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Fossil Pollen Analysis of *Tsuga canadensis* decline in Larkum Pond in Otis Massachusetts

Abstract

Fossil pollen analysis of sediment cores can provide data which is important to the reconstruction of the local flora and indicate patterns of disturbance. In this study, core samples taken from Larkum Pond in Otis, Massachusetts in February of 2007, were analyzed to identify evidence of the mid-Holocene decline of the eastern hemlock (*Tsuga canadensis*). Also, we will speculate as to its cause and comment on its ecological implications. It is hypothesized that there will be an observable decline of eastern hemlock across the sediment core sample depths. Analysis of the fossil pollen data show a marked decrease in the proportion of hemlock and an increase in the proportion of shade-tolerant, early-successional species such as beech and birch. Pine also showed an increase but to a lesser extent, presumably due to its shade-intolerant characteristic.

Introduction

Late Pleistocene and Holocene lake sediments often contain continuous depositional records of environmental, vegetational, and climatic changes over time spans of many thousands of years (Anderson et al. 1985). Across North America, paleoecologists have long studied the abrupt decline of *Tsuga canadensis* (eastern hemlock) using fossil pollen samples taken from sediment cores. The eastern hemlock was an abundant tree species in eastern North America before it declined sharply in abundance ~4700 14C yr BP (~5400 calendar years BP) (Fuller 1998). The middle-Holocene decline of the eastern hemlock is one of the most

studied events in the post-glacial vegetation history of eastern North America (Orwig and Foster 1998). Using core samples taken from Larkum Pond in Otis, Massachusetts in February of 2007, this study focuses on identifying evidence of the mid-Holocene decline of the eastern hemlock. Also, we will speculate as to its cause and comment on its ecological implications. It is hypothesized that there will be an observable decline of eastern hemlock across the sediment core sample depths.

Methods

This study focused on analyzing pollen grains recovered from a sediment core taken from the bottom of Larkum Pond in Otis, Massachusetts, in February of 2007 (Figure 1).

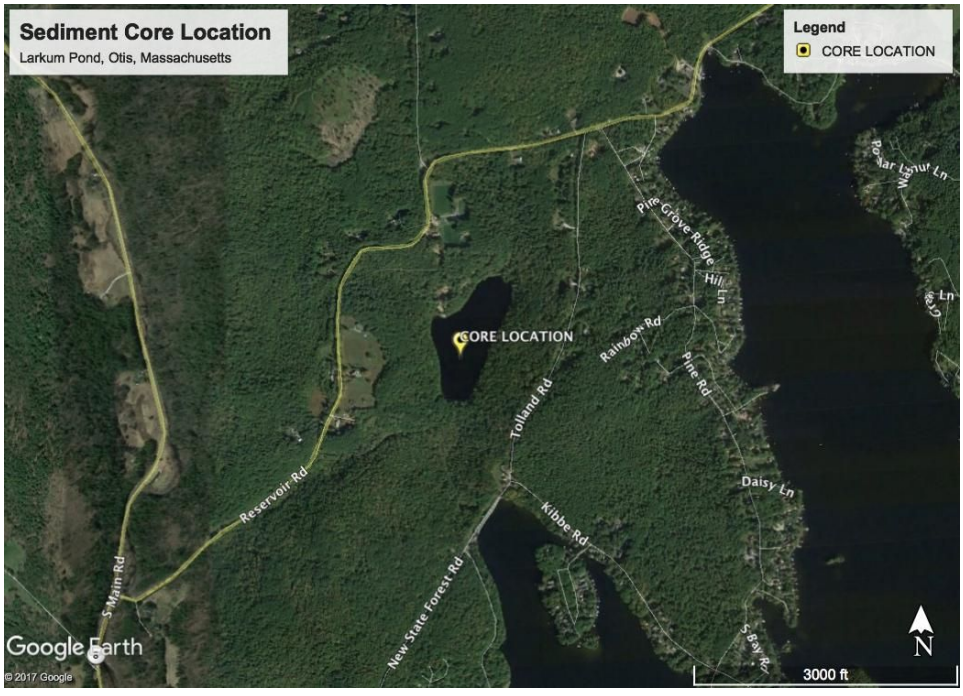

Figure 1 Satellite imagery of Larkum Pond, Otis, Massachusetts, USA. Core samples used for this study were obtained at the pinpoint location in February 2007. Image Credit: Google Earth, 2017.

