Mountain Sustainability Course Notes (Grades 4-6)

Resources:

"The Hike" by Alison Farrell
"How to Make a Mountain in Just 9 Simple Steps and only 100 Million Years" by Amy Huntington
Hand sanitizer
Mars Bars
MS 4-6 Field Guides
Pencils
Compass
Anemometer
Thermometer
Soil Thermometer
Laminates of Stadium Glacier retreat photos
Thumball

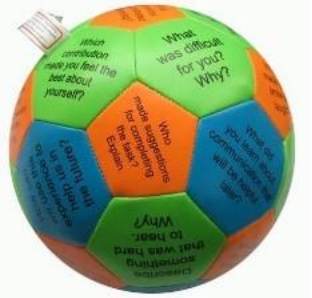
Please see corresponding
Mountain Sustainability 4-6 Field Guide

Notes to teachers and education guides: This is a circular program. We start by asking students what being on the mountain means to them. Their answer will be something along the lines of *"When I come to a mountain, I feel free/I can breathe/I'm out of the classroom/it reminds me of hiking with my family/I feel peaceful/I want to ski/I am afraid of bears…"*

At the end of the program, students have 15 minutes to reflect individually to embed some of the learned material on an emotional and visceral level by writing a poem, sketching a landscape or anything they feel inspired to record in answer to the question: "What do mountains mean to you." For those who want to share what they've done, they can post a photo of their work on social media with #mountainsmatter.

3 Things-to-Do at the end of the program are intended to empower this age group to build good habits of involvement in citizen-science, observation and record-keeping.

Activity 1: Thumball

	**Thumballs:** Stand in a circle. Toss the ball to a student who has to answer the (random icebreaker-type) question where their thumb is on the ball. Then ask them "What does being out today on a mountain feel like to you?" e.g. freedom, fresh air, quiet, out of the classroom, being close to nature, enjoying the views…

Definitions of a mountain:

There are many definitions of what should be called a mountain. One is that a mountain is a mountain if it rises more than 300 metres above the surrounding area. Another is that a mountain is a mountain if the people living near it consider it to be a mountain!

How to measure a mountain:

There are also many views on how to measure a mountain. Mount Everest is known as the highest mountain in the world. It's 8,840 metres and still growing. That's measuring it from sea-level to its highest peak. But if you measure mountains from their actual base, where they protrude from the earth's crust at land or sea, Mauna Kea, the volcano in Hawaii is the highest, at almost 10,000 metres! When you measure Mauna Kea from sea level, though, it's only about 4,000 metres.

What if we measured mountains from the earth's core to a mountain's peak? Then Chimborazo in Ecuador would be the highest mountain in the world. But because we measure freestanding mountains, from where sea meets land, Mount Everest is considered to be the highest.

How tall can mountains grow? They can't get much bigger than 9,000 metres because gravity is pulling the mountain back towards the earth, and the base of the mountain has to support it that pressure. If there is water around the base of the mountain, like the volcano, Mauna Kea, that will help support the weight. If it's a freestanding mountain, and there isn't sufficient support, the base of the mountain will start to liquify.

So you can get much higher mountain somewhere with less gravity, like on Mars, where Olympus Mons is 25,000 metres high.

Mountain creation/destruction/movement.

How does the mountain feel under your feet?

Solid, hard?

What if I told you it was moving? What if I told you it was moving so slowly that you can't even feel it?

The earth is covered by large plates of rock and on top of them sit the land and ocean. The plates of rock, tectonic plates, are always moving. They bump into each other. They slide overtop and below each other. They push up through the land and ocean on top of them as mountains and sometimes as volcanoes. Even as we stand here now, mountains are rising out of the earth, and moving, and changing shape. Himalaya mountains are rising more than 1 cm a year! Mountains growing as fast as your fingernails!

So we have rock pushing through the land and ocean because the plates underneath are colliding, pushing into each other. These are called fold mountains.

Examples: the Andes in South America are fold mountains. They are the longest mountain range in the world, and still grow about 10 cm every hundred years.

How else are mountains made? Volcanoes! Where magma, hot liquid rock, is pushed up through the earth's crust, it cools into rock, and more magma comes up and cools on top of that, and on top of that, until a volcano is formed.

Mount Garibaldi is a volcano. It last erupted about 8,000 to 13,000 years ago. It's dormant now.

And what if magma is pushed only part-way through the earth's crust and not all the way through, and it pushes the land up above it? Those are called dome mountains.

Now let's look at what shapes our mountains.

Mountains and weather

Mountains influence on weather – rain and snow fall on mountaintops more than down below because it's colder up on a mountain. As air rises to pass over a mountain, it cools and can't hold as much moisture so it lets it go as rain. So one side of a mountain often gets more rain than the other.

