# The Effects of Logging on Understory Plants
# Pre-treatment Surveys 1997-2002

by


Karen C. Danielsen
Forest Ecologist



Administrative Report 07-09
August 2007



**Great Lakes Indian Fish and Wildlife Commission**
Biological Services Division
PO Box 9, 100 Maple Road
Odanah, WI 54861
715.682.6619

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# THE EFFECTS OF LOGGING ON UNDERSTORY PLANTS
# PRE-TREATMENT SURVEYS 1997 - 2002

## INTRODUCTION

Anishinaabe bands that signed the Treaties of 1836, 1837, 1842, and 1854 retain hunting, fishing, and gathering rights within lands ceded to the U.S. Government. These lands include present-day northern Michigan, Wisconsin, and Minnesota (Figure 1). The natural resources found on these ceded lands continue to play an important role in the Anishinaabe lifeway by providing food, medicine, utility supplies and ceremonial items. Plants, in particular, serve many different functions and remain inextricably woven into Anishinaabe culture (Meeker et al. 1994).

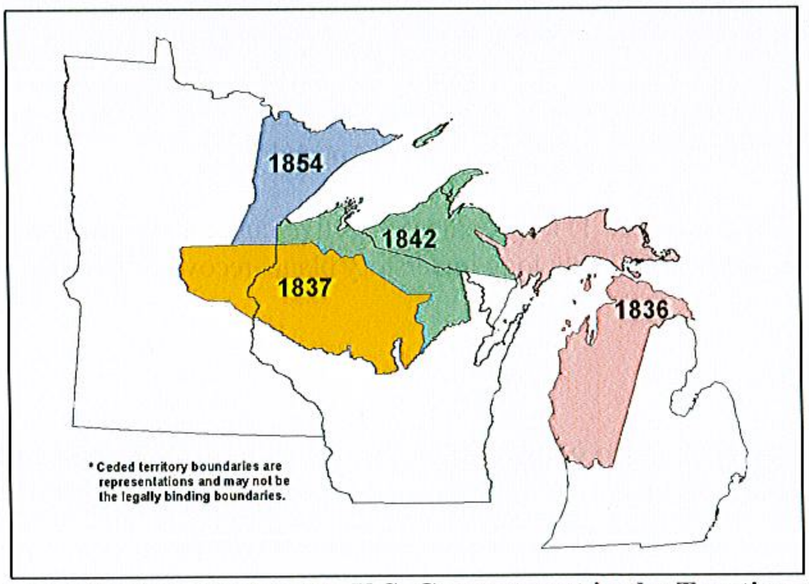


**Figure 1: Territories ceded to the U.S. Government in the Treaties of 1836, 1837, 1842 and 1854**

Many of these plant species occur within northern hardwood forests and have adapted to the environmental conditions existing under tree canopies. These "understory" plants often begin their seasonal growth during early spring while sunlight filters down through the still leafless deciduous trees. After the trees form a dense canopy of leaves, understory plants either set seed and wilt or continue growing under low light levels. Though canopy gaps form naturally by windthrow or individual tree mortality, commercial logging creates gaps to which understory plants may not be adapted.

Scientists have raised concerns regarding the impact of logging on understory plants and have emphasized the need for extensive research (Crow et al. 1994). Several studies have documented some of these impacts, such as an overall decline in understory species richness and cover, while simultaneously showing an increase in non-native species (Metzger and Schultz 1981, Whitney and Foster 1988, Duffy and Meier 1992, Bratton et al. 1994, Crow et al. 1994). These studies, however, have been limited to comparative observations of logged verses un-logged sites and have been criticized for failing to distinguish logging impacts from pre-existing site differences (Johnson et al. 1993). Subsequently, scientists and other interested individuals have emphasized the need to conduct studies that document site conditions both before and after logging treatments. Furthermore, many of these previous studies focused on sites that had experienced clear-cut logging techniques rather than the selective-cut logging techniques that are currently most often prescribed in hardwood forests.

In response, staff from the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) proposed a long-term study to be initiated before logging activities (specifically using selective-cut techniques) in order to address the need to document pre-existing site conditions unrelated to logging impacts. The USDA Forest Service recognized the merit of assessing selective-cut logging impacts to understory plants and agreed to work with GLIFWC staff to develop and implement this study on the Chequamegon-Nicolet National Forest. A Memorandum of Agreement was drafted and signed in August 1997 (Appendix B).

The goal of this study is twofold: 1) to document selective-cut logging impacts to understory plants; and 2) to document if and how long understory plants recover to pre-logging conditions.

## Report Objective

The objectives of this report are to summarize pre-treatment data and to compare these data between treatment and control plots to determine if the plots are more similar within sites than between sites.

# METHODS

## Study Sites

Four study sites, all with similar characteristics, were selected within northern hardwood stands on the Medford-Park Falls Ranger District of the Chequamegon-Nicolet National Forest (Figure 2). They all have a history of logging, but have had minimal disturbance since the 1920's. Their vegetation composition has been classified as Acer-Hydrophyllum habitat types (Kotar 1988), with the dominant tree species: sugar maple[1], basswood, bitternut hickory, white ash and green ash (Table 1). Though all the sites have silty loam soils, one site (site 1) has the moderate to well drained soils associated with ice-walled lakes, while the remaining sites (sites 2-4) have the poor to moderate drained soils associated with ground moraines (Attig 1993, Keys Jr. et al. 1995).

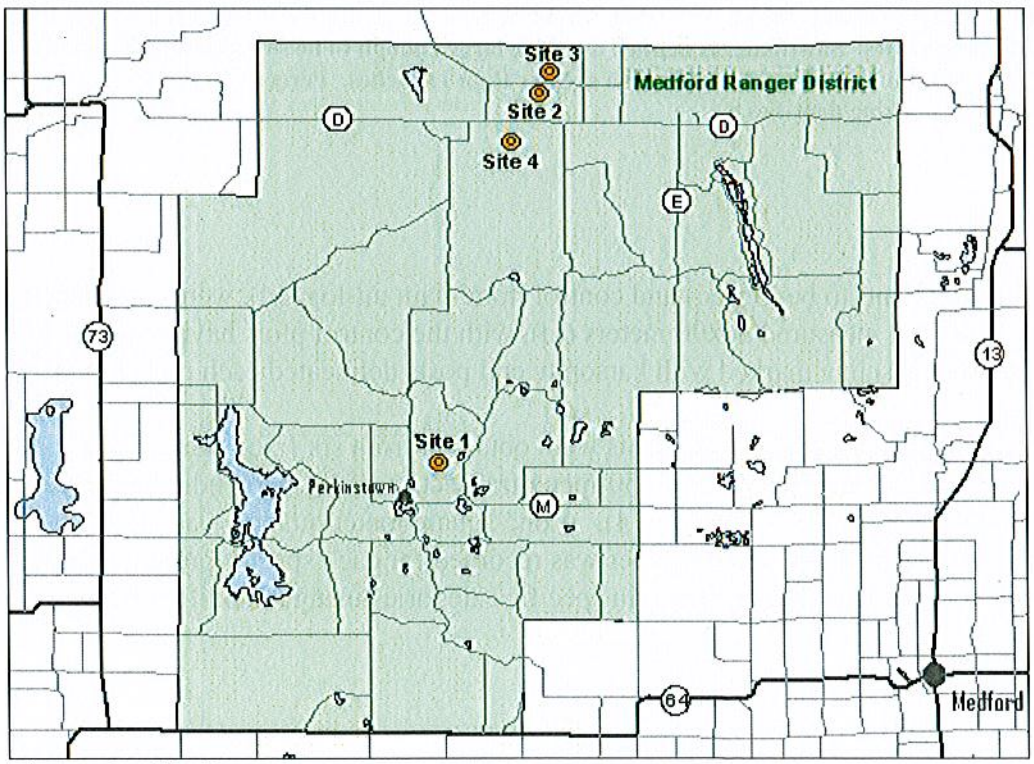


**Figure 2: Site Locations**

[1] Ojibwe and scientific names are listed in Appendix A

**Table 1: Plot descriptions: Chequamegon-Nicolet National Forest Timber Information Management Database.**

| | Site 1 | Site 2 | Site 3 | Site 4 |
|---|---|---|---|---|
| **Compartment number** | 118 | 49 | 51 | 48 |
| **Stand number** | 2 | 1 | 9 | 8 |
| **Stand area (acres)** | 93 | 86 | 62 | 140 |
| **Year of origin** | 1922 | 1914 | 1927 | 1926 |
| **Year of field survey** | 2003 | 1990 | 1990 | 1990 |
| **Forest type** | Sugar maple - basswood | Sugar maple | Sugar maple - basswood | Sugar maple |
| **Size-density class*** | Sawtimber (≥ 70%) | Sawtimber (≥ 70%) | Sawtimber (≥ 70%) | Sawtimber (≥ 70%) |
| **Basal area (sq ft/acre)** | 121 | 110 | 110 | 110 |
| **Average dbh (inches)** | 14 | 12 | 12 | 11 |

*** Size-density class was calculated by the Forest Service using average dbh (diameter at breast height) and basal area values. Sawtimber is defined as a tree large enough to be sawed into lumber; for hardwoods, this means a tree with a dbh greater than 11 inches. Percentage values in parentheses represent stocking densities.**

## Study Design

Paired plots, treatment (to be logged) and control (to remain un-logged), were established at each study site. Each plot measured 50x90 meters (m), with the control plots having a 10 m buffer on all sides. A 90 m baseline marked with karsonite end posts delineated each plot (Figure 3).

