Dendrochronology and Geochemistry of Long Island Trees

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Abstract

To help understand the effect of short term climatic changes on ring width variations of trees on Long Island, time series were performed on 6 *Liriondendrin tuliperfera* (tulip poplars) and 1 white oak from Caumsett State Park, and 6 *Pinus rigidas* (pitch pines) from Sears Bellows and Hubbard County Parks. Prolonged drought periods on Long Island occur during years 1927-1932, 1960-1970 and 1980-1988. All trees document drought periods by marked decrease in growth ring width regardless of specie or location.

In addition base cations were analyzed in two tulip trees and two pitch pines. Based on the limited number of trees in this study there is a suggestion that Ca concentration in tree rings may be increasing with time. According to studies done in other areas (Aberg 1995, Bondietti et al 1989, Likens et al 1996), the increase of available base cations such as Ca is a precursor to the impending decrease in its availability due to removal of base cations from the system by acid rain. The implications of an increase in Ca followed by a decrease in Ca available to trees may be detrimental to Long Island’s trees and the Pine Barrens ecosystem.

Introduction

Long Island's climate is relatively humid. In the past, however, there have been periods of severe drought as well as periods of above average rainfall. For example, the drought of the 1960’s was not only severe, but also prolonged. The effect of such changes in climate on the width of tree rings on Long Island in particular, is not known. Changes in climatic factors would dictate a change in the materials storms and wind carry, and the influx of such foreign material has the potential of changing the cation chemistry of the growth rings of trees. Wind can transport materials over thousands of miles or simply redistribute them on a more local scale. Measuring the effects and changes in amounts and type of this input can not be easily done directly.

Within the last few decades, scientists have turned their attention to trees as environmental recorders (Aberg 1995, Bondietti et al 1989, Baes III 1987, and many others). Studies have shown that there are correlations between the chemical composition of tree rings and soil chemistry (Baes III 1984, Bondietti at al 1989, Aberg 1995). One advantage of using trees in such studies is that the age of each growth ring can be precisely determined. Another is that with time the new growth becomes lignified, preserving its chemical characteristics for that year. Therefore if the soil chemistry has changed over time, it should be reflected in the annual growth rings of trees. This feature allows one to observe the evolution of the tree’s environment over time.

Tree samples, for this study, were taken from three (3) locations on Long Island: Caumsett State Park, Sears Bellows County Park and Hubbard County Park. The tree ring widths of 6 pitch pines (Pinus rigida) from Sear Bellows and Hubbard Parks and 4 tulip poplars (Liriodendron tulipifera) from Caumsett Park have been used in time series analyses to see if there is a correlation among the trees with respect to their growth ring variation with time.

Results

The ring widths of each tree were measured and detrended to correct for natural exponential growth trends. Intervals of below average growth of the trees were compared to the periods of drought on Long Island expressed by the P.D.S.I. 1927-1932, 1960-1970 and 1980-1988 are intervals of depressed growth as well as periods of drought on Long Island. The fact that depressed growth in all trees sampled, regardless of location or specie, occur during severe drought periods on Long Island supports the idea that climate has a significant effect on the annual growth rings of trees (figure 1).

Further Common interval ring series analyses were carried out using the Program ARSTAN (Tucson-Mendoza-Hamburg-Lamont ProgLib). One function of this program is to mathematically compare trees of the same specie, in order determine if they can be compared, based on correlation values. Samples at each site exhibit positive correlation to each other, showing that trees at each site show comparable effects. On the basis that trees are positively correlatable on the basis of ring width, elemental analyses were performed on two pitch pines (hp03, hp07) from Hubbard Park, and two tulip poplars (csp02, csp05) from Caumsett State Park. Samples were analyzed in 5 year intervals for Ca, Sr, K and Al.

