

National Park Service
U.S. Department of the Interior

Kenai Fjords National Park
Seward, AK



Exit Glacier

A Teacher's Guide



Welcome to Exit Glacier

This is a unique opportunity to visit a glacier up close and learn more about Exit Glacier's role in creating the landscape around us. We hope you have an educational and fun visit to your National Park. Topics you might like to cover while you are here include: the creation of the National Park System, glacial landscapes, glaciers and glaciology, and plant succession. This guide features a map of the area, descriptions of trails, information and an outline for use in educational programs, and a list of additional sources to help you plan your visit.

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Basics to Know Before You Arrive

Nature Center: The Nature Center at Exit Glacier is open from mid May through September, depending on weather conditions. If it is open, you are welcome to come inside, ask the rangers questions, view the 3D model of the Park and the various animal pelts and skulls, and visit the Alaska Geographic bookstore. We ask that large groups please be considerate of other visitors in the Center.

Restrooms: If visiting in spring or fall, know that Exit Glacier facilities lack running water. Groups should use the pit toilets next to the bus parking zone and bring enough drinking water, as there will be no opportunities for refills. If visiting during summer, there are flush toilets and running water at the Nature Center plaza. Be advised that there are no other facilities at Exit Glacier.

Food: There are picnic tables located behind the Nature Center for group use. If there is snow-cover, groups may eat on the Nature Center porch or in the parking lot. Food should be kept in vehicles until snack/lunch time. Please help keep our park clean and “bear friendly” by not leaving food scraps or trash behind. This Leave No Trace ethic can be used as an introduction to

the role of stewardship in National Parks. This can also segue into a program about wildlife in the park (and why it should remain wild).

Gear and Weather: The Kenai Fjords area is a temperate rainforest where rain and cooler temperatures should be expected, so come prepared for inclement weather. Depending on the season, visitors may encounter snowy or flooded trails. Hiking boots or rubber boots are recommended, especially when visiting the outwash plain. The cool winds blowing off the glacier also make an extra layer appropriate at the edge of the glacier. Dressing for the conditions could be incorporated into lesson plans.

Being Bear Aware: This is a wild space, and we do have bears in the area. Large groups (which often make a lot of noise) are less likely to encounter bears. As a precaution, however, on guided programs the ranger leads the group at all times and appoints an adult to stay at the back of the group. Besides visitor safety in bear encounters, the greatest concern is that no food or food scraps are made available to bears in any way. Visitor cooperation is needed in helping to look after the park!

Cell Phones: There is no cell phone reception at Exit Glacier. If your group has an emergency or is scheduled for a program and will be late, please contact Park Headquarters in Seward at 907-422-0500. They will radio messages to the appropriate rangers.



A Kenai Fjords park ranger talks to a group on the outwash plain. NPS/HALLIE PAYNE

Introduction to the National Park System and Kenai Fjords

What is a National Park? A National Park is an area of land that has been set aside by an act of Congress for the conservation and celebration of a particular resource. National Parks preserve our natural and cultural resources for the education, inspiration, and enjoyment of all current and future generations. Parks provide important opportunities for recreation and research while still maintaining the integrity of their environments.

For many of the classes National Parks are a new concept. Spend some time thinking about why we have them. Ask students if they have visited any parks before and what was special about those places.

Why is Kenai Fjords a National Park? Kenai Fjords became a National Park in 1980 in order to protect the Harding Icefield and its outflowing glaciers and coastal fjords. At approximately 600 square miles, the Harding Icefield is the largest icefield wholly contained within the United States. A quick glance at the park map clearly shows how ice dominates this landscape. As a National Park, Kenai Fjords enables all people to participate in the conservation and enjoyment of and find inspiration from the unique environment of the Harding Icefield and its surrounding areas, such as Exit Glacier.

Visiting Exit Glacier is a great way to get a feel for what makes this such a unique environment and National Park.

Trails

There are several ways of combining the trails here at Exit Glacier in order to create a program targeted to the ages, abilities, and interests of students. Each of the trails is listed with one way distance, approximate one way walking time and appropriate topics/points of interest.

