Monitoring Lichens at Black Rock with Citizen Scientists

M.Harding 7/1/2013

> "The most imminent threat to lichen diversity in the park is climate change. A climate shift causing greater aridity in southwestern North America would lead to the slow extirpation of many rare species that occur in the Mojave Desert and may already be under way. Many of these rare species are thought to be relics, most likely surviving from the Pleistocene, when the climate was wetter."
>
> -**Kerry Knudsen**, *The Lichen Flora of Joshua Tree National Park*

Overview

In 2010, park staff, with the help of lichenologist, Kerry Knudsen, developed a protocol with the goal of studying the long-term effects of a changing climate on lichen community composition in Joshua Tree National Park. The protocol was designed using easily repeatable methodologies, not requiring expertise, in order to implement using citizen scientists with the dual purpose of serving as an educational outreach opportunity. Results of this project have provided us with simplistic baseline data about lichen presence and absence at a site near Black Rock Campground, but more importantly, has connected over 70 local high school students with the park and some of the more inconspicuous life forms it is working to conserve.

Background

Of the 145 different species of lichen found in Joshua Tree National Park, approximately one quarter are "montane" species, restricted to high elevation sites, and most likely persisting from the Pleistocene when the California deserts were less arid. These unusual desert montane lichen communities are made up of species that more commonly occur above 6000ft, but in JOTR are rare (where the highest elevations barely exceed 5500ft) and highly sensitive to the drying climate (Knudsen et al 2013). Most climate models are projecting the temperature could continue to increase three to six times the warming already observed in Joshua Tree National Park over the last century, along with decreases in annual precipitation (Gonzalez 2012). The implications of such change could mean significantly reduced lichen diversity in JOTR, and places heightened importance upon the inventory and conservation of high elevation lichen communities within the park.

In order to understand how the park's montane lichen communities are responding to climate change, we realized the need to collect baseline data about their current condition with which to compare future data. Considering the almost imperceptible growth rate of desert lichens, the lack of resources designed for in the field identification, and difficulty of species differentiation even among experts, this proved to be a difficult task while maintaining the goal of using simplistic methodologies suitable for a citizen science protocol.

Participating Citizen Scientists

The annual Student Summit on Climate Change is a collaborative effort between Joshua Tree National Park and its partners; Joshua Tree National Park Association and the National Parks Conservation Association. It was designed in 2008 as a way to gather high school students from the surrounding underserved communities of the California desert and teach them about climate change, its affect on park resources, and to inspire students to engage their schools and classrooms in an ongoing dialog about climate change. Park staff recognized this venue as a great opportunity for implementing a citizen science protocol documenting lichen communities projected to be negatively affected by an increasingly warming and drying climate.

Over the course of the last four annual Student Summits on Climate Change, 72 students have participated in the lichen monitoring protocol. Each year, roughly 20 students are selected by their teachers, and bused in from local area high schools including Desert Hot Springs, Coachella, Palm Springs, Morongo Valley, Yucca Valley, and Twentynine Palms. The students spend the first half of the day participating in discussions and educational exercises designed to get them thinking about climate change, how what they do might affect the global climate, and how the change in climate will affect their surroundings. In the afternoon, the kids are broken up into groups and lead to a nearby site which hosts a prolific montane lichen community. Here they learn about the scientific method and how to execute a scientific study designed to capture the measurable affects of climate change on our natural resources.

Methods

There are five permanent monitoring sites, each with a specific 8.5”x11” panel which is relocated each year by park staff using GPS localities and photographs. The study sites were chosen in 2010 based on ease of accessibility from Black Rock Campground (where the Student Summit takes place), and the presence of our target montane lichen communities.

Park staff selected five boulders interspersed across a north facing slope approximately 0.3 miles east of the Black Rock Nature Center and marked each with a piece of capped rebar adjacent to the rock. Numbers 1-5 were assigned to the sites and engraved into the rebar cap, and a GPS point was recorded for each site. On each rock, one 8.5”x11” panel was selected, aimed at trying to capture the highest diversity of lichens for observation. The panel corners were marked with painters tape. Aspect, slope, and measurements describing the location of the panel on the boulder face (distance from ground, distance from edge of rock, etc.) were recorded (Table 1). Three photos of each panel were taken; one 1 meter away, one 5 meters away, and one close-up. See Appendix A for photo documentation.

Table 1. Black Rock lichen panel site location information recorded by Mitzi Harding and Vicky Chang during project establishment on 5/3/2010.

Site ID	UTMs (NAD83) E	UTMs (NAD83) N	Elev (m)	Aspect	Slope Panel	Slope Hillside	Rock Type	Placement (top left corner of panel) Vertical	Placement (top left corner of panel) Horizontal	Notes
1	556717	3770474	1214	5	70	20	Gneiss	42 cm to ground	45 cm to adjacent rock to the east	larger rock to east shading rock panel
2	556658	3770460	1217	344	70	15	Gneiss	78 cm to ground	52 cm to east edge of rock	*Coleogyne ramosissima* directly in front of rock, not affecting exposure
3	556659	3770488	1212	340	52	20	Gneiss	200 cm to ground	20 cm to west edge of rock	*Stipa speciosa* to the west, may affect exposure
4	556651	3770471	1216	344	72	22	Gneiss	51 cm to ground	70 cm to west edge of rock	
5	556683	3770473	1214	0	54	12	Gneiss	47 cm to ground	32 cm to adjacent rock to the west	

Lichenologist, Kerry Knudsen, visited the Black Rock lichen panels in 2011 in order to identify which lichen were growing in each of the panels (Table 2). Some species were identified to species level, if a field ID was easily achieved, but most were only identified to genus. Identification of those specimens to the species level would have required obtaining a collection and further investigation in the laboratory, but in an effort to leave the study panels undisturbed, it was agreed that ID to the genus level would suffice.

Each year, on the morning of the student summit, park staff relocates the same 8.5” by 11” panels using the photos and measurements from 2010, and mark the corners with painter’s tape. Students are broken into 5 groups, and each group is assigned to a particular site for the afternoon. First, they are asked to carefully study the panel using hand lenses, magnifying glasses and flashlights, then give detailed descriptions of all the different types of lichen they see. They are provided with a guide to help them learn appropriate terminology and standards of descriptions. Next, the students are asked to determine the percent cover within the panel of each of the different lichen species they just described. This is achieved by overlaying the panel with an 8.5”x11” sheet of plasticine transparency film. The transparency bears a grid of 494 square centimeters. The students must choose one of the lichens to observe, attach the transparent grid to the rock(carefully lining it up with the taped corners of the panel) then carefully mark each square in which the lichen occurs in with a marker. They repeat this step for all of the lichens they listed and described, using a new transparency sheet for each of the lichens. Finally, the students count the number of squares occupied by each of the lichens and calculate the percent cover. Afterwards, the lichen descriptions and calculations are matched with the genera known to occur on the panel. See Appendix B for the description guide, protocol, data sheet, and grid handouts.

Table 2. Summary of Black Rock lichen panel survey performed by Kerry Knudsen 04/11/2011. Specimens not identified to the species level would require damage to the study site for further identification.

