Preliminary Analysis of the Effects of Periodical Cicadas on Tree Growth in Southern Indiana

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Abstract

The purpose of this study is to investigate the effects of Brood X periodical cicadas (*Magicicada spp.*) on annual growth increment in hardwood trees throughout the southern region of Indiana. Twenty-one study sites have been established in proximity to Bloomington, Indiana. We have selected 25 trees on each site (441 trees total) and installed dendrometer bands on all of the trees. Twenty-three species are represented in this analysis. Study areas include several forest settings (i.e., floodplain, upland, bottomland, etc.). We took two cores per tree at breast height (1.4m above the ground) with a 5.15mm Swedish increment borer. The annual rings on these cores will be cross-dated, measured, and statistically analyzed to produce a correlation between yearly tree-ring growth and periodical cicada damage to the trees. After completion of the laboratory analysis, we will examine the effects of periodical cicadas on the incremental growth of all the sampled species.

Introduction

Insects have been instrumental in determining the overall physiological health, form, and existence of woody plants throughout previous centuries (Ayres and Lombardero 2000; Coupe and Cahill 2003). Periodical cicadas (*Magicicada spp.*) can be described as root parasites that feed on the xylem fluids of various hardwood trees throughout the eastern portion of the United States (White and Strehl 1978) (Fig.1). Deciduous tree communities are used as breeding sanctuaries by these insects during their emergence every thirteen or seventeen years (Williams and Simon 1995). Throughout recent history, woodlands have become fragmented due to agriculture, logging, and urbanization producing a high concentration of periodical cicadas within relatively small areas of forest land (Medley *et al.* 2003).

In this study, we hope to uncover the effects that Brood X (seventeen-year) periodical cicadas have on hardwood tree growth in southern Indiana during the entire life cycle of the insect. We will integrate tree-ring measurements (dendrochronology), periodical cicada and individual tree physiology (biology and ecology), and comparisons of growth to local climate signals in trees (climatology) to obtain a complete picture of the effect of periodical cicadas on the growth of trees in the eastern deciduous forests of southern Indiana.

Fig. 1. Periodical cicada.

Past Tree Growth Theories

Two theories have been introduced relating to periodical cicadas and their effects on tree growth. One idea suggests that the deadening of growth shoots in woody branches by ovipositing female cicadas can affect the flowering and/or fruiting of some tree species in the two to three years following an emergence (Cook *et al.* 2001; Cook and Holt 2002). On the other hand, another theory suggests that the feeding on xylem fluids through the roots of deciduous trees by periodical cicada nymphs can produce a negative trend in radial growth (Karban 1980; Koenig and Liebhold 2003). A decrease in tree-ring width by insect damage may affect the successional rate and competitive abilities of particular tree species in a forested stand (Mattson and Addy 1975; Morrow and LaMarche 1978; Schowalter 1996; Parish *et al.* 1999; Carson and Root 2000; Carson *et al.* 2004). Our study will strive to discover the effects of periodical cicadas on annual tree-ring growth within eastern hardwood trees, and to compare these results to previous studies.

Research Questions

We examined Brood X periodical cicadas and their effects on tree-ring growth in the deciduous hardwood forests of southern Indiana. The research questions we wish to answer are as follows:

· Is there a specific ecological signal due to periodical cicadas that can be detected in the growth rings of eastern deciduous trees?

· Do periodical cicadas decrease or increase hardwood tree-ring growth due to oviposition damage?

· Do periodical cicadas decrease or increase hardwood tree-ring growth due to root parasitism damage?

· Is there a release in growth when periodical cicadas emerge due to the cycling of nutrients in deciduous trees?

· What particular species of deciduous hardwood tree(s) are most affected by periodical cicadas?

Fig. 3. Floodplain field site (Blue Creek #2).

Fig. 4. Upland field site (Green Bluff).

Fig. 5. Bottomland field site (Friendship Road).

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Study Sites

We intend to study twenty-one individual forest sites in Brown, Monroe, and Owen Counties in Indiana (Table 1 and Fig. 2). These woodlands were selected as part of a long-term, collaborative study that will investigate the effects that periodical cicadas have on individual tree silviculture and the structure of eastern hardwood forest communities. Dr. Keith Clay (Indiana University) selected ten of the most dominant tree species and five of the next three most dominant species on each site, installed dendrometer bands (to measure the diameter growth of trees through time) and identification tags on each tree, and took a GPS (Global Positioning System) point at each forest site. The forested plots range in size between 4 - 8 hectares with many different types of habitat (*i.e.* wet floodplain, dry upland, and mesic bottomland) and dominant forest types (Fig. 3-5). We will use these hardwood forest sites and tree species to determine the effects that periodical cicadas have on tree-ring growth in southern Indiana.

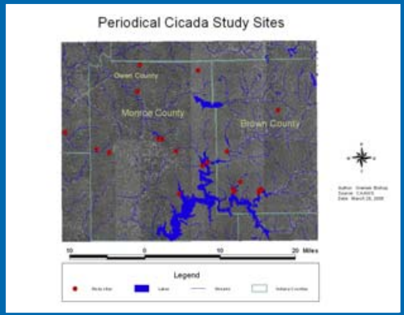

Fig. 2. Southern Indiana research site map.

