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The Relationship between Moss Growth and Treefall Gaps in an Eastern Deciduous Forest

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Abstract

Mosses are a rarely studied component of forest treefall gaps which ought to receive more attention so as to further understand their role in forest ecosystems. The aim of this study was to determine if a) there is a relationship between canopy gaps and moss growth on forest floors, and b) to determine if there is a difference between the effect of canopy gaps on the vertical depth and abundance of acrocarpous and pleurocarpous moss growth types. The study took place during the summer of 2015, in an eastern deciduous forest biome of the University of Notre Dame Environmental Research Center (UNDERC), located between upper Michigan and Wisconsin. Treefall gaps plots were paired with closed canopy plots along bog border habitats, and were analyzed for gap effect on moss bed depth and abundance.

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Introduction

Treefall gaps are key promoters of plant diversity in forest ecosystems. They commonly result from disturbances such as windstorms and create pockets of increased light availability on the forest floor, promoting the growth of shade intolerant plants and maintaining forest diversity (Schnitzer and Carson, 2001; Spies and Franklin, 1989; Brokaw, 1985; Brokaw, 1987; Abe et al. 1995). As such, they have been extensively studied with regards to vascular plants (Schnitzer and Carson, 2001; Spies and Franklin, 1989; Brokaw, 1987). However, there is a surprising lack of literature on canopy gaps and their interactions with non-vascular plants.

Mosses, which are categorized under the phylum, Bryophyta and the class, Musci, are a highly diverse non-vascular plant group characterized by their ability to absorb nutrients through the cell walls of their leaves and their lack of true roots (Schfield, 1985; Mauseth, 2009; Gornall et al., 2011). These plants are capable of growing in nearly every terrestrial ecosystem on the planet, and are generally considered to be pioneer species due to their ability to inhabit barren or newly regenerating locations (Watson, 1964).

The method that mosses use to obtain nutrients leaves them highly vulnerable to desiccation. Mosses are poikilohydric, meaning that they lack the ability to prevent water loss (Stuvier et al. 2014; Skre and Oechel, 1981). These plants combat desiccation by being able to shut down most chemical processes during dry spells, and rehydrate when re-exposed to water (Skre and Oechel, 1981). Additionally, mosses may be separated into two growth categories: pleurocarpous, or slow and sprawling growth, and acrocarpous, which are characterized by vertical branching and fast, pioneering growth (Muller, 2012). Like most vascular plants, however, moss growth is linked to light availability (Bergamini and Peintinger, 2002; Natalia et al, 2008; Sedia and Ehrenfeld, 2003) and forest floor disturbance (Mills and Macdonald, 2004).

While the role that mosses play in treefall gap regeneration is not widely researched, they are known to be important for forest ecosystem development. Groundcover mosses are thought to act as substrate stabilizers for future plant generations, and studies suggest that these organisms may also be capable of promotion or deterrence of vascular seed germination (Stuvier et al., 2014; Sedia and Ehrenfeld, 2003; Gornall, 2011). Shallow moss beds that fix nitrogen through a symbiotic relationship with cyanobacteria may promote seed germination (Stuvier et al., 2014), likely due to their ability to capture seeds and provide a stable environment for germination (Sedia and Ehrenfeld, 2003). Mosses that grow to a depth of 7cm or greater, however, have been found to deter vascular seed germination and survival, likely due to a decrease in light availability for newly germinated seeds (Stuvier et al., 2014). Thick, extensive moss beds may also result in cooler soils or prevent developing plant roots from reaching nutrients, thus impeding vascular plant generation (Schfield, 1985; Gornall, 2011; Sedia and Ehrenfeld, 2003).

