The Relationship between Moss Growth and Treefall Gaps

BIOS 35502-01 Practicum in Field Biology

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Abstract:

Mosses are a rarely studied component of treefall gaps in forest ecosystems – and ought to receive more attention due to their potential to promote or deter vascular seedling germination and survival. The aim of this study, therefore, was to determine if there is a relationship between canopy gaps and moss growth along forest floors and to determine if there is a difference between the effect of canopy gaps on the depth and abundance of acrocarpous versus pleurocarpous mosses. The study took place in an eastern deciduous forest biome on the University of Notre Dame Environmental Research (UNDERC) property located between upper Michigan and Wisconsin. I paired treefall gap and closed canopy plots along bog border habitat and ran a single transect from east to west in all plots. I then recorded the number of moss beds, as well as bed depth(s), and moss type (acrocarpous/pleurocarpous) within a half meter of either side of the transects. Afterwards, I analyzed the data via regressions and paired t-tests, and found that while canopy gaps have no significant effect on moss depth, moss abundance was positively related to treefall gap presence.

Introduction:

Treefall gaps are key promoters of plant diversity in forest ecosystems. They are caused by disturbances such as windstorms and result in increased light availability on the forest floor which promotes the growth of shade intolerant plants and maintains 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 relationships to non-vascular plants such as mosses.

Mosses, one of three types of bryophytes, are a highly diverse group of non-vascular plants characterized by their ability to absorb nutrients through leaves and lack of true roots (Schfield 1985; Mauseth 2009; Gornall et al. 2011). This ability to absorb nutrients directly from the surrounding air also leaves mosses highly vulnerable to desiccation because they are poikilohydric: meaning that they lack the ability to prevent water loss (Stuvier et al. 2014; Skre and Oechel 1981). Additionally, mosses may be separated into two categories: pleurocarpous mosses, which tend to grow in a slow and sprawling manner, and acrocarpous mosses, 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 forest ecosystems is not widely researched, there are a number of studies suggesting that these organisms may be capable of both promoting and deterring 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 have been known to promote vascular seed germination (Stuvier et. al. 2014). This is likely due to the ability of shallow beds to capture seeds and provide a stable environment for germination (Sedia and Ehrenfeld 2003).

Mosses that grow to be 7 cm deep or greater, however, have been found to deter vascular seed germination and survival (Stuvier et al. 2014). The most likely reason for seed mortality in this case is a decrease in light availability for newly germinated seeds (Stuvier et. al. 2014). Cooler soils under extensive moss beds and an inability for developing roots to reach nutrient rich soils through thick mosses also impede vascular plant generation (Schfield 1985; Gornall 2011; Sedia and Ehrenfeld 2003).

The potential for light availability and forest floor disturbances in treefall gaps to affect moss growth is important to study because of its implications for the success of vascular plant germination. The aim of this study therefore sought 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, I hypothesized that treefall gaps would 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 treefall gap plots where light availability and forest floor disturbance are likely to be the greatest. I also hypothesized that acrocarpous and pleurocarpous mosses would both have greater depths and abundances in treefall gap plots than in closed canopy, but that treefall gaps will have a stronger effect on acrocarpous mosses than pleurocarpous mosses.

Methods:

Sampling:

I sampled a total of 20 sites within the University of Notre Dame Environmental Research Center (UNDERC) property, located between northern Wisconsin (Vilas County) and upper Michigan (Gogebic county). The property qualifies as eastern deciduous forest, and has remained uncut for approximately 100 years. Plots were located across Craig's Bog, Cranberry Bog, Tenderfoot Bog, and Ed's Bog. Ten of these plots were defined as treefall gaps while the other ten acted as their closed canopy "pairs" (located within 10-20m). The age of the treefall gap plots ranged from approximately 1-3 years. All plots bordered a bog habitat and included a mix of coniferous and deciduous trees. I did this in the hopes of having a large moss sample size in each plot (Natalia et al. 2008) so that statistical trends would be apparent. Additionally, gap plots lacked vegetation above 2m (Brokaw, 1982).

