240	0.029263
Witch-Hazel	4	12	129240	9.29E-05
Lisimachia	3	6	129240	4.64E-05
red maple sa	5	20	129240	0.000155
blueberry	15	210	129240	0.001625
raspberry	58	3306	129240	0.02558
black birch	28	756	129240	0.00585
highland blue	1	0	129240	0
big-toothed a	1	0	129240	0
	360		D=	0.200093
			1/D=	4.99768

SHANNON		pi=ni/N	pi ln pi
Black birch	53	0.147222	-0.28205
Red maple	1	0.002778	-0.01635
Big-toothed a	3	0.008333	-0.039896
Pin cherry	1	0.002778	-0.01635
N. Red Oak	1	0.002778	-0.01635
morpho3	1	0.002778	-0.01635
False Solom(	123	0.341667	-0.366923
Fern	62	0.172222	-0.302934
Witch-Hazel	4	0.011111	-0.049998
Lisimachia	3	0.008333	-0.039896
red maple sa	5	0.013889	-0.059398
blueberry	15	0.041667	-0.132419
raspberry	58	0.161111	-0.294134
black birch	28	0.077778	-0.198637
highland blue	1	0.002778	-0.01635
big-toothed a	1	0.002778	-0.01635
	360		-1.864385
			H'=1.86439

Plot 2	
pH	4.1
phosphorus	3
Potassium	140
Magnesium	80
Calcium	380
Ex Acidity (M	44
Aluminum	650
Iron	385
Manganese	40
Zinc	4.7
Organic Matt	12.1
Nitrate	16

stdev	bl birch	aspen	average
height	1.737523	2.730787	2.234155
DBH	13.52558	29.35601	21.44079
area	0.663039	1.970631	1.316835

Figure 33. 88-2 Herbaceous plants and saplings

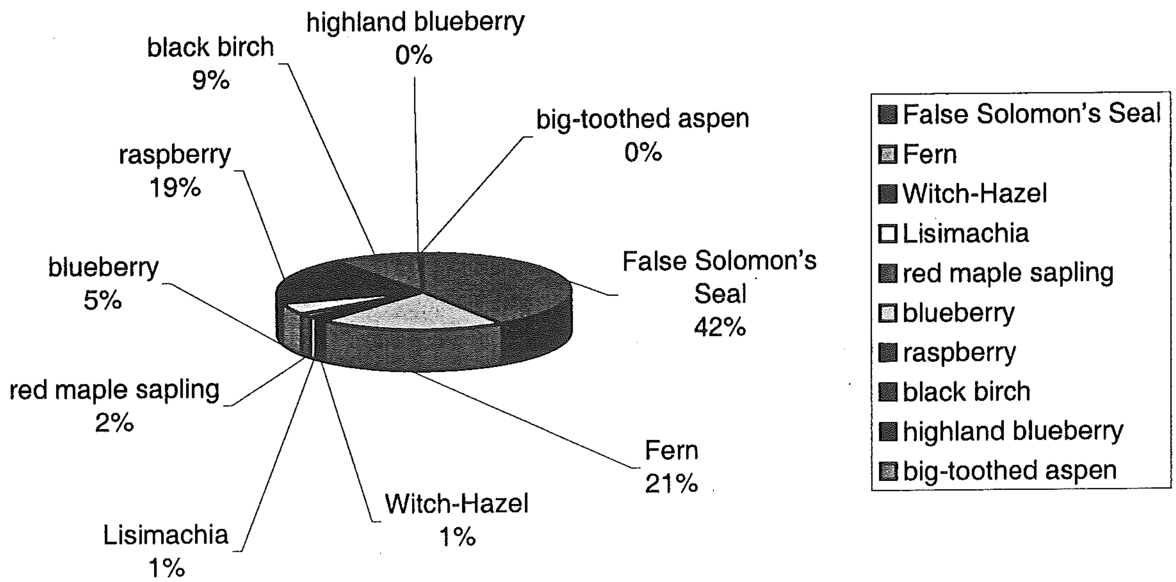
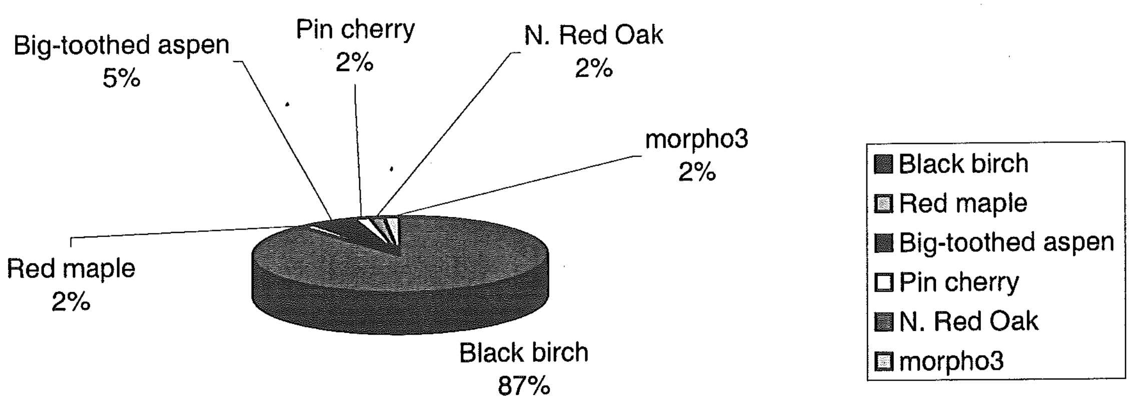