Within each plot, data for understory plants were obtained from six fixed sampling points placed at random distances along each of seven 50-meter transects running perpendicular to the baseline at 0, 15, 30, 45, 60, 75, and 90 m (Figure 4). A one-square meter quadrat was placed at each sampling point, within which percent cover was recorded for each species present (Bonham 1989). Percent cover was estimated within specific categories using a modified Braun-Blauquet Scale:

<< 1%
< 1%
1-5 %
6-25 %
26-50 %
51-75 %
76-100 %

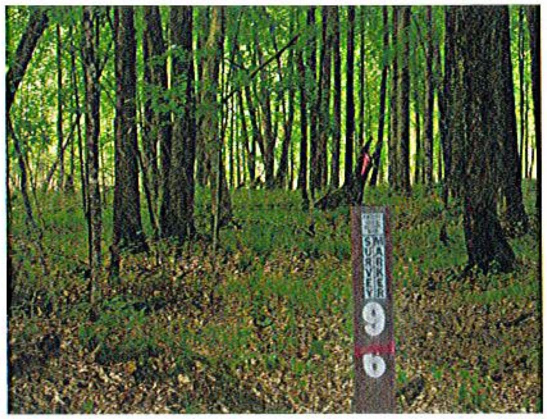


**Figure 3: Site 1, Control Plot**

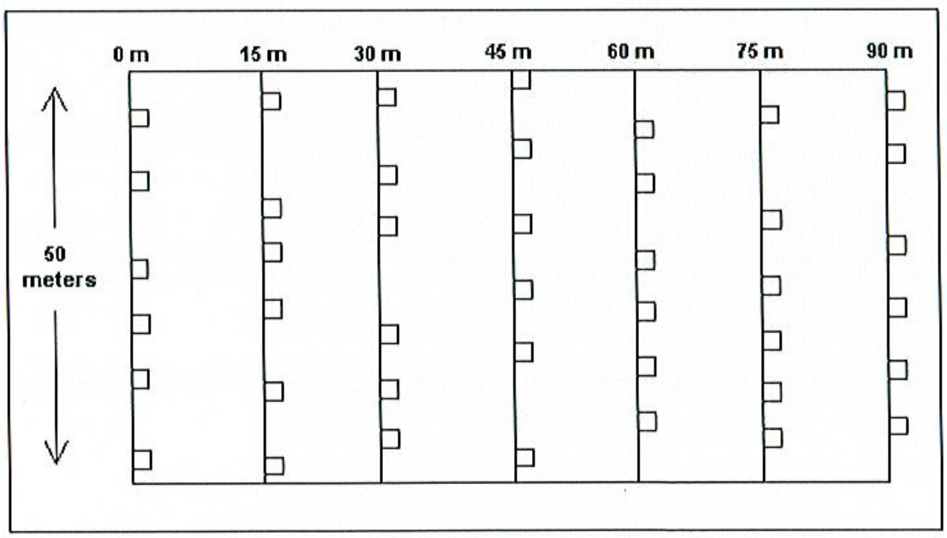


**Figure 4: Plot Design - seven transects, measuring 50 meters each, were laid out every 15 meters along a 90-meter baseline. Data were collected within six randomly placed square-meter quadrats along each transect.**

Data collection began six years prior to treatments (selective-cut logging began in 2003) and generally occurred twice each year, once in late May to record early blooming spring ephemeral forbs and again in late July to record late blooming summer plants (Table 2). Not all sites were sampled for all years and seasons. However, pre-treatment sampling occurred at all sites for at least three spring and three summer seasons. Multiple-year sampling allowed for data collection under varying annual weather patterns, which have been documented to affect plant species cover and distribution (Bonham 1989, Kennedy and Addison 1987, Bierzychudek 1982).

**Table 2: Pre-treatment sampling, year and season by site**

| | | Site 1 | Site 2 | Site 3 | Site 4 |
|---|---|---|---|---|---|
| 1997 | Spring | | | | |
| | Summer | x | x | x | x |
| 1998 | Spring | | x | x | x |
| | Summer | x | x | x | x |
| 1999 | Spring | x | x | x | x |
| | Summer | x | x | x | x |
| 2000 | Spring | x | x | x | x |
| | Summer | x | x | x | x |
| 2002 | Spring | x | | | |
| | Summer | x | | | |

## Pre-treatment Data Analysis

Mean species richness (number of species) for each plot was calculated by averaging the plot's species richness over all years. Mean species richness comparisons between plots were analyzed using the Kruskall-Wallis One-Way Analysis of Variance (Zar 1984) through the software package *Systat 10.2 for Windows.*

Species composition was characterized through mean percent cover, mean frequency and importance values. Mean percent cover for each species was calculated by averaging the percent cover of that species (determined by averaging the percent cover in all 42 quadrats in each plot) over all the years. Because percent cover data were recorded using modified Braun-Blauquet categories, midpoint values for each of the categories were used for calculations. The mean frequency for each species was calculated by averaging the frequency of that species over all the years.

Importance values use both percent cover and frequency values to determine the overall status of a species within each plot. The importance value for each species was calculated as the sum of that species' relative cover and relative frequency over all years (modified by Cox 1976). Relative cover for each species was calculated by dividing that species' percent cover by the total sum of all the species' percent cover. Relative frequency for each species was calculated by dividing that species' frequency by the total sum of all the species' frequencies.

Species composition comparisons between plots (using mean percent cover values for all species) were analyzed using two multivariate methods, Bray-Curtis Ordination (Ludwig and Reynolds 1988) and Cluster Analysis (Neff and Marcus 1980), through the software package *PC-ORD 4.14 for Windows.* For both methods, the Sørensen distance measure was used because it has been demonstrated to work best for ecological data (McCune and Mefford 1999).

# RESULTS

## Species Richness

During pre-treatment sampling, a total of 127 plant species were recorded (Appendix A). As yet, voucher specimens have been collected for 50 of the species. All voucher specimens were cataloged in the GLIFWC herbarium and the Robert W. Freckmann Herbarium at University of Wisconsin – Stevens Point.

Species richness ranged from a low of 32 species to a high of 58 species (Table 3). For all four sites, species richness was greater in the spring survey than in the summer survey. The presence of spring ephemeral forbs offers the most likely explanation. During summer, these ephemeral forbs wilt, with above-ground parts often disappearing altogether.

The control plot at site 3 showed the highest mean species richness with over 50 species. The treatment plot at site 4 showed the lowest mean species richness with less than 40 species.

For the spring sampling period (Figure 7), comparisons between control and treatment plots revealed that mean species richness at sites 2 and 3 was significantly greater, with a significance level ($\alpha$) of 0.05, within the control plots than in the treatment plots (for both sites: chi-square approximation [$x^2$] = 3.971, probability [$p$] = 0.046, degrees of freedom [df] = 1). At sites 1 and 4, the difference in mean species richness between control and treatment plots was not significant (site 1: $x^2 = 0.429$, $p = 0.513$, df = 1, = 0.05; site 4: $x^2 = 3.137$, $p = 0.077$, df = 1). Sample size (the number of years of data) was three for all four sites.

For the summer sampling period (Figure 8), mean species richness at site 4 was significantly greater within the control plot than in the treatment plot ($x^2 = 4.744$, $p = 0.029$, df = 1). At sites 1, 2 and 3, the difference in mean species richness between control and treatment plots was not significant (site 1: $x^2 = 0.398$, $p = 0.528$, df = 1; site 2: $x^2 = 1.729$, $p = 0.189$, df = 1; site 3: $x^2 = 2.551$, $p = 0.110$, df = 1). Sample size (the number of years of data) was five for site 1 and four for sites 2, 3 and 4.

**Table 3: Species richness (number of species) by plot**

| | | Site 1 | | Site 2 | | Site 3 | | Site 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Control** | **Treatment** | **Control** | **Treatment** | **Control** | **Treatment** | **Control** | **Treatment** |
| **1997** | **Spring** | | | | | | | | |
| | **Summer** | 37 | 37 | 41 | 37 | 46 | 32 | 43 | 32 |
| **1998** | **Spring** | | | 45 | 40 | 58 | 46 | 40 | 32 |
| | **Summer** | 40 | 43 | 38 | 37 | 53 | 44 | 40 | 30 |
| **1999** | **Spring** | 44 | 40 | 48 | 41 | 56 | 53 | 42 | 40 |
| | **Summer** | 39 | 45 | 49 | 41 | 51 | 50 | 41 | 40 |
| **2000** | **Spring** | 45 | 47 | 50 | 41 | 58 | 49 | 43 | 37 |
| | **Summer** | 40 | 44 | 46 | 44 | 56 | 51 | 44 | 34 |
| **2002** | **Spring** | 39 | 42 | | | | | | |
| | **Summer** | 41 | 36 | | | | | | |
| **Mean** | **Spring** | **42.7** | **43.0** | **47.7** | **40.1** | **57.3** | **49.3** | **41.7** | **36.3** |
| | **Summer** | **39.4** | **42.3** | **43.5** | **39.8** | **51.5** | **44.3** | **41.3** | **34.0** |

