MIREN ROCKS

The MIREN rock survey

Pictures: Simon Dierickx

1 Overview of the MIREN rock survey protocol and contributions

The overall goal of the Mountain Invasion Research Network (MIREN) rock survey protocol is to study rock cliff vegetation around the world. We aim to (1) investigate the impact of rock climbing on these communities, (2) investigate the impact of rock climbing on the spread of alien plant species, (3) study the importance of rocks in species ranges edges, (4) compare the species composition of rock cliff vegetation with their surroundings and (5) assess the importance of the rock microclimates as microrefugia and on the distribution of rock vegetation. Data generated using the standardized protocol described in this document can be used to evaluate and quantify the processes and mechanisms shaping rock cliff communities at regional to global scales. We encourage the implementation of the protocol across the globe. We envisage revisiting the plots every five years to facilitate the investigation of long-term changes in rock vegetation. We primarily target bolted climbing routes (sport climbing, with fixed anchors), but we are open to trad(itional) climbing routes (without fixed anchors) as well. The protocol described below is developed for sport climbing. If you want to sample trad climbing routes, the protocol will be slightly different (see section 5.1). We explicitly exclude Bouldering and Via Ferrata (Or Klettersteig) routes.

If you plan to join MIREN Rocks, please let us know at miren.rocks@gmail.com!

2 Safety and permits

As rock climbing inherently carries a certain level of risk, we want to stress the importance of following all rock climbing safety measures. Only join the MIREN rocks survey if you have sufficient experience in rock climbing. MIREN is not responsible for possible accidents during the MIREN rock survey. We think it is also very important to reach out to the local climbing community and communicate openly about the goals of our research project. We encourage interested researchers to team up with local climbers since they often have invaluable information on the rock site, safety measures and the legal framework.

We recommend having two people to sample the plots. At least one team member should be familiar with the local flora. Identifying species while hanging on the rocks can be quite time-consuming if you're not confident in your plant knowledge. We approached the rock cliffs from above and rappelled down with two individuals, which helped manage tasks like securing the 1 m² plots, taking pictures, and recording all necessary data. A partner on the ground is essential, not only for belaying if necessary but also to provide general support, monitor safety, and manage equipment. This added support allows the climbers to focus on data collection, knowing assistance is immediately available if needed. When conditions and team allow, having a second climber work alongside the primary surveyor on an adjacent route can significantly improve field efficiency. With both climbers in close proximity, they can exchange equipment, share observations, and assist each other in real time. However, this approach requires that both team members be experienced climbers capable of handling simultaneous field tasks at height.

We used an additional safety rope, meaning we were secured to two ropes at all times. It's crucial to ensure there's no risk of accidentally unlocking your safety equipment. Some participants have used height work equipment rather than standard rock-climbing gear for safety and stability. A seat harness for ascents on a single rope (e.g., the Petzl Sequoia, designed specifically for height work for tree climbing) provides enhanced support and balance, ideal for field tasks on vertical surfaces. When ascending, static height work ropes are preferable to dynamic climbing ropes, as they offer stable, controlled positioning, which is a key feature for surveying biodiversity. Given the physical demands of this work, especially in dry or high-heat conditions, it's crucial to bring ample water and to work during cooler parts of the day when possible. Monitoring weather forecasts to select cooler, stable days will help maintain fieldworker comfort and productivity, reducing the risk of heat-related issues.

Lastly, be sure to contact local authorities or the organizations managing the rock climbing site to obtain the necessary permits for your fieldwork! If you install temperature sensors, make sure to communicate this to the local climbing community.

3 Protocol methodology

We will use a hierarchical approach for recording plant species on cliff faces (Figure 1). Within each **Site**, sampling occurs along one or more **Paired transects** (but see section 5.2 if sampling unclimbed transects is not feasible). A paired transect consists of one climbed and one unclimbed transect. Along each transect, plant species composition will be recorded in several **Plots** of 2 by 2 m². Sites are potentially subdivided into different **Sectors** (e.g. a north facing and a south facing sector within one site). Further description of Sites, sectors, Transects and Plots can be found below. We have set the minimum amount of plots to be able to join MIREN rocks at 30 (15 climbed + 15 unclimbed). Note, however, that unclimbed transects are not always easy to find, so you might end up with more climbed than unclimbed transects.

