

Impacts of rock climbing on lichen and bryophyte cliff communities in Eastern Washington, USA

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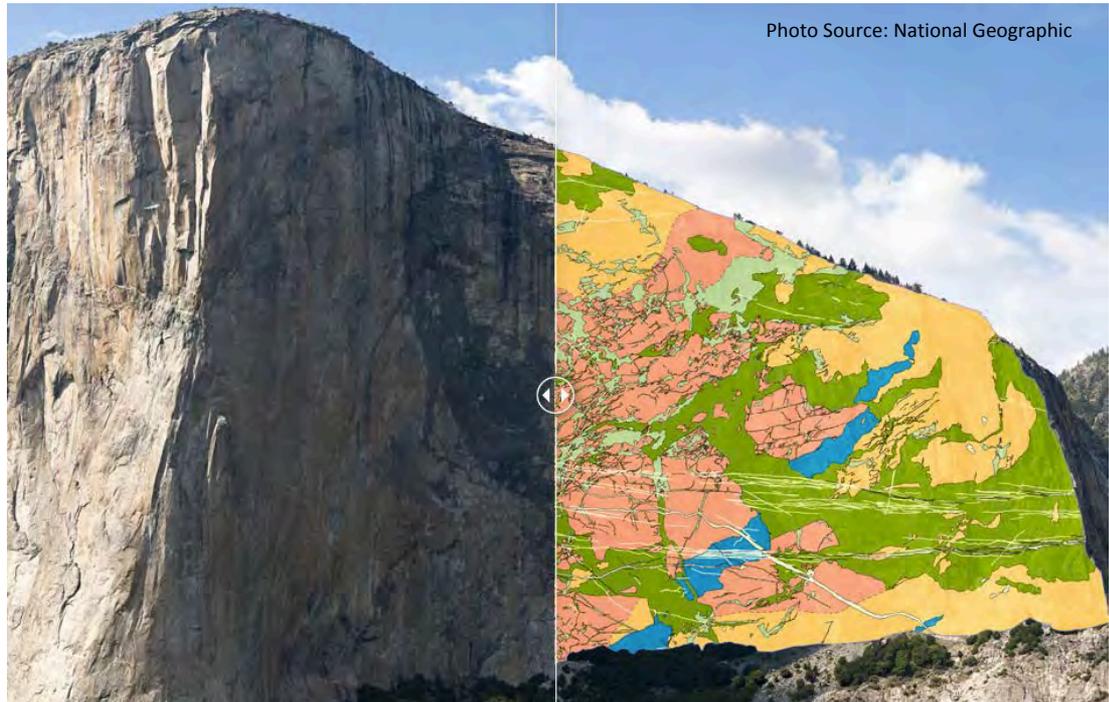
Why Cliffs?

Understudied

Unique diversity

Abiotic variables =
Harsh Environment

Geologic history



Cliff Ecosystems

Ancient individuals

Escape competition/disturbance

Glacial relicts

Endemism



Thuja occidentalis

ideo.columbia.edu



Racomitrium microcarpum

Photo By: Stéphane Leclerc, BRYOQUEL



Umbilicaria cinereorufescens

Photo By: Troy McMullin, CNALH

Lichen and Bryophyte Cliff Communities



Most abundant and diverse taxa in most cliff systems

Understudied groups



New, rare, and endangered species

PNW cliff flora mostly unknown

Rise of Rock Climbing

United States

>200,000 climbing areas

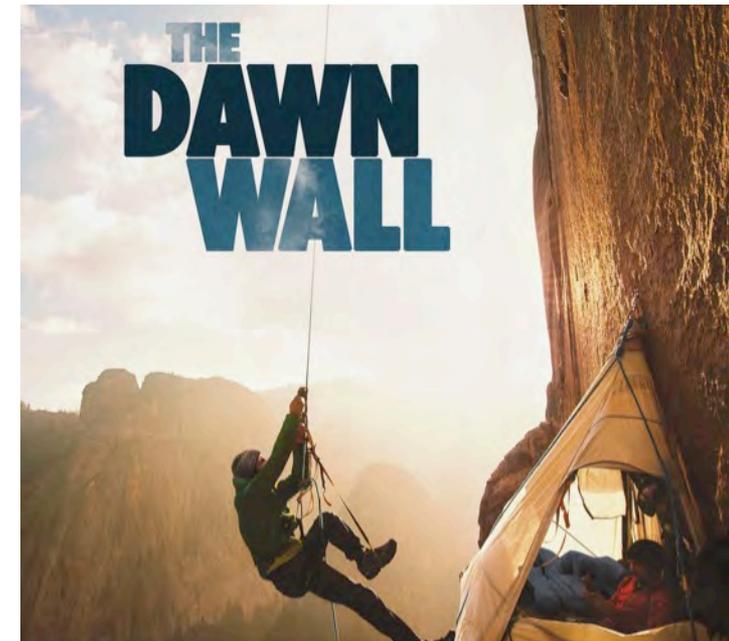
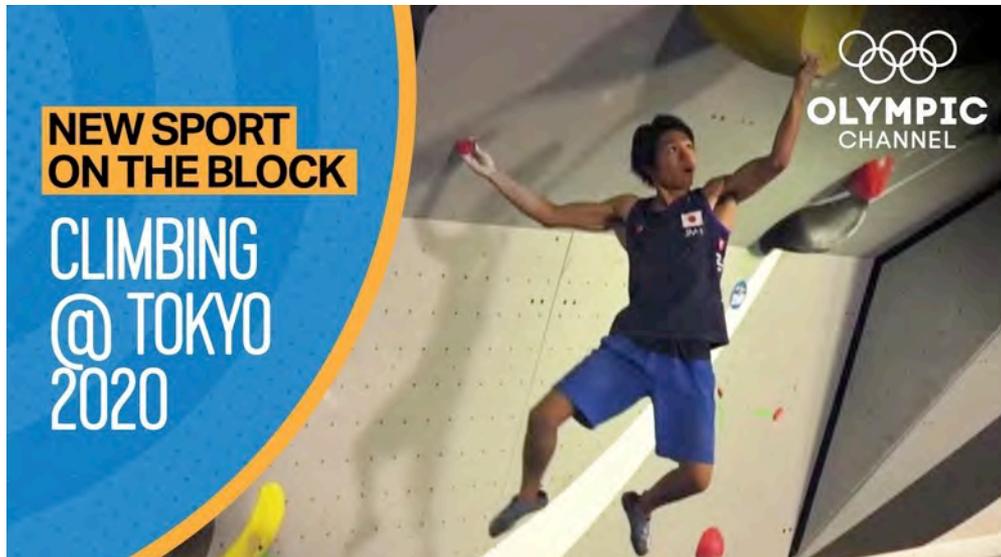
>10 million climbers (Cordell 2012)

