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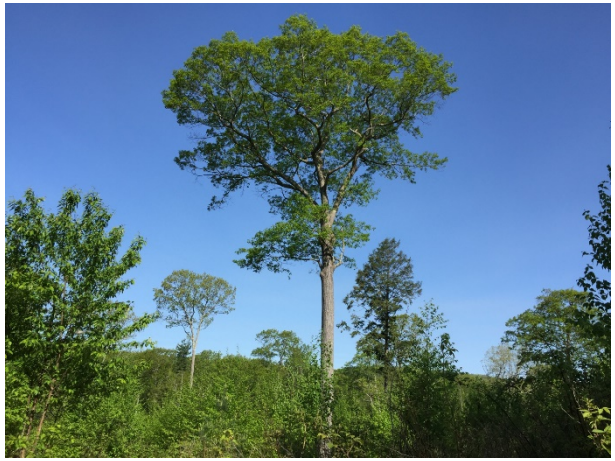
Impacts of forest management on carbon and nitrogen cycling: implications for understory plant invasions

Research Highlights

- Plant invasions are often associated with forest disturbance.
- Invasive plants and disturbance can both change soil conditions, making it difficult to determine whether invasive plants are passengers or drivers of changing soil nutrient availability (MacDougall and Turkington 2005).
- This study is the first step in a series of projects designed to disentangle the impacts of forest disturbance and invasive plants on soil nutrient availability.
- We found that logging strongly influences soil conditions, and the majority of these changes were sustained over long periods of time (25 years).
- Logging had the strongest effect on net potential nitrification, which is an indicator of soil nitrogen availability. However, nitrification was also highly variable. Increased soil nitrogen availability has been hypothesized to promote plant invasions (Tyler et al. 2007, Lee et al. 2012), and the high heterogeneity of recently disturbed forests suggests that some microsites may be more susceptible to invasion than others.

Management Implications

- Forest disturbance can alter environmental conditions that promote plant invasions. Therefore, careful monitoring for invasive plants following forest disturbance could prevent large-scale invasions that require costly eradication measures.
- Because altered soil conditions persist long-term (25 years) following timber harvest, lengthy follow-up may be required.
- However, it may be possible to pinpoint smaller areas that have the highest risk of plant invasions following disturbance.



A young, regenerating shelterwood harvested in 2014

One of 48 unmanaged reference plots that will serve as a point of comparison for the shelterwood chronosequence

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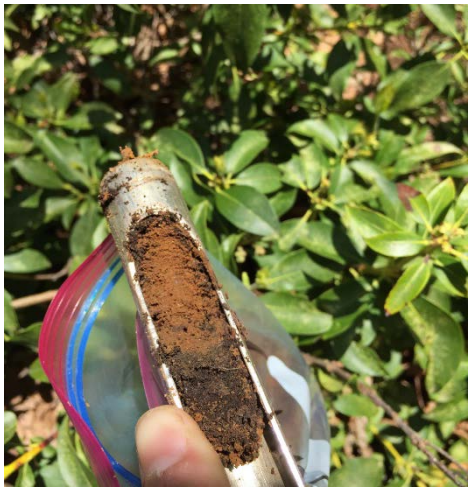
Research Summary

Local forest disturbances can be key drivers of plant invasions (Moles et al. 2012; Lockwood et al. 2013). Such disturbances include land use conversion and fragmentation, treefall gaps, and management, such as logging. One theory linking plant invasions and disturbance is the fluctuating resource hypothesis, which posits that increases in resource availability, such as the release of nutrients from community control following disturbance, can predict the invasibility of a site (Davis et al. 2000). There is a long history of research on the impacts of forest disturbance on soil nutrient stocks and fluxes (Mroz et al. 1985, Knoepp and Swank 1997). There has also been a surge of interest in the direct effects that invasive plants have on soil nutrient availability through their leaf litter and root inputs, which can create positive feedbacks that promote their dominance (Ehrenfeld 2003, Liao et al. 2008, Suseela et al. 2016). These complex relationships between forest disturbance, invasive plants, and soil nutrient cycling call into question the causality of observed patterns between plant invasions and altered soil conditions. Specifically, invasive plants can be drivers of altered nutrient cycling, passengers of conditions created by prior site disturbances, or a combination of both (MacDougall and Turkington 2005, Bauer 2014).



10-cm deep soil sample from a forest plots. Orange coloration indicates the presence of the iron sulfides.

During the summer of 2019, I conducted a large, observational study that focused specifically on one facet of the relationship between forest disturbance, plant invasions, and soil conditions: nutrient cycling as a function of forest disturbance. This initial study investigates the long-term impacts of logging on carbon (C) and nitrogen (N) availability and how these changes vary across the landscape. The study system for this project is a chronosequence of irregular shelterwoods—a type of harvest used to promote oak regeneration—harvested between 3 and 25 years ago. This study also includes undisturbed reference sites and pre-logging data from stands scheduled to be harvested in the upcoming months.

Fieldwork at Yale-Myers Forest

Further Resources

Bauer JT (2012) Invasive species: “back-seat drivers” of ecosystem change? Biol Invasions 14:1295–1304.

Davis MA, Grime JP, Thompson K (2000) Fluctuating resources in plant communities: a general theory of invasibility. J Ecol 88:528-534

Ehrenfeld JG (2003) Effects of exotic plant invasions on soil nutrient cycling processes. Ecosystems 6:503-523.

Knoepp JD, Swank WT (1997) Forest management effects on surface soil carbon and nitrogen. Soil Sci Soc Am J 61:928-935.

Lee MR, Flory SL, Phillips RP (2012) Positive feedbacks to growth of an invasive grass through alteration of nitrogen cycling. Oecologia 170:457-465.

Lockwood JL, Hoopes MF, Marchetti MP (2013) Invasion ecology, 2nd edn. Wiley-Blackwell, Chichester.

Liao C, Peng R, Luo Y, et al (2008) Altered ecosystem carbon and nitrogen cycles by plant invasion: a meta-analysis. New Phytol 177:706-714

MacDougall AS, Turkington R (2005) Are invasive species the drivers or passengers of change in degraded ecosystems? Ecology 86:42-55

Moles AT, Flores-Moreno H, Bonser SP, et al (2012) Invasions: the trail behind, the path ahead, and a test of a disturbing idea. J Ecol 100:116-127

Mroz G, Jurgensen MF, Frederick D (1985) Soil nutrient changes following whole tree harvesting on three northern hardwood sites Soil Sci Soc Am J 49: 1552-1557.

Suseela V, Alpert P, Nakatsu CH, et al (2016) Plant–soil interactions regulate the identity of soil carbon in invaded ecosystems: implication for legacy effects. Funct Ecol 30:1227-1238.

Tyler AC, Lambrinos JG, Grosholz ED (2007) Nitrogen inputs promote the spread of an invasive marsh grass. Ecol App 17:1886-1898.