

MOUNT ST. HELENS

VOLCANIC RESEARCH AREA



The May 18, 1980, eruption seared, buried, burned, and flooded the lands around Mount St. Helens.

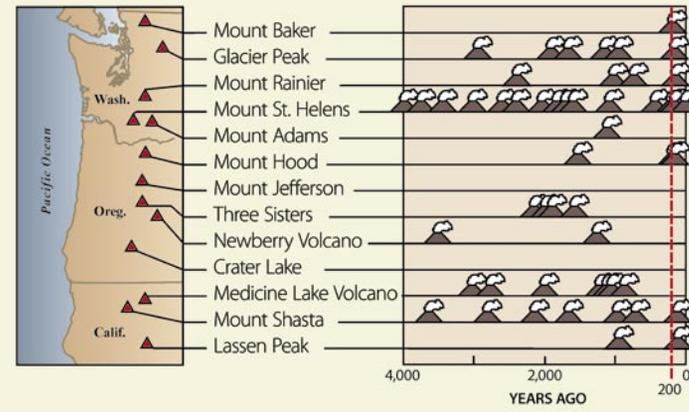
INTRODUCTION

IN 1980, MOUNT ST. HELENS, a snow-capped mountain in southwest Washington's Gifford Pinchot National Forest, exploded. A debris avalanche, the largest in recorded history, and a laterally directed blast, as well as mudflows, pyroclastic flows, airborne ash and stones, and growth of a new lava dome created a real-time

laboratory for scientists. Recognizing the unique opportunities for study, Congress passed the Mount St. Helens National Volcanic Monument Act in 1982, placing 106,255 acres within the monument to allow "geologic forces and ecological succession to continue substantially unimpeded."

Courtesy of U.S. Geological Survey/Cascades Volcano Observatory

Cascade Eruptions During the Past 4,000 Years



Over the past 4,000 years, Mount St. Helens has been the most active Cascade Range volcano, with about 20 eruptive periods.

Scientists from the USDA Forest Service Pacific Northwest (PNW) Research Station and many other institutions arrived within weeks to assess disturbance effects and develop a research strategy to study initial and long-term ecological responses. Their research has illuminated the way in which species and ecological processes respond to disturbance, and has contributed to planning for the recovery of other disturbed areas.

ENVIRONMENT

Geology. The Cascade Range volcanoes extend from southern British Columbia to northern California. Mount St. Helens has a rich eruptive history—over the millennia, debris avalanches, pyroclastic flows, lava flows, and mudflows have built, torn apart, and rebuilt the volcano. Throughout much of southwest Washington, the soils are made mostly of weathered tephra deposits, which consist of fine ash and gravel-sized volcanic rock debris that were ejected from Mount St. Helens.

Mount St. Helens had a geologically young symmetrical cone before the 1980 eruption. Afterward, with its top gone, a deep crater, and exposed slopes, Mount St. Helens looked like the active volcano it had been all along. From the May 18, 1980, eruption to 1986, the volcano erupted an additional 21 times and then stopped.

In September 2004, Mount St. Helens awakened again with earthquakes, dome-building events, and small ash and steam explosions.

Before the 1980 eruption, 11 glaciers covered Mount St. Helens. Glaciers sculpted steep cliffs and deep bowls and carved broad, U-shaped valleys in the surrounding landscape. Climate and volcanism continue to influence the topography and characteristics of valleys, cliffs, lava caves, lakes, streams, springs, and wetlands. Average precipitation on the mountain is 140 inches a year, with average temperatures of 59 °F in July and 28 °F in January.