Washington State

> 9,150 routes

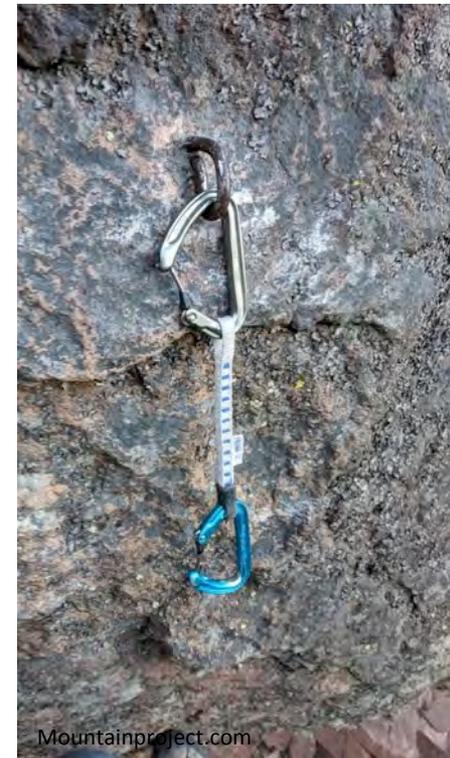
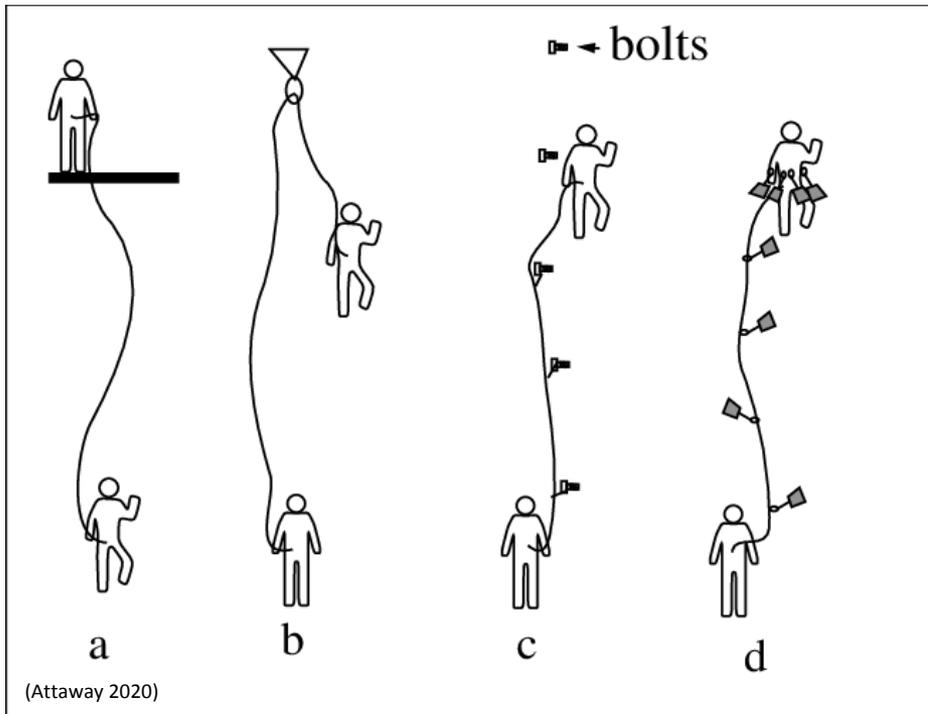
1915 Spokane Mountaineers Club

Spokane area >600 routes on granite/basalt



Rock Climbing Basics

- Types of climbing: Top Rope (a/b), Sport (c), Traditional (d), Ice, and Bouldering (not shown)
- Route levels for rope climbing: 5.4-5.15 (Yosemite Decimal Sys.)





Route Development



Photo by: Drew Dochstader 2013



Photo provided by: EWU Rock Wall



Photo provided by: EWU Rock Wall

Current Local Management

What is included?

- Run by climbers
- Re-bolting, seasonal cleaning
- Leave no trace practices
- Crag clean-ups
- Seasonal route closures

No regulations...

- Route development
- Species of concern are unknown



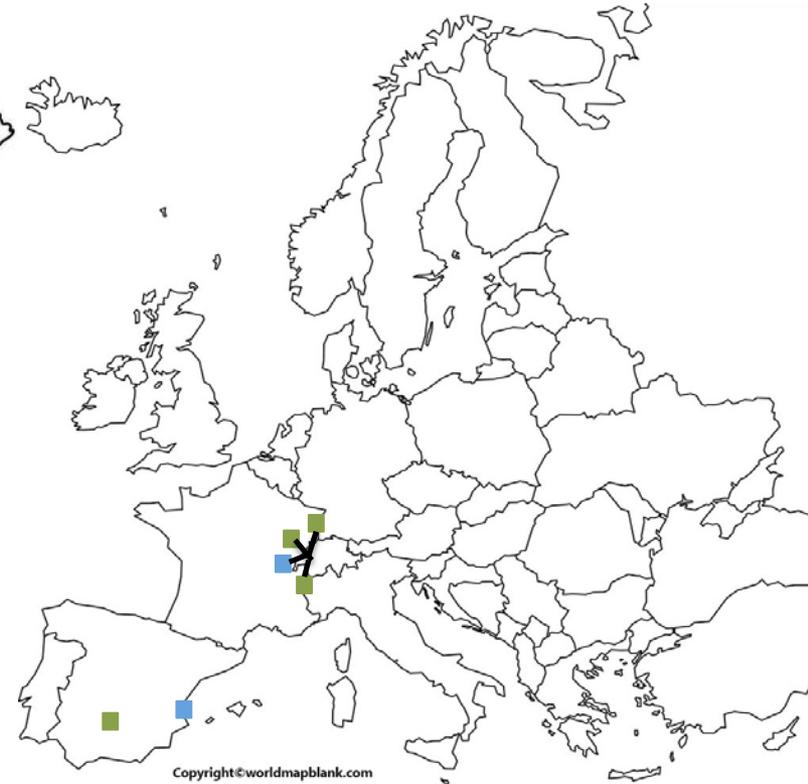
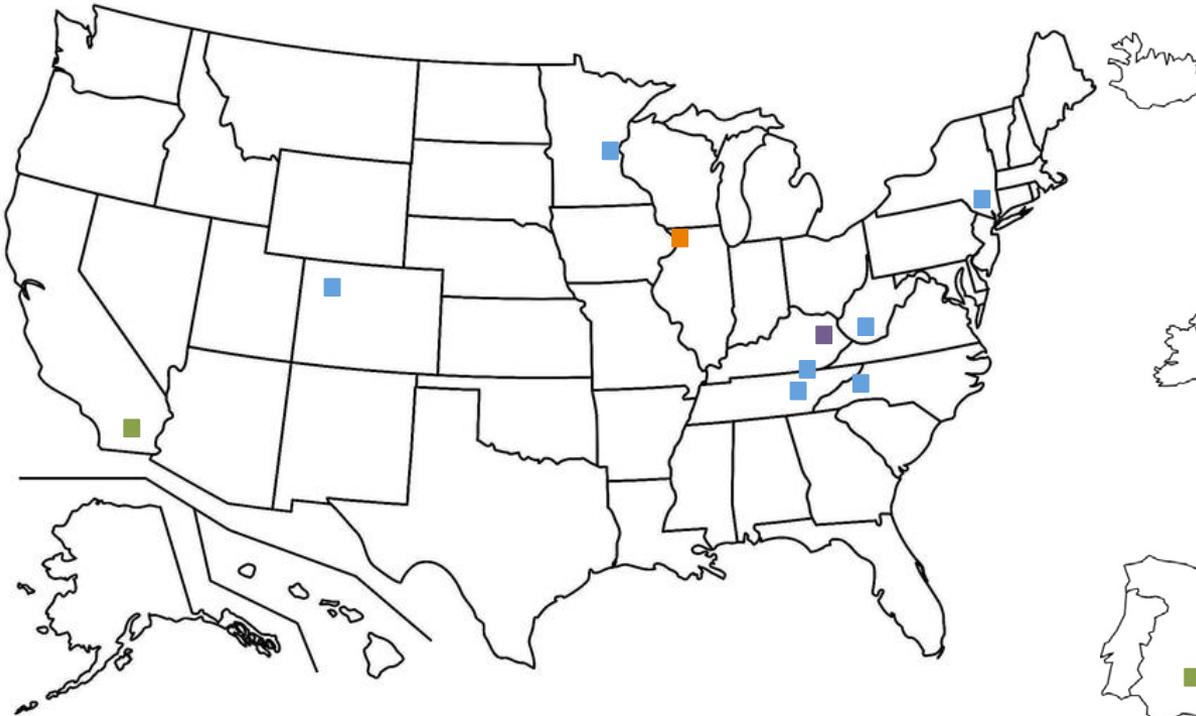
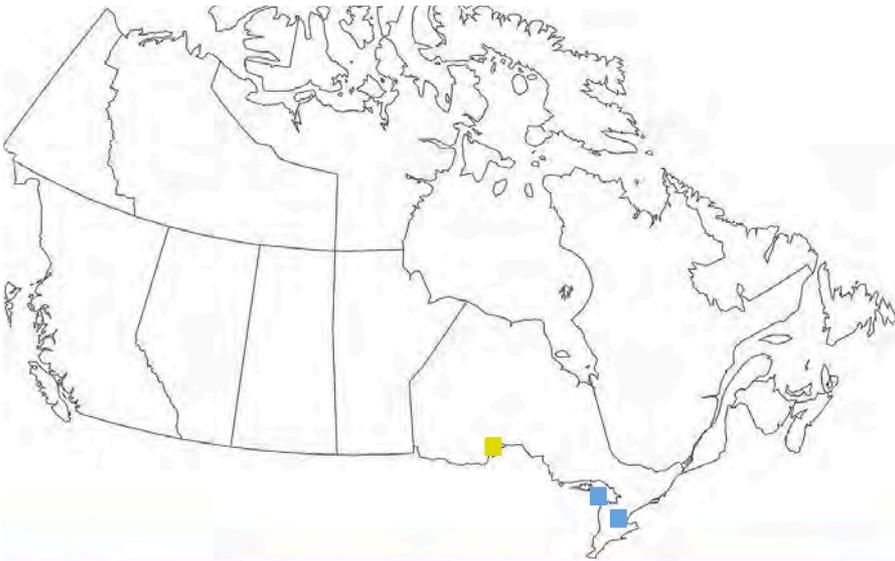
Local Climbing Organizations:

- Bower Climbing Coalition
- EPIC Adventures
- Access Fund Pacific Northwest
- Mazamas Pacific Northwest



Previous Studies

-  = Vascular Plants
-  = Vascular Plants + Lichens
-  = Vascular Plants + Lichens + Bryophytes
-  = Lichens + Bryophytes
-  = Lichens





Objectives

Assess the impacts of rock climbing on biodiversity in Eastern Washington

Improve development practices/management of rock climbing areas for lichens and bryophytes

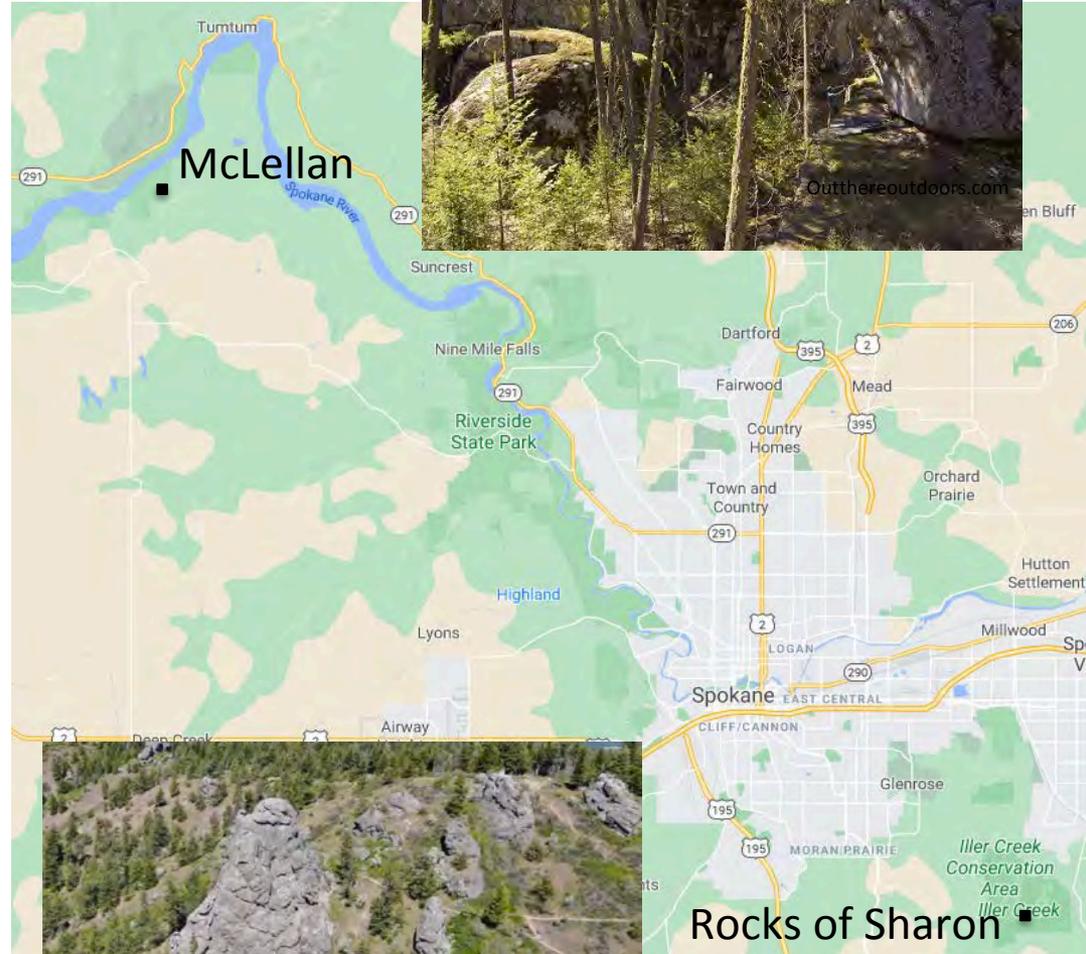
Enhance lichen and bryophyte flora knowledge of western North America

Study Questions

1. Does climbing impact taxa cover, diversity and richness?
2. What abiotic variables explain climbed vs. unclimbed taxa cover, richness, and diversity?
3. What species are dominant in climbed vs. unclimbed transects?
4. What route variables explain climbed taxa cover, richness, and diversity?

Study Sites

	McLellan	Rocks of Sharon
Route Age	5-10+ years	30+ years 65+ years
Routes/Sport Routes	115/84	61/47
Transect Climb/ Unclimbed	10/10	6/6



Abiotic Factors

Slope

Aspect

Rock heterogeneity

Canopy cover



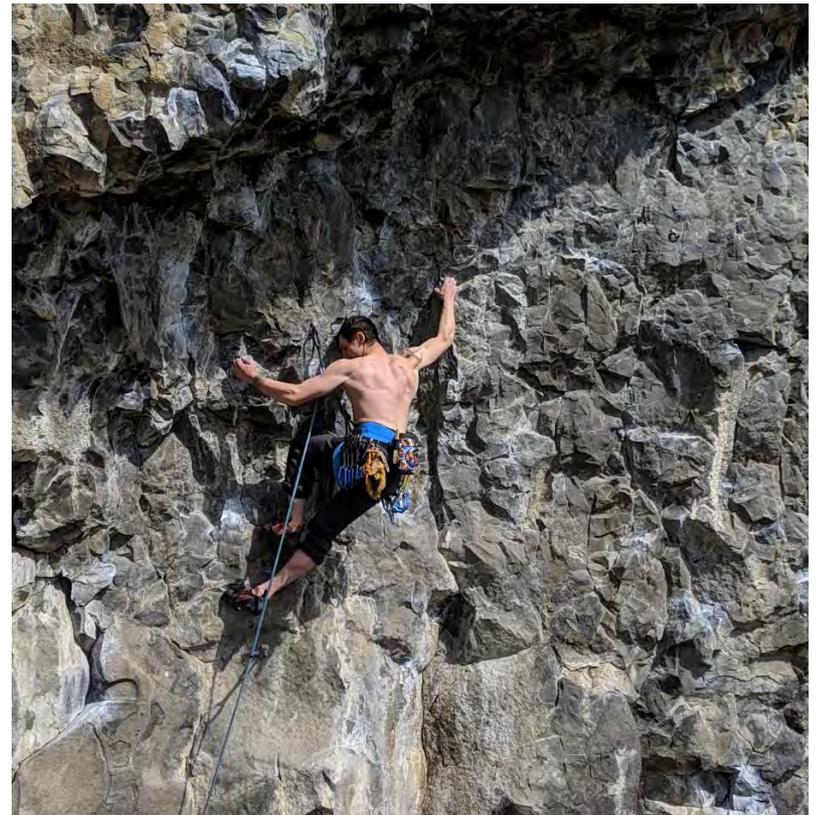
Route Variables

Climbing Frequency

Climbed vs. unclimbed

Level of route (5.4-5.13)

Age of Route (0-30+ years)



