Excellent work! 50/50

Title: The effect of human disturbance on wildflower density in the Great Smoky Mountain National Park

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Abstract

Human interference poses a serious threat to all levels of ecology. The impacts of this disruption can be seen in the disturbance of ecosystem functions, posing hazards to wildlife, and changes in community structure. We analyzed wildflower diversity, abundance, and co-occurrence by comparing data on plots contiguous to a hiking trail in The Smoky Mountains National Park and those removed from direct human contact. Our results show that wildflower diversity does not vary significantly at varying distances from the trail. This suggests that human impact is not important in structuring these herbaceous communities. Further studies, however, may look into the confounding factors of edge effects (i.e. decreasing light availability, decreasing temperature, etc) and human caused disturbance.

Introduction

The level of anthropogenic activity and its proximity to an ecosystem affects an ecosystem's biodiversity. This has been seen in both large systems, such as rain forests (Klein *et al.* 2006), and smaller systems such as meadows (Albrecht *et al.* 2007). While many studies focus on the effects of agricultural activity near natural habitats, human impact is not limited to these areas.

Hiking trails in the Great Smoky Mountains National Park cut through the natural habitat, causing open areas with increased levels of sunlight leading to changes in local microclimates (Chen *et al.* 1993). These open areas can also cause changes in the composition of plant species

that normally reside there. The increased light availability near a trail can create an environment that promotes an increased productivity of sun-tolerant plants (Smith *et al.* 2007). These sun-tolerant plants may subsequently out-compete shade-tolerant plants that originally inhabited the area, and thus change the species composition of the local community.

This study was done to test the effect of human activity on wildflower diversity. A gradient of human impact was based on proximity to a hiking trail with the habitat closest to the trail was considered to have the highest level of disturbance, while areas further away were least disturbed by humans. We hypothesize that evenness, richness, and diversity of herbaceous flowering plants will be lower in areas nearest the trails because human impact may create a more stressful environment where fewer species and individuals are able to thrive. Communities at different distances from the trail may also be very dissimilar because of different survival strategies being favored. Furthermore, we hypothesized that our co-occurrence analyses in EcoSim will suggest that competition may not be structuring the communities in the more disturbed plots. Here the wildflower community may be structured by the increase in stress rather than competition.

Methods

We measured wildflower community structure at Porter's Creek Trail in the Great Smoky Mountains National Park using 15 transects. Great! These transects were equally spaced across .8 miles of trail and the side of trail from which measured was chosen at random. However, it was impossible to accurately quantify the data in some areas due to geographical features, particularly steep slope or proximity to water. In such instances, the more accessible side of the trail was used. If neither side could be used, we moved to the next possible site. We also added

additional plots near the trailhead where we observed a higher abundance of wildflowers in order to obtain ~~attain~~ more data.

We collected data from three plots at each perpendicular transect: one plot immediately at the trail edge, and two further plots five and ten meters from the trail. Distances were determined using a tape measure. Plots were .58 m^2 in area and measured using a circular disk (i.e. hula hoop). In each of the 45 total plots, we identified wildflower species using a variety of field guides (Venning 1984, Niering and Olmstead 2001, White *et al.* 2003) and recorded which species were present and the amount. We also measured the elevation at each transect using a Garmin© Oregon 550t GPS system. All data was compiled into matrices for diversity and abundance by site.

Our data were analyzed in a variety of ways. We used a t-test in Microsoft Excel to determine whether species richness, Shannon's Diversity, and Shannon's Evenness in plots located adjacent to the trail (i.e. plots with the highest level of human impact) were significantly different from the plots located five and ten meters (i.e. plots with the lowest level of human impact) from the trail. Shannon's Diversity Index and Shannon's Evenness were calculated according to the methods in Weaver and Shannon (1949).

In addition to diversity analyses, we also used EcoSim to analyze co-occurrence within our plots. EcoSim co-occurrence module looks for non-random patterns for species co-occurrence using a presence-absence matrix. EcoSim compares observed data to the simulated data (5000 randomized iterations of the observed data), meaning that EcoSim is comparing the observed data to a null model. The C-score co-occurrence test is a measure of the strength of competition within the community. The observed c-score would need to be significantly larger than the expected c-score in order to suggest that competition played a role in structuring the

butterfly community. We used EcoSim's co-occurrence analysis to test our hypothesis that competition was not structuring wildflower communities closest to the trail due to a trade off between stress tolerance and competitive ability. In all of our statistical analyses we considered results to be significant when $p \leq 0.05$.

