Herbaceous Community Assembly in Soil Disturbances with Varying Microtopography

Keywords: forest change, microtopography, windthrow, dispersal, seed bank, diversity

Introduction: The herbaceous layer makes up 80% of the total plant species richness in a forest. Despite having low biomass, the herbaceous layer has disproportionately large effects on ecosystem functioning through nutrient cycling and litter deposition [1]. Herbaceous species are highly susceptible to species extinction, making it crucial to understand how communities respond to disturbance as anthropogenic disturbances increase worldwide.

Natural disturbances, such as treefall, maintain forest heterogeneity and promote herbaceous diversity. Herbaceous community response to natural disturbance can be predicted by the scale and severity of the disturbance as it affects the canopy, herbaceous layer, and/or soil [2, 3]. Microsites that result from these acute disturbances may be crucial to promoting herbaceous species [1]. Despite the importance of disturbance and microtopography in herbaceous community assembly, there has been little research on their individual and combined effects.

Treefall is a common small-scale canopy and soil disturbance which creates microtopography. When a tree falls, it creates a gap in the canopy and its uprooting exposes bare mineral soil. In this disturbance, pit and mound microtopography is created; the pit is a hole that the tree root mass and associated soil once occupied, whereas the mound consists of the tree roots and soil. There are microsite-specific differences in soil moisture and temperature in pits and mounds when compared to undisturbed soil – rare species established through dispersal are more common in these disturbances, and community assembly differs by microsite [4, 5].

Because light gaps and soil disturbance are tightly coupled with a treefall disturbance, it is difficult to determine the effects of each on the herbaceous community. Soil disturbance and its resulting microtopography may be more important in determining herbaceous community composition than light gaps [6]. I aim to determine the individual and combined effects of light gaps and soil disturbance microtopography on herbaceous community assembly.

Hypotheses: Soil disturbance will result in increased herbaceous species richness and abundance, but light gaps will not affect herbaceous species richness and abundance. I predict that the presence of microtopography in soil disturbances will increase species richness and increase the proportion of the herbaceous community made up of long-disturbance dispersers.

Research Objectives:

(1) Assess existing pit and mounds in study sites to parameterize experimental disturbances
(2) Examine individual and combined effects of soil and light disturbance on herbaceous species
(3) Determine the role of seed bank vs dispersal in community assembly disturbances

Objective 1: Assess existing pit and mounds to parameterize experimental soil disturbances

This study will take place in four old-growth stands of southeastern deciduous forest. I will assess all existing pit and mounds within two randomly located hectares in each forest stand. For each pit and mound, I will determine length, width, depth of pit, height of mound, and leaf area index (LAI) above the pit and mound.

Objective 2: Examine individual and combined disturbances

Using a 2x3 factorial block design, I will examine the effect of two levels of light (closed canopy, open canopy) and three levels of soil disturbance (no disturbance, disturbance with microtopography, and disturbance with no microtopography) on herbaceous species richness and abundance. There will be 6 experimental plots in each forest stand, and each plot will be a replicate for all soil conditions. Light conditions will be randomly assigned.

Canopy manipulation. Light levels will be manipulated in plots by girdling all canopy trees whose canopy covers a plot, so that light is roughly consistent across replicates.

Soil manipulations. Using the parameterized pit and mound dimensions, I will create experimental soil disturbances. The first 5 cm of topsoil will be gathered to preserve the seed bank, and mineral soil underneath will be removed and thoroughly mixed to the parameterized depth. All living plants will be removed to prevent survival or vegetative recolonization. To create microtopography, I will pour the soil into a pit and mound shape of average specifications, then redistribute topsoil. For no microtopography, soil will lay flat after mixing.

Community assessment. Each summer for three years following disturbance, I will survey the herbaceous community in each plot using permanently placed quadrats. There will be two quadrats located in each soil condition (no soil disturbance, soil disturbance with no microtopography, soil disturbance with microtopography), and pits and mounds will be evenly represented. In each quadrat, all herbs will be identified down to species and counted.

Light assessment. To determine light level variation and its effects, I will take hemispherical photographs above each quadrat as a proxy for leaf area index (LAI).

Data analysis. I will use a mixed effects ANOVA to determine the effects of disturbance on species richness and abundance.

Objective 3: Community assembly and diversity in disturbance

In order to determine species presence in buried seed, I will remove a small portion of the topsoil from each quadrat and incubate it in a greenhouse under summer sampling conditions. I will then compare the herbaceous species present as buried seed to the species present in each condition to determine the proportion of the herbaceous community represented by long-distance dispersal.

Broader Impacts: This research will determine the effects of light, soil disturbance, and microtopography on herbaceous community richness and abundance. Understanding herbaceous community response to disturbance is an important research objective, because soil and light disturbance may become more common in forest ecosystems due to climate change [7]. Storm frequency and intensity may increase as a result of climate change, and soil-disturbing animals may experience range shifts, such as armadillos invading forest ecosystems. Furthermore, it is crucial to understand the importance of soil disturbance and microtopography in increasing the abundance of rare herbaceous species. Because trees in old-growth forests are responsible for the creation of pit and mound habitat, it is crucial to preserve these reservoirs of biodiversity.

This project will represent a collaboration between Sewanee, the University of Pittsburgh, and the University of Georgia, so that expertise in investigating disturbance, herbaceous response, and plant identification and incubation is brought together. Because the study will take place in the vicinity of Sewanee, the University will provide undergraduate research assistants which I will train in experimental design, plant identification, and plant care. This work will be presented at conferences and published to allow for the sharing of this research and its conservation implications.

References: [1] Gilliam, F. S. (2007). *Bioscience*, *57*, 845-858. [2] Roberts, M. R. (2004). *82*, 1273-1283. [3] Roberts, M. R., & Gilliam, F. S. (2003). *Oxford University Press, Oxford*, 302-320. [4] Peterson, C. J., Carson, W. P., McCarthy, B. C., & Pickett, S. T. A. (1990). *Oikos*, 39-46. [5] Peterson, C. J., & Campbell, J. E. (1993).*Bulletin of the Torrey Botanical Club*, 451-460. [6] Royo, A. A., Collins, R., Adams, M. B., Kirschbaum, C., & Carson, W. P. (2010). *Ecology*, *91*, 93-105. [7] Dale, V. H. *et al.* (2001). *BioScience*, *51*, 723-734.