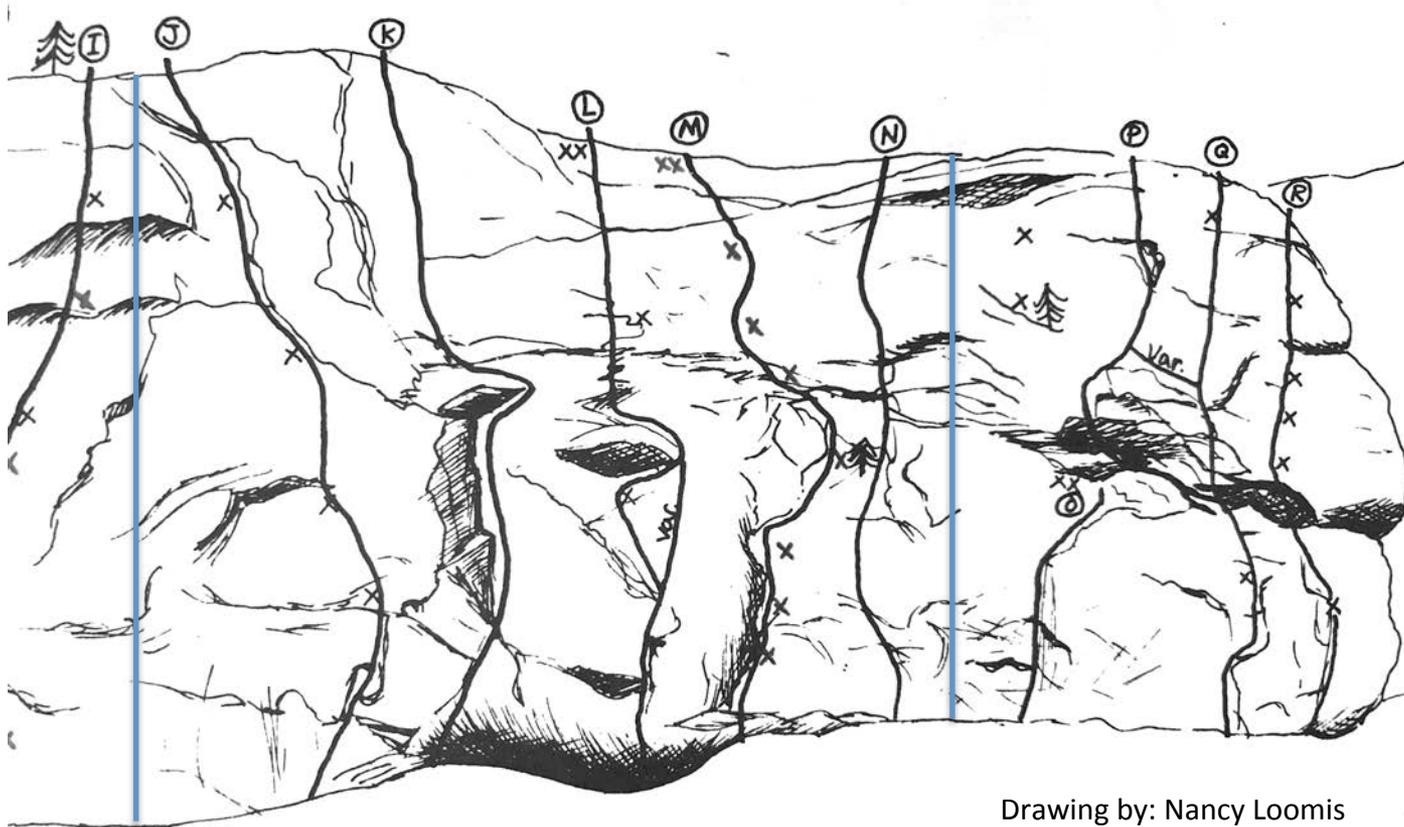
Study Design

Field work: August- December 2020

All Transects: 11m height, quadrats placed every 3m

Climbed transects: scouted for and selected based on accessibility, age, and popularity

Unclimbed transects: no visible climbing damage or mention of previous routes on face



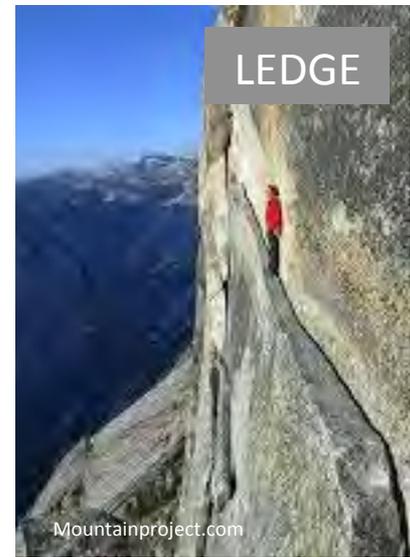
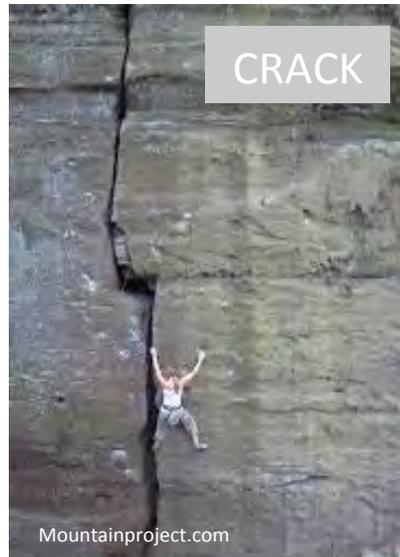
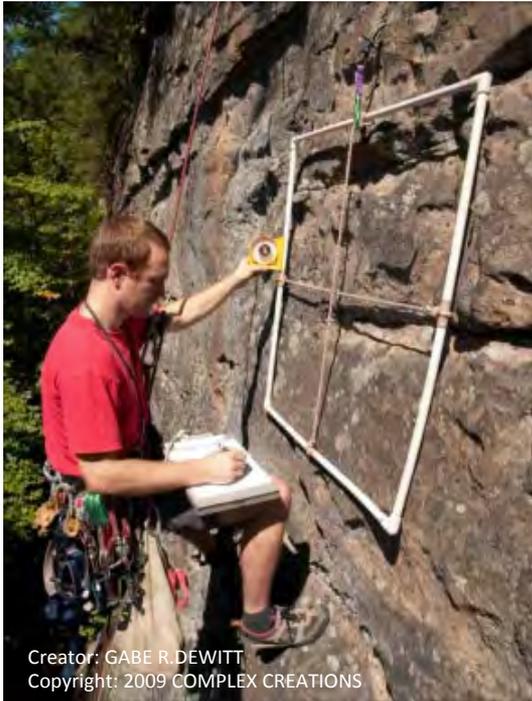
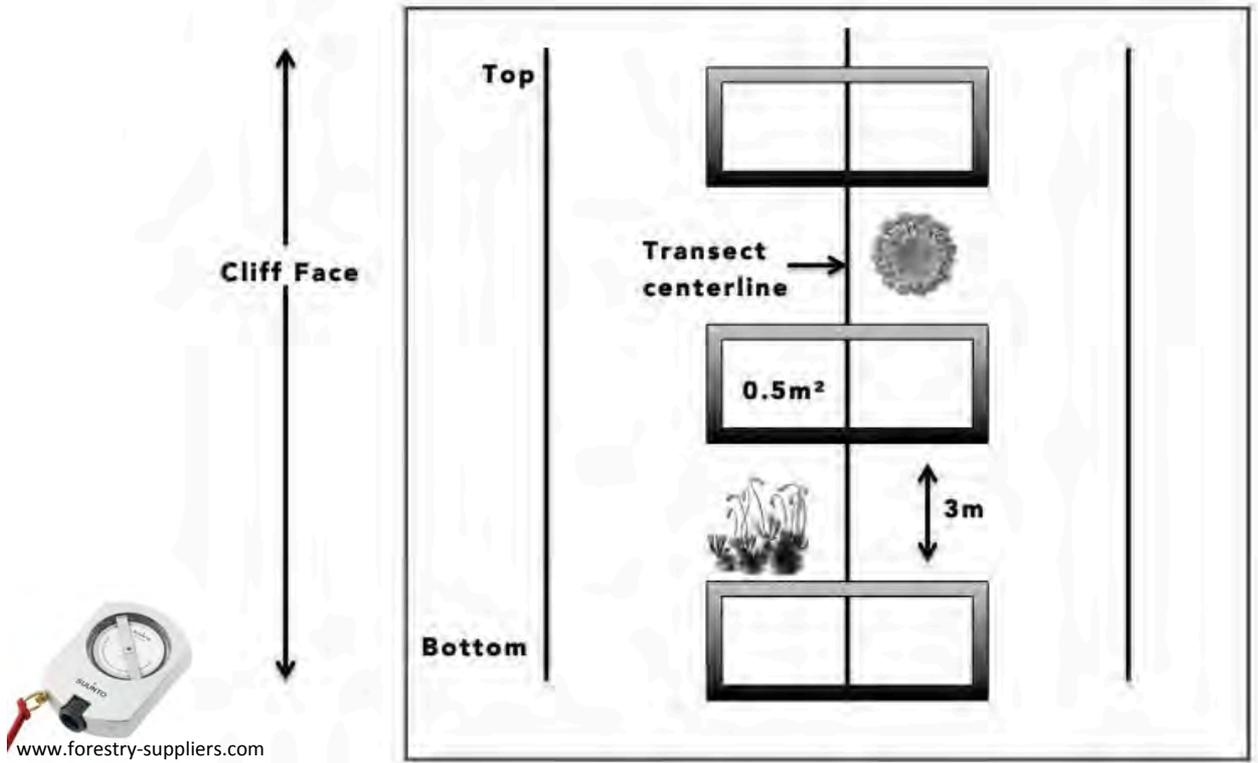
Drawing by: Nancy Loomis