Figure 25. 88-2 Woody plants



Plot 88-3

P3 Species	Common Name	Height (m)	circumferei	DBH (in)	DBH (mm)	Basal Area	(x-avgx)^2
Betula lenta	Black birch	4	2.3	0.732484	18.6051	0.271727	0.314222
Betula lenta	Black birch	3.2	1.6	0.509554	12.94268	0.131498	0.4911
Betula lenta	Black birch	3.8	1.7	0.541401	13.75159	0.148448	0.46763
Betula lenta	Black birch	6.2	5.9	1.878981	47.72611	1.788059	0.913508
Betula lenta	Black birch	3.95	1.9	0.605096	15.36943	0.185432	0.418416
Betula lenta	Black birch	5	3.8	1.210191	30.73885	0.741729	0.0082
Betula lenta	Black birch	5	3.8	1.210191	30.73885	0.741729	0.0082
Betula lenta	Black birch	6.78	4.8	1.528662	38.82803	1.183478	0.123338
Betula lenta	Black birch	6.7	6.3	2.006369	50.96178	2.038726	1.455505
Betula lenta	Black birch	4.64	2.1	0.66879	16.98726	0.226525	0.366943
Betula lenta	Black birch	5.2	4.3	1.369427	34.78344	0.949762	0.013801
Betula lenta	Black birch	6.47	4	1.273885	32.35669	0.82186	0.000109
Betula lenta	Black birch	5.6	1.3	0.414013	10.51592	0.086809	0.555731
Betula lenta	Black birch	6.47	6	1.910828	48.53503	1.849185	1.034089
Betula lenta	Black birch	5.6	2.9	0.923567	23.4586	0.43199	0.160234
Betula papyrifera	White birch	6.25	5.9	1.878981	47.72611	1.788059	0.913508
Betula papyrifera	White birch	6.15	2.5	0.796178	20.22293	0.321039	0.26137
Betula papyrifera	White birch	6.15	6.1	1.942675	49.34395	1.911338	1.16436
Hamamelis virginiana	Witch-hazel	3.56	2.2	0.700637	17.79618	0.248613	0.340671
Hamamelis virginiana	Witch-hazel	3.56	1.8	0.573248	14.56051	0.166427	0.443365
Hamamelis virginiana	Witch-hazel	3.56	2.3	0.732484	18.6051	0.271727	0.314222
Quercus alba	White Oak	6.15	6.4	2.038217	51.7707	2.103961	1.617166
Prunus virginiana	chokecherry	4.9	4.1	1.305732	33.16561	0.863467	0.000972
Prunus virginiana	chokecherry	4.9	3.7	1.178344	29.92994	0.703204	0.016661
		5.157917		1.163747	29.55918	0.832283	

Herbacious Species

Species	Common Name	# individuals
Dennstaedtia punctilobula	Fern	36
Vaccinium vacillans	Early lowbush bl	70
Acer rubrum	red maple	4
Hamamelis virginiana	Witch-hazel	5
Maianthemum canadense	Lily-of-the-vally	8
Lisimachia quadrofolia		28
Rubus idaeus	raspberry	202
Betula lenta	Black birch	2
Prunus virginiana	chokecherry	1

Total samples 373

		Freq.
Black birch	17	0.653846
White birch	3	0.115385
Witch-hazel	3	0.115385
White oak	1	0.038462
Chokecherry	2	0.076923
Total	26	

		Freq.	total
fern	36	0.101124	382
blueberry	70	0.196629	
red maple	4	0.011236	

witch-hazel	5	0.014045		
Lily-of-the-valley	8	0.022472		
Lisimachia	28	0.078652		
raspberry	202	0.567416		
black birch	2	0.005618		
chokecherry	1	0.002809		
Total	356			
SIMPSON		n(i)*(n(i)-1)	(N(N-1)	(ni(ni-1))/(N(N-1))
Black birch	17	272	145542	0.001869
White birch	3	6	145542	4.12E-05
Witch-hazel	3	6	145542	4.12E-05
White oak	1	0	145542	0
Chokecherry	2	2	145542	1.37E-05
fern	36	1260	145542	0.008657
blueberry	70	4830	145542	0.033186
red maple	4	12	145542	8.25E-05
witch-hazel	5	20	145542	0.000137
Lily-of-the-valley	8	56	145542	0.000385
Lisimachia	28	756	145542	0.005194
raspberry	202	40602	145542	0.278971
black birch	2	2	145542	1.37E-05
chokecherry	1	0	145542	0
	382		D=	0.328592
			1/D=	3.043284

SHANNON		pi=ni/N	pi ln pi
Black birch	17	0.044503	-0.138501
White birch	3	0.007853	-0.038064
Witch-hazel	3	0.007853	-0.038064
White oak	1	0.002618	-0.015564
Chokecherry	2	0.005236	-0.027499
fern	36	0.094241	-0.222588
blueberry	70	0.183246	-0.310955
red maple	4	0.010471	-0.04774
witch-hazel	5	0.013089	-0.056754
Lily-of-the-valley	8	0.020942	-0.080963
Lisimachia	28	0.073298	-0.191545
raspberry	202	0.528796	-0.336924
black birch	2	0.005236	-0.027499
chokecherry	1	0.002618	-0.015564
	382		-1.548222
			H'=1.54822

Plot 3

pH	4
phosphorus	6
Potassium	225
Magnesium	125
Calcium	490
Ex Acidity (ME/100g)	58
Aluminum	665
Iron	245
Manganese	86

Zinc	9.4
Organic Matter %	18.5
Nitrate	20

var

11.40332

stdev	stdev	bl birch	wh birch	witch haz	choke	average
3.376881	height	1.153364	0.057735	0	0	0.302775
	DBH	13.7783	16.366	2.140194	2.287963	8.643116
	area	0.669677	0.884722	0.055343	0.113323	0.430766