Treefall gaps and moss growth patterns are important to study in tandem due to their implications for the success of new vascular plant growth. Therefore, the aim of this stud is to answer two questions a) do treefall gaps affect moss depth and abundance along forest floors, and b) is there a difference between the effect of canopy gaps on the depth and abundance of acrocarpous and pleurocarpous mosses? With these questions in mind, the hypothesis of this study is that treefall gaps will have deeper moss beds and higher moss abundance than their closed canopy counterparts, and that mosses will be deeper as they approach the center of gap plots where light availability and forest floor disturbances are the greatest. Additionally, both acrocarpous and pleurocarpous mosses are likely to have both greater depths and abundances in gap plots, as compared to closed canopy plots. However, treefall gaps should have a stronger positive effect on acrocarpous moss growth and abundance, as compared to pleurocarpous mosses, due to their more rapid growth rate.

Methods

This study took place during the summer of 2015 at the University of Notre Dame Environmental Research Center (UNDERC), located between northern Vilas County in northern Wisconsin and Gogebic County in upper Michigan. The property qualifies as eastern deciduous forest, and has remained uncut for approximately 100 years. Plots were located across Craig's Bog, Cranberry Bog, Tender Bog, and Ed's Bog.

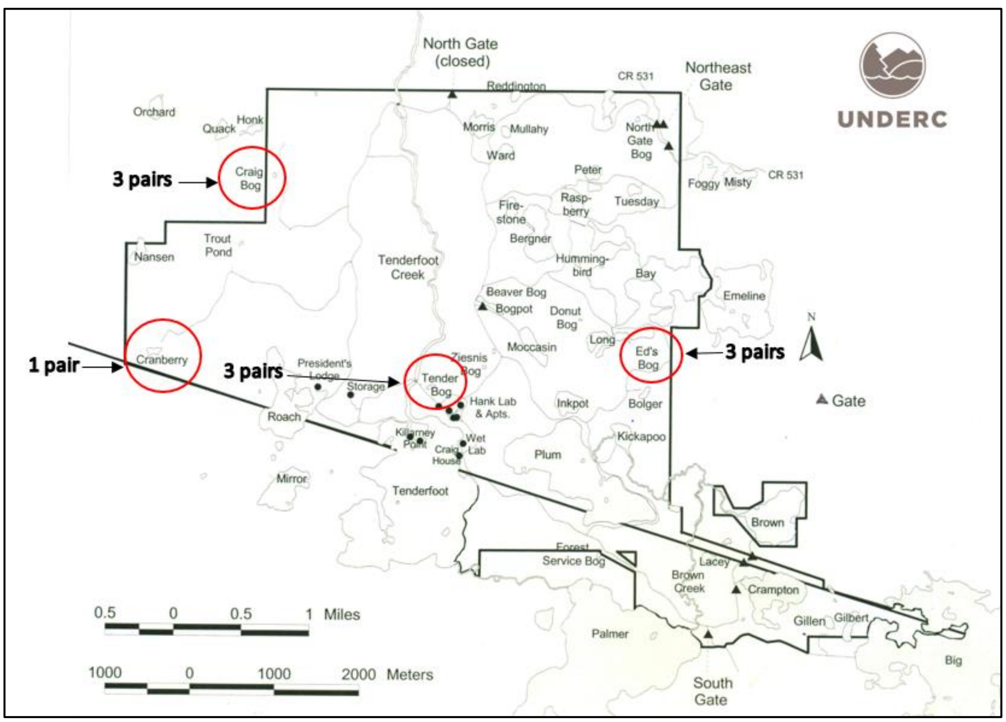

Figure 1. Map of the UNDERC property. Locations of study sites are outlined in red, with the number of treefall gap and closed canopy pairs indicated.

Treefall gaps were defined according to Runkle (1992) as “an area within the forest where the canopy (leaf height of tallest stems) is noticeably lower than in adjacent areas…due to the death of a large branch, a single tree, or a few trees.” Additionally, all gap plots bordered a bog habitat, included a mix of coniferous and deciduous trees (Natalia et al., 2008), and lacked vegetation above 2 m (Brokaw, 1982). Gap ages were estimated to be between 0 and 3 years, based on the criteria laid out by Runkle (1992).

