Current and Future Status of the *Fraxinus nigra* swamp in the Bessey Creek Nature Preserve, Cheboygan County MI

Evan Batzer, Grady Congdon, Rachel Hillabrand, Daniel Labuz

EEB 556- Field Botany of Northern Michigan

19th August 2011

Abstract

With the continued movement of pests such as the emerald ash borer (*Agrilus planipennis)*, northward into upper Michigan, current vegetation analysis will be important to understanding how different plant communities will be affected. In this study, the woody vegetation of Bessey Creek Nature Preserve (BCNP) was measured and analyzed to provide a more complete knowledge of the tree community of BCNP. We sampled tree species with a diameter at breast height (DBH) of >1.5 cm. Both the east and west sides of Bessey Creek were sampled using a plotless point-quarter method. We recorded ten species, with an *Acer rubrum* complex and *Fraxinus nigra* dominating the Preserve with relative densities of 34.5% and 27.3% respectively. We found, however, the most frequently observed trees were not the biggest. *Thuja occidentalis* and *Ulmus Americana*, though uncommon, had the highest mean DBH. The mean canopy coverage was 85.93%. This value and the relative density of *Fraxinus nigra* are expected to fall with the impending spread of the emerald ash borer to this area. The loss of *F. nigra* will create opportunities for shade intolerant species to grow; reflecting what seems to have happened in the past with the loss of *U. americana*. We expect that the forest will continue to be dominated by *Acer rubrum* and its hybrids in the future.

Introduction

Bessey Creek, a stream flowing into Douglas Lake, Cheboygan County, Michigan, has long been the focus of research and conservation within the Northern Michigan scientific community (Gates 1912, Haynes & Hellquist 1978). The creek mouth, now under ownership of the Little Traverse Conservancy, is of conservation interest, as it exhibits a gradient of aquatic habitats and wetlands along Douglas Lake.

The most extensive wetlands in the United States appear the Great Lakes region. Hardwood swamp wetlands are very common, and are characterized by standing water and high tree and aquatic coverage. Frequently found in low lying areas, these swamps are flooded for long periods during the year. Within this variety of ecosystems, red maple and black ash dominated swamps are frequently found in limestone rich areas (Tiner 2005). Productivity of limestone-rich swamps is high relative to bogs, and exhibits superior species diversity when compared to swamps in other regions of the U.S. This abundance of plant species in Michigan swamps is partially due to the higher levels of inflow and outflow of the surface waters (Prince 1997).

The vicinity surrounding Bessey Creek is part of an outwash-lake plain swamp ecosystem. Early 19th century land surveys indicate the presence of conifer and hardwood swamps in the northwestern edge of Douglas Lake, continuing into the Pellston plain (Albert & Comer 2008). Pearsall *et al.* (1995) characterized the preserve as an outwash-lake plain hardwood swamp. An outwash-lake plain hardwood swamp is indicated by the presence of American elm (*Ulmus americana)*, Red Maple (*Acer rubrum)*, and Black Ash (*Fraxinus nigra)*, alongside sensitive fern (*Onoclea sensibilis)* groundcover (Pearsall *et al* 1995). The lack of Northern white cedar *(Thuja occidentalis*) and other conifer species distinguishes this ecosystem from other swamps.

The community composition of the swamp in Bessey Creek Nature Preserve, like all forest types, can be subject to change. While natural disturbances can alter community composition, there are other factors that can influence the forest type of the Preserve. Continued succession has occurred since the logging of the region in the late 1900s, restructuring the shoreline marsh and forest communities of the preserve. In addition, increased human land use in the area surrounding Douglas Lake has altered the rate of lake eutrophication, thus changing the

levels of dissolved gases and available nutrients—regionalized oxygen deficits are present in areas nearest to development (Lind & Davos-Lind 1993). Given Bessey Creek's close proximity to a number of residential properties, this alteration of water chemistry could have a profound effect on the aquatic and shoreline plants found at the stream's mouth.

Looking to the future, the Bessey Creek Nature Preserve is likely to be invaded by the emerald ash borer (EAB), *Agrilus planipennis,* which has been spreading across the Northeastern United States. Infestations of emerald ash borers have dramatically reduced the number of ash trees within Michigan and the surrounding area, and are responsible for the death of over one billion native ash individuals (BenDor *et al.* 2006).

The emerald ash borer is an insect parasite of ash trees (*Fraxinus* spp.) introduced into the vicinity of Wayne Country, Michigan in 2002 (MacFarlane &Meyer 2003). The EAB is renowned for the voracity with which it devastates ash communities, and its clandestine infection method. Trees infested with EAB die within 3-4 years, depending on age and health of the individual (Poland & McCullough 2006). Prepupal beetle larvae burrow into the bark of the infected ash tree, feeding on the phloem of the cambial region. Burrowing larvae form distinct s-shaped feeding galleries that are frequently over 20-30 cm long (McCullough & Katovich 2004). While these galleries may be visible once bark has been removed, infested trees may not exhibit signs of infestation until two years after larvae have entered vascular tissue (Poland & McCullough 2006). Adult ash borers emerge through a D-shaped exit hole in the bark after overwintering (McCullough & Katovich 2004).

The objective of this study was to identify the present state of woody flora within the BCNP, including the size and abundance of tree species present. With this information, we will

be able to make comparisons with historic data of Bessey Creek, and determine what human and environmental factors may have contributed to its current condition. It will also provide insights into how the Bessey Creek plant community might be affected by future events, most notably the arrival of the emerald ash borer. We predict that the EAB will cause a loss of canopy coverage and will reduce the population of *Fraxinus nigra*. Results from this study will give the Little Traverse Conservancy a better understanding of how to manage the BCNP while also providing baseline data on tree communities prior to the arrival of the emerald ash borer.