Forest types. Before the 1980 eruption, three general forest zones occurred near Mount St. Helens. The western hemlock zone extended up to 3,000 ft and was dominated

by Douglas-fir, western redcedar, and western hemlock. Higher up, from 3,000 to 4,200 feet, Pacific silver fir, noble fir, and Douglas-fir grew in the Pacific silver fir zone. Highest of all was the mountain hemlock zone, from 4,000 to 5,250 feet, with mountain hemlock and Pacific silver fir. In the understory shade huckleberries, salal, currants, Oregon grape, and vine maple thrived, along with mosses, ferns, and flowers. Red alder, black



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Scientists set up permanent study plots in 1980 to observe how life responded after the blast. Their research has produced a valuable record of long-term ecological changes on the volcanic landscape.

cottonwood, and willow grew near water and in disturbed areas. The area also reflected a history of timber harvest, with clearcuts and managed second-growth stands near large areas of old forest. Wet and dry meadows formed occasional openings in the forests.

Terrestrial animal species. The Mount St. Helens area had diverse habitats, including forests, cliffs, meadows, wetlands, lakes, and streams, which supported animals typical of the region. Fifteen species of amphibians—frogs, toads, salamanders, and newts—called the area home, along with four species of reptiles. Fifty-five species of mammals from the tiny Trowbridge’s shrew to the towering Roosevelt elk lived near the mountain, as well as 70 to 80 species of birds, some year-round and others nesting in the summer. Thousands of invertebrate species such as insects and spiders lived in the area.

Streams and lakes. Before 1980, only 39 lakes existed near Mount St. Helens. Most had no fish until European-American settlers began stocking them with nonnative species. Spirit Lake was connected to the ocean via rivers and supported cutthroat and rainbow trout and coho salmon. Mountain streams were small, shallow, and steep, feeding into larger streams that flowed through broad, U-shaped valleys. Three main river systems drained the land—on the north and northwest the Toutle River, on the west the Kalama, and on the south and east the Lewis River. Anadromous (sea-run species) such as lampreys, salmon, and steel-



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Mount St. Helens and Spirit Lake in 2004: reflections of the forces of nature and resilience of life.

head and resident fish (trout and other species) used these rivers.

Disturbances. Insect and disease outbreaks, wildfire, windstorms, as well as a variety of human actions had affected the Mount St. Helens area, but the 1980 eruption thrust volcanic disturbances to the forefront of public attention.



THE 1980 ERUPTION

ON THE MORNING OF MAY 18, an earthquake caused a massive slab of Mount St. Helens’ northern flank to collapse in a gigantic debris avalanche. With the cover removed, superheated gases and rock fragments exploded from Mount St. Helens’ side, and tore across 230 square miles around the volcano. This gas-charged

blast traveled at hurricane speeds of 200 to 250 miles per hour and temperatures of 680 °F, creating a vast area of leveled and scorched trees.

The next events followed each other rapidly, with some overlap. Mount St. Helens continued to spew an ash plume for more than 9 hours after the lateral blast, reaching over 15 miles into the atmosphere. Volcanic deposits blanketed an area mainly to the northeast—the direction of the prevailing wind during the eruption, creating a tephra-fall zone. The ash plume turned daylight to darkness over 120 miles away, and circled the earth in 15 days.

One lobe of the debris avalanche that had been the summit, northern slope, and inside of Mount St. Helens slammed into Spirit Lake. The resulting water wave rushed up surrounding valley walls and dragged trees with it back into the lake. The bed of Spirit Lake rose 200 feet and the surface was covered with a mat of trees. A second lobe of the debris avalanche traveled over a 1,300-foot ridge, and spilled into the South Coldwater

drainage. The third, and largest lobe hurtled 14 miles down the Toutle River Valley, burying 23 square miles to an average depth of 150 feet with mounds, referred to as hummocks.

Water from melting snow and glaciers picked up sand, small rocks, boulders, and logs and formed mudflows that traveled down the volcano's sides. The mudflows tore out bridges, ripped houses from their foundations, and clogged the Columbia River, temporarily blocking the shipping channel.

For several hours after the initial explosion, pumice-rich pyroclastic flows surged from the crater at high speeds and fiery-hot temperatures (at least 1,300 °F), and eventually covered 6 square miles north of the volcano with pumice many feet deep.

