Life Returns to Mount St. Helens

One year after a major eruption turned much of the mountain into an apparent grave, the slopes show abundant signs of resurrection

by Roger del Moral

Picking my way across a dry and barren mudflow 5,000 feet up on the slopes of Mount St. Helens last September, only four months after the eruption that devastated the mountain and far from any visible vegetation, I discovered an isolated, yet active, ant nest. These ants, probably *Formica subnuda,* were at the top of a food chain whose lower levels, hidden in the mudflow, were unknown. Decomposing organisms and living plants may have formed the base of the chain, but without disturbing the nest, I could not determine whether soil animals or fungi were involved. Despite my curiosity, I decided that my ignorance was less important than the existence of this microcosmic ecosystem in a veritable desert. The ants were adding nutrients to the mud and hastening the reestablishment of less ad hoc food chains. After watching the activities of these tiny survivors for a while, I continued up the slope, searching for signs of life among the ruins of what was once the most perfect of the Cascade volcanoes.

As Mount St. Helens marks the first anniversary of its May 18, 1980, eruption, it has already been exposed to more hours of scientific scrutiny than most volcanoes are ever subjected to. Logistical and technical problems plagued efforts to study earlier eruptions of other North American volcanoes. Mount Katmai in Alaska, for example, erupted in 1912, but ecologist R. F. Griggs (to whom scientists owe a major debt for his pioneering botanical and geologic studies of that volcano) was unable to approach the mountain until 1916. By contrast, the proximity of Mount St. Helens to scientific centers provides a rare opportunity to apply advanced methods in comprehensive, long-term studies of how ecosystems recover after a major volcanic eruption.

As an ecologist interested in competition and succession in stressful environments, I found myself among the hundreds of scientists drawn to the mountain by the opportunity to document in detail the recovery process and by the exciting chance to test ecological, evolutionary, and biogeographical hypotheses. Biologists observing events as they unfold on Mount St. Helens are asking many questions: Which species first colonize the various completely destroyed habitats? Are succession processes on totally denuded sites fundamentally different from processes on sites with a residual biota? Does repeated extinction and recolonization result in populations that are genetically distinct from populations of the same species in stable habitats? Might communities whose species occur in proportions different from the regional norm be produced?

Ray Atkeson

Above: Residents of Portland, Oregon, had a spectacular view of the July 22, 1980, eruption of Mount St. Helens, one of several sizable blasts that followed the major eruption of May 18. The mountain's proximity to urban centers has been a boon to scientists. Right: Two months after the May 18 eruption, a parsley fern was found growing in a protected area along a creek on the slope of the mountain. The fern, which survived a small mudflow, is growing out of a mud-covered crevice.

My first field experience on the volcano after the eruption was on a reconnaissance trip last July with Jerry Franklin of the U.S. Forest Service and several other biologists. While we were awed by the magnitude of the destruction, I was impressed even then by the early evidence of biological recovery. Since that time, I have made several research trips into various parts of the volcano's "red zone" (the Forest Service's designation for the potentially most dangerous land, to which access is closely controlled). I have also spoken with many other scientists investigating resurrection on the mountain. The emerging picture is one of diversity—diversity of impact and, consequently, of the conditions to which organisms must adapt. Al-