Materials and Methods

Site Description

BCNP (45° 36' 3.57" N, 84° 42' 57.0" W) is also known as Lancaster Creek. It is located on the northwest shore of Douglas Lake, flowing from Lancaster Lake into Marl Bay of Douglas Lake. Preserve boundaries stretch from the road alongside private property lines, ending a few meters past the shores of Douglas Lake. The area of the preserve is 0.5 acres (0.202 ha).

There are four distinct habitats at Bessey Creek (roadside, swamp, littoral marsh, and aquatic shoreline). The high-light, high-disturbance environment of the roadside provides an opportunity for the growth of graminoids and herbaceous, weedy species. Continued maintenance of the street requires the removal of overhanging or disruptive plants, leading to a floral community composed of plants characteristic of early succession (Trombulak & Frissell 2000). Bordering the roadside is the swamp, which hosts a community composed of trees and shrubs tolerant of seasonally high water levels. The black ash (*Fraxinus nigra*) and maple (*Acer* spp.) dominate the canopy. Beneath the tree cover, the land is mostly composed of small shrubs, such as winterberry (*Ilex verticillata*) and the speckled alder (*Alnus incana*) (NHESP 2001). In

the littoral marsh, small shrubs and graminoids capable of withstanding high water levels, saturated soils, and frequent disturbance are observed. Sweet gale (*Myrica gale*), is found throughout the shoreline as a soil stabilizer and nitrogen fixer. Prevalent herbs of the littoral include blue-flag (*Iris versicolor*) and swamp cinquefoil (*Comarum palustre)*. Numerous sedges and grasses are found growing along the beach and into shallow water (Kost *et al.* 2007). Beyond the littoral marsh lies the open water of the aquatic zone on the southern boundary of the Bessey Creek preserve. Most plants within this area are fully submerged or floating, with occasional grasses and sedges capable of emerging above the water's surface. Numerous *Potamogeton* species are present, alongside the bull-head pond lily (*Nuphar variegatea*) and the fragrant water lily (*Nymphaea odorata*) (Haynes & Hellquist 1978).

Sampling methods of overstory

Using the Point-Quarter Method (Krebs 1999) we sampled from the roadside along a straight line towards Douglas Lake. Once a random number was chosen along the thirty meters, we then found the closest tree (DBH>1.5cm) and measured its DBH. We assigned this tree as our center tree. From the chosen tree, four quadrants were visualized: right front (SW), right back (NW), left front (SE), and left back (NE), each corresponding to a north-south oriented axis (Figure 1). Using the four quadrants we then picked the closest tree and recorded the species identity, the distance (in meters) from the center tree, and DBH in cm. Trees with a DBH of less than 1.5 cm were not sampled. Sampling continued along the original transect until the shoreline was reached. We then turned ninety degrees east and measures 20 paces; from there, random sampling continued towards the roadside until the northern boundary was contacted. On the east side of the creek, the same methods were used to sample in one direction only. The 22 points sampled gave a total of 110 trees for analysis.

When identifying tree species for this study we came across a few ambiguous maples. Two species (*Acer rubrum* and *Acer saccharinum)* have the ability to hybridize. Hybrid *Acer* have been reported in wetland areas when both parent species are present (Barnes & Wagner, -1981); in this study we have combined these taxa together into one group called the *Acer rubrum* complex.

Analysis of Overstory

Using the data collected from our plotless sampling, we calculated the mean DBH in cm (using a DBH tape), frequency of tree species by counting the total of each tree species, and relative density by dividing total amount of each tree species by the total amount of trees sampled. Using the DBH, the basal area (m^2) of each tree species was calculated (Eqn. 1) in order to find a relative dominance. (Albert 2011):

$$BA\ (m^2) = (\text{dbh in cm})^2 \times (7.854 \times 10\text{-}5) \qquad \text{Eqn. 1}$$

To compare the species diversity between the east and west side of Bessey Creek, the Shannon-Wiener Index was used (Krebs 1999: Equation 2).

$$H' = -\sum_{i=1}^{} \ln(P_i)$$

Eqn. 2

The variable *Pi* is the proportion of species *i* relative to the total number of species. Values can range from 1.5 to 4.5 with a high value correlating to an even distribution (high diversity) of species (Krebs 1999).

Canopy Cover

Canopy cover readings were taken using a spherical densiometer. Transect lines used for plotless sampling were followed, pausing every 15 paces to take a new reading. Using the method described by Lemmon (1956), the densiometer was held level at chest height, roughly 40 cm away from the body, so as to prevent researcher from appearing in mirror. Each point within the grid was assigned a value of one. When corresponding canopy covered that point, the value was added to total. Densiometer readings continued along transect lines to the shores of Douglas Lake on the west and east sides of the preserve.

Results

Of the ten tree species that appeared in our sampling plots, the *Acer rubrum* complex was the most frequent with 38 stems followed closely by *Fraxinus nigra* with 30 stems and *Alnus incana* with 24 stems. The other eight species had an occurrence of less than ten stems each (Figure 2). Therefore, the *Acer rubrum* complex had the highest denisty with it accounting for 34.5% of the tree species in Bessey Creek Preserve. The species with the second highest density was *Fraxinus nigra* with 27.3% of the canopy (Figure 3). *Thuja occidentalis* had the greatest mean DBH with 38.5 cm. *Ulmus americana* had the second highest mean DBH with 22.7 cm. (Figure 4). Each of these trees only appeared once in our sampling plots. The *Acer rubrum* complex has the highest relative dominance followed by *Fraxinus nigra* (Figure 5). As basal area is used in calculating relative dominance, the graph of basal area is similar (Figure 6).

