Fire History and Age Structure Analysis in the Sherburne National Wildlife Refuge: Establishing Reference Conditions in a Remnant Oak Savanna Woodland

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***Abstract**—Oak savanna woodlands were once a dominant ecotone throughout the upper Midwest. These ecosystems represented a transitional zone between prairie communities to the west that eventually graded into Big Woods forest. Most of the oak savanna landscapes of most of the Midwest were extensively homesteaded and farmed during the middle 1800s and few intact savanna landscapes remain today. Given the current interest in preserving, maintaining, and restoring these systems, it is imperative that the natural factors that have shaped these areas are investigated. This research investigates the potential of developing reference conditions in a relatively intact oak savanna in the Sherburne National Wildlife Refuge, Minnesota. This research provides a context for current management activities centered on maintaining and restoring oak savanna ecosystems.*

Introduction

Oak savanna woodlands were once a dominant ecotone in southwestern Minnesota and throughout the upper Midwest. These ecosystems represented a transitional zone between prairie communities to the west that eventually graded into Big Woods forest. Most of the oak savanna landscape of southern Minnesota (and indeed most of the Midwest) were extensively homesteaded and farmed during the middle 1800s and few intact savanna landscapes remain today.

The structure, origin, and factors that have maintained presettlement oak savanna have not been well documented or established. Fires are thought to have maintained these landscapes, perhaps ignited by Native Americans, but the disturbance regime of these landscapes prior to widespread Euro-American impact remains elusive. Given the current interest in preserving, maintaining, and restoring these systems, it is imperative that the natural factors that have shaped these areas are investigated. Prescribed fires have become an important tool in this regard, but the fire management activities can be better implemented if the natural role of fire is known.

Reconstructing the historic fire regime in oak savanna woodlands is challenging because few are of sufficient age to extend to periods before appreciable impacts by human activities. However, this information is critical for establishing reference conditions that can be utilized to guide restoration activities and initiate management activities.

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This research will investigate the potential of developing reference conditions in a relatively intact oak savanna in the Sherburne National Wildlife Refuge, Minnesota. Vegetation plots will be established throughout the remnant to determine the variability in savanna structure and composition. Fire scars will be collected throughout the remnant to determine the variability in fire frequency and associated changes in savanna age-structure and composition related to fire activity.

This research provides a context for current management activities centered on maintaining and restoring oak savanna ecosystems. The principal questions to be answered include:

- What is the fire frequency of the oak savanna remnant and how much variation exists over space?
- How has fire frequency changed over time?
- Are there particular time periods where fire is more/less prominent?
- Are forest compositional and structural characteristics related to fire frequency?
- Has the seasonality of fire changed over time?

Identifying the historic fire regime of oak savanna landscapes, the associated forest structures, and spatial variations is critical to developing sound management guidelines for the restoration of these landscapes. Since this study area is one of the few old-growth remnants of this ecosystem in the refuge, information developed in this study will be useful to management of other parts of the refuge. Few detailed investigations of oak savanna fire history and age structure have been completed. This research will add substantially to our understanding of the vegetation dynamics and disturbance regime that characterize this landscape.

The information in this paper is taken from the study's "Progress Report, Spring 2007."

Field Sampling

Field sampling for age structure and compositional patterns was completed during summer 2006 at 55 points within the study area. Our sampling used an alternating pattern of grid points. At every other grid point we collected increment cores for age determination. Each grid point was inventoried for compositional attributes. Age structure data were collected from 28 points.

Our original design included sampling of 65 grid points. However, some points fell in wetland areas with little or no tree cover and some points were omitted due to their proximity to a cemetery, road, or other impediment to sampling.

Age and composition data collection is complete for the study area; however, we have not collected fire-scar samples as of March 2007. Fire scar samples will be collected during spring and summer 2007 outside the time period where oaks are susceptible to oak wilt.

Stand Composition

A great deal of variation in stand composition exists across the study area (table 1). This is mostly manifested as differences in relative amounts of pin and bur oak as stem density and basal area are quite variable. The study area is largely composed of northern pin oak that dominates both basal area and stem density (and therefore species importance) with lesser amounts of bur oak. In fact, only a limited number of sites are dominated by bur oak. Of the grid points sampled, 92.7 percent contained pin oak and/or bur oak. Aspen and sugar maple were also present at a few sites, sometimes in large numbers.