	Lichens observed	**Description**
Site 1	*Xanthoria elegans*	orange with round margin/thallus
	Xanthoparmelia sp.	light green foliose
	Physcia sp.	grey foliose
	Candelariella sp.	mustard yellow
	Lobothallia praeradiosa	brown/green/grey/tan; big highly developed thallus
	Sarcogyne or Lecidea	black crustose
Site 2	*Candelariella sp.*	mustard yellow
	Acarospora socialis	bright green/yellow
	Physcia sp.	grey foliose
	Xanthoparmelia sp.	light green foliose
	Aspicilia sp.	grey/black crustose
	Lecidea sp.	black crustose
	Sarcogyne pravigna	black crustose (turns reddish when wet)
	Xanthoria elegans	orange with round margin/thallus
Site 3	*Aspicilia cuprea*	charcoal grey
	Xanthoparmelia sp.	light green foliose
	Candelariella sp.	yellow
	Acarospora sp.	brown
	Lecidia sp.	black (darkest on panel)
	Heteroplacidium compacta	brown crustose
	Acarospora socialis	bright green/yellow
Site 4	*Candelariella sp.*	mustard yellow
	Xanthoparmelia sp.	light green foliose
	Aspicilia sp.	grey, flat and crusty
	Lobothallia praeradiosa	brown/green/grey/tan; big highly developed thallus
	Heteroplacidium compacta	brown crustose
	Caloplaca sp.	orange/red/rust
Site 5	*Candelariella sp.*	mustard yellow
	Acarospora socialis	bright green/yellow
	Aspicilia sp	grey/black crustose
	Xanthoparmelia sp.	light green foliose
	Lobothallia praeradiosa	brown/green/grey/tan; big highly developed thallus
	Caloplaca sp.	orange

Results

The data collected over the last four years was intended to be combined and averaged in order to provide future researchers with a fairly accurate snapshot in time of lichen diversity and relative abundance in the Black Rock "Student Summit Panels". Most of the students' observations and calculations across the four years of the study have been more variable and inconsistent than expected. Only the genera which are very easily distinguished from the others, or the rock itself, in color and/or form were included in the final results due to the extremely high variance in the data reported for more cryptic species such as *Aspicilia sp.* and *Sarcogyne sp*. (Table 3).

Table 3. Aggregated results of the student's data across four years of observation. Mean, standard deviation, and relative standard error highlight low precision and high variation around the mean of percent cover recorded each year.

Panel ID	Lichen	Calculated Percent Cover				Mean % cover	Standard Deviation	Relative Standard Error
		2010	**2011**	**2012**	**2013**			
Site 1	*Xanthoria elegans*	15	11	13	12	12.75	1.71	6.7%
	Xanthoparmelia sp.	24	15	12	22	18.25	5.68	15.6%
	Candelariella sp.	29	18	28	40	28.75	9.00	15.6%
		2010	**2011**	**2012**	**2013**			
Site 2	*Xanthoparmeliasp.*	18	6	14	13	12.75	4.99	19.6%
	Physia sp.	5		7		6.00	1.41	11.8%
	Xanthoria elegans	5	4	5	7	5.25	1.26	12.0%
	Acarospora socialis	13	8	13	22	14.00	5.83	20.8%
	Candelariella sp.	27	18	22	19	21.50	4.04	9.4%
		2010	**2011**	**2012**	**2013**			
Site 3	*Xanthoparmelia sp.*	47	22	60	53	45.50	16.54	18.2%
	Acarospora socialis	7	12	7	11	9.25	2.63	14.2%
	Candelariella sp.	13	10	11	18	13.00	3.56	13.7%
		2010	**2011**	**2012**	**2013**			
Site 4	*Xanthoparmelia sp.*	26	46	43	39	38.50	8.81	11.5%
	Candelariella sp.	11	21	14	15	15.25	4.19	13.8%
	Caloplaca sp.	2	1		2	1.67	0.58	17.3%
		2010	**2011**	**2012**	**2013**			
Site 5	*Xanthoparmelia sp.*	21	23	20	30	23.50	4.51	9.6%
	Candelariella sp.	36	38	18	37	32.25	9.54	14.8%
	Caloplaca sp.	3	4		3	3.33	0.58	8.7%
	Acarospora socialis	6	6	6	7	6.25	0.50	4.0%

Since the students were given a grid of 494 cm^2 , and asked to mark each 1 cm^2 square in which a given lichen occurs, regardless of how small the portion of thallus falling in that square, we expected the actual area of distribution to be very imprecise. Hence, recording the value of % cover seemed to give a better picture of how much of each lichen occurred on the panels relative to the other co-occurring lichens on the same panel. This method was utilized with the goal of gaining an understanding of relative abundance of one lichen compared to another. In time, if conditions do indeed get warmer and drier, one would expected more drought tolerant species such as *Acarospora socialis* to increase in % cover, while species more sensitive to drought such as *Xanthoparmelia sp.*, would decrease in relative abundance.

Discussion and Conclusion

Lichens are extremely slow growing and the precision with which they must be monitored would be better achieved with a system less prone to observer error, especially considering the use of unskilled citizen science participants. In the pursuit of creating a monitoring protocol suitable for untrained citizen scientists, specifically high-school students, the detail and precision required for obtaining a data set accurate enough for comparison with future data sets and detecting change was compromised.

The inconsistency of the student's data is likely due to a variety of factors. First, the exact placement of the panels from year to year was not precise enough. Relocating the exact 8.5"x11" panels with no permanent markers in the actual rock face proved to be very difficult. Students also struggled with holding the transparency still while marking the squares in which each lichen occurred. This issue could be easily overcome by drilling a few bolts into the rock to permanently mark the exact panel, and punching holes into the transparencies to hang them from said bolts. Second, the level of attention to detail and desire for accuracy varied greatly from group to group. One group would use the entire allotted time, and others would be done within an hour. Perhaps, if the students had more time, we could ask each group to rotate sites and evaluate each panel. This method would give us higher replications of data collected, more data to aggregate, and therefore lower our overall relative standard error. Another solution could be that staff members and/or teachers placed with each group stay more focused on quality control of the data collected.

The data set obtained from this exercise will serve as a simple presence/absence record of the most conspicuous members of the lichen communities on the Black Rock Lichen Panels. However, the simple, easy to use protocol succeeded in giving students the ability to closely observe, describe, and learn about lichen, while gaining experience in scientific data collection and data analysis as it relates to measuring the effects of climate change. Another protocol should be developed using photo-technology to document the lichen panels year after year, as well as other rare montane communities (not restricted by ease of access by citizen science) on

our highest peaks such as Quail and Queen Mountains. This is likely the best approach to detecting real change in lichen cover and distribution over time. With the right hardware, this could be achieved using citizen scientists, but simply using trained staff may prove to be a better use of time and money.

Literature Cited

Gonzalez, P. 2012. Climate Change Trends and Ecological Vulnerabilities for Planning at Joshua Tree National Park. National Park Service, Washington D.C.

Knudsen, K., M. Harding, and J. Hoines. 2013. The lichen flora of Joshua Tree National Park: An annotated checklist. Natural Resource Technical Report NPS/JOTR/NRTR—2013/743. National Park Service, Fort Collins, Colorado.