Weather's influence on mountains – wind makes trees grow in funny shapes, their trunks sometimes twisted, with short branches often growing off only one side, few leafy trees/bushes (salal!).

- Shape of trees you'll notice:
  - ***Krummholz*** = stunted or deformed vegetation in the subalpine
  - ***Flagging*** = where you have growth on only one side of a tree due to winds

Subalpine tree growth.
Photo by Martha Warren

It's more efficient for plants in the subalpine to have needles instead of leaves so they don't have to wait to grow new leaves in Spring to create food for themselves from sunlight through the process of photosynthesis!

Why measure the weather?

Similar to the North and South Poles, mountains are experiencing faster rates of climate-change, and this could have a huge impact on us as people. Most research date comes from Utah, Colorado and Tibet. Areas already in crisis include the Andes and the Hindu Kush Himalaya. So we need to collect data; we need to keep track of the weather so we can see how it's changing over time, and then try to prepare and adapt to the new conditions.

Because mountains, and vegetation, and animals will have to adapt in response. Where a mountain was once cold and dry, but has become warmer and more humid, how will the vegetation change? How will natural hazards be different? How will animals and humans adapt? How will our water availability from glaciers and snow packs change? These are the big questions of mountain sustainability.

Activity 2: Recording weather

Support students in completing weather section of Field Guide. Small group work of 3-4 participants.

Weather experiments: anemometer, soil thermometer, compass.
How to measure wind direction? Wind direction – observation of vegetation, flagging, wet finger, compass…
How to measure the air temperature? Thermometer.
How to measure wind speed and temp? Anemometer (Repeat after me, ane-mometer!)
Soil thermometer. Measure 5 cm below ground. Measure the surface temperature. Then measure the air temperature 2 metres above.
Soil temp is important because warmer temperatures accelerate chemical weathering on mountains and determine what vegetation will grow. If our mountains grow warmer with climate change, what changes in plants will we see? What changes will happen for microorganisms so small we can't even see them with the naked eye?

Mountains and water/glaciers.

Glaciers form when layers of snow pile up over time. The increasing weight of the snow compresses it into a layered sheet of ice that begins to slide slowly down the mountain. It's pulled along by gravity, scraping over everything in its path. It will sculpt the mountain and carve deep valleys. The Átl'ka7tsem/Howe Sound was carved by glaciers.

Glaciers erode, wear away, parts of the mountain as they slide down, dragging rocks along with them. Glaciers form when layers of snow pile up over time. The weight of the snow squeezes it into a layered sheet of ice, and it will begin to move slow, due to gravity, scraping over everything in its path. It will sculpt the mountain and carve deep valleys. It will scrape up the mountain. It will carry rocks of all sizes with it.

Glaciers can move from a few centimetres a day to a few hundred metres a day. The underside of the glacier moves more slowly than its top. With global warming, however, glaciers sometimes look like they're moving backwards. Because as they

melt, the terminus, or end of a glacier is higher rather than lower on the mountain as you might expect from gravity. This is called glacial retreat.

Our local mountains, Skypilot, Copilot and the Ledge, have retreating glaciers. Stadium Glacier sits in a cirque, a bowl-shaped indentation, next to Skypilot.

Skypilot, Copilot and the Ledge.
Photo by Martha Warren

The figure below on the left show the size of the glacier from 1969 to 2016. What is it doing? (Getting smaller!) In the picture on the right, the blue in the Landsat image is from September 1984. The tiny black polygon you see is the glacier outline in September 2021.

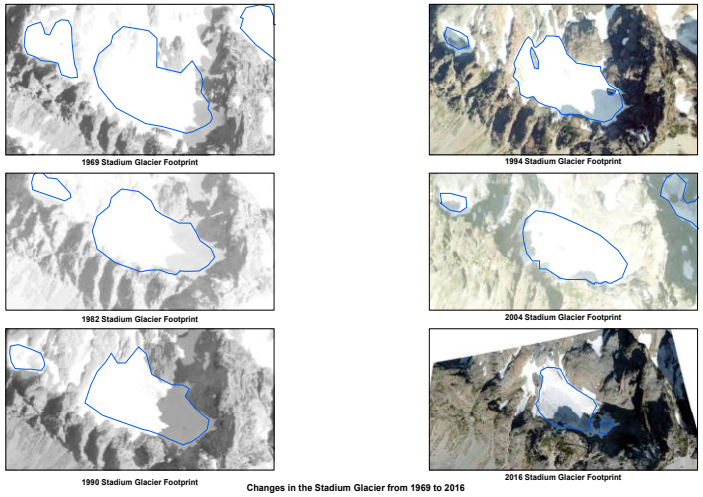
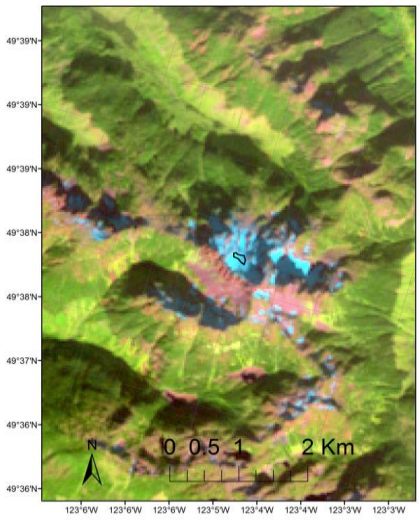


Figure by Robert Plummer



Stadium Glacier September 28, 1984 (blue) and September 2, 2021 (black polygon)

Figure by Scott Williamson

Activity 3: How is a chewy chocolate bar like a glacier?

