Periodical Cicadas and Tree-Ring Growth in Greene-Sullivan State Forest, Indiana

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Abstract

The purpose of this study was to investigate the effects of Brood XXIII (13-year) periodical cicadas (*Magicicada spp.*) on annual growth increment in deciduous hardwood trees throughout Greene-Sullivan State Forest in southwestern Indiana. We selected 52 trees on a moist, upland site within this particular woodland tract. Black oak (*Quercus velutina*), sassafras (*Sassafras albidum*), flowering dogwood (*Cornus florida*), and sugar maple (*Acer saccharum*) were used to represent this analysis. We took two cores per tree with 5.15mm Haglof™ increment borers. The canopy classification and DBH (Diameter at Breast Height) of each tree was recorded to describe the forest. Annual tree-rings in all cores were cross-dated, measured, and statistically analyzed to produce a correlation between yearly ring growth and periodical cicada damage to the trees. After the completion of a super-posed epoch analysis to overlap growth changes before and after emergence, we conducted a spectral analysis to differentiate any cyclic patterns in tree-ring growth.

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 hoped to uncover the effects that Brood XXIII (thirteen-year) periodical cicadas have on hardwood tree growth in Greene-Sullivan State Forest, Indiana during the entire life cycle of the insect. We integrated 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 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 strove 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 XXIII periodical cicadas and their effects on tree-ring growth in the deciduous hardwood forest of Greene-Sullivan State Forest, 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?

Study Site

We selected 52 trees (104 cores) on a moist, upland site in Greene-Sullivan State Forest, Indiana (Fig. 2 & 3). Twenty black oak (*Quercus velutina*), twenty sassafras (*Sassafras albidum*), eight flowering dogwood (*Cornus florida*), and four sugar maple (*Acer saccharum*) trees were cored for this study. These tree species were selected as part of a long-term, collaborative study that will investigate the effects that periodical cicadas have on tree-ring growth and the structure of eastern hardwood forest communities. Dr. James H. Speer and I selected a forested plot that ranged between 10-20 hectares in size. We used this deciduous forest site and tree species to determine the effects that Brood XXIII periodical cicadas have on tree-ring growth in Greene-Sullivan State Forest (Fig. 4).

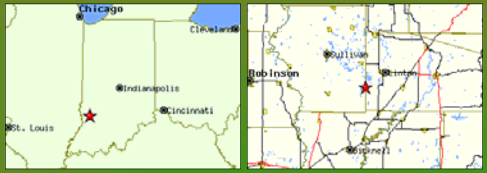

Fig. 2. Location of Greene-Sullivan State Forest southeast of Terre Haute, Indiana.

Fig. 3. Taking tree core samples from Greene-Sullivan State Forest.

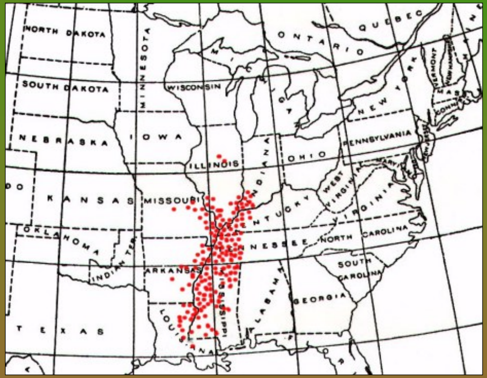

Fig. 4. Distribution map of Brood XXIII periodical cicadas.

Results

Our preliminary results are based on four tree species (*Quercus velutina*, *Sassafras albidum*, *Cornus florida*, and *Acer saccharum*) in Greene-Sullivan State Forest. The standardized tree-ring width indices vary greatly between each tree species and forest site (Fig. 5-8). Superposed epoch analyses were created for each tree species to display any cycle of years that tree growth can be affected by periodical cicadas (Fig. 9-12). Black oak, flowering dogwood, and sugar maple analyses do not show much growth response due to periodical cicadas. However, the sassafras analysis shows a four-year cycle before the emergence year where tree-ring growth is released by periodical cicadas while these insects are still underground.

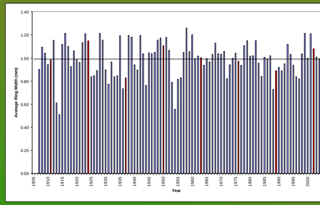

Fig. 5. Greene-Sullivan black oak standardized ring-width chronology.

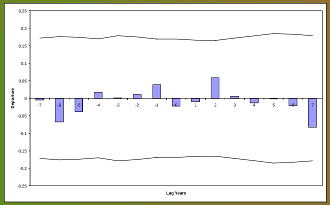

Fig. 9. Greene-Sullivan black oak standardized superposed epoch analysis.

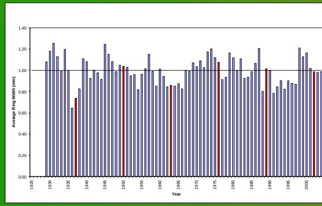

Fig. 6. Greene-Sullivan sassafras standardized ring-width chronology.

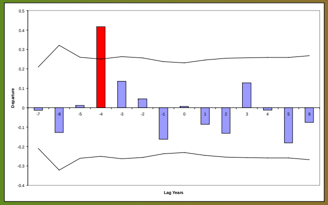

Fig. 10. Greene-Sullivan sassafras standardized superposed epoch analysis.

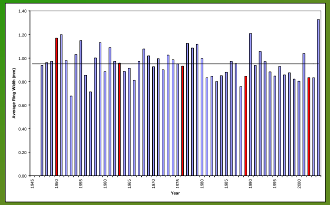

Fig. 7. Greene-Sullivan flowering dogwood standardized ring-width chronology.

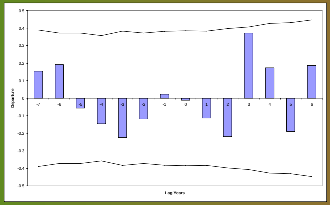

Fig. 11. Greene-Sullivan flowering dogwood standardized superposed epoch analysis.

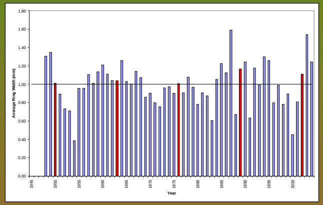

Fig. 8. Greene-Sullivan sugar maple standardized ring-width chronology.

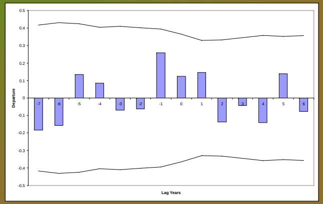

Fig. 12. Greene-Sullivan sugar maple standardized superposed epoch analysis.

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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