19 Ecological Perspectives on Management of the Mount St. Helens Landscape

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19.1 Introduction

The dramatic change and dynamic nature of recently disturbed landscapes often create major challenges for management of public safety and natural resources. This was certainly the case at Mount St. Helens following the 1980 eruption. The eruption triggered an immediate response that entailed search and rescue of missing people and protection of human health and property. Monitoring geological hazards and further volcanic activity was a key tool for providing warnings to the public and aided the State of Washington, USDA Forest Service, and other agencies in decisions regarding access, pending and current dangers, and area closures. As volcanic activity quieted and biotic and geomorphic change commenced, the perspectives of environmental scientists became pertinent to land- and water-management issues.

The sequence of management issues at Mount St. Helens forms a framework for considering the perspectives and roles of environmental scientists in management of the area. Before March 20, 1980, 123 years had elapsed since the previous eruption of Mount St. Helens, and management of the area focused on recreation and forestry for wood production. Between March 20 and May 18, 1980, the mountain underwent a period of mild volcanic activity, and concern focused on the hazards it posed to people and property. Immediately after the massive eruption, search and rescue efforts became all consuming. Thereafter, concerns gradually shifted to long-term management of the hazards and the commercial, educational, recreational, and research opportunities of the area. During this period, environmental scientists became strongly engaged. During the first few years after the initial eruption, their engagement was highly energetic. The pace of their engagement decreased to quite modest in the mid-1980s and to very little in the 1990s and 2000s. These shifting roles were influenced by changes in the eruptive behavior of the volcano; the progress of construction projects to minimize hazards; and the rate of geomorphic and ecological change in uplands, rivers, and lakes.

In this chapter, we present a brief synopsis of the roles of environmental scientists in management issues related to the 1980 eruption of Mount St. Helens. First, the chapter describes the geographic and temporal contexts of the eruption and surrounding landscape. Then, it reviews selected examples of hazard- and land-management issues involving environmental sciences and scientists. Finally, it summarizes the advisory role of environmental scientists in protecting natural processes and features, human life, property, and commercial development. The discussion focuses on the posteruption period when environmental scientists were most active and when the ecological changes considered in this book were taking place.

19.2 Broad-Scale Context: Resource Management Before and After the Eruption

Before 1980, patterns of resource use and ecological conditions in the Mount St. Helens area strongly reflected land-ownership patterns and the related management objectives and approaches. Much of the land within about 30 km of the volcano was a mosaic of federal, state, and private ownership, managed primarily for timber production and recreation (Figure 19.1). The Gifford Pinchot National Forest managed most of the mountain and lands to the north and east. Some of the federal forest lands to the east had a distinctive pattern of dispersed-patch clear-cuts with plantations established in the previous 30 years, whereas lands on the volcano below tree line and to the north primarily supported older, natural forests. Mount St. Helens, Spirit Lake, and the Mount Margaret area north of the volcano were intensively used for recreation by hikers, hunters, fishers, campers, miners, and transient and permanent residents of private cabins and lodges.

State-owned land was concentrated on the south and west side of Mount St. Helens and managed by the Washington Department of Natural Resources (DNR) largely for forest products. The DNR implemented clear-cutting and intensive

