Analysis of the Effects of Buckthorn on Carbon Storage in McDonald Woods.

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Abstract

The purpose of this research was to test the effects of *Rhamnus cathartica* (common buckthorn) invasion and removal on woodland carbon dynamics. Buckthorn is a highly invasive shrub/tree found throughout the upper Midwest and in much of Chicago Botanic Garden's Mary Mix McDonald Woods (Glencoe, IL). We investigated ecological structure and carbon dynamics in a buckthorn-invaded area (buckthorn), areas where buckthorn has been removed for 6-13 years (restored), and an area where buckthorn has never invaded (control). We characterized the structure of buckthorn, restored, and control stands by surveying vegetation and measuring coarse woody debris and leaf litter biomass. We quantified soil carbon storage by measuring the abundance and recalcitrance of particulate organic matter (POM). We evaluated carbon loss by measuring soil erosion after rainfall events and soil carbon dioxide (CO_2) exchange. These results enable us to quantify the competitiveness of buckthorn in the forest ecosystem and to become more aware of the positive impacts restoration can have on the forest dynamics.

Buckthorn: An Invasive Tree

- Invasive species are non-native organisms that degrade the diversity and functioning of natural habitats.
- Buckthorn is native to Eurasia. Following European settlement, buckthorn was brought to the U.S. and planted in landscaping.
- Buckthorn reproduces and disperses prolifically. It has escaped human control and is now one of the worst invaders of wooded areas throughout the upper Midwest.
- Buckthorn has been shown to reduce plant diversity, degrade wildlife habitat, alter ecosystem functions such as decomposition and nitrogen cycling, and promote earthworm invasion.
- Strong differences in the biotic and abiotic structure of invaded and uninvaded areas of McDonald Woods caused us to wonder if carbon capture, processing, and storage (all of which are strongly influenced by vegetation) differed in response to buckthorn invasion and removal.

(DeDeyn et al. 2008, Heneghan et al. 2007, Heneghan et al. 2004)

OBJECTIVES:

- To quantify soil particulate organic matter in sites that are buckthorn-invaded, never invaded by buckthorn, and restored in 1996, 2001, and 2003.
- To determine if there is carbon loss due to buckthorn invasion.
- To analyze whether restoration of buckthorn-invaded woods can promote carbon sequestration.

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Question

Does buckthorn affect erosion, soil CO_2 flux, and carbon storage in McDonald Woods?

Buckthorn thicket: bare ground.

Buckthorn thicket canopy: dense monoculture of buckthorn.

2001 restoration site: diverse canopy and herbaceous cover.

Control site: thick leaf litter, dense canopy of oak and maple.

Methods

Five 50m x 80m sites: Buckthorn thicket, Maple/Oak Control , 1996 cleared, 2001 cleared, 2003 cleared. Six 10m x 10m plots were set up in each site. All sampling was done in each plot.

CO_2 Flux:
We used the NaOH method to determine how much CO_2 was being released from the soil in each of the plots. Data were taken 7/7/09, 7/15/09, 7/21/09.
(Zilbiliske 1994)

Erosion Traps:
We used the mesh-bag method to catch erosion in each plot during a severe rain event June 19, 2009.
(Hsieh 1992)

Litter Collection:
One 0.6m x 0.6m quadrat of coarse woody debris and leaf litter were collected from the NW corner of each plot, dried, separated, and weighed.

Percent Organic Matter:
•Soil was collected from each of the 6 plots in each study site.
•Soil was dried and % moisture was determined.
•Soil was separated into litter, coarse matter, fine matter, and clay/silt by sodium hexametaphosphate method.
•Samples were sent to Morton Arboretum Soil Lab for percent organic matter determination by loss-on-ignition done in a muffle furnace at 360°C for 6 hours.
•MASS soil lab damaged the samples, making results inconclusive.
(Scharenbroch 2008)

Results

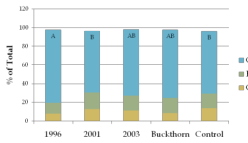

Figure 1. Mean percent fractions of clay/silt, fPOM, and cPOM in soil from each of the five sites in McDonald Woods.

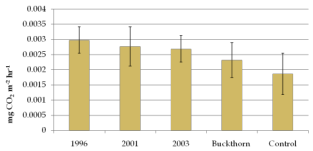

Figure 2. Mean carbon flux (mg CO_2 m^{-2} hr^{-1}) from soil in each of the five sites in McDonald Woods. Site differences: $p < 0.0001$, effects of sampling date: $p = 0.0099$, site x date interaction: $p = 0.9695$. Error bars are ± 1 S.D.

Results (continued)

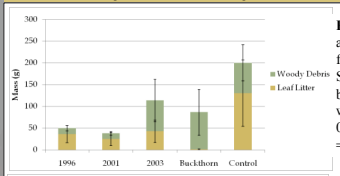

Figure 3. Mean mass of leaf litter and woody debris in each of the five sites in McDonald Woods. Sites differed in their leaf litter biomass ($p < 0.0001$), coarse woody debris biomass ($p = 0.0035$), and total litter biomass ($p = 0.0006$). Error bars are ± 1 S.D.

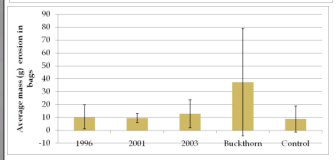

Figure 4. Mean soil mass loss through erosion following rainfall events in each of the five sites in McDonald woods. Erosion appeared to weakly differ by site: $p = 0.10$. Error bars are ± 1 S.D.

Conclusions

- The high proportion of clay and silt in the soil suggests high recalcitrance in McDonald woods soil. Previous research done by Heneghan et al. showing high levels of carbon in the soils under buckthorn in McDonald woods supports this, although POM analysis would have shown whether or not there are differences among the sites in woods.
- The absence of leaf litter in the buckthorn area suggests that the leaf carbon is going somewhere. Erosion, earthworms, and CO_2 flux could explain this phenomenon.
- However, CO_2 flux does not show this trend. Why?
- CO_2 flux could be affected by the time of year. Buckthorn leaves are known to rapidly decompose soon after the leaves drop in late November, only taking 2-3 weeks to break down. This would cause an increase in the CO_2 being released in the buckthorn area.
- Erosion traps suggest a weak trend that the buckthorn infested area loses more matter in rain events than other areas of the woods that have been restored or never invaded. The weather this summer only allowed for one set of erosion data to be collected, if more had been collected, the data may have been stronger.
- Restoration practices appear to have a positive effect on the carbon stores in the woods, as supported by the increased biodiversity of trees and herbaceous plants, higher amounts of leaf litter, and smaller amounts of erosion.

References and Acknowledgments

Special thank you to: Alan Lane, College First Student, Chicago Botanic Garden; Chicago Botanic Garden Plant Science Department; and NSF-REU grant 0648972 for support.

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