The impacts of rapid canopy loss in oak woodland restoration

Kyndall Hadley[1], Matt Evans[2], Jacob Zeldin[2], Andrea Kramer[2]

[1]Northwestern University Evanston, IL 60201; [2]Chicago Botanic Garden Glencoe, IL 60022

Introduction

Restoration involves assisting the recovery of habitat function and diversity in degraded, damaged, and destroyed ecosystems It does this by reducing threats, improving physical conditions, species composition, structural diversity, ecosystem functionality, and external exchanges (e.g. gene exchange)[3].

Restoration in midwestern oak woodlands aims to increase native species richness and decrease invasive non-native species cover and species richness. It largely involves removing invasive species such as buckthorn (*Rhamnus cathartica*) and reintroducing fire and seeds of desired native species. This process is ongoing and active, requiring long-term commitment and flexibility to respond to continuing disturbances and unexpected changes caused by things like new invasive or aggressive species or climate change. These unplanned impacts can significantly alter the restoration's trajectory and require new management strategies. The best way to track restoration progress towards desired outcomes involves monitoring communities over time. This is resource-intensive but, when possible, can provide critical information to inform management.

One site where restoration and habitat monitoring have been ongoing is McDonald Woods, a 100-acre woodland managed by the Chicago Botanic Garden in Glencoe, Illinois. Prior to colonial settlement, it was an oak-hickory woodland maintained by the Native Americans with regular fires. By the early 1990's, it was highly degraded due to fire suppression and invasive species. Restoration and habitat monitoring has been ongoing since then, including work aimed at decreasing the invasive species like buckthorn, and burning and seeding following buckthorn removal.

Decades of fire suppression changed the dominant trees in the woodlands, with maple and ash trees growing where only oaks and hickories could survive. Under these species, only very shade-tolerant understory species could survive, until 2013-2016, when all adult ash trees in the woods were killed by an introduced invasive insect (Emerald Ash borer: EAB)[1]. This loss of ash trees dramatically increases understory light levels, which could alter basic community composition and enable the spread of sun-loving invasive or aggressive understory plants [2] like tall goldenrod (*Solidago altissima*) which would require new management approaches.

Here, I use habitat monitoring data collected in 2010 and 2020/21 to compare the change in plant communities of ash-dominant and oak-dominant areas to determine whether restoration efforts are achieving their goals of increasing native diversity and decreasing non-native diversity in both sites.

Hypotheses

- Native richness will be similar between areas, and there will be an increase in both areas between years.
- There will be slightly more non-native species -as measured by non-native effective species and non-native richness- in the ash areas than the oak areas.
- There will be more *Solidago altissima* in the ash versus oak areas because of the rapid increase in light

Methods

Surveying

- 5 transects with 5-11 ½ m^2 quadrats in Ash and Oak (307 and 185 in 2010 and 2020/21 respectively)
- In each quadrat, plants identified to species, given abundance measure (1-5) based on % cover

Analysis

Assessed whether habitat (ash or oak) and time (2010 or 2020) predicted variation in native species richness, non-native species effective species (inverse Simpson metric), and non-native species cover predicted variation using generalized linear models with poisson distributions for count data in "R." Evaluated with anova. Models without significant interaction were simplified using backwards elimination of predictor variables.

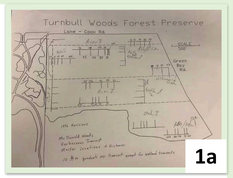


Figure 1- (a) Map of the transect locations in McDonald Woods. (b) Kyndall and Matt monitoring the woods

Results

	Comparing Ash vs Oak
Response variables	
Native richness	
Year	***
Type	***
Year*Type	*
Non-native effective species	
Year	**
Type	***
Year*Type	NS
Non-native richness	
Year	***
Type	***
Year*Type	NS

Figure 3- Table of significance values in the differences between ash and oak monitoring data ***: p < 0.0001, **: p < 0.001, *: p < 0.01

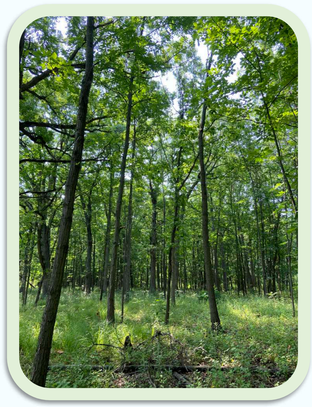
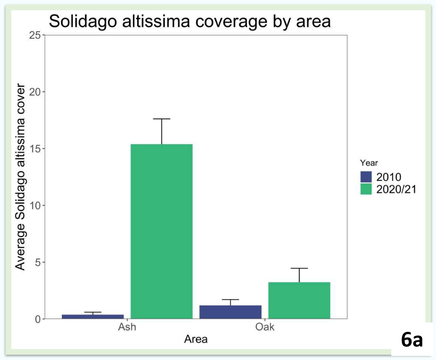
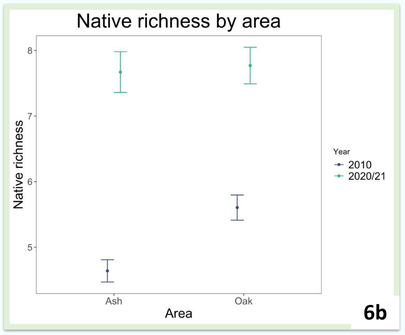
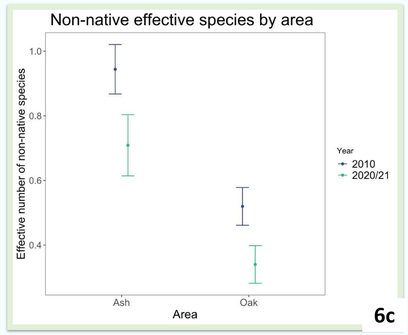