Within hours, a lush landscape was seared and smoldering. Forests were scorched; many plants and animals were killed; and 57 people died, including David Johnston, a geologist monitoring the volcano from a ridge that would later be named in his memory.

The blast area extended out to 17 miles in a 180° arc north of the mountain, displaying a pattern that could be divided into three zones: the tree-removal zone (where no trees remained), the blowdown zone (where forests were toppled like matchsticks), and the scorch zone (where standing trees were seared).

Lakes, rivers, land, and the life they supported, appeared decimated. The familiar Pacific Northwest landscape was unrecognizable, scoured of vegetation and buried under ash, pumice, rock, and mud. Stream channels were rerouted, new ponds and lakes formed, rock once part of the mountain lay in heaps across the ground, and a gaping amphitheater-shaped crater replaced the once-symmetrical mountain.



Survivors performed key ecological roles. Gophers mixed volcanic ash into underlying soil. Surviving trees and shrubs produced food and nesting areas for animals, and shade for plants.



USDA Forest Service

Tree-removal zone during the first summer after the May 18, 1980, eruption.



Joseph Means

Blowdown zone. The lateral blast on May 18, 1980, toppled trees on thousands of acres in just a few minutes.



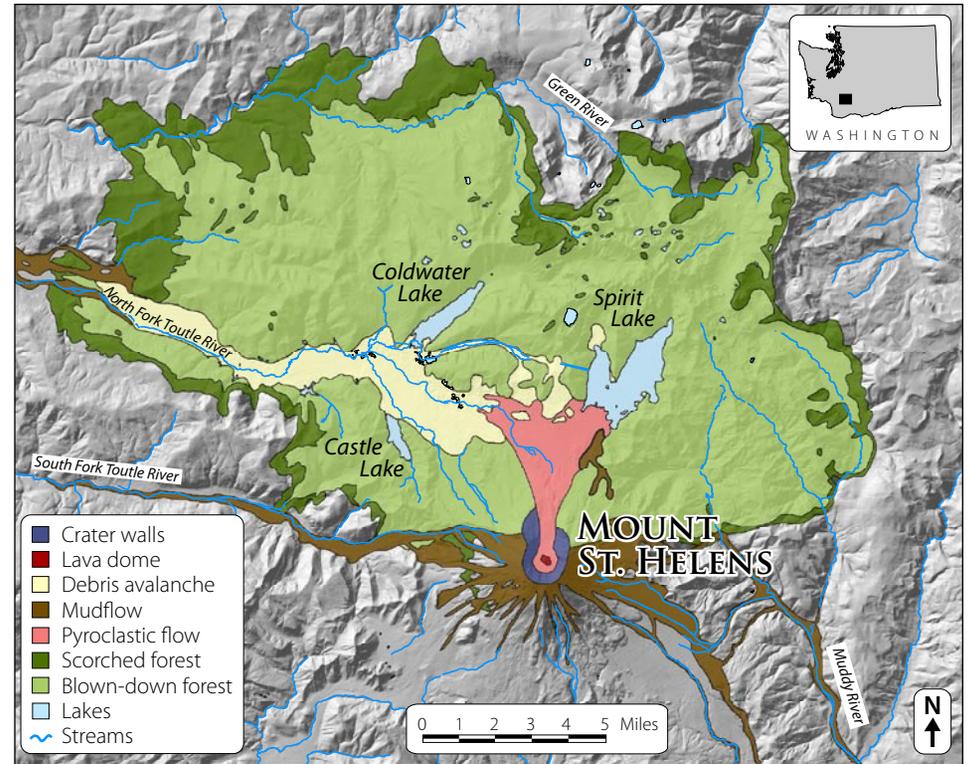
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Scorch zone. Hot gases killed trees but most dead trees remained standing.

follow predictable successional stages. What they discovered surprised them.