The canopy coverage for the entirety of Bessey Creek Preserve was found to have a mean value of 85.93%. The west side alone had a value of 84.58% and the east side of the creek a value of 89.03%.

The Shannon-Weiner Index was used to determine value of diversity for the tree species in BCNP. The Shannon-Weiner Index for the entire preserve was 1.639 which indicates a somewhat uneven distribution of species.

Discussion

Community composition between historical data of the Bessey Creek area and present sampling shows very little change in the overall species composition of the preserve. Data from Gates (1912) and Pearsall *et al.* (1995) indicate that the swamp has been dominated by *Acer rubrum* , *Fraxinus nigra,* and *Ulmus americana*. Current analysis indicates the presence of all three tree species, although *U. americana* is poorly represented. The relative density of *U. americana* in the preserve has dropped from a dominant percentage to just 0.9%. In addition, Gates (1912) does not indicate the presence of any *Betula papyrifera* individuals within the area surrounding northern Douglas Lake. The current survey observes them existing with a 2.7% relative density.

While large *B. papyrifera* individuals were observed to exist (the largest had a DBH of 15.4 cm), observations during the survey indicated a high number of dead *B. papyrifera* trees. *Betula papyrifera* individuals suggest a recent disturbance—without the removal of a large proportion of canopy cover, it is unlikely that these trees would have been able to sprout within the crowded banks of Bessey Creek. Average canopy cover of over 85% suggests trees of early succession may not have the shade tolerance and adequate resources to reestablish themselves within the community. The removal of large quantities of *U. americana* individuals could have created the conditions necessary for the arrival of early successional tree species.

Gates (1912) indicates the presence of *U. americana* seedlings within the thickets surrounding Douglas Lake, accompanied by facultative soil quality and wetness coefficients as described by Pearsall *et. al* (1995) and Albert and Comer (2008). In the past century, these seedlings should have reached maturity, and established within BCNP. However, in our sampling of the area, *U. americana* is conspicuously absent. Despite indications of new growth less than a century earlier, only one American elm individual was sampled within the vicinity of Bessey Creek preserve. This individual was an overstory tree with a DBH of 22.7 cm. While it is possible that competition has forced the elm trees out of the swamp, a more likely culprit is the fungal parasite *Ophiostoma novo-ulmi*, also known as Dutch Elm Disease (DED) which has been well established in Northern Michigan (USDAFS 2010). DED arrived in the United States in the early 1930s, and has since devastated the nation's elm populations. DED is responsible for the death of more than half of the *U. americana* population in the northern United States (Stack *et al.* 1996).

While the major effects of the Dutch Elm Disease parasite have passed through northern Michigan, a new threat to the health of North American plant communities is spreading throughout the United States and Canada. Emerald ash borers have shown distinct preference to North American ash species, which exude fewer defensive chemicals than the co-evolved Manchurian, blue and European ash species native to Eurasia (Pureswaran and Poland 2009). Given that the Bessey Creek ash population is constituted of only black ash, it is likely that borers will selectively infest this ash community. High proportions of ash trees in the preserve (27.3% of the canopy) also imply large consequences of infestation for the entire swamp ecosystem. Affected ash trees quickly lose 30-50 percent of their leaf cover within two years of infestation, often dramatically changing sub-canopy forest composition (McCullough and

Katovich 2004). The current canopy cover of 85.9 percent will be very much reduced, perhaps giving way to quick-colonizing, shade intolerant species. This canopy reduction due to the loss of *Fraxinus* will also facilitate inhabitation of invasive herbaceous species (Hausman et al. 2009). Management and removal of affected *Fraxinus* stands has been demonstrated to aid in a secondary spread of damaging exotics- in Ohio, EAB management efforts have produced plots of land invaded by *Cirsium Arvense, Lonicera Japonica,* and *Rhamnus Cathartica* (Hausman et al. 2009). In the short term, it is likely that the sporadically dispersed tree species in the plot today will become dominant after arrival of the EAB. Paper birch, speckled alder, and winterberry trees should be able to grow quickly once provided additional light, and will dominate the community until the arrival of larger, more shade-tolerant species.

Loss of ash trees will likely continue the trend towards red maple dominated forests that have been seen during the last century. Abrams (1998) notes the large amounts of red maple growth in areas where other species used to be concentrated. The highly generalist behavior of red maple, combined with the removal of native competitors due to human disturbance or disease, gives red maple a distinct advantage in the recolonization of empty land. *A. rubrum* trees are able to grow well in dry or saturated sites, performing best in the absence of strong competition. If a removal of *Fraxinus nigra* trees occurs, the soil of Bessey Creek will be too wet to support the growth of strong competitors such as sugar maple or *Pinus* spp., thus leaving red maple to grow unimpeded. While quick-colonizing tree species may be present within Bessey Creek Nature Preserve immediately following the arrival of the EAB, it is *Acer rubrum* that will come to dominate the preserve's overstory and canopy.

Conclusion

Without proper management and inspection of the Bessey Creek Nature Preserve, it is unlikely that the tree community present today will persist into the foreseeable future. In the absence of major disturbances, the Bessey Creek area would continue to be characterized by the historic *U. americana-A. rubrum-F. nigra* tree community of the 19th and early 20th centuries. However, as the threat of the emerald ash borer mortality grows nearer, the presence of the EAB will markedly change the current species composition of the preserve. Without stopping the spread of the EAB, the Bessey Creek Nature Preserve will likely develop into an *Acer rubrum*-dominated hardwood swamp, with more light penetration to the understory that could result in new successional trajectories for herbaceous vegetation that may include more exotic species within the conservation site.

