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Alison Wood

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WOOD, ALISON C. St. Olaf College, Northfield, MN 55057, USA.
Comparison of Big Woods Forest Composition in Nerstrand Big Woods State Park and Norway Valley, as determined by woody plant sampling.

ABSTRACT

This study compared the forest composition of a Big Woods area in Nerstrand Big Woods State Park to a Big Woods area in Norway Valley by measuring density, frequency, and size of tree species along random line transects. Tree diameters were compared using statistical analysis. Species diversity was also calculated to make further comparisons. Differences were found between mature tree, sapling and seedling composition of the two sites. Red oak was the dominant mature tree species in Nerstrand while sugar maple was the dominant mature tree species in Norway Valley. Sugar maple was the most dominant seedling and sapling species in both areas, however they had a much higher density in Norway Valley than in Nerstrand. The mean mature tree diameter was greater in Norway Valley than in Nerstrand. While there are definite similarities between these two Big Woods areas, there are significant differences in forest composition. In the future, further study of the forest composition in both areas would enable ecologist and conservationists to follow the patterns of succession and better understand Big Woods ecosystems.

INTRODUCTION

The maple-basswood forests are rated as rare by The Nature Conservancy (Big Woods Project 1995). The Big Woods was the largest continuous stand of maple-basswood forest in south-central Minnesota (Milbert 1994). It acted as a green barrier to the frequent prairie fires that raged in the past and would stretch continuously for miles. During the time of settlement in the 19th century, the forests were made into farmland and separated into woodlots. The Big Woods is a unique part of Minnesota's natural heritage and beauty.

During a study by Minnesota DNR (1983), the sugar maple/basswood association is dominant in the majority of the Big Woods community. Milbert (1994) stated that maple-basswood forest types have increased in number in the past 40 years as part of a composition shift from oak forests. There are a number of areas where other tree species have established their dominance through site factors, cutting history, and presettlement conditions, however, sugar maple is the most dominant tree in much of the maple/basswood community. The sugar maple has a nearly ideal situation: it provides an almost complete shade cover and pumps nutrients into the soil from its fallen leaves each fall, creating an environment that benefits its own longevity.

Nerstrand Woods, better than any other state park, is representative of the Big Woods type of vegetation which once covered 3,400 sq. miles of south central Minnesota. It was established as a state park in 1945. The area was originally covered by northern hardwoods, which includes such trees as maple, basswood, elm, oak. Pre-European settlement, the area was continually disturbed from fire and other natural disturbances (Miller 1983). Due to these disturbances, the early successional communities of oak and aspen were more abundant than the maple-basswood communities of today. (Miller 1983)

According to the Minnesota Department of Natural Resources (1978), sugar maple became more abundant after the control of fire by white settlers. Miller (1983) noted that most of Nerstrand Woods has, at some time, undergone timber harvesting. In 1862, the land sections that comprise Nerstrand Woods State Park were subdivided into 139 woodlots. Today, due to it's state park status, Nerstrand Woods is one of the last remaining large remnants of the Big Woods ecosystem. Thus, the park has become the focal point for maple-basswood forest restoration. (Eckhoff 1993)

Therefore, vegetation studies done in Nerstrand Woods can be used as a data set for comparison to other possible Big Woods areas. It is important to restore and maintain any areas of Big Woods to save an important component of Minnesota's landscape.

The City of Northfield also lies in an area classified as Big Wood during Pre-Settlement times. The study area on the St. Olaf campus is in an existing forest named "Norway Valley." This area was spared from clear-cutting due to its steep incline. It would have been very difficult to farm. Norway Valley is a much smaller example than the Big Woods represented in Nerstrand Woods State Park. St. Olaf biological reports have classified Norway Valley as a maple-basswood forest. This paper will compare the forest composition of Norway Valley, Northfield Minnesota and Nerstrand Big Woods State Park using tree population data collected from both areas. Three null hypotheses will be tested. First, the densities, frequencies and coverage of tree species are the same at both Norway Valley and Nerstrand. Second, the mean DBH (diameter at breast height) of mature tree species at both sites are the same. Third, within each site, mature tree, sapling and seedling species are the same and occur at the same relative densities, frequencies and coverage.

METHODS

Norway Valley is located within the grounds of the St. Olaf College campus. It is located along the south-side of campus and is surrounded on all sides by development, such as houses or roadways. The area has been classified as a maple-basswood forest. Walking trails cut small pathways through the vegetation. The study site was located within the center of this wooded area, avoiding walking trails when possible.

