Succession in a Glacial Landscape

Any time a great disturbance such as a flood, a volcanic eruption, or a glacier impacts the land and its plant communities, there follows a very orderly process of reclamation called plant succession. The best place in the park to witness this process in action is the Exit Glacier valley. When it was advancing, the glacier marched over this landscape and eradicated the forest that once grew here. Its present day retreat enables the rebuilding process which over time turns rocks to soil and gravel plains to forest.

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Arrivals and Departures

When a glacier advances it is like a bulldozer, scraping away everything in its path. Forests are overwhelmed and broken up in the relentless forward march. A glacier in retreat leaves behind little but rock, silt, and a series of streams. However, in a remarkably short time, plants begin to reclaim the open ground. First, the spores of lichens and mosses waft into niches in the rock, spreading slowly and clinging to tiny fragments of soil. Next, seeds of fireweed and dryas, which resemble dandelion seeds, drift on the wind and take root in gravel. Shrubs move in next, their seeds traveling mostly by wind and occasionally by animal. These include willow (*Salix* sp.), which survives in the wetter spots best and has its seeds borne in a cottony mass; and alder, its tiny seeds winged like a maple's.

Of all the initial pioneer plants arriving in the process of plant succession, perhaps the most important is the alder. In Kenai Fjords National Park, it is shrubby, Sitka alder (*Alnus crispa*). Alder has mastered a method of fertilizer production capable of providing food from a soil that is mostly rock. The alder forms a symbiotic relationship with bacteria found in the soil. This specialized bacteria, called *Frankia* ssp, inoculates the alder and makes a small nodule on its roots. Within its diminutive space, the bacteria take in gaseous nitrogen and convert it into nitrates, the building blocks needed for plant growth.

Alder's partnership with bacteria benefits the entire forest. Alder is deciduous, dropping its leaves in winter. These leaves form the basis for rich new soil that stimulates the growth of the very plants that will one day replace the alder—cottonwood trees (*Populus balsamifera*). Cottonwoods are fast-growing, deciduous trees capable of surviving in difficult situations. Bury the base of most trees and they smother, but not cottonwood. Cut it down and it sprouts again. Let a river tear it loose, and it sprouts from its own driftwood.

Alder, a pioneer plant. NPS photograph by Lisa Gordon

Unlike the fluffy seeds of the cottonwood, Sitka spruce seeds are tiny and winged, and only travel about a mile from the parent tree. A glacier in retreat often leaves the nearest source of spruce far down the valley. Eventually, spruce seedlings spring up beneath the faster-traveling cottonwoods and reach for the light. The spruce overwhelms the cottonwoods with shade. They take advantage of the nitrogen-rich soil manufactured by the alder that came first. Within 150-200 years, there is little sign of the deciduous trees left and spruce becomes dominant.

Sitka spruce seedlings prefer sunny locations. In the dark understory of a coniferous forest, it is hemlock seedlings that do best. Given another century or so, hemlocks may become the dominant tree in other areas. In Kenai Fjords, the mixture of spruce and hemlock may be more balanced.

Reading the Clues

Alder and cottonwood currently dominate Exit Glacier valley. This is one of the ways in which glacial activity can be dated. As the ice melts away, the land is recolonized. Succession is fairly predictable—from mosses and lichens, dryas and fireweed, to alder and willow, then cottonwood, and finally spruce and hemlock. Anyone who is familiar with its pattern can trace out a rough idea of where the ice was and how long ago. If ice advances again, or in places where landslides, windstorms, fires, or human activity have reset the clock, the plants of early succession can be found at work.

The former height of Exit Glacier can be measured by the vegetation. Clumps of spruce and hemlock trees cling to the sides of the valley, while cottonwood trees remain lower. Where cottonwoods grow there was more recently ice. When the glacier last advanced, it wasn't high enough to wipe out the spruce and hemlock groves on the slopes above. They survived to reveal the extent of the ice just a few hundred years earlier.

Resilient but Fragile

Given such a short amount of time to work, and starting with nothing but gravel and stone, it's amazing that there is any soil on the ground at all. The thin layer of soil is easily damaged, even by footsteps. Winter storms can wash it away. The plants of the rainforest don't need deep taproots; instead, they have shallow roots that spread out, clinging to what little soil exists, clutching the bedrock beneath. This broad web of roots, each holding onto the other, connects the trees in a rainforest. This helps the forest withstand windstorms. When a storm does topple a tree, it will often snap the trunk while the roots still hold the base of the tree in place. At Exit Glacier, visitors can observe the thin, dense mat of roots and soil where the river pouring out of the glacier tears into the bank, undercutting the vegetation.

In a place where nutrients are at a premium, everything that dies is instantly taken apart and recycled to support life. Fallen trees become nurse logs, the next generation of trees sprouting on the decaying wood. Dead trees hold water, allowing seedlings to make it through dry spells safely. Fungi convert tough, hard lignin into digestible nutrients. Some kinds of plants, like the blue-berried skunk currant (*Ribes glandulosum*), are seldom found on the ground, doing best on top of old logs and stumps.

The Bigger Picture

Climbing up the slopes, the trees face increasingly shorter seasons and heavier snows, and are replaced by lush meadows of wildflowers. This mosaic benefits wildlife: Black bears take shelter in dense clumps of alder, climbing up to subalpine meadows to consume nutritious summer foods, and entering mature spruce forests in the fall to eat blueberries.

Even out in the midst of the Harding Icefield, there are plants beginning to colonize the nunataks as ice melts and more rock is exposed. Seeds make their way to these rock islands surrounded by ice. They hang on in a land where they are likely covered in snow all but two to three months of the year.

Exit Glacier, like many glaciers in Kenai Fjords National Park, is undergoing rapid recession now. Seedlings of alder, cottonwood, and dwarf fireweed quickly colonize the seemingly barren landscape, exposed by melting ice. A visit to the glacier is just one snapshot in time. Next year, 50 years from now, a century ahead in time, succession will create a different place, still linked to the past by the patterns that shape its changing landscape. Patterns we are still learning to recognize.

NPS photograph by Paul Ollig

The forest begins near Exit Glacier.

A walk up to Exit Glacier shows increasingly younger vegetation, culminating in bare rock beside the blue walls of ice. Look carefully, not far from the ice the first colonizers are taking hold. Dwarf fireweed, alder, willow, mosses, and lichens are beginning the process of transforming the debris and bedrock into a garden of life.