I measured the circumference of each gap plot, as well as 2 diameters so that I could later calculate the plot area (Runkle 1981) and recreate a similarly sized plot pair in nearby closed canopy. Sites were measured according to “extended gap,” or the overhead gap plus the distance to the trunks of the surrounding trees (Runkle 1981). I also recorded these to determine the plot center. The difference of canopy density between treefall gaps and closed canopy plots was visually apparent, and was affirmed by densitometer readings taken from the center of each plot. Treefall gap plots were only acceptable with less than or equal to 85% canopy density, and closed canopy plots were only acceptable with more than or equal to 90% canopy density.

I ran a transect down the center of each site and documented all mosses within a half meter of each side of the transect. All transects started at the western edge of the plots and ended at the eastern edge to control for the amount of light received by mosses across all plots. Each bed was measured for depth and the distance from the western edge of the transect. If a moss bed was longer than 10 cm along the transect, I recorded every 10 cm interval under the same sample number. Moss bed depth was measured by placing a ruler at the base of each bed and recording its height in centimeters. For large beds, I took depth measurements at 10 cm intervals along the transect. If the bed was very wide, but still fell within the transect, I took multiple depth measurements for a single distance measurement at 10 cm intervals. Finally, I recorded samples as either acrocarpous, pleurocarpous, or a mix of both.

Analysis:

To determine which plot type had greater average moss depths, I ran a paired t-test. To determine which plot type had the greater average moss abundance, I also ran a paired t-test. For this study, I defined abundance as the number of samples (moss beds) recorded within each plot transect. To test for whether moss depth in treefall gap plots increases with distance from the gap edge, I performed a simple linear regression. To test for whether moss depth in closed canopy plots increases with distance from gap edge, I performed another linear regression. Since these two regressions lacked site pairing and varied in size, I used the information from the first 50% of the area sampled in the plots to account for variations in plot size.

To determine which plot type had greater pleurocarpous moss depth, I ran a paired t-test. To determine which plot type had greater moss abundance, I ran an additional paired t-test. I also used a simple linear regression to analyze the potential relationship between pleurocaropus moss depth and distance from the plot edge. This regression for pleurocarpous mosses used plots from both gap and closed canopy sites, and since the total area sampled was the same (due to site pairing), I used data from 100% of the area sampled. To determine which plot had greater acrocarpous moss depth, I also ran a paired t-test. To determine which plot had greater acrocarpous moss abundance, I ran a final paired t-test. I used the total number of pleurocarpous or acrocarpous mosses within each plot (regardless of whether they were mixed) to run the abundance paired t-tests. For the depth paired t-tests, however, I did not include mixed data for the depth paired t-tests because I found acrocarpous mosses to be deeper on average than pleurocarpous mosses, so using mixed data could skew the results (Fig. 1). No regression was done for acrocarpous mosses because there were too few unmixed data-points to perform a final test.

Results:

Moss Depth and Abundance According to Plot Type:

There was no statistically significant difference between the average depths of mosses within treefall gap sites and closed canopy sites ($p = 0.546$; Fig. 2). Treefall gap sites, however, had significantly higher moss abundance than closed canopy sites ($p = 0.028$; Fig. 3).

As distance from the edge of the plot increased in treefall gap plots, there was no significant change in moss depth ($R^2 = 0.0106$, $p = 0.0627$; Fig. 4). As distance from the edge of the plot increased in closed canopy plots, there was no significant change in moss depth ($R^2 = 0.0058$, $p = 0.2638$; Fig. 5).

Pleurocarpous Moss:

There was higher average pleurocarpous moss depth in treefall gap plots, but the difference was not significant ($p = 0.115$; Fig. 6). There was also higher pleurocarpous moss abundance in treefall gap plots, but the difference was not significant either ($p = 0.088$; Fig. 7). As pleurocarpous distance from the edge of the plot increased, there was no significant change in pleurocarpous moss depth ($R^2 = 0.0083$ and $p = 0.066$; Fig. 8).