Results

We counted a total of 118 blooming wildflower individuals during the wildflower surveys along the Porter's Creek trail representing 10 different species. Those species included Yellow Trillium (*Trillium luteum*), Red Trillium (*Trillium erectum*), Hooked Buttercup, (*Ranunculus recurvatus*), Sweet White Violets (*Viola blanda*), Marsh Blue Violets (*Viola cucullata)*, Foamflower (*Tiarella cordifolia*), Toothwort (*Lathraea*), Blue Phlox (*Phlox divaricata*), Hispid Buttercup (*Ranunculus hispidus*), and a small white aster (species unknown). Each plot surveyed had an average of 7.62 flowering individuals representing an average of 0.52 species (Figures 1 and 2).

A t-test asking if species richness (S) differed between the plots adjacent to the trail and the plots located five meters from the trail was insignificant ($p=0.14$). A t-test asking if species richness differed between the plots adjacent to the trail and the plots located ten meters way from the trail was also insignificant ($p=0.50$).

A t-test asking if Shannon's Diversity (H') differed between plots located immediately adjacent to the trail differed from plots located five meters from the trail was insignificant ($p=0.62$). Another t-test asking Shannon's Diversity differed in plots located immediately adjacent to the trail differed from plots located ten meters away from the trail was also insignificant ($p=0.46$).

A t-test asking if Shannon's Evenness (J') differed between plots located immediately adjacent to the trail differed from plots located five meters from the trail was insignificant ($p=0.62$). Another t-test asking if Shannon's Evenness differed between plots located adjacent to the trail and plots located ten meters away from the trail was also insignificant ($p=0.46$). See Table 1 for a summary of the t-test results.

A co-occurrence analysis in EcoSim found that our observed c-scores (number of checkerboard units) at each distance (0m, 5m, and 10m) were not significantly higher than the simulated expected c-scores. See Table 2 for a summary of the EcoSim simulation.

Elevation data were not included in our analyses due to a malfunctioning GPS unit. (see Discussion section for additional justification).

Are these the p-values? ok

Distances Compared	Species Richness (S)	Shannon's Diversity (H')	Shannon's Evenness (J')
0 m and 5 m	0.14	0.62	0.62
0 m and 10 m	0.50	0.46	0.46

Table 1. Results of t-tests comparing Species Richness (S), Shannon's Diversity (H'), and Shannon's Evenness (J') at plots located 0, 5, and 10 meters from the Porter's Creek Trail. A p-value less than 0.05 was considered significant. The plots located adjacent to the trail at 0 m had the most human impact while plots located at 10 m had the least human impact.

Distance From the Trail:	0 m	5 m	10 m
Observed C-score	2.13333	0.50000	1.10000
Expected C-score	2.12491	0.50000	1.12676
p-value	0.79	1.00	0.87

Table 2. EcoSim analysis of co-occurrence analyses at 0, 5, and 10 meters from the trail. A p-value less than 0.05 is considered significant.