Appendix A:

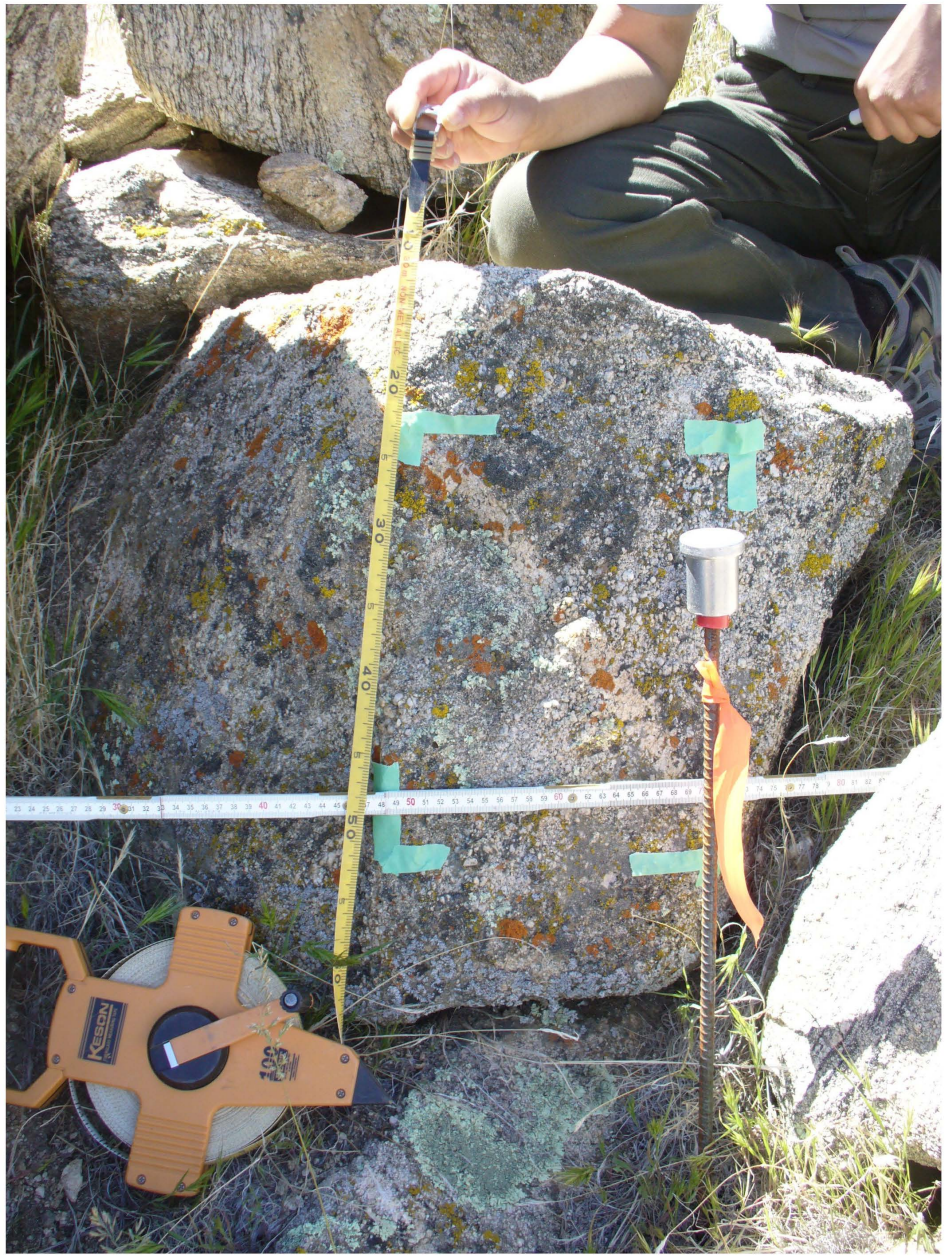
Photo Documentation of Black Rock lichen monitoring panels.

Photos by Mitzi Harding and Vicky Chang, April 2010.