Figure 34. 88-3 Herbaceous plants and saplings

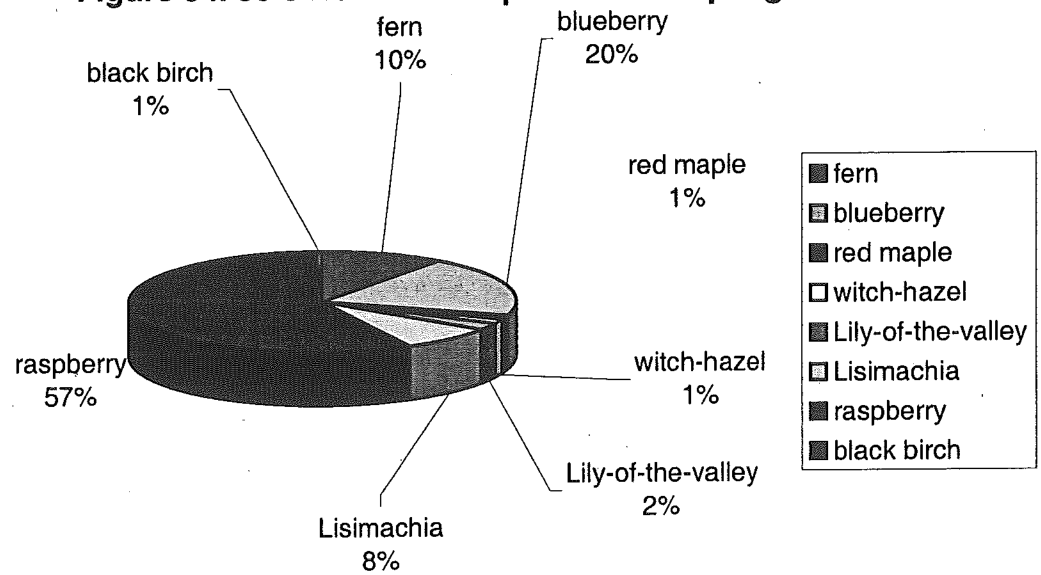
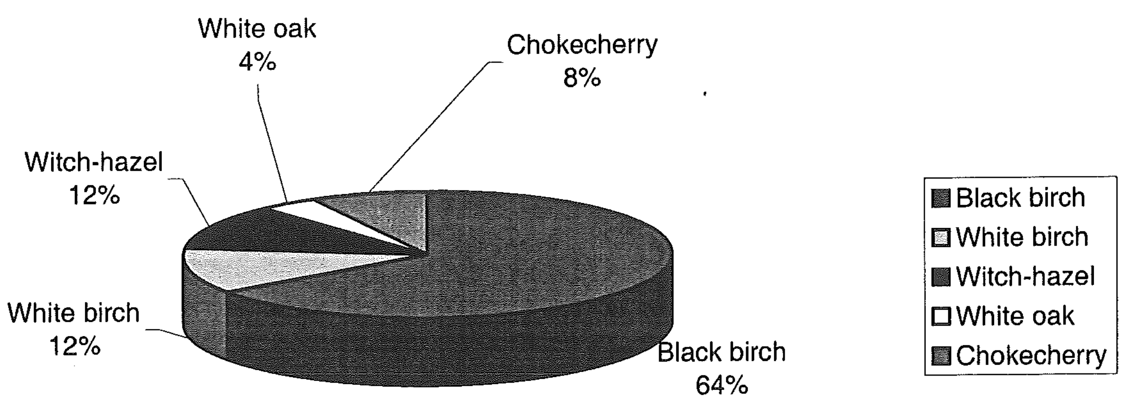


Figure 26. 88-3 Woody plants



Plot 88-4

P4 Species	Common Name	Height (m)	circumfere	DBH (in)	DBH (mm)	Basal Area	x-avgx	(x-avgx)^2
Betula lenta	Black birch	7.42	6.7	2.133758	54.19745	2.305831	1.312425	1.72246
Betula lenta	Black birch	8.5	8	2.547771	64.71338	3.287439	2.294034	5.262592
Betula lenta	Black birch	5.85	4.1	1.305732	33.16561	0.863467	-0.129939	0.016884
Betula lenta	Black birch	7.5	4	1.273885	32.35669	0.82186	-0.171546	0.029428
Betula lenta	Black birch	5.93	3.2	1.019108	25.88535	0.52599	-0.467415	0.218477
Betula lenta	Black birch	7.25	5.8	1.847134	46.9172	1.72796	0.734555	0.539571
Betula lenta	Black birch	7.38	6.1	1.942675	49.34395	1.911338	0.917932	0.8426
Betula lenta	Black birch	6.75	3.5	1.11465	28.3121	0.629236	-0.364169	0.132619
Betula lenta	Black birch	6.36	3.3	1.050955	26.69427	0.559378	-0.434027	0.188379
Betula lenta	Black birch	2.1	1.1	0.350318	8.898089	0.062153	-0.931252	0.867231
Betula lenta	Black birch	7.4	4.9	1.56051	39.63694	1.233303	0.239898	0.057551
Betula lenta	Black birch	7.65	3.6	1.146497	29.12102	0.665706	-0.327699	0.107387
Betula lenta	Black birch	8	5.2	1.656051	42.06369	1.388943	0.395538	0.15645
Betula lenta	Black birch	2.85	1.2	0.382166	9.707006	0.073967	-0.919438	0.845366
Betula lenta	Black birch	6.34	1.5	0.477707	12.13376	0.115574	-0.877831	0.770588
Betula lenta	Black birch	8.2	6.5	2.070064	52.57962	2.170224	1.176818	1.384901
Betula lenta	Black birch	6.34	3.1	0.987261	25.07643	0.49363	-0.499776	0.249776
Betula lenta	Black birch	8.2	4.6	1.464968	37.21019	1.08691	0.093504	0.008743
Acer pensylv	Striped maple	2.5	1	0.318471	8.089172	0.051366	-0.942039	0.887438
Liriodendron	Tulip-poplar	7.03	4	1.273885	32.35669	0.82186	-0.171546	0.029428
Liriodendron	Tulip-poplar	5.6	3.6	1.146497	29.12102	0.665706	-0.327699	0.107387
Carya cordifc	Bitternut hickory	2.95	1.6	0.509554	12.94268	0.131498	-0.861908	0.742885
Betula allegh	Yellow birch	6.45	4	1.273885	32.35669	0.82186	-0.171546	0.029428
Hamamelis v	Witch-hazel	2.5	1.2	0.382166	9.707006	0.073967	-0.919438	0.845366
Hamamelis v	Witch-hazel	1.5	1.1	0.350318	8.898089	0.062153	-0.931252	0.867231
Betula papyri	White birch	8	5.9	1.878981	47.72611	1.788059	0.794653	0.631474
Prunus virgin	Chokecherry	8.3	4.5	1.433121	36.40127	1.040166	0.046761	0.002187
Prunus virgin	Chokecherry	8.3	7.6	2.420382	61.47771	2.966914	1.973509	3.894737
Prunus virgin	Chokecherry	4.1	3	0.955414	24.26752	0.462296	-0.531109	0.282077
		6.112069		1.250824	31.77092	0.993405		

