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Site factors affecting black ash ring growth in northern Minnesota

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ABSTRACT

Black ash (*Fraxinus nigra*) is a species used for basketmaking by several Native American Tribes in Eastern North America. In recent years, there has been a decline in availability of quality 'basket trees', and the purpose of this study was to determine what site characteristics allow for the growth of appropriate ring widths required for black ash splints used to make baskets. Three ecosystems – lowland wet forest (2 study sites), upland mesic forest (2 study sites) and a series of woodland ponds (4 study sites) – were studied on the Chippewa National Forest in northern Minnesota. At each study site 4–16 plots, each 5-m in radius, were centered on a subject black ash tree. On each plot basal area of all trees and environmental variables such as herbaceous vegetation, composition and structure were measured. On the lowland study sites, volume of soil in hummocks on which single trees grew was also measured. Regression was used to relate ring width to environmental variables. Tree DBH had a significant positive influence on ring width for upland and woodland pond sites (R^2 = 51.0%, $p < 0.001$; R^2 = 42.0%, p = 0.031, respectively). Percent cover of herbaceous vegetation showed a significant negative impact on 5-year ring growth on the lowland sites (R^2 = 59.9%, $p < 0.001$) but no significant trends for uplands or woodland ponds. Thus, it seems likely that these herbs, principally sedges, limit tree growth on lowland sites, where total soil volume available for roots is extremely limited by high water tables.

1. Introduction

Black ash (*Fraxinus nigra* Marsh) is a tree of wetland or mesic sites that is commonly used for furniture, veneer, pulpwood and non-timber forest products. The species is also important ecologically since it occupies high pH wetlands known as rich fens which are important as bird nesting sites and as habitat for many smaller species of plants throughout much of the North American boreal forest (Benedict and David, 2000). Black ash has been important to several Native American Tribes (Mohawk, Micmac, Passamoquoddy, Penobscot, and Ojibwe) culturally and economically for basketmaking. It is utilized throughout most of its northern range from the Canadian Maritime Provinces and northeastern U.S. to Eastern Manitoba and the Lake States of Michigan, Minnesota and Wisconsin. Prior to the current threat from the Emerald Ash Borer (*Agrilus planipennis*) a number of Tribes were concerned over declines in locally available trees for basket making. The St. Regis Mohawk tribe began a small project to restore former stands on the Reservation in 1990. To compliment this restoration effort, this study sought to identify sites that would grow the highest percentage of trees in a stand with the characteristics required for basket making. Perhaps what was learned from this study can assist in restoration efforts after Emerald Ash Borer infestations.

Little is known about black ash growth and ecosystem interactions compared to other tree species. We relied on traditional ecological knowledge of Native American basket makers, as well as knowledge of factors affecting growth of other trees species, to guide this project. Basket makers have learned from experience that relatively few black ash trees (approximately 5–20%) are suitable for basket making because they require 2–3 mm thick rings to create the wood strips that are woven into baskets. Their guidelines for selecting a 'basket tree' are as follows: (1) a minimum DBH of 12.5 cm; (2) a minimum length butt log of 2 m relatively free from surface defects; (3) approximately 20 years of ring growth with a minimum ring width of approximately 2 mm. To find such trees, basketmakers will look for trees with good crown form and few obvious defects that are growing on slightly higher microsites within swamps or in stands that do not have permanent standing water (Richard David, Personal Communication, 1999).

Basket makers have observed that trees situated slightly higher than the majority of trees on relatively large hummocks within a lowland forest have a tendency to produce basket-quality trees. Single dominant mature trees typically occupy individual hummocks in these wetland forests with other trees occupying the

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remainder of the stand. It is speculated that these hummocks have been occupied by several generations of trees on these microsites. Therefore, on the lowland site forest in this study, volume of the hummock on which the subject trees grew was measured to see if there was some significance to the basket maker's observations. Despite the fact that trees had some roots that extended beyond the hummocks, it was thought that a higher volume of roots above the water table might have a positive effect on tree growth. Jones et al. (1996) suggest that higher microtopography affects the fine-root dynamics of forest wetland trees, which should in turn lead to higher productivity.

Ring width is particularly important for basket trees, and is the one factor that cannot be seen prior to cutting into the tree. Therefore, we had two objectives for this study: (1) to determine what site factors influence ring width of black ash; (2) to assess the relative differences in potential to produce good basket trees of black ash among lowland, upland, and forest pond ecosystems of northern Minnesota. Stands were not chosen to be statistically comparable because we wanted to look at these three types found in Northern Minnesota. The following four hypotheses were developed in consultation with basket makers of the Mohawk Tribe for objective 1:

H1. Ring width will be positively related to tree diameter.

H2. Trees on sites that have perennial standing water will have narrower ring widths than sites without.

H3. Trees on sites with perennial standing water will have a positive relationship between soil volume of the hummock on which the tree grows and ring width.