Paved Trail: 0.5 mile, 20 minutes

Moraines, Succession, Exit Glacier

The paved trail is handicap accessible with several benches en route, The trail ends at the (covered) interpretive kiosk.

The paved trail is the most direct way to access the multiple viewpoints of the



glacier and is a good route for younger/less able children or classes with less time. It provides an opportunity to touch on many of the key topics of the park, including glacial landscapes (U-shaped valleys, moraines, outwash plain, etc), plant succession and, of course, Exit Glacier.

Glacier View: 0.5 mile, 20 minutes

Moraines, Succession, Moose, Exit Glacier

The trail to Glacier View is a gravel, handicap accessible trail with a bench at the half way point.

The trail branches off from the paved trail directly behind and to the left of the Nature Center. It immediately crosses the 1917 moraine deposited by Exit Glacier. This is a good place to introduce the concept of glacial landscapes. The trail passes through the forest, providing multiple opportunities to talk about plant succession and forest animals in terms of their habitat and behavior. The trail continues along Exit Creek and ends at the Exit Glacier viewpoint. Discussion of glacial formation and dynamics, as well as landscape impacts (e.g. the role of meltwater), would be relevant.

At the viewpoint the trail continues on to connect to the paved trail.

Toe of the Glacier: 1 mile, 45 minutes

Moraines, Outwash Plain, Braided Streams, Exit Glacier

The outwash plain is sometimes impassable due to high water levels. Check with rangers before your trip.

When water levels are low, it is possible to cross the outwash plain and reach the toe of Exit Glacier. This can be an exciting experience and great way to learn about the power of glaciers and their meltwater streams, and the associated landforms such as braided streams, kettle ponds, and moraines. Be sure, however, to check with the rangers and assess the plain before starting out. Glacial meltwater is very cold and it is often difficult to tell how deep the streams are due to their chalky color (a great tangible for discussion about glacial flour).

It is important to be aware of the safety concerns on this trail. Not only should care and precaution be taken when crossing the streams of the outwash plain, but establishing safety rules at the toe of Exit Glacier is also of



Braided streams on the outwash plain.

NPS/HALLIE PAYNE



Edge of the Glacier Trail.
NPS/HALLIE PAYNE

paramount concern. NEVER approach the glacier in such a way that ice is overhead, and obey all posted signs.

There is no defined trail over the outwash plain – simply choose the route which makes the most sense. The outwash plain is accessed from either the paved trail or the trail leading from the edge of the glacier.

Edge of the Glacier: 1.2 miles, 1 hour

Exit Glacier, Moraines, Succession, Striations, Geology

The edge of the glacier is accessed either from the paved trail or from the outwash plain. This trail gains 250 ft. in elevation and features steep rocky sections and some narrow parts. It is often a few

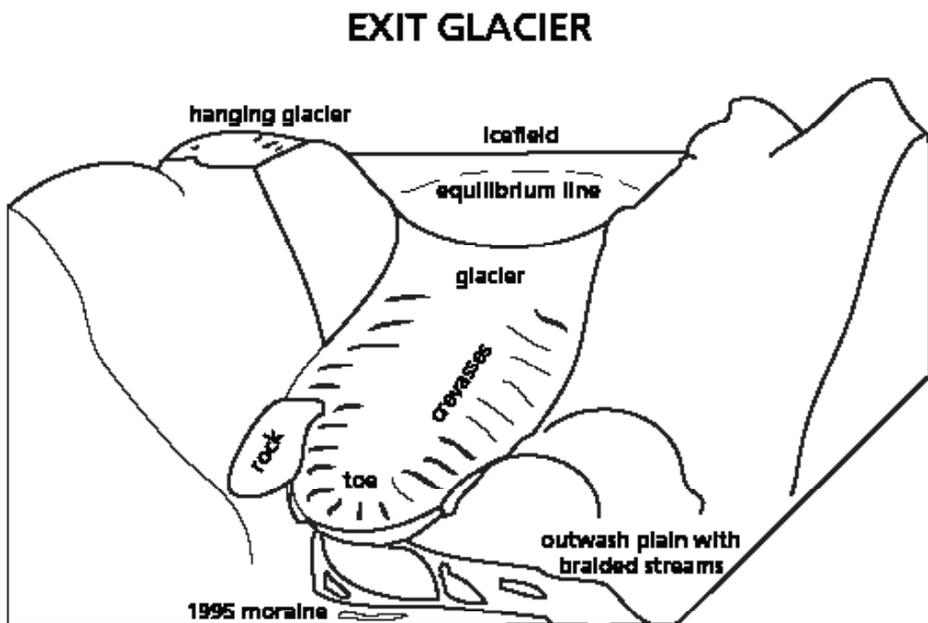
degrees cooler at the glacier's edge. If this trail is part of your plans, make sure students are adequately dressed and prepared.