Nerstrand Big Woods State Park is the largest remnant of the Big Woods ecosystem in Minnesota. It is located approximately 11 miles southeast of Northfield, Minnesota. The area in Nerstrand that was surveyed in this study was cut between 1940 and 1957. In 1983, basswood appeared to be the dominant tree in this area.(MN DNR 1983) The study site was located within an area of least human disturbance located between the picnic grounds parking lot and the Pioneer camp. The area sloped upwards from a small creek and flattened as it approached a hiking trail.

Forest composition was examined using three different levels of vegetation: seedlings, saplings and mature trees. One square meter plots (0.71 x 1.41 m) were used to sample seedlings. Seedlings were defined as individuals less than 0.5 meters tall. All species of woody plants were included in the sample data.

Saplings were sampled using a 10 square meter plot (2.24 x 4.47m). One corner of the one meter^2 plot was used as a corner for the 10 meter^2 plot. Saplings were defined as individuals greater than 0.5 meters tall and less than 13 cm DBH, diameter at breast height. All sapling species within the plot were counted.

Mature trees were measured using the plotless sampling method. It is known as the point-quarter method and was developed by Cottam and Curtis (1956 as cited by Shea 1995). Point-quarter sampling used point to plant distances to estimate the area occupied by an average tree. Mature trees were defined as those greater than 13 cm DBH. The same corner of the one meter^2 plot used for the sapling plot was used as the point-quarter sample point. The distance from point to tree was measured using a meter measuring tape. The DBH was also be recorded for each mature tree sampled using a DBH tape. If multiple trunks were present, all of the trunks were measured, calculated and then added together. Finally, the species of each mature tree were recorded.

To construct plots, two 50 meter transects were extended at each site using a 50 meter measuring tape. A total of four transects lines were marked. One transect at each site covered a slope, while the other covered a hilltop. The transects were placed on both hilltop and sloped areas in order to cover all possible microclimates. Plot points were set at 0 meters, 15 meters, 30 meters and 45 meters of each line, using the transect tape as the central point for sapling, seedling and trees counts. For both sites, a total of 16 plots were sampled.

Calculations for density, frequency, coverage and importance value were computed for the mature trees using equations for point-quarter sampling (Brower and Zar 1990). Calculations of density were also done for the seedlings and saplings using Brower and Zar (1990). A one-way ANOVA was done to compare mean DBH at the two sites. A two-way ANOVA was done to compare mean DBH within species at both sites. To evaluate species diversity, a Simpson Index was found for seedlings, saplings and mature trees and well as for total species counts.

RESULTS

Seedlings

Sugar maple was the most dominant seedling species found in both Norway Valley and Nerstrand. In Norway Valley, sugar maple seedlings had a density of 1.813 plants per m^2 (Table 1 contains an overview of all seedling counts and density measurements from Norway Valley). The second most abundant seedling in Norway Valley was Hackberry, with .188 plant per m^2. Only one red oak individual was recorded and no basswood seedlings were recorded in Norway Valley (Table 1).

In Nerstrand, sugar maple seedlings also had the highest density, however only .688 plant per m^2 were recorded (Table 2 contains an overview of all seedling counts and density measurements from Nerstrand). The second most abundant seedling found in Nerstrand was red oak, with .625 plants per m^2. No basswood seedlings were recorded in Nerstrand (Table 2).

The values found using a Simpson Species Diversity Index indicate that seedling diversity is higher in Nerstrand, 0.66=Simpson, than in Norway Valley, 0.35=Simpson (Table 3). As indicated by a p-value of 0.01, the difference between the diversity values was significant.

Table 3: Simpson Species Diversity Index

Tree class	Norway Valley	Nerstrand	p-value
Seedlings alone	0.35	0.66	0.01
Saplings alone	0.50	0.83	0.01
Mature trees alone	0.46	0.69	0.05
Species grand totals	0.42	0.73	0.01

Saplings

Sugar maple was also the most dominant sapling species in both areas. In Norway Valley, sugar maple had by far the most

	Tree species	# of seedlings	Seedling density(m2)	# of saplings	Sapling density(m2)
1	Sugar maple	29.000	1.813	73	0.456
2	Elderberry	1.000	0.063	10	0.063
3	Hackberry	3.000	0.188	9	0.056
4	Basswood	0.000	0.000	1	0.006
5	Green ash	1.000	0.063	14	0.088
6	Ironwood	1.000	0.063	0	0.000
7	Red oak	1.000	0.063	0	0.000