Site 1

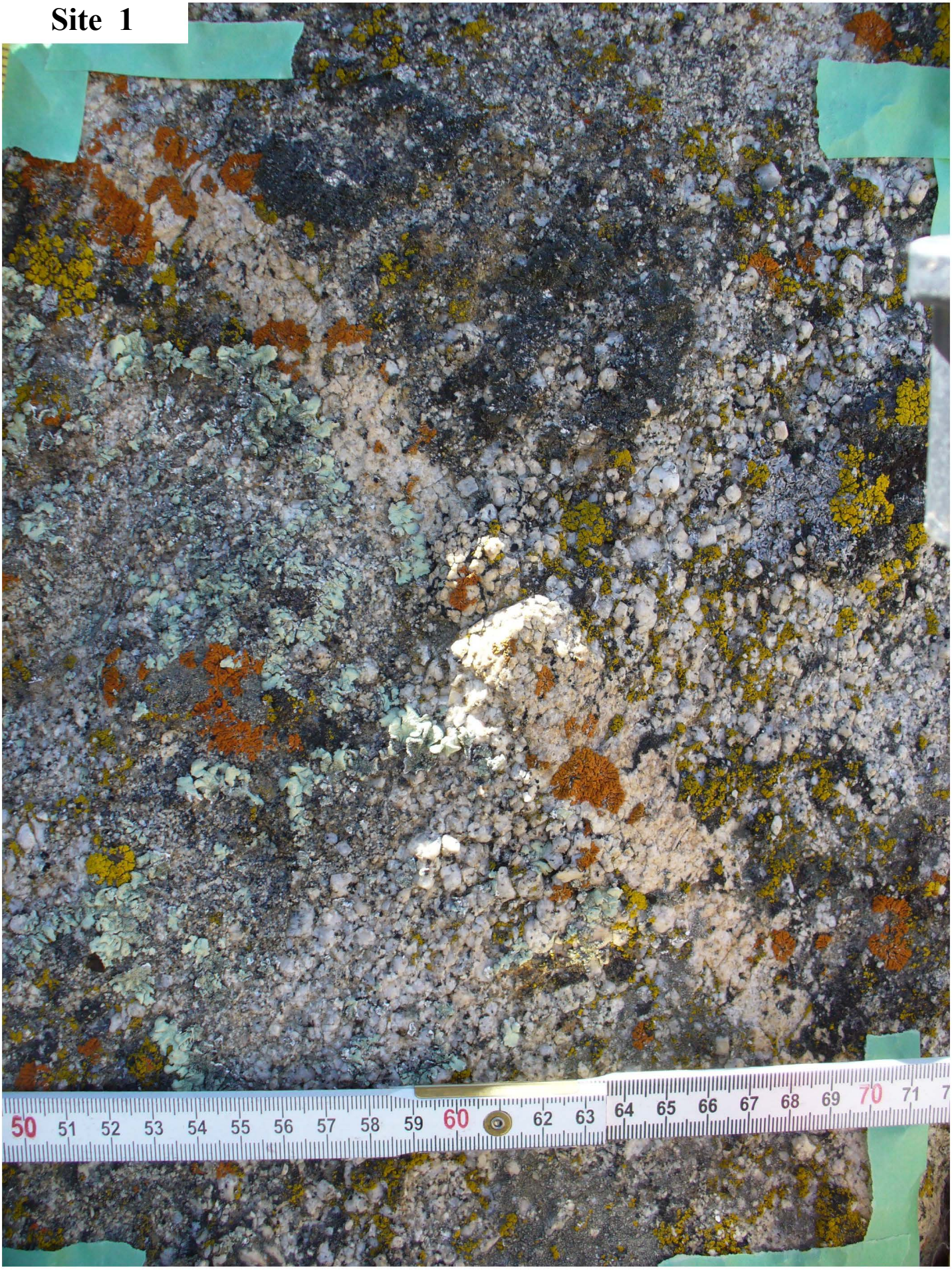
NAD83 556717E / 3770474N

1 meter away



3 meters away

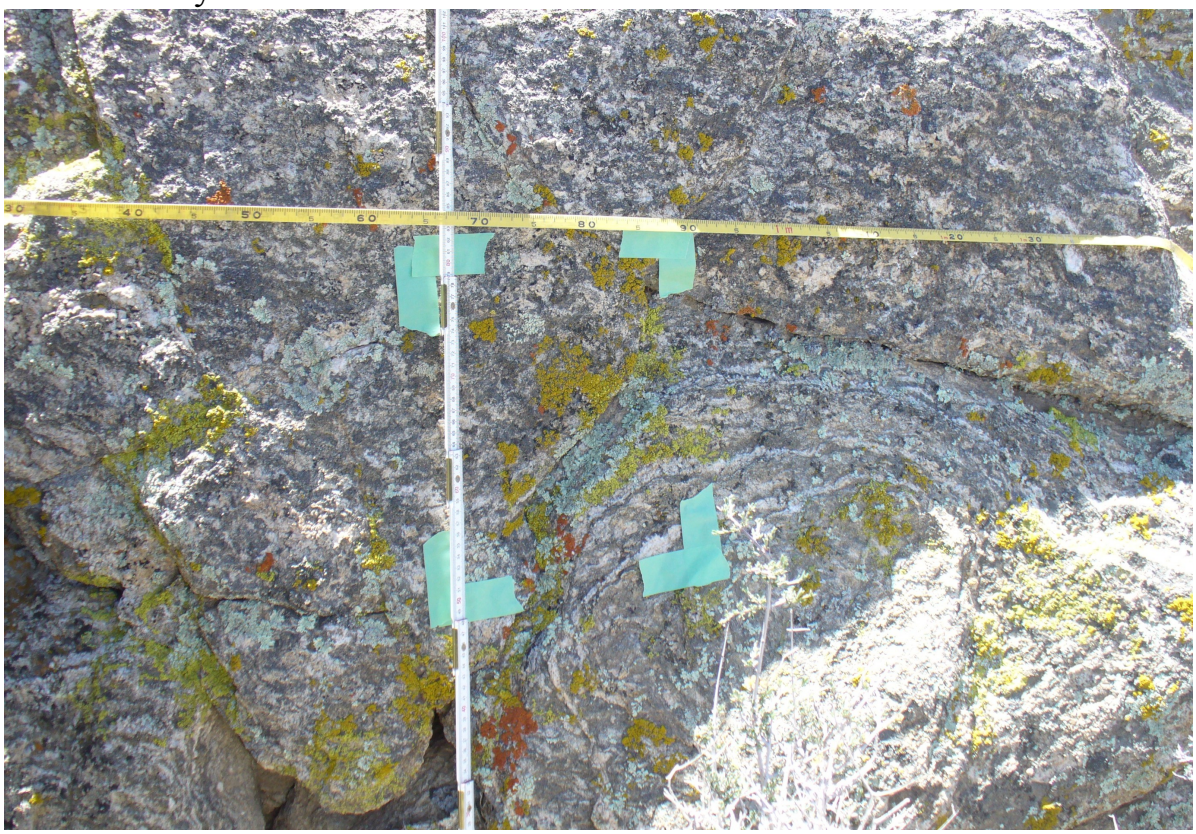
Site 1



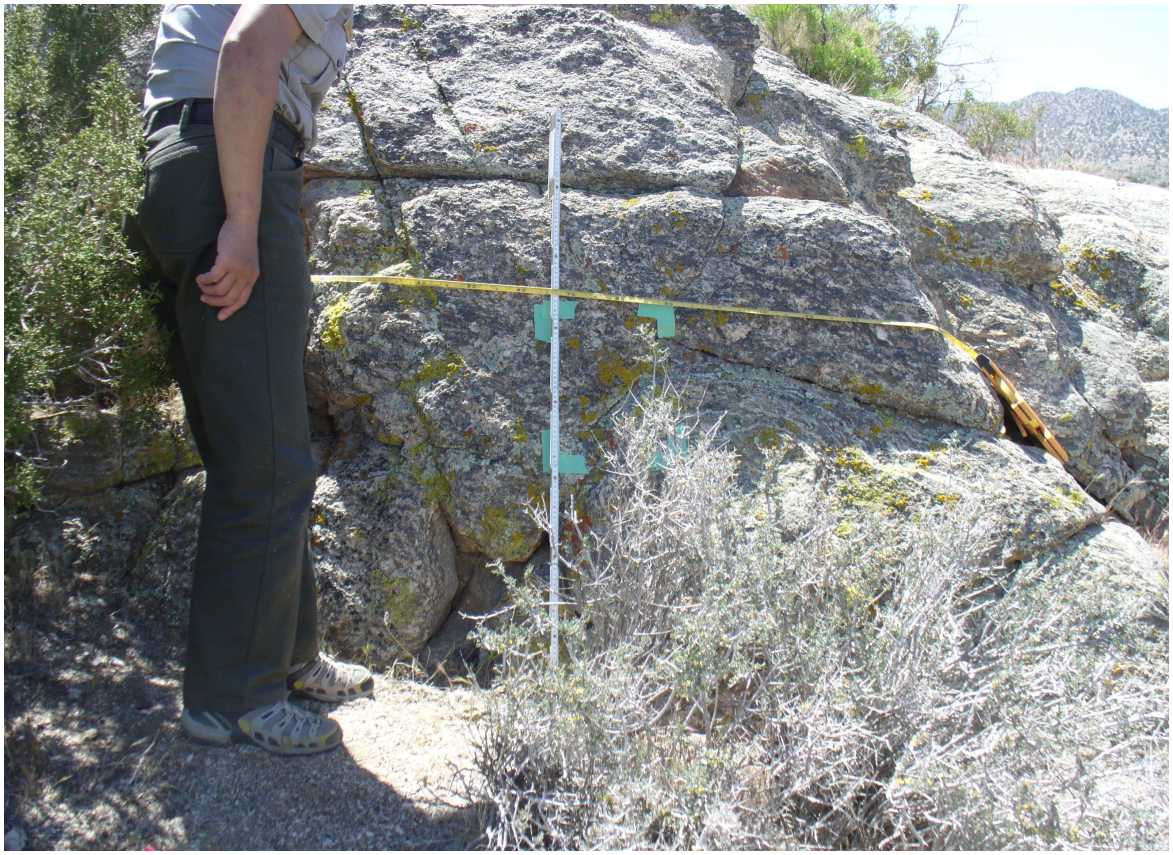
Site 2

NAD83 E:556658 N:377046

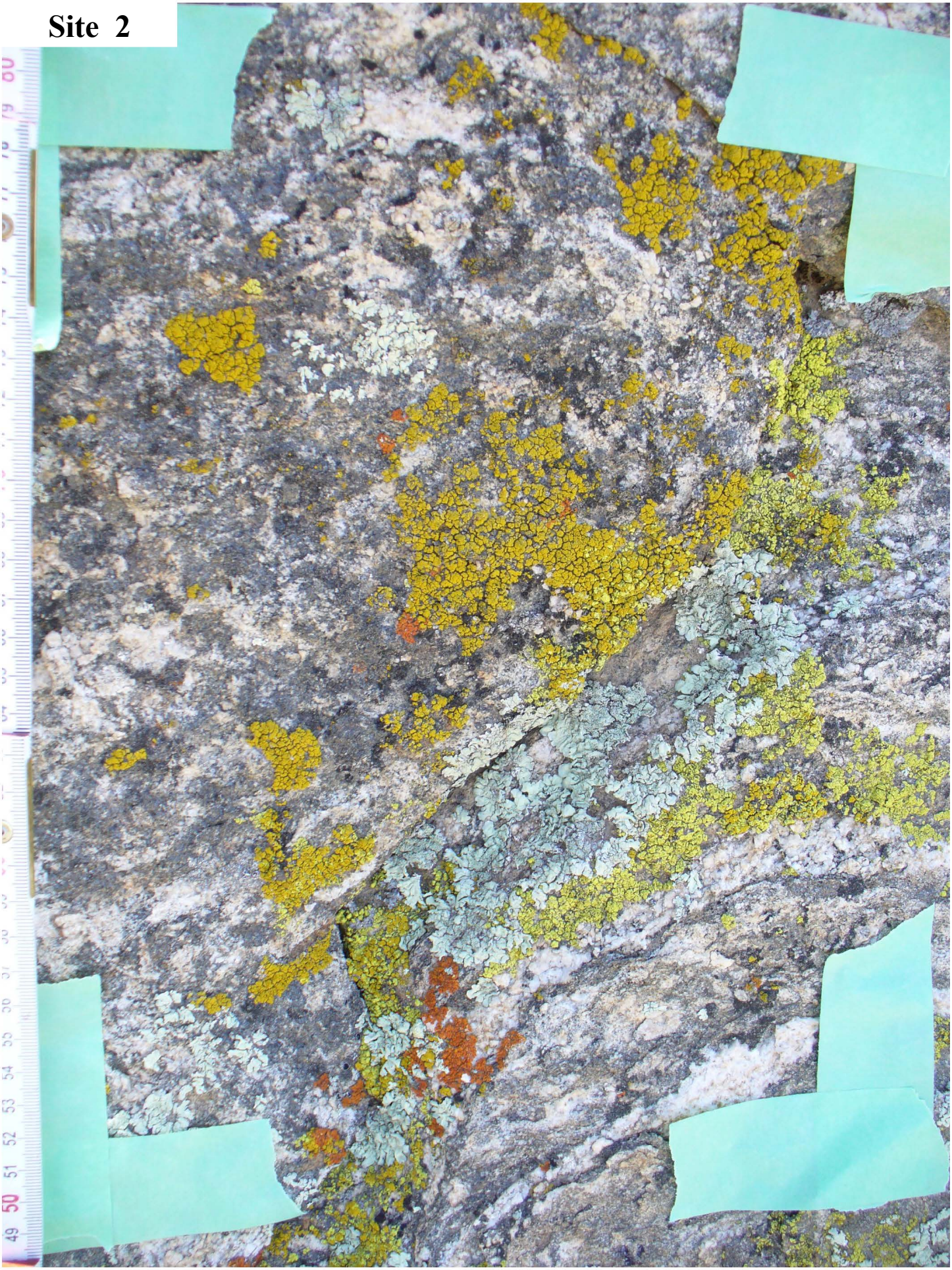
1 meter away



3 meters away



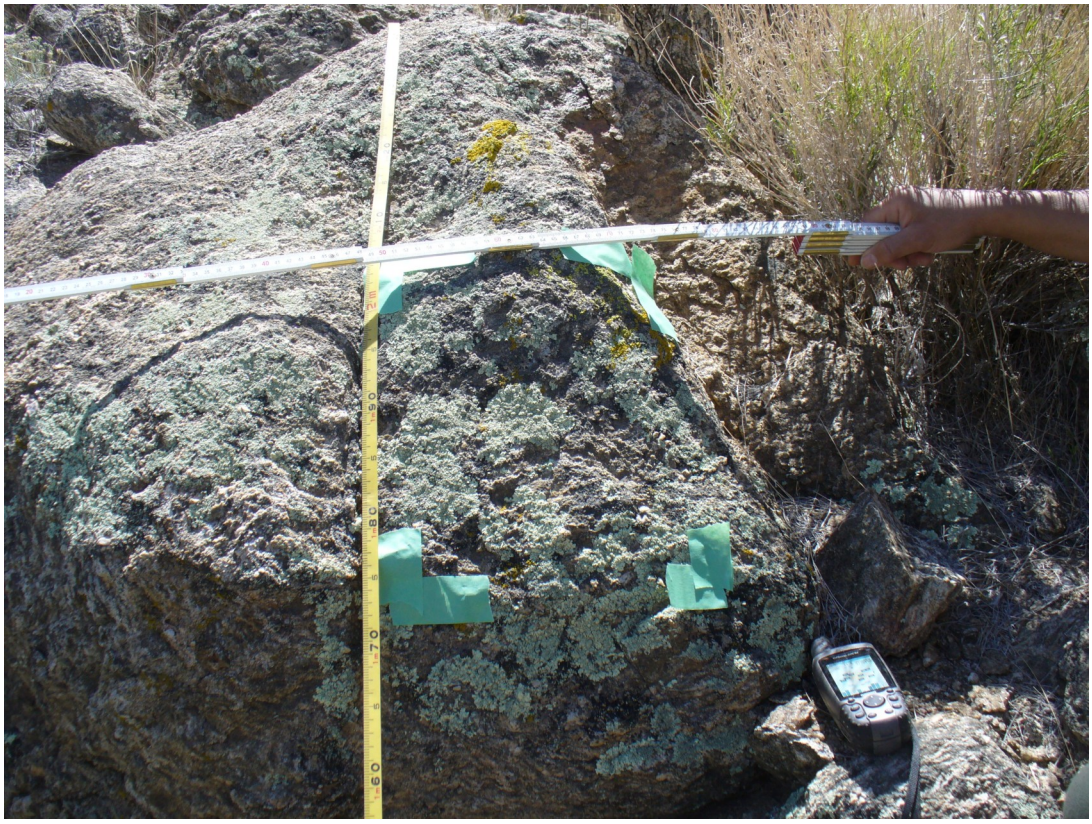
Site 2



Site 3

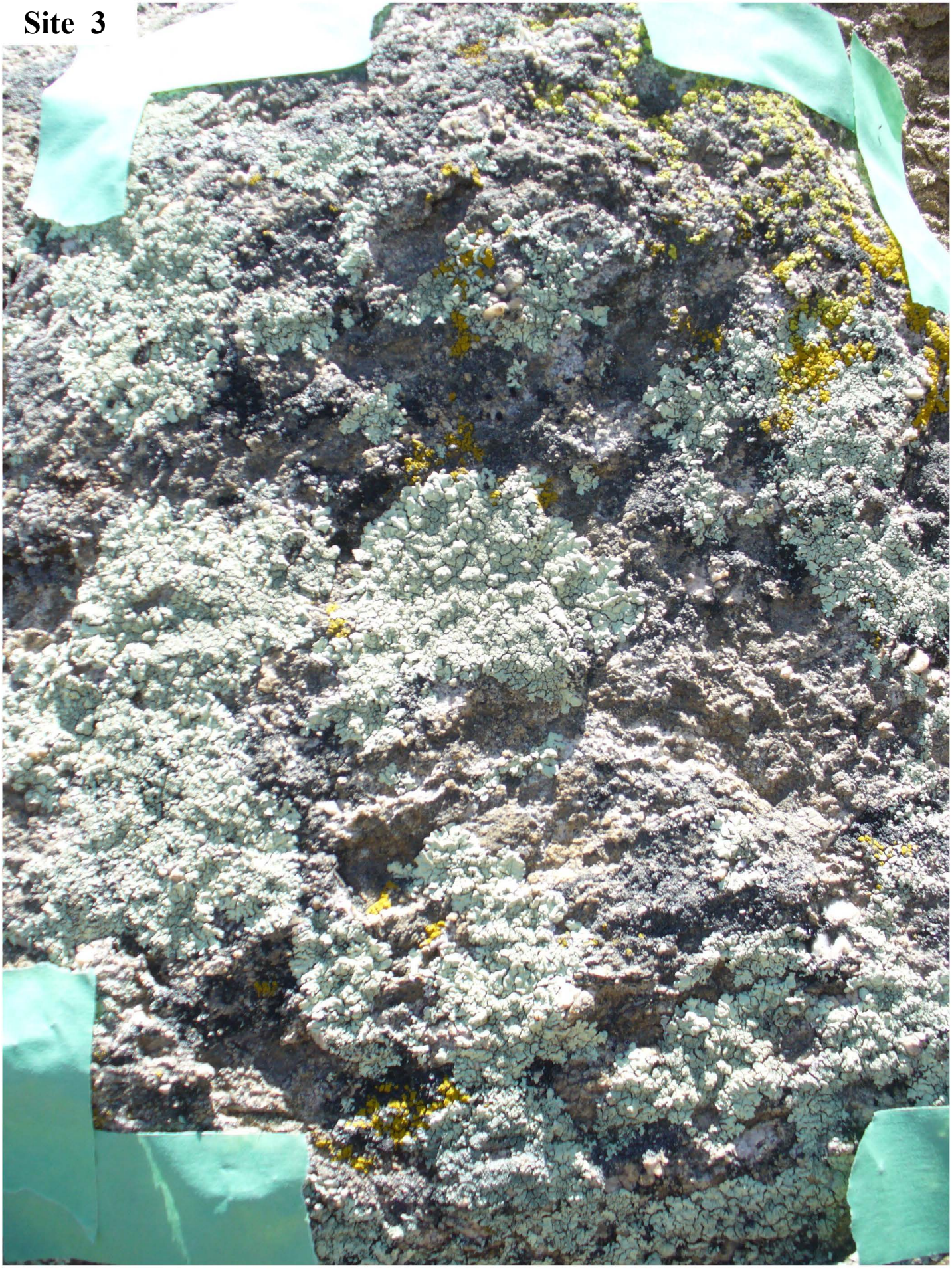
NAD83 E: 556659 N:3770488

1 meter away



3 meters away

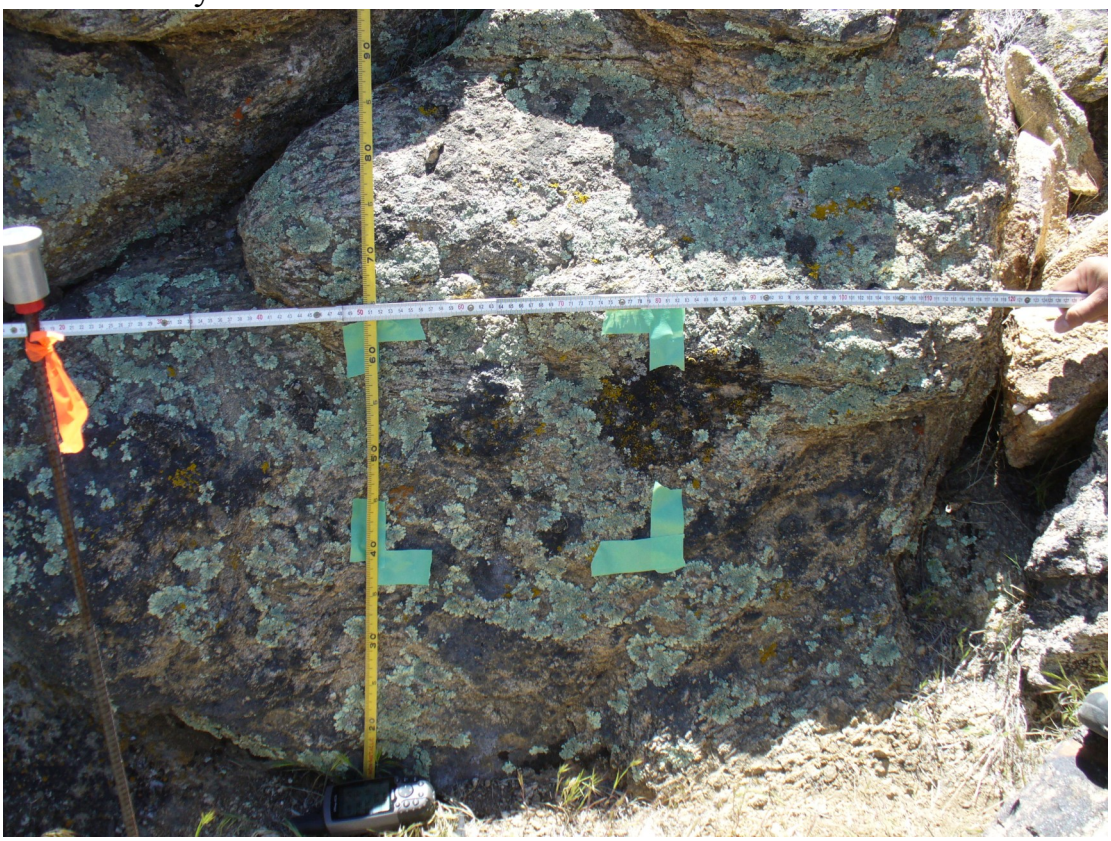
Site 3



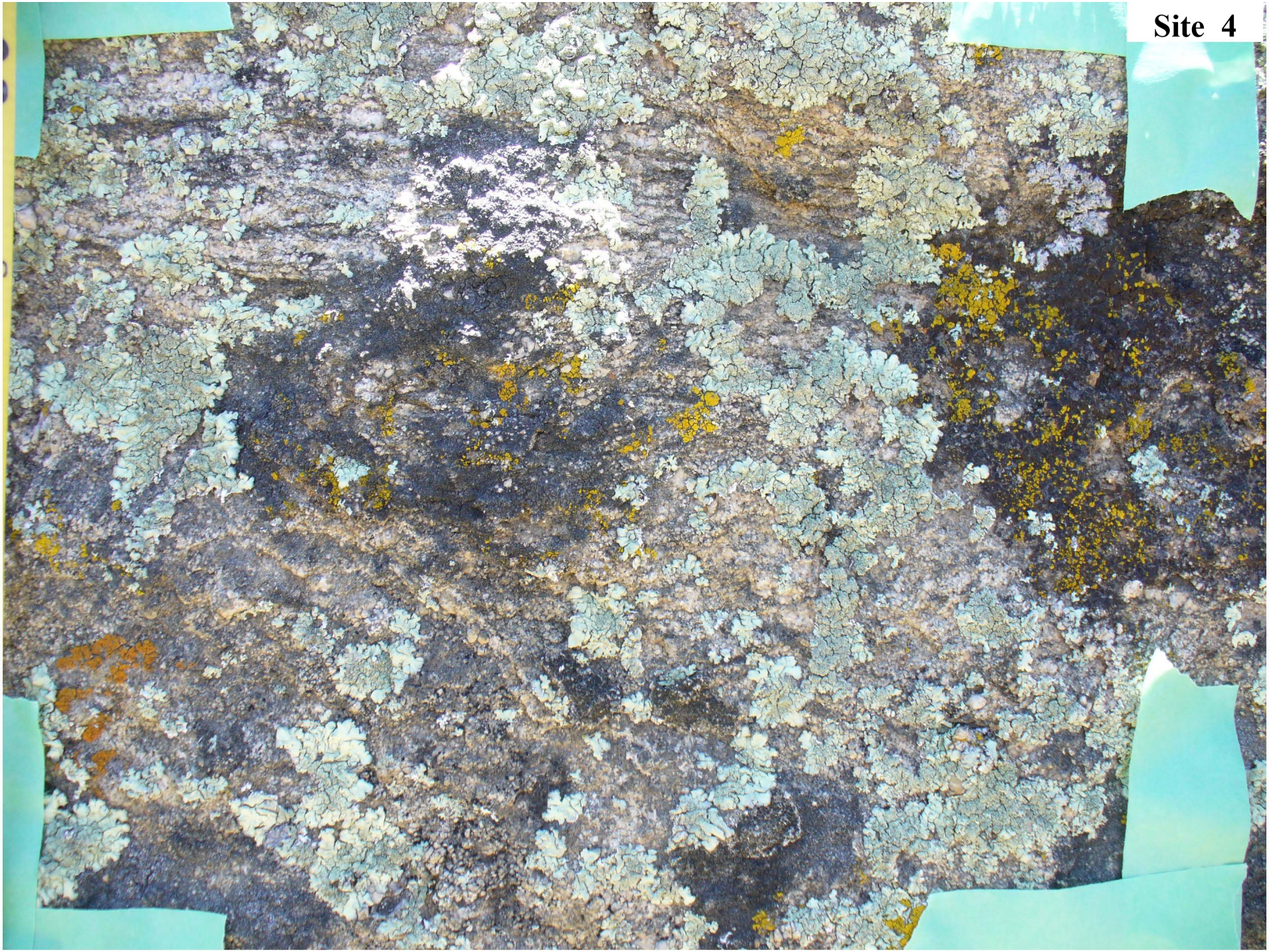
Site 4

NAD83 E:556651 N:3770471

1 meter away



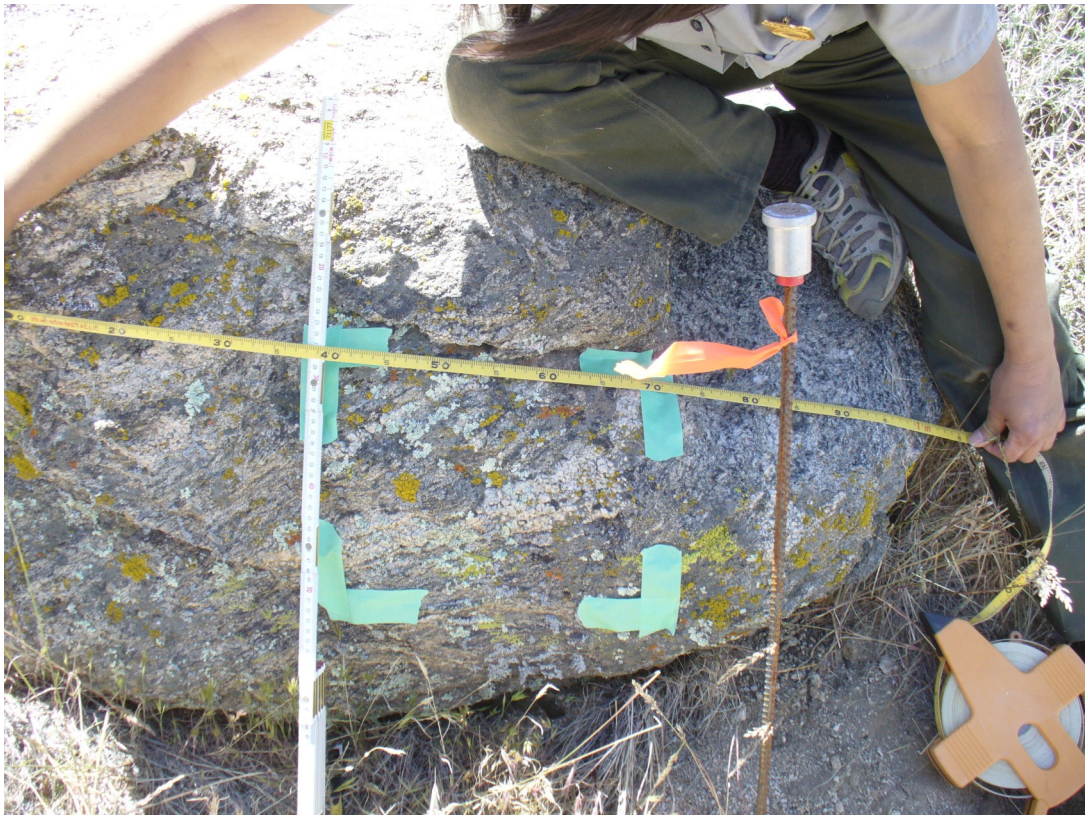
3 meters away


Site 4

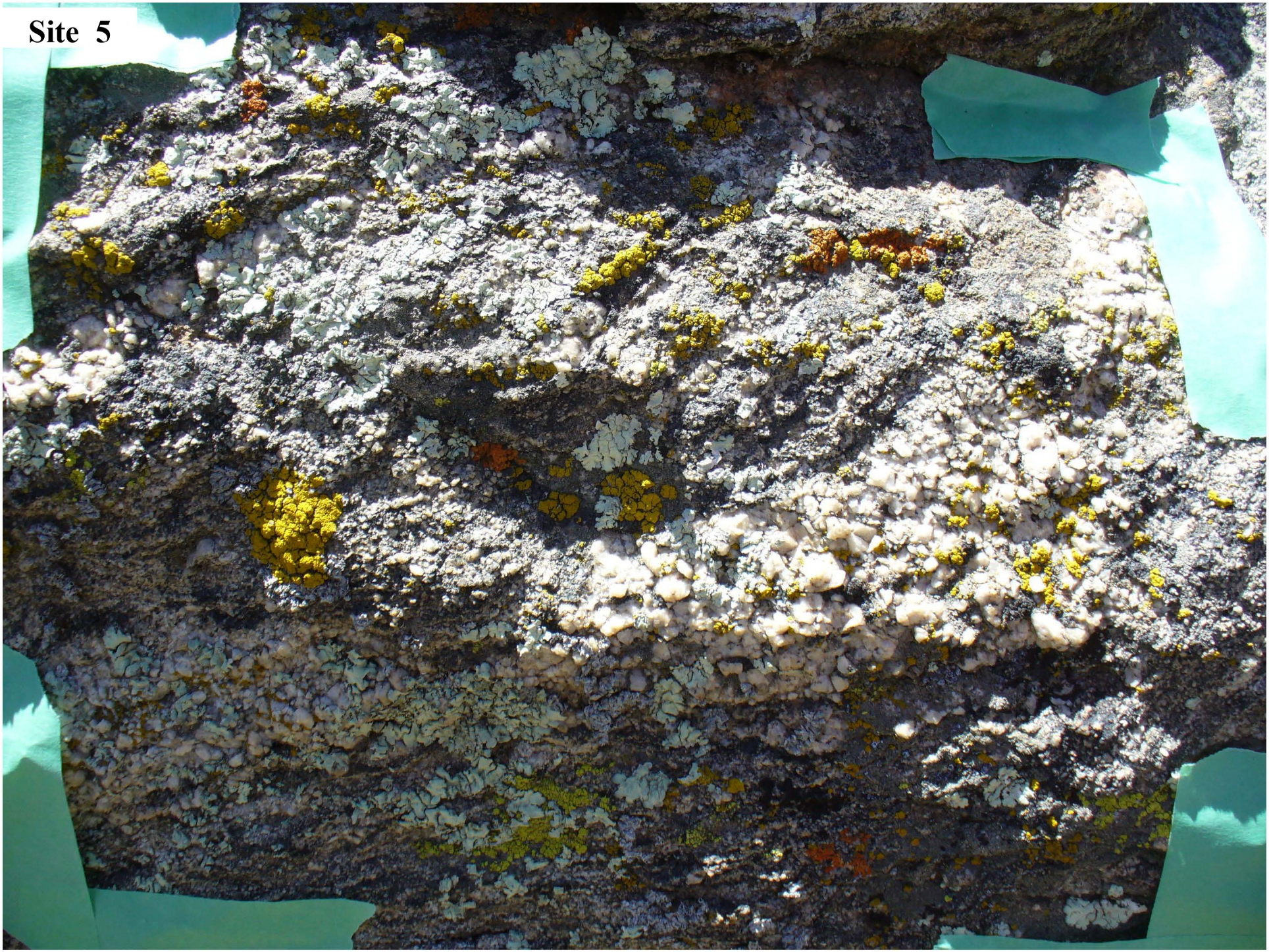
Site 5

NAD83 E:556683 N:3770473

1 meter away



3 meters away


Site 5

Appendix B:

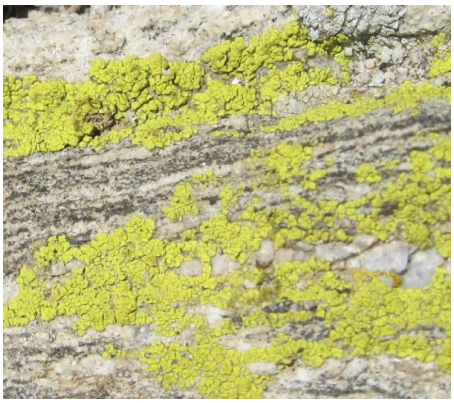
Materials for monitoring Black Rock lichen panels.