Herbacious species

Species	Common name	# individuals
Liriodendron	tulip sapling	1
Acer rubrum	red maple saplin	1
Acer sacchar	sugar maple sap	4
Maianthemur	Lily-of-the-valley	9
Hamamelis v	Witch-hazel sapli	2
Rubus idaeu	raspberry	79
Smilacina rac	False Solomon's	54
Dennstaedtia	fern	31
Vaccinium va	Early lowbush bl	6
Lisimachia quadrofolia		3
Acer pensylv	striped maple	2
Betula lenta	Black birch	2

total samples 225

		Freq
Striped mapl	1	0.032258
Black birch	20	0.645161

Tulip	2	0.064516
Bitternut hick	1	0.032258
Yellow birch	1	0.032258
White birch	1	0.032258
Chokecherry	3	0.096774
Witch-hazel	2	0.064516
Total	31	

		Freq
tulip sapling	1	0.005155
red maple sa	1	0.005155
sugar maple	4	0.020619
Lily-of-the-va	9	0.046392
witch-hazel s	2	0.010309
raspberry	79	0.407216
false solomoı	54	0.278351
fern	31	0.159794
lisimachia	3	0.015464
blueberry	6	0.030928
striped maple	2	0.010309
black birch	2	0.010309
Total	194	

SIMPSON		n(i)*(n(i)-1)	(N(N-1)	(ni(ni-1))/(N(N-1))
Striped maple	1	0	50400	0
Black birch	20	380	50400	0.00754
Tulip	2	2	50400	3.97E-05
Bitternut hick	1	0	50400	0
Yellow birch	1	0	50400	0
White birch	1	0	50400	0
Chokecherry	3	6	50400	0.000119
Witch-hazel	2	2	50400	3.97E-05
tulip sapling	1	0	50400	0
red maple sa	1	0	50400	0
sugar maple	4	12	50400	0.000238
Lily-of-the-va	9	72	50400	0.001429
witch-hazel s	2	2	50400	3.97E-05
raspberry	79	6162	50400	0.122262
false solomoı	54	2862	50400	0.056786
fern	31	930	50400	0.018452
lisimachia	3	6	50400	0.000119
blueberry	6	30	50400	0.000595
striped maple	2	2	50400	3.97E-05
black birch	2	2	50400	3.97E-05
	225		D=	0.207738
			1/D=	4.813754

SHANNON		pi=ni/N	pi ln pi
Striped maple	1	0.004444	-0.024072
Black birch	20	0.088889	-0.215144
Tulip	2	0.008889	-0.041982
Bitternut hick	1	0.004444	-0.024072
Yellow birch	1	0.004444	-0.024072
White birch	1	0.004444	-0.024072

Chokecherry	3	0.013333	-0.057567
Witch-hazel	2	0.008889	-0.041982
tulip sapling	1	0.004444	-0.024072
red maple sa	1	0.004444	-0.024072
sugar maple	4	0.017778	-0.071641
Lily-of-the-va	9	0.04	-0.128755
witch-hazel s	2	0.008889	-0.041982
raspberry	79	0.351111	-0.367491
false solomoı	54	0.24	-0.342508
fern	31	0.137778	-0.273091
lisimachia	3	0.013333	-0.057567
blueberry	6	0.026667	-0.096649
striped maple	2	0.008889	-0.041982
black birch	2	0.008889	-0.041982
	225		-1.964751
			H'=1.96475

Plot 4

pH	4
phosphorus	5
Potassium	205
Magnesium	155
Calcium	960
Ex Acidity (M	58
Aluminum	468
Iron	166
Manganese	72
Zinc	7.9
Organic Matt	17.9
Nitrate	17

var

21.72064

stdev	stdev	black birch	tulip	witch	chokecherr	average
4.660541	height	1.721872	1.011163	0.707107	2.424871	1.466253
	DBH	15.64426	2.287963	0.571991	18.97654	9.370188
	area	0.880155	0.110417	0.008354	1.31145	0.577594

Figure 35. 88-4 Herbaceous plants and saplings

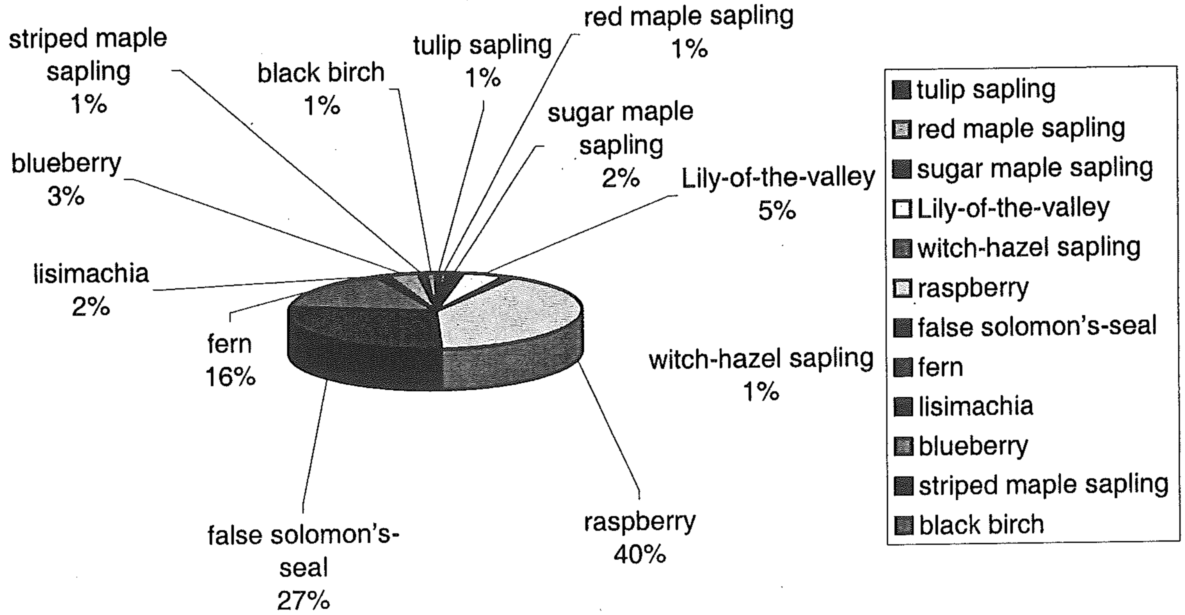
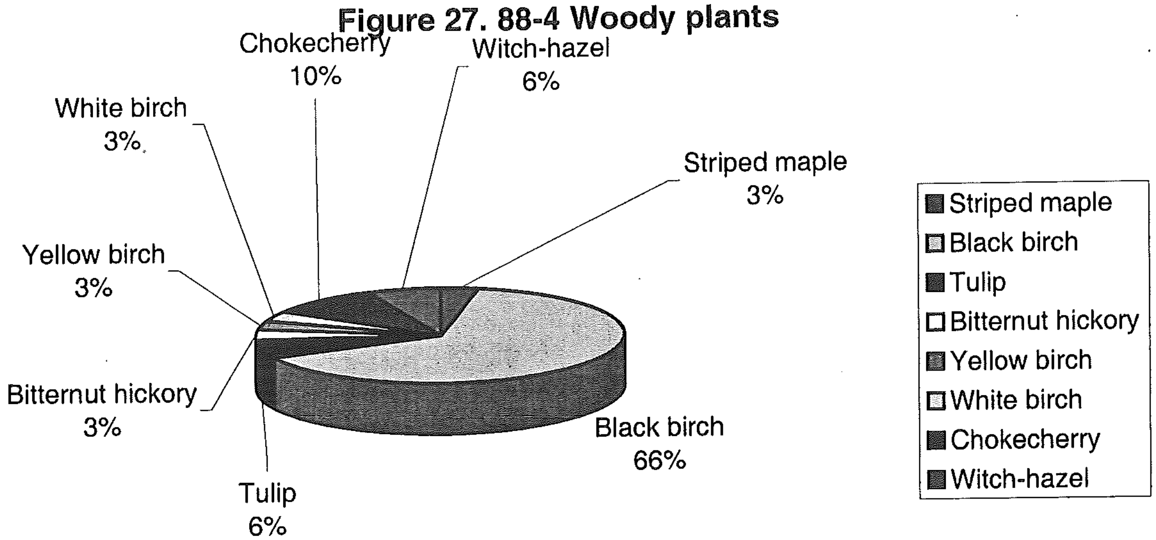