Table 1—Species identification code for tree species located in plots. Number inventoried indicates the number of each species present in all plots combined. Codes are used in figures in this paper.

Four-letter code	Scientific name	Common name	Number inventoried
QUEL	*Quercus ellipsoidalis*	Northern pin oak	1,386
QUMA	*Quercus macrocarpa*	Bur oak	515
POTR	*Populus tremuloides*	Quaking aspen	241
POGR	*Populus grandidentata*	Big-tooth aspen	15
ACSA	*Acer saccharum*	Sugar maple	75
ACRU	*Acer rubrum*	Red maple	18
FRPE	*Fraxinus pennsylvanica*	Green ash	31
FRNI	*Fraxinus nigra*	Black ash	43
ULAM	*Ulmus Americana*	American elm	9
OSVI	*Ostrya virginiana*	Eastern hophornbeam	5
PRPE	*Prunus pensylvanica*	Pin cherry	7
PRVI	*Prunus virginiana*	Choke cherry	7
PRSE	*Prunus serotina*	Black cherry	14
SASP	*Salix sp.*	Willow	1

Stem density (fig. 1, 2) and basal area (fig. 3, 4) appear to have no spatial pattern at a landscape level. That is, there does not initially appear to be any clustering of large/small values (fig. 5). However, basal area and stem density appear greatest south of the road running east-west through the study area. This has not been investigated using a spatial autocorrelation or variogram approach as of yet to determine if there are spatial patterns that can be quantified.

Tree diversity is generally higher south of the road and includes sugar maple, ash, and cherry in greater abundance than are found elsewhere within the study area (fig. 6). *Corylus sp.* is present in high abundance at nearly every sampled grid point (note we have not yet summarized sapling/shrub data). There are places that have less *Corylus* than others. This may be related to some aspect of the environmental conditions within a stand but more likely reflects fire history to some degree. We suspect that those areas that are burned most frequently might be enabling hazel to germinate readily from root stock. This has led to enormously high stem densities in some areas of the savanna at the sapling/shrub level.

Stem Density Information

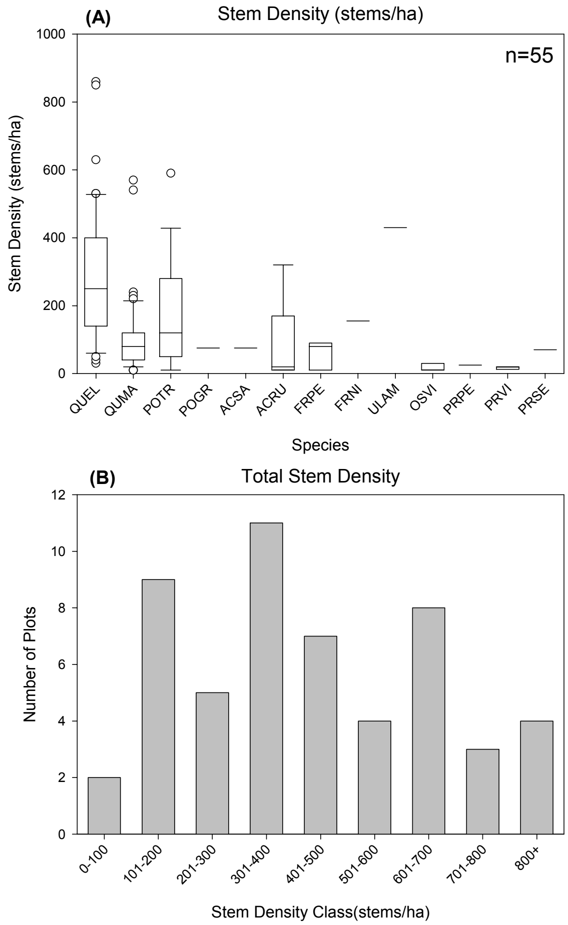

Figure 1—Stem density of sampled forest structure plots in the Sherburne National Wildlife Refuge. (A) Box and whisker plots of stem density of individual species where present in a plot. Horizontal line in each box represents the median value. Each outliner is depicted as an open circle. (B) Total stem density determined in individual plots.