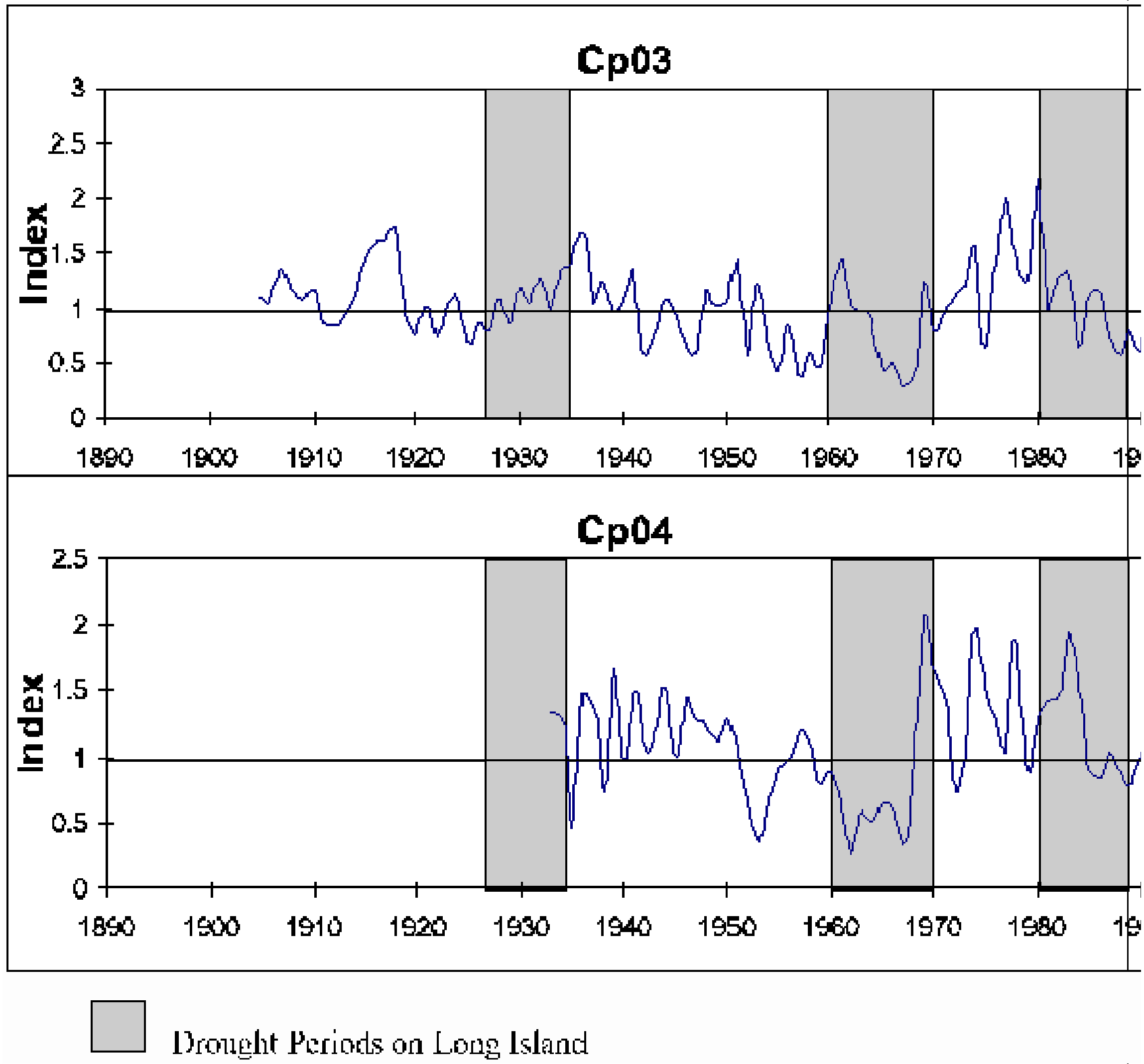


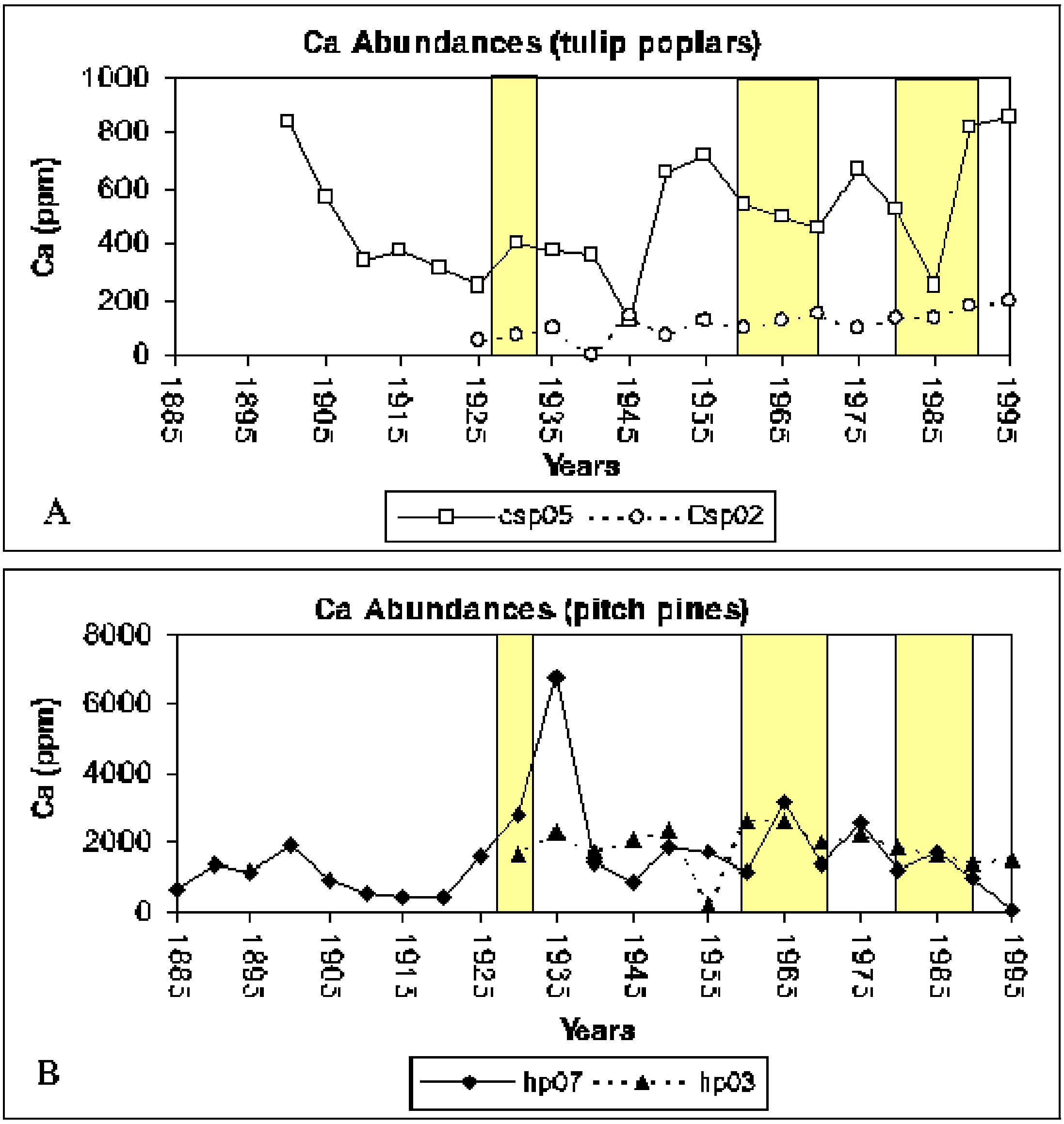
Figure 1: Detrended ring widths with drought periods for Long Island overlay.

