PCAP Project
Angela Brandt
18 March 2013

The relationship between environmental heterogeneity and plant invasion: implications for invasive plant management in the Cleveland Metroparks

Hypothesis and prediction:

- Research Question: Does environmental heterogeneity affect plant invasions?
- Hypothesis: Heterogeneity in resource availability increases habitat invasibility.
- Prediction: If heterogeneity in resource availability increases habitat invasibility, then the diversity and abundance of invasive plants will increase with variability in light.

Methods:

I used data collected as part of the Cleveland Metroparks' Plant Community Assessment Program (PCAP) (Eysenbach and Hausman 2012) in northeastern Ohio to determine how light availability related to the diversity and abundance of invasive plants. Approximately 100 plots were sampled across the Metroparks' 16 reservations in each of 2010 and 2011 using a stratified random sampling design to allocate plots across the Metroparks' total land area in a spatially balanced fashion. Sampling within each plot followed the protocols of the North Carolina Vegetation Survey to collect data on both the plant community and abiotic environmental factors within the plot. Each plot consisted of a 2 × 5 array of 10 × 10 m modules, with four of those modules being intensively sampled to obtain the visually-estimated percent cover of each plant species present. At a randomly-selected point within each intensive module, canopy cover was measured in the four cardinal directions using a densiometer.

For the current study, I used data only from forested upland plots (184 plots total). I calculated the diversity and abundance of invasive plants as the richness and total percent cover of species classified as "adventive" in each plot. I allowed total cover to sum to more than 100% because individual species could have overlapping canopies. I used the percent of open canopy as a metric of light availability, which I calculated by multiplying the mean of the four densiometer readings in each intensive module by 1.04. I obtained the overall light availability for the plot by calculating the mean percent of open canopy and variability in light availability by calculating the variance of open canopy in the intensive modules. One plot only had one intensive module sampled, thus the variance in open canopy across that plot could not be calculated and the sample size for analysis was 183.

I used a simple linear regression to relate diversity and abundance of invasive species to the mean and variance in open canopy within each plot. I included the mean percent open canopy in the model as a covariate because previous work has shown that invasion increases with higher resource availability and environmental heterogeneity in resources tends to increase with resource availability. Invasive richness was square root transformed and invasive abundance, mean percent open canopy, and variance in percent open canopy were natural log transformed to achieve normality. Due to invasive species being absent from some plots, 0.001 was added to the total cover of invasive plants before transformation. Diagnostic plots were checked to ensure the

statistical models met the assumptions of equal variance and normality. All analyses were performed in R version 2.14.2 (R Development Core Team 2012).

Results:

As predicted, invasive species richness increased with variability in light availability (P = 0.0002) but not with mean light availability (P = 0.20; Table 1). Invasive species abundance also increased with variability in light availability (P = 0.001) but not with mean light availability (P = 0.83; Table 1).

Table 1. Diversity and abundance of invasive plants in forested plots of the Cleveland Metroparks sampled in 2010 and 2011 increased with variability in the percent of open canopy but not the mean percent open canopy in a simple linear regression. Diversity was measured as invasive species richness; abundance as the total cover of invasive species. Significant P-values are in bold; n = 183 plots.

	Invasive diversity			Invasive abundance		
Predictor	Estimate ± SE	t	P	Estimate ± SE	t	P
Intercept	2.23 ± 0.15	15.18	**<0.0001**	-0.74 ± 0.42	-1.76	0.080
Mean open canopy (%)	-0.17 ± 0.13	-1.28	0.20	-0.079 ± 0.37	-0.21	0.83
Variance in open canopy ($\%^2$)	0.28 ± 0.076	3.75	**0.0002**	0.72 ± 0.22	3.28	**0.001**

Discussion:

Management of invasive plants is a primary goal of the Metroparks' conservation program and understanding the distribution of invasive plant species is one objective of PCAP, with the ultimate goal of improving management efforts and reducing the impact of invasions on native plant communities and the Metroparks ecosystems. Theory predicts that environmental heterogeneity can increase habitat invasibility; for example, more variable environments might result in more gaps being available for an invasive species to colonize. My results show that the diversity and abundance of invasive species in the parks increases with environmental heterogeneity, measured as the variance in light availability within forested plots, but not with mean light availability. My results thus suggest that the parks staff will need to consider both variation in resources as well as total resource availability when planning management activities within the parks.

Next steps:

- Consider if variance is the best metric to use for heterogeneity of light availability (units of measurement are not intuitive)
- Improve the explanatory power of my statistical models – most of the variation in diversity and abundance of invasive plants is not explained by my predictors
- Determine how many species in each plot could not be classified as "native" or "adventive", and their abundance
- Consider whether to include all life forms or restrict my analysis to understory plants
- Produce a graph to visually communicate the trends in my results

References:

Eysenbach, S. R., and C. E. Hausman. 2012. Plant Community Assessment Program (PCAP) Preliminary Report. Cleveland Metroparks Technical Report 2012/NR-XX. Division of Natural Resources, Cleveland Metroparks, Fairview Park, Ohio.

R Development Core Team. 2012. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.