The Changing Alpine Treeline Ecotone of Glacier National Park

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NATIONAL PARK SERVICE
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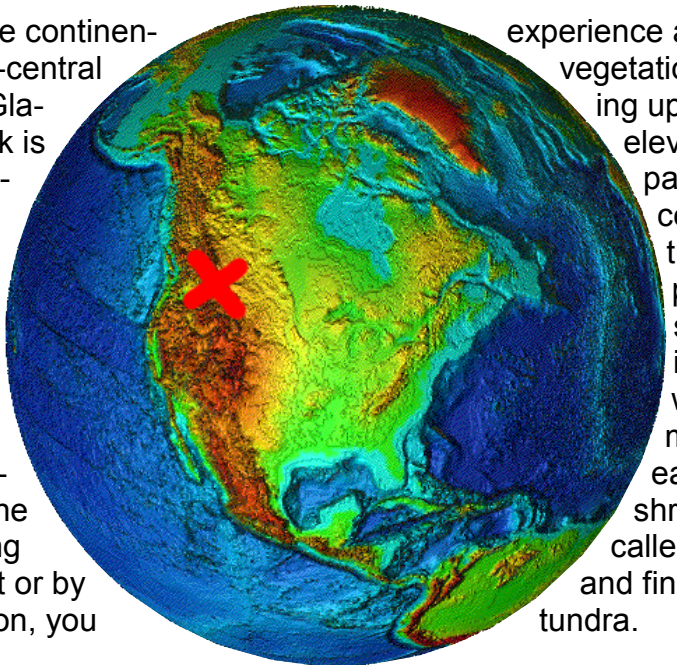


Located along the continental divide in west-central North America, Glacier National Park is an excellent location to observe and study alpine treeline. Travelling through the park – on foot, by horse, bicycle, or car – you can't help but notice changes in the vegetation. Going from east to west or by changing elevation, you experience a range of vegetation types. Moving up from lower elevations you pass through continuous mature forest, into patches of smaller trees interspersed with subalpine meadows, to areas of scattered shrublike trees called krummholz, and finally into alpine tundra.

What is alpine treeline?

Alpine treeline is the zone of transition between continuous, mature forest and alpine tundra. In Glacier, this typically begins about 6500' elevation and continues for several hundred to a thousand feet upwards. The term ecotone is often included as it refers to the zone of transition between two ecological communities, for alpine treeline the transition between forest and alpine tundra. Similar definitions include forest line/timberline (uppermost elevation of continuous forest), tree-line (uppermost elevation of erect, upright trees), and tree- or krummholz-limit (uppermost elevation of prostrate, dwarf, shrublike trees or krummholz).

As in much of North America, conifers are the most common tree type found at alpine treeline in Glacier. Predominate species include subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), whitebark pine (*Pinus albicaulis*), and Limber Pine (*Pinus flexilis*). Krummholz (German for "crooked wood") refers to morphological form and is the result of extreme environmental conditions including wind and cold.

Why is there an alpine treeline?

Alpine treeline results from many complex and interacting causes, with two general regulating factors being climate and topography.

Climate:

- Temperature – treeline roughly corresponds to a 50ºF (10ºC) isotherm for the warmest month of the year (isotherm is a line on map connecting points of equal, average temperature).
- Wind – shapes or trains trees, batters them with icy pellets, flails the branches, and dries out foliage.
- Precipitation or moisture – helps determine what species grow where, how much a tree grows, or if they can establish at all.
- Snow – protects from extreme cold and harsh winds, but also weights down limbs, breaks branches, and fails to melt in time to allow seeds to establish and grow.

Topography

- Aspect – in Glacier, north-facing slopes are typically cooler and have slightly lower alpine treelines than south-facing slopes.
    - Different species are often found on opposing slopes, depending upon the exact combination of temperature and moisture.

