Red Oak Borer and Oak Decline in the Ozark Highlands of Missouri

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Abstract

An unprecedented out break of red oak borer, *Enaphalodes rufulus*, has occurred in the lower Midwestern United States. Although generally not a mortality agent red oak borer appears to be a significance contributor to general oak decline and mortality. There is a need to understand the factors that influence abundance of this borer and to predict site conditions, individual tree characteristics, etc., that may influence such outbreaks. The objective of this project was to explore dendrochronology as a means to determine the role of tree age, growth and climate in long term red oak borer activity and to quantify the historic importance of red oak borer. In an oak (*Quercus*) dominated forest in Missouri, 31 trees (scarlet oak, *Q. coccinea* and black oak, *Q. velutina*) were destructively sampled, and cross sections removed at 1 m intervals. Based on wound occurrence, overall borer activity in the stand has increased dramatically over the past 70 years, particularly strongly during the past twenty-five years. The abundance of wounds was related to tree age, growth rate, and climate. Borer activity increased with tree age and mean growing season temperature, but was not related to precipitation and basal area increment. These data will be used to construct predictive models to identify vulnerable trees and stands and evaluate the importance of factors such as climate, management history, and site conditions.

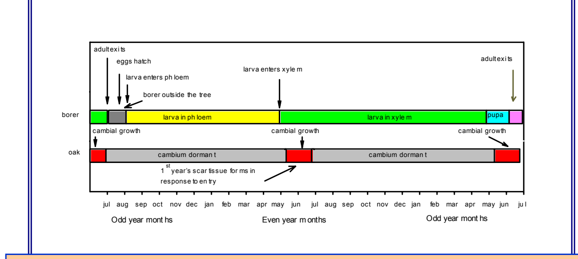
Larvae tunnel into the xylem of living trees after spending approximately a year in the phloem. The tunnels are extensive and over the course of many years, and many generations of insects, the wood quality can be severely degraded.

Background

Oak decline episodes have been noted from the Ozark Highlands since the early part of the last century. Associated with such decline are preceding years of drought, and decline occurred most often on low vigor stands with low site index and productivity. A current decline is distinct from previous Ozark-related declines in that outbreak levels of red oak borer has occurred in the decline stands. Although common in oak forests that have been stressed, red oak borer populations are much greater than ever recorded.

The role of the red oak borer in decline is not fully understood. Little is know about its role in decline and its occurrence historically and currently in the Ozarks.

Red Oak Borer Life History and Oak Growth



CAN DAMAGE FROM WOOD BORING INSECTS INDICATE PAST ABUDANCE AND IMPORTANCE IN A FOREST?

Although it is associated with tunnels in the xylem, red oak borer larvae spend a year in the inner bark, and therefore, its entrance into the tree causes a wound.

In order to determine the temporal representation of the wounding, it is critical to understand both the red oak borer life cycle as well as the seasonality of oak growth.

The red oak borer has a two-year life cycle. In year 1, following emergence of the adult and egg hatch, the larvae tunnel create a small wound and enter the tree. By that time, however, an oak tree has ceased active growth. The resulting wound is a dormant season scar. The following year, the larvae are within the bark and feeding on the phloem. Year 2, then, is the time wounding occurs since active tree growth is taking place simultaneous with borer activity.

Study Area and Methods

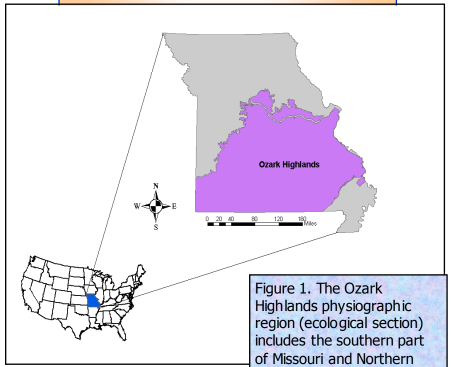
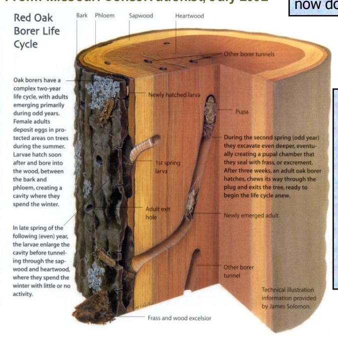


Figure 1. The Ozark Highlands physiographic region (ecological section) includes the southern part of Missouri and Northern Arkansas. Although historically pine was common, the forests are now dominated by oaks.

From: Missouri Conservationist, July 2002



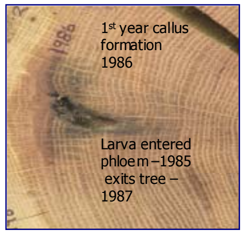
The complicated two-year life cycle of the red oak borer makes it challenging to study, but its activity over the two year period also damages the tissue in that wounds are obvious and can be dated to a precise year.

FIELD SITES:
The study area was located in the Mark Twain National Forest 3 km east of Bixby, Missouri. The stand sampled was designated salvage; it had a high proportion of trees with poor crown quality and mortality at the area was approximately 25%.

The forest was characteristic of a second growth Ozark forest; it was dominated by black oak (*Quercus velutina*) and scarlet oak (*Q. coccinea*).