	Tree species	# of seedlings	Seedling density/m2	# of saplings	Sapling density/m2
1	Sugar maple	11	0.688	13	0.081
2	Ironwood	1	0.063	13	0.081
3	Green ash	0	0.000	7	0.044
4	Gooseberry	0	0.000	3	0.019
5	Red oak	10	0.625	0	0.000
6	Basswood	0	0.000	5	0.031
7	Prickly ash	1	0.063	13	0.081
8	Red maple	2	0.125	0	0.000
9	Unknown	0	0.000	5	0.031

number of individuals, with a density of .456 plants per m^2 (Table 1). Green ash and elderberry were the second and third most dominant species, respectively. However, the number of green ash and elderberry individuals was very small, 14 and 10, in comparison to sugar maple; 73 sugar maple individuals were sampled (Table 1).

Although sugar maple was also the most dominant sapling species in Nerstrand, ironwood and prickly ash saplings have identical densities to that of sugar maple saplings. There existed a three-way tie between the most common sapling species in the Nerstrand site(Table 2). The next dense species is green ash. Red oak, which had a high seedling density, was not found in the sapling sample.

The Simpson species diversity comparison calculated that Nerstrand had a higher sapling diversity number, 0.83, than did Norway Valley saplings, 0.50. The difference between these values was significant, due to a p-value of 0.01 (Table 3).

Mature Trees

The species with the greatest importance value was not the same in Norway Valley and in Nerstrand. In Norway Valley, sugar maple was calculated as having the greatest importance value (Table 4 contains all mature tree data from Norway Valley). The second most important species was basswood. While basswood was second in rank, it had less than half the number of individuals than had sugar maple (Table 4). No mature green ash were sampled.

Contrary to what would be expected from looking at the seedling and sapling data, the most important mature tree species in the Nerstrand site was red oak (Table 5 contains all mature tree data from Nerstrand). Sugar maple and large-toothed aspen had equal number of individuals, although sugar maple had a higher calculated importance value, .364= sugar maple compared to .327=large-toothed aspen (Table 5).

Using a one-factor ANOVA, a comparison of the mean mature tree DBH at each site was made. The mean DBH in Norway Valley was greater, 37.909 cm, was greater than the mean DBH in Nerstrand, 27.795 (Table 6). The difference in DBH was significant,

Tree species	# of Indiv.	Rel. density	Density(m2)	# pts. w/ species	Frequency	Rel. frequency	Area covered-m2	Coverage	Rel. coverage	Importance value
1 Sugar maple	22	0.688	0.092	8	0.500	0.533	2401	10.040	0.558	1.779
2 Red oak	0	0.000	0.000	0	0.000	0.000	0	0.000	0.000	0.000
3 Ironwood	0	0.000	0.000	0	0.000	0.000	0	0.000	0.000	0.000
4 Butternut	0	0.000	0.000	0	0.000	0.000	0	0.000	0.000	0.000
5 Large-toothed aspen	0	0.000	0.000	0	0.000	0.000	0	0.000	0.000	0.000
6 Basswood	9	0.281	0.038	6	0.375	0.152	1854	7.827	0.435	0.868
7 White oak	0	0.000	0.000	0	0.000	0.000	0	0.000	0.000	0.000
8 Ash	0	0.000	0.000	0	0.000	0.000	0	0.000	0.000	0.000
9 Elm	1	0.031	0.004	1	0.063	0.067	28	0.113	0.006	0.104

Tree species	# of Indiv.	Rel. density	Density (m2)	# pts w/ species	Frequency	Rel. frequency	Area	Coverage	Rel. coverage	Importance value
1 Sugar maple	4	0.125	0.020	4	0.250	0.190	174	0.871	0.049	0.364
2 Red oak	17	0.531	0.084	8	0.500	0.380	2720	13.441	0.759	1.670
3 Ironwood	1	0.031	0.005	1	0.063	0.048	18	0.088	0.005	0.079
4 Butternut	1	0.031	0.005	1	0.063	0.048	15	0.077	0.004	0.083
5 Large-toothed aspen	4	0.125	0.020	2	0.125	0.095	378	1.890	0.107	0.327
6 Basswood	3	0.094	0.015	3	0.188	0.143	159	0.794	0.045	0.282
7 White oak	1	0.031	0.005	1	0.063	0.048	91	0.454	0.026	0.105
8 Ash	1	0.031	0.005	1	0.063	0.048	18	0.088	0.005	0.084
9 Elm	0	0.000	0.000	0	0.000	0.000	0	0.000	0.000	0.000