This route leads to the edge of Exit Glacier and travels over rock and ground that was covered by ice as little as seven years ago. This gives a chance to witness the power of glaciers (bare ground, striations, perched boulders, etc.) and to see the earliest stages of plant succession. A stop to sit and take in the presence of Exit Glacier is a worthwhile chance for students to absorb the immensity of the ice. This would be a good place to journal, draw, or just contemplate.

Note: The Harding Icefield Trail is not described in this booklet because it is usually not a good option for school groups, though small groups of older students may enjoy the challenge. The icefield trail is 3.8 miles long and climbs 3200 ft. It does provide stunning views of the Harding Icefield and excellent opportunities to discuss plant communities in transition. This is a strenuous climb. A recommended time is usually 6-8 hours.

Planning a Program: Topics and Information

There are many topics that you can cover at Exit Glacier. The two main items of discussion are glacial effects on landscape and plant succession, both of which easily fit in one program due to their integral links. Other focuses may include ecosystems, animals and wildlife, or geology. We are always looking for new ideas – if you come up with a great lesson or program, we'd love to see and hear about it! In the following pages you will find brief overviews of the content of our Exit Glacier programs.



This diagram shows Exit Glacier and some of its surrounding features. Crevasses, or large cracks in the ice, often form along the margins of the glacier where greater friction causes the ice to move more slowly. The equilibrium line is the elevation at which annual snow accumulation and annual melting are equal. Below this line, all seasonal snow melts during the summer. The position of Exit Glacier's equilibrium line is a factor in the current retreat of the ice. NPS/LISA GORDON

Glaciology and Glacial Landscapes

Exit Glacier and the glaciation of its valley are key components of any trip to the area. A common theme for a program is Exit Glacier's role in forming the landscape. This section will give you information to understand and look for evidence of glacial processes, as well as sources for further reading.

How glaciers form: Glacier formation requires two conditions: large amounts of snow and relatively cool summers. This allows for yearly snow layers to accumulate. When annual snow melts and refreezes throughout the year, the snowflakes transform into a granular compacted snow called firn. Newer snow layers accumulate atop this firn layer and compact it even more, causing the granular crystals to fuse together and form ice. Once the ice responds to the pull of gravity and begins to flow downhill, a glacier is born. Kenai Fjords is an area dominated by ice because of the regional climate. Though this is not the coldest part of Alaska, its geographical situation along a coast ringed with mountains leads to large amounts of precipitation and cool summer temperatures. These conditions were even more extreme during the last ice age (23 -10,000 years ago), allowing for the massive collection of snow and ice needed to create the Harding Icefield and its 38 outflowing glaciers that still exist today.

How glaciers move: Movement is a key part of the definition of a glacier. All glaciers, even ones that are retreating or getting smaller, are moving downhill, away from their source area. Exit Glacier moves at about a foot a day. Glaciers move in two basic ways. One is to slide over the ground on a bed of glacial meltwater flowing underneath (listen carefully at the edge of the glacier and you can hear this water running beneath Exit Glacier). The other is to move by a process known as internal deformation. Under extreme pressure, such as the weight of overlying ice combined with the pull of gravity, solid ice will actually flow, like a very slow river. As glaciers move downhill, the rock and sediment in the ice scour and abrade the underlying bedrock, dramatically changing the landscape. The fjords and U-shaped valleys of Kenai Fjords National Park are a result of the slow erosive processes of glaciers over many thousands of years. Look for the "U" shape of the Exit Glacier valley.