FIELD METHODS:

- Established 2 20m transects
- Sampled all black and scarlet oaks
- Cross sectioned at 1 m intervals
- Measured tree height, dbh, slope, aspect



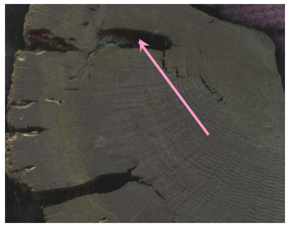
LAB METHODS:

- Cross dated trees using drought years (1934, 1936, 1952, 1953,1954, 1966, 1980,1988)
- Determined year of insect injury
- Measured tangential extent of callous tissue
- Presence / absence of tunnel
- Distance from pith

Results & Discussion

The goal of this project was to find evidence of wood boring insects in the dendrochronological record for the past 70 years. Little did we realize how temporally extensive the record of activity could be. The two samples of ancient oak wood pictured below are from Missouri, but were not in the study area under consideration. Although it may be well known that wood boring insects have been part of the Missouri forest ecosystems for decades, it's fascinating to discover that wood boring insects were active in oak trees thousands of years ago.

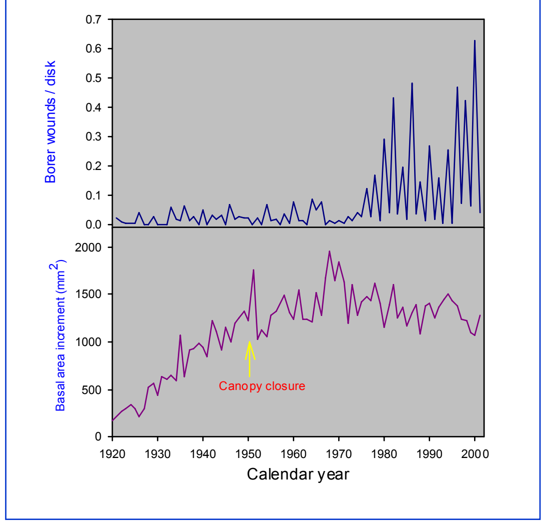
Wound in an ancient oak, carbon-dated to about 1280 AD



Tunnel from a wood boring insect in an ancient oak, occurring about 6000 years ago!!

In the study area, a total of 743 wounds were identified from the sampled cross sections. The wounds were tree-ring dated and we constructed oak borer larval injury chronologies spanning more than 60 years (Fig. 2a). The predominance of wounds (89%) occurred biennially, supporting our supposition that red oak borer caused most of the cambial injuries. This is consistent with the synchronized two-year life cycle of the red oak borer (Solomon 1995). Borer wounds increased abruptly during the late 1970's at a stand age about 50 years (Fig 2a).

Figure 2a. Distribution of borer wounds in the study area forest since 1920. Data represent average borer wounds / cross section.
2b. Basal area increment (BAI) of the stand.



Basal Area Index (BAI) represents the cross-sectional increase in tree growth. In theory, BAI might plateau approximately at stand canopy closure. Canopy closure, and hence cessation of the tree (and stand's) most vigorous growth, may be considered a point at which stress occurs more frequently, and consequently secondary agents like red oak borer may become more common. In this study, however, the onset of high level of red oak borer occurred at least 2 decades after canopy closure (Fig 2b.)

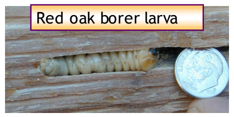
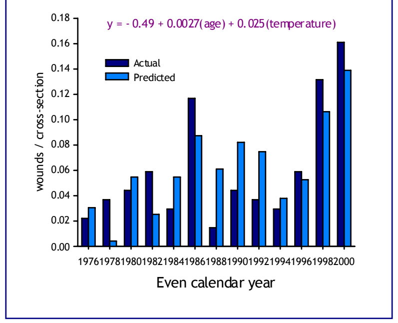


Figure 3. Distribution of borer wounds during the last 25 years. Significant (p <0.01) variables in this model include the square of forest age, mean January to October monthly temperature. The overall r^2 = 0.60, the partial r^2 for temperature = 0.40, the partial r^2 for forest age = 0.20.

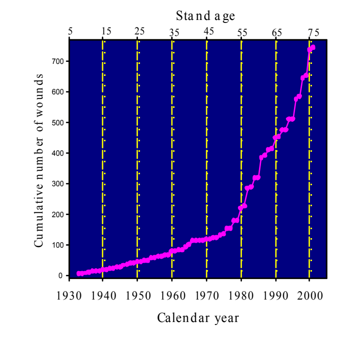


The frequency of injuries that occurred annually was modeled as a function of life cycle, age of the forest, and climate. Borer wounds increased abruptly 25 years ago and were positively associated with temperature. A multiple regression equation explained about 80 percent of the variation in the frequency of borer wounds over 67 years. Borer wounds were significantly (p<0.01) associated with the red oak borer life cycle, the interaction of forest age and life cycle, and the interaction of temperature (mean May through October) and life cycle. Temperature explained 40% (Fig 3) of the annual variance in borer wounds.

If trends examined at this site are similar at other areas, then modeling the cumulative distribution of wounds through the age of the stand can provide substantiate implications for management (Fig 4). In the area studied, borer activity occurred early in the stand, but increased steadily at age 55.

Such trends may be expected to differ with site productivity or site index, and to some extent, with temperature. The ability to determine the age of a stand when wood-boring insects may be abundant could determine harvesting guidelines.

Figure 4. Cumulative distribution of borer wounds and stand age. Such data can be important when determining site species rotation age.



CONCLUSION:
Oak decline episodes in the past were likely accompanied by red oak borer and possibly other borer damage. We found significant relationships between some climatic variables and red oak borer abundance. Precipitation, however was not related to wounds. Although the role of drought in oak decline episodes may be valid, the role of red oak borer in past declines was probably minimal.

Since this represents a case study, the strength of the relationships identified in this study need to be corroborated with other studies. Monitoring data will be critical for identifying decline sites. Further analysis to examine how crown vigor, stand composition, and site conditions may be related to historic declines and insect activity will be critical to evaluate.