Since no treefall gaps on the property had been previously documented, all gaps used in this study had to be found manually. This was done by walking a minimum of 10 m into the forest from the nearest road until a gap which fit the study’s parameters was found. A total of ten treefall gaps were used in this study, and these were each paired with a closed canopy control plot located within 10-20 m of the gap edge. Paired controls were required to have similar features as gaps with regards to tree species composition (deciduous or coniferous), groundcover, and moisture. All plots were purposefully located near neighboring bogs so as to maintain a high soil moisture to prevent moss desiccation. If a suitable control could not be found within a 10-20 m distance from the original gap, the site was discarded.

Gap sites were measured according to the “extended gap,” or the overhead gap and the distance between trunks of surrounding trees (Runkle, 1981). The circumference and two diameters for each gap plot were determined to calculate plot area (Runkle, 1981) and establish a similarly sized pair in nearby closed canopy. The differences between canopy densities of treefall gap and closed canopy plots were confirmed by densitometer readings taken from the center of each plot. Since most gaps in the area were relatively small, treefall gap plots were considered acceptable with less than or equal to 85% canopy density. Closed canopy plots were considered acceptable with greater than or equal to 90% canopy density.

A transect line was established down the center of each site, and all moss beds within 0.5 m of either side of the line were documented. Each transect began at the western edge of the plots and ended at the eastern edge to prevent bias in transect placement due to variability in moss bed frequency across plots. Moss beds were then located and measured for depth and distance from the western edge of the transect. For this study, abundance was defined as the total number of moss beds observed within each plot, and moss beds were defined as being located within a discrete and measurable area, and visually distinct from surrounding mosses. Moss depth was measured by placing a ruler at the base and center of each bed and recording its height in centimeters. Most moss beds were under 10 cm wide and long, but those that ran wider or longer along the transect were measured at 10 cm intervals under the same sample number. The average of these larger beds was used for analysis. Finally, each moss bed was recorded as acrocarpous or pleurocarpous. Occasionally, acrocarpous and pleurocaarpous mosses grew together in the same moss bed. These samples were labeled as “both.” Photographs of each sampled moss bed were taken to ensure that moss beds were correctly categorized.

Analysis

Comparisons between treefall gap and closed canopy plot types were analyzed with paired t-tests. These were run for greatest total average moss bed depth and abundance, pleurocarpous average depth and abundance, and acrocarpous average depth and abundance. Samples containing both pleurocarpus and acrocarpous mosses were not used for paired t-tests focusing on growth types, as the potential differences between depths could skew results. Additionally, paired t-tests were used to compare data from the first edge meter to data in the center meter of each treefall gap plot to determine if moss bed depth or abundance varied spatially along transects.

Results

Moss Depth and Abundance According to Plot Type

While the average depth of moss beds within treefall gap sites was slightly higher than that of closed canopy sites, the difference between depths was not enough to be statistically significant ($p = 0.508$). Abundance data, however, shows significantly greater average numbers of moss beds within treefall gap sights as compared to closed canopy sites ($p = 0.028$). A paired t-test of treefall gap plots was also carried out to compare average moss depths from the first meter along the western plot edges to average moss depths within the middle meter of plots. This test found no statistically significant spatial difference of moss depths ($p = 0.953$).