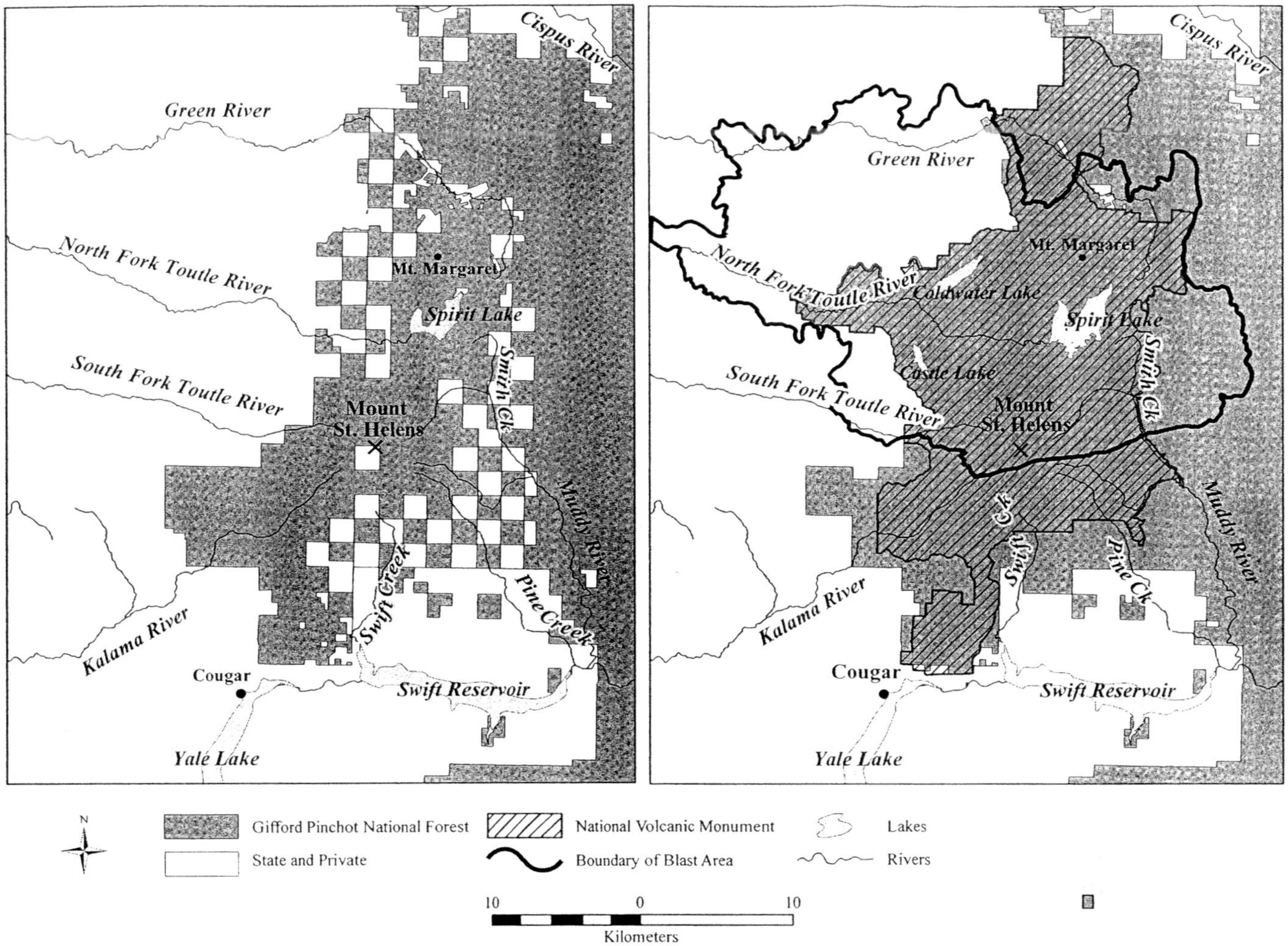

FIGURE 19.1. Map of ownership pattern of the Mount St. Helens area before (left) and after (right) establishment of the National Volcanic Monument.

forestry practices to establish plantations dominated by Douglas-fir (*Pseudotsuga menziesii*).

In the decades before 1980, the extensive private industrial forest lands west of the volcano were used largely for resource extraction, principally by the major landowner, the Weyerhaeuser Company, and to a lesser extent for recreation. Several decades of timber extraction and road construction had removed much of the native forest from private lands, and young conifer plantations grew in their place.

The May 18, 1980, eruption profoundly altered the landscape. Fifty-seven people died, many millions of dollars worth of timber was blown down, and the forest road network was either obliterated or made impassable by tephra deposits and toppled trees. Private cabins and lodges were swept away or buried by deep volcanic material. A logging camp and 18 bridges along the Toutle River and several bridges on the Muddy River were washed away by the mudflows. Great concern was expressed about future mudflows and floods.

The long-term management of the vast area impacted by the volcano was immediately under discussion. It was clear that some of the federal lands would be the focus of geological studies and tourism and would likely be dedicated to such activities. However, the future of land not in the major impact zones was less certain. After much debate and some movement in alternative management directions, Congress passed the Mount St. Helens National Volcanic Monument Act in 1982, which established the 43,300-ha Monument, set policy for management of the area, and changed some of the land-ownership patterns (see Figure 19.1). A critical feature of the legislation was direction for "allowing geologic forces and ecological succession to continue substantially unimpeded" (Public Law 97–243, Sect 4.b.1). This charge set up a tension between protection of natural processes and protection of people, property, and commercial development. There was substantial involvement by environmental scientists in the decisions leading up to the designation of the Monument and in its proscribed management. Scientists also had roles in implementing management practices through advisory panels and other activities. These roles are considered next in terms of four time periods.

19.3 Temporal Context of Management Issues

19.3.1 Before March 21, 1980

In the decades before the eruptive events of 1980 began, resource-management concerns at Mount St. Helens focused on timber, wildlife, fish, and recreation. The Forest Service, DNR, and private companies extracted timber as a renewable resource and provided access to lands for fishing, hunting, hiking, and camping. The Washington Department of Fish and Game managed fishing and hunting. Very few people lived close to the mountain year round. Visitors to the region appreciated the beauty of the symmetrical, snow-capped mountain, but did not consider the volcano to be a hazard.

In a prescient scientific analysis during the 1970s, United States Geological Service (USGS) geologists Dwight ("Rocky") Crandell and Donal Mullineaux surveyed potential volcanic hazards of Mount St. Helens and other Cascade Range volcanoes. They found that Mount St. Helens had been distinctively active during the Holocene (the past 10,000 years), leading them to predict that Mount St. Helens would erupt soon (Crandell and Mullineaux 1978): "Mount St. Helens has had a long history of spasmodic explosive activity, and we believe it to be an especially dangerous volcano. In the future Mount St. Helens probably will erupt violently and intermittently just as it has in the recent geologic past, and these future eruptions will affect human life, property, agriculture, and general economic welfare over a broad area."

Environmental scientists had little direct role in management of the area before 1980, in part because concepts about ecological effects of human activities and natural-disturbance processes in the region were just developing. Ecologists had described plant species (St. John 1976) and vegetation communities in the area (Franklin 1966) and the relationships of those communities to soil and topography (Franklin and Dyrness 1973). The Forest Service's Area Ecology Program had conducted vegetation inventories in the late 1970s at several locations in the vicinity of Mount St. Helens as part of a regional effort to characterize plant associations. Herpetologists and fish biologists had conducted numerous surveys in the area as well (Crawford 1986; Crisafulli et al., Chapter 13, this volume). The 1980 eruption occurred just as the field of ecology was recognizing the contributions it could make to management of forest, stream, and lake systems and to outdoor recreation (e.g., Lubchenco 1991; Swanson and Franklin 1992).

