Temperature effects on the physiological traits of *Quercus rubra* in New York

Rex Chen, Dept. of Earth and Environmental Engineering, Columbia University
Stephanie Searle, Dept. of Biological Sciences, University of Canterbury
Kevin Griffin, Dept. of Earth and Environmental Sciences, Columbia University

Abstract

The effects of long-term temperature changes on the physiological traits of northern red oaks (*Quercus rubra*) are still uncertain. Therefore, we established a nighttime urban-to-rural gradient with four sampling sites in the state of New York (Figure 1) and looked at the seasonal changes in temperature. Currently, nighttime temperatures of the four sites are highest at Central Park and decreases at sites that are further up north. In order to obtain a better picture of *Quercus rubra's* responses to their environment, a study was conducted along the summer months of May 2009-July 2009. Leaf carbohydrates were measured. Also measured were the oxygen isotope discrimination and chlorophyll fluorescence. We found that northern red oaks have higher % leaf starch values at cooler temperatures. We also found that chlorophyll fluorescence of mature red oaks exhibited higher fluorescence values under increasing nighttime and average daytime temperatures.

Figure 1: Map of field sites: Central Park (CP), Lamont (LDEO), Black Rock Forest (BRF), and Ashokan (ASH)

Methods

Oxygen isotope discrimination: Gas samples are incubated in exetainers at temperatures of 15˚ C and 26˚ C. ^{18}O of each sample was ejected into 3-mL gas-tight exetainers. Measurements of the ratio of $^{18}O/^{16}O$ gases will be taken with a mass spectrometer.
Chlorophyll Fluorescence Measurements: The maximum quantum yield of PSII (Fv/Fm) were measured using a Walz Mini-Pam Photosynthesis Yield Analyzer after a 20 minute dark adaptation with dark clips in 14˚ C and 26˚ C .
Leaf Carbohydrate Measurement: Sugars of ground samples of 15mg were extracted with methanol and chloroform. Starches were extracted with perchloric acid. Carbohydrate values were measured using a Unico 1100 Spectrophotometer.

Introduction

Since northern red oaks (*Quercus rubra*) is a dominant tree species group in North America, it is important to understand how long-term temperature changes affects their physiology. %Starch and %Sugar measurements of leaf carbohydrates, a product of photosynthesis and substrate for respiration are taken. Chlorophyll fluorescence, a characteristic of the light reactions of photosynthesis is also taken. This parameter reflects the health of Photosystem II and can tell the extent to which it is using the energy absorbed by the chlorophyll and the extent to which it is being damaged by excess light (Maxwell and Johnson, 2000). ^{18}O is a damaging reactive oxygen species in the plant cell so the oxygen isotope discrimination of ^{18}O against ^{16}O is also measured.

Results and Discussion

Results for oxygen isotope discrimination are not available yet. Mature red oaks of each site have higher Fv/Fm when measured at 14˚ C than 26˚ C except for Black Rock Forest in the first sampling period (Figure 2). This indicates that for each site, Photosystem II is under less stress at 14˚ C than at 26˚ C. Therefore, the extent in which Photosystem II under 14˚ C being damaged by excess light, and the amount of energy being used that is absorbed by chlorophyll is lower than it is under 26˚ C. In contrast, there is a significant relationship with the average Fv/Fm of the sites increasing in response to the higher temperatures at the sites under 14˚ C (Figure 3). These results show that in the long run as temperature increases, Photosystem II will be under less stress, become less damaged and will use less energy. Northern red oaks in the Ashokan site have the highest percentages of starch for all four sampling periods. Central Park has the lowest percentages of starch and sugar compared with the other three sites (Figure 4). This may be due to the lower nighttime temperatures at the sites further away from Central Park because plants generally respire less under colder temperatures and accumulate carbohydrates as a result. There is also a significant relationship between % leaf starch and temperature, with % leaf starch decreasing in response to higher temperatures (Figure 5). This shows that in the long run as temperature increases, % leaf starch will decrease because the plants may respire more and therefore need to use more energy.