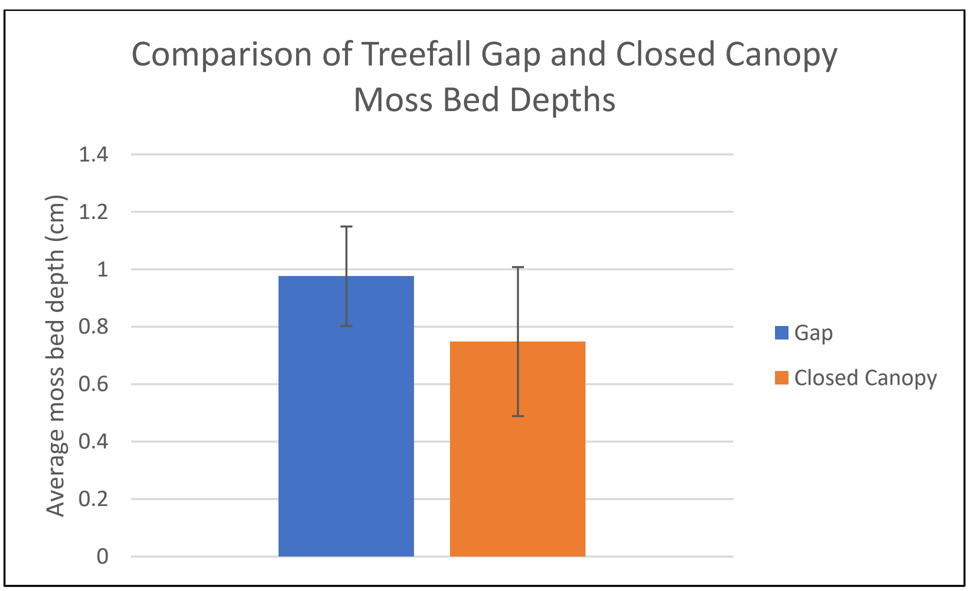

Figure 2. Paired T-test comparison of average moss depths in gap and closed canopy plots ($p = 0.508$). Standard error included.

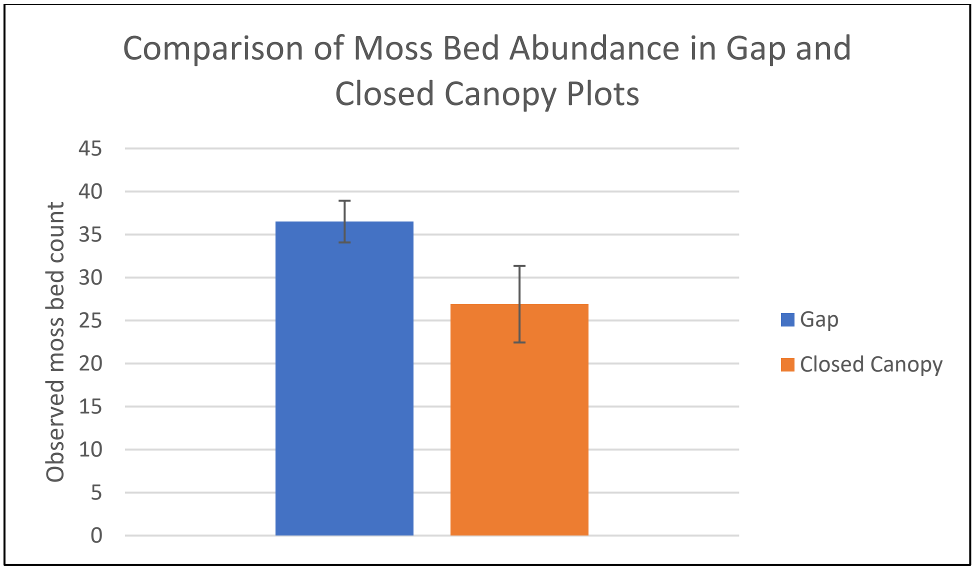

Figure 3. Paired T-test comparison of average moss abundance in gap and closed canopy plots (p = 0.028). Standard error included.

Pleurocarpous Moss

Pleurocarpous mosses were, by far, the most common growth type found in both treefall gap and closed canopy sites. Depth and abundance results for this growth type appeared, on average to be slightly greater in treefall gap sites in comparison to closed canopy controls. However, paired t-tests for both depth (p = 0.145) and abundance (p = 0.422) indicate that these trends are not significant.