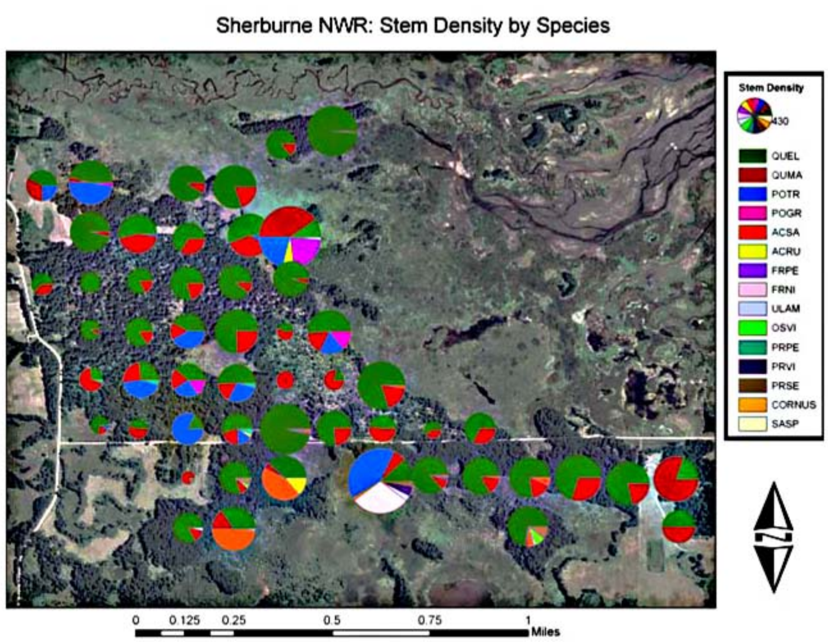

Figure 2—Stem density by species across the landscape. The relative size of each circle reflects the total stem density of each plot.

Basal Area Information

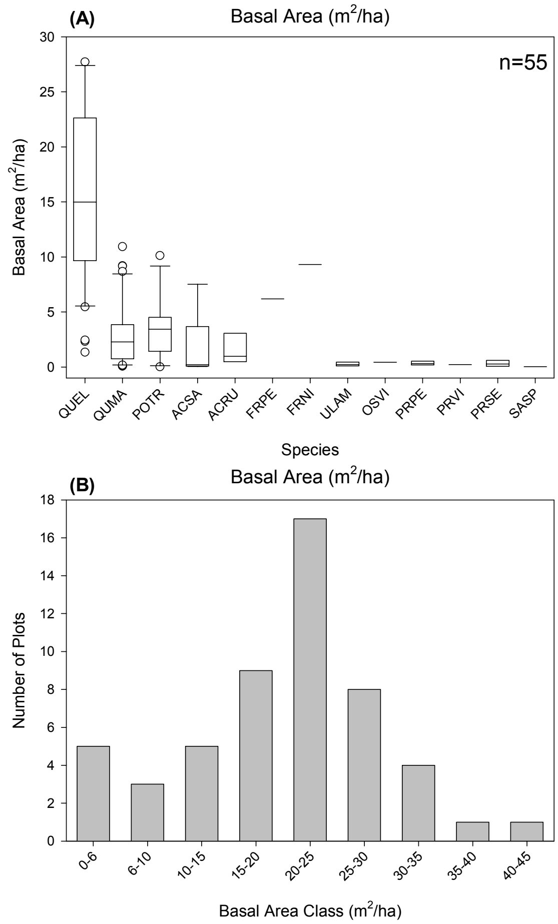

Figure 3—Basal area of sampled forest structure plots in the Sherburne National Wildlife Refuge. (A) Box and whisker plots of basal for individual species where present in a plot. Horizontal line in each box represents the median value. Each outlier is depicted as an open circle. (B) Total basal area determined in individual plots.