 Blue = unclimbed transect

 Black = rock climbing routes, climbed transects

Survey Methods

- 0.5m² plots, 8 per transect
- Describe or Identify species
- Estimate percent cover
- Collect samples
- Slope
- Rock features
- Canopy cover
- Aspect, Height



Plot Example



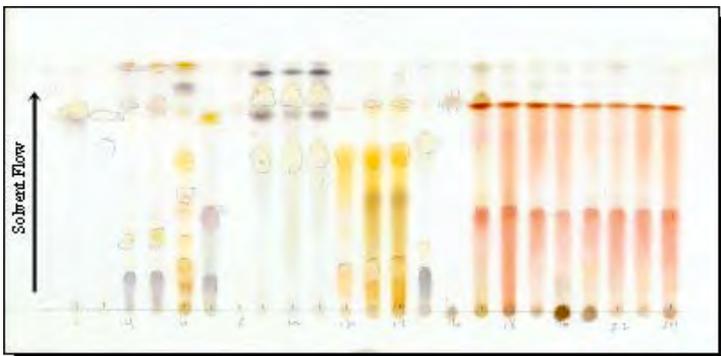
Identification Methodology

Morphological: Methods include using compound and dissecting microscopes to make cross sections and slides of specific features

Chemical (Lichens): Spot tests and Thin Layer Chromatography (TLC) for species that cannot be identified morphologically

Lichens: 550+ collections, 250+ hours

Bryophytes: 270+ collections, 100+ hours



Number of Species per Taxa

Lichens: 118 species, 83 Groups

Mosses: 27 species, 21 Groups

Liverworts: 2 species, 2 Groups

Vascular plants: 2 species, 2 Groups



Statistical Approach

Packages: vegan, BiodiversityR, nlme, tidyr, diplyr, sjplot, ggplot2



Does climbing impact taxa cover, diversity and richness? What route variables explain climbed taxa cover, richness, and diversity?



GLME + ANOVA
+ DREDGE

How different or similar were sites?
How did environmental variables explain communities?



NMDS + ENFIT

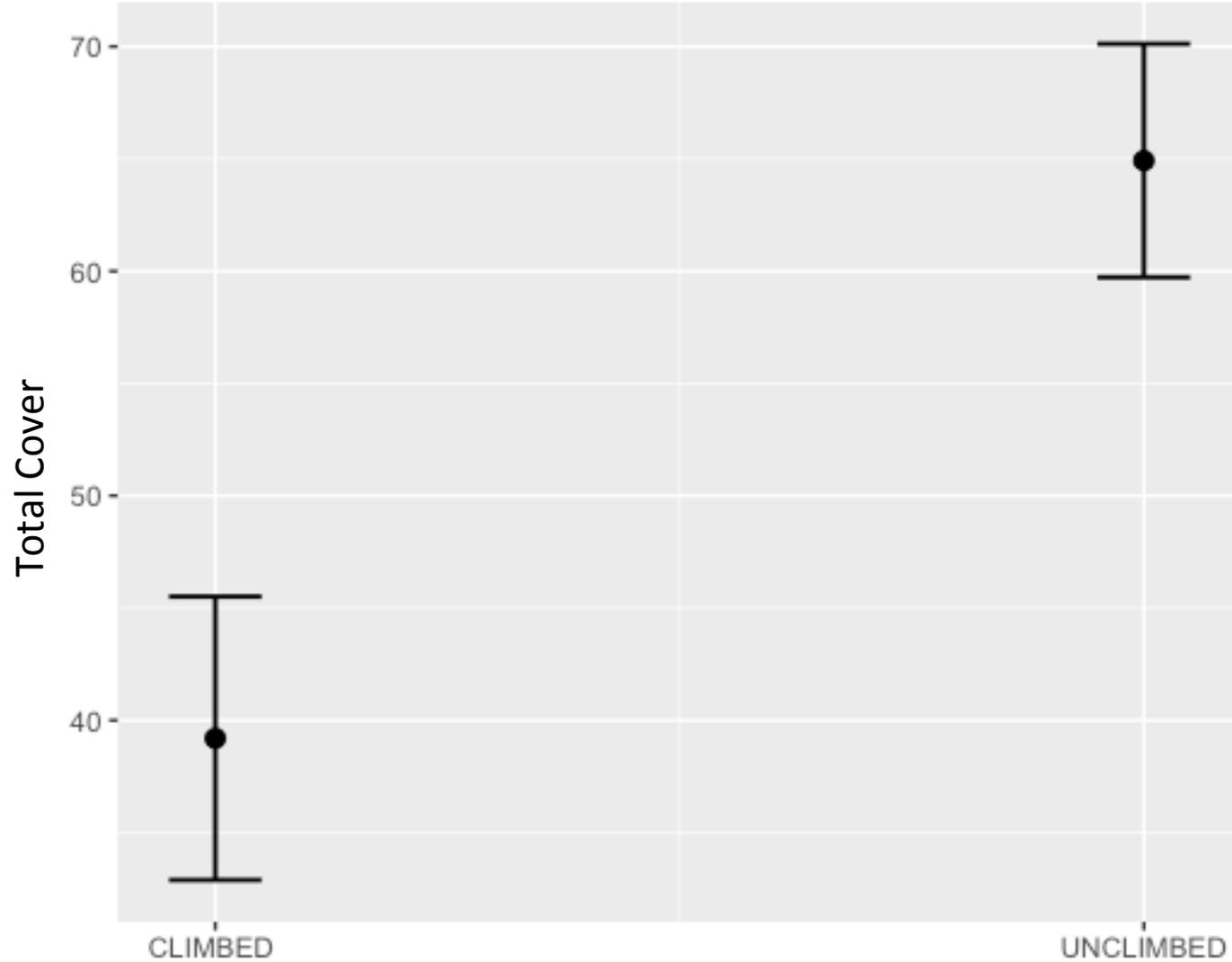
What species are dominant in climbed vs. unclimbed transects?