Figure 27. 88-4 Woody plants



Plot 88-6

P6 Species	Common Name	Height (m)	circumference (in)	DBH (in)	DBH (mm)	Basal Area	(x-avgx)^2
Betula lenta	Black birch	5.1	2.5	0.796178	20.22293	0.321039	0.000826
Betula lenta	Black birch	6.15	5.1	1.624204	41.25478	1.336036	0.972708
Betula lenta	Black birch	5.55	3.8	1.210191	30.73885	0.741729	0.153626
Betula lenta	Black birch	6.1	3.9	1.242038	31.54777	0.781281	0.186196
Betula lenta	Black birch	4.56	2	0.636943	16.17834	0.205465	0.020826
Betula lenta	Black birch	5.93	4.5	1.433121	36.40127	1.040166	0.476638
Betula lenta	Black birch	2.7	1.2	0.382166	9.707006	0.073967	0.076071
Betula lenta	Black birch	3.5	2.2	0.700637	17.79618	0.248613	0.010234
Betula lenta	Black birch	4.97	3.1	0.987261	25.07643	0.49363	0.020694
Betula lenta	Black birch	3.5	2	0.636943	16.17834	0.205465	0.020826
Betula lenta	Black birch	2.95	1.3	0.414013	10.51592	0.086809	0.069152
Betula lenta	Black birch	2.87	1.5	0.477707	12.13376	0.115574	0.054851
Betula lenta	Black birch	3.8	2.2	0.700637	17.79618	0.248613	0.010234
Betula lenta	Black birch	2.14	1.6	0.509554	12.94268	0.131498	0.047646
Betula lenta	Black birch	3.62	1.7	0.541401	13.75159	0.148448	0.040533
Betula lenta	Black birch	3.25	1.4	0.44586	11.32484	0.100678	0.06205
Betula lenta	Black birch	5.3	2.8	0.89172	22.64968	0.402711	0.002802
Betula lenta	Black birch	4.8	1.6	0.509554	12.94268	0.131498	0.047646
Betula lenta	Black birch	5.7	2.5	0.796178	20.22293	0.321039	0.000826
Betula lenta	Black birch	3.5	1.4	0.44586	11.32484	0.100678	0.06205
Betula lenta	Black birch	6.1	4.2	1.33758	33.97452	0.906101	0.309496
Betula lenta	Black birch	3.4	2	0.636943	16.17834	0.205465	0.020826
Betula lenta	Black birch	4.94	2.9	0.923567	23.4586	0.43199	0.006759
Betula lenta	Black birch	2.56	1.3	0.414013	10.51592	0.086809	0.069152
Betula lenta	Black birch	4.4	2.2	0.700637	17.79618	0.248613	0.010234
Betula lenta	Black birch	5.77	3.5	1.11465	28.3121	0.629236	0.078098
Betula lenta	Black birch	2.7	1.1	0.350318	8.898089	0.062153	0.082727
Betula lenta	Black birch	3.84	2	0.636943	16.17834	0.205465	0.020826
Betula lenta	Black birch	6.24	4.1	1.305732	33.16561	0.863467	0.263877
Betula lenta	Black birch	6.27	3.4	1.082803	27.50318	0.593794	0.059544
Betula lenta	Black birch	2.74	1	0.318471	8.089172	0.051366	0.089049
Betula lenta	Black birch	2.47	1.3	0.414013	10.51592	0.086809	0.069152
Betula lenta	Black birch	5.45	3.2	1.019108	25.88535	0.52599	0.031051
Betula lenta	Black birch	2.73	2	0.636943	16.17834	0.205465	0.020826
Betula lenta	Black birch	5.54	2.4	0.764331	19.41401	0.29587	0.002906
Betula lenta	Black birch	5.54	1.7	0.541401	13.75159	0.148448	0.040533
Betula lenta	Black birch	3.9	2	0.636943	16.17834	0.205465	0.020826
Betula lenta	Black birch	5.85	3.1	0.987261	25.07643	0.49363	0.020694
Betula lenta	Black birch	6	2.1	0.66879	16.98726	0.226525	0.015191
Betula lenta	Black birch	4.57	1.8	0.573248	14.56051	0.166427	0.033617
Betula lenta	Black birch	4.04	2.8	0.89172	22.64968	0.402711	0.002802
Betula lenta	Black birch	5.54	3.8	1.210191	30.73885	0.741729	0.153626
Betula lenta	Black birch	3.9	1.5	0.477707	12.13376	0.115574	0.054851
Betula lenta	Black birch	5.85	4.5	1.433121	36.40127	1.040166	0.476638
Betula lenta	Black birch	6.7	2	0.636943	16.17834	0.205465	0.020826
Betula lenta	Black birch	6	3.5	1.11465	28.3121	0.629236	0.078098
Betula lenta	Black birch	4.57	2.2	0.700637	17.79618	0.248613	0.010234
Betula lenta	Black birch	4.04	1.4	0.44586	11.32484	0.100678	0.06205
Betula lenta	Black birch	6.7	4.4	1.401274	35.59236	0.99445	0.415604
Liriodendron	Tulip-poplar	3.14	1.5	0.477707	12.13376	0.115574	0.054851
Acer rubrum	Red maple	4	3.2	1.019108	25.88535	0.52599	0.031051