Acknowledgements

We would like to thank Doug Fuller and Cindy Mom of the Little Traverse Conservancy for his continued support and enthusiasm of our work. Sherry Webster, Peggy Meade, Alicia Farmer, and all of the staff of the University of Michigan Biological Station have been an enormous help coordinating the logistics of day-to-day study. Thank you.

Literature Cited

Abrams, M. D. 1998. The red maple paradox. Bioscience 48:355-364.

Albert, D. A. 2011. Forest Ecosystems Course Pack. University of Michigan Biological Station, Pellston, Michigan, USA.

Albert, D. A. and P.J. Comer. 2008. Atlas of early Michigan's forests, grasslands, and wetlands: an interpretation of the 1816-1856 General Land Office surveys. Michigan State University Press, East Lansing, Michigan, USA.

Barnes, B. V. and W. H. Wagner. 1981. Michigan Trees. University of Michigan Press. Ann Arbor , Michigan, USA.

BenDor, T. K., S. S. Melcalf, L .E. Fontenot, B. Sangunett, and B. Hannon. 2006. Modeling the spread of the Emerald Ash Borer. Ecological Modeling 1997:221-236.

Gates, F. C. 1912. The vegetation of the region in the vicinity of Douglas Lake, Cheboygan County, Michigan. Pages 46-106 *in* R Dezeeuw, editor. Fourteenth Report of the Michigan Academy of Science. Wynkoop Hallenbeck Crawford Co., Lansing, Michigan, USA.

Gates, F. C. 1926. Plant successions about Douglas Lake, Cheboygan County MI. Botanical Gazette 82:169-182.

Hausman, C. E., J. F. Jaeger, and O. J. Rocha. 2010. Impacts of the Emerald Ash Borer (EAB) eradication and tree mortality: potential for a secondary spread of invasive plant species. Biological Invasions 12: 2014-2023.

Haynes, R. R. and C. B. Hellquist. 1978. The distribution of the aquatic vascular flora of Douglas Lake, Cheboygan County, Michigan. Michigan Botanist. 17:183-191.

Kost, M. A., D. A. Albert, J. G. Cohen, B. S. Slaughter, R. K. Schillo, C. R. Weber, and K. A. Chapman. 2007. Natural communities of Michigan: Classification and description. Michigan Natural Features Inventory, Report Number 2007-21, Lansing, Michigan, USA.

Krebs, C.J. 1999. Ecological Methodology. Addison-Wesley Educational Publishers Inc., Boston, Massachusetts, USA.

Lemmon, P. E. 1956. A spherical densiometer for estimating forest overstory density. Forest Science. **2**:317-320.

Lind, O. T. and L. Davalos-Lind. 1993. Detecting the increased eutrophication rate of Douglas Lake, Michigan: the relative areal hypolimnetic oxygen deficit method. Lake and Reservoir Management. 8:73-76.

MacFarlane, D.W. and S.P. Meyer. 2003. Characteristics and distribution of potential ash tree hosts for Emerald Ash Borer. Forest Ecology and Management. 213: 15-24.

NHESP: Natural Heritage Endangered Species Program. 2001. Black Ash Swamp (S2). Massachusetts Division of Fisheries & Wildlife. http://www.nhesp.org.

Pearsall, D. R., B. V. Barnes, G. R. Zogg, M. Lapin, and R. R. Ring. 1995. Landscape ecosystems of the University of Michigan Biological Station. School of Natural Resources and the Environment. University of Michigan, Ann Arbor, Michigan, USA.

Poland, T.M. and D.G. McCullough. 2006. Emerald Ash Borer: Invasion of the urban forest and the threat to North America's ash resource. Journal of Forestry 104:118-124.

Prince, H. C. 1997. Wetlands of the American Midwest: a historical geography of changing attitudes. University of Chicago Press. Chicago, Illinois, USA.

Pureswaran, D.S. and T.M. Poland. 2009. Host selection and feeding preference of *Agrilus planipennis* (Coleoptera: Buprestidae) on ash (*Fraxinus* spp.). Environmental Entomology 38:757-765.

Stack, R.W., D. K. McBride, and H. A. Lamey. 1992. Dutch Elm Disease. Publications of the North Dakota State University School of Agriculture, Fargo, North Dakota, USA.

Tiner, R. W. 2005. In search of swampland: a wetland sourcebook and field guide Rutgers University Press, Piscataway, New Jersey, USA.

Trombulak S. C. and C. A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 13:18-30.

United States Department of Agriculture Forestry Service. Alien Forest Pest Explorer-Dutch Elm Disease. United States Department of Agriculture. September 13, 2010.