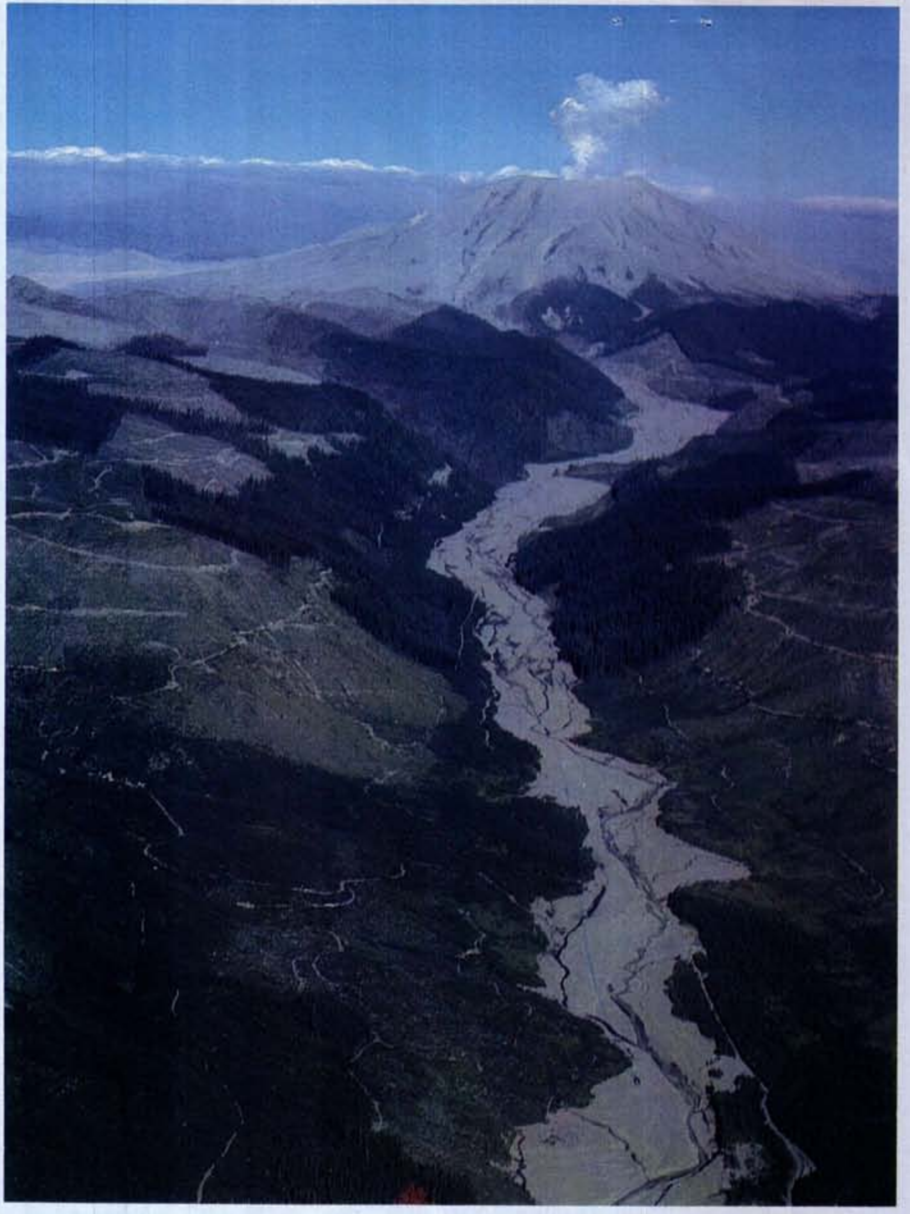
Roger del Moral

titude and season influenced the nature and extent of the damage suffered by different parts of the mountain. In May, much of the landscape was still covered with snow. By contrast, when I visited the volcano late in the summer of 1980 after a minor eruption, I found that hot-gas emissions had scorched exposed plants. These withered bits of straw provided an inkling of what might happen if a big eruption occurred when there was no snowpack to cushion the blow.

The May 18 eruption, like subsequent smaller eruptions, was a series of events, each producing different conditions. In some places, biotic recovery has begun with survivors; in others, colonizers from outside the impacted zone are required. Many ecosystems won't return to anything resembling their preeruption state for years. But almost all affected ecosystems are showing resilience, and the message is clear: while it took a beating, life was never obliterated from Mount St. Helens.

The eruption, which followed two months of relatively minor volcanic activity, unexpectedly concentrated its force on the land to the north. Although geologists had anticipated a major eruption and the magnitude of the blast was not unprecedented, no one was prepared for the degree of devastation spawned by the unusual lateral direction of the eruption. More than a cubic mile of ash was injected into the atmosphere, eventually coating hundreds of square miles of forest and agricultural land. Millions of insects were knocked dead from the sky. Heat scorched trees up to sixteen miles north of the crater, and the blast blew down trees in an arc of 160 degrees, extending more than ten miles from the crater. In most areas within a six-mile radius of the crater all life was destroyed. Large, rapid mudflows, confined to the lower elevations of several of the mountain's major stream systems, crested over twenty-five feet and buried the flood plains of the Muddy River to the east and both forks of the Toutle River to the west. A flow of hot debris then swept all life from the northern flank of the mountain and the upper Toutle Valley, creating an eerie moonscape. (Unlike the sterile surface of the moon, however, the debris is rich in organic residuals.) Melting glaciers and snowfields triggered smaller mudflows on the upper slopes. For example, on the southeast flank of the mountain, the

James Lee, Earth Images



melting of Shoestring Glacier caused a mudflow along Pine Creek that covered vegetation on the edges of the creek while removing it from the creek bed. In total, the eruption of Mount St. Helens had a profound impact on a region of about 160 square miles.