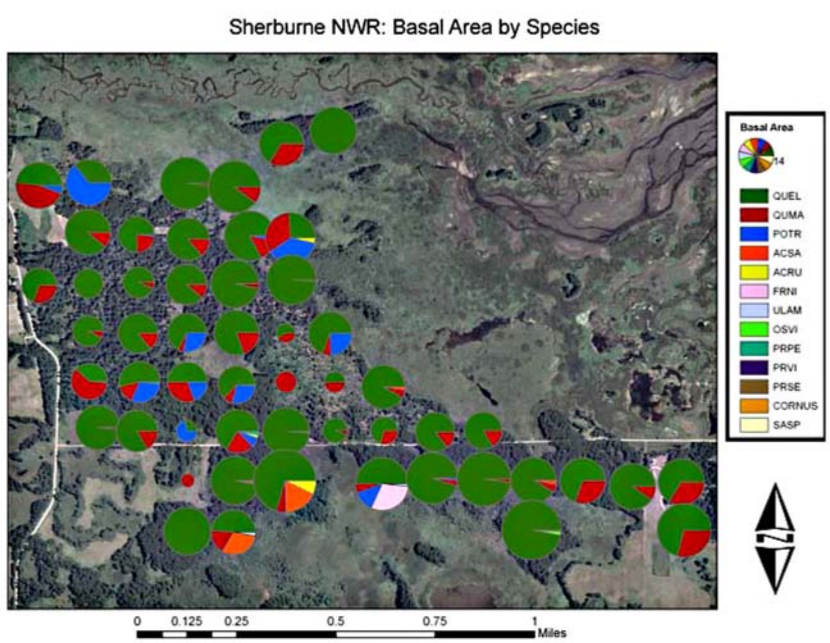

Figure 4—Basal area by species across the landscape. The relative size of each circle reflects the total stem density of each plot.

Species Importance Values

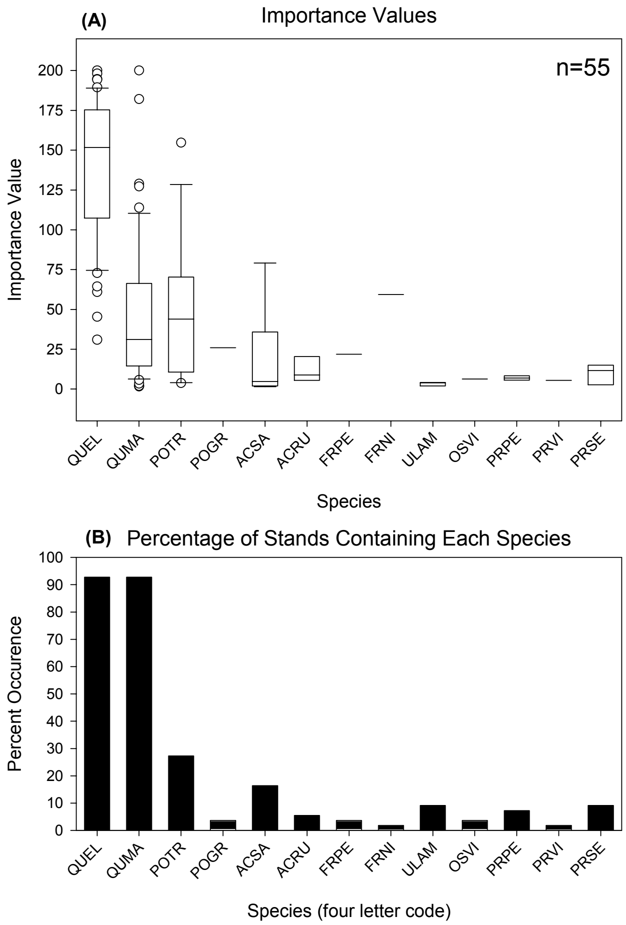

Figure 5—(A) Box and whisker plots of importance values for individual species where present in a plot. Importance value is calculated by adding together the relative density and basal area of a given species (B) after first multiplying each by 100. Importance values range from 0 to 200, with 200 indicative of a stand that is composed of only one tree species. Horizontal line in each box represents the median value.