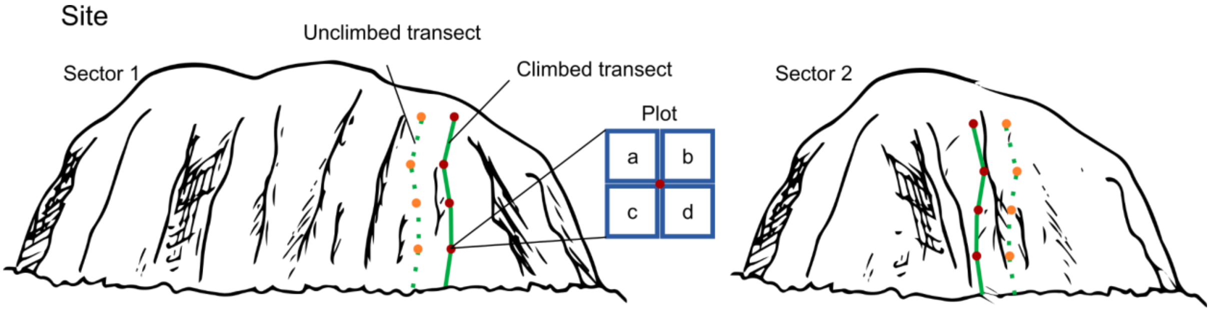


Figure 1: A rock climbing site with 2 paired transects (in total 2 climbed and 2 unclimbed transects). The vegetation is recorded in a plot of 2 m x 2 m, consisting of 4 subplots of 1 m² (a, b, c, d)

3.1 Site

In this survey, a Site is defined as a rock cliff which is used and equipped for rock climbing. The protocol is specifically designed for climbing sites with routes having fixed anchors (but see section 5), which are used to locate the plots and mark them for resurveys. It could be that a Site consists of different climbing Sectors, which are often physically isolated from each other. These sectors often get distinct names. If this is the case, the hierarchical protocol gets an additional fourth layer: Sites>Sectors>Paired transects>Plots.

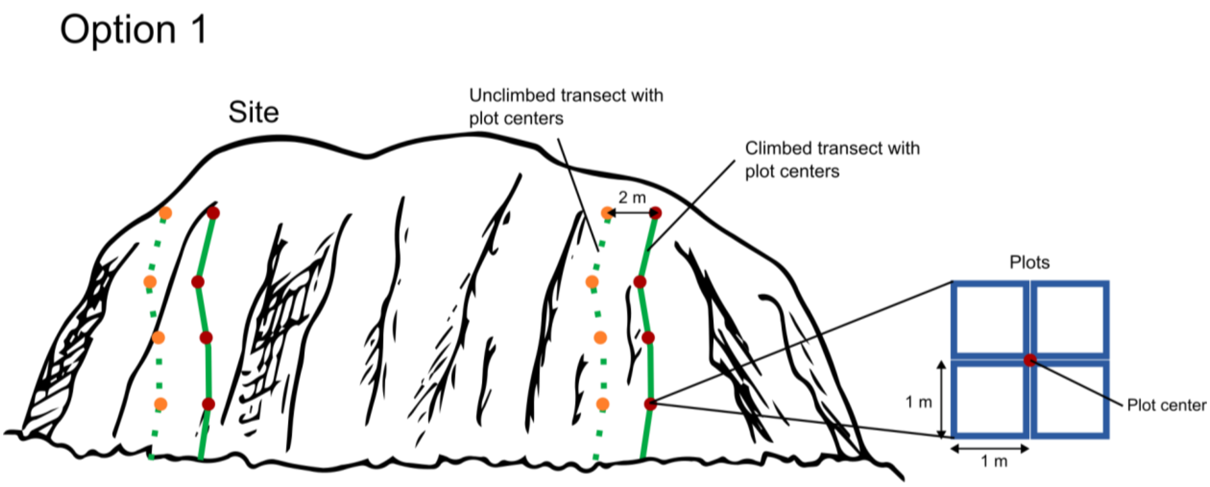
The delineation of a Site will depend on many local factors and we do not seek to constrain these. Ideally, a new Site should not be in, or part of, an existing 'MIREN rocks' site (see www.mountaininvasions.org for an up-to-date map). Please contact us (miren.rocks@gmail.com) before starting the survey to check whether your region is suitable for inclusion in the MIREN rocks database.

3.2 Paired transects

As much as possible, we will sample pairs of transects, consisting of a climbed and an unclimbed transect. A climbed transect is a climbing route, which is equipped with fixed anchors for climbing (e.g. bolts, pitons). These climbing routes should have a minimum length of 15 m. We did not set a maximum length. Unclimbed transects have no evidence of climbing (no chalk or permanent equipment), are not mentioned in local guidebooks and occur at least 2 m from established climbing routes (Harrison et al, 2022, see Figure 2 - Option 1). Given our 2 m by 2 m plots, centered around the bolted anchor, the plots of the climbed and unclimbed transect will touch at the sides. Please consider a wider spacing between climbed and unclimbed transects if you notice that the impact of climbing goes beyond 1 meter at either side of the bolted anchor. It is important that paired climbed and unclimbed transects have similar environmental conditions (e.g. slope, aspect, microenvironment) and only differ in terms of climbing use.

In climbing sites where a dense network of routes does not allow the placement of unclimbed transects directly next to the climbed transects as described above, the unclimbed transects could also be placed in a separate, unclimbed part of the rock site (Figure 2 - Option 2). Since bolting is missing here (or climbing is not allowed), we advise reaching the transect via the top of the rock (rappelling down). Also in option 2, paired climbed and unclimbed transects should have similar environmental conditions. If that is also not possible, consider contrasting highly popular with rarely used transects to get contrasting climbing intensity. If none of that works, see section 5.2.