Rank Abundance

Climbing reduces lichen and bryophyte cover in cliffs

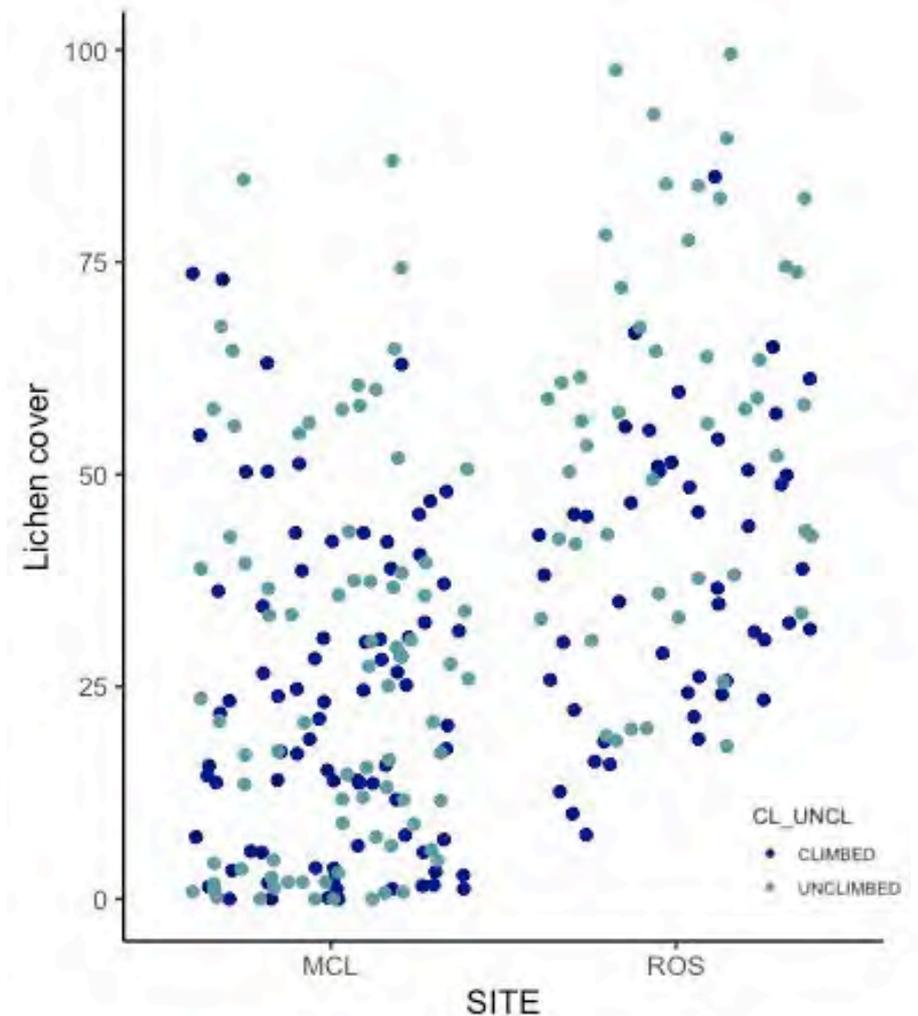
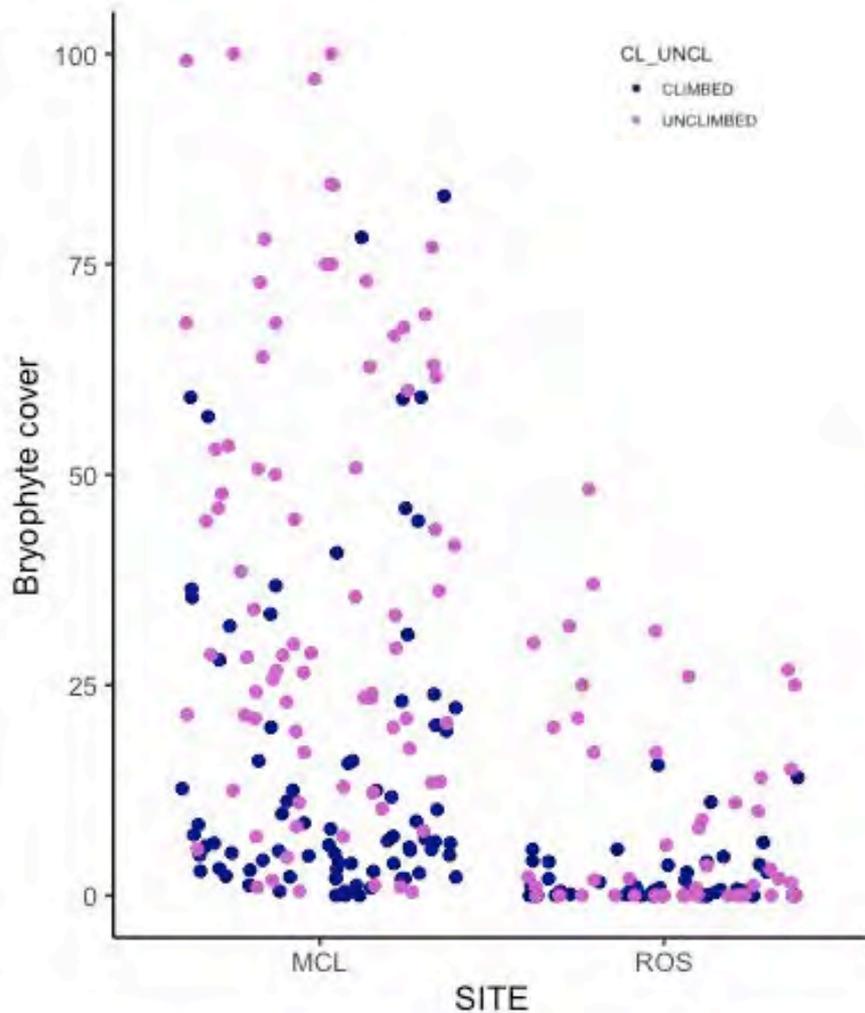
Effects Plot of All Taxa Cover



Climbed vs. Unclimbed

P-value < 0.001

Lichen and Bryophyte Cover by Site



How did Climbing Impact Taxa Richness, Diversity, and Cover?

SITE	Total Cover	Lichen Cover	Bryo/Plant Cover	Total SR	Lichen SR	Bryo/Plant SR	Total SD	Lichen SD	Bryo/Plant SD
BOTH	■	□	■	□	■	■	□	□	■
MCL	■	□	■	□	■	■	□	□	■
ROS	■	■	□	□	□	□	□	■	□

■ = Negative impact, □ = No impact; SR = Species Richness, SD= Species Diversity



How did Climbing Impact Lichen Morphology Groups?

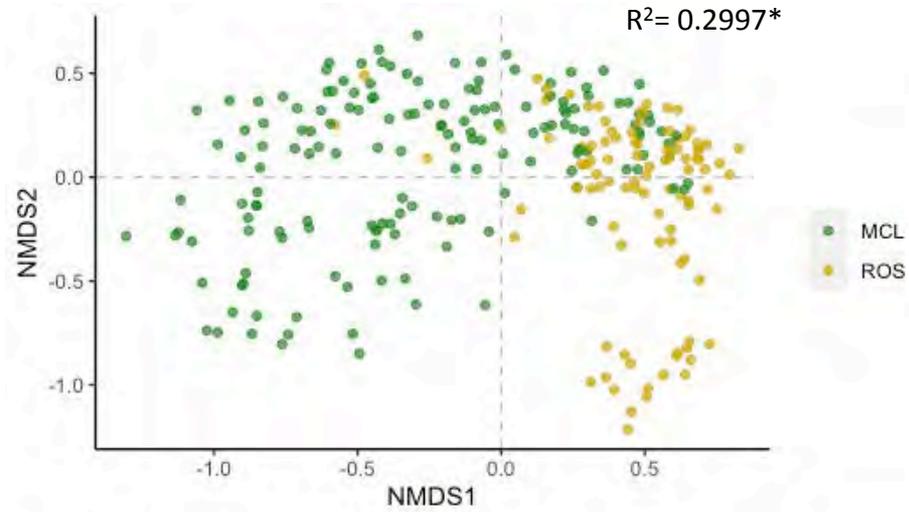
SITE	Crustose	Crustose Endolith	Leprose	Fruticose	Foliose	Foliose Umbilicate	Foliose Squamulose
BOTH	Positive impact	Positive impact	No impact	Negative impact	Negative impact	Negative impact	No impact
MCL	Positive impact	Positive impact	No impact	Negative impact	No impact	No impact	No impact
ROS	Positive impact	No impact	Negative impact	Negative impact	Negative impact	Negative impact	No impact