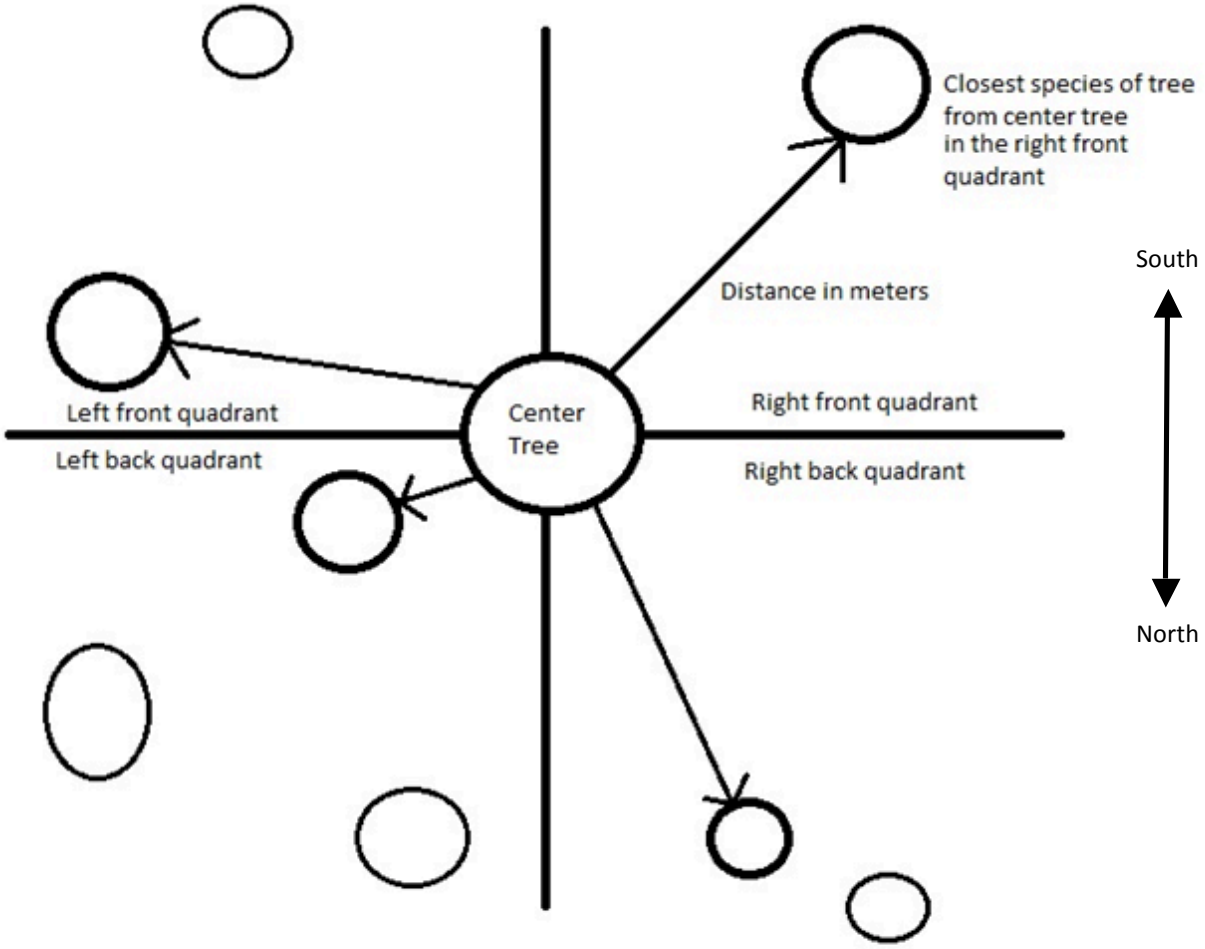

Figure 1. The point-quarter method used to sample Bessey Creek Nature Preserve

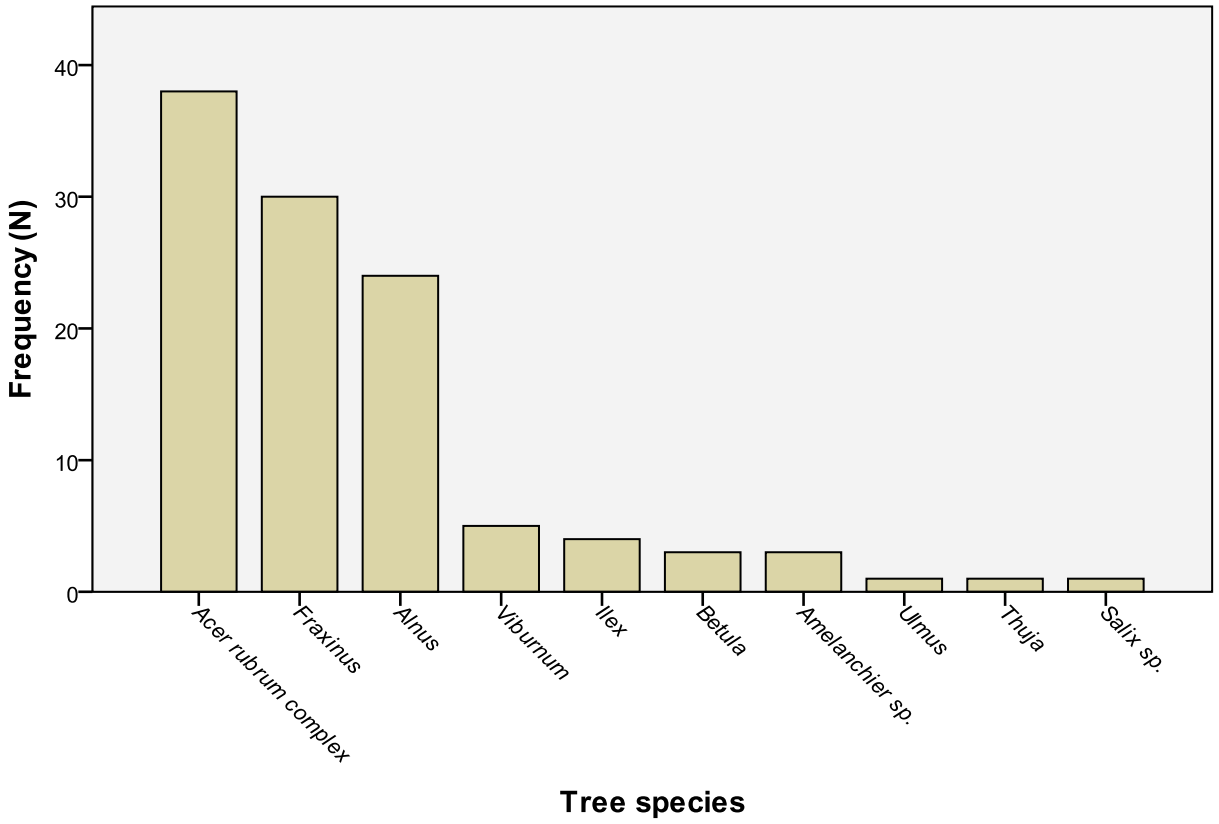

Figure 2. The frequency of the ten most abundant tree species in Bessey Creek Nature Preserve, Cheboygan County, MI. Thuja*: Thuja occidentalis*. Ulmus: *Ulmus americana*. *Acer Rubrum* complex: *Acer rubrum* and *Acer rubrum x saccarhinum* hybrid. Betula: *Betula papyrifera*. Fraxinus: *Fraxinus nigra*. Alnus: *Alnus incana*. Viburnum: *Viburnum lentago*. Ilex: *Ilex verticillata*.