Acer rubrum	Red maple	3.52		1.8	0.573248	14.56051	0.166427	0.033617
Acer rubrum	Red maple	3.57		1.3	0.414013	10.51592	0.086809	0.069152
Acer rubrum	Red maple	3.57		1.8	0.573248	14.56051	0.166427	0.033617
Acer rubrum	Red maple	2.35		1.3	0.414013	10.51592	0.086809	0.069152
Quercus albɛ	White Oak	2.25		1.3	0.414013	10.51592	0.086809	0.069152
		4.406071			0.761488	19.34179	0.349777	
Herbaceous plants and saplings			# individuals					
Dennstaedtia	Fern			40				
Rubus idaeu:	Raspberry			51				
Maianthemur	Lily-of-the-valley			70				
Vaccinium cc	Highbush blueberry			3				
Smilacina rac	False Solomon's Seal			2				
Vaccinium vɛ	Early lowbush blueberry			3				
Betula lenta	Black birch			7				
Acer rubrum	Red maple			2				
Lisimachia trifolia				5				

Total #indivic 239

		Freq.
Black birch	49	0.875
Tulip	1	0.017857
Red maple	5	0.089286
White Oak	1	0.017857
Total	56	

		Freq
fern	40	0.218579
raspberry	51	0.278689
lily-of-the-vall	70	0.382514
highbush blu	3	0.016393
false solomoı	2	0.010929
early lowbusl	3	0.016393
black birch sɛ	7	0.038251
red maple sa	2	0.010929
lisimachia	5	0.027322
Total	183	

SIMPSON		n(i)*(n(i)-1)	(N(N-1)	(ni(ni-1))/(N(N-1))
Black birch	49	2352	56882	0.041349
Tulip	1	0	56882	0
Red maple	5	20	56882	0.000352
White Oak	1	0	56882	0
fern	40	1560	56882	0.027425
raspberry	51	2550	56882	0.04483
lily-of-the-vall	70	4830	56882	0.084913
highbush blu	3	6	56882	0.000105
false solomoı	2	2	56882	3.52E-05
early lowbusl	3	6	56882	0.000105
black birch sɛ	7	42	56882	0.000738
red maple sa	2	2	56882	3.52E-05
lisimachia	5	20	56882	0.000352
	239	D=		0.200239

		1/D=	4.99403

SHANNON		pi=ni/N	pi ln pi
Black birch	49	0.205021	-0.324885019
Tulip	1	0.004184	-0.022914073
Red maple	5	0.020921	-0.080900118
White Oak	1	0.004184	-0.022914073
fern	40	0.167364	-0.299177255
raspberry	51	0.213389	-0.329608928
lily-of-the-vall	70	0.292887	-0.35965599
highbush blu	3	0.012552	-0.054952108
false solomo	2	0.008368	-0.040027752
early lowbus	3	0.012552	-0.054952108
black birch s	7	0.029289	-0.10340533
red maple sa	2	0.008368	-0.040027752
lisimachia	5	0.020921	-0.080900118
	239		-1.814320625
			H'=1.814320625

Plot 6

pH	4.1
phosphorus	2
Potassium	230
Magnesium	110
Calcium	490
Ex Acidity (M	53
Aluminum	600
Iron	319
Manganese	52
Zinc	8
Organic Matt	16.8
Nitrate	18

var				
5.23714	stdev	bl birch	red maple	average
stdev	height	1.316896	0.619411	0.968153
2.28848	DBH	8.661062	6.30229	7.481676
	area	0.317755	0.182988	0.250371

