The impact of soil amendments on soil nutrients, reinvasion, and native plant community: a restoration study

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Abstract:

Invasive species have long been a menace to restoration efforts, making it exceptionally difficult for surrounding natives to thrive . Rhamnus cathartica (Common Buckthorn) is one such invasive, which Heneghan et al. (2006) have shown as having rapid leaf litter decomposition, high soil Nitrogen levels, and an expansive and shallow root system. A novel restoration method uses soil Carbon addition , allowing for an increase in soil microbial biomass and activity, consequently lowering soil Nitrogen availability, via increased microbial uptake (Perry et al. 2010). Using Buckthorn's traits as the means to control it, a reduction of native species can perhaps be hindered. More specifically, lowering Nitrogen availability may decrease the amount of reinvasion, ultimately favoring native species (Perry et al. 2010). Our study demonstrates that while soil amendments may have little effect chemically, the physical disturbance of the soil leads to variable, but generally reduced reinvasion in plots treated with Buckthorn mulch. Additionally, soil amendments appeared to have little effect on overall species richness and native species richness; however, a trend toward dominance by native species and a lack of herbaceous invasives was seen in amended soil.

Introduction:

As an invasive species, Buckthorn was originally introduced in the 1880s as an ornamental shrub (Heneghan et al. 2006). However, Buckthorn quickly became a significant problem as a threat to surrounding native communities, because of its following properties (Heneghan et al. 2006):

- Rapid leaf litter decomposition
- High soil Nitrogen levels, as well as elevated pH and water content
- An expansive and shallow root system
- An associated high number of invasive Eurasian earthworms
- High fecundity in dense thickets

Such characteristics of Buckthorn allow it to be a successful invader, consequently contributing to its "legacy effect," of facilitating other invasive species to come into the community, eventually overtaking native plants. By combining this ecological knowledge with current restoration practices, we foresee more effective – and promising – restoration results.

Objectives:

For this experiment, we sought to:
- reduce available soil Nitrogen through Carbon addition
- reduce the amount of Buckthorn reinvasion
- and lastly, increase the number of native species

Hypotheses:

- Soils that undergo mulch treatments will have lower nitrogen content than those that do not.
- Buckthorn reinvasion will be limited by reduced nitrogen availability and soil disturbance.
- Inhibition of Buckthorn's legacy effect will allow the number of native plant species to increase in amended soils.

Methods:

Research Site Description

Vegetation surveys and soil samples were collected at Whippoorwill Farm, a 9 acre site located 25 miles north of Chicago.
- Previous horse pasture, 1930s-1980s
  - Dense Buckthorn thicket by 2007
- Restoration method
  - Buckthorn cut and herbicided
  - Commercial mulch or Buckthorn mulch rototilled into the soil – Summer 2007
  - Native seeds spread – Fall 2007

Methods cont.

- 4 treatments, each with 5 replicated 52m^2 hexagonal plots
  - Buckthorn
  - No Mulch
  - Buckthorn Mulch
  - Commercial Mulch
  - A native seed mixture provided by Prairie Moon Nursery of MN, was seeded on all treatments, except Buckthorn

Soil Nutrients

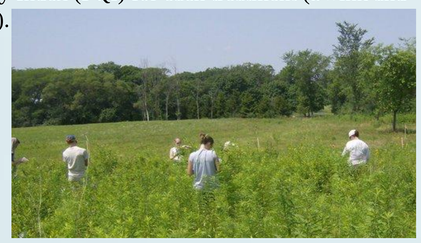
- Nitrate, ammonium, phosphate analysis
  - KCl extracted soils
  - Epoch microplate reader used to read samples, following the Allison Lab Protocol

Reinvasion

- Reinvasion counted using two sets of 0.25m^2 quadrants per plot, for a total of 10 replicates per treatment
- Seedlings, saplings, and resprouts were considered to be evidence of Buckthorn reinvasion

Native Plant Community

- Plants identified and classified for cover, using Braun-Blanquet Ordinal Cover Estimate system (Mueller-Dombois and Ellenbert, 1974)
- Plant community composition calculated by assigning plants to several categories:
  - Woody Invasive
  - Herbaceous Invasive
  - Introduced
  - Aggressive Native
  - Native
- Dominant categories consisted of species that received a cover class of 4 or greater (25% or greater)
- Calculated the mean coefficient of conservation (C) and Floristic Quality Index (FQI) for each treatment (Swink and Wilhelm, 1994).



Results

Soil Nutrients

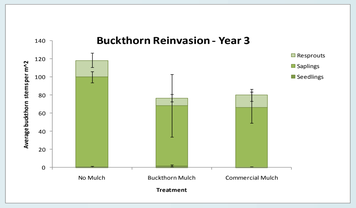
- No significant difference between treatments for PO_4, NH_4, or NO_3

Treatment	PO_4	NH_4	NO_3
Buckthorn	0.5277	1.2644	0.0294
No Mulch	0.5198	1.1663	0.0322
Buckthorn Mulch	0.5794	1.2403	0.0328
Commercial Mulch	0.6265	1.2469	0.0352

Table 1: Average Soil Nutrient Values by Treatment (mg/g dry soil)

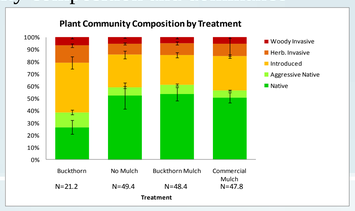
Reinvasion

- Possible trend toward reduced reinvasion seen in both mulch treatments, but high variability, particularly in the Buckthorn mulch treatment (ranging from 0-194 saplings/m^2) - statistically insignificant.

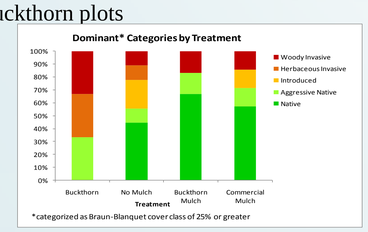


Native Plant Community

Plant community composition and dominance

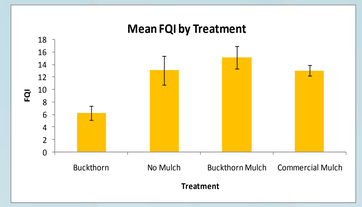


- Higher native species richness and overall species richness in all but the Buckthorn plots



- Buckthorn plots were dominated by Aggressive Native, Woody Invasive, and Herbaceous Invasive
- The No Mulch treatment was less dominated by Aggressive Native, Woody Invasive, and Herbaceous Invasive species
- The two mulch treatments were largely dominated by Native species, and had no domination by Herbaceous Invasives

FQI by treatment



Conclusions/Discussion

Soil Nutrients
- Little significance between treatments for all nutrients analyzed.

Reinvasion
- Trend toward reduced reinvasion for plots receiving Buckthorn mulch treatment.
- Soil amendment itself may have no chemical impact, but it may be the physical disturbance that has an effect on reduced Buckthorn reinvasion.

Native Plant Community
- Plant community composition is similar for the No Mulch and the two mulch treatments.
- Community dominance is quite different for the mulch treatments, which were largely dominated by native species, and had no domination by Herbaceous Invasives
- Mean FQI <20, appropriate for early stages of restoration.

Future studies
- Different amounts, sources, and frequency of Carbon addition
- Chemical disturbance versus physical disturbance

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