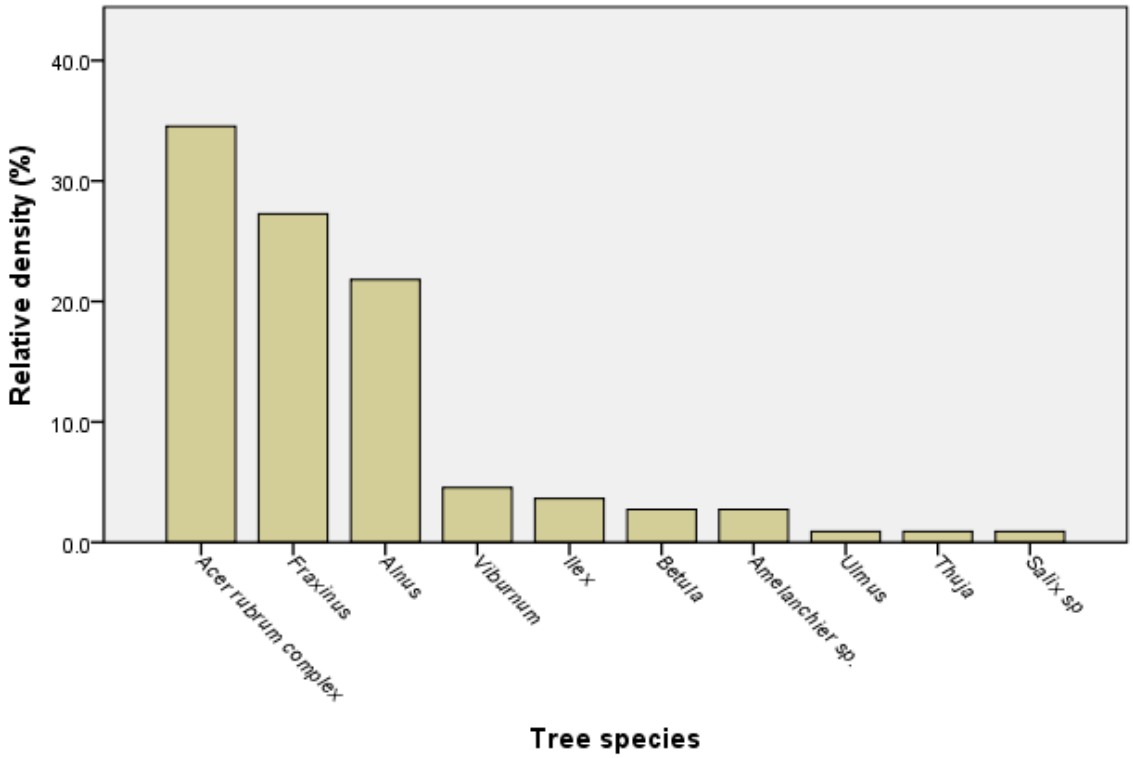

Figure 3. The relative density of the ten most abundant tree species in Bessey Creek Nature Preserve, Cheboygan County, MI. Thuja: *Thuja occidentalis*. Ulmus: *Ulmus americana*. *Acer rubrum* complex: *Acer rubrum* and *Acer rubrum x saccarhinum hybrid*. Betula*: Betula papyrifera*. Fraxinus: *Fraxinus nigra*. Alnus: *Alnus incana*. Viburnum: *Viburnum lentago*. Ilex: *Ilex verticillata*. Sample size 110 trees.