RECENT AND CONTINUING ECOLOGICAL RESEARCH

THE SPECTACULAR 1980 ERUPTION created outstanding opportunities for scientists to learn how plants and animals respond to a large, infrequent disturbance. The post-eruption Mount St. Helens ecosystem became a living laboratory for dozens of scientists from PNW Research Station, USDI Geological Survey, and over 70 universities and agencies. Within months, the scientists established a network



Map shows the disturbance zones created by the May 18, 1980, eruption of Mount St. Helens.

Scientists expected that in certain areas, no organisms would have survived, and the establishment of new life would be slow and

of permanent ecological study plots and began studies of short- and long-term ecological changes. The research program has yielded major findings.

Legacies. Living and dead organisms, termed “legacies,” were present throughout much of the disturbed area. Based on the types, amounts, and distribution of legacies, three distinct zones were apparent: zones where nearly all life was eliminated, zones of intermediate survival, and zones of widespread survival. Survivors produced seeds, spores, and offspring—these survivors initiated populations in adjacent areas where species did not survive. Dead trees, as well as surviving plants, provided food and habitat for colonizing animals, and played many important ecological roles.

Survival mechanisms. Scientists learned that four factors were critical for survival.

- **Timing.** The time of day as well as season of the year helped some organisms survive. Nocturnal animals

were below ground, for example, when the eruption began. At higher elevations, May is still late winter, and plant buds had not yet opened. Patches of snow and ice shielded some organisms from the searing heat and abrasion of the blast.

- **Location.** Rock outcroppings, cliffs, and ridges protected some areas from the brunt of the blast. Plants and animals in these sheltered sites had better chances of survival, whereas valley floors and terraces collected thick deposits of ash that smothered life.
- **Life histories.** Animals away at the time of the eruption (some salmon and migratory birds), in daytime retreats (bats, mice, voles), below ground (pocket gophers), or in water (trout and some amphibians) were protected and survived. Plants with dormant belowground buds had high survival.
- **Size.** Small animals such as deer mice, yellow-pine chipmunk, and Trowbridge's shrew tended to be in protected places, and large animals such as deer, elk, and bear were exposed. The size factor affected tree survival also. Saplings buried in late-winter snowbanks survived, but large trees were toppled by the blast or scorched by the hot gases.



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Sun-loving, nitrogen-fixing prairie lupines colonized many open areas and enriched the soil, attracting many insects, small mammals, and birds.

Plant succession. Succession, the sequential change of plant species through time, takes centuries after a major disturbance in Pacific Northwest forests. Scientists found that at Mount St. Helens the pace of succession during

the first 25 years after the 1980 eruption varied substantially across disturbance zones. Succession proceeded rapidly in zones with numerous surviving plants. As these survivors grew, produced seed, and spread, they helped additional species to colonize. In areas with few or no plant survivors, the pace of plant colonization has been slow because seed dispersal is limited and conditions are harsh. Plants such as lupine and alder that have special associations with nitrogen-gathering bacteria in their roots grow well in the nutrient-poor volcanic soils and add nutrients that enable other species to establish. The wet climate also helped plants recolonize. Erosion, often a destructive process, exposed buried plants that grew and spread.

Unusual plant communities developed with species not typically encountered together in the Cascade Range. Tree species associated with old-growth forests, such as western hemlock and silver fir, often established along with rapidly colonizing plants such as fireweed.

Elk and other grazers affected plant communities by eating foliage and spreading seeds. In all areas, even the most severely affected zones, ground cover and the number of plant species increased after the eruption, in some places dramatically. By 2005, the establishment and spread of species has dominated plant succession, but few species replacements, the hallmark of succession, have occurred.

Mammals. Small mammals survived in some disturbance zones, and their survival meant colonization could occur from nearby populations. Some primary colonists were the deer mouse, yellow-pine chipmunk, Trowbridge's shrew, and Richardson's vole. Even in severely disturbed areas, several rodents and insect-eating mammals colonized within a few years as they found patches of habitat. Although large mammals such as elk did not survive the blast, these species are highly mobile and so were among the first to return.