Handouts (lichen description guide, protocol, and data sheet) and cm^2 grid to be reproduced on to transparency sheets.

DESCRIBING LICHEN

Growth Form

Crustose lichens form crusts that are so tightly attached to the rocks or soils they grow on that they can't be removed without damaging the substrate.



Foliose lichens are somewhat leaf-like, composed of **lobes**. They are relatively loosely attached to their substrates.

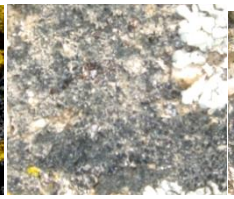
If you're unsure which growth form category the lichen fits into, take some notes on why it is hard to determine.

Color

Be specific when describing color. Here are some suggestions for color descriptions:

Orange

Yellow



Ash-Grey

Black

Chocolate Brown

Light Blue-Green

Bright Green

If the lichen you are describing doesn't match one of these color descriptions, feel free to come up with others to accurately explain what you see. Sometimes the reproductive structures on lichens can look like a different color, and often their color changes as they get older as well. If you observe more than one color, write it down!

Texture

Most lichens you encounter today will be either smooth or rough. Determine the texture by sight or with a slight touch. This is can be a diagnostic characteristic for the species, and may also indicate the reproductive stage of the lichen.

Black Rock Lichen Survey
Student Summit on Climate Change
Friday March 1, 2013

Each group should have:

- Transparencies
- Markers
- Painter's tape
- Clip board with protocol and data sheet
- Something to write with
- Calculator
- Loupes, Magnifying glasses, and flash lights

Panel re-location (completed beforehand):
Using GPS points recorded in 2010, study sites were relocated. Once rebar was found, photos taken in 2010 were used to re-locate the same 8.5"x11" panels that were observed previous years. Panels were re-marked along edges and/or corners with painter's tape