The number of animals killed as a direct result of the explosion was high. Subterranean animals, such as pocket gophers, appear to have survived in many places even within the blast zone, but mammals and birds living above ground had no protection from the blast. The Washington Department of Game estimates that among the more prominent casualties were 5,200 elk, 6,000 black-tailed deer, 200 black bears, 11,000 hares, 15 mountain lions, 300 bobcats, 27,000 grouse, and 1,400 coyotes; the agency has estimated heavy additional losses due to ashfall. The eruption also severely damaged twenty-six lakes and killed some eleven million fish, including trout and young salmon.

Animals outside the blasted areas must contend with altered habitats and reduced quantities and quality of food. In the blowdown zone, elk and deer are now common near water and where fresh forage has emerged from the ash. These survivors may have to forage more widely, but their reduced numbers will ease competition stresses. Zoologists expect the populations of vertebrates to build up as the vegetation recovers, and they are hoping to determine how much the vertebrate pioneers may change their behavior with respect to habitat and resource use as their numbers increase. Significant changes in behavior would constitute evidence for interspecific competition, normally difficult to observe in nature.

Ralph Perry

Far left: Twelve miles or so west of Mount St. Helens (visible in the distance), clear-cut and forested areas along the North Fork of the Toutle River escaped direct effects of the eruption. Large, rapid mudflows, however, buried the river's flood plain. Left: Closer to the volcano, trees were blown down and a hot debris flow, placed on top of the mudflow, swept all life from the upper Toutle Valley.

Larger vertebrates may form a crucial link in the process of vegetation recolonization. Where heavy ash or mudflows dried to form a hard, uniform crust, there are few cracks to shelter germinating seeds. But large animals wandering in search of food or water make tracks that trap seeds and provide microsites suitably mitigated for germination and growth.

Insects suffered incalculable tolls, primarily from the ash effects of the May 18 eruption and from sizable blasts that occurred on May 25 and June 12. Abrasion of the exoskeleton and ingestion of ash during preening were major causes of death. Studies of agricultural areas in central Washington have revealed that although honeybees and other beneficial insects suffered greatly, most insect populations recovered quickly. Nearer Mount St. Helens, where higher altitudes mean a later spring, fewer insects were exposed at the time of the eruption. In the blowdown area, many species have been encountered, but except near water, their numbers are reduced. I noted that seed set in lupines, which are dependent on insects for outcrossing (the production of offspring from individuals of the same species but different strains), was poor even where the vegetation received little damage. I believe this poor seed production was a result of the relative paucity of pollinating insects.

Insect colonists will come from pools of insects outside the blast zone, and new insect communities will eventually develop. Will these communities be similar in species number and composition to communities in similar but unaffected habitats? Daniel Simberloff's experiments during the 1960s, in which all insects were removed from a series of very small Florida keys, indicate that such communities will soon return to the same number of species but that the composition, largely a matter of chance, will be quite different. In the Mount St. Helens blast zone, the habitat is larger than in the island experiments and there is no significant barrier to migration. Will this alter the results? Will novel, stable assemblages of insects be formed?