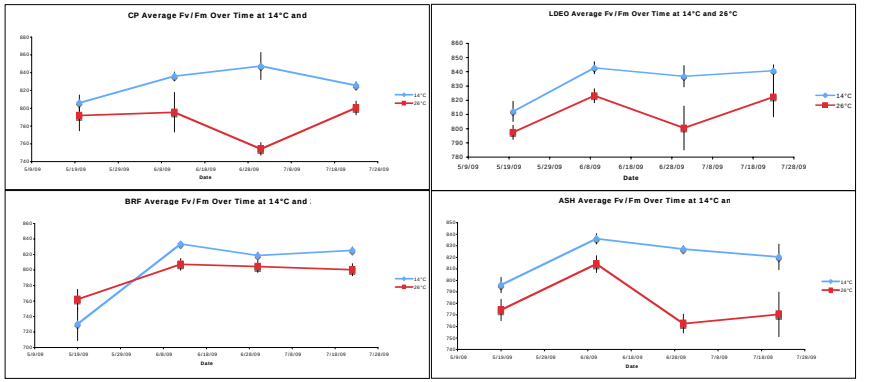

Figure 2: Response of average fluorescence under 14˚ C than 26˚ C for all sampling periods over time.

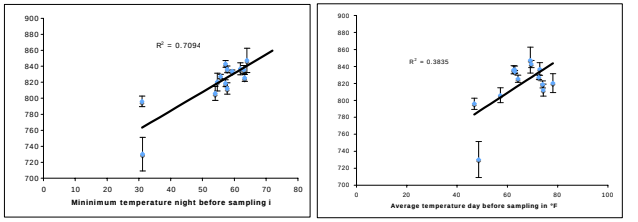

Figure 3: Response of average fluorescence under 14˚ C in the growth cabinets for all sampling periods against minimum temperature (˚ F) of the night before sampling (P-value = 0.0001569) and average temperature (˚ F) of the day before sampling (P-value = 0.01820).

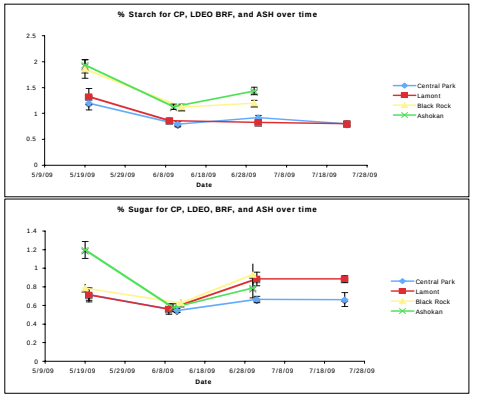

Figure 4: Response of % Starch and % Sugar in leaves for all sites and for all sampling periods over time. % Starch and % Sugar values in leaves for CP and LDEO during the fourth sampling period are not available yet.

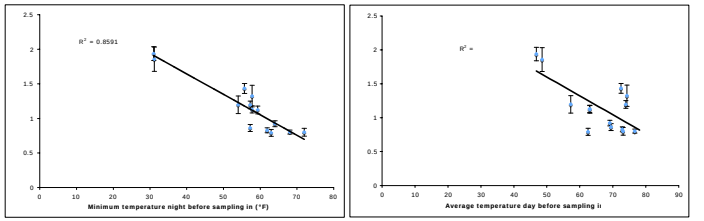

Figure 5: Response of % Leaf starch for all sampling periods against minimum temperature (˚ F) of night before sampling (P-value = 0.000001884) and average temperature (˚ F) of day before sampling (P-value = 0.005031).

Conclusion

- As long-term temperatures increases, Fv/Fm values of Northern red oaks increases.
- As long-term temperatures increases, percentages of leaf starch of Northern red oaks decreases.

References
Maxwell, K., and G. N. Johnson. 2000. Chlorophyll fluorescence – a practical guide. *Journal of Experimental Botany* 51:659-668.

Acknowledgments
Special thanks to Sam Thomas for taking the Fv/Fm measurements in May. Thanks to Danielle Bitterman for taking the CP and LDEO Fv/Fm measurements from the last sampling period.