Microscope slides used for this study were collected and prepared by Kennedy Clark PhD., Professor of Environmental Studies at Massachusetts College of Liberal Arts in North Adams, Massachusetts. Sub-sampling, sediment processing, and slide creation were completed before this study and were provided to the research team for this study. Twelve slides were surveyed at the core depth range of 565cm and 657cm to identify six pollen taxa: pine, oak, beech, birch, and eucalyptus. All other pollen types were placed into a separate category named "other". Eucalyptus is a non-native pollen added to the sediment during processing to facilitate assessing charcoal abundance relative to pollen abundance, although this study focused only on the pollen grains.

Each slide was processed using a compound microscope using the 40x lens. The stage micrometer was used to ensure that each millimeter of the slide was surveyed. A visual identification key was used to identify the pollen grains accurately, and a data sheet was used to record each occurrence of the six target pollen grains. After the twelve slides were processed, data were compiled onto a graph showing relative abundance of each pollen type.

Results

Eastern hemlock pollen grain relative abundance was highest at 35% at a depth of 635cm and declined after that (Figure 2). An increase in the proportion of birch and beech correlates with the decline of eastern hemlock at depths shallower than 635cm. Eastern hemlock decreases precipitously at 607cm and fails to regain relative abundance after this point. Pine abundance increases but not to the magnitude of the other species.