There is no minimum amount of paired transects to survey to be included in the database, since transect length will differ considerably among regions. However, we estimate that at least 30 plots (15 climbed and 15 unclimbed) would be needed to have sufficient regional explanatory power. More might be necessary if the diversity and heterogeneity in microenvironments and plant communities are high, or if rock faces are very smooth and vegetation presence is low in general. In that case, consider monitoring across a range of climbing grades, as vegetation is usually more present on easier climbs. Of course, we want to stimulate you to sample as many plots as possible.



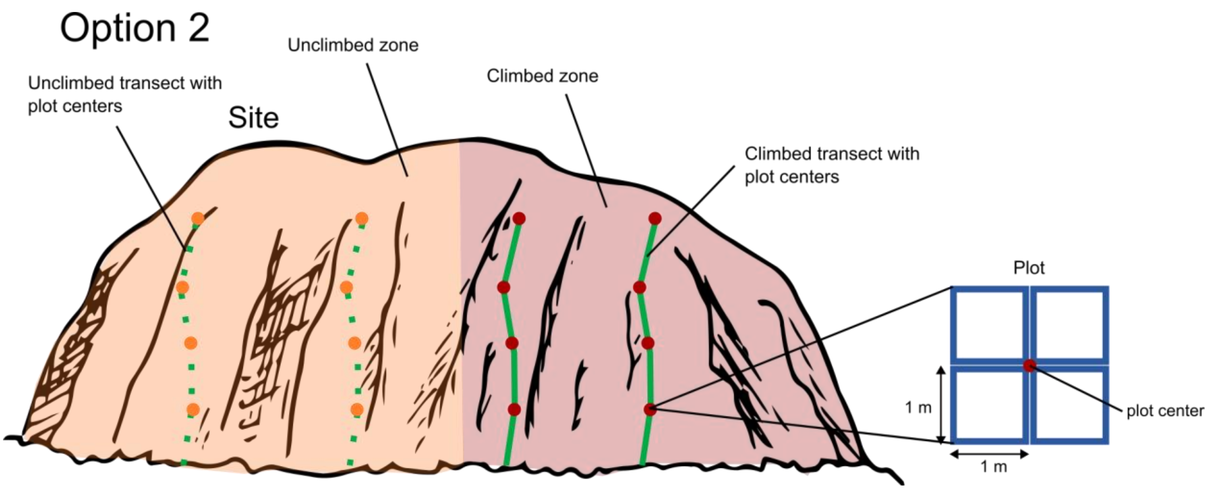


Figure 2: two options to position paired climbed and unclimbed transects within a rock site

3.3 Plots

Along each transect, we will sample the vegetation and environmental conditions in squared plots of 2 m by 2 m, consisting of 4 subplots of 1 m². For the climbed transect, the squared plots will be centered around the fixed anchors (e.g. fixed bolts and pitons). These fixed anchors serve as permanent markings and will allow resurveys in the future. The minimum separation between the plot centers of two consecutive plots should be 3 m. You should aim to have at least 3 plots per transect.

For option 1 (Figure 2), unclimbed transects will be chosen at either side of a climbed transect. The plot centers of the unclimbed transect will be positioned at the same height as the plot centers of the climbed transect and at a minimum distance of 2 m from the plot centers of the climbed transect. At this minimum distance of 2 m, the subplots of the climbed and unclimbed transect touch each other at the sides. Paired plots must have similar conditions (heterogeneity, slope, aspect). For option 2 (Figure 2), try to position the unclimbed plots at the same height as the climbed plots of the corresponding transect. Also here, pay special attention to having similar environmental conditions in paired plots.

We will work with a fixed grid of 1 m by 1 m (e.g. consisting of plastic tubes, see Appendix 6.1) to position the subplots around a plot center. We advise using chalk to draw each of the subplots consecutively on the rock, after which you can start collecting data in each of the subplots (see section 4).

4 Data collection

The following descriptions are based on the criteria to include a dataset in the global MIREN Rocks database. All data sheets must include the date of the survey and the names and emails of recorders to facilitate data checking. If you have any questions regarding data collection, contact miren.rocks@gmail.com.

All data should be submitted to miren.rocks@gmail.com using this template. For the northern hemisphere, the deadline to submit the data is October 30th 2024. For the surveys in the southern hemisphere, data should be submitted before April 30th 2025. Please contact us if sampling in the coming summer season in the northern hemisphere is too soon.