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The deer mouse survived in many locations and was the first small mammal to colonize areas where the eruption destroyed all life.



Marty Raphael

The northern flicker nests in holes in snags and eats only ants; it is one of many bird species that benefited from the dead trees left after the eruption.

Birds. The powerful eruption instantly killed all birds within the blast area. Birds, too, are highly mobile, and some birds entered within hours after the eruption. The pattern of bird recolonization was closely tied to habitat structure. In the first years after the eruption, little habitat existed and few bird species lived in the area, but as plants developed more complex habitats, many more bird species colonized the area.

Amphibians.

Scientists expected that few amphibians would have survived the eruption and any that did would not live long. However, 12 of the 15 species survived and persisted.

Several species, such as the western toad, have flourished. In areas without amphibian survivors, the pace of recolonization has been surprisingly rapid.



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The song sparrow (nest shown here) and dark-eyed junco were among the bird species that colonized the small patches of surviving vegetation.



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The western toad survived in many locations, protected beneath soil and snow, and has colonized ponds created during the eruption.

Fish. Fish survived differently in lakes and streams. Ice and snow protected most lake-dwelling fish, which contributed to their high survival rate, but heavy sediment loads and high temperatures killed fish in streams. Stream conditions improved quickly as sediment was flushed from channels and riparian vegetation began to shade the streams. Even though the streams had warm water, scarce pools, and reduced cover, salmon and trout thrived because their main food, aquatic and terrestrial insects, was temporarily abundant.

Insects and spiders. Beetles and spiders were the first colonizers of the pyroclastic flow zone (area closest to the crater), and fed on other insects blown into the area. Insects continue to influence ecological recovery by feeding on plants and other insects, cycling nutrients, pollinating flowers, disturbing the soil and distributing fungal spores, and serving as prey for a variety of predators.



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Moist, stable conditions around ponds created good conditions for plant establishment and growth. Ponds became biological hotspots.

Ecological interactions. Scientists discovered important interactions between plants and animals. Animals mixed soil, consumed plants, dispersed seeds and fungal spores, and served as predators and prey. Within days of the eruption, gophers mixed underlying nutrient-rich soil with nutrient-poor and drought-prone volcanic deposits. Roots of plant seedlings came in contact with fungal spores, essential to their survival. Amphibians and other animals used tunnels excavated by gophers to escape the summertime heat. Beavers

created ponds and wetlands that benefited many other species.

Small mammals transported seeds from surviving patches of vegetation to barren areas where the seeds germinated. Topped trees created pools, creating favorable habitat for fish and amphibians. Dead trees provided nesting and foraging sites for birds and hiding cover for other animals, supported fungi, and released nutrients and carbon into the developing soil.

ECOLOGICAL RESEARCH IN THE 21ST CENTURY AT MOUNT ST. HELENS

IN JUST ITS FIRST 25 YEARS, the Mount St. Helens research program has made major contributions to the science of disturbance ecology. The findings on biological legacies, plant and animal colonization, and ecological interactions are used in forest management and the restoration of land after forest fires or other disturbances.

Scientists see these results as only the beginning of long-term ecological research at Mount St. Helens. They are continuing studies on the patterns of plant and animal colonization and biological interactions in the blast area, and they expect to see more species replacements occur as the often sparse landscape develops forest cover. Researchers continue to monitor long-term plots established in 1980, building extensive databases on the ecological changes.

The new eruptions in 2004–2005 offer opportunities for new research on geothermal systems within the crater, the effects of small mudflows on streams flowing out of the crater, and the effects of ashfall and sulfur dioxide emissions on ecosystems across the larger area. If larger eruptions should occur, ecological scientists view those as new research opportunities.

HAZARD MANAGEMENT

IN THE POST-ERUPTION ENVIRONMENT, reducing hazards to human life and property was paramount, and in some instances overrode environmental concerns.



Tom Iraci

Mount St. Helens began erupting again in late 2004. Scientists think that the volcano will likely be active off and on in years to come.