19.3.2 March 20 to May 18, 1980

During the initial eruptive period, USGS and university geologists and geophysicists began monitoring the deforming volcano, gas emissions, and earthquakes (Thompson 2000). This information provided a basis for making short-term predictions of impending volcanic events. Local officials and the public grew more wary of a potential major eruption and its impacts, and officials established zones of restricted entry to protect the inquisitive. An interagency center for tracking volcano developments was established at the Gifford Pinchot National Forest to provide information to the USDA Forest Service, emergency personnel, and the public. Washington Governor Dixie Lee Ray declared a state of emergency, assumed control of the zone of restricted entry, and called in the National Guard to provide security. Logging continued in restricted-entry zones during regular weekday hours, but recreational activity, including use of personal cabins, was prohibited.

Ecologists immediately became interested in studying ecological effects of the eruption. The Mount St. Helens Research and Education Coordinating Committee was established in Vancouver, Washington, at the request of the USGS to coordinate requests for access to the mountain for scientific and educational purposes (Allen 1982). It was composed of representatives from the Oregon and Washington State geology departments and universities in the region. When it was possible to obtain the requisite permits from the Committee to enter the restricted area, some environmental scientists made observations and collected samples. These incipient studies were interrupted by the massive eruption on May 18.

19.3.3 May 18, 1980, and Immediately After

The violent eruption focused attention of federal, state, and local authorities on search and rescue for the dozens of people feared lost. These efforts were complicated by poor weather, continued minor eruptions of tephra, and the large number of agencies attempting to help with this natural disaster. The Federal Emergency Management Agency (FEMA) quickly assumed the role of coordinating communication regarding search and rescue and established an information center (Brown 1982). By May 21, when the state was declared a national disaster area, attention turned to protecting lives and property. USGS geologists and University of Washington geophysicists were responsible for assessing the potential of future volcanic activity and communicating associated hazards to government officials who were responsible for communicating with the public. Environmental scientists could not gain access to the central portion of the volcanically disturbed area, so they focused their late-May sampling on the margins of the volcanically disturbed area.

There was immediate concern about the health hazards of the huge volume of ash spread from the newly formed crater to most of eastern Washington and the states beyond. The Washington Department of Social and Health Services (DSHS), the Centers for Disease Control and Prevention (CDC), and the National Institute for Occupational Health and Safety (NIOSH) worked together to determine that the ash did not cause cancer, but it did induce short-term acute respiratory irritation. Furthermore, the ash could cause long-term chronic respiration illness for individuals who had high and long-term exposure, a group that included scientists on the mountain.

19.3.4 Management Issues After May 1980

For the next few years, Mount St. Helens produced a series of minor eruptions and mudflows of diminishing magnitude. High levels of water and sediment yields persisted, particularly in the Toutle River, where the debris-avalanche deposit provided a nearly limitless sediment source. Also during this period, forest, lake, and stream systems began to display their ecological responses to the disturbances: surviving plants sprouted; surviving animals emerged from their burrows and protective snow and ice cover; dispersal of fungi, plants, and animals proceeded; ecological communities developed; and physical and biogeochemical change proceeded in terrestrial and aquatic systems.

Management issues involving ecological concerns after the 1980 eruption had two immediate goals: responding to hazards and meeting resource and recreation objectives of government and private landowners. The establishment of the Mount St. Helens Monument in 1982 set scientific research and education as major goals. The strength and relative importance of these goals evolved over time as volcanic, hydrologic, ecological, and management circumstances changed. Geographically, both the goals and the actions differed according to whether the lands were managed by the Forest Service, state, private forestry companies, or local residents and corporations.

The May 18 eruption created a host of new environmental hazards. The St. Helens Forest Lands Research Cooperative (1980) was formed of members drawn from the forestry research staff of DNR, the Forest Service, and the Weyerhaeuser Company to identify immediate major environmental threats. The Cooperative recognized that floods or mudflows could occur from unstable deposits, tephra-covered hill slopes, breaches of dams blocking new lakes, and sediment-filled channels. Also, both the blast-toppled and standing dead trees across large expanses were considered potentially susceptible to fires and insects. Catastrophic wildfire or insect outbreaks could affect living forests and the potential to salvage standing and downed dead trees. The diversity and complexity of the dangers was a major challenge to resource managers. Ecologists, foresters, geologists, engineers, and hydrologists were called upon to assess these risks by various agencies, including the U.S. Army Corps of Engineers (the Corps), FEMA, Forest Service, USGS, Washington Department of Game, and the Soil Conservation Service (now named the Natural Resources Conservation Service). For flood and sediment hazards downstream from the volcano, the issues and responses were partially determined by the needs of the cities of Kelso and Longview and the Columbia River shipping channel.

19.3.4.1 Warning of Impending Hazards

After the eruption, the need to establish and maintain a long-term monitoring and warning system was paramount. USGS scientists provided information on volcanic activity and potential hydrologic hazards. FEMA, state, and county officials delivered information about hazards and evacuation procedures to the public. Environmental scientists had little role in the hazard protection system, but did benefit by having a safer work environment.

19.3.4.2 Managing Hill-Slope Erosion

There was great concern by local citizens and government officials that storm-water runoff and sediment shed from the tephra-covered hill slopes would cause extreme flooding and channel change in downstream areas. The St. Helens Forest Lands Research Cooperative (1980) identified erosion and its impacts as major threats, which led to two management questions:

- Would salvage logging increase or decrease water and sediment runoff?
- Could aerial application of plant seeds lead to vegetation cover that would suppress water and sediment movement?