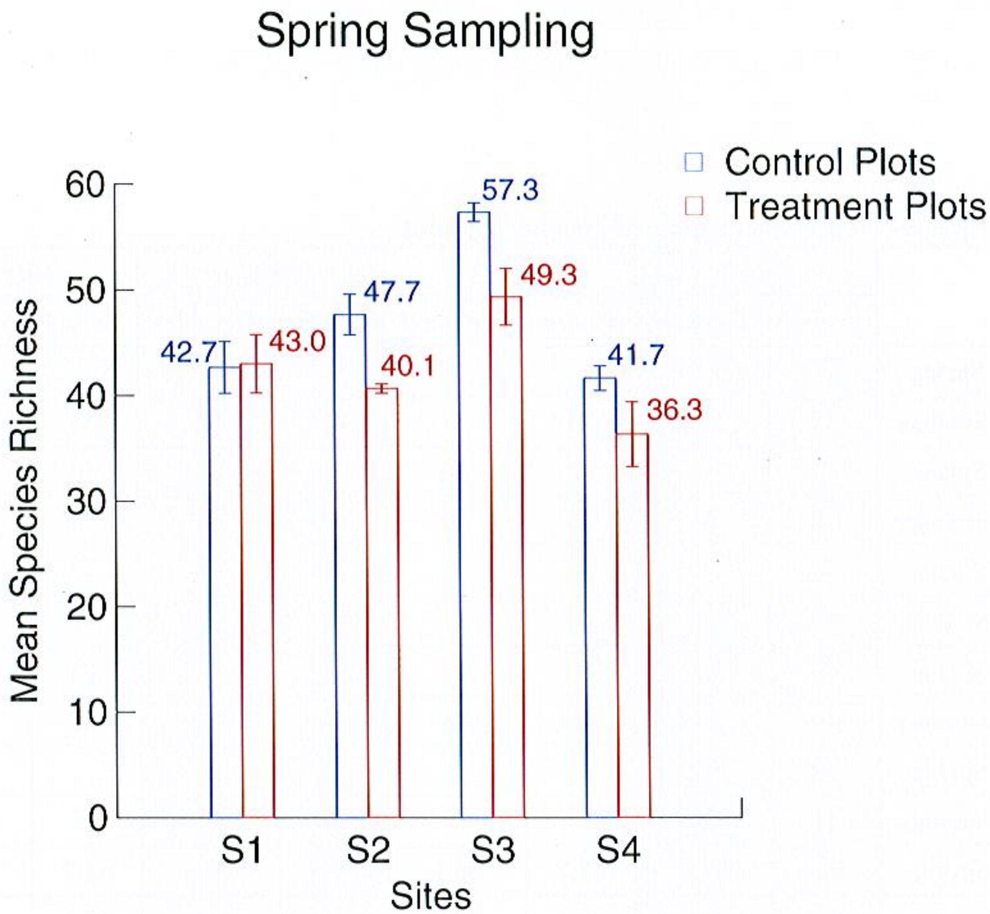


**Figure 7: Mean species richness for spring pre-treatment sampling. Error bars represent 1 standard error.**

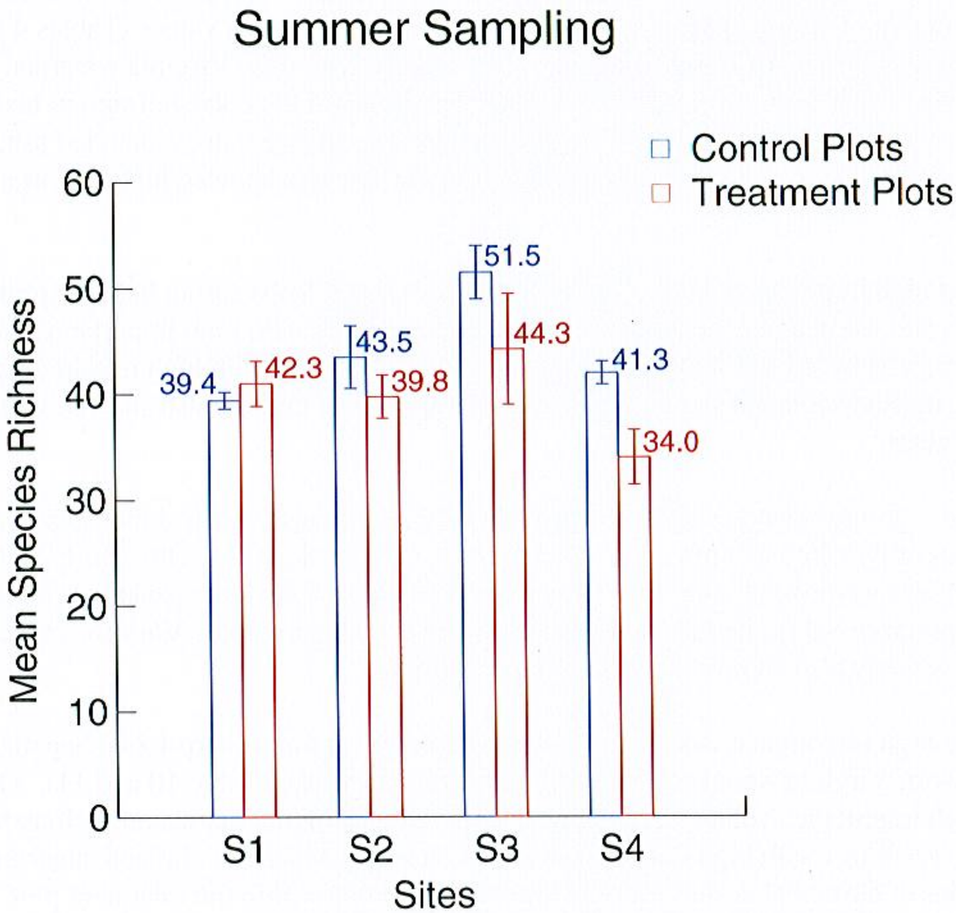


**Figure 8: Mean species richness for spring pre-treatment sampling. Error bars represent 1 standard error.**

## Species Composition

Importance values were calculated to determine the overall status of a species within each plot. At site 1, a number of spring ephemeral forbs showed high importance values (Tables 4 and 5). These species included sharp-lobed hepatica, spring beauty, trout lily, Virginia waterleaf and wood anemone. Other forbs with high importance values were blue cohosh, fragrant bedstraw, lady fern and maidenhair fern. Tree seedlings with high importance values included ash, bitternut hickory and sugar maple. Various species of currant also showed high importance values.

Site 2 showed high importance values for the spring ephemeral forbs spring beauty, trout lily, white trillium and wood anemone (Tables 6 and 7). Other forbs with high importance values were lady fern, jewelweed and Pennsylvania sedge. Tree seedlings with high importance values included ash, musclewood and sugar maple. Various species of currant also showed high importance values.

Site 3 showed high importance values for the spring ephemeral forbs sharp-lobed hepatica, starflower, trout lily, white trillium and wood anemone (Tables 8 and 9). Other forbs with high importance values were jewelweed, Pennsylvania sedge and various fern species. Tree seedlings with high importance values included ash, musclewood and sugar maple. Various species of currant and raspberry also showed high importance values.

Site 4 showed high importance values for the spring ephemeral forbs sharp-lobed hepatica, two-leaved miterwort, Virginia waterleaf, wild leek and wood anemone (Table 10 and 11). Other forbs with high importance values were Pennsylvania sedge, stinging nettle and various fern species. Tree seedlings with high importance values included American elm and sugar maple. Various species of currant also showed high importance values within the treatment plot.

Not surprisingly, more spring ephemeral forbs showed high importance values during the spring sampling period (Tables 12 and 13). By the summer sampling period, spring beauty, trout lily, white trillium and wood anemone had wilted and became less apparent within the plots. Instead, tree seedlings and summer-growing forbs showed higher importance values.

**Table 4: Importance value (IV), mean frequency (MF) and mean percent cover (MC) for the species with the ten highest importance values calculated for site 1, control plot.**

| Site 1 – Control Plot | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Spring** | | | | **Summer** | | | |
| **Species** | **IV** | **MF** | **MC** | **Species** | **IV** | **MF** | **MC** |
| Hepatica, sharp-lobed | 12.67 | 0.97 | 7.92 | Hepatica, sharp-lobed | 14.93 | 0.9 | 6.57 |
| Spring beauty | 11.64 | 0.98 | 5.01 | Ash sp. (seedling) | 13.33 | 0.62 | 9.3 |
| Ash sp. (seedling) | 10.73 | 0.69 | 8.68 | Bedstraw, fragrant | 13.01 | 0.56 | 10.64 |
| Bedstraw, fragrant | 9.89 | 0.54 | 10.84 | Maple, sugar (seedling) | 11.36 | 0.72 | 4.33 |
| Currant sp. | 9.88 | 0.25 | 14.67 | Virginia waterleaf | 9.43 | 0.56 | 3.99 |
| Virginia waterleaf | 9.72 | 0.66 | 6.68 | Hickory, bitternut (seedling) | 9.37 | 0.54 | 4.83 |
| Anemone, wood | 9.14 | 0.76 | 3.99 | Currant sp. | 9.11 | 0.3 | 9.13 |
| Maple, sugar (seedling) | 9.07 | 0.75 | 4.51 | Fern, lady | 7.3 | 0.06 | 10.8 |
| Cohosh, blue | 8.98 | 0.24 | 12.42 | Cohosh, blue | 6.96 | 0.24 | 6.29 |
| Trout lily sp. | 8.92 | 0.83 | 2.61 | Hog peanut | 6.21 | 0.07 | 9.06 |

