Radial Growth Responses in Old-Growth Mixed-Pine Ecosystems of Upper Michigan

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Abstract

Fire is an important type of natural disturbance in forest ecosystems dominated by red pine (*Pinus resinosa* Ait.) and eastern white pine (*P. strobus* L.) in the northern Lake States. Both species (especially red pine) are adapted to a frequent fire regime characterized by low- to moderate-intensity surface fires occurring every 11.5-32.7 years that prepare the mineral seedbed for regeneration and control competing vegetation. In order to examine the age structure and radial growth patterns of these pine species, and relate these patterns to all known local fires, we collected a total of 200 samples (160 increment cores and 40 partial cross-sections) from red pine and eastern white pine trees in old-growth mixed-pine stands in the Seney Wilderness Area of eastern Upper Michigan. Using standard dendroecological methods, the age structure of these old-growth stands is uneven-aged, and show pulses of regeneration following known fire events. Additionally, analyses of samples dated from 1652-2006 suggest that the immediate response of the majority of trees to fire in these stands is a decline in radial growth with several trees showing growth increases that is sustained for five to ten years after a fire. These results suggest that natural fire appears to negatively effect the growth of the surviving pine trees for several years following the fire but also allows for new pine regeneration. Our increased understanding of these patterns will help resource managers design silvicultural systems that emulate natural fire regimes, which will also help restore the structure and function of these once extensive mixed-pine forest ecosystems.

Introduction

Mixed-pine forest ecosystems in the northern Lake States are composed of three major pine species: red pine (*Pinus resinosa* Ait.) eastern white pine (*P. strobus* L.), and jack pine (*P. banksiana* Lamb.). Prior to European settlement, many of these forest ecosystems were maintained by low- to moderate-intensity surface fires occurring every 11.5 to 32.7 years (Drobyshev et al. 2008). Since this time, the composition and structure of these forest ecosystems has been altered by both natural and human disturbances.

Following European settlement in the late 1800s, many of these ecosystems were harvested extensively. The slash from the harvested trees fueled destructive wildfires in the early 1900s, and following these fires, many areas were cleared and agriculture was promoted but failed due to the sandy soils. In the 1920s and 1930s, fire suppression efforts were implemented, reducing both natural- and human-caused fires. The combination of these activities have affected many of the forested stands in the northern Lake States and resource managers are now actively working to restore these once extensive and important forest ecosystems.

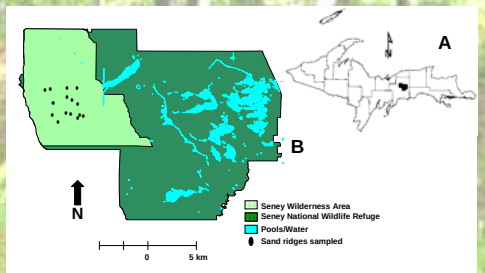

Figure 1: (A) Location of Seney National Wildlife Refuge and (B) Seney Wilderness Area with location of study sites.

In this study, we examine the radial growth patterns of red pine and eastern white pine in Seney National Wildlife Refuge (SNWR) Wilderness Area, which is located in the eastern part of the Upper Peninsula of Michigan (Fig. 1). The 95,238-acre refuge is part of the Seney Sand Lake Plain Ecoregion containing mainly mixed-pine ecosystems with scattered northern hardwood stands. SNWR contains a 25,150-acre designated Wilderness, which includes an extensive system of string bogs and sand ridges dominated by relatively undisturbed, old-growth mixed-pine forest ecosystems. As a result, these old-growth forest ecosystem provide an excellent reference system where we can examine how these species respond to natural disturbances in a relatively unaltered setting.

Objectives

1. Determine the age structure of old-growth mixed-pine forest ecosystems at SNWR.
2. Examine radial growth patterns of both red pine and eastern white pine in response to fire.
3. Compare the radial growth responses of non-suppressed and suppressed individuals to fire and canopy disturbances.

Methods

In 2006, we collected 200 live samples (183 red pine and 17 eastern white pine) on fifteen different sand ridges dating back to 1652 (Fig. 2). To characterize the age structure and radial growth patterns, we collected increment cores (158) and partial cross-sections (42). The samples were sanded and then scanned into WinDENDRO (Regents Instruments, Inc.) for analysis. Additionally, we visually cross-dated samples and utilized COFECHA to verify tree ages. Once cross-dated, ring widths of samples were analyzed in WINDENDRO to show increases and decreases in radial growth using the criteria in Table 1. These patterns were then compared with the known fire events (see Drobyshev et al. 2008) that have occurred at SNWR Wilderness Area.