4.1 Site

- Country/location
- Site name: Official name of climbing site
- Type of cliff: Natural cliff, quarry, …
- Grade system of routes: Yosemite Decimal System, French Grading Scale, UIAA, Australian scale, UK system - numerical, UK system - adjective
- Is the site managed/cleaned for climbing purposes by local climbing organizations?: Yes/No
    - How is it cleaned?
    - How often is it cleaned? Multiple times per year/ once per year / once every few years
    - When was the last cleaning (if known?)
- If the Site has different sectors, also record the sector names
- Estimate of climbing intensity of site:
    - Numbers of climbers per year (in classes: 1: 0-100, 2: 100-500, 3: 500-1000, 4: 1000-2000, 5: >2000. Sources: climbing books, local climbing association or websites like thecrag.com or mountainproject.com)
    - Year of opening of the site
    - Climbing season length (months)
- Microclimate temperature (optional, see section 4.4)
- For communication purposes, we welcome pictures of the surveyed sites and of you when climbing and conducting the research protocol

4.2 Transect

- Geolocation: Coordinates should be recorded at the base of each transect and reported as latitude and longitude in decimal degrees using the WGS 84 datum; please check that the mapped locations are correct using GIS or Google Earth before submitting data.
- Elevation at the base of the transect: in meters above sea level; obtained using a digital elevation model or Google Earth; at the same locations as geolocation is recorded.
- Overall aspect/orientation (°) using a compass
- Overall slope (°) - overhanging transect (>90°), slab transects (<90°) using an inclinometer
- Type of rock substrate: we will follow the classification system of thecrag.com (see Appendix 6.2)
- Total length of the transect (m)
- Date of survey: dd/mm/yyyy
- For climbed transects:
    - Local name of the route
    - Year the route opened
    - Multipitch: Yes/No
    - Grade of route
    - Popularity of the individual climb (0-5; relative within the site) inferred by the number of stars or popularity (source: climbing books, local climbing association or websites like thecrag.com or mountainproject.com)
    - Time to approach the transect (in minutes)
- For unclimbed transects
    - Position compared to the paired climbed transect: Left/Right

- Distance to paired climbed transect (in m)

4.3 Plot

The following is to be recorded in each 2 m x 2 m plot:

- Plot code: Unique identifier for each plot, recorded in the form **Country.Site.Transect.PlotSubplot** (e.g. BE.FRE.C6.2a).
    - Country is the official two-letter country code (e.g. Belgium = BE).
    - Site should be three letters (e.g. FRE = Freyr). This code will be given to you by MIREN. If there are different sectors in one site, please number them (eg. FRE1, FRE2, …)
    - Transect consists of a letter (C1-C… for climbed routes, U1-U... for unclimbed routes) and a number. Transects are numbered from 1 onwards. Pairs of transects get the same transect number (e.g. C6 and U6 = 6th climbed and unclimbed transect).
    - Plots are numbered from 1 onwards, with 1 being the lowest plot. Paired plots should get the same number.
    - Subplots are labelled a (top left), b (top right), c (bottom left), d (bottom right) (see Figure 1)
- Name and cover of each species: see section 3.3.1 for species nomenclature information and see section 3.3.2 for the ordinal projective foliage cover estimates to be used.
- Height of the plot center above the base of the route (m)
- Anchor number (measured from bottom)
- Aspect (°) - measured using a compass
- Slope (°) - measured at plot centre using (in)clinometer
- At the subplot level: surface heterogeneity in classes (see Appendix 6.3)
- At the subplot level: total vegetation cover (by vascular plants, in %)
- Take a picture of every subplot

4.3.1 Species information

Vascular plants

All angiosperms, gymnosperms, and ferns, both native and non-native, that create foliar cover in a subplot are to be recorded.

- If a species can only be identified to the family or genus level, assign a region-specific name. This name should combine the taxonomic level, country code, site code, and a unique identifier (e.g., *Acacia BE.FRE1* or *Asteraceae BE.FRE2*).
- If a species cannot be identified even to the family level, use a name consisting of its life form (e.g., graminoid, herb, fern, vine, shrub, or tree), the region code, and a unique identifier (e.g., *shrub BE.FRE3*).

Bryophytes and lichens

Bryophytes (mosses, liverworts, and hornworts) and lichens present in each subplot will also be recorded. Since field identification of these groups is challenging, we will employ the following dual approach:

1. **Morphotype classification**
    - Bryophytes and lichens will be classified into morphotypes instead of species, following the guidelines in Appendix 6.4.
2. **Bryophyte harvesting**
    - In each subplot, a 10x10 cm square will be selected non-randomly to target the area with the highest density of bryophytes (if present).
    - Harvest all bryophytes within this square using a knife or similar tool. Place the collected samples in a pre-labeled paper bag (with the subplot code).
    - Dry the samples at room temperature for three days, then send them for identification to:
      Alain Vanderpoorten
      University of Liège
      [contact details]

Bryophytes - optional species-level identification

If in-house expertise is available for identifying bryophytes and/or lichens to the species level, such data is encouraged in addition to morphotype classifications. These observations should be recorded on the same form and using the same methods as those for vascular plants.

4.3.2 Species cover estimates

Estimate total plant cover (in %) of each plant species. Plant cover is defined as the proportion of the rock that is shaded by vegetation foliage when projecting it perpendicularly on the rock surface. This value needs to include cover from all locations of each species within the plot boundaries. Note that the sum of all species-specific cover estimates can exceed 100 % due to overlap in coverage. In order to help the estimation of the plant cover, you can find physical representations of 1, 2 and 5% as a reference in Appendix 6.5. We urge you to take these examples with you in the field.
Estimations are at the 1% resolution, yet for small plants, covers of 0.1 (~3 x 3 cm) and 0.5% (~7 x 7 cm) could be used. It is important to calibrate cover assessment among a survey team, and an accuracy assessment should be conducted (see Appendix 6.6). Surveying should only begin once accuracy standards have been met.