Why is the glacier blue? Glaciers are blue for the same reason that water is blue. When visible light passes through a glacier, the longer wavelengths on the spectrum (red light) are absorbed. The structure of the ice crystals and impurities in the glacier cause the blue light (which has one of the shortest wavelengths) to scatter and reflect back out. The longer light travels through the ice the more, red light is absorbed, and the bluer it appears.

Why is it windy by the glacier? There is often a cool wind blowing down from

the glacier, especially evident at the edge of the glacier. This special wind is called a katabatic wind. As air masses move across the Kenai Mountains, they cool over the icefield. This cooler, denser air begins to sink and flows down the glacier to the valley. You can compare this to cold air rushing out of a freezer, except here the freezer is the 600 square mile Harding Icefield. A larger temperature and density difference between the two air masses means a stronger wind.

Glacial landforms to look out for:

U-Shaped valleys– The steep sides and flat bottom of the Exit Glacier Valley and Resurrection Bay are clear indicators that these are glacially carved. Fjords are inundated glacial valleys.

Cirques– Small alpine glaciers carve out bowls in mountain peaks. Looking north (away) from Exit Glacier you can see several cirques and a few cirque glaciers.

Striations– Small scratch marks formed as the glacier ice slowly scraped back and forth over underlying rock. These indicate the direction of glacial flow.

Moraines: Moraines are deposits of rock and sediment accumulated by a glacier. There are several types, including recessional moraines (formed at the toe of retreating glaciers), lateral moraines (formed along the sides), and medial moraines (forming between the meeting of two or more glaciers). Glaciers are often described as bulldozers, and while it is true that glaciers tend to have a bulldozer-like affect on their surroundings, very few moraines are formed by the downslope push of the ice. Only one type, appropriately called a “push” moraine, is formed this way. A better metaphor for moraine formation is to think of the glacier as a giant conveyor belt carrying rock down from the mountains and unloading along the glacier’s edge. Moraines are a key element in studying the story of Exit Glacier as they allow us to track the changes of Exit Glacier over time. Along the trails you will pass over several moraines which are marked with the dates when they were formed by Exit Glacier. Following the timeline between these mo



**A moraine at the toe of Exit Glacier.
NPS/DOUG CAPRA**

raines is a way to track the stages of plant succession from the older cottonwood forests by the Nature Center to the bare rock at the edge of the glacier today.

The outwash plain: The outwash plain is a dynamic environment and setting for the tumultuous interactions between glaciers, melt water, and the surrounding area. The braided stream systems (many channels in one river bed) are a common feature of rivers formed from glacial melt. This braiding is a result of the high sediment

load carried by glacial rivers. The amount of sediment that can be transported by the streams varies with water volume and speed. When water velocity slows or levels drop, sediment is deposited, causing channels to change and divert. The chalky color of glacial streams is due to the high concentration of ‘glacial flour’ (very fine rock particles) suspended in the water. These high loads of glacial flour lower water quality, often making rivers too silty and nutrient poor to support abundant aquatic life. The outwash plain also contains several examples of moraines, one from 1995 (in the center of the outwash plain) and another from 1997. The distance between these moraines and Exit Glacier reflects how Exit Glacier has changed in recent years. Despite its retreat, Exit Glacier remains a powerful erosive force evident in the sheer size and volume of rocks littering the outwash plain along with the fine grains carried in the numerous streams.



The outwash plain. NPS COLLECTION

More Resources:

Alaska’s Glaciers: Frozen in Motion. Katherine Hocker. Anchorage, AK: Alaska Geographic, 2005.

Sculpted by Ice: Glaciers and the Alaska Landscape. Michael Collier. Anchorage, AK: Alaska Geographic, 2004.

All About Glaciers. National Snow and Ice Data Center.
<http://www.nsidc.org/glaciers>

Plant Succession

Plant succession is the ordered change of plant communities over time. Plants sequentially replace each other as the dominant species or type. The Exit Glacier area is a great place to study this process as it occurs following the retreat

of the glacier. Below is a simple outline of the different stages of succession found here at Exit Glacier.