Experimental studies showed that salvage logging reduced erosion. Activities that mixed tephra layers, especially with older soil, greatly increased water-infiltration capacity, thereby reducing water and sediment movement from hill slopes (Swanson and Major, Chapter 3, this volume). Furthermore, field studies led to the unanticipated conclusion that ground disturbance reduced rather than increased erosion in the blast area. In some parts of the blast area, small gullies cut down to the old soil surface, released plants buried in the preeruption soil, and allowed buried seed to germinate. Hence, an active salvage and tree-planting program was initiated by the Forest Service, DNR, and timber industry, in which tephra was mixed with underlying soils as tree seedlings were planted, which planting trials and erosion studies had shown to be important for seedling survival and establishment (Winjum et al. 1986).

Emergency funds were available for a few months after the May eruption to protect life and property. In an effort to control erosion, the Soil Conservation Service proposed a $16.5 million program of seeding a nonnative-grass/legume/fertilizer mix in fall 1980 over much of the blast area and debris-avalanche zone (USDA Soil Conservation Service 1980). An initial proposal to spread nonnative seed over the entire volcanic area drew a sharp, negative response from ecologists, as evidenced by a resolution from the Second International Congress of Systematic and Evolutionary Biology in July 1980, which stated "this Congress vigorously opposes any proposal for mass seeding of grasses or any other species on the newly created substrate." Subsequently, the U.S. Congress reduced the allocation to a $2 million program of aerial application by the SCS over about 8660 ha of Weyerhaeuser, state, and national forest land in the fall of 1980 (Carlson et al. 1982). The expenditures of emergency funds for seeding had to occur before the emergency funding expired and before the fall rains, even though no native seeds were available.

Distributing nonnative plant seeds was largely ineffective for erosion control. The timing of the seed distribution was not appropriate for successful germination (Stroh and Oyler 1981; Klock 1982). Erosion was not reduced (Swanson and Major, Chapter 3, this volume). Where nonnative seeds did establish plants, they were associated with greater mortality of native conifers (Dale 1991; Dale and Adams 2003). Building upon these observations from Mount St. Helens and studies elsewhere, the practice of broadcast seeding of nonnative plant species onto newly disturbed sites has now been supplanted by a commitment by the Natural Resource Conservation Service and others to use native species, where possible (e.g., see Brindle 2003).

19.3.4.3 Managing the Flow of Water from Lakes Blocked by the Debris Avalanche

The massive debris avalanche of May 18 raised the elevation of the blockage to Spirit Lake and obstructed Coldwater and Castle creeks and many small tributaries of the Toutle River, forming new lakes with potentially unstable outlets. As impoundments gradually filled with water, it was anticipated that they would overtop or erode through their blockages or that the dams would fail, as had occurred elsewhere (Costa 1991; Parkes et al. 1992). Therefore, the Corps created stable drainage outlets for Castle and Coldwater lakes to discharge over bedrock and through armored channels and intentionally breached some of the small impoundments.

Controlling the level of Spirit Lake posed a complex problem that required both short- and long-term management strategies. Communities and logging operations downstream were greatly concerned about the potential for catastrophic damage from a breach of the lake. Hence, the Corps designed a drainage system that would maintain the lake's surface elevation at a level that would reduce threats to downstream areas. From November 1982 until spring 1985, the Corps controlled the lake level by pumping water through a 1113-m-long pipeline over the western Pumice Plain and debris-avalanche deposit while a 2450-m-long tunnel was constructed from the western shore of Spirit Lake through bedrock to upper South Coldwater Creek. Since the tunnel opened in May 1985, Spirit Lake water has followed this course to the North Fork Toutle River. Hence, the short-term measure provided time to determine and implement long-term solutions.

Development and operation of the pumping and tunnel systems for Spirit Lake and the construction of outlet channels on the dammed lakes involved trade-offs between protecting human life and property and maintaining natural processes and features. Although the threat of major mudflows from breaching of lakes was vastly reduced, the western Pumice Plain and debris-avalanche area had a massive canyon cut through the 1980 deposits, lake levels were artificially regulated, south Coldwater Creek's hydrologic regime was dramatically altered, and a road was built across an ecologically sensitive portion of the landscape to facilitate the construction and maintenance of the pumping station. Moreover, human-created barriers prevented anadromous fish from reaching Spirit Lake and north Coldwater Creek. Additionally, the Spirit Lake tunnel requires periodic closure for maintenance; during this time, lake level can rise substantially, grossly reconfiguring the ecology of the littoral and riparian zones. These compromises were readily accepted because the threat to human life and property was so severe. However, proposals to remove the large mat of wood floating on Spirit Lake were resisted by ecologists interested in letting this unusual natural feature and its ecological role to persist (see Dahm et al., Chapter 18, this volume). Furthermore, water-quality issues were considered in the decision of whether to keep Spirit Lake water in the Toutle River system or to divert it to the Lewis River. Initially, water quality in Spirit Lake was poor (Dahm et al., Chapter 18, this volume), and microbiologists discovered the pathogenic bacteria *Legionella* and *Klebsiella* in Spirit Lake (Dahm et al., Chapter 18, this volume), which contributed to the decision to keep the water drained from Spirit Lake in its natural watershed. Natural processes vastly improved water quality before flow from Spirit Lake to the Toutle River was reestablished.

These water-flow-management efforts illustrate the benefits of cooperation among interested parties in resolving hazardous situations. The Corps worked with local communities and federal and state agencies to resolve potential crises that could have resulted from an impoundment being breached. Similar combinations of short- and long-term strategies might be appropriate when consequences of no action are so dire.

