How shore orientation, slope, and substrate type affect lichen richness and abundance in the Boundary Waters Canoe Area Wilderness

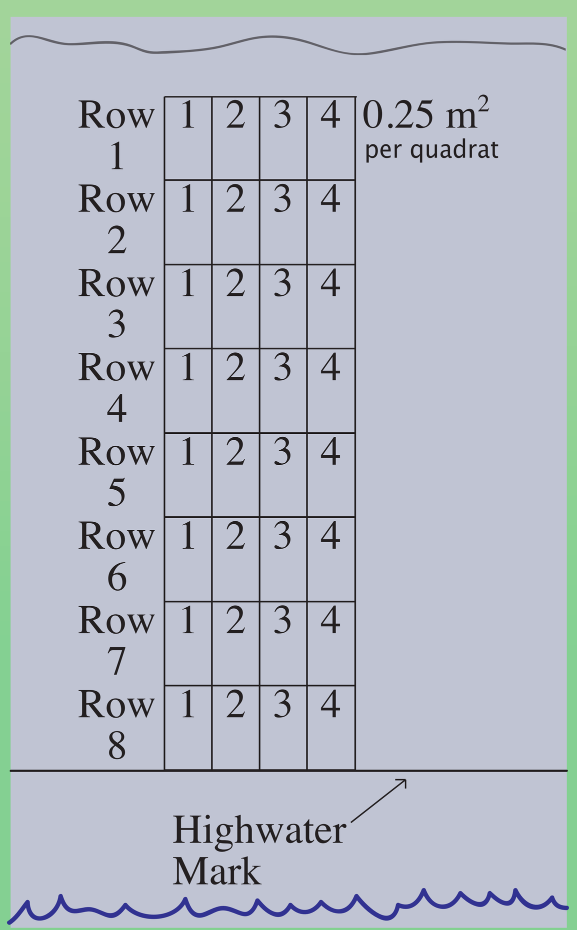
Christopher J. Naus, Jasmine R. Wiley, Matthew J. Sisco, Jamie K. Dins
Dr. Todd Wellnitz and Dr. Evan Weiher
Department of Biology, University of Wisconsin-Eau Claire

Substrate surfaces, such as bare rock, provide an essential habitat template for sessile organisms. The orientation and type of substrate on which sessile organisms grow are an important determinant of community composition and influence its resistance and resilience to perturbation. Saxicolous-rock inhabiting-lichens are important pioneer species of bare rock and dominate the aquatic-terrestrial transition zones in lakeshore habitats. To investigate how substrate type, slope and aspect influenced lichen communities, we surveyed the rocky shores of glacial lakes within the Boundary Waters Canoe Area Wilderness (BWCAW) of northern Minnesota.

"Team Lichen" members Jamie, Matt, and Chris collecting data from a shore on Ensign Lake using the grid system.

Materials and Methods:

We quantified lichen richness and abundance from sixteen shoreline sites on six lakes. At each site, a 1 X 2 m plot was placed perpendicular to the high water mark (HWM) and divided into 32, $0.25 m^2$ quadrats. Eight quadrats from each plot were randomly selected and measured for total percent cover, species richness, and species abundance (as a fraction of total percent coverage). Lichens were all identified to genus and to species when possible. Shoreline aspect, slope, distance from highwater mark (HWM), distance to vegetation, and rock samples were collected to determine substrate composition. The effects of these factors on lichen species richness and percent cover were examined using backward selection linear models.



A diagram of the grid system used to sample lichen. The grid was placed at the high water mark and lichen was randomly sampled in 1 quadrat from each row.

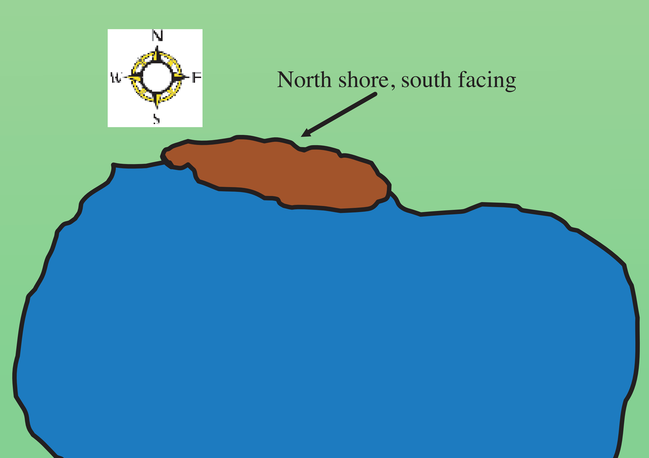


Diagram showing a south facing, north shore. Four sites from each aspect were sampled.