Acrocarpous Moss:

There was higher acrocarpous moss depth in treefall gap plots, but the difference was not significant ($p = 0.824$; Fig. 9). There was also greater acrocarpous moss abundance in treefall gaps, and this result was of statistical significance ($p < 0.0001$; Fig. 10).

Discussion:

The results of this study partially support the initial hypothesis because I found moss beds to be more abundant in treefall gap plots as opposed to closed canopy sites. Treefall gap presence, however, did not have a significant effect on moss depth, regardless of moss type (pleurocarpous/acrocarpous) or distance from the site edge.

While previous research suggests that increased light availability and ground disturbance – both of which result from treefall gaps – would be expected to have a positive effect on moss depth (Mills and Macdonald 2004; Schnitzer and Carson, 2001; Spies and Franklin 1989), this is clearly not the case. It is possible that the canopy gaps were not old enough to have a significant effect on vertical moss growth/depth. Additionally, it is possible that the loss of canopy cover decreases the surrounding humidity enough for mosses to feel the effects of desiccation and decrease their photosynthetic productivity, thus preventing mosses from effectively increasing their depth in treefall gaps (Skre and Oechel 1981; Hylander 2005).

As opposed to moss bed depth, I did find canopy gap presence to have a significant positive effect on the number of moss bed samples available in each transect. While the added light availability and lack of forest cover may be incapable of promoting vertical moss growth, increased forest floor disturbance from treefall gaps may increase moss bed proliferation and immigration into gap locations (Mills and Macdonald 2004; Muller et. al. 2012). As these results are based purely on the number of moss beds within each transect, however, it is too soon to say if moss bed area also increases with treefall gap presence.

This suggestion that treefall gaps result in increased numbers of moss beds is further supported by the results of pleurocarpous and acrocarpous moss abundance. I found that canopy gaps had no significant effect on pleurocarpous sample abundance, but they did have a significant positive effect on acrocarpous moss sample abundance. This may be related to the growth rates of the two types of mosses: pleurocarpous mosses have been found to be slow growing, and may not have been impacted by the formation of treefall gaps, while acrocarpous mosses tend to grow quickly in disturbed areas and may be considered “pioneer species” (Muller et. al. 2012).

While replications of this study are recommended, my findings are relevant because they shed light on a little studied aspect of treefall gaps, and may provide a baseline understanding for future studies. Since moss depth is not promoted by treefall gaps, and since gaps are known to be locations of rapid vascular plant regeneration (Brokaw 1987), it is likely that the inhibiting effects of mosses on vascular plant germination and growth are not at play in treefall gaps. However, one study that explored the effects of different moss species on *Pinus sylvestris* seedlings found that *Polytrichum commune*, an acrocarpous moss found in the majority of my plots, could have the effect of deterring vertical seedling growth (Stuvier et al. 2014). Therefore, it would be interesting to use this study as a stepping stone for future studies to determine what the role of increased moss presence in treefall gaps is with regard to initial vascular plant growth.

Conclusion:

This study found that treefall gaps have no effect on moss depth, but they did have a positive effect on moss bed abundance within treefall gap plots – specifically, there was a strong positive effect on the number of acrocarpous mosses found within treefall gap plots.

Tables/Graphs:

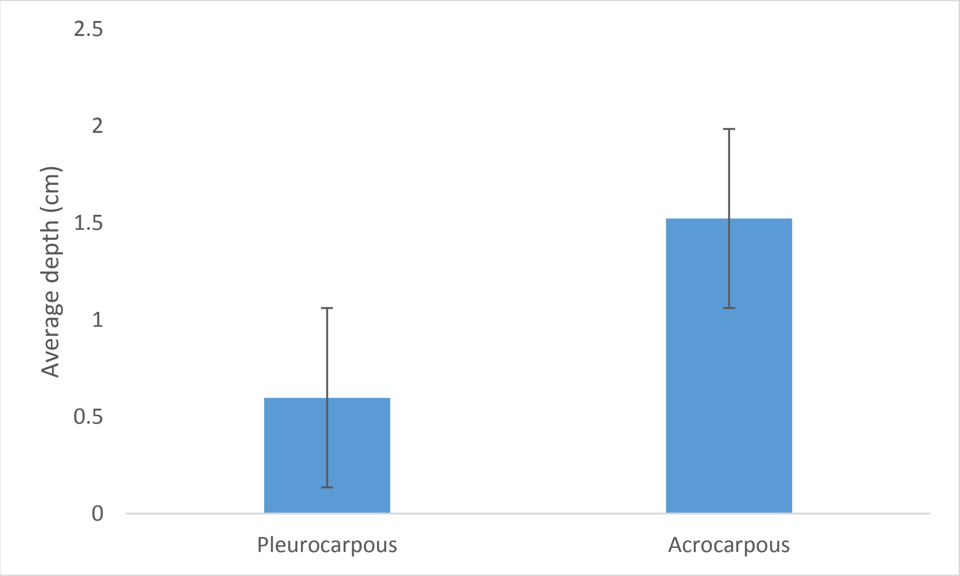

Figure 1. Average depth paired t-test of pleurocarpous mosses vs. acrocarpous mosses (df = 19.0, p = 0.008005). Error bars represent standard error.

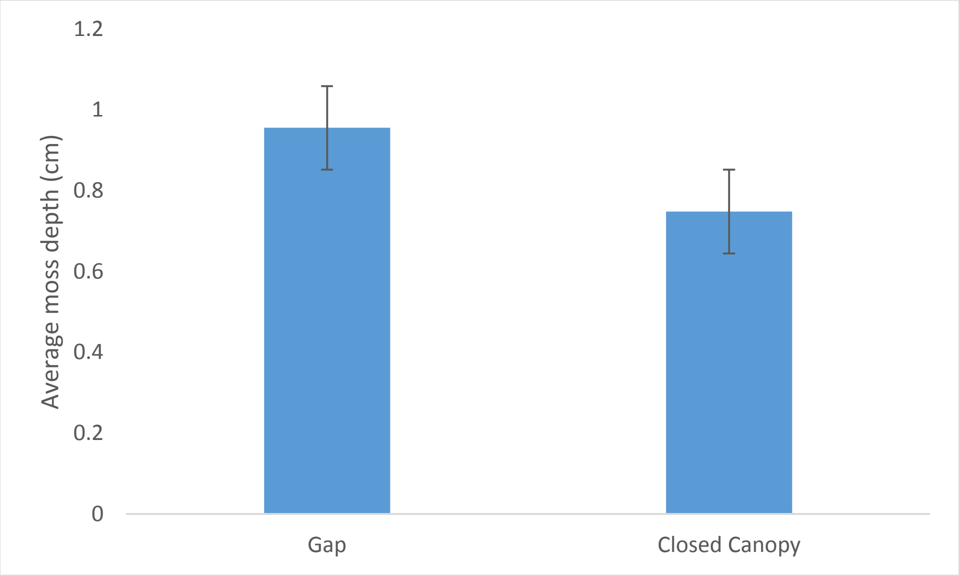

Figure 2. Average depth paired t-test of mosses in treefall gap vs. closed canopy plots (df = 9.0, p = 0.546). Error bars represent standard error.