4.4 Microclimate measurements

The measurements of the microclimate temperature are optional. The goal is to measure microclimate temperature at the rock site level (or sector level) and compare it to the microclimate temperature of an open (non-shaded), flat habitat near the rock site. More specifically, we ask you to install (1) one temperature logger at the rock face of every site or at every sector within a rock site. Make sure to cover the different rock cliffs facing different directions, since we expect the microclimate to differ strongly between different directions, and (2) one temperature logger in an open (non-shaded), flat habitat near every rock site which serves as a control. The data should be delivered in the SoilTemp data format: https://www.soiltempproject.com/how-to-submit-data/.

Here, we describe the specifics of the temperature measurements:

- Temporal specifications of the measurements:
    - We ask you to measure temperature during the growing season for at least 3 months

    - Measure at a minimal temporal resolution of 1 measurement every 30 minutes.
- Installation location:
    - The logger in the rocks should also be installed above the trees and away from shrubs to avoid their shade. Being exposed to the sun, it is absolutely necessary to shield the sensors from the sun!
    - The logger in the open habitat should be installed just above the soil surface (e.g. between 5 and 15 cm above the surface) at a non-shaded location, far from trees or other shade-casting objects. Being exposed to the sun, it is absolutely necessary to shield the sensors from the sun! If there is a lot of wildlife in the region, it could be necessary to protect the logger with a wire cage (e.g. a shopping basket).
- Recommended loggers:
    - We recommend using the TOMST Thermologger on the rock face, because it is very accurate and it comes with a handy screw to attach it to the rock (Figure 3). Best use the included screw and a plug (not included) to attach it to the rock. Please make sure to order the triple radiation shield from TOMST to shield this logger from the sun (per default it comes with a single shield). This logger can also be used to measure the temperature in the open, flat habitat. Maclean et al. (2021) have shown that a single radiation shield is not enough.
    Note: installing the microclimate sensors on the rock face can be challenging. Some cliffs have cracks that you can utilize, while others don't. Some participants have used drills, but that can add extra complexity to the process.
    - For the open flat habitat, you can also use the Thermologger, or you can use the (more expensive) TOMST TMS-4, which is specifically designed to be installed in the soil. Please make sure to order the triple radiation shield from TOMST to shield this logger from the sun (per default it comes with a single shield). If these TOMST sensors are not available in your country, we recommend using Lascar or Hobo loggers (or another brand with similar accuracy), installed with a Gill-style radiation shield (which can be self-made, see Figure 4).

Figure 3: TOMST Thermologger can be used to measure the temperature at the rockface, as it comes with a handy screw and triple radiation shield. Pictures from https://tomst.com/, Jonas Lembrechts and Kobe Burdack

Figure 4: Lascar logger with a self-made double radiation shield, made from two white funnels. The inner funnel has holes to stimulate air flow. Pictures from Pieter De Frenne

4.5 Surrounding vegetation

To answer research questions 3, 4 and 5, we would need information on plant species occurring in open habitats in the region surrounding the surveyed rock sites. Therefore, we ask you to provide a list of plant species that occur in open natural habitats in the region surrounding the surveyed rock sites. This list can be expert-based or extracted from databases, like GBIF. If you have the time or just happen to have data, community data (i.e. plot-level data) are welcome as well (but not mandatory).

5 Deviations from standard protocol

5.1 Traditional climbing

The protocol above is developed for sport climbing routes with fixed anchors. If you want to join with a traditional climbing site, there are a few things to consider:

- If you aim to compare climbed and unclimbed transects (but see 5.2), make sure the climbed transect is being climbed (e.g. existing route in a climbing book, signs of chalk). The same for unclimbed transects: make sure it is not climbed.
- Since it will be hard to have permanent markings to facilitate resurveys, we don’t consider these sites for future resurveys
- Data on anchor numbers are not needed
- Be extra careful!!

5.2 Only climbed transect

If it is not possible to sample unclimbed transects, your data can still be valuable (e.g. for research questions 3 to 5). So also welcome data from only climbed transects. For this, you follow the same protocol as above, but omit the data collection along unclimbed transects. The minimum amount of plots to be able to join MIREN rocks is still 30. Hence, now you’ll have to sample at least 15 plots along climbed transects.

6. Appendices

6.1 Fixed frame

We advise using a frame consisting of two plastic tubes of 1 m, connected with 1 m ropes (Figure 5). Best to hang the frame to a second rope with a prusik knot for easy vertical movement along the wall. A sprit level attached to one of the tubes allows to level the frame horizontally. Adding coloured tape could aid the estimation of the species cover (Figure 6).