Ca concentrations in the trees sampled on Long Island (figure 2) are comparable to Ca concentration obtained in studies conducted in other areas. Even though pitch pines are in less fertile soil than the tulip trees, the Ca concentration in the pitch pines are greater than those observed in tulip poplars. K is constant with time in tulip poplars but increases in pitch pines. Al abundances on Long Island are similar to those observed at other locales.

K/Ca and Al/Ca are variable in all trees whereas Sr/Ca is somewhat constant. The low variability of Sr/Ca may suggest that the Sr/Ca ratio of the source has been constant with time.

Comparison of the elemental data with the Palmer's Drought Severity Index shows that depressed concentrations of Ca may occur in tulip trees at times of drought on Long Island. This may suggest that the lack of rain or decrease in soil solution inhibits the availability of Ca to the trees, whereas, during rainy periods Ca is more available to the trees. The Sr/Ca ratio does not change significantly with time in the trees. Since Ca and Sr are dominantly introduced by atmospheric deposition, this steady ratio may indicate that the Sr/Ca of the source is not changing.

Calcium abundance in trees have been the subject of investigation in North Carolina, New Hampshire and Sweden, and decreasing Ca abundance is common in all locales. These studies also show that the loss of Ca and base cation availability to trees is the conclusion to a multi-stage process: (a)acid deposition (such as acid rain caused by sulfate and nitrate industrial emissions), (b)soil reaction (cation exchange) with acid deposition, (c)cation exchange encourages the release of base cations from soil particles which inturn increases in cation availability to trees, (d)with increases base cation availability in soil solution, flushing of base cations from soil by run off etc. eventually strips the base cations out of the soil with time making it unavailable to trees. The data for the trees for Long Island suggest that a similar process may be occurring here. The tulip trees show an increase from 1915 to 1995. The record for the pitch pines is not as clear. From 1915 to 1975 there was an increase in Ca, but these trees may be undergoing a reduction in Ca since then.



Drought Periods on Long Island taken from the Palmers' Drought Severity Index

Figure 2: Ca abundances observed in Tulip poplars (A) and Pitch Pines with time, with Long Island drought interval overlay

Conclusion

Ca abundances in tulip trees studied here appear to be increasing with time. The trend for the pitch pines is not as clear. If acid rain is responsible for some of the increases in Ca, this has serious implications. Ca depletion would be inevitable according to trends observed in other areas. The removal of Ca and other base cations from the soil will encourage the mobilization of harmful elements such as Al into soil solution and then into trees.

References

Aberg, G., 1995, The Use of Natural Strontium Isotopes as Tracers in Environmental Studies, Water, Air and Soil Pollution, 79:309-322

Baes III, C.F., and McLaughlin, S.B., 19984 Trace Elements in Tree Rings: Evidence of Recent and Historical Air Pollution, Science 224:494-497

Bondietti, E.A., Baes III, C.F., and McLaughlin, S.B., 1989, Radial Trends in Cation Ratios in Tree Rings as indicators of the Impact of Atmospheric Deposition on Forests, Canadian Journal of Forest Research, 19:586-594

Liken, G.E., Driscol, C.T. and Buso, D.C., 1996, Long Term Effects of Acid Rain: Response and Recovery of a Forest Ecosystem, Science, 272:244-245

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