Heavy metal exposure and drought effects on the photosynthesis of mature *Betula populifolia*

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ABSTRACT

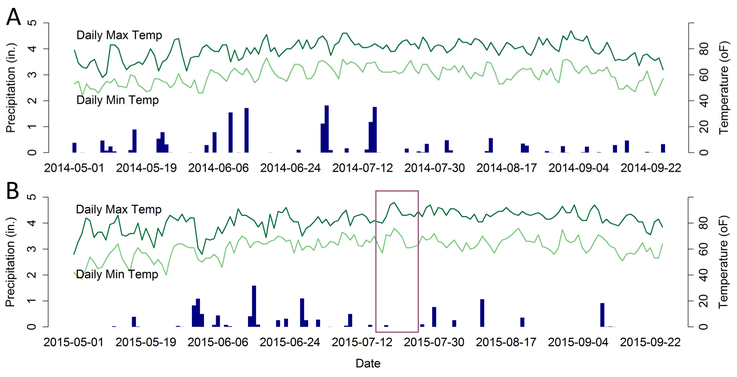
The interacting effects of heavy metal contaminated soil and drought on the photosynthesis of *Betula populifolia* (gray birch) were studied in the summer of 2015. Climate change predictions suggest North America will experience more intense droughts, frequent heat events, and extreme precipitation. In the urban environment predictions about the effects of climate change – particularly changing hydrologic patterns – on plant growth may be complicated by pollution from both current and historic sources. The interaction between heavy metals contamination and plant water relations during drought is complex. Side effects of heavy metal exposure appears to confer drought tolerance in some species but not in others. The study tests the hypothesis that photosynthetic and transpiration rates of mature gray birch growing in high metal load (HML) soils will be less affected by a short heat wave and drought followed by a month of below average precipitation compared to the low metal load (LML) plots. Photosynthesis and transpiration were measured monthly from May 2015 to September 2015 using a portable gas exchange analyzer. Measurements were made in trees from two LML plots and two HML forested plots in Liberty State Park, Jersey City, New Jersey.

INTRODUCTION

- Heavy metal (HM) pollution from historic and current sources is a global issue[1]
- North America climate change forecasts: more intense droughts, frequent heat events, and extreme precipitation[2]
- **How will changing climate patterns – particularly drought – influence the growth rate of trees growing in HM contaminated soils?**
  - Some plants appear to develop a tolerance for drought when exposed to HM[3]
  - Other studies document metal stress amplifying the effects of drought[4]
- **Hypothesis:** mature *Betula populifolia* (gray birch) growing in high HM plots will exhibit lower photosynthetic and transpiration rates compared to low HM plots.

STUDY PERIOD WEATHER

Figure 1: Daily maximum and minimum temperatures with precipitation totals from May to September 2014 (A) and 2015 (B). Purple box indicates heat wave in July 2015.



METHODS

Gas exchange measurements on *B. populifolia* leaves from excised branched were used to calculate photosynthesis and transpiration rates.

- Measurement conditions: 400 µmol CO_2 m^{-2} s^{-1}, 1500 µmol photons m^{-2} s^{-1}
- May to September 2014 and 2015

Table 1: Experimental design. HML = High metal load. LML = Low Metal Load. Total metal load = rank sum index of As, Cr, Cu, Pb, and Zn concentrations.

Plot	25	14/16	48	41
Total Metal Load[4]	4.31	3.56	1.56	0.85
Grouping	HML	HML	LML	LML
Trees per month	5	5	5	5
Leaves per tree	2	2	2	2

RESULTS & DISCUSSION

Figure 2: Net photosynthetic rates measured at four LSP study plots from May to October 2014 and 2015. Solid circles represent mean values for a plot in a given month, bars show standard deviation.