19.3.4.4 Managing Downstream Sedimentation and Floods

Because of the immediate threats to human life and property downstream from large deposits, sedimentation concerns began to be addressed in the first weeks and months after the eruption and are still a problem. The Corps undertook a series of short- and long-term measures to control sediment delivery and channel capacity. Immediate steps included dredging segments of river channel where sediment accumulated and where disposal sites were nearby. Two low sediment-retention structures constructed by the Corps in 1980 and 1981 on the Toutle River were quickly filled with sediment and breached. Subsequently, the Corps completed a 55-m-high, 504-m-long sediment-retention structure on the North Fork of the Toutle River in 1988 with an anticipated lifetime of five decades (see Figure 3.5), but by April 1998 it had filled above all discharge pipes and was flowing over the spillway. The large discharge over the spillway has caused more sediment than expected to accumulate downstream of the structure. During summer 2004, the Corps, USGS, Forest Service, and Washington Department of Fish and Wildlife began meeting to discuss possible options for sediment control in the basin.

The sediment-retention structure created a new environmental problem. The structure impeded upstream movement of fish, including several stocks of salmon and steelhead trout (Bisson et al., Chapter 12, this volume). To mitigate these barrier effects, a fish-collection facility was constructed about 1 km downstream of the structure, in which migrating fish are captured and trucked above the structure and placed in tributaries to spawn. Young fish are able to negotiate the structure as they migrate downstream to the ocean, but they frequently experience mortality or injury during high flows (Bisson et al., Chapter 12, this volume). This fish-collection facility causes adult salmonids returning to spawn in the upper reaches of the North Fork of the Toutle River to be dependent on humans to transport them upstream. The sediment-retention structure has altered natural sediment transport and storage, hydrology, and river habitat and has hindered the pace and altered the pattern of geomorphic and ecological response. The effectiveness of the retention structure in terms of the environmental problems it created can best be gauged over several more decades by its long-term success in reducing downstream hazards from erosion as well as the ability of the fish-collection system to maintain the upstream movement of fish stocks.

19.3.4.5 Salvaging Downed Wood and Establishing Timber Operation

Salvaging standing dead and downed wood became a point of disagreement between those people promoting timber salvage for its wood products value and those promoting natural processes. Immediately after the eruption, the timber industry, some elected officials, and others were alarmed about the loss to the Pacific Northwest economy of more than 650 million board feet (or 1.5 million m^3) of wood (USDA Forest Service 1981a). The Forest Service, DNR, and private timber companies called for rapid salvaging of the downed wood to avoid loss due to decay, wildfires, or outbreaks of the Douglas-fir beetle (*Dendroctonous pseudotsugae*) and silver fir beetles (*Pseudohylesinus granulatus* and *P. grandis*) starting in dead trees and spreading to live trees. Yet, local ecologists did not agree with this dire prediction. In retrospect, it is apparent that no management action was necessary to avert insect outbreaks because the Mount St. Helens ash was a potent natural insecticide that caused rapid insect mortality by disrupting their ability to maintain water balance (Edwards and Schwartz 1980; Shanks and Chase 1981). Similarly, fire was not a likely scenario because the nonflammable tephra coated woody debris and limited the potential for fire to spread.

In the 1980s, management strategies were shifting from an emphasis on removal of wood from streams for the sake of maximizing extraction of wood products and fish passage to retention or even placement of wood in streams to maintain or create complex habitat. As was common practice at that time, the Forest Service, DNR, and private forest companies removed wood from streams in the first few years after the May 18 eruption (Franklin et al. 1988). However, the Forest Service retained wood in a few stream reaches so that stream ecologists could observe its effect on recovery of aquatic ecosystems, including fish (Franklin et al. 1988). These experiments showed that wood left in large alluvial valley streams increased habitat complexity, which supported more trout but also retained sediment in the channel (Baker 1989).

Objections notwithstanding, plans to salvage the standing and downed wood were promptly put in place by the private timber companies and the Forest Service. The Weyerhaeuser Company quickly harvested much of the downed wood on their lands (Snyder 1999). The Forest Service performed an environmental assessment (EA) as required by the National Environmental Policy Act (NEPA) to determine the appropriate way to handle damaged timber on 5600 ha in the Gifford Pinchot National Forest. The stated goal was to avoid loss of wood to insects, decay, or fire and to remove from streams timber that "threatens downstream improvement" (USDA Forest Service 1981a). The management scheme selected from the set of alternatives put forth in the EA would have salvaged more than 1 million m^3 of damaged timber. However, there was a strong protest about this decision from local stakeholders and some environmental scientists who wanted to preserve much of the disturbed land for research, recreation, and education. Subsequently, the EA decision was overridden by legislation designating 43,300 ha as a national monument. Neither broad-scale insect outbreaks nor fire occurred in the vicinity of Mount St. Helens. Even so, more than two decades later, the ecological consequences of salvage logging after natural disturbances are still debated (Lindenmayer et al. 2004).

The issue of salvage logging leads to the question of how managers should respond when confronted by different opinions about proposed management plans. These differences occurred as a result of the developing state of ecological knowledge and conflicting values. Some groups supported the economic gain to the communities that would occur with salvage logging, while others preferred preservation of natural processes, encouragement of tourism, and focus on the potential for scientific investigations. Furthermore, consequences of actions are sometimes not known for decades or even centuries. The apparent inaccuracies of science-based judgment regarding salvaging of downed trees in the blast area raised intriguing management issues concerning decision making in the face of uncertain or conflicting scientific evidence. Where possible, the decision makers chose a strategy of quick response for economic gain versus waiting and seeing the long-term effects. The issue is really about risk. What and how much risk are resource managers willing to accept, given various levels of uncertainty? In some situations at Mount St. Helens where scientific opinions differed, an outside review helped clarify the differences (Brown 1982). In the case of salvage logging, land managers proceeded (as they saw appropriate) with the NEPA process, and it was a flood of concern to Congress that led to expansion of the area set aside as the Mount St. Helens National Volcanic Monument and therefore protected from salvage logging.