**Table 5: Importance value (IV), mean frequency (MF) and mean percent cover (MC) for the species with the ten highest importance values calculated for site 1, treatment plot.**

| Site 1 – Treatment Plot | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Spring** | | | | **Summer** | | | |
| **Species** | **IV** | **MF** | **MC** | **Species** | **IV** | **MF** | **MC** |
| Fern, maidenhair | 21.73 | 0.02 | 63.67 | Fern, maidenhair | 22.62 | 0.03 | 47.2 |
| Fern, lady | 15.44 | 0.02 | 47 | Bedstraw, fragrant | 13.85 | 0.72 | 10.42 |
| Virginia waterleaf | 12.29 | 0.69 | 12.83 | Ash sp. (seedling) | 12.42 | 0.67 | 7.22 |
| Spring beauty | 11.65 | 0.95 | 6.66 | Virginia waterleaf | 11.84 | 0.66 | 5.43 |
| Trout lily sp. | 10.15 | 0.89 | 4.26 | Hepatica, sharp-lobed | 11.15 | 0.69 | 4.28 |
| Ash sp. (seedling) | 8.8 | 0.59 | 8.18 | Maple, sugar (seedling) | 9.85 | 0.65 | 2.9 |
| Bedstraw, fragrant | 8.5 | 0.64 | 7.37 | Fern, lady | 9.39 | 0.05 | 16.14 |
| Hepatica, sharp-lobed | 8.38 | 0.65 | 5.96 | Hickory, bitternut (seedling) | 8.71 | 0.5 | 6.11 |
| Maple, sugar (seedling) | 7.87 | 0.67 | 3.83 | Jack-in-the-pulpit | 6.23 | 0.39 | 2.39 |
| Currant sp. | 7 | 0.06 | 12.77 | Cohosh, blue | 6 | 0.18 | 7.68 |

**Table 6: Importance value (IV), mean frequency (MF) and mean percent cover (MC) for the species with the ten highest importance values calculated for site 2, control plot.**

| Site 2 – Control Plot | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Spring** | | | | **Summer** | | | |
| **Species** | **IV** | **MF** | **MC** | **Species** | **IV** | **MF** | **MC** |
| Trout lily sp. | 13.25 | 0.87 | 10.78 | Sedge, Pennsylvania | 17.47 | 0.69 | 17.95 |
| Ash sp. (seedling) | 9.63 | 0.79 | 4.1 | Ash sp. (seedling) | 11.74 | 0.67 | 5.18 |
| Jewelweed | 9.36 | 0.65 | 7.32 | Maple, sugar (seedling) | 11.2 | 0.61 | 4.16 |
| Trillium, white | 8.79 | 0.54 | 8.95 | Jewelweed | 10.42 | 0.52 | 7.13 |
| Anemone, wood | 8.69 | 0.55 | 7.21 | Fern, lady | 9.71 | 0.08 | 17.99 |
| Sedge, Pennsylvania | 8.67 | 0.52 | 9.2 | Trillium, white | 8.8 | 0.45 | 4.45 |
| Maple, sugar (seedling) | 8.5 | 0.64 | 5.17 | Fern, wood sp. | 8.42 | 0.1 | 13.42 |
| Musclewood (seedling) | 6.93 | 0.22 | 12.51 | Currant sp. | 7.9 | 0.14 | 13.72 |
| Leek, wild | 6.87 | 0.18 | 13.3 | Musclewood (seedling) | 7.85 | 0.17 | 12.55 |
| Spring beauty | 6.74 | 0.56 | 2.43 | Ironwood (seedling) | 6.22 | 0.19 | 7.18 |

**Table 7: Importance value (IV), mean frequency (MF) and mean percent cover (MC) for the species with the ten highest importance values calculated for site 2, treatment plot.**

| Site 2 – Treatment Plot | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Spring** | | | | **Summer** | | | |
| **Species** | **IV** | **MF** | **MC** | **Species** | **IV** | **MF** | **MC** |
| Sedge, Pennsylvania | 17.26 | 0.71 | 22.32 | Sedge, Pennsylvania | 18.29 | 0.68 | 17.71 |
| Trout lily sp. | 14.98 | 0.86 | 11.39 | Maple, sugar (seedling) | 13.68 | 0.68 | 5.79 |
| Trillium, white | 11.33 | 0.61 | 9.67 | Ash sp. (seedling) | 11.62 | 0.65 | 2.92 |
| Maple, sugar (seedling) | 10.83 | 0.7 | 5.34 | Musclewood (seedling) | 9.12 | 0.13 | 16.12 |
| Currant sp. | 9.15 | 0.13 | 19.66 | Jewelweed | 9.02 | 0.37 | 6.79 |
| Spring beauty | 8.97 | 0.61 | 3.43 | Fern, lady | 8.95 | 0.12 | 15.18 |
| Anemone, wood | 8.76 | 0.5 | 6.7 | Trillium, white | 8.82 | 0.37 | 6.66 |
| Musclewood (seedling) | 8.43 | 0.1 | 18.88 | Hickory, bitternut (seedling) | 7.41 | 0.36 | 3.37 |
| Jewelweed | 7.84 | 0.42 | 7.36 | Cohosh, blue | 7.37 | 0.07 | 14.41 |
| Fern, lady | 6.94 | 0.08 | 15.75 | Enchanter's nightshade, alpine | 7.25 | 0.28 | 6.4 |

**Table 8: Importance value (IV), mean frequency (MF) and mean percent cover (MC) for the species with the ten highest importance values calculated for site 3, control plot.**

| Site 3 – Control Plot | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Spring** | | | | **Summer** | | | |
| **Species** | **IV** | **MF** | **MC** | **Species** | **IV** | **MF** | **MC** |
| Sedge, Pennsylvania | 11.69 | 0.72 | 18.35 | Sedge, Pennsylvania | 11.15 | 0.6 | 13.54 |
| Jewelweed | 10.04 | 0.75 | 9.07 | Ash sp. (seedling) | 9.7 | 0.66 | 6.06 |
| Maple, sugar (seedling) | 9.53 | 0.78 | 6.77 | Maple, sugar (seedling) | 9.43 | 0.67 | 4.95 |
| Ash sp. (seedling) | 7.93 | 0.6 | 7.95 | Musclewood (seedling) | 9.18 | 0.16 | 18.8 |
| Trillium, white | 7.74 | 0.51 | 9.6 | Currant sp. | 6.62 | 0.17 | 14.21 |
| Anemone, wood | 6.38 | 0.52 | 4.23 | Fern, wood sp. | 6.01 | 0.2 | 9.88 |
| Raspberry sp. | 5.98 | 0.25 | 12.98 | Raspberry sp. | 5.85 | 0.26 | 9.07 |
| Starflower | 5.97 | 0.46 | 5.15 | Starflower | 5.64 | 0.39 | 2.88 |
| Currant sp. | 5.92 | 0.21 | 14.63 | Jewelweed | 5.48 | 0.42 | 2.7 |
| Hazelnut, beaked (seedling) | 5.72 | 0.21 | 13.36 | Trillium, white | 5.32 | 0.34 | 4.01 |

**Table 9: Importance value (IV), mean frequency (MF) and mean percent cover (MC) for the species with the ten highest importance values calculated for site 3, treatment plot.**

| Site 3 – Treatment Plot | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Spring** | | | | **Summer** | | | |
| **Species** | **IV** | **MF** | **MC** | **Species** | **IV** | **MF** | **MC** |
| Maple, sugar (seedling) | 14.36 | 0.89 | 10.77 | Maple, sugar (seedling) | 16.75 | 0.84 | 10.07 |
| Jewelweed | 13.61 | 0.78 | 13.59 | Ash sp. (seedling) | 11.12 | 0.67 | 4.98 |
| Ash sp. (seedling) | 10.2 | 0.67 | 7.08 | Sedge, Pennsylvania | 11.09 | 0.57 | 7.31 |
| Trillium, white | 9.79 | 0.56 | 8.17 | Fern, lady | 11.03 | 0.12 | 16.75 |
| Sedge, Pennsylvania | 9.21 | 0.45 | 11.13 | Musclewood (seedling) | 9.95 | 0.36 | 10.54 |
| Anemone, wood | 8.4 | 0.58 | 4.09 | Fern, wood sp. | 9.69 | 0.23 | 10.55 |
| Musclewood (seedling) | 7.97 | 0.33 | 11.57 | Jewelweed | 7.37 | 0.46 | 3.42 |
| Fern, interrupted | 6.17 | 0.01 | 21 | Hepatica, sharp-lobed | 7.23 | 0.3 | 7.08 |
| Hepatica, sharp-lobed | 5.97 | 0.27 | 6.88 | Trillium, white | 6.54 | 0.32 | 4.56 |
| Raspberry sp. | 5.68 | 0.25 | 7.7 | Currant sp. | 4.91 | 0.14 | 5.47 |

