Geology

Serpentine Readings Jigsaw

"The mineral and chemical composition of serpentine-derived soils is unusual and extreme, leading to high levels of plant speciation and endemism."-USFS 2018 Conservation Strategy Report

The Klamath Mountains are known for their unique serpentine soils and the rare and endemic plant species that live there. In this section you will learn about how these serpentine soils formed.

Serpentine soil is formed by a type of rock called serpentinite. Can you hear the word serpent in there? It is named this because the rock often looks scaly and green, like a serpent, or a snake's skin. The rocks that make up serpentine soils in the Klamath Mountains were formed way back in the Paelozoic era, when life on Earth proliferated and diversified rapidly, about 440 million years ago.

These rocks formed on the ocean floor and slowly traveled towards the North American continent in a process called plate tectonics, the scientific theory that the Earth is broken into rigid plates that move and interact with each other. As the ocean plate interacted with the land plate here on our coast, these rocks from the ocean floor were plastered onto the continent. This created a random distribution of serpentinite rock, essentially forming "islands'' of serpentine soils (which helps to explain the rare and endemic plant species as you will learn from that group).

We are particularly curious about the soils made from serpentinite rocks because they are quite strange compared to most soils that plants grow in. Serpentine soils are rich in Iron and Magnesium and also have high amounts of heavy metals which aren't great for living things to absorb. Lastly, they have low amounts of essential nutrients for plants like Nitrogen and Calcium (remember all these elements from the Periodic Table of Elements?). The Plant Adaptation group will tell you more on why this matters.

	
Green serpentinite rocks. Photo from Six Rivers National Forest	Serpentine on the North Fork of the Smith River at Stony Creek. Photo from Smith River Alliance

Text and first photo adapted from US Forest Service Klamath-Siskiyou Serpentines.

https://www.fs.fed.us/wildflowers/beauty/serpentines/geology.shtml

Second photo from Smith River Alliance https://smithriveralliance.org/stony-creek/

Plant Adaptations

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Just like you, plants require essential nutrients to survive and thrive. These include Nitrogen, Phosphorus and Potassium, along with Calcium, Magnesium, Nickel and Iron. Each of these elements supports the development of the plant, from creating chlorophyll to building proteins. Plants obtain these nutrients from the soil they live in and they need them in specific concentrations-lots of Nitrogen and Calcium, a little Magnesium, and not much heavy metals like Nickel or Iron. This is for most plants. But plants thriving on serpentine soils are not most plants!

Serpentine soils would sound deadly to your average garden plant: Low levels of Nitrogen, which are required for making proteins, and therefore the plants very existence. Low amounts of Calcium which is needed for building cell walls and cell membranes, and too much Magnesium which can limit the plant's ability to take up that tiny bit of available Calcium! Plus, so many heavy metals which can be toxic. What's a plant to do?

Adapt! Plants that grow on serpentine soils are adapted to tolerate these unusual conditions. They can concentrate heavy metals like Nickel into other tissues, like their leaves, so that it doesn't affect them as much. They can selectively uptake Calcium through their roots in place of all the Magnesium hanging around (notice on the Periodic Table of Elements how Calcium and Magnesium are in the same column indicating that they have similar chemical properties).

In most soils, Nitrogen comes from decomposing dead organisms. But that decomposed material is sparse on serpentine so one plant, *Darlingtonia californica* obtains its Nitrogen in an entirely different way-by consuming insects! *Darlingtonia* lure in insects and then trap them preventing their escape. When the insects tire and die microorganisms like bacteria and protozoa inside the stem of the *Darlingtonia* decompose the trapped insects and "Voila!" Nitrogen is available! What a feast of nutrients for this tricky plant! (Even more carnivorous plants found on serpentine soils are Horned butterwort (*Pinguicula macroceras*) and Round-leaved sundew (*Drosera rotundifolia*)-look them up!)

The carnivorous plant *Darlingtonia californica* obtains Nitrogen from decomposed insects. Photo by Maureen Jules.

Serpentine plants also have to adapt to the drying air and hot sunlight. This *Sedum moranii* has thick, fleshy leaves to hold water. Photo by Norman Jensen.