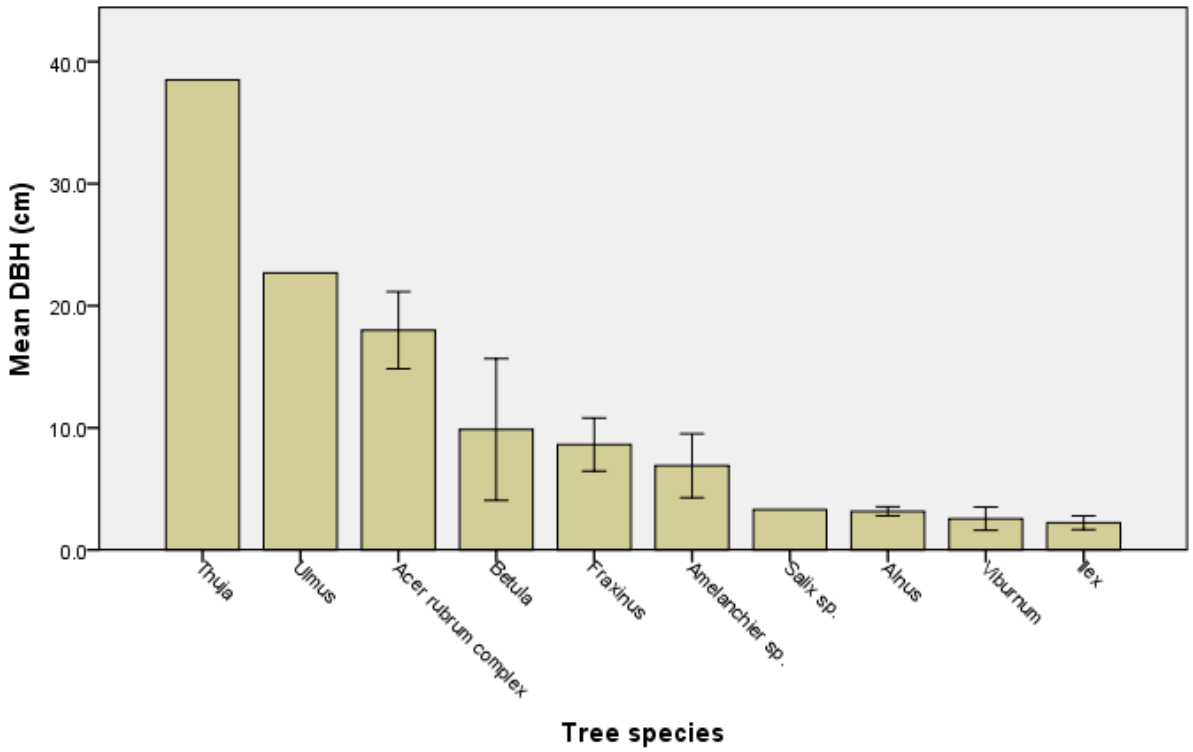

Figure 4. The mean DBH (Diameter at Breast Height) in cm of the ten most abundant tree species in Bessey Creek Nature Preserve, Cheboygan County, MI. *Acer rubrum* complex: *Acer rubrum*, *Acer rubrum* x *Acer saccarhinum* hybrid. Fraxinus: *Fraxinus nigra*. Thuja: *Thuja occidentalis*. Ulmus: *Ulmus americana*. Betula: *Betula papyrifera*. Alnus: *Alnus incana*. Viburnum: *Viburnum lentago*. Ilex: *Ilex verticillata*. Sample size 110 trees. Error bars represent +/- 2 standard error of mean. *Thuja*, *Ulmus,* and *Salix* sp. have no error bars due to only 1 observed species of each.