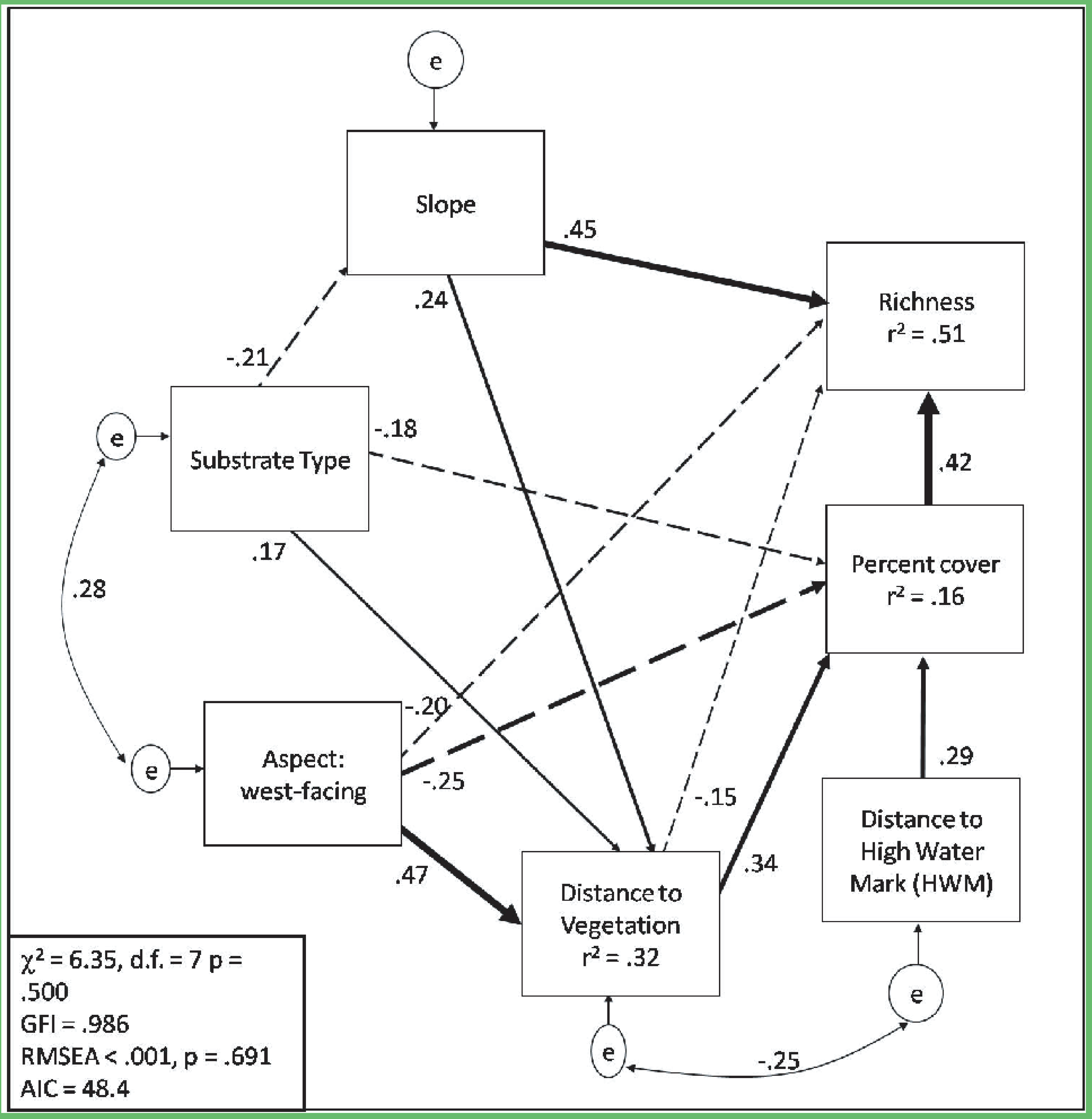


Figure 1: Structural equation model (SEM). All relationships shown in the SEM are significant. Single-headed arrows represent the strength of effect between two variables (line thickness is proportional to the strength of the relationship, values are standardized partial regression coefficients and are equivalent to an independent correlation coefficient). Double-headed arrows show correlations. The box in the lower left hand corner shows that this model has good fit to the data.

