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Impacts of Rock Climbing on Lichen and Bryophyte Cliff Communities in the Arid West

Giovanna M. Bishop
Eastern Washington University, gbishop3@eagles.ewu.edu

IMPACTS OF ROCK CLIMBING ON LICHEN AND BRYOPHYTE CLIFF COMMUNITIES IN THE ARID WEST

Giovanna Bishop, Graduate Fellow
Advisor: Dr. Jessica Allen, Biology

Introduction

Cliff ecosystems support a unique suite of biodiversity. The wealth of diversity and complexity of communities have led some ecologists to describe cliff systems as similar to old growth forests (Larson et al. 2000; Larson et al. 1998; Kelly and Larson 1997). A potential major threat to cliff communities is the increasingly popular sport of rock climbing (Schmera et al. 2018; Tessler and Clark 2016; Holzschuh 2016; Nuzzo 1996). Rock climbing areas have been steadily growing over the past several decades, and in 2018 the Access Fund estimated there were 30,000 climbing areas in the United States (Access Fund 2019). The Outdoor Industry Association estimates that there were 2.8 million outdoor climbers in 2018, which would average to ~83 climbers per climbing area. It is essential that the impact of rock climbing to cliff systems is investigated, and conservation strategies are developed.

Lichens and bryophytes are the most biodiverse groups living on cliffs in many biomes (Baur et al. 2007; Matthes 2000; Farris 1998). Abiotic factors of cliff ecosystems are key variables that shape the diversity and cover of plant communities in unclimbed areas (Holschuh 2016). These abiotic factors include the aspect, slope, insolation and rock heterogeneity of the cliff system, as well larger rock features such as ledges or cracks. Many lichen and bryophyte species are substrate specific, making cliff ecosystems with unique geological histories or rock types areas of interest. Biotic variables also impact lichen and bryophyte cliff communities. For instance, studies have found that cliffs can harbor rare species due to the decrease in competition from vascular plants (Müller et al. 2006; Graham and Knight 2004). Lichenologists and bryologists have infrequently studied cliff systems due to the difficulty of accessing sites, however recent studies have uncovered new species for North America, as well as the presence of endangered or rare species (Brinker and Knudsen 2019; Boggess et al. 2017; Holzschuh 2016) Both groups are understudied and many areas in the world do not have any keys or guides to the local flora. Furthering our knowledge of lichens and bryophytes of Eastern Washington is the first step to conserving cliff systems and managing the impacts of rock climbing. The west side of the Cascades has had extensive research done on the lichen and bryophyte floras, however the east side of the cascades does not have a formal key or guide. This study will fill the gap in our knowledge of what communities exist on cliff faces in the northern reaches of the arid west.

Previous Research on Impacts of Rock Climbing

In 2016 Holzchuh wrote a review paper on every study published on the impacts of rock climbing to cliff biodiversity and cover. Overall, lichens were impacted the most and were found to be the most abundant group of plants in cliff ecosystems as a whole. Methodology has evolved over time, and important route and abiotic variables have been found to be essential in cliff research. Only half of studies in the review included lichens and bryophytes, and many of those studies were not able to identify either group to the species level. It is important research is continued since results have varied and rock climbing has risen to rapidly.

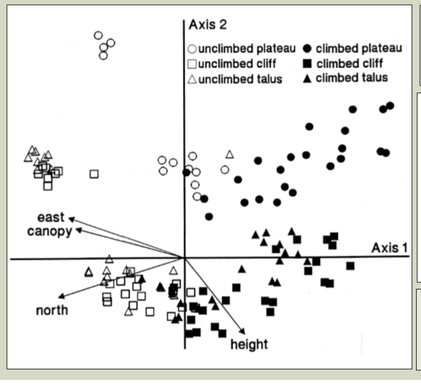

Figure 1: (left) Ordination produced by a CCA (canonical correspondence analysis) of lichen species present in each quadrat in climbed vs. unclimbed transects. (McMillan & Larson 2002)

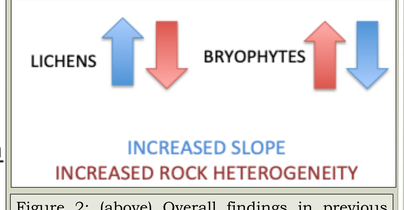

Figure 2: (above) Overall findings in previous studies. Increased slope influences lichen cover positively, yet bryophyte cover negatively and vice versa for increasing rock heterogeneity.

Objectives

- Assess the impacts of rock climbing on lichen and bryophyte cliff community biodiversity in Eastern Washington
- Improve development practices and management of rock climbing areas for lichens and bryophytes
- Enhance lichen and bryophyte flora knowledge of the arid west

Hypotheses and Questions

Abiotic Hypotheses: Community composition will differ along the vertical gradient of the cliff (e.g., the species present at the top/middle will be significantly different from those at the bottom); Cliff slope will be the main factor in determining bryophyte and macro-lichen cover; Cliff face aspect and exposure will be the main determinant of the type of lichen and bryophyte community present.

Route Hypotheses: Climbed community composition will be significantly different than unclimbed community composition; Climbing intensity will be the most significant route variable when looking at impacts of rock climbing on overall diversity and cover; Old routes with high climbing intensity will have low diversity and cover compared to old routes with low climbing intensity, which will have high diversity and cover.