19.3.4.6 Protecting Natural and Scientific Values

The large scientific and public outcry about lands being set aside from active management concerned not only salvage logging but also the extent of lands to be protected. In October

1981, the Forest Service designated an Interpretive Area of 33,350 ha, including 10,270 ha of state and private lands, with the primary objective of protecting "significant geological features in the impact area of the volcano . . . " (USDA Forest Service 1981b). Protests were led by citizens and scientists over the absence of several key ecological features and the amount of timber planned for salvage on federal land. Petitions signed by more than 112 scientists were sent to Congressional delegates, who called for hearings, which gave scientists and others the opportunity to voice their concerns publicly (U.S. Congress 1982). Subsequently, Congress passed the Mount St. Helens National Volcanic Monument Act in August 1982 (Public Law 97-243). The boundaries of the compromise plan were drawn with input from the political, geological, ecological, environmental activist, and local communities. Involvement of ecological scientists meant that the boundaries included sites that had been affected by all types of volcanic disturbances as well as unaffected areas that could serve as controls in scientific studies. Land exchanges among the diverse owners through trades and purchases were necessary to develop the contiguous block of land that became the National Volcanic Monument.

A major goal in establishing the Mount St. Helens Volcanic Monument was preserving the land for research, recreation, and education. The Monument Act designated that a comprehensive management plan be developed to guide science, education, and recreation in the Monument. In 2005, the selected plan is still being implemented by the Forest Service to balance (1) protection of sensitive sites and processes for scientific research; (2) development and operation of access and support facilities for public interpretation; and (3) needs for safety, public access, and tourism (USDA Forest Service 1985). The Plan retained certain aspects of the management of the Mount St. Helens landscape before 1980 and gave fresh direction for the future. Initially, some expressed concern about the ability of the Forest Service to manage the land for this mix of values. However, during the past 25 years the Forest Service has balanced protection of habitats and research with creating opportunities for education and recreation while attending to public safety.

An important component of the Act was establishment of a Scientific Advisory Board to advise and recommend to the Secretary of Agriculture ways to manage the science being conducted at the Monument and to "retain the natural and ecologic and geologic processes and integrity of the Monument" [Public Law 97-243, Sec. 7 (a) (1), (2), Aug. 26, 1982]. Board members were appointed by the secretaries of Agriculture and Interior, Governor of the State of Washington, and Director of the National Science Foundation. By establishing the Scientific Advisory Board, the Act positioned scientists in an unprecedented role as part of the management process. The Board advised the Forest Service on such issues as fish stocking in lakes, a cross-Monument highway, the sediment-retention structure, and the preferred alternative for the Comprehensive Management Plan for the Monument. The existence of the Board provided a formal mechanism for scientists to have input to the evolving management questions. This perspective was especially important for balancing the goal of sustaining naturalness with providing for human needs and wants, desired commodities, and services from the area. However, this Board was disbanded 10 years after its first meeting, as directed by the Monument Act. Termination of the Board left the Monument without a recognized scientific voice to provide recommendations on management and other issues requiring scientific input. Input from the science community on new and recurring issues has been handled on an ad hoc basis since 1992.

A notable feature of the Monument is its acceptance of dynamism, both in the wording of the Act to let natural processes proceed substantially unimpeded and in management of the public-access system. This recognition of change is unusual for natural areas and contrasts with the admonition from the Leopold Committee on Wildlife Management in the National Parks (Leopold et al. 1963) that such areas be managed to "represent a vignette of primitive America." The concept of freezing in time the condition of a place is unrealistic in the face of active volcanism, ongoing ecological and geomorphic change, and policies evolving to meet the changing needs of the people.

Predictably, tension developed between preserving natural processes and features, as stipulated in the Monument Act, while also protecting opportunities for economic development. Differences in these objectives often put geologists and ecologists, who wished to preserve "naturalness," in conflict with groups supporting commercial development, recreation, and other developments. Although most disagreements over land use and development of the volcanic area were settled by the establishment of the Monument in 1982, some issues linger after more than two decades, as reflected in persistent proposals for a cross-Monument highway. The management implications of effectively working with contentious issues are that the scientist must stay informed and involved in the management process to protect the interests of science, which also serves to preserve education and interpretation opportunities.

19.3.4.7 Restoring Fish, Wildlife, and Ecological Resources

Various practices were established to benefit fish and wildlife at Mount St. Helens, and each approach was influenced by management objectives of the landowners and managers (Franklin et al. 1988). Within the Monument, the Forest Service policy is not to enhance habitat. Beyond the borders of the Monument, several types of enhancement measures have been used. For example, snags (i.e., standing dead trees) were left in place to serve as nesting sites, perches, food resources, and roosts (see Figure 3.1), and artificial structures, such as nesting boxes, raptor roosts, and perches, were also created for use by birds.

The Washington Department of Fish and Game worked with Weyerhaeuser Company and the Rocky Mountain Elk Foundation to restore populations of elk by developing winter-range foraging areas. The resulting pastures of grasses and legumes were used extensively by elk during the winter months when high-elevation forage was covered by snow. However, subsequent studies showed that in areas without the seeding, abundant natural forage developed from resprouting plants that survived the eruption and from plants that had established from windblown seeds (Merrill et al. 1987). Similarly, the absence of forest for thermal cover was initially thought by scientists to restrict elk colonization, but this turned out not to be a constraint. Elk avoided thermal stress by spending the heat of the day in wallows or lying on the ground where heat was lost through conduction. Hunting was limited or prohibited, depending on location, so the populations were not strongly influenced by harvesting. A combination of rapidly developed, high-quality forage, a string of relatively mild winters, and the near absence of hunting resulted in a remarkable rebound of elk populations in the Mount St. Helens area within 5 years of the eruption.