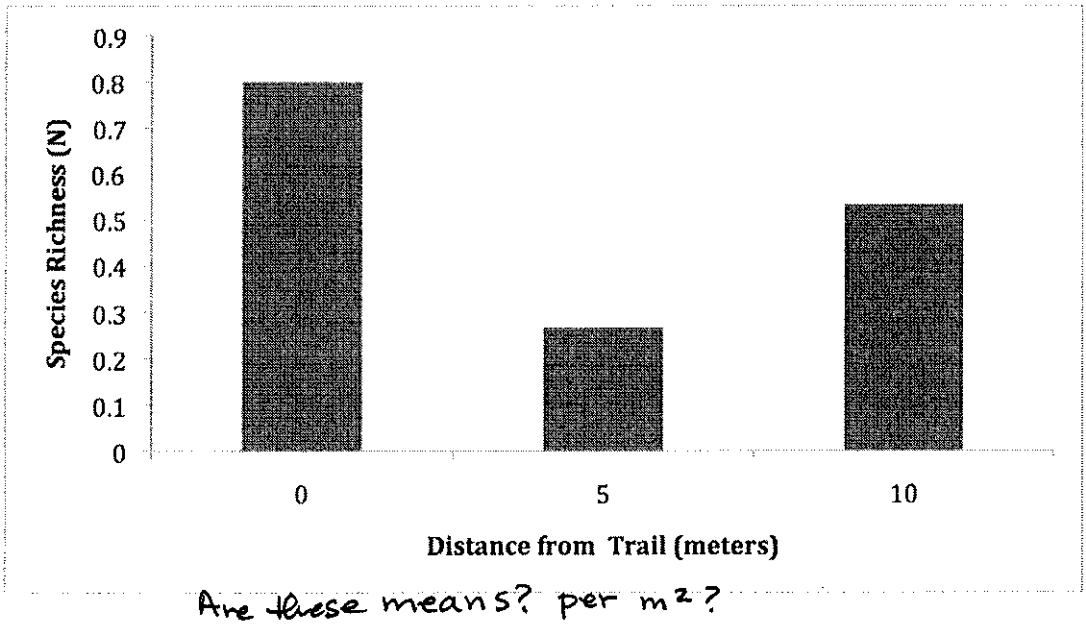

Figure 1. Species richness (N) vs. distance from the trail (meters). Differences between distances were found to be insignificant.

Discussion

While anthropogenic activity is known to have negative effects on forest flora (Roovers *et al.* 2005), it is possible that other environmental changes could create a buffer against these negative effects. We expected to find a greater diversity of wildflowers further away from the trail where there was less human impact. However, our results revealed no significant correlation between distance from the trail and wildflower abundance One potential reason could be due to an increased amount of sunlight in the areas surveyed closest to the trail, as increased sunshine could create a more suitable growing environment for flowers better adapted to germinate under these conditions. We may have detected no difference in wildflower diversity due to the increased sunlight compensating for an increase in disturbance. During the time of year this study was conducted (mid-April), spring ephemerals are blooming. These ephemerals flower before the deciduous trees leaf out taking advantage of an increase in light availability. Since disturbances can cause an increase in forest floor flora richness (Falk *et al.* 2008), it is possible

that increased sunlight surrounding the path could be the cause of why we did not find a difference in species richness between the different zero, five, and ten meter distances.

Our results may have differed if we had also completed surveys at a greater distance than 10 meters away from the trail. A distance of ten meters may not have been a large enough distance from the disturbed area to get an accurate measurement of a true gradient in human impact. Studies have shown that a distance of 100 meters from a forest edge is needed to accurately represent pristine forest (Broadbent *et al.* 2008). Although the Great Smoky Mountains National Park is not a pristine forest, this may suggest ten meters was too small a distance to obtain accurate measurements of undisturbed forest flora.

Expanding the number of transects along the trail would have allowed for an increased amount of flowers to be sampled. When walking between sites along the trail, we passed several species and many large aggregations of flowers that were not sampled. In our random sampling, we passed several large gatherings of flowers, we only sampled one large group (75 hooked buttercup).

We additionally hypothesized (i) competition structures the wildflower communities further way from the trail where there was the least human impact and (ii) competition does not structure communities closest to the trail with the most disturbance. Our EcoSim co-occurrence analysis confirmed hypothesis (ii) suggesting that competition is not playing a significant role in structuring the wildflower community. However, our EcoSim analyses did not confirm that competition was structuring plots further away from the trail (5 and 10 meters). We did not expect competition to play an important role in structuring the wildflower community closer to the trail because areas with increased stress (disturbance) generally do not contain vegetation with great competitive ability. We may not have found that competition structured the

communities further away from the trail (the plots with less human impact) because we needed to survey further away from the trail. Our 10 meter transect may not have encompassed much of a gradient in anthropogenic disturbance.

Lastly, elevation, and therefore temperature, may have been correlated with wildflower richness. We had intended to measure elevation and include it in our analyses, but the GPS device was unable to connect to the necessary number of satellites. As a result, we were given inaccurate measurements of altitude. However, due to a lack in elevational change over the 0.8 miles of trail surveyed, we believe this did not severely inhibit our ability to interpret our survey data.

This study could be combined with future research regarding the role that sunlight plays in communities. Further studies may expand the gradient of human impact and increase the number of sites. We would expand this study to other trails within the Great Smoky National Park. Furthermore, national parks are set up to preserve natural environments. Further studies could explore how trails impact surrounding habitats and how to lessen the effects of anthropogenic activity. Overall, our study suggests that neither human impact nor competition structure wildflower communities within 10 meters of Porter's Creek Trail.

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