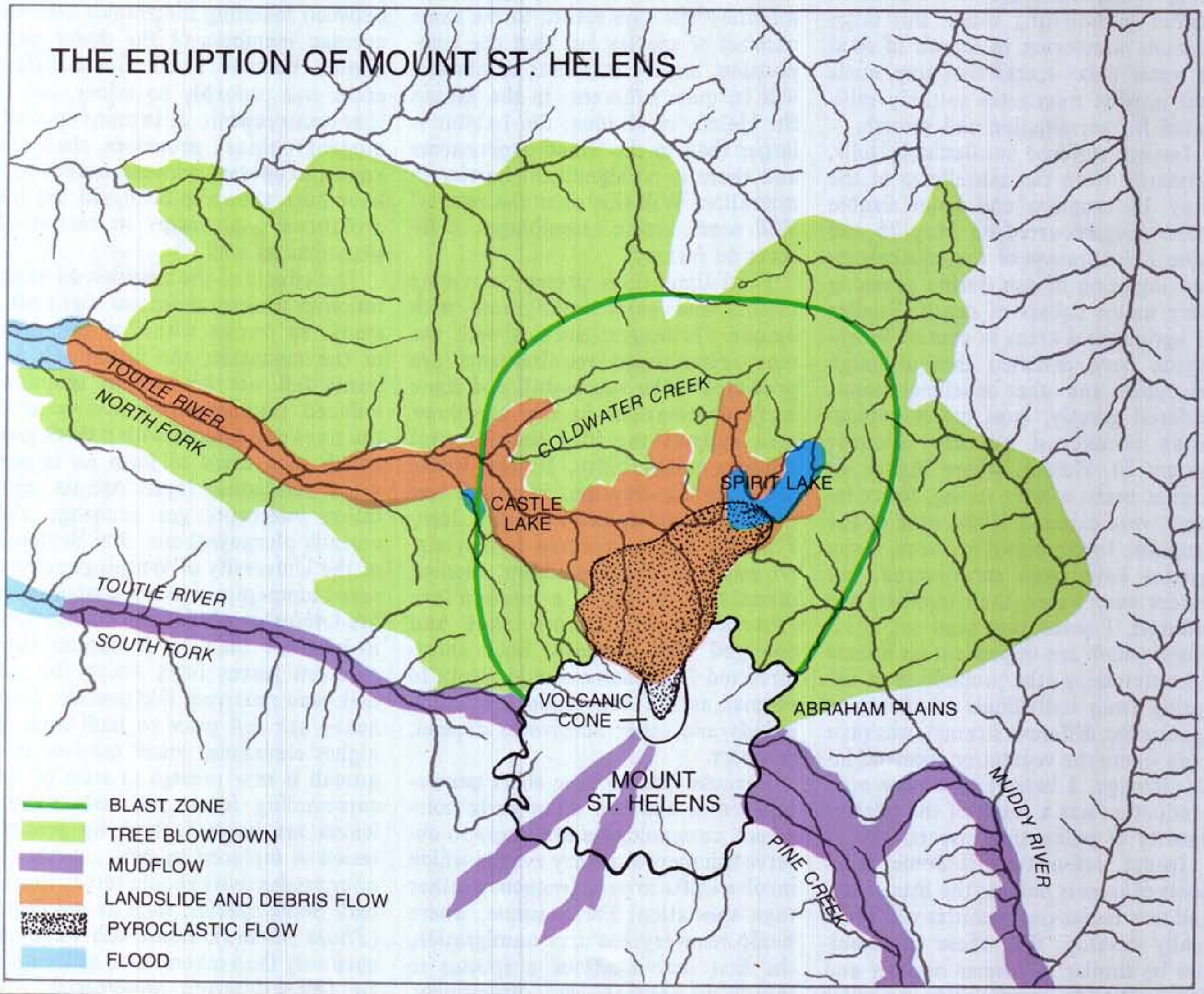
Food limitations present surviving insects and early immigrants with unique challenges. Species with the most generalized requirements are predicted to be successful, and some early observations in the blowdown area support the idea that survival requires adaptability. In the weeks after the big eruption, when ash was ubiquitous and aphids were rare, Jerry Franklin and I observed a ladybug, normally an aphid predator, feeding directly on the sap of a bracken fern (*Pteridium aquilinum*) that had emerged from the ash. Such short-circuited food chains should return to normal as the vegetation, on which aphids and other herbivores depend, recovers.

Because insects have short generation times and are often early colonizers, entomologists are likely to observe microevolutionary events, which involve shifts in gene frequency rather than speciation. For example, where biotic recovery requires immigration, the first individuals of a species to invade an area are, not surprisingly, usually the best able to disperse. Reduced competition and the absence of predators in their new environment may permit a "founder effect" to occur, that is, the genetic differences between founding individuals and the average members of the donor population become fixed. Such differences will probably be minor, but if they occur repeatedly in many species, biogeographical processes that are known to operate between islands will have been shown to be significant for evolutionary processes in terrestrial situations as well.