Glacial Recession: As Exit Glacier recedes, it leaves behind bare ground. Along the face and sides of the glacier you may see new moraines emerging. Newly revealed terrain is a blank slate, a new beginning for plant life.



**An alder sapling growing on the outwash plain.
NPS/LISA GORDON**

Starting out: The first plant life to arrive are mosses and lichens whose spores are carried in on the wind. Lichens excrete an acid that breaks down rocks and gravel into smaller components. Moss and lichens also increase the organic content in groundcover, a key ingredient in soil building. You will be able to see this initial stage of development along the glacier's edge.

Seedling stage: "Pioneer" plants, such as Dwarf Fireweed and Sitka Alder are the next to establish. Most plants depend on broken down organic matter in soils to obtain nitrates, the usable form of nitrogen and key nutrient for all plant life; however, in the glacial deposits there is little to no organic matter. Alder are able to move in and survive here because they are "nitrogen-fixers," meaning that they do not need nutrient laden soil to obtain their nitrogen. They have a symbiotic relationship with bacteria in their roots, which take



**Alder and willow shrubs on the Edge of the Glacier trail.
NPS/HALLIE PAYNE**

nitrogen from the air and turn it into nitrates. This not only enables the plants to colonize recently glaciated areas, but also to create soil through the build up of nutrients and organic matter (e.g. dropped leaves). Watch for young alder saplings and fireweed shoots out on the outwash plain or growing in rocky crevices along the edges of the glacier.

Shrub stage: As soil begins to accumulate, small shrubs, such as Felt Leaf Willows, join with the pioneering alders to inhabit the area. These species are highly favored by moose. Look for moose sign in the form of scat and pruned shrubs through browsing and grazing. An interesting fact about willow – the cambium layer just beneath the bark contains salicylic acid – the active ingredient in aspirin. Maybe moose like to munch on willow because they have a headache? (Moose antlers can weigh up to 70 lbs!) Shrub habitat spans between the 1926 moraine and the outwash plain.



A Sitka Spruce growing up in a stand of cottonwood. NPS/LISA GORDON

Sub Mature Stage: After a period of 50-100 years, a cottonwood forest develops. Cottonwoods are the main species; however, they are not the only trees growing here. There are also many full growth willows and alders – indicative of the way that forest slowly evolve, changing from one stage to the next gradually over time. Look closely, you might even find some young spruce trees.

Mature Forest: Sitka Spruce and Western Hemlock form a mature forest in the Exit Glacier ecosystem. In earlier successional stages, spruce trees grow intermingled with cottonwoods and other species. Eventually the spruce dominate the forest, depriving the cottonwoods of sunlight and nutrients. It takes a long time (over two hundred years) to transition from a mixed sub-mature/mature forest to an evergreen mature forest. At Exit Glacier, spruce cover the surrounding mountainsides, while at the Nature Center we find cottonwoods, alders and willows. This is one indication that the area above the Nature Center was not covered by ice as recently as the valley floor.

More Resources:

Forest service lesson plan about succession (based on fire controlled forest): <http://www.nden.k12.wi.us/k8/eighfor2.htm>

An active game to help students understand the concept of plant succession: http://alaska.fws.gov/fire/role/unit1/complete_succession_race.pdf

Sample Program Outline

An Exit Glacier program for upper elementary students following a route to the Glacier View or out to the Edge of the Glacier and back.

Topic: Learning about Exit Glacier and ways it affected (and continues to affect) this area.

Introduction (Nature Center Plaza): Welcome to the National Park. What makes this place special? Why does it exist? What are we going to do today?

Moraines (1917 Moraine): Moraines provide an introduction to glacial influence on the area (how they form, why they form, what they can tell us about the area) and lay the groundwork for looking for the different stages of succession. Moraines can be introduced conceptually as glacial tracks that can tell us where the glacier traveled, much like tracking animals.

Succession (Various moraines): As the trail progresses, ask students to observe how the forest changes – are the trees getting younger or older? Are they the same type? What is the biological relationship to time and the presence of Exit Glacier? Where might moose live in this forest and why?