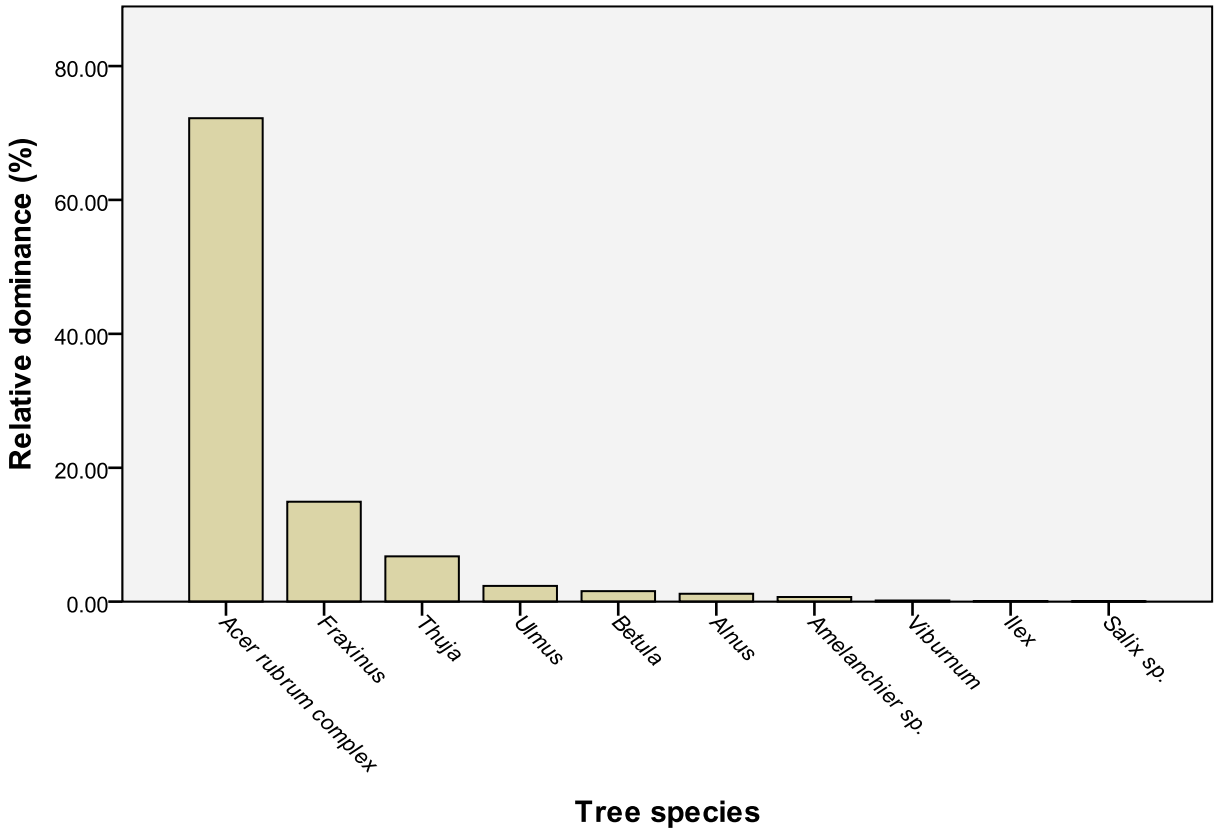

Figure 5. The relative dominance of the ten most abundant species in Bessey Creek Nature Preserve, Cheboygan County, Mi. *Acer rubrum* complex: *Acer rubrum*, *Acer rubrum* x *Acer saccarhinum* hybrid. Fraxinus: *Fraxinus nigra*. Thuja: *Thuja occidentalis*. Ulmus: *Ulmus americana*. Betula: *Betula papyrifera*. Alnus: *Alnus incana*. Viburnum: *Viburnum lentago*. Ilex: *Ilex verticillata*. Sample size 110 trees.

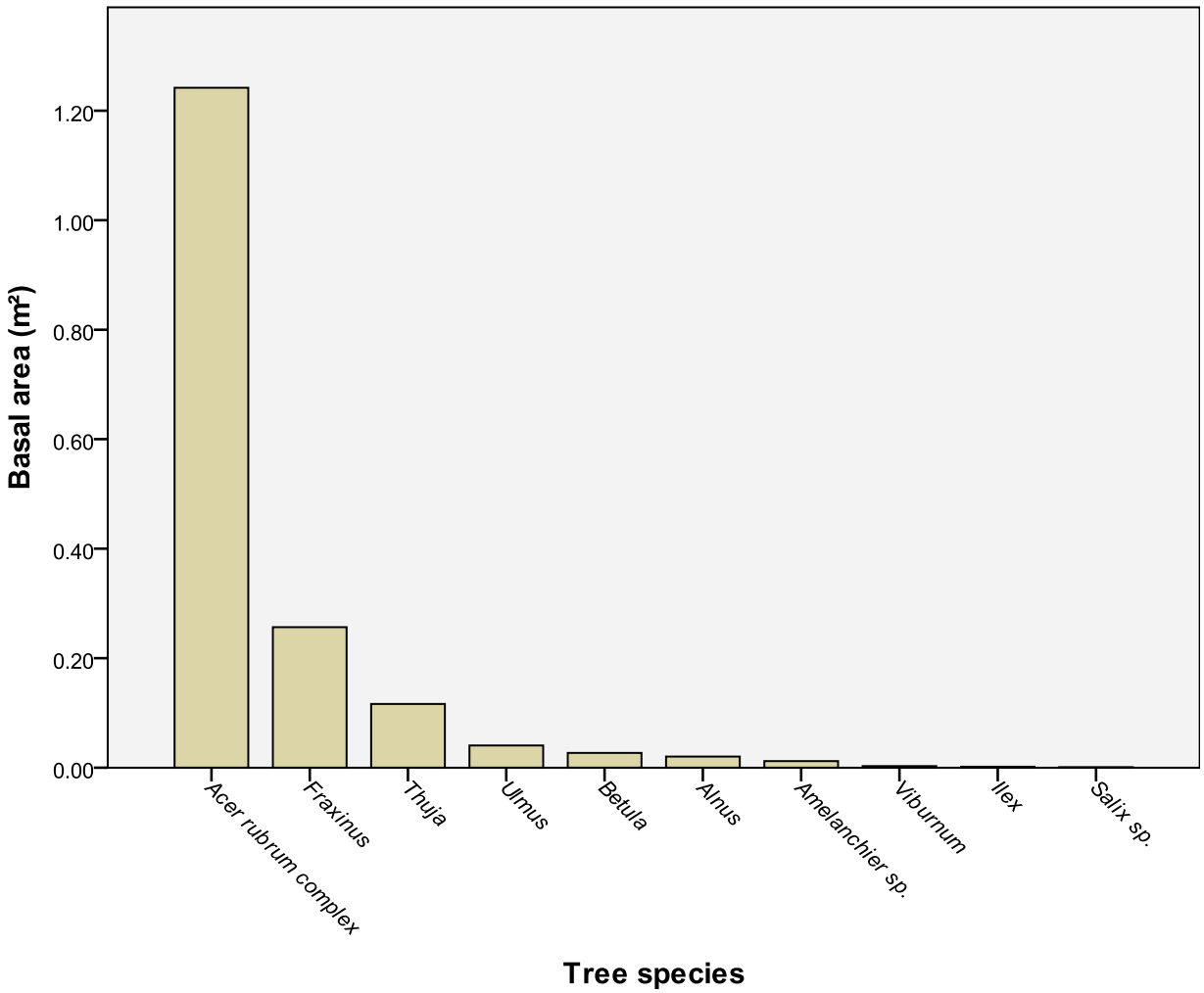

Figure 6. The mean basal area (m²) of the ten most abundant tree species in Bessey Creek Nature Preserve, Cheboygan County, MI. *Acer rubrum* complex.: *Acer rubrum and Acer rubrum x saccarhinum* hybrid. Betula: *Betula papyrifera*. Fraxinus: *Fraxinus nigra.* Thuja: *Thuja occidentalis*. Ulmus: *Ulmus americana*. Alnus: *Alnus incana*. Viburnum: *Viburnum lentago*. Ilex: *Ilex verticillata*. Sample size 110 trees. Error bars represent +/- 2 standard error of the mean. *Thuja*, *Ulmus*, and *Salix* sp. do not have error bars due to only one of each species observed.