The fuzzy leaves of *Eriogonum libertinii* are covered in tiny hairs and grow close to the ground to trap moisture and reduce drying out in the sun and wind. Photo by Shauna Hee.

Text and photos adapted from US Forest Service Klamath-Siskiyou Serpentines.

https://www.fs.fed.us/wildflowers/beauty/serpentines/adaptations.shtml

https://www.fs.fed.us/wildflowers/beauty/serpentines/communities/darlingtonia.shtml

Rare and Endemic Species

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Life on serpentine soil would be challenging for the average plant. The amounts of nutrients plants need are all out of whack (your Plant Adaptation expert will tell you more about this) and it is dry with high amounts of sunlight. Luckly, plants on serpentine are not the average plant. They are unusual and rare plants that know how to survive, and thrive in these conditions.

These conditions create strong selective pressures meaning that plant species who can tolerate serpentine specifically adapted to do so over time making them different from their relatives who live off serpentine. Due to the way serpentine soil was originally distributed in the Klamath Mountains (ask your Geology expert), serpentine soils are often isolated from surrounding areas creating their own on land "islands." Over time, due to the challenging conditions and geographic isolation, plants **speciate**-which means form new species. Many of these species are rare-not many around and hard to find. Some are even **endemic** meaning they only live on serpentine soils in the Klamath Mountains and nowhere else on Earth!

What's really interesting about many serpentine plants is that they're not really found in non-serpentine soils. In lab experiments scientists found that serpentine species actually grow quite well in regular soils, so the scientists thought there must be something else going on to explain why we don't find them there. Scientists concluded that competition plays a role. Imagine two plants: one adapted to serpentine and one not. When the serpentine plant tries to grow on regular soil, the other plant competes with it taking the nutrients and water it needs. However, when the serpentine plant grows in serpentine soil, it can still survive (your Plant Adaptation expert will explain how) while the plant not adapted to serpentine will die. Then the serpentine plant has all the resources all to itself-no competition, no sharing. We think this lack of competition on serpentine soils might be part of why these plants "stay" on serpentine and are only found here.

	
Lilium bolanderi is an endemic species, growing in rocky serpentine only in the Klamath Mountains of Northern California and Southwest Oregon. Photo by Rick York © CNPS	*Arabis aculeolata* is endemic to the northernmost part of the Klamath Mountains. Photo by Jennifer Kalt.

Text and photos adapted from US Forest Service Klamath-Siskiyou Serpentines.

https://www.fs.fed.us/wildflowers/beauty/serpentines/center/index.shtml

Plant Communities

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As you will learn from the other experts making up your team, serpentine soils are strange. As a result, the plants that live there are strange too-they have unique adaptations, small populations that are not encountered often, or live only in the Klamath Mountain region and nowhere else in the world! When different plant species live and interact together in an area it's called a community, just like how when people live and interact together we form communities. On serpentine soils there are many different types of plant communities depending not only on the soil, but also the amount of rainfall or the elevation for example.

One of these special plant communities is the Darlingtonia wetland. *Darlingtonia californica* is carnivorous plant found on serpentine soils (your team's Plant Adaptation expert will tell you more about it). They need moving water so a Darlingtonia wetland is also called a fen-it's like a bog but instead of stagnant, unmoving water, a fen has water that flows. This also means *Darlingtonia californica* can be found along the edges of rivers and streams too. Many other plants also favor these conditions including rare and endemic wildflowers.

Another plant community on serpentine soil is the Jeffrey Pine Forest. These areas are dominated by Jeffrey Pine trees as well as grasses and wildflowers. Trees growing here are small and stunted looking, growing just as large as they can with the limited amounts of nutrients that serpentine soil provides. Since it is also hot and dry the shrubs, grasses, and wildflowers living in Jeffrey Pine communities also have adaptations like waxy or hairy leaves to prevent drying out and grow small and close to the ground. Unlike other plant communities in the Klamath Mountains, the Jeffrey Pine communities on serpentine soils have remained relatively unchanged over thousands of years, fascinating scientists in the region!

	
Darlingtonia fen. Photo by Sydney Carothers	Jeffrey Pine community: Jeffry Pine trees and low lying shrubs. Photo by Susan Erwin

Text and photos adapted from US Forest Service Klamath-Siskiyou Serpentines.

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