**Table 10: Importance value (IV), mean frequency (MF) and mean percent cover (MC) for the species with the ten highest importance values calculated for site 4, control plot.**

| Site 4 – Control Plot | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Spring** | | | | **Summer** | | | |
| **Species** | **IV** | **MF** | **MC** | **Species** | **IV** | **MF** | **MC** |
| Nettle, stinging | 17.47 | 0.5 | 28.16 | Nettle, stinging | 23.41 | 0.54 | 25.64 |
| Sedge, Pennsylvania | 13.08 | 0.7 | 11.81 | Maple, sugar (seedling) | 12.76 | 0.75 | 3.98 |
| Fern, lady | 12.78 | 0.09 | 27.5 | Fern, lady | 11.91 | 0.22 | 13.8 |
| Hepatica, sharp-lobed | 10.6 | 0.64 | 6.52 | Sedge, Pennsylvania | 11.85 | 0.56 | 7.25 |
| Maple, sugar (seedling) | 10.51 | 0.69 | 4.83 | Hepatica, sharp-lobed | 11.78 | 0.64 | 5.12 |
| Elm, American (seedling) | 9.24 | 0.48 | 7.33 | Elm, American (seedling) | 10.21 | 0.47 | 6.08 |
| Fern, maidenhair | 8.45 | 0.13 | 17.8 | Fern, maidenhair | 9.23 | 0.09 | 12.81 |
| Mitrewort, two-leaved | 8.21 | 0.54 | 4.64 | Mitrewort, two-leaved | 6.6 | 0.39 | 2.22 |
| Fern, wood sp. | 8.09 | 0.19 | 12.3 | Hickory, bitternut (seedling) | 6.41 | 0.35 | 2.81 |
| Anemone, wood | 7.56 | 0.54 | 2.55 | Virginia waterleaf | 5.57 | 0.37 | 0.99 |

**Table 11: Importance value (IV), mean frequency (MF) and mean percent cover (MC) for the species with the ten highest importance values calculated for site 4, treatment plot.**

| Site 4 – Treatment Plot | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Spring** | | | | **Summer** | | | |
| **Species** | **IV** | **MF** | **MC** | **Species** | **IV** | **MF** | **MC** |
| Nettle, stinging | 24.56 | 0.53 | 24.05 | Nettle, stinging | 24.72 | 0.56 | 19.24 |
| Maple, sugar (seedling) | 16.61 | 0.66 | 7.64 | Maple, sugar (seedling) | 19.45 | 0.71 | 6.35 |
| Hepatica, sharp-lobed | 12.89 | 0.59 | 4.77 | Hepatica, sharp-lobed | 14.42 | 0.57 | 3.82 |
| Elm, American (seedling) | 12.61 | 0.49 | 6.15 | Elm, American (seedling) | 13.9 | 0.49 | 5.29 |
| Virginia waterleaf | 11.6 | 0.53 | 4.35 | Currant sp. | 9.71 | 0.07 | 12.97 |
| Anemone, wood | 11.55 | 0.52 | 4.15 | Virginia waterleaf | 8.65 | 0.38 | 1.35 |
| Jewelweed | 6.74 | 0.14 | 5.58 | Fern, wood sp. | 6.37 | 0.04 | 8.5 |
| Leek, wild | 6.26 | 0.26 | 2.63 | Leek, wild | 6.24 | 0.24 | 1.89 |
| Fern, lady | 6.17 | 0.05 | 6.58 | Mitrewort, two-leaved | 5.98 | 0.2 | 2.35 |
| Currant sp. | 6.04 | 0.06 | 8.4 | Jack-in-the-pulpit | 5.87 | 0.22 | 1.94 |

**Table 12: The five top ranked species in control and treatment plots by site based on importance values during spring (1 = highest rank).**

| | Site 1 | | Site 2 | | Site 3 | | Site 4 | |
|---|---|---|---|---|---|---|---|---|
| | Control | Treatment | Control | Treatment | Control | Treatment | Control | Treatment |
| Anemone, wood | | | 5 | | | | | |
| Ash sp. ( seedling) | 3 | | 2 | | 4 | 3 | | |
| Bedstraw, fragrant | 4 | | | | | | | |
| Currant sp. | 5 | | | 5 | | | | |
| Elm, American (seedling) | | | | | | | | 4 |
| Fern, lady | | 2 | | | | | 3 | |
| Fern, maidenhair | | 1 | | | | | | |
| Hepatica, sharp-lobed | 1 | | | | | | 4 | 3 |
| Jewelweed | | | 3 | | 2 | 2 | | |
| Maple, sugar (seedling) | | | | 4 | 3 | 1 | 5 | 2 |
| Nettle, stinging | | | | | | | 1 | 1 |
| Sedge, Pennsylvania | | | | 1 | 1 | 5 | 2 | |
| Spring beauty | 2 | 4 | | | | | | |
| Trillium, white | | | 4 | 3 | 5 | 4 | | |
| Trout lily, yellow | | 5 | 1 | 2 | | | | |
| Virginia waterleaf | | 3 | | | | | | 5 |

**Table 13: The five top ranked species in control and treatment plots by site based on importance values during summer (1 = highest rank).**

| | Site 1 | | Site 2 | | Site 3 | | Site 4 | |
|---|---|---|---|---|---|---|---|---|
| | Control | Treatment | Control | Treatment | Control | Treatment | Control | Treatment |
| Ash sp. (seedling) | 2 | 3 | 2 | 3 | 2 | 2 | | |
| Bedstraw, fragrant | 3 | 2 | | | | | | |
| Currant sp. | | | | | 5 | | | 5 |
| Elm, American (seedling) | | | | | | | | 4 |
| Fern, lady | | | 5 | | | 4 | 3 | |
| Fern, maidenhair | | 1 | | | | | | |
| Hepatica, sharp-lobed | 1 | 5 | | | | | 5 | 3 |
| Jewelweed | | | 4 | 5 | | | | |
| Maple, sugar (seedling) | 4 | | 3 | 2 | 3 | 1 | 2 | 2 |
| Musclewood (seedling) | | | | 4 | 4 | 5 | | |
| Nettle, stinging | | | | | | | 1 | 1 |
| Sedge, Pennsylvania | | | 1 | 1 | 1 | 3 | 4 | |
| Virginia waterleaf | 5 | 4 | | | | | | |

**Species Composition Comparisons**

For the spring sampling period, both the Bray-Curtis Ordination and the Cluster Analysis showed that treatment and control plots were more similar within sites than between sites (Figures 9 and 10). Site 2 control and treatment plots were the most similar, whereas site 4 control and treatment plots were the least similar. Furthermore, sites 2 and 3 showed close affinities to one another.

For the summer sampling period, the Cluster Analysis indicated that the treatment and control plots were more similar within sites than between sites. The Bray-Curtis Ordination showed that site 2 control and treatment plots were the most similar, while site 3 control and treatment plots were the least similar. Interestingly, the control plot at site 3 was less similar to its own paired treatment plot than to the treatment plot at site 2 (Figures 11 and 12).