Figure 37. 88-6 Herbaceous plants and saplings

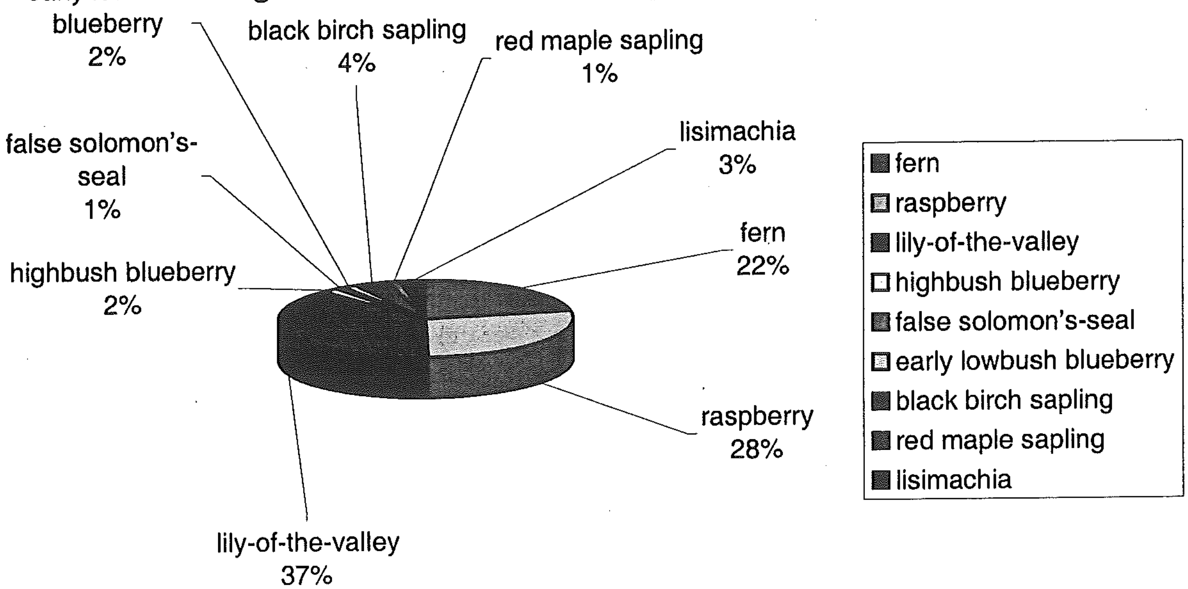
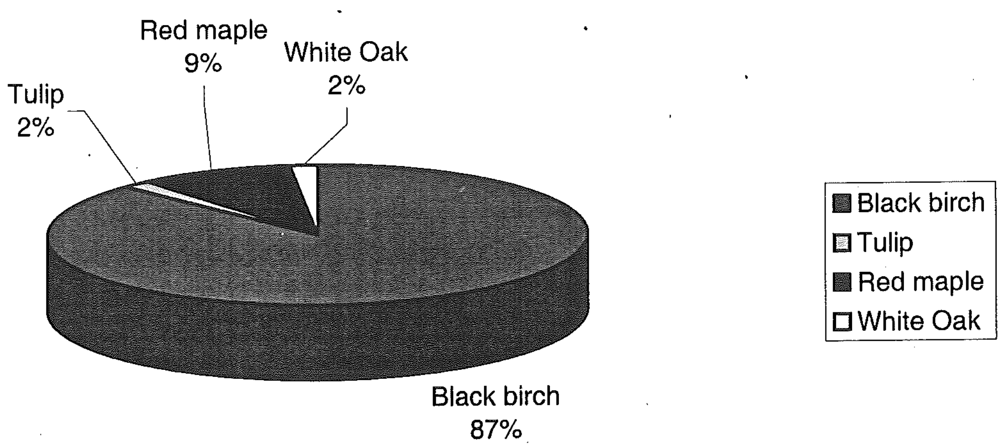


Figure 28. 88-6 Woody plants



Plot 88-7

P7 Species	Common Name	Height (m)	circumferei	DBH (in)	DBH (mm)	Basal area	(x-avgx)^2	var
Betula lent	Black birch	6.25	3.9	1.242038	31.54777	0.781281	0.010985	64.6994
Betula lent	Black birch	5.7	3.4	1.082803	27.50318	0.593794	0.006836	stdev
Betula lent	Black birch	6.1	3.4	1.082803	27.50318	0.593794	0.006836	8.043594
Betula lent	Black birch	6.95	4.8	1.528662	38.82803	1.183478	0.257055	
Betula lent	Black birch	6.05	3	0.955414	24.26752	0.462296	0.045871	
Betula lent	Black birch	3.3	1.3	0.414013	10.51592	0.086809	0.347703	
Betula lent	Black birch	4.14	2	0.636943	16.17834	0.205465	0.221848	
Betula lent	Black birch	2.5	1.1	0.350318	8.898089	0.062153	0.377388	
Betula lent	Black birch	4.93	3	0.955414	24.26752	0.462296	0.045871	
Betula lent	Black birch	5.55	3.7	1.178344	29.92994	0.703204	0.000715	
Betula lent	Black birch	5.1	4.1	1.305732	33.16561	0.863467	0.034967	
Betula lent	Black birch	3.02	1.3	0.414013	10.51592	0.086809	0.347703	
Betula lent	Black birch	3.63	1.9	0.605096	15.36943	0.185432	0.24112	
Betula lent	Black birch	3.42	1.5	0.477707	12.13376	0.115574	0.314607	
Betula lent	Black birch	4.4	2.5	0.796178	20.22293	0.321039	0.126333	
Betula lent	Black birch	2.7	1.7	0.541401	13.75159	0.148448	0.278809	
Liriodendrc	Tulip-poplar	8	12.8	4.076433	103.5414	8.415845	59.8979	
Acer rubrui	Red maple	3.4	1.6	0.509554	12.94268	0.131498	0.296997	
Acer rubrui	Red maple	2	1.5	0.477707	12.13376	0.115574	0.314607	
Acer rubrui	Red maple	2.32	1.1	0.350318	8.898089	0.062153	0.377388	
Acer rubrui	Red maple	2.6	1.3	0.414013	10.51592	0.086809	0.347703	
Acer rubrui	Red maple	2.7	1.1	0.350318	8.898089	0.062153	0.377388	
Quercus al	White Oak	3.13	2.9	0.923567	23.4586	0.43199	0.059771	
morpho 3		2.87	1.2	0.382166	9.707006	0.073967	0.363012	
		4.198333		0.877123	22.27893	0.676472		

Herbacious plants and saplings		# individuals
Acer pensy	Striped maple	1
Acer rubrui	Red maple	15
Liriodendrc	Tulip-poplar	1
Betula lent	Black birch	7
Betula	birch	1
Quercus al	White Oak	1
Acer sacch	Sugar maple	2
Quercas ru	Northern Red Oak	1
Smilacina r	False Solomon's Seal	9
Vaccinium	Early lowbush blueberry	49
Rubus idae	Raspberry	46
Maianthem	Lily-of-the-valley	9
Vaccinium	Highbush blueberry	5
Dennstaed	Fern	26

Total samp 197

		Freq
Black birch	16	0.695652
Tulip-popla	1	0.043478
Red maple	5	0.217391
White oak	1	0.043478
Total	23	
		Freq

Striped ma	1	0.00578
Red maple	15	0.086705
Tulip-popla	1	0.00578
Black birch	7	0.040462
morphobirc	1	0.00578
White Oak	1	0.00578
Sugar map	2	0.011561
N. Red Oal	1	0.00578
False Soloi	9	0.052023
Early lowbı	49	0.283237
Highbush t	5	0.028902
Raspberry	46	0.265896
Lily-of-the-'	9	0.052023
Fern	26	0.150289
Total	173	