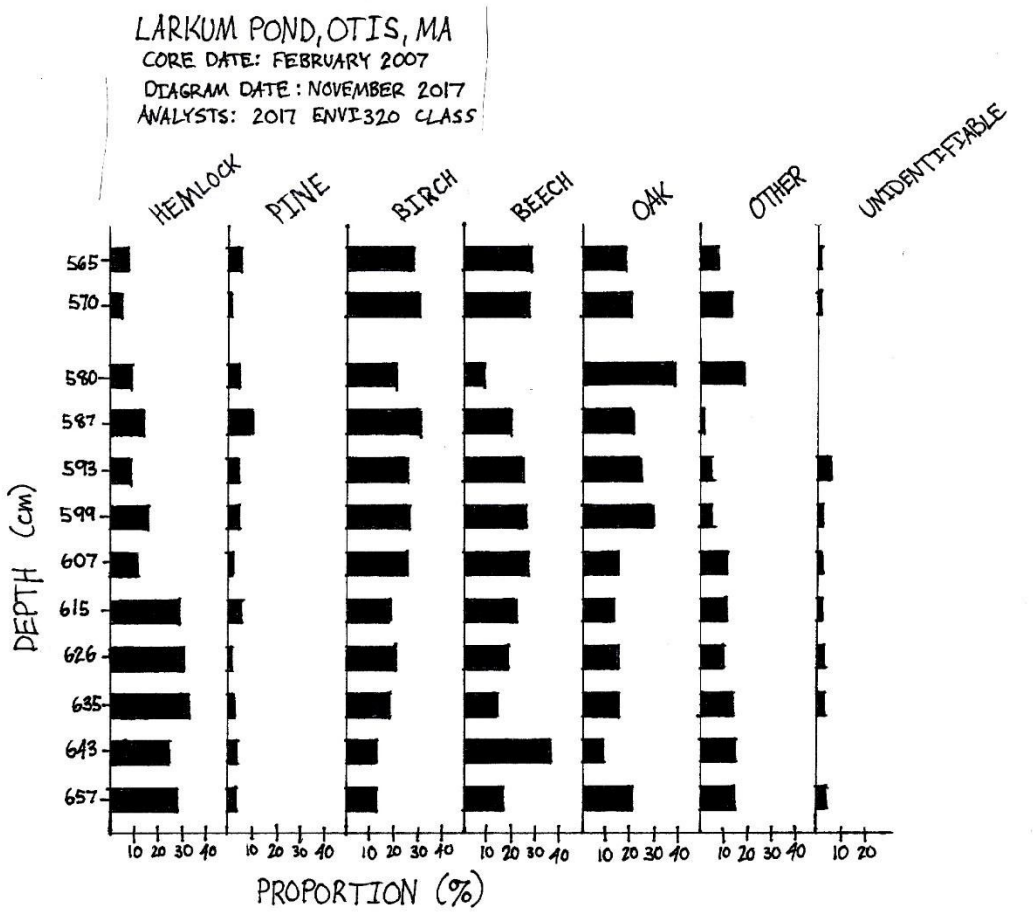

Figure 2 Pollen grain analysis results for Larkum Pond in Otis, Massachusetts. At 635cm, a decline in eastern hemlock is observed while successional species (birch, pine, beech, oak) increased thereafter.

Discussion

Analysis of the fossil pollen slides from Larkum Pond indicate a decline in the proportion of eastern hemlock pollen at 607cm, co-occurring with an increase in the abundance of pine, beech, birch, and to a lesser degree, oak after that. This sudden and abrupt range-wide decline in hemlock occurred at 4750 ^{14}C years (~5,500 calendar years) during which hemlock pollen percentages fell to less than 10% in most sediments (Bennet and Fuller 2002). Between 615cm

and 607cm, there is an approximate 20% decrease in hemlock pollen abundance. Post-decline, successional species follow with an increase in abundance. This is likely due to increased light penetration to the forest floor, the decimation of hemlock saplings, and the increase in shade-tolerant species such as sugar maple, beech, and birch. Pine also increased in proportion but to a lesser extent relative to other species. This is presumed to be due to the shade-intolerant nature of pine. This could infer that instead of wide-spread defoliation and decimation of the hemlock species, there was an abundance of small micro-climates created in the absence of hemlock-dominant stands which would favor shade-tolerant species.

The decline in hemlock was abrupt across its range and has been interpreted as an insect or pathogen outbreak, climate change, or a combination of both (Calcote 2003). This is a likely scenario, similar to the modern insect invasions that affect modern stands. The Hemlock Wooly Adelgid is a modern pest with a devastating potential, and it currently affects large tracts of hemlock (Orwig and Foster 1998). It is likely that the mid-Holocene decline in hemlock is due to a similar vector like a pest or pathogen.

The ecological implications of the decline of a long-lived, dominant species like hemlock are massive. Since hemlock is shade-tolerant but also disturbance-intolerant, a range-wide decline would impose significant changes to the forest landscape. Both flora and fauna would be affected micro and macroscopically with new habitats being created in the presence of increased canopy cover and new species increasing in basal area.

Conclusion

In this study, core samples taken from Larkum Pond in Otis, Massachusetts in February of 2007, were analyzed to identify evidence of the mid-Holocene decline of the eastern hemlock (*Tsuga canadensis*). We hypothesized that there is an observable decline of eastern hemlock across the sediment core sample depths. Analysis of the fossil pollen data show a marked decrease in the proportion of hemlock with a co-occurring increase in the proportion of shade-tolerant, early-successional species such as beech and birch. Pine also showed an increase but to a lesser extent, presumably due to its shade-intolerant characteristic.

Literature Cited

Bennett, K D, and J L Fuller. 2002. Determining the age of the mid-Holocene *Tsuga canadensis* decline, eastern North America. The Holocene 12: 421-429.

Orwig, D A, and D R Foster. 1998. Forest response to the introduced hemlock wooly adelgid in southern New England, USA. Journal Torrey Botanical Society 125: 60-73.

Fuller, J. L. (1998), ECOLOGICAL IMPACT OF THE MID-HOLOCENE HEMLOCK DECLINE IN SOUTHERN ONTARIO, CANADA. Ecology, 79: 2337–2351.