Multiproxy isotope dendroclimatology for mature white pine (*Pinus strobus* L.) in southern Ontario, Canada

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Abstract

In this study tree-ring width, trace element composition, and stable carbon isotope chronologies constructed from measured specimens from a mature white pine plantation (*Pinus strobus* L.) in southern Ontario are presented. In 2015, tree samples were collected from the 80-year old plantation near Lake Erie, Ontario. A tree-ring chronology of ring width was constructed from 15 series. Trace element concentration per ring year was constructed from two series scanned at 500µm resolution. Two carbon isotope chronologies $\delta^{13}C$ were constructed using two individual trees at sub-annual resolution.

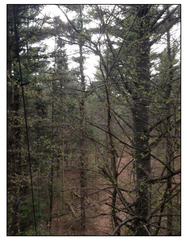
As forests cover approximately 30% of the Earth's land area and serve as it's largest terrestrial carbon sink, it is important to identify relationships between environmental variables and forest growth. In light of climate change where the volume of water resources may change over regions across the globe, how have forests adapted to climate change over the past and what seasonal climate variables are most important to their sustainability at all time scales.

Objectives

The aim of the present study is to investigate the environmental control on carbon uptake of a mature afforested white pine forest in southern Ontario using a multi-proxy approach centered on carbon isotopes. Specifically, the aim is to identify the environmental effects on the $\delta^{13}C$ of tree wood, and 2: identify if there is a relationship between ecosystem-scale measurements and $\delta^{13}C$ of tree wood.

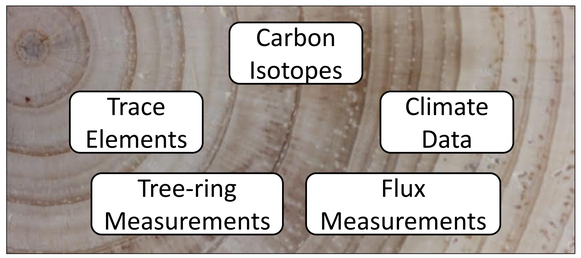
Study Site

The study took place in an afforested area of southern Ontario near Lake Erie. The site was a cleared oak savanna prior to its afforestation in 1939. The site is currently a mature stand of white pine interspersed with deciduous hardwoods.