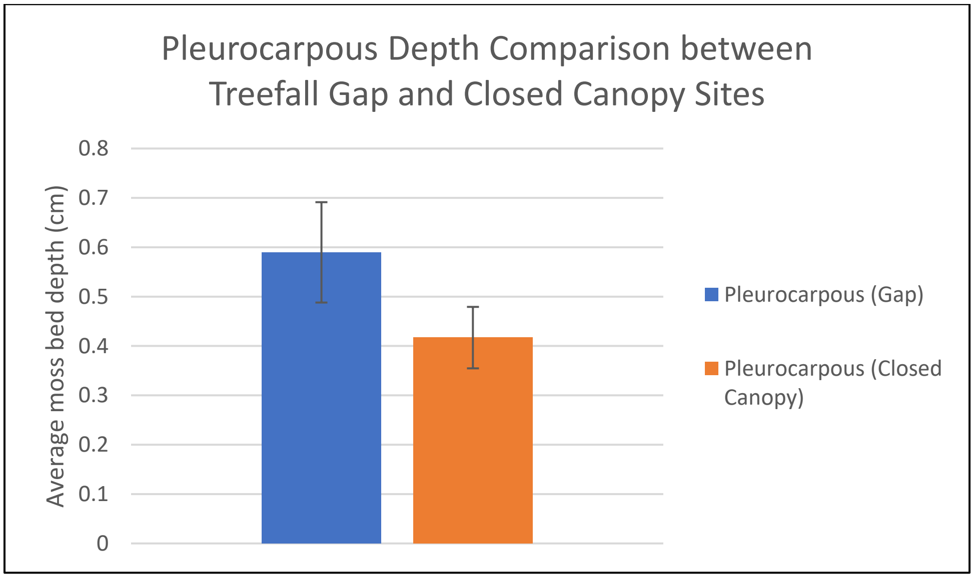

Figure 4. Paired T-test comparison of average moss depths in gap and closed canopy plots (p = 0.145). Standard error included.

Acrocarpous Moss

As with pleurocarpous mosses, acrocarpous mosses trended towards higher abundance in treefall gap sites. However, data for both depth ($p = 0.437$) and abundance ($p = 0.143$) proved to sparse to provide significant results.

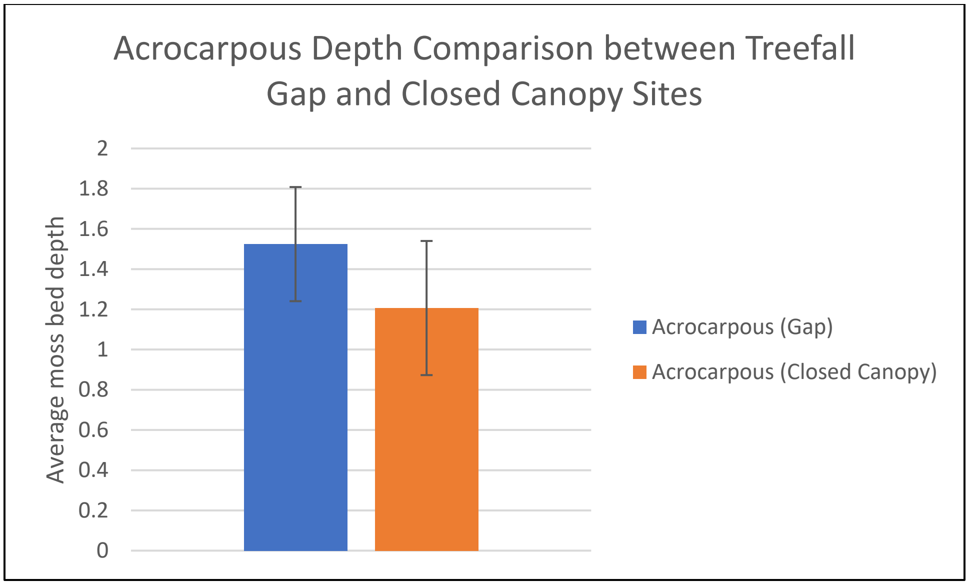

Figure 5. Paired T-test comparison of average moss depths in gap and closed canopy plots ($p = 0.437$). Standard error included.