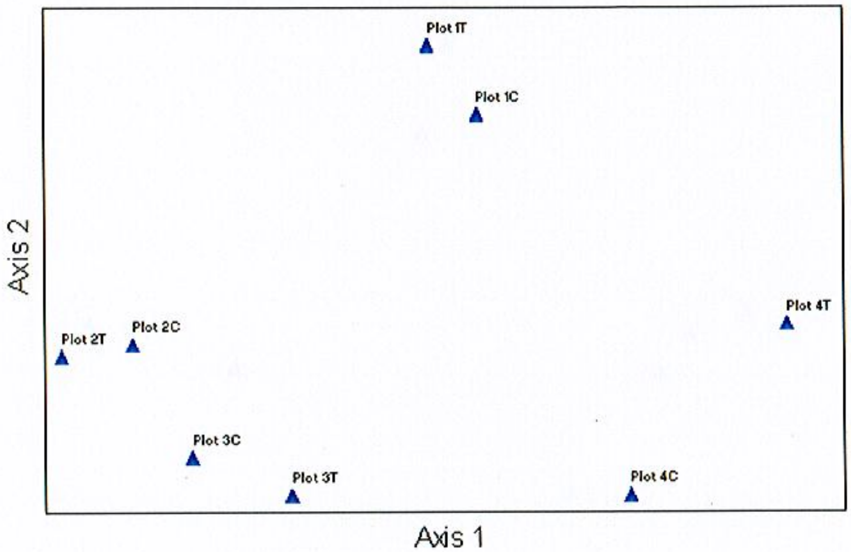


**Figure 9: Bray-Curtis Ordination for spring pre-treatment sampling.**

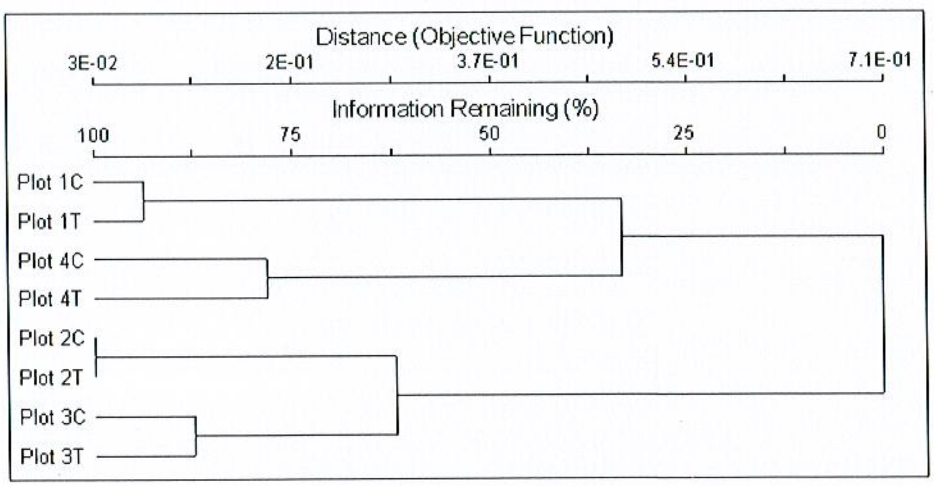


**Figure 10: Cluster Analysis for spring pre-treatment sampling.**

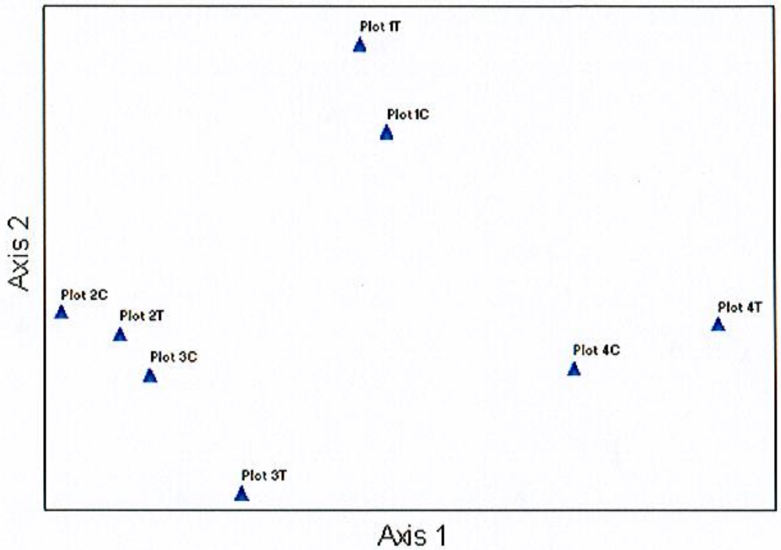


**Figure 11: Bray-Curtis ordination for summer pre-treatment sampling.**

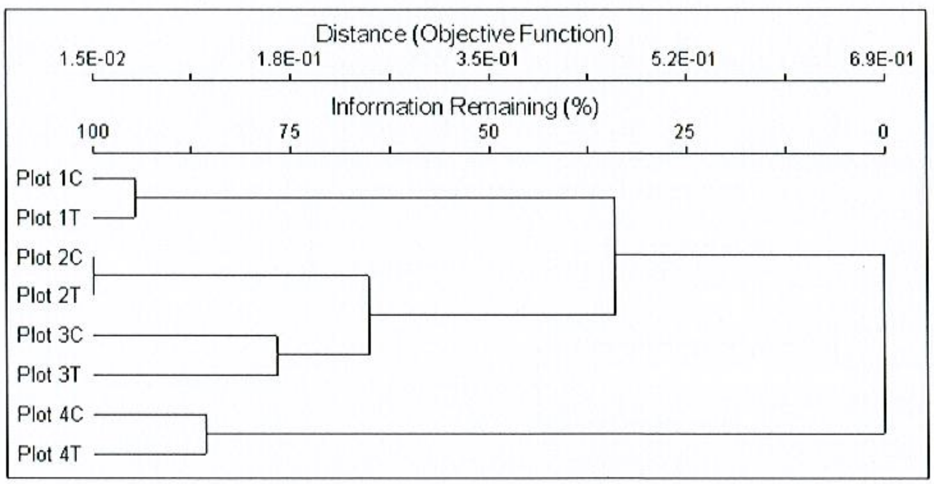


**Figure 12: Cluster Analysis for summer pre-treatment sampling.**

## SUMMARY

Pre-treatment sampling has been completed at all sites and the data have been analyzed. Vouchers specimens have been gathered for 50 of the 127 species documented within the plots.

Analyses of pre-treatment data showed that species richness did not differ statistically between most control and treatment paired plots. Statistical differences between paired plots occurred at sites 2 and 3 during the spring sampling period and site 4 during the summer sampling period. Analyses of post-treatment data will need to take into account these seemingly inherent differences between these paired plots.

Ordination and cluster analysis also demonstrated similarities between control and treatment plots within each site, with the exception being site 3 for the summer sampling period. In this case, ordination indicated that the control plot at site 3 was less similar to its treatment plot than to the treatment plot at site 2. However, cluster analysis did show more similarity between paired plots within site 3 than between sites 2 and 3. Perhaps the near proximity between sites 2 and 3 best explains this result. Both ordination and cluster analysis demonstrate a close relationship between these sites.

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# APPENDIX A

| English Name | Scientific Name | Ojibwe Name | Origin |
|---|---|---|---|
| Anenome, wood | *Anemone quinquefolia* | | native |
| Aralia, sarsaparilla, wild | *Aralia nudicaulis* | waaboozojiibik | native |
| Aralia, spikenard | *Aralia racemosa* | (gi)chi-okaadaak | native |
| Ash sp. | *Fraxinus* sp. | | native |
| Ash, white | *Fraxinus americana* | baapaagimaak | native |
| Aster sp. | *Aster* sp. | | native |
| Aster, large-leaved | *Aster macrophyllus* | migiziibag | native |
| Avens sp. | *Geum* sp. | | native |
| Avens, yellow | *Geum aleppicum* | | native |
| Baneberry sp. | *Actea* sp. | | native |
| Baneberry, red | *Actea rubra* | waashkobijiibikak | native |
| Baneberry, white | *Actea pachypoda* | weekizigun | native |
| Basswood | *Tilia americana* | wiigobaatig | native |
| Bedstraw, fragrant | *Galium triflorum* | | native |
| Bellwort, large-flowered | *Uvularia grandiflora* | waabishkijiibik | native |
| Bellwort, sessile-leaved | *Uvularia sessifolia* | | native |
| Bindweed, fringed | *Polygonum cilinode* | | native |
| Bindweed sp. | *Polygonum* sp. | | native |
| Birch, yellow | *Betula alleghneiensis* | wiinizik | native |
| Bloodroot | *Sanguinaria canadensis* | miskojiibik | native |
| Buttercup sp. | *Ranunculus* sp. | | native |
| Buttercup, hooked | *Ranunculus recurvatus* | | native |
| Buttercup, small-flowered | *Ranunculus abortivus* | | native |
| Canada mayflower | *Maianthemum canadense* | agongosimin | native |
| Cherry sp. | *Prunus* sp. | | native |
| Cherry, choke | *Prunus virginiana* | asasaweminagaawanzh | native |
| Cherry, pin | *Prunus pensylvanica* | bawa'iminaan | native |
| Cherry, wild black | *Prunus serotina* | ookwemizh | native |
| Cohosh, blue | *Caulophyllum thalictroides* | bezhigojiibik | native |
| Currant sp. | *Ribes* sp. | | native |
| Currant, wild black | *Ribes americanum* | amikomin | native |
| Dandelion | *Taraxacum officinale* | doodooshaaboojiibik | non-native |
| Dogwood, alternate-leaved | *Cornus alternifolia* | moozomizh | native |
| Dutchman's breeches | *Dicentra cucullaria* | ojidimo miskishmandaumin | native |
| Elderberry sp. | *Sambucus* sp. | bibigwemin | native |
| Elm, American | *Ulmus americana* | aniib | native |
| Enchanter's-nightshade, alpine | *Circaea alpina* | | native |
| Enchanter's-nightshade, common | *Circaea leutitiana* | | native |
| Fern, beech | *Phegopteris connectilis* | | native |
| Fern, cinnamon | *Osmunda cinnamomea* | | native |
| Fern, grape rattlesnake | *Botrychium virginianum* | gickensine' namukuk | native |
| Fern, grape sp. | *Botrychium* sp. | | native |
| Fern, interrupted | *Osmunda claytoniana* | | native |
| Fern, lady | *Athyrium filix-femina* | a'sawan | native |
| Fern, maidenhair | *Adiantum pedatum* | | native |
| Fern, oak | *Gymnocarpium dryopteris* | | native |
| Fern, sensitive | *Onoclea sensibilis* | | native |