Figure 5: Fixed frame connected with a prusik knot to a second rope

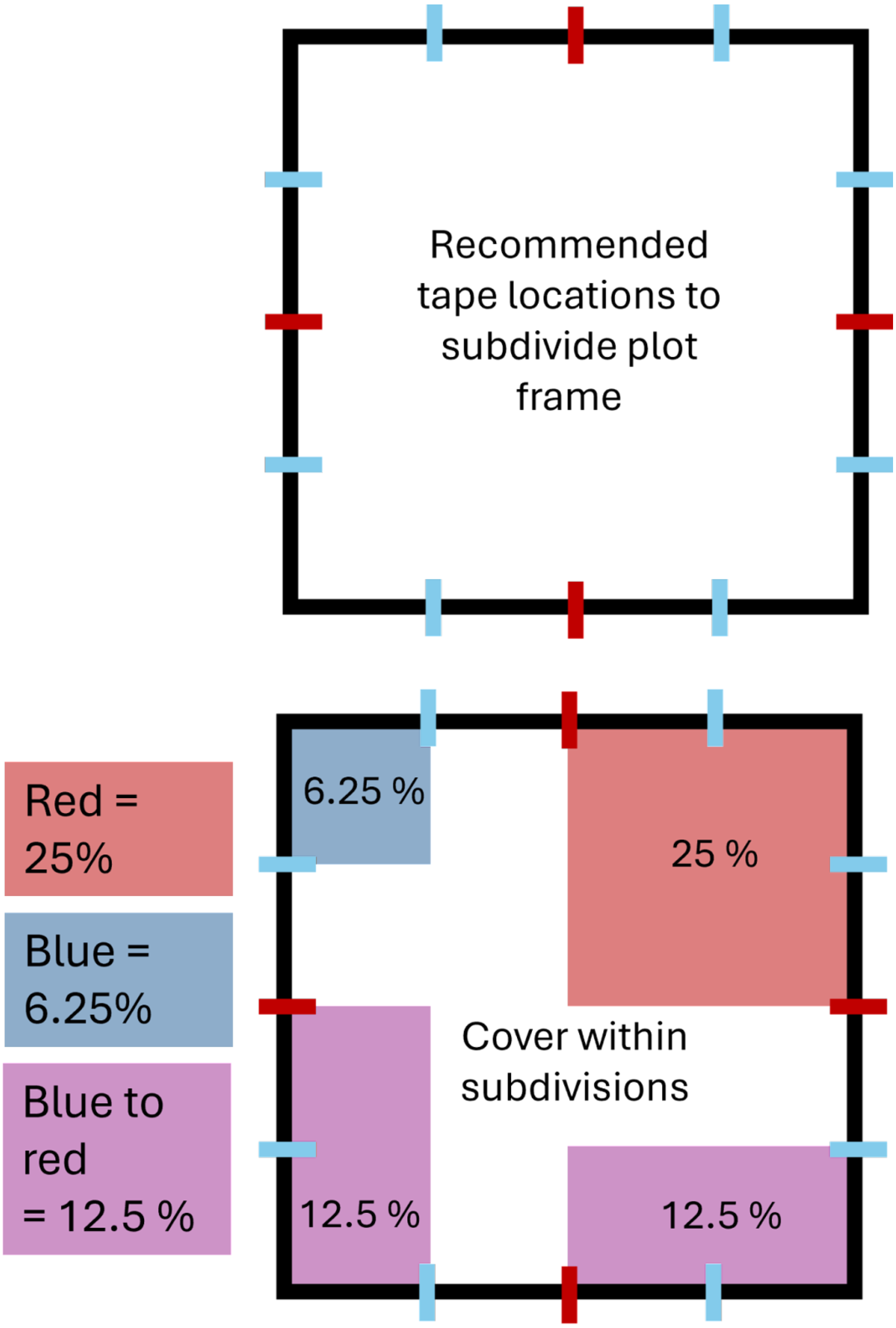


Figure 6: Recommendations for plot subdivisions to assess cover using colored guides (tape). Figure from Georgia Harrison & Laura Boggess

6.2 Geological substrates

We will follow the classification system of thecrag.com, which can be downloaded here. For more information, you can visit thecrag.com

6.3 Surface heterogeneity classification (Protocol from Georgia Harrison & Laura Boggess)

Surface heterogeneity describes the abundance and size of surface features on cliff faces such as ledges, pockets, and cracks. These features can capture soil, water, and propagules so quantifying their abundance is key to understanding cliff-face vegetation. In addition, overhanging features can impact the vegetative community below, and their presence should be considered.

Assign a surface heterogeneity value between 0-10 for each plot. 0 is smooth rock, 10 is highly fissured. Score only the rock, so if vegetation is present, try to picture the plot without any vegetation or soil, and score only the rock. See photos (Figure 7) below for proposed examples.

Only quantify features **within the plot**. Exclude features that are not inside the plot boundary. Note if a plot is below an overhang. Overhangs should be at least 0.5 m deep.