FOR STUDENTS TO COMPLETE:

1) Record observer names, date, school, and site number on data sheet.
2) On the data sheet, describe each different type of lichen you see on the panel.
3) Assess percent cover for each type of lichen:
   a. Each student gets a transparency and selects a different lichen to observe.
   b. On the transparency, record site number (can be found on the rebar cap), lichen type (letter from "ID" column on data sheet), date, and observer.
   c. Securely attach transparency to panel using provided tape, and/or have a partner hold securely in place. It is very important not to move the transparency while recording presence/absence.
   d. Mark each square on the transparency grid in which selected lichen type occurs. Even if only a small amount of thallus falls within the square, mark it as present there.
   e. Count the number of squares you marked on the transparency, and record that number on the data sheet in the "Presence" column.
   f. Calculate and record percent cover on the data sheet.

Repeat step 3(a-f) for each different type of lichen on the panel, using a new transparency sheet for each type of lichen.

Student Summit on Climate Change, Black Rock Lichen Survey 2013

DATA SHEET

Names:	
Date:	
School:	
Site Number:	

Please be as descriptive as possible!

ID	Form	Color	Texture	Notes	Presence		Percent cover
	foliose or crustose?	Color? use more than one word!	Smooth, Rough, Wrinkled, flaky, etc.?	Other observations? How does it compare to the other lichens?	How many squares does it touch?	divide by total # of cells and x100	(Presence ÷ 494)x100 =
A					(_____ ÷ 494) x100 =		
B					(_____ ÷ 494) x100 =		
C					(_____ ÷ 494) x100 =		
D					(_____ ÷ 494) x100 =		
E					(_____ ÷ 494) x100 =		
F					(_____ ÷ 494) x100 =		
G					(_____ ÷ 494) x100 =		

Date: _____ Observer: _____ Site #:_____ Lichen Type (Letter): _____