The effects of the eruption on vegetation in various zones are also under study. In forests within a few miles of the mountain, the initial ash deposits fell wet because of eruption-induced thunderstorms and covered the trees and ground with a thick goo, which soon dried to form an impervious, cementlike layer. Ash on vegetation interrupts gas exchange and curtails photosynthesis. Jini Seymour of the University of Washington measured temperature in ash-coated silver firs (*Abies amabilis*) and found them to be more than 30°F warmer than adjacent leaves from which the ash had been removed. Fortunately, since heavy ash fell prior to bud burst in higher elevations, much ash-free new growth is now present in most of the surrounding forest. As ash-covered leaves are washed clean by precipitation or replaced by new growth, conifer productivity should return to normal. Some species, such as red cedar (*Thuja plicata*), retain ash more tenaciously than others, such as Douglas fir (*Pseudotsuga menziesii*), but

Eyewitness accounts, photographs, and instrument records have been used to piece together the initial sequence of the May 18, 1980, eruption of Mount St. Helens, the youngest and most active Cascade volcano. A huge bulge formed rapidly, high on the north face of the mountain's volcanic cone, in the weeks prior to May 18. Then, at 8:32 A.M. on that day, an earthquake struck the mountain, triggering an avalanche on the north face that is now thought to be the largest ever witnessed by humans. Superheated groundwater close to the magma flashed into steam, resulting in a lateral explosion that pulverized rock and trees and sent a hurricane-force, hot-gas-propelled bolt of ash off the north face and across the Toutle River Valley to the north and west. Temperatures in this inferno were estimated to exceed 900°F. Comparable to a 400 megaton nuclear blast, the explosion blew down trees in a 160° arc up to fourteen miles north of the crater and totally devastated a somewhat smaller "blast zone." Seconds later, overlying rocks were incorporated into a high-velocity debris flow, driven by rapidly melting glacial ice. On the western flank of the mountain, this chocolate-colored mass swept down the upper Toutle River Valley, eventually forming a mudflow that swept the entire drainage area. To the north, a lobe of this hot debris flow crashed into Spirit Lake while another swept over 500-foot-high Coldwater Ridge, removing all life in its path. As the summit of the mountain collapsed, two vertical columns of ash-laden gas and steam were injected more than 65,000 feet into the air. This ash was eventually deposited, in layers up to five inches thick, over 49 percent of Washington State and beyond. Close to the mountain, ash deposits were less thick, but they fell wet, forming a sticky goo on all surfaces. The plume of blasted ash also removed much of the remaining summit and lowered the peak from 9,677 feet to about 8,400 feet. As a consequence, the feeding zone of all glaciers has disappeared. Shortly after these events and continuing throughout the next day, an indeterminate number of pyroclastic flows, or nuées ardentes *(hot, gas-charged avalanches of fluidized rock fragments), were ejected from the crater, so that much of the upper debris flow was covered with more than seventy feet of finely powdered ash and pumice.*

The volcano remains active, with frequent small, harmonic tremors and occasional bursts of steam and ash. Sizable eruptions, with their attendant small pyroclastic and pumice flows, occurred on May 25, June 12, July 22, August 7, October 17 and 18, and December 27 of last year. Future eruptions are expected, but most geologists believe that another large eruption is not likely.



whether various species of forest trees will show important differences in mortality or productivity is not yet clear.

At higher elevations, snow protected the plants beneath the canopy of forest trees from direct ash deposits, but impacts still accrued in this understory vegetation. Many plant species already flattened by snow were trapped by heavy ash. Erosion and rain may eventually remove sufficient ash to free such plants, but the damage may have been too severe or too much of the growing season may have passed for them to survive. Mosses and lichens, which form low mats, are the most severely damaged. Other species, such as the erect-growing huckleberries (*Vaccinium* spp.), were able to emerge from the ash layer as the snow melted. These plants grew well during 1980, probably because there was less competition from other plants and because the high insect mortality reduced grazing pressure. Many of these emergents have sent roots into the nutrient-rich ash and may thus benefit directly from improved nutrition.