Table 1. Example Table of plot-level abiotic information to be collected:

Subplot ID	**Surface heterogeneity (0-10)**
BE.FRE.C6.2a	2
BE.FRE.C6.2b	4

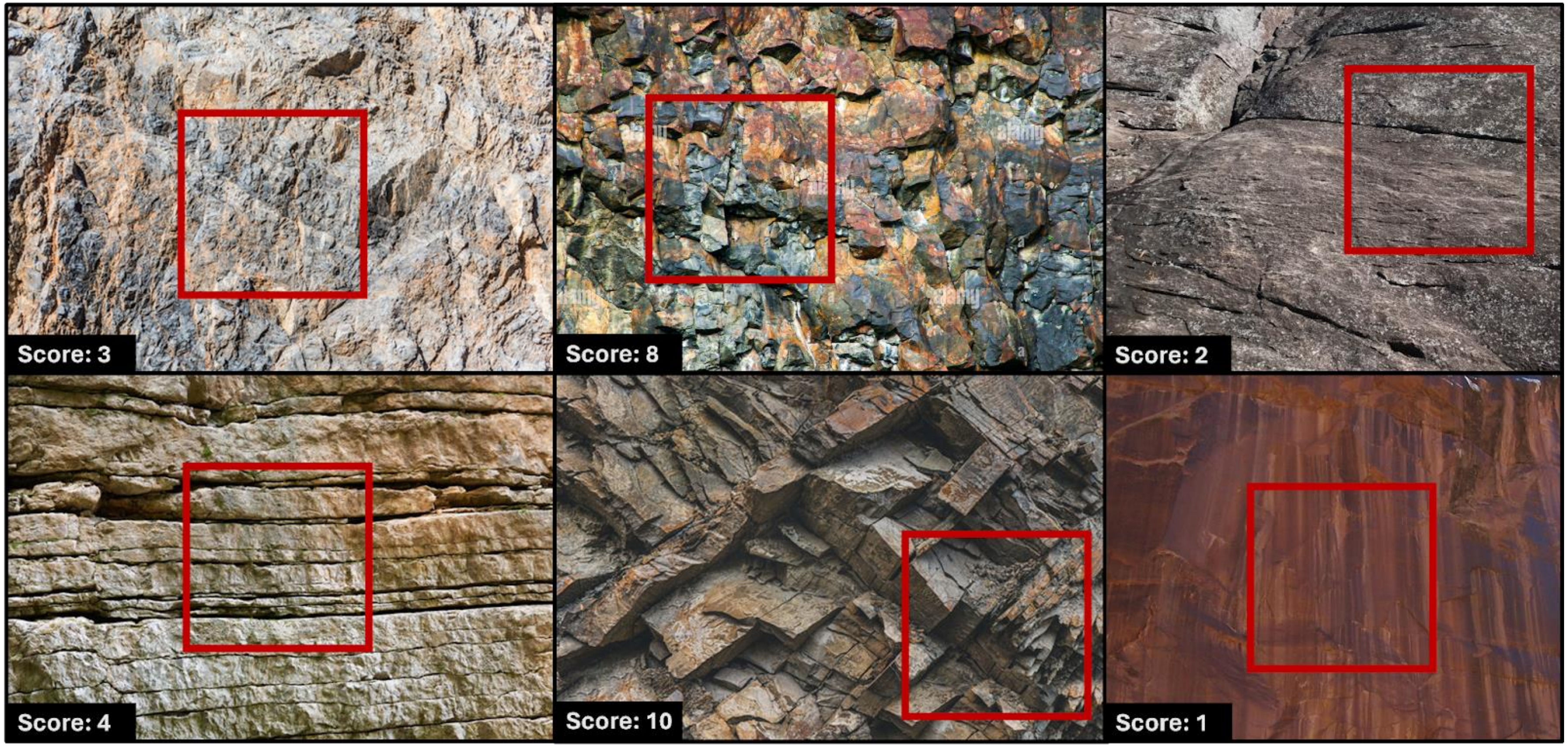


Figure 7: Example cliff face photos to score surface heterogeneity. Red box is plot frame, only score surface heterogeneity within plot frames. Not included in photos is the distinction between overhanging or non-overhanging features.

**Note: these photos are just found from the internet, but it may be useful to create a guide with example photos and their scores with photos from a specific site.*

6.4 Bryophyte and lichens classification (Protocol from Georgia Harrison & Laura Boggess)

Lichens and bryophytes (mosses, liverworts, and hornworts) are the most abundant and diverse taxa on cliffs. While identification can be challenging, collecting at least some data for these groups is essential to understanding ecological processes on cliffs. When species identification is not possible, recording cover for lichen and bryophyte morphotypes can still provide valuable information. Here, we use this morphotype identification in addition to species-level identification of bryophytes by Alain Vanderpoorten using 10x10 cm samples (see under 4.3.1).

Lichens and bryophytes (mosses, liverworts, and hornworts) are the most abundant and diverse taxa on cliffs. While identification can be challenging, collecting at least some data for these groups is essential to understanding ecological processes on cliffs. When species identification is not possible, recording cover for lichen and bryophyte morphotypes can still provide valuable information.