| English Name | Scientific Name | Ojibwe Name | Origin |
|---|---|---|---|
| Fern, unknown sp. | | | native |
| Fern, wood sp. | *Dryopteris* sp. | | native |
| Ginger, wild | *Asarum canadense* | namepin | native |
| Ginseng, dwarf | *Panax trifolius* | nesoobagak | native |
| Goldenrod sp. | *Solidago* sp. | | native |
| Goldenrod, zigzag | *Solidago flexicaulis* | ajidamoowaanow | native |
| Grass, bottle-brush | *Elymus hystrix* | | native |
| Grass, long-awned wood | *Brachyelytrum erectum* | | native |
| Grass, oat | *Danthonia spicata* | | native |
| Grass, rough-leaved rice | *Oryzopsis asperifolia* | | native |
| Grass, unknown sp. | | | native |
| Hazelnut sp. | *Corylus sp.* | | native |
| Hazelnut, beaked | *Corylus cornuta* | bagaaniminzh | native |
| Hepatica, round-lobed | *Anemone americana* | animozid | native |
| Hepatica, sharp-lobed | *Anemone acutiloba* | animozid | native |
| Hickory, bitternut | *Carya cordiformis* | | native |
| Hog peanut | *Amphicarpae bracteata* | bagwaji-miskodiisimin | native |
| Honeysuckle, American fly | *Lonicera canadensis* | ozaawaaskined | native |
| Honeysuckle, red | *Lonicera dioica* | | native |
| Horsetail sp. | *Equisetum* sp. | | native |
| Indian pipe | *Monotropa uniflora* | | native |
| Ironwood | *Ostrya virginiana* | maananoons | native |
| Jack-in-the-pulpit | *Arisaema triphyllum* | zhaashaagomin | native |
| Jewelweed | *Impatiens capensis* | ozaawashkojiibik | native |
| Juneberry | *Amelanchier laevis* | gozigwaakomin | native |
| Leatherwood | *Dirca palustris* | jiibegob | native |
| Leek, wild | *Allium tricoccum* | bagwaji-zhi/agaagawanzh | native |
| Lily, bluebead | *Clintonia borealis* | (g)odotaagaans | native |
| Maple, red | *Acer rubrum* | zhiishiigimiiwanzh | native |
| Maple, sugar | *Acer saccharum* | ininaatig | native |
| Meadow rue, early | *Thalictrum dioicum* | | native |
| Mint, hairy wood | *Blephilia hirsuta* | | native |
| Mitrewort, naked | *Mitella nuda* | | native |
| Mitrewort, two-leaved | *Mitella diphylla* | | native |
| Musclewood | *Carpinus caroliniana* | ski'agoniminzh | native |
| Nettle, stinging | *Urtica dioica* | mazaan | native |
| Oak, red | *Quercus rubra* | mitigomizh | native |
| Partridge berry | *Mitchella repens* | binewimin | native |
| Phlox, blue | *Phlox divaricata* | | native |
| Pine, white | *Pinus strobus* | zhingwaak | native |
| Plantain, common | *Plantago major* | ginebigwashk | non-native |
| Poison ivy | *Toxicodendron radicans* | animikiibag | native |
| Raspberry sp. | *Rubus* sp. | | native |
| Raspberry, dwarf red | *Rubus pubescens* | skizhu-min | native |
| Raspberry, red | *Rubus ideaus* | miskominagaawanzh | native |
| Saxifrage, swamp | *Saxifraga pensylvanica* | | native |
| Sedge sp. | *Carex* sp. | | native |
| Sedge, bladder | *Carex intumescens* | | native |
| Sedge, colonial oak | *Carex communis* | | native |
| Sedge, hairy wood | *Carex hirtifolia* | | native |
| Sedge, long-stalk | *Carex pedunculata* | | native |

| English Name | Scientific Name | Ojibwe Name | Origin |
| --- | --- | --- | --- |
| Sedge, Pennsylvania | *Carex pensylvanica* | | native |
| Sedge, plantain-leaved | *Carex plantaginea* | | native |
| Sedge, tufted | *Carex gracillima* | | native |
| Self heal | *Prunella vulgaris* | baasibagak | non-native |
| Shin leaf sp. | *Pyrola* sp. | bine(wi)bag | native |
| Smilax, cat briar | *Smilax hispida* | manito minanganwinz | native |
| Smilax, common carrion flower | *Smilax herbacea* | ginebigominagaawanzh | native |
| Solmans' plume | *Maianthemum racemosum* | agongosimizh | native |
| Soloman's seal | *Polygonatum pubescens* | naaniibide'oodegin | native |
| Spring beauty | *Claytonia virginica* | meeautikwaeaugpineeg | native |
| Starflower | *Trientalis borealis* | | native |
| Sweet cicely | *Osmorhiza claytonii* | ozagadigom | native |
| Toothwort, cut-leaved | *Cardamine concatenata* | aemaushtaunishaessiwung | native |
| Trillium, white | *Trillium grandiflorum* | baushkindjibgwaun | native |
| Trout lily, yellow | *Erythronium americanum* | numaegbugoneen | native |
| Trout lily sp. | *Erythronium* sp. | | native |
| Twisted stalk | *Streptopus lanceolatus* | agwingosibag | native |
| Unknown sp. | | | native |
| Viburnum sp. | *Viburnum* sp. | | native |
| Violet sp. | *Viola* sp. | | native |
| Violet, downy yellow | *Viola pubescens* | ogitebagoons | native |
| Virginia creeper | *Parthenocissus quinquefolia* | bebaamooded manidoo-biimaakwad | native |
| Virginia waterleaf | *Hydrophyllum virginianum* | nebanaanikweyaag | native |
| White lettuce | *Prenanthes alba* | doodooshaaboojiibik | native |
| Wild strawberry, woodland | *Fragaria vesca* | ode'imin | native |
| Willow sp. | *Salix* sp. | oziisigobimizh | native |
| Winter cress | *Barbarea vulgaris* | | non-native |
| Wood rush, hairy | *Luzula acuminata* | | native |
| Yarrow | *Achillea millefolium* | ajidamo waawano | native |

# APPENDIX B
# MEMORANDUM OF AGREEMENT

GREAT LAKES INDIAN FISH & WILDLIFE COMMISSION

• MEMBER TRIBES •

MICHIGAN WISCONSIN MINNESOTA

## MEMORANDUM OF AGREEMENT

This Memorandum of Agreement by and between the USDA Forest Service, Chequamegon National Forest, hereinafter called Chequamegon National Forest, and the Great Lakes Indian Fish and Wildlife Commission, hereinafter called Commission, shall establish the conditions and material obligations of the parties hereto, under which the Chequamegon National Forest and the Commission shall cooperate on the study "Effects of Logging on Understory Plants", as more specifically set forth in the attached study plan.

The parties recognize that the Chequamegon National Forest in discharging its obligations in the management of lands under its jurisdiction, including lands within the 1837 and 1842 ceded territories, could benefit from long-term studies conducted on National Forest lands where the information collected could be applied to resource management questions of concern to resource managers.

In discharging its obligations in the co-management of living natural resources in the ceded territories, the Commission is, among other things, concerned about the long-term effects of timber harvest activities on understory herb and shrub species of the northern hardwood forests that are used by the Ojibwa people.

Considering the responsibilities of both parties it is desirable and mutually beneficial to cooperate in the establishment of long-term studies on National Forest lands where both agencies could derive considerable benefits from such cooperation. The attached document titled: "Study Plan for GLIFWC-USFS Study on the Effects of Logging on Understory Plants" describes in detail the purpose, scope and methodology of the study. The study plan, as it may be properly amended from time to time, is incorporated by reference into this Agreement.

This Agreement will guide the actions of each agency in cooperating and collaborating on this project.

1. **Term**. The term of this Agreement is intended to be indefinite because of the nature of the research project. Useful information will only be obtained after at least 10 - 15 years. However, each party recognizes its inability to commit to many years in the future.

Therefore the Agreement shall coincide with the duration of the underlying research project unless specifically terminated by either party.

2. **Duties of the Parties.**

A. The Chequamegon National Forest shall:

1. Provide technical assistance in choosing stands for surveys based on criteria outlined in the study plan.

2. Assist in the establishment and maintenance of study plots.

3. Collect and maintain records about the locations of study plots and any management activities conducted in the study plots or the surrounding stands. Such records shall include season of timber harvest and the type of equipment used during the harvest.

4. Ensure that there will be no timber harvest or other invasive management (e.g. road or trail construction, mineral exploration) in control plots until both parties have agreed to terminate the study.

5. Ensure that any timber harvest or other invasive management in the study plots is conducted according to the methods outlined in the study plan. The Chequamegon National Forest shall notify the Commission in a timely manner when timber harvest activities in the treatment plots are completed so that post-harvest surveys can be scheduled.

6. Provide housing in Medford for Commission staff during the field season (approximately 1-2 weeks in late May and 2-3 weeks in July-August).

7. Maintain records of the season of harvest and type of equipment used during timber harvest in treatment plots. All harvest information will be shared with the Commission upon request.

B. The Commission carries the overall responsibility to conduct this research project. The Commission shall:

1. In cooperation with the Chequamegon National forest, locate study plots and establish permanent baseline data based on criteria outlined in the study plan.

2. Conduct plant surveys using methods described in the study plan at the appropriate time intervals and write survey reports summarizing plant survey data. Copies of survey reports will be provided to the Chequamegon National Forest within one year of completing the field work.

3. Provide the Chequamegon National Forest the opportunity to review and comment on any manuscripts resulting from this study before they are submitted for publication

4. Provide the Chequamegon National Forest copies of any voucher specimens or photographic vouchers collected.

3. **Incorporation of Fiscal Management Requirements**. This Agreement shall be administered in accordance with the provisions of the Commission's Fiscal Policies and Procedures Manual. The Chequamegon National Forest will refer to this Agreement as MOU # 7-0902-MPF-MOU-4.

4. **Termination**. Either party may terminate this Agreement by providing 90 days written notice to the other.

5. **Rights in Materials**. The Commission shall retain the copyright and all rights in data produced by this study pursuant to this Agreement. The Chequamegon National Forest is granted a license to use any and all such materials for educational or professional use provided such use does not undermine the Commission's purpose or programs.