H4. Competing vegetation, including other trees and ground layer vegetation will negatively affect ring width.

1.1. Study areas

Three ecosystem types—lowland forest, upland forest, and forest ponds were studied on the Chippewa National Forest in Northern Minnesota. The stands were selected based on their potential to contain trees suitable for basket making. The sites had to contain a high percentage of black ash trees that a basket maker might choose when looking for trees to harvest.

The lowland and upland ecosystems (two sites each) were located on the Blackduck Ranger District on the north side of Lake Winnibigoshish approximately 1.3 km west of Farley Creek at approximately N47.5307°; W94.2030°. These sites were within 800 m of each other and situated on nearly level, poorly drained silt-loam soils that form part of an old lake plain. The elevation difference between the upland and lowland was approximately 1 m. Soils for the lowland and upland sites were silt-loam, with a forest floor layer 1–4 cm thick. The A horizon was a gray loamy-clay 15–20 cm thick. The B horizon was gray clay >40 cm thick over a sandy parent material.

The lowland sites had perched water tables and were not directly influenced by the regional water table because of the low permeability of the soils (Dale Nichols USDA Forest Service Retired, Grand Rapids, MN Personal Communication). Drainage for lowland and upland sites was primarily surface runoff due to the impervious clay soils, and both had an estimated slope of 0–3%. The uplands appeared to drain much more quickly than the lowland sites, which had surface water a few to several cm deep throughout the year. There were small depressions up to a few meters wide with slightly deeper water on the lowland sites.

Although the elevation difference between the upland and lowland sites was slight, the depth to water table, and therefore the vegetation was very different. The ground layer vegetation of the lowland sites had a large component of Carex spp., especially *Carex tuckermanni*, and *C. brunnescens*, along with *Iris versicolor*. The upland understory indicator plants were: American basswood (*Tilia americana*), *Poa* spp., *Laportea canadensis* and *Asarum canadense*.

The third black ash ecosystem, woodland ponds, had four study sites and is located on the Chippewa National Forest on the north side of Leech Lake at approximately N47.2948°; W94.4285°. All of these sites were vernal forest ponds, with the single exception of one site located in a depression with perennial water. They varied in size from 0.5 to 1 ha. All ponds were forested with almost pure stands of black ash situated within a matrix of northern hardwood forest dominated by sugar maple (*Acer saccharum*) and American basswood. The soils in the vernal ponds were on sandy-loam soils, located on the Guthrie Till Plain.

2. Methods

2.1. Five-year ring growth and environmental factors

A series of plots with nested subplots (5 m and 2 m radius, respectively) were placed in a grid with approximately 20 m spacing at each study site. There were a total of 67 plots, 24 in uplands, 24 in lowlands and 19 in woodland pond ecosystems. Because the focus of this study was to determine what site factors influence the growth of basket trees each plot was centered on a black ash subject tree. The nearest black ash subject tree of at least 5 cm DBH was located (all were within 5 m of the grid point) at each grid point. In the 5 m-radius plot, height and diameter of all trees greater than 5 cm DBH were measured. Basal area at the plot center was also measured with a 10-factor prism. Crown class (dominant/codominant, intermediate, or overtopped) was determined for each subject tree and each subject tree was also cored with an increment borer.

The cores were air-dried, mounted in wooden core holders, and progressively sanded with 100, 200, and 400 grit sand paper. Ring width was measured and total age at DBH determined using a flatbed scanner and analyzed with the WinDendro™ software (Version 6.01, Regent Instruments Inc., Quebec, Canada). Visual counting using a dissecting microscope was used to check the accuracy of WinDendro™, which was found to be within plus or minus 2–5 years of the scanned core ages. WinDendro™ automatically placed the scanned data into a text file, which was then analyzed in Microsoft Excel using a macro program XLSTEM (Version 1.2, Regent Instruments Inc., Quebec, Canada).

Within the nested 2 m-radius subplots all seedlings less than 1.5 m tall were counted. Percent cover of forbs, grasses, sedges, and shrubs less than 1.5 m tall was visually estimated to the nearest 5% within all subplots.

To estimate hummock volume for trees within the lowland study sites, the length of two axes at water level at the bottom of the hummock and height from the top of the hummock to water level were measured. Hummock volume was calculated using the formula for one-half of an ellipse to estimate rooting volume above the water for each hummock. Water levels can fluctuate after periods with varying rainfall, so all hummocks were measured on the same day so that the relative soil volume among hummocks would be comparable. The following formula for an ellipsoid was used to calculate the soil volume available for rooting: ($V = \{4/3\pi abc\}1/2$), where a and b are the two radii of the hummock at the water level, and c is the height of the hummock (Fogiel, 1989).

2.2. Statistical analyses

Simple linear regression was used to investigate the relationship of 5-year ring growth with basal area of trees and vegetation surrounding each subject tree, subject tree DBH, and, for the