- Ridgetops – on the east-side of the Continental Divide ridges are often severely wind-swept, restricting the location and shape of trees. On the less breezy west-side, ridgetops are often warmer than nearby basins or cirques and may have more trees present.
- Geology and soils – soil type & underlying rocks help determine what species grow where, in conjunction with available moisture, by providing a suitable growing medium with the appropriate nutrients. Although rarely found to entirely preclude tree growth (trees can grow out of cracks in rocks), soil & geological patterns are often visible in the spatial patterns of trees.

Competing theories about the physiological limits of trees exist. Research in Glacier and elsewhere throughout North America and the world is helping to further refine our understanding of trees and the variability among sites. One theory is that minimum temperatures must be maintained during the growing season to permit shoot growth – trees will not survive where average temperatures are too low. Another theory suggests the foliage of plants becomes desiccated (dries out) in winter and prevents trees from successfully establishing in new areas. A third theory suggests that cold temperatures and short growing seasons limit photosynthesis and the rate at which carbon and other necessary nutrients can be absorbed, preventing growth & establishment.

Disturbance also plays a crucial role in determining the location, spatial distribution, and species composition of alpine treeline.

- Fire – a common, natural event in Glacier. Many species benefit from fire, it clears out competing vegetation and ash created provides needed nutrients. Intense fire can also kill live trees and allows different species to flourish.
- Avalanches and landslides – the rapid downhill movement of snow or earth – occur on steep slopes and prevent the normal development of a forest, although the areas outside their path are typically left undisturbed.
- Solifluction – the slow, creeping downhill movement of soil – damages plant roots and alters the distribution of trees on the landscape.

Compared to alpine treelines further west along the pacific coast, treeline in Glacier is usually higher in elevation as a result of a more continental climate (colder winters with less snowfall and warmer summers). In the Cascade and Olympic Ranges of Washington, treeline occurs at lower elevations in a more maritime climate (cool, cloudy, and wet winters with mild, dry summers). However, alpine treeline will vary over large & small areas due to natural variability.

How has alpine treeline in Glacier changed?

Changes in alpine treeline occur primarily in three ways: establishment of new trees, growth, and death.

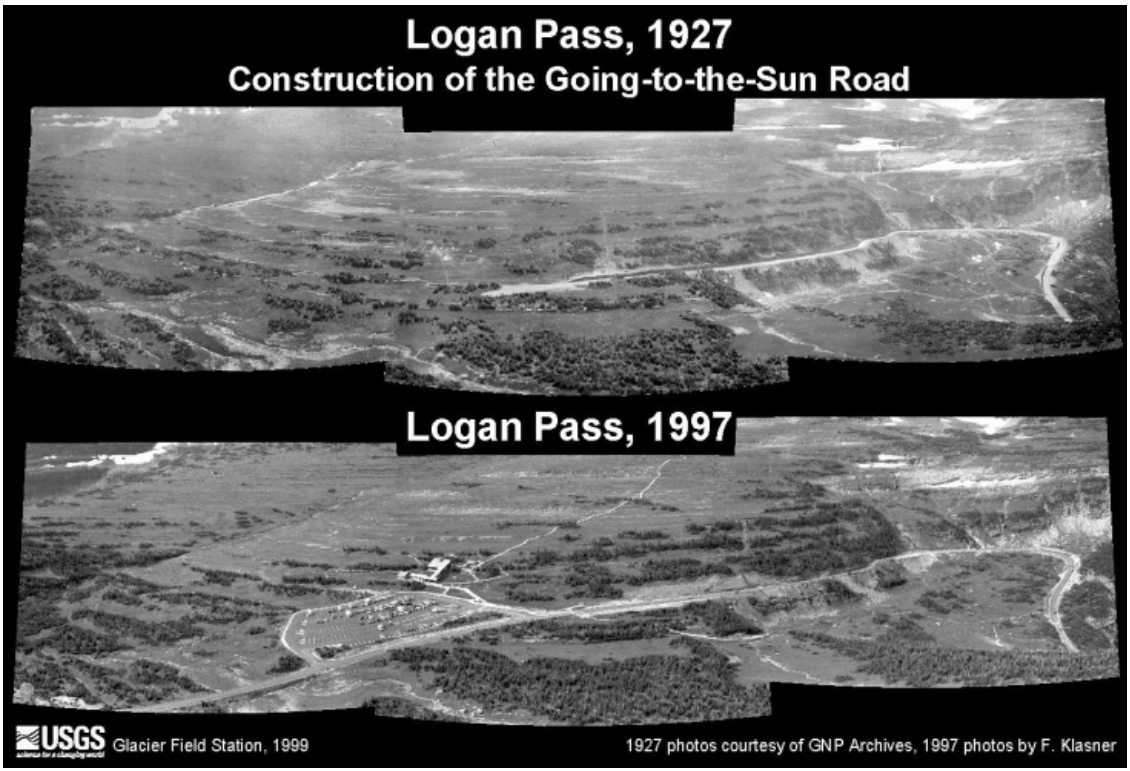
1. Trees establishing from seeds can be found within existing clusters or in meadows away from other trees. Layering – when limbs are pressed into the ground and take root – is another way for a tree to become established.
2. At alpine treeline trees typically grow in a very dense fashion, making full use of the protection provided by existing branches and neighboring trees, with lower branches growing outward and building upward.
3. Tree mortality rates at alpine treeline are usually very low. However, branches or portions of an individual tree may dry out or succumb to other forces. Alternatively, entire trees may die from disease or other causes, or be removed through landslides or avalanches.

