Using photosynthetic capacity to understand the role of urban brownfields as a carbon sink

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ABSTRACT

Gas exchange measurements were used to calculate photosynthetic and carbon storage parameters of Betula populifolia in the Hudson River brownfield. Following exposure to high temperature in an urban area, carbon exchange was investigated under a variety of stressors such as urban heat island effect, altered hydrology, and polluted soils which can impair growth and urban forest. High carbon sequestration is a critical component of the response to climate change, it is important that we improve our understanding of the ability of urban green spaces to serve as carbon sinks. The study hypothesized that photosynthesis will be impaired by increasing soil metal load and increasing temperature. Two forested plots were selected to serve as the high metal load treatment while two others were a low metal load treatment. Measurements were made monthly from May to September 2014. The sites were chosen by the New Jersey Urban Ecosystems Research Network (NJUERN) and its component NJAES for loaning us the science van. This project was funded through a McIntyre Stennis Grant. Special thanks to Dr. Karina Schaffer, Ed Chirico, Isabella Cocuzza, and Bossker George for their assistance with the project. And thanks to NAES for loaning us the science van.

INTRODUCTION

• Urban trees in the continental US may have a gross C sequestration rate of 22.8 million tC/year and should be accounted for in global carbon budgets
• Urban trees are subject to unique abiotic stressors, including 1) higher temperatures, 2) less water availability, and 3) polluted soils
• Carbon sequestration models should be parameterized with urban specific data to reflect these impacts
• Future conditions predicted by climate change already exist in cities making urban environments an ideal microcosm to study potential ecological responses to climate change

STUDY GOALS

• Compare the effects of soil metal load and temperature on three photosynthetic parameters used in carbon models
• We hypothesize higher metal load and higher temperature will
  • Decrease maximum carboxylation rates (V\text{cmax})
  • Increase CO2 compensation point (Γ)
  • Increase mitochondrial respiration (R\text{dark})

STUDY SITE

Figure 1: Plots of the interior forest of Liberty State Park (LSP) in Jersey City, New Jersey. An abandoned rail yard spontaneously colonized by early successional hardwood forest and several other vegetative assemblages.

METHODS

Gas exchange measurements on Betula populifolia leaves from excised branches were used to calculate photosynthesis, transpiration rates, and related parameters.

Figure 3: LI-COR 6400 portable photosynthesis system IRGA chamber with leaf.

Light procedure:
• V\text{cmax} = internal leaf CO2 concentration at which CO2 binds to Rubisco, controls photosynthesis rate and below ambient CO2
  • higher in Plot 14/16 than in 48
  • higher in July than in June and September

RESULTS & DISCUSSION

V\text{cmax} = rate at which CO2 binds to Rubisco, controls photosynthesis rate and below ambient CO2

Figure 6: V\text{cmax} boxplot grouped by site and month.

Γ = internal CO2 concentration when V\text{cmax} and respiration are equal. Higher Γ values are associated with stress. Significantly:
• higher at Plot 48 than 25 and 14/16
• higher in September than July

Figure 7: Γ boxplot grouped by site and month.

Table 1: Experimental design of study plots. Measurements were made monthly from May to September 2014. HML = High metal load. LML = Low Metal Load.

<table>
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<th>25</th>
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<th>48</th>
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<td>HML</td>
<td>LML</td>
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<td>S</td>
<td>S</td>
<td>S</td>
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Ecosystem Demography Model v2 (EDM.v2) 

Used equations from EDM.v2 to calculate an example of carbon model values for V\text{cmax}, R\text{dark}, and Γ.

Figure 9: Daily precipitation (blue bars) with max and min temperatures from May 1, 2014 to October 31, 2014. Boxes indicate measurement days. Weather data from Liberty Science Center weather station, Jersey City.

Overall, 2014 had a mild growing season.
• Difficult to draw conclusions about role of temperature
  • T\text{avg} = 94°F on 9/2/14
  • July: hottest and wettest. T\text{avg} = 84°F, P\text{avg} = 6.85 in.
  • August: driest, P\text{avg} = 2.13 in.

Prior work with tree rings found high metal load plots had lower growth rates. Failure to reject initial hypotheses suggests:
• other conditions may more strongly influence growth
• photosynthetic rates at HML plots could be overcompensating to provide energy for maintenance

Plot 48 results opposite of initial hypotheses.
• Consistent with visibly poor condition of trees at plot
• Potentially caused by Hurricane Sandy damage

The EDM.v2 carbon model parameterizations:
• are comparable for V\text{cmax}
• underestimate Γ and R\text{dark}

Future research will:
• collect a second season of data in 2015
• characterize other edaphic conditions at the site

ACKNOWLEDGEMENTS

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WORKS CITED