Jim MacMahon of Utah State University has shown that pocket gophers are major agents of ash-layer disruption. These little burrowing rodents improve soil aeration and water infiltration. As a consequence, minerals from ash are more rapidly incorporated into the soil, where they can be used by plants. Silviculturists normally view pocket gophers as unmitigated pests because they eat young conifers, but for the next few years, gophers may prove valuable allies in the reestablishment of tree seedlings in clear-cuts and blowdown areas.

For most plant species, recovery in heavily ashed areas will be rapid. Young Douglas firs, silver firs, and noble firs (*Abies procera*) may suffer heavy mortality, and species of lichens, mosses, and other low-growing plants will be disproportionately rare for many years, but overall forest productivity should soon return to preeruption levels. When nutrients from the ash, such as phosphorus and potassium, are added to the soil, they may actually generate a pulse of enhanced productivity. Understanding the differential effects of Mount St. Helens' ash deposits on vegetation will improve the ability of ecologists to read the history encoded in tree rings, pollen records, and soil profiles in other volcano-dominated ecosystems.

Less apt to survive than trees that were primarily subjected to ash deposits are the scorched conifers found in a narrow but expanding band between green timber and standing dead trees. Many trees in this border zone, such as western hemlock (*Tsuga heterophylla*), Douglas fir, and noble fir, survived the initial surge of heat and gas from the main eruption but were weakened by it and also received heavy ash deposits. During the dry summer, many trees gradually succumbed from internal heat or other factors. Fortunately, young saplings beneath many of these trees escaped virtually unscathed by virtue of the snowpack present during the eruption. Thus, the next conifer generation is already well established and should experience a burst of growth now that the saplings are released from competition with their parents.

Still closer to the volcano, where stands of large trees did not survive the first blast, stark contrasts appear between areas that had been clearcut shortly before the eruption and areas that had been covered with forest. In most parts of the blowdown area, snow again offered some protection to ground-layer vegetation, and terrain closest to the mountain received less ash than more distant areas directly in the path of fallout. In the clear-cut areas, regeneration of herbaceous vegetation began shortly after the eruption. Species that commonly grow on recent clear-cuts, such as fireweed (*Epilobium angustifolium*), pearly everlasting (*Anaphalis margaritacea*), and bracken fern, have ecological characteristics distinct from those of forest understories. They grow fast, produce many easily dispersed seeds, and are able to colonize newly disturbed sites rapidly, tolerating high light, high temperatures, and drought.

In contrast, areas in the blowdown region that were covered by deep forest at the time of the eruption lacked herbaceous vegetation as snows returned in the winter of 1980. The forest understory normally consists of herbs and shrub species adapted to cool, moist, dark conditions. These grow slowly; produce few, poorly dispersed seeds; and are intolerant of high-light or high-temperature conditions. Any such understory plants that survived the adverse impact of the blast and ash layers were thus confronted with an inimical environment.

Recovery in these blowdown areas will require invasion by aggressive species from the surrounding clear-cuts. As succession proceeds, conditions will gradually alter in favor of species adapted to the forest. A major prediction to be tested during the 1981 growing season is that within the blowdown area, pioneer species from clearcuts will make up the bulk of new growth in the once forested parts. However, since the flattened trees create microsites favorable to the survival and regeneration of some understory vegetation, the next forest generation will be fostered by the slowly decomposing remains of dead trees.

The potential juxtaposition of plants having markedly different ecological strategies offers opportunities to test some ecological theories. Prevailing opinion would predict, for example, that in open microsites, pioneer species should outcompete the forest species, whereas in protected sites, the reverse should happen. As conditions improve, overall dominance should rest with forest species.

The region of tree blowdown and its surrounding ring of moribund trees presents the U.S. Forest Service with difficult management options. Standing dead and downed trees ameliorate the microclimate of the substrate, retard erosion, and foster natural succession. Trees blown into stream channels reduce erosion and siltation and promote the recovery of streamside vegetation and fauna. Furthermore, there is a widespread desire to preserve much of this region for interpretive, recreational, and scientific purposes. The Forest Service, which manages most of the affected land, must reconcile these factors with the value of downed timber and the danger of fire or of beetle infestations in Douglas fir, starting in moribund vegetation and moving into healthy, economically valuable forests. Salvage removal of downed timber is beginning, although not in areas designated for detailed study by the Forest Service Special Planning Team.