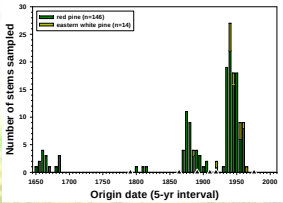

Figure 2: Number of stems in the SNWR Wilderness. Triangles on the x-axis denote major fire years.

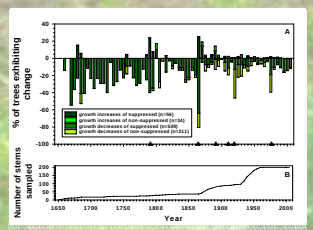

Figure 3: (A) Percent of trees exhibiting increases and (or) decreases in radial growth. Triangles on the x-axis denote major fire years. (B) Sample size used to show percent of trees exhibiting radial change.

Table 1. Criteria for determining radial growth increases and decreases.

Suppressed (< 1 mm per yr)
Non-suppressed (> 1 mm per yr)
Increases in trees included:
Suppressed trees
a) radial growth doubles over three year period
b) growth ten years after increase needs to be twice the preceding 10 years growth
Non-suppressed
a) 50% ring increase over three year period
b) growth ten years after increase needs to be twice the proceeding ten years growth
Decreases in trees included:
Suppressed
a) growth reduced by 33%
Non-suppressed
b) growth reduced by 50%

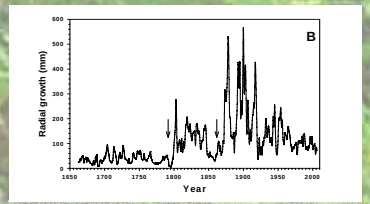

Figure 4: (A) Image of partial cross-section 95-1. (B) Radial growth pattern of a representative sample from 1662-2006. Downward facing arrows denote radial growth increases from suppression.

Results

Increases and decreases in radial growth are related to the past fire history. Major fire years (i.e., more than 20% of the sampled area showing fire scars) 1791, 1864, 1891, 1910, 1919 and 1976, are closely associated with radial growth (Fig. 3). Trees surviving centuries and multiple fires show the plasticity capable by red pine (Fig. 4). Radial growth changes were analyzed for all fires and major fires by both the conservative (five years following a fire) and moderate (ten years following a fire) approaches (Fig. 5). The suppressed trees (< 1 mm growth per year) show more responses to fire than the non-suppressed trees (> 1 mm growth per year).

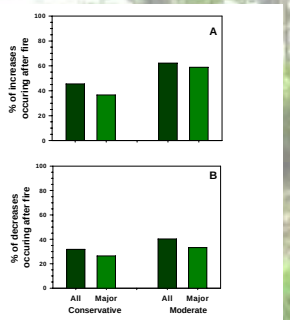

Figure 5:(A) Percent of increases occurring after all fires (n=39) and after major fires (n=6), utilizing both a conservative approach (within five years after fire) and a moderate approach (within ten years after fire). (B) Percent of decreases occurring after all fires and after major fires, using the same two approaches.

Discussion

Radial growth increases and decreases can occur due to a frequent low-intensity fire regime. While larger fires cause more residual effects to pine species than small, single sand ridge fires, all fires can cause a short-term decrease in growth due to cambium and needle scorch. However, several years following fires the increases in growth become more frequent.

Our results suggest that future management suggestions for mixed-pine forest ecosystem restoration would include low- to moderate-intensity prescribed burns that occur at a frequent interval (once every 11-33 years). In overstocked stands, overstory red pine and eastern white pine stems should be retained, while mechanical thinning may need to be implemented to help reduce fuel loading before prescribed fires. Our results clearly show that existing red pine and eastern white pine trees that receive increased sunlight and nutrients have the ability to show increased radial growth rates, even following an extended period of suppressed growth.

References

Drobyshev, I.V., Goebel, P.C., Hix, D.M., Corace III, R.G., and Semko Duncan, M. E. 2008. Fire history of red pine-dominated forest ecosystems of the Seney National Wildlife Refuge, Upper Michigan. Canadian Journal of Forest Research. 38:2497-2514.

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