Studies in Glacier have identified very little change in the *position* of alpine treeline over the past several hundred years. Comparison of recent photographs of alpine treeline with those from the beginning of the

20th century confirms this (elsewhere in North America and throughout the world, similar studies have shown dramatically different results). Possible localized exceptions to this stability include sub-alpine areas above the Scenic Point or Ptarmigan Tunnel trails, where large dead trees are visible where forest fires once burned – leaving a dramatically different landscape behind. This is not to say however, that there have been no changes at alpine treeline.

Another way of looking for changes in the alpine treeline ecotone is by identifying the species present, the physical forms trees take, and the area they occupy. Tree species change over time through the process of succession, with pioneer species preparing the way for others. Whitebark pine is a common pioneer species, while subalpine fir often establishes in areas with whitebark pine and eventually becomes the dominant species. Repeated photographs from Logan Pass (see photo on previous page) indicate that krummholz vegetation has grown more upright while expanding into the meadow between clusters of trees. Relative to meadow area, tree growth & establishment in meadows and other spaces is resulting in an increase in area of trees at the alpine treeline ecotone. This is being accompanied by an increase in tree density (existing clusters of trees more tightly populated).

Humans are responsible for some of the most significant changes at alpine treeline. In studies from Glacier and elsewhere, the exclusion of fire increases plant density and changes species composition. Trampling by hikers fragments clusters of trees. Even a single party of hikers walking through an alpine meadow has a significant, measurable impact on the vegetation. Past management actions by the National Park Service also served to introduce pollutants into the soil at alpine treeline. Trails were oiled during the 1930's, all the way up to alpine treeline, in attempts to minimize dust along trails (see photo on previous page). During the 1950's, in an effort to stop the spread of a non-native blister rust from devastating a common alpine treeline species (whitebark pine), Agent Orange (a defoliant) was used to kill host plants in its life cycle (wild currants and gooseberries). Park infrastructure has also had profound effects on the alpine treeline landscape, as seen in the photo below with the construction of the Going-to-the-Sun Road, Logan Pass parking lot, and Visitor Center. Approximately 35% of Glacier's land area is between 6000'-8000' (the zone where the alpine treeline ecotone is found). This zone receives a disproportionate amount of attention as a tourist attraction, increasing the importance of careful management.