■ = Negative impact, □ = No impact, ■ = Positive impact



NMDS Results All Taxa

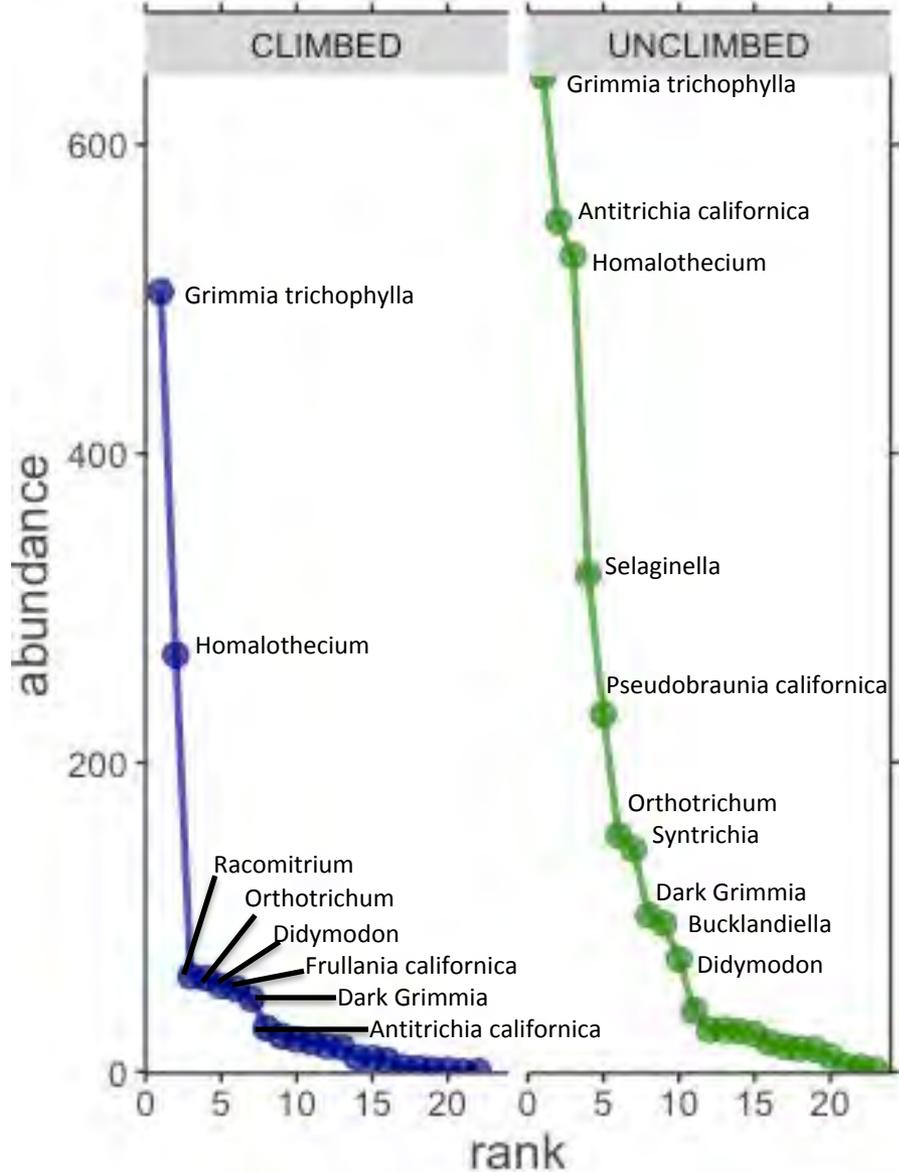
MCL vs. ROS by Site



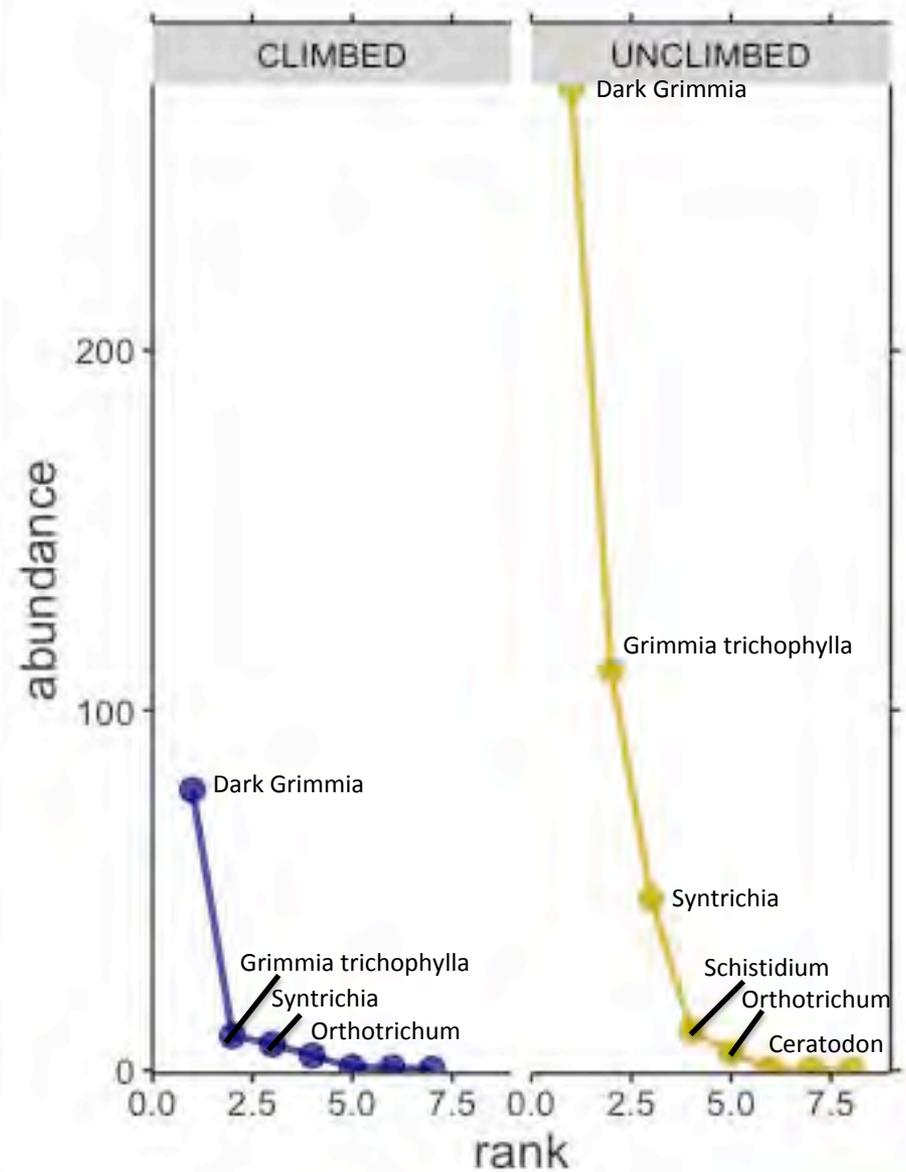
R^2 values with * indicate $p < 0.05$

Ranked Abundance Results: Plants

McLellan

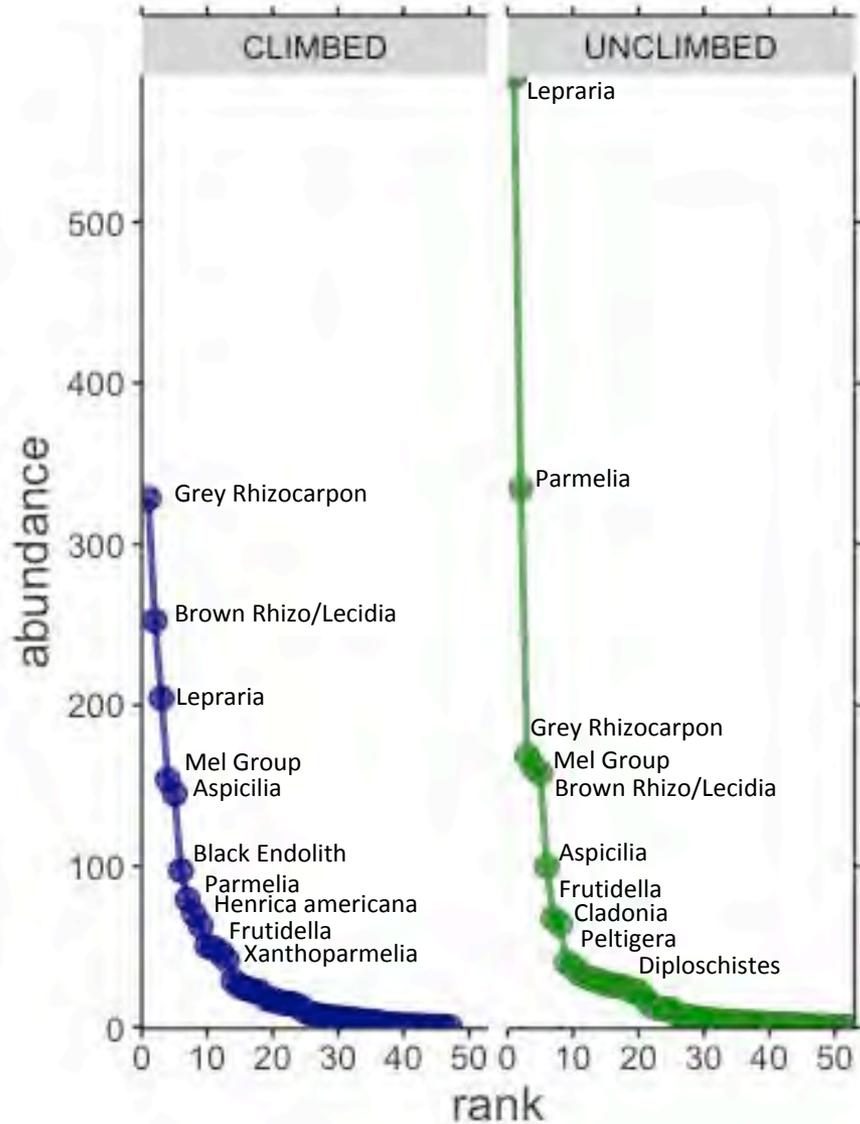


Rocks of Sharon

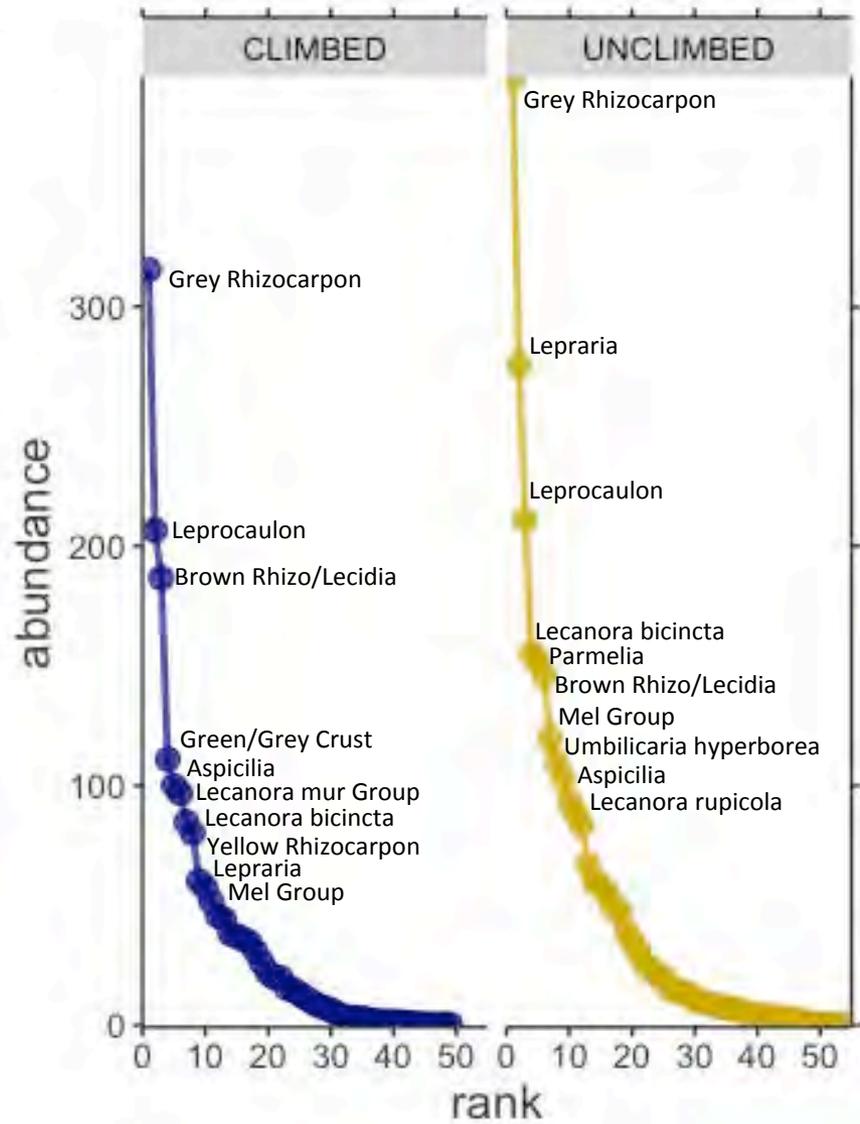


Ranked Abundance Results: Lichens

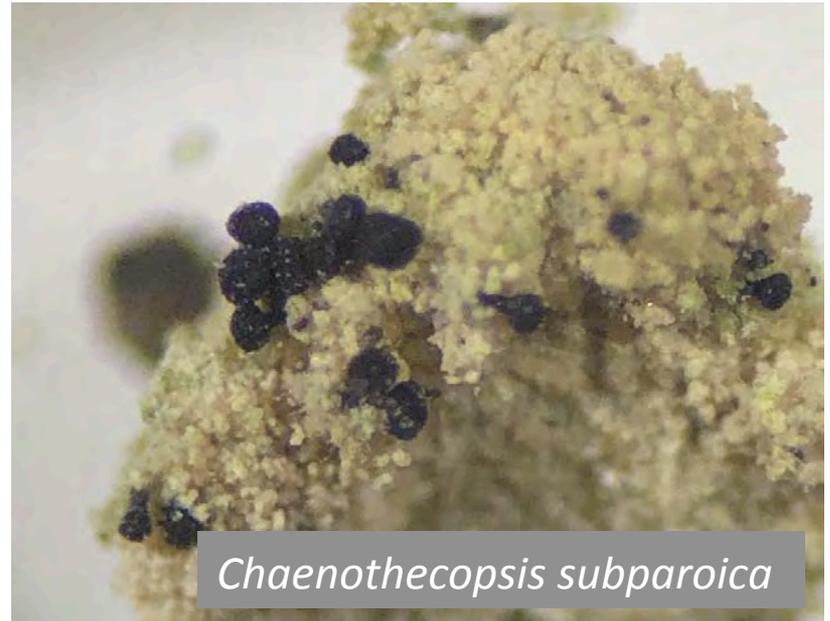
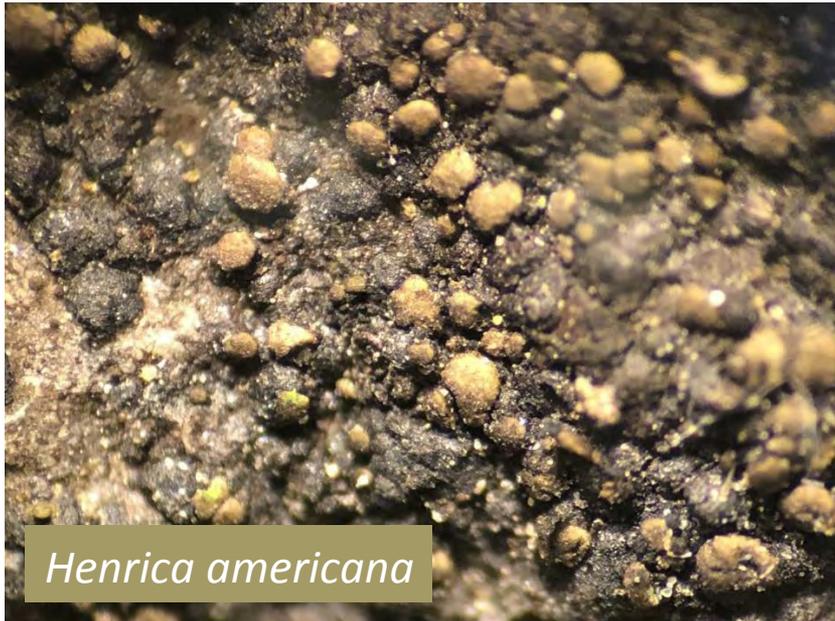
McLellan Lichens



Rocks of Sharon Lichens



Cool species finds



Management Suggestions

1. Update Development Practices

- Do not clean off the whole cliff face or even the whole strip that the route will be on, stick to the holds along the route and any loose rock
- Not every cliff face needs to be developed, not every single possible route needs to be created
- Cliffs with high bryophyte, foliose and fruticose lichen cover should be reconsidered for development, cliffs with higher crustose lichen cover prioritized.

2. Education and Climber Engagement

- Include climbers in impacts of rock climbing research and conservation management
- Educate climbers on the importance of lichens and bryophytes
- Create guidelines for seasonal cleaning and development to restrict the amount of damage to lichen and bryophyte communities

Acknowledgements

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Protect America's Climbing



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Questions?