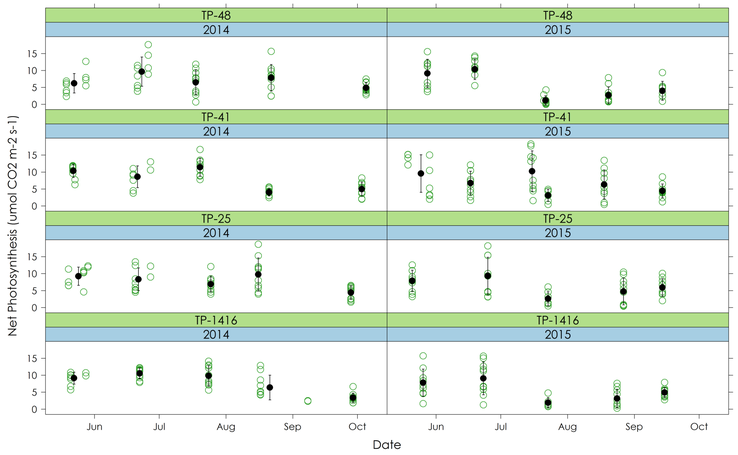


Figure 3: Net transpiration rates measured at four LSP study plots from May to October 2014 and 2015. Solid circles represent mean values for a plot in a given month, bars show standard deviation.

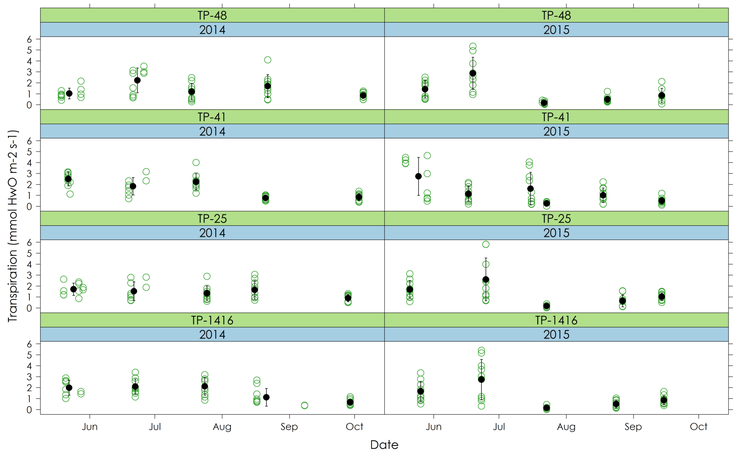
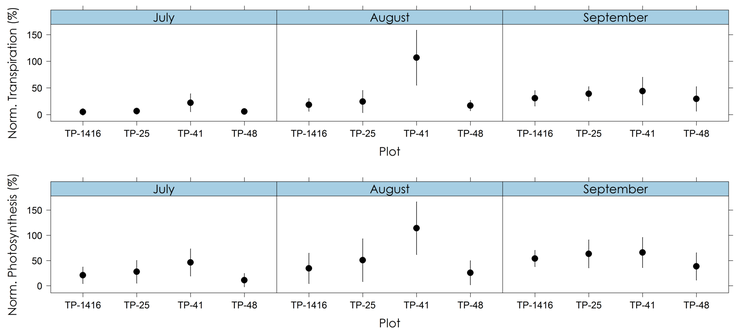


Figure 4: Mean of photosynthesis (A) and transpiration (B) measurements made from July to September 2015 (post drought) normalized to June 2015 plot means (pre drought). Bars indicate standard deviation.



Inter-annual variation

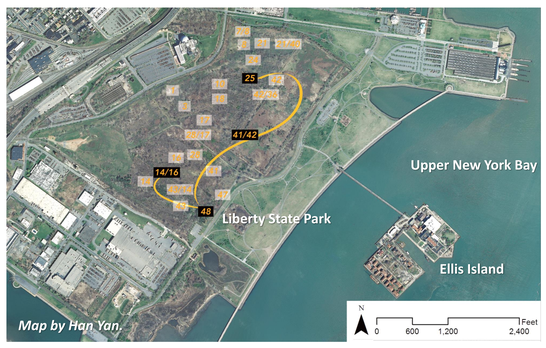
- Photosynthesis and transpiration dramatically decrease following heat wave in July 2015
- Rates remain low in August 2015 (monthly precip. 2 in. below average)

Plot to plot variation in summer 2015

- Normalized photosynthesis and transpiration in July – September 2015 to mean rates in June 2015 for each plot
  - Accounts for inter-plot variability under average conditions
- Differences between plots tested with Kruskal-Wallis one way ANOVA
  - TP-41 (low metal load) rates in August 2015 significantly higher than other plots in August
  - Second low metal load plot showed no difference
  - Inconclusive if metal load had an effect on drought response

STUDY SITE

Figure 5: 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.[4]



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