Why are changes in alpine treeline important?

Research in Glacier and elsewhere has shown that the location and spatial patterns of alpine treeline are significant. Both clusters of trees and the openings between them are vital for snow accumulation & melt, soil development, species diversity, & wildlife habitat. One study found digging by grizzly bears for food helps maintain healthy plant populations in meadows. Other research is working to identify ways of reversing the decline in alpine treeline species such as whitebark pine. Ultimately, the National Park Service and U.S. Geological Survey are interested in knowing as much as possible about how and why ecosystems such as the alpine treeline ecotone have changed and are changing.

All these changes involve dynamic, ongoing processes that are difficult or impossible predict. National Parks serve as a kind of living laboratory, where natural mechanisms of change, such as fire and grizzly bears, are maintained for our benefit and study. In a study similar to those occurring at alpine treeline, Glacier National Park & the U.S. Geological Survey are working to learn more about changes in the grasslands and tree cover where the eastern border of the park meets the Blackfeet Indian Reservation and the Great Plains.

Changes in alpine treeline are just one example of many in mountain regions throughout the world. Mountains occupy over 20% of the worlds land area and are extremely important for vital natural resources including water, timber, minerals, and biodiversity. Change in the mountains results from both human influences and natural variation – with diverse effects on cultures, social structures, economic systems, vegetation, climate, and other natural and human systems.

What is being done in Glacier?

Glacier National Park manages alpine treeline ecosystems, as it does all other types of ecosystems, with several goals in mind. Maintaining ecosystem function is a primary goal. This means that natural processes are permitted to occur, naturally. A second goal is to provide people with the opportunity to experience, learn about, and enjoy these ecosystems. This sometimes leads to challenging decisions, such as preserving a desirable current state versus allowing for natural changes which may lead to a less-certain future.

Two programs that exemplify these goals are *Leave-No-Trace* and *Fire Management*.

- Leave-No-Trace is exemplified by the *attitude & behavior* of trying to leave our National Parks and other wild areas as we found them, so that those who come after us enjoy the same opportunities we do.
  - ***You*** can help by staying on maintained trails, not harassing wildlife, and taking out all the litter that you brought in.
- The fire management program in Glacier permits fires begun through natural causes to burn, provided there are no serious safety concerns. Park managers also ignite fires as a management tool.

You can help by being careful with your own campfires and reporting any fires you see to a park ranger.

How Can I Learn More?

The best way to learn more about alpine treeline is to observe for yourself. In Glacier National Park, alpine treeline typically occurs at about 6500' in elevation. Hike a trail that goes up to and above this elevation or take a shuttle bus to Logan Pass. As you go, notice the size, shape, and color of the trees and identify the species you see. Look at areas without trees as well and think about why that particular vegetation is growing there. A good way to prepare is to ask questions of park naturalists, attend their programs, stop by the visitor centers, and read the interpretive displays throughout the park.

While at home you can also visit your local library for reference materials, or go online and search for alpine treeline, *Leave-No-Trace*, or fire management. Glacier National Park's excellent web page: *http://www.nps.gov/glac/home.htm*, provides numerous resources, as does the USGS-Glacier Field Station web page: *http://www.mesc.usgs.gov/glacier*.

References:

Much of the general information regarding treeline for this pamphlet has been drawn from the following excellent reference, available at Glacier National Park Visitor Centers and from the Glacier Natural History Association:

Timberline: Mountain and Arctic Forest Frontiers. By Stephen F. Arno and Ramona P. Hammerly. 1984. The Mountaineers: Seattle, WA.

An excellent reference on mountain related issues, covering such diverse topics as alpine treeline, human population, mountain cultures, and geography, available at libraries and bookstores is:

Mountains of the World: A Global Priority. Edited by Bruno Messerli and Jack .D. Ives. 1997. Parthenon Publishing: London, UK.

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