<u>6.4.1 Lichens</u>

Lichens are symbiotic organisms composed of fungi and algae or cyanobacteria. They are phenotypically plastic and the same species can look different under different environmental conditions, making them difficult to identify in the field. To meet this challenge, we recommend assigning a unique morphotype to each unidentified species of lichen.

Lichens are generally categorized into three main growth forms (Figure 8):

1. Crustose: These lichens form a crust adhering tightly to the substrate. They cannot be removed without damaging the substrate. Crusts are the most common morphotype in cliff plots.
    a. *optional*: Powder lichens are a subtype of crusts whose bodies (thalli) are covered in powdery lichenized propagules and tend to occupy ecologically different niches from non-powder crustose lichens. To distinguish between powder or non-power lichens, rub a finger on top of the thallus and if dust or powder comes off, this organism can be classified as a powder lichen.
2. Foliose: These are leaf-like lichens that are attached at some points, allowing some parts to lift away from the substrate. They generally have a flat, leafy appearance and a distinct upper and lower surface.
3. Fruticose: These lichens are bushy or hair-like and grow away from the substrate in all directions. They are often cylindrical or branched and do not have a distinct upper and lower surface.

When collecting lichen data, describe the morphotype by determining growth form, then noting the color and texture (Table 2). Overall, classifying into lichen morphotypes is still likely underestimating overall diversity. As a result, if you're not sure if two lichens are the same or different species, split the species and give it a different descriptor for morphotype so that you could recognize it in future plots. It is better to have more, distinct groups which are recognizable in future plots than fewer, coarse groups.

Table 2. Example Cover table for functional groups. For Taxon Group, L = Lichen, B = Bryophyte

Subplot ID	Taxon Group	Growth form	Color	Texture/additional notes (optional)	Cover (%)
BE.FRE.C6.2a	L	Crustose	White	bubbles	10
BE.FRE.C6.2b	B	Acrocarp moss	Light green	feathery	15

Figure 8: Three main lichen morphotypes. Powder lichens (not pictured) are a sub-type of the crustose group.

6.4.2 Bryophytes

Bryophytes are non-vascular plants, including mosses, liverworts, and hornworts. They are typically found in moist, shaded environments. First, determine the major group (Figures 9 and 10).

1. Mosses: usually have clearly differentiated stems and leaves. They grow in dense green clumps or mats.
2. Liverworts: can be leafy like mosses, but often have a flatter, more ribbon-like appearance with less obvious differentiation between stems and leaves. They can also be thalloid, which are flat and spread out like a thin crust.
3. Hornworts: These have a thalloid body similar to some liverworts but differ mainly in their reproductive structures which are elongated and horn-like.

Mosses can be further delineated into two main groups: "acrocarp" and "pleurocarp" based on growth patterns and reproductive structures (Figure 9). Acrocarp vs Pleurocarp:

1. Growth Pattern: Acrocarpous mosses grow upright and tend to form dense clumps, while pleurocarpous mosses spread out, forming mats.
2. Reproductive Placement: Acrocarpous mosses have reproductive structures at the top of vertical stems; pleurocarpous mosses bear theirs along the sides of branches.
3. Environmental Preference: Acrocarpous mosses are more adaptive to varying moisture conditions and can survive drying, whereas pleurocarpous mosses thrive in consistently wet habitats.

Figure 9: Major groups of mosses: Top row: acrocarpous moss with reproductive structures on the tip of the stalk. Bottom row: pleurocarpous moss with the reproductive structure emerging from a side branch

Figure 10: Left: Hornwort with typical horn-like reproductive structures. Right: Liverwort, here with umbrella shaped reproductive structures

6.5 Physical representations of 1, 2 and 4% cover as a reference (print on A4 format!)

1%

This square should be
10 cm x 10 cm

2%

This square should be
14.14 cm x 14.14 cm

4%

This square should be 25 cm x 16 cm

6.6 Setting accuracy standards (Protocol from Georgia Harrison & Laura Boggess)

To ensure data collection with high accuracy, conduct a calibration test and accuracy assessment for surface heterogeneity and cover (either virtually or in-person) at each site. The team leader should explain the protocol and provide a few examples (i.e. show a picture of a plot with a surface heterogeneity score of 0, 5, and 10) and justification for the score. Then, to ensure that the sampling group will be consistent, each member of the group should conduct their own assessment for standard plots. Repeat until the group is consistently scoring within accuracy standard.

We recommend using a 10% accuracy standard, and aiming for at least three plots in a row that meet the accuracy standard. Virtually, this accuracy assessment could also be conducted with a form or survey, but it is best if surveyors receive instant feedback (i.e. I scored this plot a 5, but the team agrees it is a 3).

Table 3. Example accuracy training table for surface heterogeneity. Set a standard for accuracy (i.e. within 1 surface heterogeneity unit, or within 10% cover).

Plot	**Surface heterogeneity (personal)**				
	Team member 1	**Team member 2**	**Team member 3**	**Team member 4**	**Meeting accuracy standards?**
A	8	2	5	6	No
B	6	4	7	5	No
C	9	8	8	9	Yes