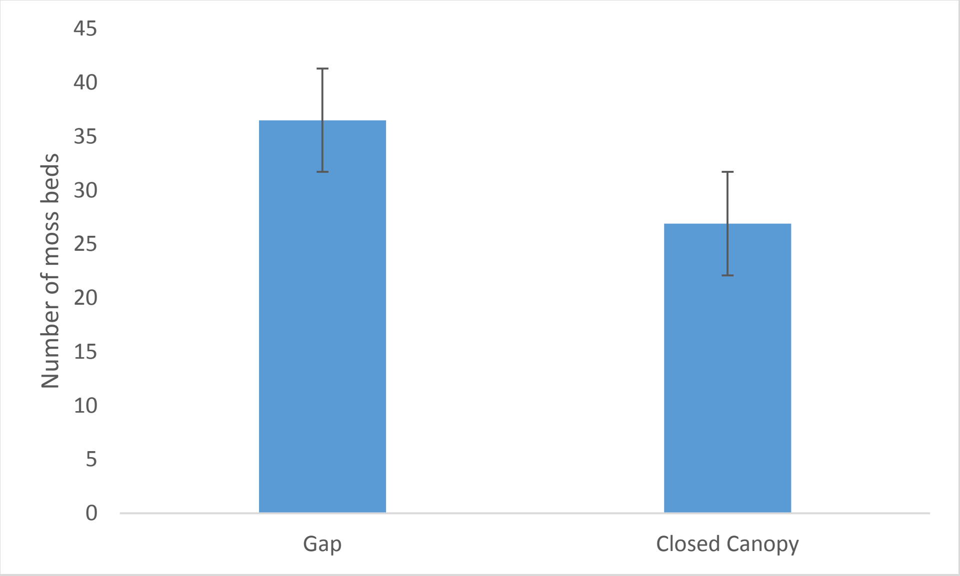

Figure 3. Abundance paired t-test of mosses in treefall gap vs. closed canopy plots (df = 9, p = 0.028). Error bars represent standard error.

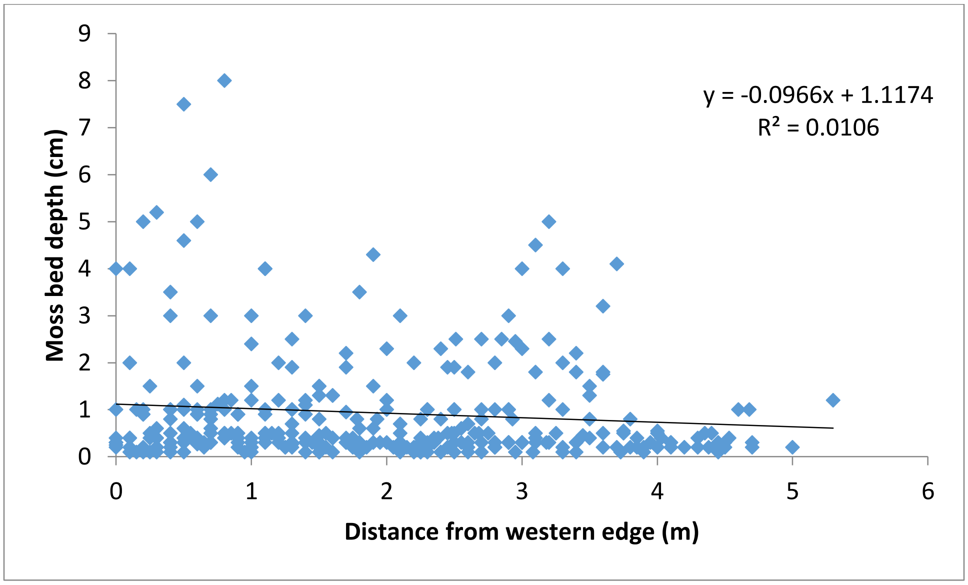

Figure 4. Treefall gap regression of bed depth vs. distance using 50% of the transect area. (df = 1, F = 3.4876, R^2 = 0.0106, p = 0.0627).