Table 6: ANOVA comparing DBH means for each site

One Factor ANOVA X_1 : where Y_1 : DBH (cm)

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	2488.871	2488.871	23.097
Within groups	85	9159.455	107.758	p = .0001
Total	86	11648.326		

Model II estimate of between component variance = 58.125

One Factor ANOVA X_1 : where Y_1 : DBH (cm)

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
norway valley	33	38.818	12.407	2.16
nerstrand	54	27.795	8.937	1.216

One Factor ANOVA X_1 : where Y_1 : DBH (cm)

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
norway val... vs. nerstrand	11.023	4.56*	23.097*	4.806

* Significant at 95%

Table 7: AVONA for 2 factors / Comparing DBH, Species & Site

Anova table for a 2-factor Analysis of Variance on Y_1 : DBH (cm)

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Tree species (A)	1	656.635	656.635	7.868	.0064
where (B)	0	1527.139	•	•	•
AB	1	149.191	149.191	1.788	.1852
Error	76	6342.611	83.455		

There were 7 missing cells found. 7 cases deleted with missing values.

The AB Incidence table on Y_1 : DBH (cm)

Tree species	where:	norway v...	nerstrand	Totals:
Tree species	Sugar maple	23 35.126	4 21.525	27 33.111
Tree species	Red oak	0 •	38 28.864	38 28.864
Tree species	Ironwood	0 •	1 14.8	1 14.8
Tree species	Butternut	0 •	1 13.5	1 13.5

Page 2 of the AB Incidence table on Y_1 : DBH (cm)

Tree species	where:	norway v...	nerstrand	Totals:
Tree species	Large-toot...	0 •	4 33.275	4 33.275
Tree species	Basswood	9 50.433	4 26.95	13 43.208
Tree species	White oak	0 •	1 34	1 34
Tree species	Ash	0 •	1 14.8	1 14.8

Page 3 of the AB Incidence table on Y_1 : DBH (cm)

	where:	norway v...	nerstrand	Totals:
Tre...	Elm	1 19.2	0 •	1 19.2
Totals:		33 38.818	54 27.795	87 31.976

therefore rejecting the null hypothesis that there was difference in mature tree DBH between Norway Valley and Nerstrand.

Using a two-factor ANOVA, a comparison of tree species, site and DBH was made. The differences in mean DBH for each species in relation to site was not significant. The p-value calculated was .1852 therefore, the null hypothesis stating that the mean DBH for mature tree species is the same for all species at both sites was accepted (Table 7).

DISCUSSION

Seedlings

Sugar maple was the dominant seedling species at both study sites. Due to its high shade tolerance (Baker 1949), sugar maple is able to grow in forested areas where very little light reaches the floor. This fact is reflected in the high importance score of sugar maple for both sites. The only other important seedling species in Norway Valley is hackberry. Hackberry will never become part of the upper canopy. It will never be in competition with oak or maple, for example, for light resources in the upper vegetation level. Red oak was more important in Nerstrand than in Norway Valley. Baker notes that red oak is an intermediate shade tolerant species (1949). Perhaps the canopy at the Nerstrand site is not as dense as Norway Valley. More light may pass through and the oak seedlings have a better chance of survival. The diversity index supported that Nerstrand was composed of a greater number of species than Norway Valley. The greater the number of species, the greater the health of an area. Perhaps, Nerstrand was a more healthy maple-basswood forest.

Saplings

Sugar maple was also the dominant sapling species both sites. Again, this could reflect the shade tolerance of sugar maples (Baker 1949). The Nerstrand site also contained ironwood and prickly ash in densities as great as sugar maple. Green ash had the second largest importance value at both sites. Green ash, as is red oak, is an intermediate shade tolerant species (Baker 1949). It must wait for a gap to open in order to receive the resources needed to compete with sugar maple. Again, species diversity is greater for Nerstrand than Norway Valley.