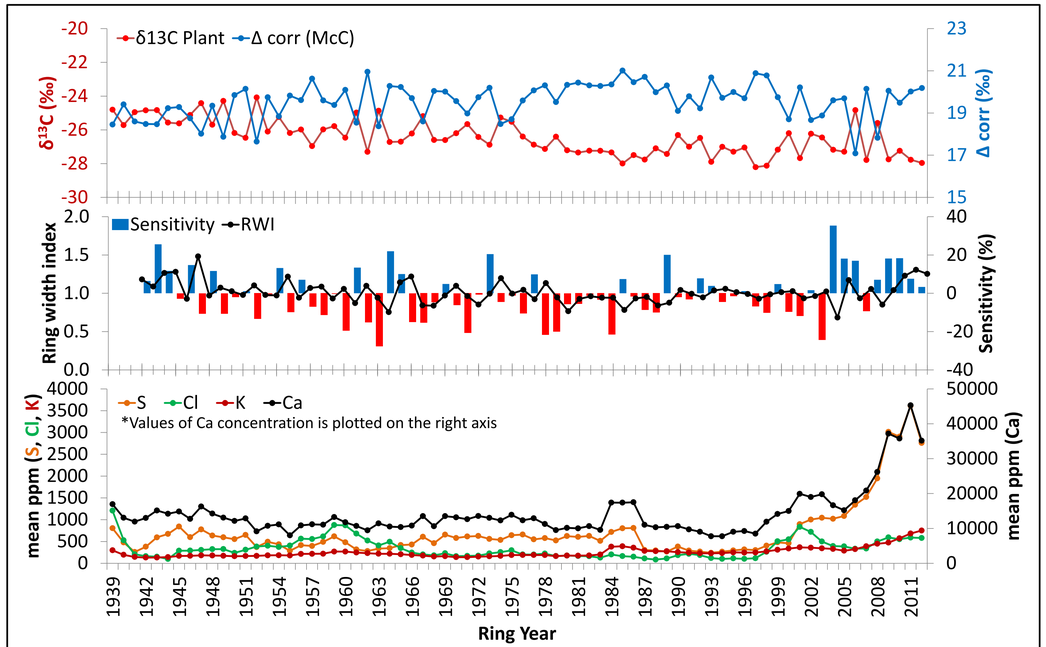


Material and Methods

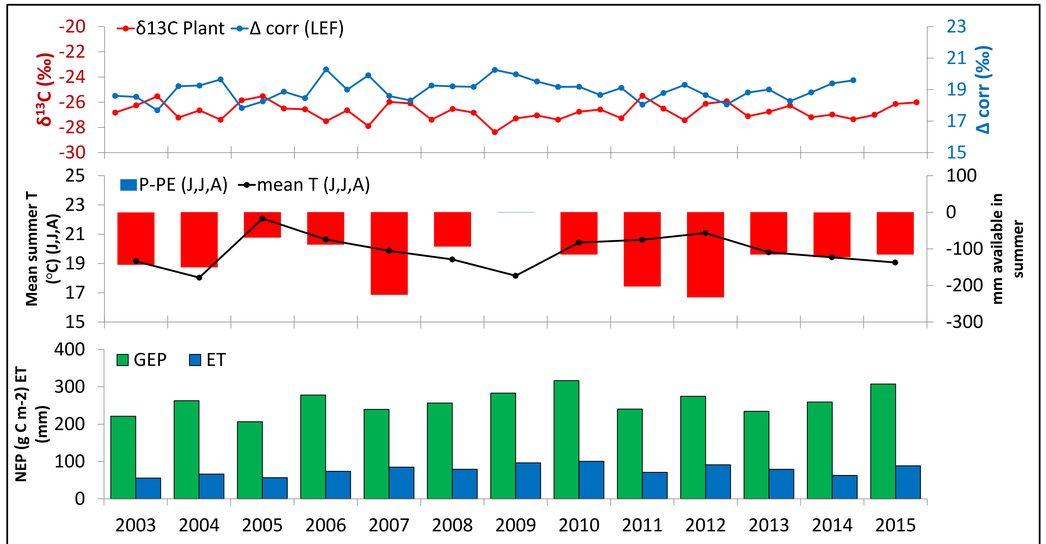
This is a multi-proxy study that used several methods to construct each data set. Data points were assigned a calendar date based on position within the tree ring and simple (Pearson) correlations between proxies to climate and ecosystem flux data were made aligned with calendar dates.



Results



Multiproxy multi-decadal and life history results: Mean annual isotope results $\delta^{13}C$ Plant (uncorrected) and $\Delta^{13}C$ (corrected for atmospheric $\delta^{13}C$), tree-ring measurements corrected for age effects (mean ring index) and trace element concentrations for S, Cl, K, Ca from tree rings from Turkey Point for the years 1939 through 2012.



Multiproxy results following TPFS initiation (2003-2015): Seasonal isotope results $\delta^{13}C$ Plant (uncorrected) and $\Delta^{13}C$ (corrected for atmospheric $\delta^{13}C$), mean annual summertime (months: June, July, August) temperature, potential evaporation (PE) and water availability (precipitation-PE) in summer (JJA) (Environment Canada) and springtime (months: April, May) accumulation volume of carbon and released water (evapotranspiration, ET) for the ecosystem measured using eddy covariance.

Simple Correlations of Proxies:		
Best correlations in Spring (April, May)		
ET (evapotranspiration)	$\Delta^{13}C$	0.45
GEP (gross ecosystem productivity	$\Delta^{13}C$	0.64
Best correlations in Summer (June, July, August)		
PE (potential evaporation)	$\Delta^{13}C$	—0.69
P-PE (water availability)	$\Delta^{13}C$	0.48
Mean summer temperature	$\Delta^{13}C$	—0.61
Annual ring-width data		
Stand sensitivity	$\Delta^{13}C$	0.48

Discussion

Growing season carbon isotope / water relationships:

Summer Temp:	Atmospheric Demand (PE):	Water Availability (P-PE):	Ecosystem Productivity:	$\delta^{13}C$ tree:
↑	↑	↓	↓	↑

Uncorrected tree-ring $\delta^{13}C$ is a record of instantaneous water use efficiency by the tree (molar ratio of water loss to CO_2 fixation). This data, corrected for atmospheric effects, yields $\Delta^{13}C$ which has a greater correlation with other proxies and measurement data due to detrending of data for atmospheric effects. When the plant is stressed (because of low water, temperature, or other factors) the tree responds by closing its stomata, forcing carbon fixation of $^{13}CO2$, which is undesirable by rubisco. The agreement and relatively high correlation of other environmental parameters centering on water and temperature in this chaotic system suggests that water and temperature may be limiting growth in this ecosystem. The availability of trace element data may also be environmentally related to climate change and forest ecosystem response to changing parameters, and is the subject of my future work.

Acknowledgements

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