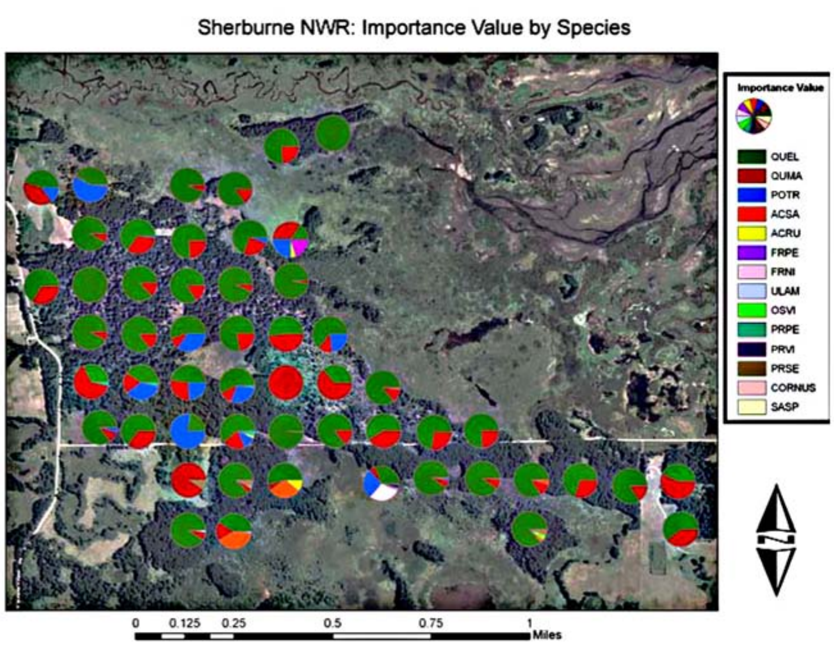

Figure 6—Basal area by species across the landscape.

Age Structure Data

We are processing increment cores for determination of age-class patterns. We hope to use the age-structure information to refine our search for fire-scarred trees. We will concentrate our search effort for fire scars near areas that contain older trees to help extend the fire history further back in time.

Preliminary analyses indicate that most of the sampled trees germinated in the mid 1900s. There appears to be a dramatic pulse in regeneration during the early 1950s. The oldest trees dated so far have inner-ring dates in the middle 1800s with a few that extend further into the past.

The low density area near the center of figure 7 contains trees dating to the early 1800s (1801 is the oldest so far). Increment cores from these trees were collected separately from the age-structure grid points for a dendrochronology class during fall 2006. Older trees also appear to be near the outer edges of the study area.

We have not assessed the relative ages of bur oak versus pin oak in a formal sense, but it appears the oldest trees are mostly bur oak.

Figure 7—Oldest sampled trees by species.

Tree Size Observations

In nearly every plot where both *Quercus ellipsoidalis* and *Q. macrocarpa* were present, *ellipsoidalis* was larger in diameter on average (fig. 8). However, initial examination of the age data suggests that *Q. macrocarpa* were nearly always older.

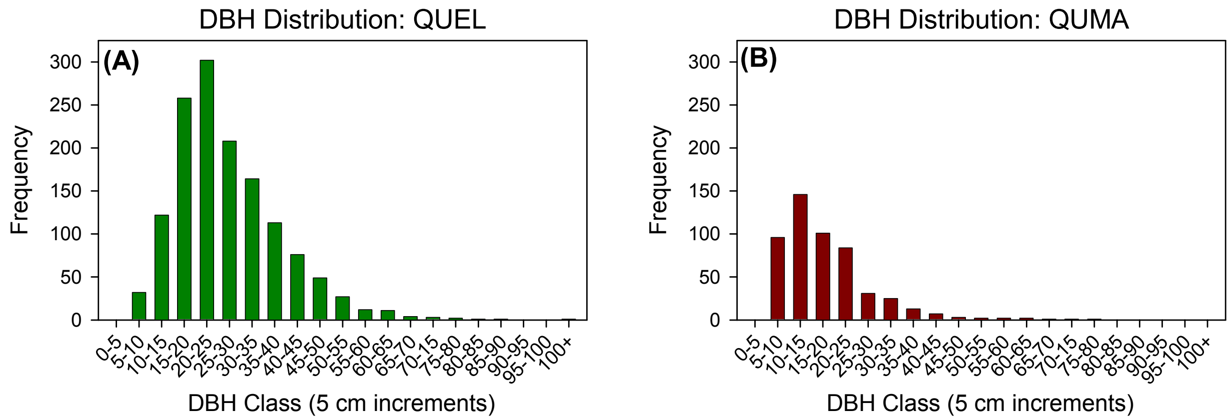

Figure 8—Diameter distribution of *Quercus ellipsoidalis* (A) and *Q. macrocarpa* (B) within the study area. Diameter at breast height is reported in 5-cm classes. Trees less than 5 cm in diameter were considered saplings and were recorded elsewhere.