Management Questions: Are there any species of concern at any of the sites within my study? Did I find any new county or state records, and are those species of concern? Are there any unclimbed cliffs with high diversity that should stay undeveloped at any site? Are there any specific routes with species of concern that should be monitored? How are rock climbers in Eastern Washington impacting lichen and bryophyte communities? Do sites need to implement management or conservation plans?

Study Sites

All sites have a granite rock type, and were formed by the Missoula floods that swept through the Spokane River Valley over 15,000 years ago. Each site is within the Priest River Metamorphic complex and have similar geological histories and geochemical make-ups.

Tumtum- Historic site, land ownership issues, 59 routes, 42 sport

McLellan- Newly developed site, since around 2000, within Fisk State Park, 115 routes, 84 sport

Minnehaha- Developed in 1950s and and climbed on heavily in the 1960s/70s, within John Shields Park, 67 routes, 21 sport

Dishman -First developed routes in 1980 by Dane Burns, again in 1990s, within Dishman Hills Conservancy, 48 routes, 30 sport

Rocks of Sharon- Traditional routes in 1950s, John Shields and crew first developed bolted routes in mid 1990s, within Dishman Hills Conservancy, 61 routes, 47 sport

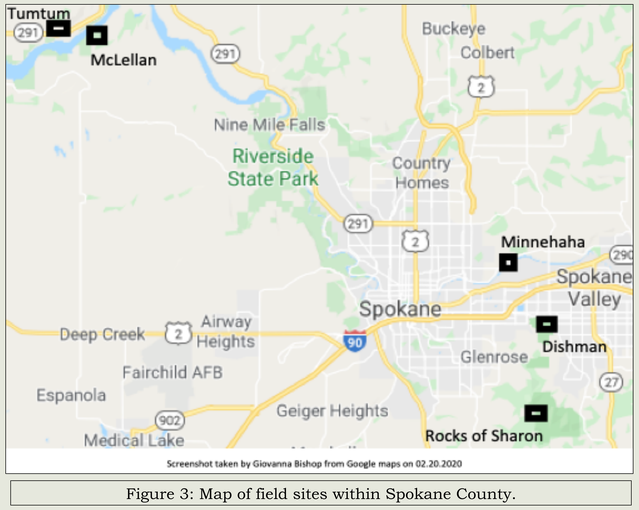

Figure 3: Map of field sites within Spokane County.

Study Design

Field work: June- September 2020

- All Transects: 15m height, 0.5m² quadrats placed every 3m (5 total)
- Climbed transects will be scouted for and selected based on accessibility, age, and popularity, while unclimbed transects will be chosen based off no visible climbing damage or mention of previous routes on face.

Data Collection:

- Describe or identify species in the field if possible, collect for identification if needed.
- Estimate percent cover for each species within each quadrat.
- Note aspect, height of quadrat, slope of cliff face, and slope of the center of each quadrat.
- Measure rock features (pockets, cracks, and ledges) within quadrats.
- Take photos for 3D modeling or use a drone to take photos of each transect.
- Estimate canopy cover and insolation based on density of woods and overall exposure the cliff has to the sun.

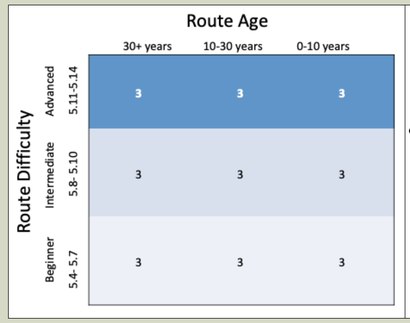

Figure 4: Experimental design. Left gives a visual for how many replicates per route variable, Right shows how quadrats will be placed along transects.

Statistical Approach

I will use ranked abundance plots, linear regressions paired with Shannon's Diversity Index (SDI), and species accumulation curves to analyze the richness and diversity within transects at each site and as a whole. To investigate climbing and site impacts I will use an NMDS for both lichens and bryophytes as well as each group separately. Moreover, I will use an ANOVA to interpret climbing impacts and site impacts to species richness and diversity. Plot and transect abiotic variation will be estimated by how abiotic variables contributed to richness and diversity with hierarchical partitioning. I will also use linear regressions to better understand plot and transect variation. I will lastly use linear regressions to measure richness and diversity based on rock features. Programs and Packages: R(v3.5.1), vegan

Drone footage and photographs taken of each quadrat will be analyzed to more accurately interpret rock heterogeneity. This will be done by converting the photos to generate maps to better understand if lichen and bryophyte species have specific rock features or topographies they prefer as their substrate. I will attempt to use the Rumple Index (forest canopy complexity) to properly give values for rock heterogeneity for each species within quadrats by creating a terrain roughness index. Programs: Agisoft and Metashape

Expected Outcomes

- Lichen and bryophyte community composition and cover are directly influenced by rock climbing impacts
- Route difficulty and aspect have more influence on the biota than route age
- New species records for Spokane County and for Washington State
- I will provide each sites landowners with species lists and any information regarding species of concern so they can decide if they would like to implement a management plan. Management plans would then be created with the help of the local Bower Climbing Coalition and Spokane county.

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