6. **Publication of Results**. Neither party will publish any results without consulting the other. Authors of independent publications must give due credit. In the case of failure to agree upon the manner of publication or interpretation of results, either party may publish data after prior notice and submission of a draft of the proposed manuscript to the other for review. In such instances, the party publishing the data will assume full responsibility for any statement on which there is a difference of opinion

7. **Revisions to Study Plan**. This Agreement or work plans may be revised as necessary by the parties designated representative when impacted by significant budget reductions, personnel adjustments, or other appropriate reasons.

8. **Threatened and Endangered Species**. No Tribal threatened or endangered species, or any species appearing on the Regional or Forest sensitive species list, may be collected

9. **Congressional Involvement**. Pursuant to 42 U.S.C. §22, no Member of or Delegate to

the Congress of the United States shall be admitted to any share or part of this Agreement, or any benefits that may arise therefrom

10. **Parties' Designated Representatives.** The parties designate the following individuals to act on their behalf in implementing this Agreement and in carrying out the underlying research project.

Commission
Botanist/Forest Ecologist
Great Lakes Indian Fish and
Wildlife Commission
P.O. Box 9
Odanah, Wisconsin 54861

Chequamegon National Forest
Greg Knight
Forest Soils Scientist
Chequamegon National Forest
850 North 8th
Medford, Wisconsin 54451

This Agreement is entered into as of August 1, 1997.

**GREAT LAKES INDIAN FISH AND WILDLIFE COMMISSION**

By: [signature]
James H. Schlender
Executive Administrator
Great Lakes Indian Fish and Wildlife Commission
P.O. Box 9
Odanah, Wisconsin 54861

**USDA FOREST SERVICE CHEQUAMEGON/NICOLET NATIONAL FOREST**

By: [signature]
Frank Koenig
Forest Supervisor
Chequamegon/Nicolet National Forest
Park Falls, Wisconsin 54532

**Note: This Agreement has been executed in Triplicate Originals.**

Version 1
August 1, 1997

# GLIFWC-USFS Study on the Effects of Logging on Understory Plants

Beth Lynch, Botanist
Great Lakes Indian Fish and Wildlife Commission

## INTRODUCTION

Much of the original forest cover of the territories ceded in the Chippewa treaties of the mid-19th century was old-growth northern hardwood forests. In addition to important tree species (sugar maple (*Acer saccharum*), hemlock (*Tsuga canadensis*), yellow birch (*Betula allegheniensis*)), this plant community type includes at least 35 herb and shrub species traditionally and presently used by the Great Lakes Ojibwa (Meeker et al. 1993). These understory species have evolved in a shady, moist environment where stand destroying disturbances are rare and the recruitment of trees in small canopy gaps created by the death of individual trees is the most common mechanism for replacement of canopy trees. Timber management practices have altered this disturbance regime, and there may be significant effects to understory plant populations due to increased light and temperature on the forest floor, compaction or erosion of soils, loss of pit and mound topography, and the introduction of invasive species.

As these forests continue to be logged, there is an urgent need to understand the impacts to the non-timber components of the forest ecosystems. A recommendation of the Report of the Scientific Roundtable on Biological Diversity Convened by the Chequamegon and Nicolet National Forests (Crow et al. 1994) is to conduct research on the impacts of timber harvesting on understory plants, especially rare species and commercially important species. Species gathered by the Great Lakes Ojibwa under usufructuary rights also need attention.

The effects of logging practices on the composition of the understory are the object of some ongoing studies in the region (Crow et al. 1994, Strong et al. unpublished work plan) as well as past studies both in the region and elsewhere (Metzger and Schultz 1981, Whitney and

Foster 1988, Duffy and Meier 1992, Bratton et al. 1994), however these studies are limited by the fact that no pre-cut surveys were conducted in logged and un-logged stands that were compared. Pre-cut surveys of understory communities are critical to demonstrate that the observed differences in understory composition are the result of the silvicultural treatments rather than pre-existing site differences, and studies lacking such control have come under criticism for not providing rigorous proof of change due to logging (Johnson et al. 1993). In addition, without baseline data it is difficult to assess the magnitude of change in the populations being studied.

The objective of this long-term study is to examine the effects of selection cutting on understory plants in northern hardwood forests of the ceded territories through monitoring plant populations before, and during, periodic selection harvesting over several decades. This study is designed to determine: 1) how understory plant communities change in northern hardwood stands subjected to periodic selection cutting using typical logging practices; 2) how the suite of plants used by the Great Lakes Ojibwa in northern hardwood forests is affected by periodic selection cutting; and 3) how the impacts to understory plant communities differ under the influence of different logging operators and equipment.

This long-term study is unusual in that individual stands will be monitored before initial harvest and for decades after as stands are subjected to periodic re-entry for selection cutting. A long-term commitment from both the GLIFWC and the USFS makes this possible. In addition, the design includes control stands that are being monitored but not logged for the length of this study are paired with the treated stands. This study is also unlike any others because GLIFWC has a commitment to address impacts to plants used by the Great Lakes Ojibwa.

## STUDY AREA

The study will be conducted on the Medford District of the Chequamegon National Forest in central Wisconsin. This study area was chosen for two reasons: staff on the Medford District perceive a need for research into the impacts of logging on understory plant communities and have expressed a commitment to work cooperatively to establish a well replicated and controlled experiment, and we believe that understory plant communities growing on the highly compactable, silty soils on this District will be particularly sensitive to logging impacts.

Six northern hardwood stands on silt loam soils associated with ice-walled lake plains and the ground moraine associated with the Copper Falls Formation end moraine (Attig 1993) have been selected (Table 1). The ice-walled lake plains are included in Landtype Association

**Table 1.** Location of stands selected for logging study on the Medford District

| study # | compartment | stand | location | LTA |
|---|---|---|---|---|
| C2 | 118 | 2 | T32N R2W Sec. 27 | Jf05 |
| C3 | 49 | 1 | T33N R1W Sec. 7 | Je05 |
| C4 | 48 | 14 | T33N R1W Sec. 18 | Je05 |
| C5 | 51 | 9 | T33N R1W Sec. 5 | Je05 |
| C6 | 10 | 60,61 | T32N R2W Sec. 17,18 | Jf05 |
| C7 | 48 | 8 | T33N R1W Sec. 18 | Je05 |

(LTA) Jf05, and the ground moraine is LTA Je05. These sites are classified as Acer-Hydrophyllum habitat types (Kotar 1988) and have relatively diverse understories and canopies composed of predominantly sugar maple, basswood (*Tilia americana*), white and green ash (*Fraxinus americana* and *F. pennsylvanica*), and butternut hickory (*Carya cordiformis*). Although the entire area was logged in the past, stands selected for this study originated in the 1920s and have had minimal subsequent entry. The locations of the stands on the Medford District are shown in Figure 1.

## STUDY DESIGN

Paired treatment and control plots have been established in stands that are scheduled to be select cut with the individual tree selection method. The locations of the control and treatment plots are shown in Figures 2a-2c. Stands were selected using the following criteria

minimum age of 60-70 years, with minimal subsequent disturbance
silt loam soils
Acer-Hydrophyllum habitat type
will be logged
large enough to accommodate treatment and control plots

Each of the stands has a 50x90 m treatment plot that will be included in the portion of the stand to be logged, and an unlogged control plot (50 x 90 m plus 10 m buffer). Information about the type of equipment used and depth of snowpack will be gathered so that the effects of ground condition and type of equipment can be determined.

Two 50x90 m plots chosen to be representative of the stand are located in each of the stands. Each plot is delineated by a 90 m baseline with perpendicular 50 m transects (Fig. 3). The endpoints of the 90m baseline are marked with karsonite posts. The location of this baseline will be mapped using a GPS unit. The control plots have been designated as permanent reserve areas within the stands, and their boundaries are marked with a paint. Locations of experimental and control plots will be documented in CDS notes, Land Status Atlas, and in Compartment Records at the Medford District office.

Information about the frequency and percent cover of understory plants, composition of shrub layer, density and basal area of canopy species, and percent canopy cover will be obtained from each plot. To describe the understory vegetation, 42 1 $m^2$ quadrats are located within each 90 x50 m plot, using a stratified random sampling design (Fig. 3). Percent cover of plants less than knee high is estimated in each 1$m^2$ quadrat. In a 1x3 m plot (including the original 1 $m^2$ quadrat) all species present are recorded and assigned a value of 1, 2, or 3 depending on whether they occur in 1, 2, or 3 of the 1-meter segments (Fig. 3). This gives an indication of how patchy a plant is, and provides additional opportunities for rare species to be detected.

To quantify tree cover, percent canopy cover is measured at 21 sampling points using a densiometer. At each point four readings are taken, one in each quarter around the sampling point. The point-quarter method is used to determine the species composition, density, and basal area of trees (>10cm dbh) in the plot (Barbour, Burk, and Pitts 1980). Point-quarter measurements are made at the 21 sampling points where percent canopy cover was measured. Shrubs and tree saplings > knee high and < 1" dbh are counted in 1x50 m transects running perpendicular to the baseline at 0, 30, 60, and 90 meters.

Data on the cover and frequency of plants in the herbaceous layer will be gathered for 3 years prior to logging to establish a record of pre-cut understory community composition. Plant surveys are conducted in late-May and again in July-August to ensure that all species are represented. After the initial logging, stands will be surveyed for understory vegetation at 1, 2, 5, and every five years thereafter. It is anticipated that stands will undergo selection harvest every 15-20 years. Data will be analyzed after each survey to provide periodic information about the composition of understory plants in control and treatment plots.

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