Mature trees

Density and importance values were consistent for most dominant seedling, sapling and mature trees in Norway Valley. Sugar maple was the most important species, however basswood surprisingly entered into the data set. Basswood was the second most dominant tree. This was strange due to the absence of basswood seedling and sapling data. Yet, that incongruence can be explained by the fact that basswood reproduce largely through vegetative clones. Basswood may not channel as many resources towards seed reproduction, which would explain the lack of basswood at the seedling and sapling stage.

In Nerstrand, red oak was the most important mature tree. Sugar maple and large-toothed aspen were tied with the second highest importance values. From the species and size of trees that were present in Nerstrand, one could infer that Nerstrand's oak dominated forests are undergoing succession. Milbert (1994) found that this change over from oak to maple is a natural succession. Succession from a oak dominated forest to a maple-basswood forest was slowly taking place. As the red oaks die, they have few saplings to take their place. Sugar maple or large-toothed aspen, either shade tolerant or fast growing species would swiftly overtake any red oak seedling or saplings.

The species diversity index calculated Nerstrand to have greater diversity, however, the p value (0.5) was not significant. There was not a large enough difference between the sites in relation to mature trees species.

By comparing the mean DBH of the trees at both sites using a one-way ANOVA, trees in Norway Valley were found to have a greater overall tree diameter. This could be explained by two main ideas: the trees in Norway Valley are older or they have less competition due to a smaller number of mature tree species.

The results of a two-way ANOVA comparing the mean DBH in relation to tree species and site were not significant. This may be due to lack of certain tree species in Norway Valley that were high density species in Nerstrand.

One problem that arose which might have affected the results of the study was the senescence of the leaves. When data was collected at the Nerstrand site, the trees still had their leaves on. However, when data was collected at Norway Valley, all save a few of the leaves had fallen off the trees. This made tree identification very difficult for mature tree species. Identification was based on bark and branch characteristics.

<u>Future of the forests</u>

By looking at the high numbers of sugar maple seedlings and sapling, Milbert's (1994) oak forest succession was occurring at both sites. Norway Valley was further into the succession process, based on the great importance of sugar maple in Norway Valley currently. In Nerstrand, this succession is just beginning. There still existed large numbers of mature red oak individuals, but an army of sugar maple saplings and seedlings were amassing in the understory waiting for the right moment.

Curtis (1978) summarized the mechanism of this oak-maple succession. Species such as red oak which occur regularly within mature trees counts but are minor members of seedling and sapling counts are an indication of the inability of red oak to reproduce in the existing conditions. The only means for these shade intolerant species to become part of the upper canopy is through gap phase reproduction. When a disturbance occurs in the upper canopy, seedlings, such as oak can become established and may be able to develop into mature trees. Without these disturbances, shade intolerant species might eventually disappear. Using these facts, it can be said that the degree of species diversity found in a forest is proportional to the chances for disturbance. "The forest is never static but rather exists in a state of a dynamic equilibrium, compounded of the opposing forces of the super-tolerant sugar maple on the one hand and a particular group of vigorous but less tolerant species, on the other hand." (Curtis 1978 p. 111)

REFERENCES

Baker, F. S. 1949. A revised tolerance table. *J. Forestry,* 47:180-181.

Big Woods Project, The. 1995. A Plan for the Big Woods Project. Faribult, Minnesota.

Braun, E. Lucy. 1950. Deciduous Forests of Eastern North America. The Free Press, New York.

Brower, J. and Zar, J. 1990. Field and Laboratory Methods of General Ecology. Third Ed. Wm. C. Brown Publishers, Dubuque, Iowa.

Cottam, G. and J.T. Curtis. 1956. The use of distance measures in phytosociological sampling. *Ecology* 37:451-460.

Curtis, J.T. 1978. The Vegetation of Wisconsin. University of Wisconsin Press, Madison.

Eckhoff, J.D. 1993. Forest Restoration: The Application of Restoration Ecology in the Establishment and Maintenance of a Maple-Basswood Forest. Plan B Paper, University of Minn. Graduate School.

Marschner. 1930. The Original Vegetation of Minnesota.

Milbert, D. 1994. Managing Landscapes in the Big Woods Ecosystem. The Big Woods Project/ MN DNR.

Miller, M. and Scholen, G. 1983. Management plan for Nerstrand Woods State Park. Office of Planning, Minn. Department of Natural Resources.

Minnesota Department of Natural Resources, Interpretive Services Section. 1978. The Bio-cultural Region System of Minn.

Shea, K. 1995. Field Ecology Lab Manual. St. Olaf College, Minnesota.