Table 1. Forest study sites

Forest Site	County	Site Description
Blue Creek #1	Brown	Floodplain, 0% slope, East/West aspect, sandy clay loam soil texture.
Blue Creek #2	Brown	Floodplain, 0% slope, East/West aspect, sandy clay loam soil texture.
Crooked Creek #1	Brown	N/A
Crooked Creek #2	Brown	Upland, 18% slope, South aspect, sandy loam soil texture.
Keith's Cabin	Brown	Upland, 45% slope, West aspect, sandy loam soil texture.
Lilly-Dickie	Brown	Upland, 50% slope, South aspect, sandy loam soil texture.
Moore's Creek	Brown	N/A
Tecumseh Trail	Brown	Bottomland, 0% slope, East/West aspect, sandy clay loam soil texture.
Bean Blossom Bottoms	Monroe	Bottomland, 0% slope, East/West aspect, sandy clay loam soil texture.
Friendship Road	Monroe	Floodplain, 0% slope, East/West aspect, loamy sand soil texture.
Hegeman	Monroe	Upland, 15% slope, North/Northwest/South aspect, clay loam soil texture.
I.U. Golf Course	Monroe	N/A
I.U. Forest Preserve	Monroe	Upland, 10% slope, East/West aspect, loamy sand soil texture.
Kent Farm	Monroe	Upland, 4% slope, Southwest aspect, sandy clay loam soil texture.
Landfill	Monroe	Upland, 8% slope, West aspect, clay loam soil texture.
Mellencamp	Monroe	Upland, 10% slope, Northeast/Southwest aspect, loamy sand soil texture.
Morgan-Monroe S.F.	Monroe	Upland, 18% slope, Northeast aspect, clay loam soil texture.
Porter's Compost	Monroe	Transition between upland and bottomland, 15% slope, South/Southeast aspect, clay loam soil texture.
Sycamore Valley	Monroe	N/A
Yellowwood S.F.	Monroe	Bottomland, 0% slope, North/South aspect, clay loam soil texture.
Green Bluff	Owen	Upland, 10% slope, East/Northeast aspect, clay loam soil texture.

Results

Our preliminary results are based on three tree species (*Acer rubrum*, *Quercus velutina*, and *Quercus palustris*) and three separate forest sites (Shakamak State Park, Greene-Sullivan State Forest, and Suburban Bloomington). The tree-ring width indices vary greatly between each tree species and forest site (Fig. 6, 8, & 10). Superposed epoch analyses were created for each study site to show a cycle of years that tree growth can be affected by periodical cicadas (Fig. 7, 9, & 11). Greene-Sullivan State Forest and Suburban Bloomington do not show any growth response due to periodical cicadas (Fig. 9 & 11). However, Shakamak State Park shows a twenty-six year cycle where tree-ring growth is released by the emergence of periodical cicadas (Fig. 7).

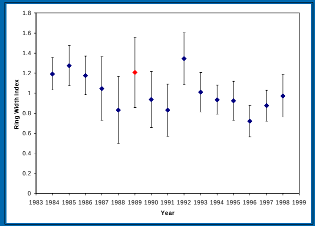

Fig. 6. Shakamak State Park tree-ring index (*Acer rubrum*).

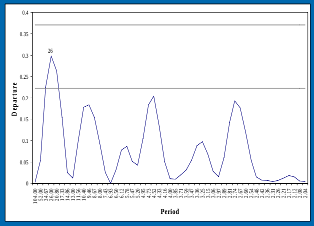

Fig. 7. Shakamak State Park superposed epoch analysis.

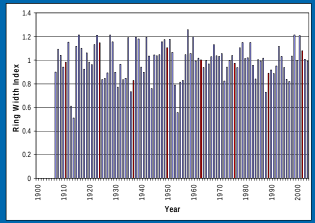

Fig. 8. Greene-Sullivan State Forest tree-ring index (*Quercus velutina*).

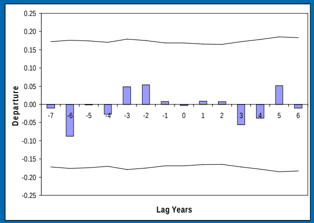

Fig. 9. Greene-Sullivan State Forest superposed epoch analysis.

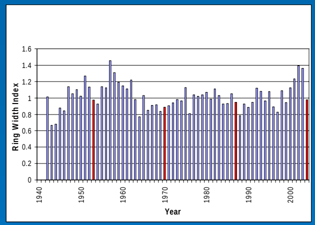

Fig. 10. Suburban Bloomington tree-ring index (*Quercus palustris*).

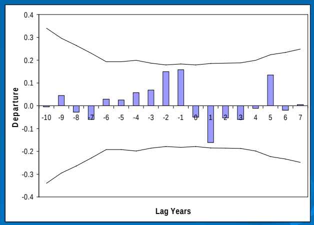

Fig. 11. Suburban Bloomington superposed epoch analysis.

Conclusions

Our research should provide information for foresters, ecologists, government and state agencies, and other forest planners to make wise land-use decisions concerning eastern hardwood forests within the United States. Also, other forest researchers can use our information to further explore the effects of periodical cicadas on the growth and structure of eastern deciduous forests. Knowledge of the effects of periodical cicadas on tree-ring growth will help others to understand how this particular root parasite may control forest dynamics. The effects of periodical cicadas on forest dynamics is little understood and may have important implications for tree dominance, forest succession, and/or carbon cycling and sequestration.

The periodical cicada research community is very interested in understanding the interactions between these insects and their host trees. Our study should provide the potential to examine the effects of periodical cicadas on a forest site through time. It may even demonstrate a mutualistic relationship with periodical cicadas and eastern deciduous trees that has been unnoticed by scholars for many centuries.

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