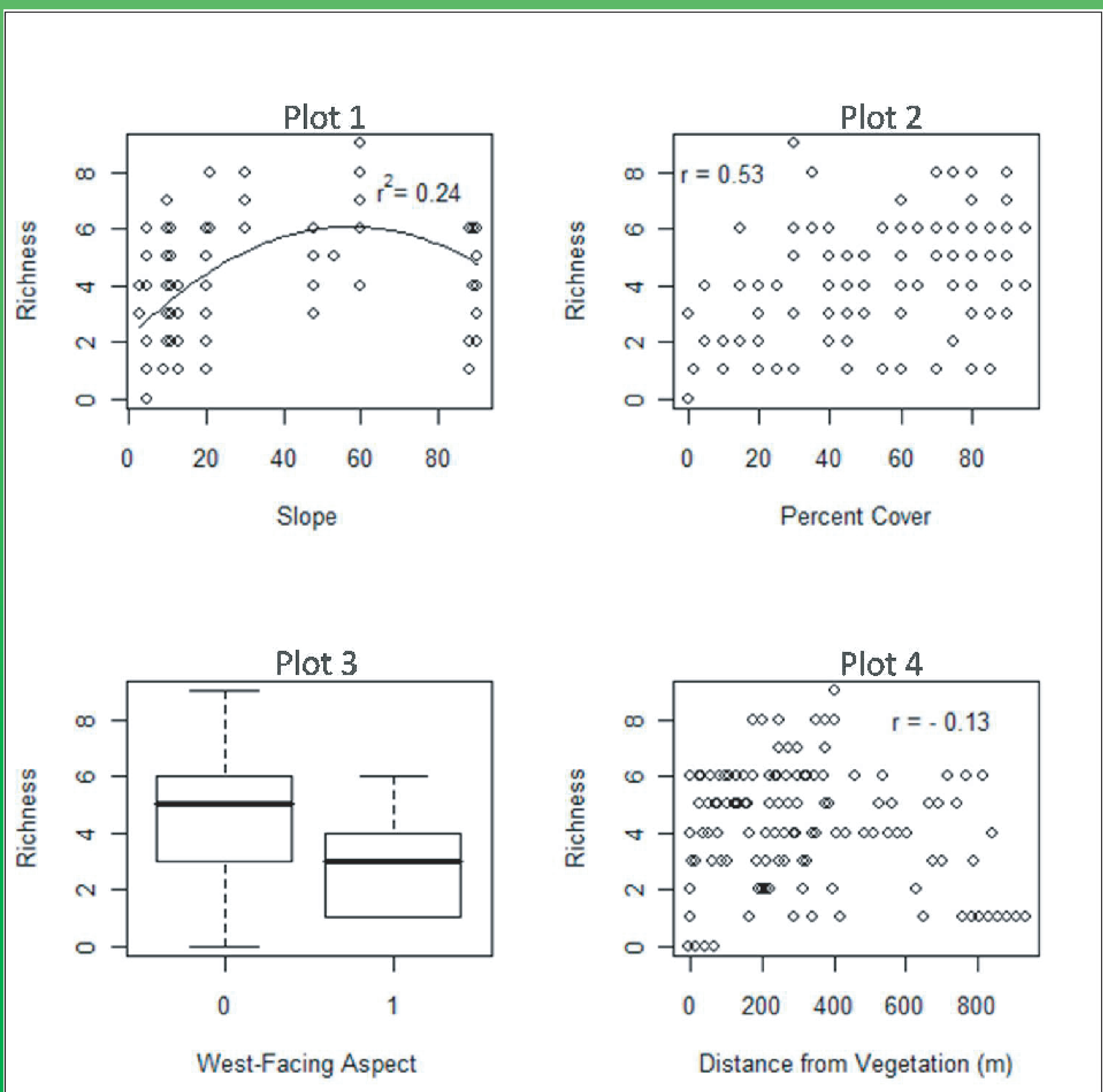


Figure 2: Four plots of lichen richness vs. environmental variables

Results

The SEM (Figure 1) showed that direct and indirect effects of environmental variables explained 51% of the variation in lichen richness. Slope and percent cover had the two strongest positive effects on lichen richness. The number of lichen species increased with slope. However, lichen richness increased with slope until slope became very steep, then began to decrease (Figure 2). West-facing aspect and distance to vegetation had a negative effect on lichen richness.

The model also showed that slope was negatively affected by substrate type and that distance to vegetation was positively affected by west-facing aspect, slope, and substrate type (in order of strength of relationship, strongest first). Percent cover decreased on the west-facing shores as well as with certain substrate types (schist sandstone, slate, and igneous granite). Sites with western aspects had the lowest species richness (~ 2 fewer species on average, Figure 2:Plot 3) and the lowest percent cover.

Conclusions:

Direct Environmental Effects:

Environmental factors associated with disturbance and stress, such as exposure (high slope and high distance to vegetation) and low cover, had strong negative effects on lichen diversity.

Grace et al. (2007) showed, in a meta analysis of vascular plant communities, that production (% cover in our research) tended to have weak effects on richness, stress tended to decrease diversity, while disturbance effects were variable, depending on the kind of disturbance. The lichen communities studied here are perhaps the most stressed and disturbed case, and so these results are not consistent with Grace et al. (2007).

Indirect Environmental Effects:

The SEM showed many indirect effects on lichen richness, and many of them were related to disturbance variables. Substrate type negatively affected slope (poor substrate=high slope), slope positively affected the distance from vegetation (high slope=large distance to vegetation), and distance to vegetation had a negative effect on lichen richness (large distance to vegetation=lower lichen richness). This is just one of the many indirect pathways to lichen richness.

Images (from top left, clockwise) of a crustose map lichen, foliose cumberland lichen, a vertical rock face showing different colored streaks of lichen growth, and a foliose trumpet lichen.

Literature Cited

Grace G, Anderson M, Smith M, Seabloom E, Andelman S, Meche G, Weiher E, Allain L, Jutila H, Sankaran M, Knops J, Ritchie M, and Willig M. 2007. "Does species diversity limit productivity in natural grassland communities?" Ecol Lett. **10**: 680-689.

A special thank you to Bill Hintz for his help with statistical analyses and Tricia Hernick for her lichen photograph.