How is a *Mars Bar* like a glacier?

You will need:
1 volunteer
1 Mars Bar or other chewy chocolate bar that's been in the freezer for 5 minutes

A Mars Bar is long and linear, u-shaped on bottom with steep sides, like a glacier.
It's flat on the bottom and steep on the sides, like a glacier.
Please gently bend your MB. You'll see it develops cracks like the crevasses of a glacier. The top layer of a glacier is brittle. It's a rigid zone.
Please pull apart your MB. The caramel undergoes "plastic flow", like the inside top layers of a glacier. This is the plastic zone of a glacier.
The nougat layer underneath is formed like firn, glacial ice and snow, compressed, less bendy. It's the intermediate stage between accumulated snow from snowfall and ice.
It leads to the basal sliding zone, and the deepest layer of compressed ice in a glacier.
If this were a Snickers bar, the peanuts could be the rocks carried along on the glacier. These are called erratics.
Lastly, please bite into the end of your Mars Bar; this is glacier retreat!
What this demonstrates is that different glacial materials flow at different rates under different conditions, and how pressure from the top layers pushes down and compresses the lower layers into glacial ice. Gravity further pulls the glacier downhill.

You can see often see striations, scrapes left on rock by a glacier as it moves. And talus or skree, loose rock from erosion.

The water that comes from glaciers and snow melt is very important to us. 60-80% of our fresh water comes from glaciers. It's what we drink. It's what we use for

hydroelectric power. It's used for farming. So there is concern that our glaciers are retreating.

Retreating glaciers also contribute to slope instability on our mountains and increased natural hazards like landslides of rock, regolith, and glacial lake outbursts.

Besides wind and rain and glaciers, what else weathers and erodes our mountains?

1. rivers;
2. vegetation – lichen (fungus and algae together.) Plants and tree roots break up the rock of the mountain. Lichens slowly dissolve mountain rock, along with wind, ice and water, break down the rock into soil;
3. Us! Walking on the mountains.

Biodiversity.

What are the differences in the physical appearance of the environment up here at 885 metres? How does the summit of our mountain, in the subalpine, look different to the coastal rainforest at base below? (Smaller trees, less underbrush, less plant diversity).

Subalpine areas can be buffeted by hurricane force winds, scoured by ice crystals, and weighted down by heavy snow—life can be a challenge for mountain trees. At the upper edges, centuries old trees may sprawl along the ground bowing before the wind. The plants that grow in this rocky, colder soil have to be very hardy.

If mountain climates change, what lives on the mountains will also change. Plants and animals adapt to life on the mountain.

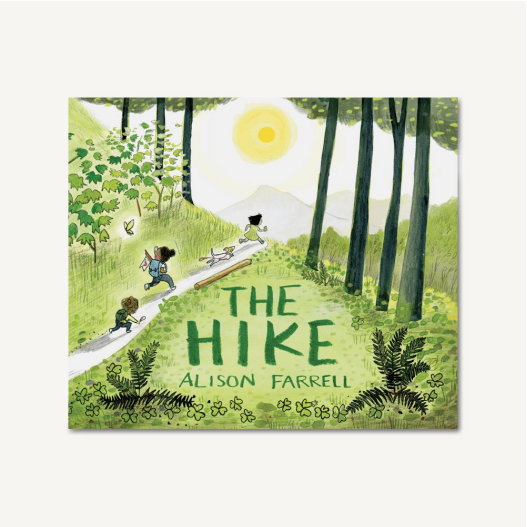
Mountain goats are affected by warmer winters. If trees start growing higher up the mountainside, then there will be less of the lichens, ferns, grasses, herbs, and shrubs that goats currently eat. They will also have to go higher up the mountain in the summer to stay cool.

Yaks in Nepal can't live at the elevation they used to because it's too warm now for them. So they are moving further up the mountains to reach a cooler environment, forcing them into a smaller area where it's harder to find food and water.

Vernal pools/ephemeral wetlands – these are shallow ponds of water in the winter and spring, and dry out to be mud and soil in the summer and fall. So they only contain water for part of the year. What can live in these? Frogs. Salamanders. When mountain climates change, if there are longer droughts, these species can't live there.