SIMPSON		n(i)*(n(i)-1)	(N(N-1)	(ni(ni-1))/(N(N-1))
Black birch	16	240	38220	0.006279
Tulip-popla	1	0	38220	0
Red maple	5	20	38220	0.000523
White oak	1	0	38220	0
Striped ma	1	0	38220	0
Red maple	15	210	38220	0.005495
Tulip-popla	1	0	38220	0
Black birch	7	42	38220	0.001099
morphobirc	1	0	38220	0
White Oak	1	0	38220	0
Sugar map	2	2	38220	5.23E-05
N. Red Oal	1	0	38220	0
False Soloi	9	72	38220	0.001884
Early lowbı	49	2352	38220	0.061538
Highbush t	5	20	38220	0.000523
Raspberry	46	2070	38220	0.05416
Lily-of-the-'	9	72	38220	0.001884
Fern	26	650	38220	0.017007
	196		D=	0.150445
			1/D=	6.646957

SHANNON		pi=ni/N	pi ln pi
Black birch	16	0.081633	-0.204533
Tulip-popla	1	0.005102	-0.026929
Red maple	5	0.02551	-0.093589
White oak	1	0.005102	-0.026929
Striped ma	1	0.005102	-0.026929
Red maple	15	0.076531	-0.196689
Tulip-popla	1	0.005102	-0.026929
Black birch	7	0.035714	-0.119007
morphobirc	1	0.005102	-0.026929
White Oak	1	0.005102	-0.026929
Sugar map	2	0.010204	-0.046785
N. Red Oal	1	0.005102	-0.026929
False Soloi	9	0.045918	-0.141469
Early lowbı	49	0.25	-0.346574

Highbush t	5	0.02551	-0.093589
Raspberry	46	0.234694	-0.340183
Lily-of-the-'	9	0.045918	-0.141469
Fern	26	0.132653	-0.267962
	196		-2.180352
			H'=2.18035

Plot 7

pH	3.8
phosphoru:	6
Potassium	255
Magnesiun	175
Calcium	650
Ex Acidity (	63
Aluminum	429
Iron	201
Manganes(	53
Zinc	10.3
Organic Mε	22.2
Nitrate	20

Figure 38. 88-7 Herbaceous plants and saplings

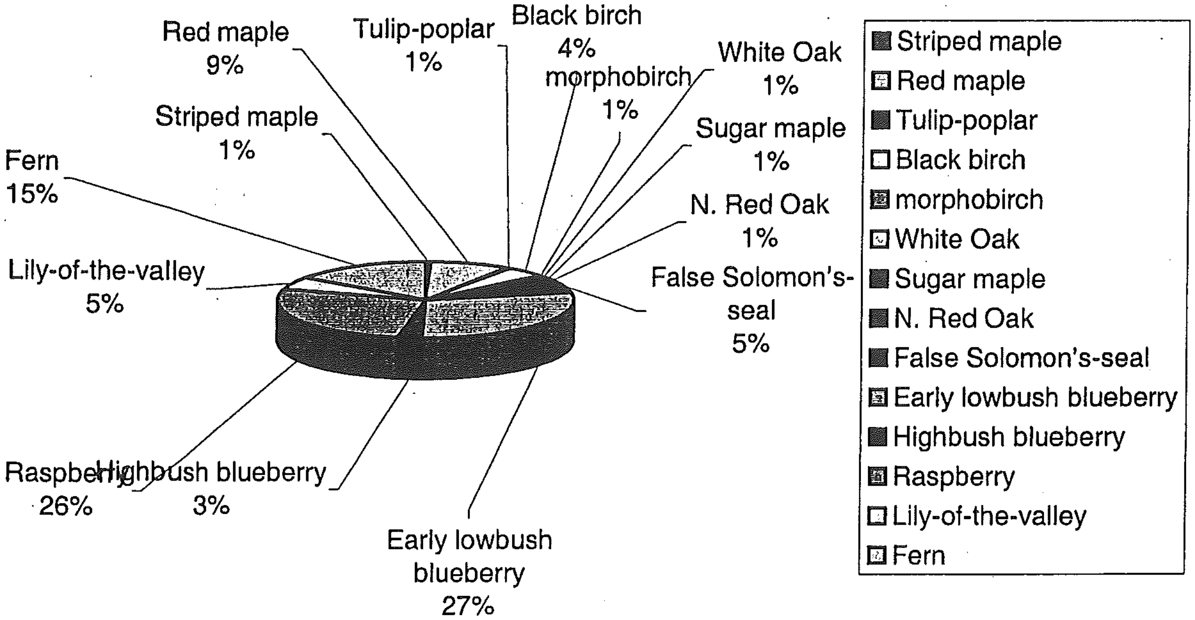
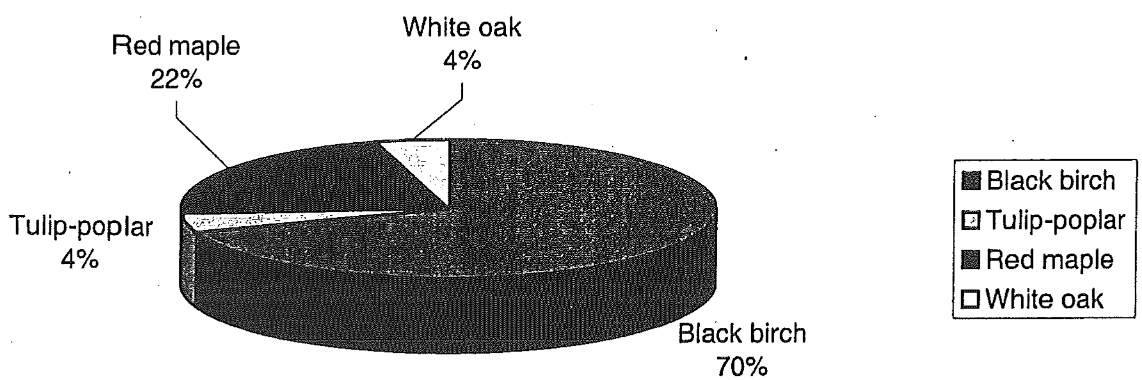


Figure 29. 88-7 Woody plants



stdev	bl birch	red maple	average
height	1.410886	0.521613	0.966249
Dbh	9.349324	1.844615	5.596969
area	0.334711	0.03132	0.183016