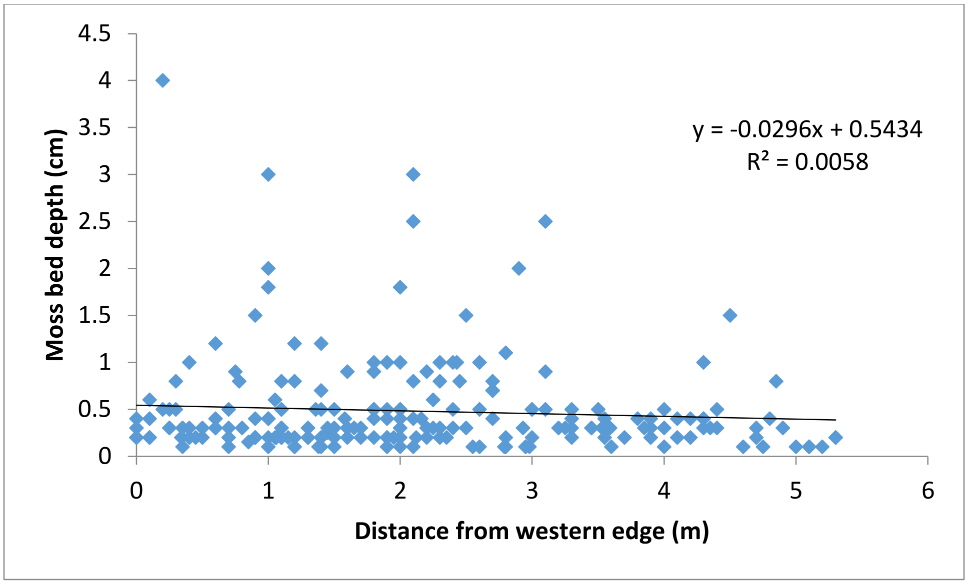

Figure 5. Closed canopy regression of bed depth vs. distance using 50% of the transect area. (df = 1, F = 1.2553, $R^2 = 0.0058$, p = 0.2638).

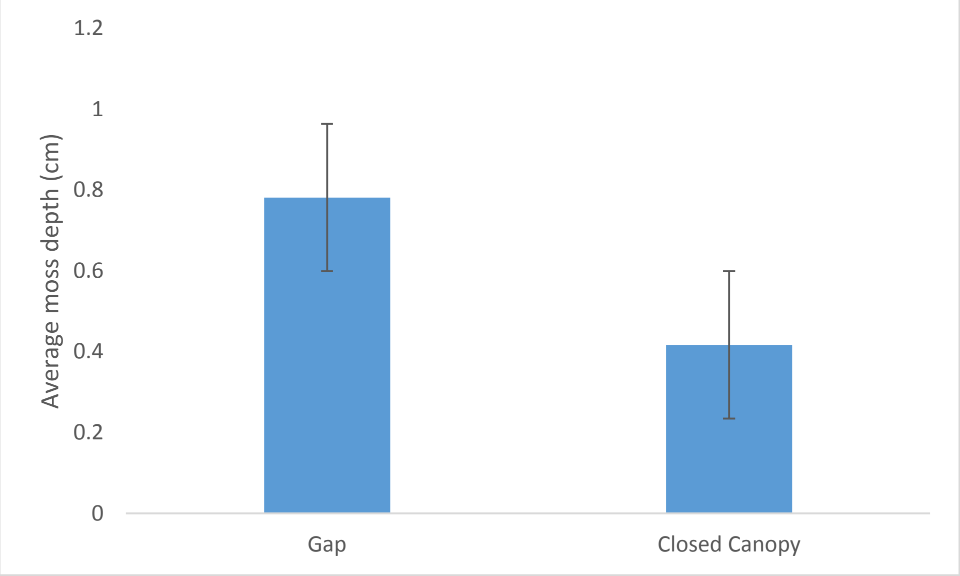

Figure 6. Average depth paired t-test of pleurocarpous mosses in treefall gap vs. closed canopy plots (df = 9, p = 0.115). Error bars represent standard error.