Glacial signatures (Edge of the Glacier Trail): Observe how the vegetation changes when the trail gains elevation. Now it is easier to see what is underneath. Talk more about how glaciers move and what they do to the landscape. Here will also be striations left on the bedrock by the glacier, which can be compared to graffiti to make a relevant conceptual analogy.

Exit Glacier (Edge of the Glacier): This is a great place for students to pause and soak in the presence of the glacier. Perhaps have students sit quietly for a minute or two and then ask for observations which may include noticing the blue color of the ice, the presence of a katabatic wind, the sounds of rushing water under the glacier.

Return to the Nature Center, recap topics covered.

Additional Park Resources

Glacier Tracks: This is a workbook intended to complement a visit to Exit Glacier for upper elementary students. It contains a variety of tasks, such as measuring the temperature of glacial meltwater, identifying plant species, a journal page, and more. Teachers can use the booklets as a pre- or post-trip activity. The booklets are free, please contact us if you are interested in using Glacier Tracks with your class.

Glacial Gab: This is a collection of relevant vocabulary for lessons involving glacial formation and processes. It is a suggestion of words students should be familiar with-- terms may be omitted to account for grade level.

Teacher's Resource Manual: In 2009, Kenai Fjords and Alaska Geographic will have limited copies of a Teacher's Resource Manual that provides more information about the National Park, including: the Harding Icefield and outflowing glaciers, the plant communities, and coastal and marine systems. Please contact us to obtain a free copy on loan or for personal use if available.

Ranger class visits and field trips: We are glad you are studying Exit Glacier and would love to be part of that process with you. In both the spring and fall seasons, Kenai Fjords National Park offers ranger class visits and ranger-led field trips at Exit Glacier free of charge. Available days often fill up fast, especially in the spring, when late-lasting snow can limit availability. In the fall season (September 1st to October 10th), there are more dates available and less weather worries, so this is an excellent time to visit us! Let us know as soon as you are thinking about a trip. Even if we aren't able to accommodate your schedule this year, we would love to talk with you and help you plan your visit.

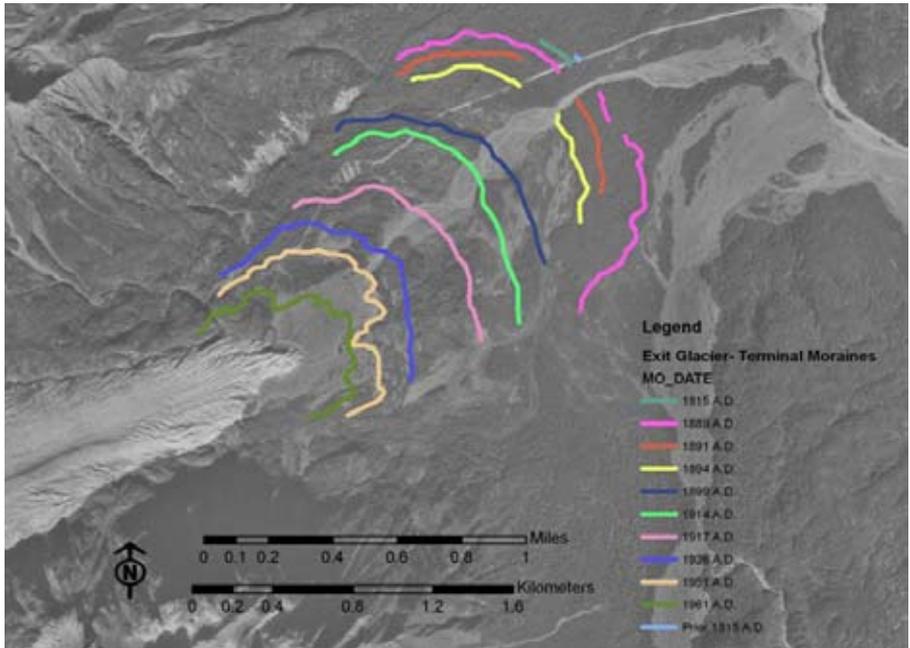
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National Park Service
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Kenai Fjords National Park

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This 1996 image shows the placement of recessional moraines deposited by Exit Glacier.
NPS COLLECTION

For more information:
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