Figure 4- Photo of McDonald Woods

Figure 5- Photo of *Solidago altissima* [4]







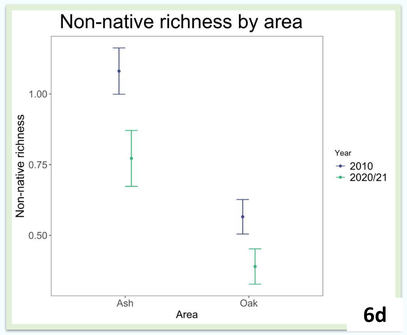


Figure 6- (a) Graph of *Solidago altissima* cover by area of the woods. (b) Graph of predicted native richness by area (c) Graph of predicted non-native effective species by area. (d) Graph of predicted non-native richness by area

Discussion

Monitoring results show that restoration has been successful thus far in increasing native species richness in both areas of the woods. It has also significantly decreased non-native cover and non-native richness in both areas. This coincides with management techniques of seeding both areas of the woods following buckthorn removal.

While restoration goals appear to be being met, there appeared to be increases in sun-loving aggressive species like *Solidago altissima* in the ash areas of the woods, which could hinder future progress. We visualized the relative abundances of this species across the two areas in the woods, and changes in its average cover are considerably higher in ash transects than oak transects. This is correlated with the rapid canopy opening caused by the emerald ash borer. One explanation could be that there was increased ability for plants to colonize the area because of the removal of buckthorn. Once canopy cover rapidly decreased, *Solidago altissima* was able to rapidly increase in abundance. Further research is needed to understand whether the increasing presence of this aggressive species will impact our ability to restore diverse native species to the ash areas.

Given the restoration's apparent successes in reaching its goals, it is also important to note that ten years is very little time in a restoration. Restorations take place over decades, and longer-term impacts of the loss of ash trees and rapid canopy loss can not yet be determined. Future projects could continue to monitor the restoration in order to continue tracking changes in the community. However, in light of the rapid increase in abundance of *Solidago altissima* in the areas where the canopy was opened rapidly, we recommend that land managers hoping to recreate native savannah and prairie conditions open the canopy gradually whenever possible. This would hopefully allow for more shade-tolerant and non-aggressive species to establish and decrease abundance of aggressive sun-loving species such as *Solidago altissima.*

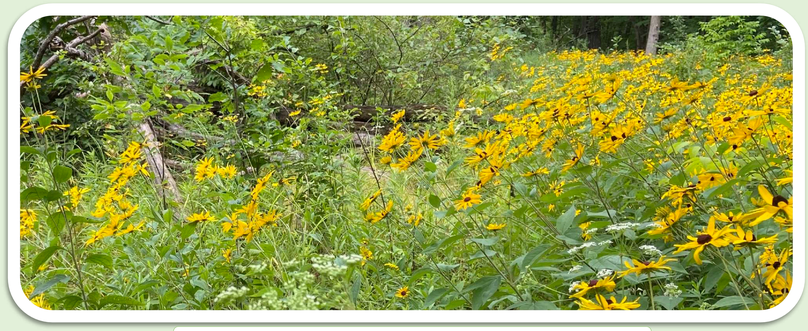


Figure 7- Brown-eyed susans (*Rudbeckia triloba*) in McDonald Woods

Acknowledgements

Thank you to everyone who made this project possible. Thank you to everyone at the Botanic Garden! Thank you to the Biological Sciences Department at Northwestern University for supporting this project and NSF-REU grant: DBI-1757800

Works Cited

1) Emerald Ash Borer Information Network. (2020). *Emerald Ash Borer*. Emerald Ash Borer Information Network. http://www.emeraldashborer.info/
2) Hoven, B. M., Gorchov, D. L., Knight, K. S., & Peters, V. E. (2017). The effect of emerald ash borer-caused tree mortality on the invasive shrub Amur honeysuckle and their combined effects on tree and shrub seedlings. *Biological Invasions*, *19*(10), 2813-2836.
3) McDonald, T., Gann, G. D., Jonson, J., & Dixon, K. W. (2016). International standards for the practice of ecological restoration–including principles and key concepts.(Society for Ecological Restoration: Washington, DC, USA.). *Soil-Tec, Inc.,© Marcel Huijser, Bethanie Walder*.
4) Warren, Robert. 2018. Tall Goldenrod in Frederick Co., Maryland. [Photograph]. Maryland Biodiversity Project. https://www.marylandbiodiversity.com/view/4386
5) Creazilla. Oak leaf clipart.