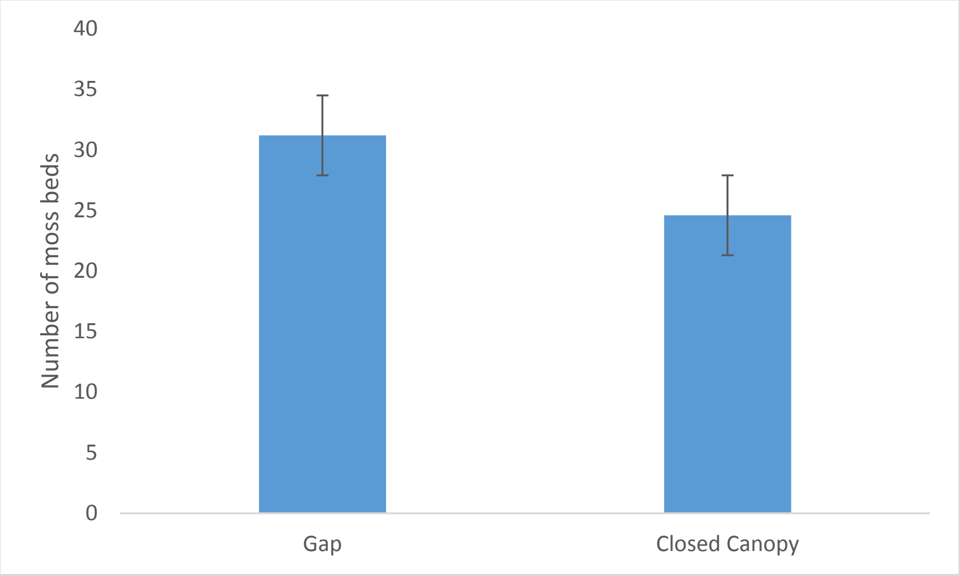

Figure 7. Abundance paired t-test of pleurocarpous mosses in treefall gap vs. closed canopy plots (df = 9, p = 0.088). Error bars represent standard error.

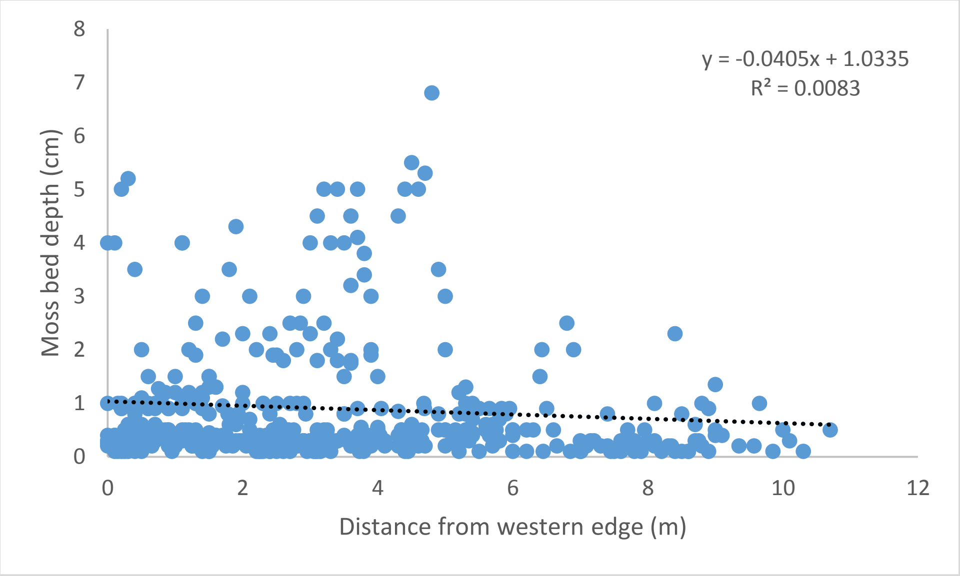

Figure 8. Pleurocarpous moss regeneration in gap sites (distance vs. depth) (df = 1, F = 3.3952, $R^2 = 0.0083$, p = 0.066).

