Comparing the Leaf Area Index (LAI) of an Urban Forest Before and After Hurricane Sandy

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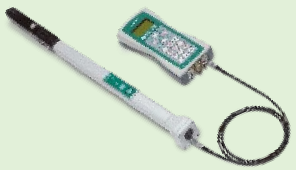
Abstract

Adequate knowledge of the costs and benefits of trees in urban environments helps to assess environmental damages caused by climate change, urban expansion and anthropogenic pollution. In addition to changes in seasonal average temperature and precipitation, more frequent extreme weather events such as hurricanes associated with climate change pose a significant threat to urban forests. The photosynthetic tissues that make up the tree canopy generate life supporting ecological services and are susceptible to environmental stresses. Leaf Area Index (LAI) for broadleaf canopies is a dimensionless unit defined as one half of the total leaf surface area per unit of ground surface area. Temporal and spatial comparison of LAI in canopies of the same species offers a quantitative method for comparing assemblage productivity in response to changing soil and climate conditions. This study tests the hypothesis that canopies of broadleaf species in soils with high heavy metal concentrations will have decreased LAI values when compared to their low metal load counterparts. It also tests the hypothesis that canopies in high metal load soils will exhibit lower regeneration rates after flooding caused by Hurricane Sandy. Measurements were collected over the course of the growing season in 2010, 2011, 2012, 2013, and 2015.

Materials, Methods, and Study Site



Materials:
- LI-COR LAI-2200 Plant Canopy Analyzer
- FV2200 software
- Excel
- Rstudio

Fig. 1 Image of the Li-COR LAI-2200 Plant Canopy Analyzer[4]

Methods and Study Site:
- LAI measurements using an indirect, optical method during the growing seasons of 2010, 2011, 2012, 2013, and 2015 (May-August)
  - Measurements taken in 4 sites in an urban brownfield forest in Liberty State Park, New Jersey.
  - Two sites above and two sites below the previously established soil metal threshold, at which metabolic stress has been documented
  - 4 measurements per site using 4 markers
  - Markers were located 4 meters apart from one another
  - Measurements taken twice per month

References

1. Nowak, D. and J. F. Dwyer. (2007) Understanding the Benefits and Costs of Urban Forest Ecosystems, *Urban and Community Forestry in the Northeast*, 2nd ed. 25-41.
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3. Gallagher F.J., Pechmann I., Bogden J., Grabosky J., and Weis P. Soil metal concentrations and productivity of Betula populifolia (gray birch) as measured by field spectrometry and incremental annual growth in an abandoned Brownfield in New Jersey, *Environmental Pollution* 156 (Dec. 2008) 699-706
4. Image from: http://www.licor.com/env/products/leaf_area/LAI-2200/

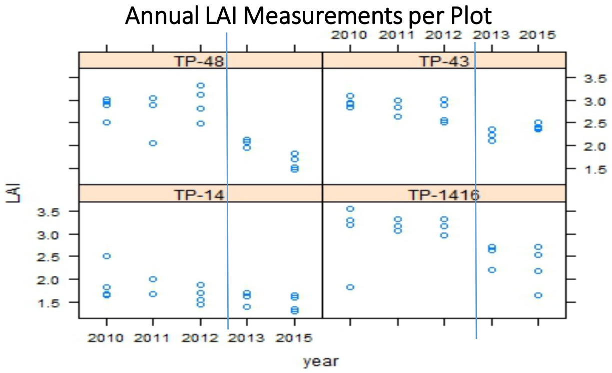

Fig. 2 Yearly Leaf Area Index in Liberty State Park organized by plot. Graph generated using Rstudio. Blue line indicates Hurricane Sandy's date (October 29, 2012).

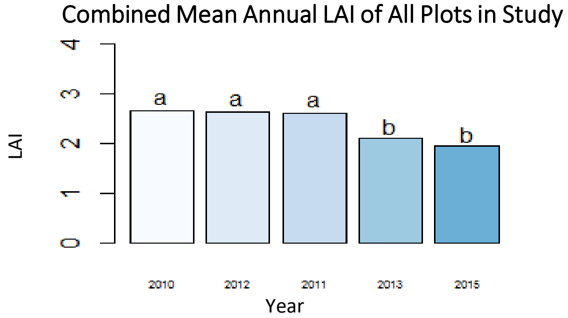

Fig. 3 Mean LAI values of all growing seasons measured (2010, 2011, 2012, 2013, 2015). Different letters indicate that the mean LAI values are significantly different from one another according to the Tukey HSD test. Generated using Rstudio.