While it was not the goal of this study to identify all moss samples, the species *Polytrichum commune* and *Helodium blandowii,* were noted as commonly occurring. *Polytrichum* was observed in 7 out of the 10 treefall gap plots and 2 out of the 10 closed canopy plots, while *Helodium* was observed in 7 out of ten treefall gap plots and 7 out of 10 closed canopy plots. Mosses were identified with the aid of *The Mosses of Michigan* (Darlington, 1964), and cross checked with the Montana state plant online field guide (Common Hair Cap Moss – Polytrichum commune; Helodium blandowii – Helodium blandowii).

Helodium blandowii, a pleurocarpous moss sample from Craig's Bog, second gap plot.

Polytrichum commune, an acrocarpous moss sample from Craig's Bog, second gap plot.

Discussion

Previous research suggests that the increased light availability and ground disturbance resulting from treefall gaps is expected to have a positive effect moss depth (Mills and Macdonald, 2004; Schnitzer and Carson, 2001; Spies and Franklin, 1989). While this current study notes an apparent trend of moss depth being positively affected by treefall gaps, the current data does not provide significant support of a link between depth and gap presence. In contrast to moss depth, treefall gaps do appear to impact moss bed abundance (Fig. 3). Added light availability and forest floor disturbances appears not to promote vertical moss growth, but treefall gaps may encourage moss bed proliferation (Mills and Macdonald, 2004; Muller et al., 2012).

This suggestion, that treefall gaps result in heightened numbers of moss beds, is not supported by the results of the pleurocarpous and acrocarpous moss abundances. Gaps were found to have no significant effect on pleurocarpous moss abundance, although they were expected to positively affect the average abundance of acrocarpous moss growth types due to the growth rates of the two types of mosses. As pleurocarpous mosses tend to grow slowly, the gaps analyzed may have been too young, and may not have had sufficient time to provide a noticeable impact on moss immigration into the area. The contrasting expectation for acrocarpous moss abundance stemmed from the tendency of these mosses to grow relatively quickly in disturbed areas. (Muller et al., 2012) This study, however, found no significant differences between acrocarpous moss abundances in treefall gap and closed canopy plots. Again, this result may stem from lack of adequate time for treefall gaps to affect moss growth, or from the limited sample size of acrocarpous mosses, as pleurocarpous samples greatly outnumbered acrocarpous samples in all plots.

All analyses display a slight, but not significant, trend towards increased moss depth and abundance in treefall gaps. Again, sampled gaps may have been too young or too few to have displayed a noticeable impact on moss presence. Future studies should therefore be completed with older or more plots so as to either clearly display a trend or show the trend to be nonexistent.

While replications of this study are recommended, these findings shed light on a little studied aspect of treefall gaps, and may provide a baseline understanding for future studies. Since moss depth does not appear to be promoted by treefall gaps, and since gaps are known to be locations of rapid vascular plant regeneration (Brokaw, 1987), it is probable that mosses in treefall gaps are more likely to aid vascular plant germination rather than deter it. However, one study that explored the effects of different moss species on *Pinus sylvestris* seedlings found that *Polytrichum commune*, an acrocarpous moss found in most of this study's plots, could result in low seedling biomass, possibly due to moss bed depth and a lack of N_2 fixation by the species (Stuvier et al., 2014).

Conclusion

This study found that treefall gaps have no effect on moss depth in terms of total averages or growth type averages. Moss growth types also show no significant differences in depth or abundance between treefall gap and closed canopy plots. Additionally, there appears to be no spatial difference in moss depths in treefall gap plots. However, this study did find that treefall gaps do appear to positively affect total average moss bed abundance.

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