Tom Iraci

Research ecologist samples pond for amphibians.

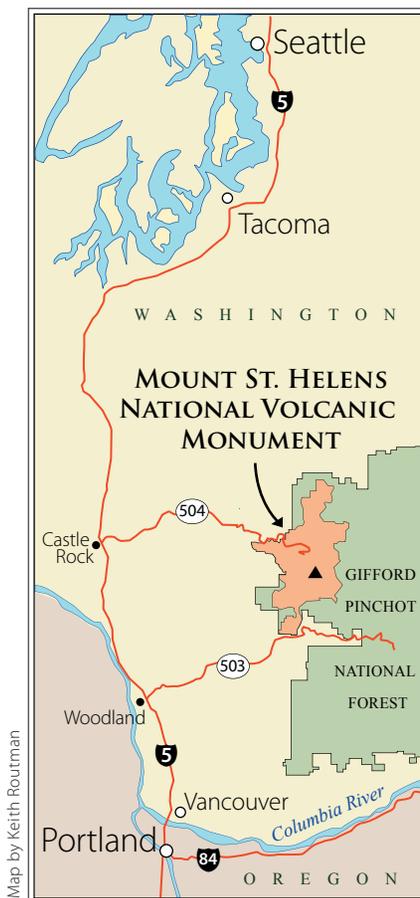
Human health. During and after the 1980 eruption, an immediate concern was the huge volume of ash. Government agencies determined the ash created short-term respiratory irritation and long-term risk for people with prolonged exposure. After disease-causing bacteria were discovered in Spirit Lake, the water was monitored and not used for any municipal or domestic water supplies.

Hydrology and sediment. Potential floods and mudflows were serious hazards. The biggest concern was that the debris avalanche deposit blocking the outlet of Spirit Lake could fail catastrophically, causing considerable loss of life and property. The Army Corps of Engineers pumped water from Spirit Lake into the Toutle River while they constructed an outlet tunnel to maintain the lake at a safe level. The Corps also constructed sediment dams on the Toutle River, but these structures filled rapidly over the past 25 years. Contractors dredged the Toutle and Cowlitz Rivers to remove sediment and reopen the shipping channel on the Columbia River.

Fish and wildlife. The large sediment dam blocks salmon and steelhead from migrating to the North Fork Toutle River and major tributaries, so anadromous fish are now collected at a fish trap below the dam and trucked upstream to spawn. Many lakes were restocked to restore popular recreational fisheries.

FACILITIES

Mount St. Helens National Volcanic Monument has several visitor centers with extensive interpretive displays and additional displays at roadside pullouts and along trails. To get information on access, recreation, and other topics, use the monument Web site, phone number, or mailing address. Some parts of the monument may be closed for safety reasons owing to ongoing volcanic eruptions.



FOR FURTHER READING

- Dale, V.H.; Swanson, F.J.; Crisafulli, C.M., eds. 2005. Ecological responses to the 1980 eruption of Mount St. Helens. New York: Springer Verlag.
- Lipman, P.W.; Mullineaux, D.R., eds. 1981. The 1980 eruptions of Mount St. Helens, Washington. U.S. Geological Survey Professional Paper 1250. Washington, DC: U.S. Department of the Interior, Geological Survey.

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RESOURCES ON THE WEB

- U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. <http://www.fs.fed.us/pnw>. This site lists all publications by Station scientists, including those based on research in the Mount St. Helens area. (March 18, 2005)
- U.S. Department of Agriculture, Forest Service, Gifford Pinchot National Forest, Mount St. Helens National Volcanic Monument. <http://www.fs.fed.us/gpnf/mshnvm>. This site has visitor information, road condition updates, and more. (March 18, 2005)
- U.S. Department of the Interior, Geological Survey, Cascades Volcano Observatory. <http://vulcan.wr.usgs.gov>. This site has extensive information and current updates on all Cascade Range volcanoes, including Mount St. Helens. (March 18, 2005)

FOR FURTHER INFORMATION

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