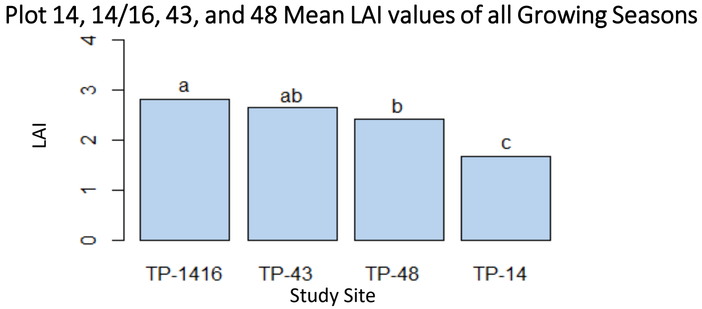

Fig. 4 Mean LAI values of all growing seasons measured (2010, 2011, 2012, 2013, 2015) of each plot. Letters indicate that the mean LAI values are significantly different from one another according to the Tukey HSD test. Generated using Rstudio.

Results

Mean LAI values of Each Year of Study per Plot

Study Plot	Mean LAI	Tukey HSD Test Standard Deviation
43	2.64	0.30
48	2.43	0.60
14	1.67	0.28
14/16	2.82	0.56

Fig. 5 The information displayed in Figure 4. The mean LAI values of all 5 years of the study (2010, 2011, 2012, 2013, 2015) combined and organized per plot. Values were found to be significantly different from one another using Tukey HSD test in Rstudio.

Average Growing Season LAI Values Organized by Plot and Year

	Plot					
Year		2010	2011	2012	2013	2015
	14	1.73	1.72	1.68	1.59	1.45
	43	2.80	2.91	2.69	2.25	2.42
	48	2.95	3.03	2.82	2.06	1.59
	14/16	3.67	3.18	3.18	2.57	2.60

Fig. 6 Chart of yearly average LAI values found for plots 14,14/16,43, and 48 for years 2010,2011,2012, 2013, and 2015.

Combined Mean Annual LAI Values of All Plots in Study

Year	Mean LAI Value of All Four Sites	Tukey HSD Test Standard Deviation	Tukey HSD Test Significant Difference
2010	2.667	0.61	A
2011	2.611	0.60	A
2012	2.629	0.65	A
2013	2.09	0.39	B
2015	1.942	0.48	B

Fig. 7 The information displayed in Figure 3. The mean values of the four study plots combined were of years 2010-2012 were not significantly different. The combined mean values of the four sites in 2013 and 2015 were not found to be significantly different from each other, but to be significantly different from years 2010, 2011, and 2012. Values found in Rstudio.

Discussion

This study tests the hypothesis that broadleaf canopies in soils with high heavy metal concentrations would experience decreased LAI values compared to broadleaf canopies in soils with low heavy metal concentration. Mean LAI values of sites 14 and 14/16 were found to be 1.67 and 2.82 respectively. Site 14, a heavy metal load site, is the lowest mean LAI value measured over this five year study. The mean LAI value of the 5 growing seasons of site 14/16 is not consistent with the findings of its partner heavy metal site. The data does not support the hypothesis that heavy metal sites will have decreased LAI values. Further knowledge regarding the photosynthetic tissue quality constructing the surface area of the canopy is needed in order to develop a more in depth assessment of canopy health in these polluted sites. This study also tests the hypothesis that canopies in high metal load soils will exhibit lower regeneration rates after flooding caused by Hurricane Sandy. Figure 3. Demonstrates that the overall mean LAI value of all sites combined was decreased after Hurricane Sandy (October 29, 2012). Mean overall LAI value of 2015 is not significantly different from the mean overall LAI value in 2013, possibly indicating a low canopy regeneration of all plots studied post-Hurricane Sandy. LAI values in figure 2. Indicate that plot 14/16 experienced higher LAI values than 14 in 2015. This information does not support the second hypothesis. Further research is needed to determine the effects of higher seasonal temperature, drought, and soil pollution within the various sights.

Acknowledgments

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