Unique spatial patterns of elk herbivory were created by the pattern of landowners with differing management objectives. Weyerhaeuser's extensive (120,000 ha) tree farm provided much forage during the first decade following the eruption when trees were still small, but palatable forage declined markedly as the forest matured. The reduced carrying capacity of the maturing tree farm shifted elk foraging to the Monument, where studies have demonstrated that elk herbivory altered plant community composition and structure (see Dale et al., Chapter 5, this volume). During the autumn hunting season, hundreds of elk temporarily reside on the Pumice Plain and debris-avalanche deposit, where they seek refuge from hunters on adjacent lands. The management of large roaming mammals is complex when adjacent lands are managed according to different objectives, with potentially severe consequences for some of the land uses and areas.

Fish stocking of streams and, particularly, lakes raised conflicts among fishermen, scientists, and resource managers (Bisson et al., Chapter 12, this volume). Ecologists argued for retaining natural organisms and processes, and the Washington Department of Fish and Game and anglers wanted to restock lakes, which had been popular fishing sites before 1980. Generally, states regulate fish and wildlife, and landowners regulate access and manage habitat, so this dispute about fish stocking in the Monument was a states rights issue. The Scientific Advisory Board made a recommendation to the Monument that allowed for some lakes to be stocked and others not. The Board's decision, which was accepted by the Forest Service, environmental scientists, and Washington Department of Fish and Wildlife, was based on maintaining the lakes with the greatest scientific value in a fishless condition and not stocking lakes that currently did not support fish. Stocking was not a large issue because fish had survived in most lakes and were sustained by self-perpetuating populations. Since 1980, fish have been stocked by Washington Department of Fish and Wildlife in 6 of the 35 lakes in the Monument and additional lakes in lands within the blast area owned by Weyerhaeuser Company. However, several of the lakes that were fishless in 1980 and were intended to be managed in a fishless condition have since developed fish populations; apparently through a combination of natural colonization and illegal stocking.

The scientific community viewed Spirit Lake as the most important body of water to keep in a fishless state to study patterns of recovery, but it was apparently clandestinely stocked by anglers. By 2000, with many large fish present in Spirit Lake, the Washington Department of Fish and Wildlife and sportsman groups wanted access to the lake for angling purposes, but according to state policy, fishing is not permitted in the lake. This situation has resulted in contention among the agencies and the public.

The next broad-scale consideration of fishing regulations for lakes in the Mount St. Helens area will occur when the management plan for the Gifford Pinchot National Forest is revised in 2009, as legislatively required. Monument officials decided to postpone case-by-case requests for open fishing until that time, when many aspects of the Monument's Comprehensive Management Plan will be evaluated to see if change in current policy is warranted. In 2005, only a few lakes capable of supporting fish remained fishless.

19.3.4.8 Providing Access and Recreation for the Public

Public access to, through, and within the Mount St. Helens area has involved long-standing traditions and arguments. Before the 1980 eruption, people could drive to the north side of the mountain, where they hiked, swam, boated, camped, and fished. The extent of roadless area and the possible Congressional designation of some areas as wilderness were being debated. After the 1980 eruption, reestablishment of road access and new forms of access, such as proposals for a tram to transport visitors to a high-elevation vista or an east–west public road through the Monument, took on new significance. The recurring theme of access within the Monument has been the balance among protecting natural resources for preservation and research, providing for recreation, and maintaining public safety and access for those with limited mobility. The area outside the Monument has emphasized economic development.

Since the eruption, access into the disturbed area has varied. Backcountry recreation has been a major theme of the Monument, particularly hikes along the 320 km of trails that were installed since the eruption and climbs to the summit to view the surrounding landscape from the crater rim. However, most visitors to the Monument view the landscape from their cars via one of the three main roads that traverse the volcanic area. Mountain bike and snowmobile use is popular in the Monument, but fishing has not been a popular activity, despite substantial investments in infrastructure (e.g., a boat-launching area and a fish-cleaning facility at Coldwater Lake). A few years after the 1980 eruption, many trails were reopened or constructed, but new hazards exist in the volcanic landscape, and some of the trails are unstable. Heavy visitor traffic on trails, including horses and other pack animals that often disperse seeds of nonnative species, could interfere with ıtural processes of succession, particularly in sensitive areas. ɔr these reasons, planners devised trail routes and travel re-rictions to balance visitor access with protection of research ɔportunities. Access to volcanically disturbed lands is often nited by gated roads or area closures.

A recurring proposal for a cross-Monument highway pass-g in front of the volcano's crater is an example of conflicts ɾer access (Adams 2002). The visitor centers have only west-de access from Interstate 5 via State Route 504, which was constructed after the eruption. Opportunities for viewing the ountain from the east are distinctive and spectacular, yet dif-cult and time consuming to access. Construction of a cross-[onument highway has been a strong desire of Lewis, Cowlitz, ıd Skamania counties and their municipalities, which all seek ıancial benefits from a direct route through the Monument. owever, to date, these proposals have been countered by con-rns about safety and protecting Spirit Lake and the Pumice ain ecological systems. A 2004 study of the economic im-ıct of the proposed Monument highway was considered by the 'ashington State legislature but not approved by the Gover-ɔr after loud public outcry. Clearly, trade-offs among access, creation, scientific research, safety, and economic develop-ent will continue to be discussed.

