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 Marsh. trees growing on a heavy metal contaminated site in Jersey City, New Jersey. Carbon dioxide exchange rates under nitrogen stress suggest that urban trees growing on polluted soils can ameliorate growing conditions for plant growth and urban stress. Higher carboxylation rates 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 improve 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 selected to have uniform microclimates, with the exception of the low metal load sites which suggests the trees may have been less stressed during this month. CO2 which reflects maximum photosynthetic rates peaked in August. Consistent with the hypothesis nothing significant differences between the high and low metal load plots. This suggests metal load alone may not be the only factor affecting photosynthetic productivity in an urban context.

RESULTS & DISCUSSION

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

![Figure 3: LICOR 6400 portable photosynthesis system IRGA chamber with leaf.](image)

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Light curve procedure:
- Vary light levels, measure net photosynthesis (A
\text{net})
- Light ranged from 2000 to 0 μmol photons m$^{-2}$ s$^{-1}$

![Figure 4: Example light curve.](image)

Figure 4: Example light curve.

A/Ci curve procedure:
- Measured A
\text{cmax} as internal leaf CO2 concentrations (Ci) varied
- Chamber CO2 concentrations ranged from 20 to 1500 ppmv CO2

![Figure 5: Example A/Ci curve.](image)

Figure 5: Example A/Ci curve.

\begin{align*}
\text{V}_{\text{cmax}} &= \text{rate at which CO2 binds to Rubisco, controls photosynthesis rate at and below ambient CO2} \\
\text{higher in Plot 14/16 than in 48} \\
\text{higher in July than in June and September}
\end{align*}

![Figure 6: V_{cmax} boxplot grouped by site and month.](image)

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\begin{align*}
\text{F} &= \text{internal CO2 concentration when A}_{\text{cmax}} \text{and respiration are equal. Higher F values are associated with stress.} \\
\text{higher at Plot 48 than 25 and 14/16} \\
\text{higher in September than July}
\end{align*}

![Figure 7: F boxplot grouped by site and month.](image)

Figure 7: F 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.

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<tr>
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<th>48</th>
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Ecosystem Demography Model v.2 (EDMv.2) 7
Used equations from EDMv.2 to calculate an example of carbon model values for V_{cmax}, R_{dark} and F

\begin{align*}
\text{R}_{\text{dark}} &= \text{CO2 released by cellular respiration for growth and maintenance. Higher rates are associated with stress.} \\
\text{higher in May than in September and July}
\end{align*}

![Figure 8: R_{dark} boxplot by site and month.](image)

Figure 8: R_{dark} boxplot by site and month.

WORKS CITED
1. Edmondson, S., Edmondson, S., Gallagher, F., Graboski, J., 2015. Urban trees are subject to unique abiotic stressors, including 1) 2) 3)
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7. Chairing, M., 2015. Daily precipitation (blue bars) with max and min temperatures from May 1, 2014 to October 10, 2014. Boxes indicate measurement days. Weather data from Liberty Science Center weather station, Jersey City.
8. Future research will:
- collect a second season of data in 2015
- characterize other edaphic conditions at the site

ACKNOWLEDGEMENTS
This project was funded through a McIntyre-Stennis Grant. Special thanks to Dr. Karina Schaffer, Ed Chirico, Isabella Cocuzzo, and Booker George for their assistance with the project. And thanks to NAES for loaning us the science van.

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.

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 budgets1.

Urban trees are subject to unique abiotic stressors, including 1) higher temperatures, 2) less water availability, and 3) polluted soils2.

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 change2.

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_{cmax})
  - Increase CO2 compensation point (F)
  - Increase mitochondrial respiration (R_{dark})

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Overall, 2014 had a mild growing season.
- Difficult to draw conclusions about role of temperature
  - T_{max} = 94°F on 9/2/14
  - July: hottest and wettest, T_{max} = 76°F, P_{max} = 6.85 in.
  - August: driest, P_{max} = 2.13 in.

Prior work with tree rings found high metal load plots had lower growth rates3. 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 EDMv.2 carbon model parameterizations:
- are comparable for V_{cmax}
- underestimate F and R_{dark}

Future research will:
- collect a second season of data in 2015
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