Activity 4: How do we live together on a mountain and look after it?

Read The Hike by Alison Farrell to point out the planning, observations of the biodiversity.



Discussion points: What do the hikers write in their sketchbooks?

What might you include in your field guide?
Why should we record what we observe?
They ate the berries! When would it be safe to eat wild berries? Is it a sustainable thing to do when you visit a mountain?
Where is a good place to look for animal tracks?

Activity 5: Hike

Theme: Interconnectedness

Look for things like -

Átl'ka7tsem/Howe Sound fjord
Duff
Lichen
Old Man's Beard

Salal
Tree roots breaking up rock to make soil
Nurse logs
Krummholz and flagging trees
Vernal pools/ephemeral wetlands
Erratics
Folded mountains – Skypilot, Copilot, the Ledge
Volcano – Mount Garibaldi
Olsen Falls
Woodpecker holes
Felsic/mafic dykes
Striations
Regolith

How have animals adapted to live in the subalpine? Here are some examples:

The Red Breasted Sapsucker get their name from how they eat! They drill rows of holes into tree trunks and then returning to those holes later to feed on the running sap and the insects attracted to it. Hummingbirds also use the Sapsucker feeding holes. The Rufous Hummingbird will follow the Sapsucker around during the day, feeding at the wells of sap that the Sapsucker keeps flowing.

Cougars will use the thick underbrush of the forest for shelter and to stalk their prey. Squamish is located in prime cougar habitat. Cougars are active throughout the year and are elusive animals that prefer to avoid contact with humans. Cougars prefer habitats with dense underbrush and rocky areas for stalking, but can also live in open areas.

Can you spot any places chipmunks might live? They live in trees and gather food on the ground in areas with underbrush, rocks, and logs, where they can hide from predators like hawks, foxes, coyotes, weasels, and snakes. They feed on insects, nuts, berries, seeds, fruit, and grain which they stuff into their cheek pouches and carry to their burrow or nest to store. Chipmunks hibernate, but instead of eating a lot and fattening up before they sleep, they keep a store of nuts and seeds to eat throughout the winter.

The black bear's greatest adaptation to living on the mountain is its ability to eat many different things. From fruits and nuts, grasses, twigs, and honey, to grubs, insects, fish, and small mammals. Its molars are great for grinding up foods and its large canine teeth for ripping apart fish. Bears can smell food up to 20 miles away. Their sense of smell also helps them locate other bears and detect and avoid danger. Bears have huge,

strong legs to move or bend large objects like rocks or tree trunks to get to food. They have large, padded feet and strong, curved claws to climb trees easily to get to fruit. Their long and sticky tongue can reach insects in trees. They can even separate and spit out unwanted nuts or berries without using their paws.

What do you think will happen if our mountains get warmer? Some species will move higher up due to climate change.

Yaks in Nepal can't live at the elevation they used to. They can't tolerate the warming climate. But as a species moves up a mountain for the cooler environment, the area they live in is smaller. If the glaciers are retreating, there may be less water to drink and less vegetation to eat. Maybe these animals will need shade or they'll suffer heat stress.

For caribou in the Rocky Mountains' Jasper Park, it's difficult to dig through the deeper snowpack further up the mountain to find food. Instead, they stand on snow to eat lichen from trees. But if a snowpack is reduced or gone completely, the caribou are unable to reach arboreal lichens. Caribou use high-elevation snow-patches for respite from summer heat and insects.

Measuring biodiversity is important so we can see how species are adapting to global climate change. Watching the Himalayan yak, for example, may tell us a lot about how cattle and other animals will be impacted by climate change.

Man-made disturbances such as recreational hiking can have an adverse effect on plant biodiversity. We've seen the destruction of lichen and vegetation on sides of trails at Sea to Sky Gondola. Here on Mount Habrich, we used to have lipstick cladonia growing along the sides of our trails. It's a kind of lichen, fungi and algae together, with small leaves and red caps. When people don't stay on the trail and walk on this lichen, it disappears.

3 Things-To-Do:

What are 3 things you can do to contribute to mountain sustainability? (Give students time to think and complete this section of the Field Guide.) Some ideas…

- Stay on the trails
- Take your trash with you
- Look but don't touch

- Water conservation – buckets in your backyard, or downpipes from the roof to fill barrels
- Plant restoration
- Watch your plastics

Activity 6: What do mountains mean to you?

Individual work. 15 minutes to complete.

We've come full-circle, back to the question: What do mountains mean to you? Write a poem, sketch, doodle, or explain why mountains matter or what they mean to you. Use the space on the back of you Field Guide for this. If you want to keep your work private, that's fine; if you'd like we can take a photo of your work to post (without your name) on social media with the hashtag #mountainsmatter. This will help increase awareness about the issues of mountain sustainability.