?.3.4.9 *Providing Interpretive Programs and Other ducational Opportunities*

ıterpretative programs play a vital role in conveying infor-ation to the public about geological events, restoration, and :ological change at Mount St. Helens. Interpretation is pre-nted to more than 1 million visitors each year to Mount St. elens through visitor center displays and exhibits, road and ail kiosks and signs, and onsite interpretive talks. The Forest ɜrvice, Weyerhaeuser Company, Cowlitz County, and Wash-gton State Parks and Recreation Commission each operate sitor centers; all five centers are on the west side of the vol-ıno. Each center has a specific focal theme; these themes clude an overview of the mountain, salvage logging and re-restation, ecological recovery, and geological events. These sitor centers are the primary Mount St. Helens destination for ost visitors (based on road tallying devices and Forest Ser-ce surveys). As access improved, new visitor centers were ɔnstructed progressively closer to the volcano. Visitor center splays, films, and onsite interpretive programs draw strongly ɔm science findings, allowing the latest discoveries to be corporated into interpretive material long before this infor-ation is published in conventional scientific outlets.

A mutually beneficial relationship quickly developed be-ɾeen the scientific and educational communities after the)80 eruption. In the first years, scientists often shared their :pertise while being provided access to sampling sites on e volcano by news helicopters. Also, some scientific re-arch received financial support from organizations that al-wed the public to pay to assist field research (e.g., Earthwatch ıd the School for Field Studies). Scientists have transferred information learned at Mount St. Helens to a great variety of audiences through annual training workshops for interpretive program staff; onsite review of interpretive talks; preparation of Monument trail signage; popular articles for the Monument's newspaper; development of visitor center exhibits; media interviews; presentations to organizations, groups, and schools; and scientific symposia presentations, field trips, and publications. Managers, elected officials, and scientists recognize the important role that scientific research has at Mount St. Helens in terms of producing exciting, new information about the dynamic volcanic landscape and biota that is so important in developing interpretive themes for visitors to the Monument and educational curricula for the classroom.

The Mount St. Helens landscape and its story have earned an important place in public education throughout the world. Major anniversaries of the May 18 eruption have been marked with copious press attention. Many ecology textbooks present examples from Mount St. Helens. Scientists have been important commentators in media presentations concerning geological and ecological developments at the volcano. Informative web sites have been developed, as well.

19.4 Conclusions

Management concerns at Mount St. Helens emerged in a sequence of overlapping stages beginning with broad-scale assessment of volcanic hazards on a geological time scale (Crandell and Mullineaux 1978). Next, protection of human life and property in the posteruption landscape was addressed. Some weeks and months later, concerns about resource protection and extraction, such as salvage logging, grew in importance. The importance of different concerns was determined, in part, by the rates at which the volcano quieted, hydrologic hazards abated, control measures were put in place, and the long-term land-use policy was determined. As the physical environment began to stabilize, focus shifted to ecological restoration of forests, fish and wildlife, recreation, interpretation, and revitalization of local economies. Thus, the contributions of environmental scientists were more important in the later stages.

The experiences at Mount St. Helens in the quarter century since the eruption reveal that the role of environmental scientists has been largely advisory. They provided information to the decision makers, but decisions were not always made solely on environmental science perspectives. In several cases, hazards to life or property overrode environmental concerns; and in some situations, environmental science was not relevant to management issues. When it was germane, environmental science provided information and perspectives on management at a variety of spatial and temporal scales. These perspectives influenced management decisions made at Mount St. Helens.

Since the major eruption of Mount St. Helens, environmental scientists have contributed to the decision-making process by communicating information, building consensus, maintaining credibility, and discovering options for new management and research directions (Dale 2002). Communication of information occurred via field tours, coverage by the press, scientific papers, and many other venues. Some nonfederal scientists became actively involved in the preservation of natural processes by lobbying for the creation of the Monument, writing letters to members of Congress, developing and endorsing petitions, and participating in Congressional hearings. Scientists helped build consensus within the scientific community about the management plan for the Monument by sharing information, teaching, developing analyses, and taking part in scientific advisory groups. Consensus among scientists about the area to be protected as a national monument and how its management would be implemented arose as scientists shared information with each other and with policy makers. Credibility of the science was maintained by publication of many peer-reviewed articles from Mount St. Helens studies. In a review of papers on vegetation response to volcanic events, more than half of the papers were based on the Mount St. Helens work. Finally, scientists have been effective in presenting options for resource management and protection. For example, scientists were involved in discussions of proposed areas for inclusion in the Monument, and they participated intensively in planning a management structure for the Monument to meet policy objectives.

Finally, scientists took advantage of the natural experimental conditions created by the eruption to explore the ecological implications of varying management strategies. By making observations along gradients of disturbance severity, the diversity of ecological responses to disturbance was documented (e.g., Dale et al. 1998). Developing understanding of the multifaceted nature of ecological responses helps avoid overly simple management solutions to complex ecological and natural resource problems. It also helps match broad-scale goals with solutions. Alternative management practices were evaluated when scientists and managers used experiments to assess and monitor effects of different treatments. Thus, the advice of scientists in questions dealing with management at Mount St. Helens led to changes in direction, improvements in management actions, and better understanding of the implications of ecological system responses to large disturbances.

The Mount St. Helens experience has provided some general lessons about the role of environmental scientists in coping with the aftermath of large-scale disturbances:

- Risks to human life or welfare sometimes outweigh potential harm to ecological systems.
- Input from environmental scientists is usually advisory.
- Environmental decision making is enhanced by advice from ecologists who have a persistent involvement with the concern.
- A formal, institutional context of providing advice makes the information more accessible and timely.
- The early involvement of ecologists in societal responses to large-scale disturbances can help avoid some problems.
- Ecologists tend to provide a long-term and broad-scale perspective on how actions can affect environmental systems, a necessary but not always integral component of decision making.

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Editors

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