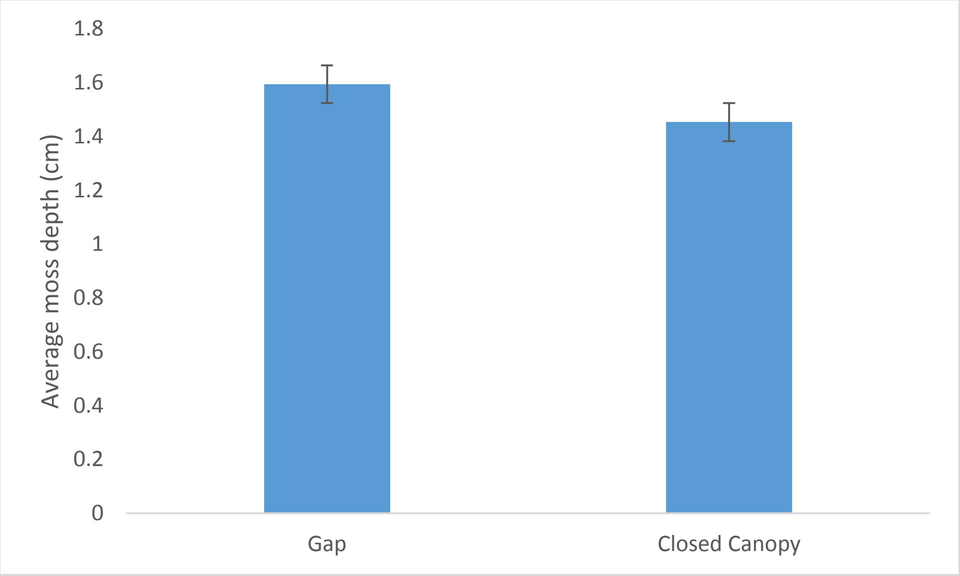

Figure 9. Average depth paired t-test of acrocarpous mosses in treefall gap vs. closed canopy plots (df = 9, p = 0.824). Error bars represent standard error.

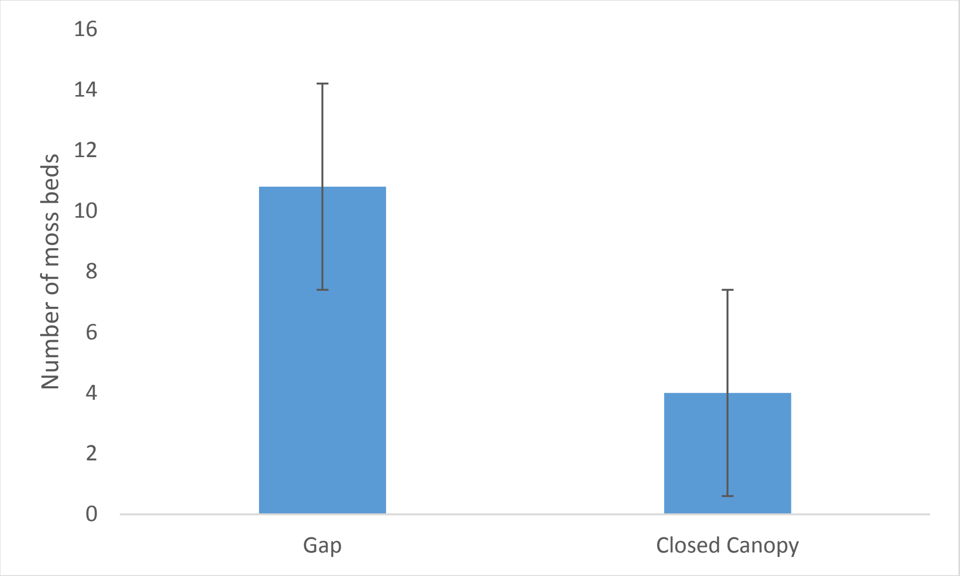

Figure 10. Abundance paired t-test of acrocarpous mosses in treefall gap vs. closed canopy plots (df = 9, p = 0.0000007). Error bars represent standard error.

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