Flood plains are intrinsically unstable habitats, and those in the area affected by the May 18 eruption will recover more slowly than either the ash or blowdown zones. The mudflows, which swept the lower thirty-two miles of the North Fork of the Toutle River, fifteen miles of the Muddy River, and many smaller streams, removed most of the vegetation in their path before settling into unstable masses. Erosion rates will be high, and successful seed invasion will be limited for many years. Last July I observed cottonwood

Douglas C. Anderson

In many places, trees that withstood the blast were scorched by heat and noxious gases and covered with ash. Where this occurred, the mountain shows a line between brown, dead trees and green, living ones.

John Marshall

(*Populus trichocarpa*) seedlings colonizing the lower North Fork of the Toutle. Because they float through the air, cottonwood seeds were among the few seeds available shortly after the May eruption. Unfortunately, subsequent erosion from minor summer rains washed these seedlings away. Bob Zasoski of the University of Washington has estimated that more than ten years will pass before the first trees are established on these mudflows and more than a century before a more or less normal forest can develop.

While mudflows devastated the lower river valleys, a huge debris flow—a turbulent, water-driven, hot mass of rocks, boulders, and uprooted trees—ravaged the upper valley of the Toutle's North Fork. A few plants miraculously survived the vast jumble, and an occasional fireweed or bracken fern rhizome sprouted, but recovery on this debris flow will depend primarily on seeds invading from less damaged areas.

Comparisons between the broad debris flow on the North Fork of the Toutle River and the much narrower mudflow, close to intact vegetation, on the South Fork will provide a test of the hypothesis that the recovery rate on a site from which vegetation has been totally obliterated depends on the proximity to a pool of colonists. According to this hypothesis, recovery should proceed much more rapidly on the South Fork than on the North Fork.

Experimental manipulations of plots established on the debris flows during the next several years may also help answer some general questions about succession. Is there a definitive sequence to the recovery pattern or do chance and local seed availability dominate the process? Are the activities of specific colonizing plant species required to facilitate the subsequent success of other species? One way to test such hypotheses is by determining whether, after a number of years, plots from which the first colonists are periodically removed differ from control plots. Another question of interest is whether succession tends to converge toward a single community type or whether initial site differences persist indefinitely. This question may be answered by comparing the initial degree of vegetation heterogeneity with that found five or ten years later. Significantly reduced variety would imply that convergence is indeed occurring.

Several slower and less publicized mudflows were driven by glaciers melting on the east, south, and west slopes of Mount St. Helens. Last September, I visited the upper portion of the six-mile-long Pine Creek mudflow, which was propelled by the now nearly defunct Shoestring Glacier on the southeast flank of the volcano. Although the preeruption vegetation in this location is not known, the area still reveals interesting aspects of vegetation recovery. The heat and toxic fumes of the main eruption killed the sparse lodgepole pine (*Pinus contorta*) and subalpine fir (*Abies lasiocarpa*) scattered on the high ridges above Pine Creek. The subsequent mudflow destroyed creek vegetation but it merely buried the snow-covered dormant ground cover of the ridge. Initially there was no vegetation on the mudflow, which varied in thickness from a few inches near the treeline to more than five feet at its upper end. The Cascade aster (*Aster ledophyllus*) was the first plant to emerge through this mud. Other herbs, including the broad lupine (*Lupinus latifolius*) and Newberry's knotweed (*Polygonum newberryi*), did not emerge until light rains created small erosion channels along which these plants were confined. Where mud was more than about a food deep, no vegetation emerged in 1980.

Since mud seals the soil and can limit oxygen exchange, buried vegetation may be suppressed through the inhibition of root respiration. An alternative mechanism, however, may operate on mudflows and in areas of heavy ash deposition. Both mud and ash insulate the soil and create a light barrier, two characteristics of a snowpack. Many plant species here and elsewhere may be fooled into "thinking" that winter continues. If this is so, as the 1980/81 winter snowpack melts and further erosion cleanses the mountain, surviving vegetation will emerge, having missed a growing season but otherwise unscathed.

North of Pine Creek lies Abraham Plains, a site that supported only limited vegetation prior to the May 1980 eruption. After the initial eruption, pyroclastic and hot-ash flows melted snowfields on the mountain's northeastern flank. The resultant mudflows covered or removed all vegetation on these plains. Revegetation in this area, unlike Pine Creek, will thus depend entirely on seed immigration.

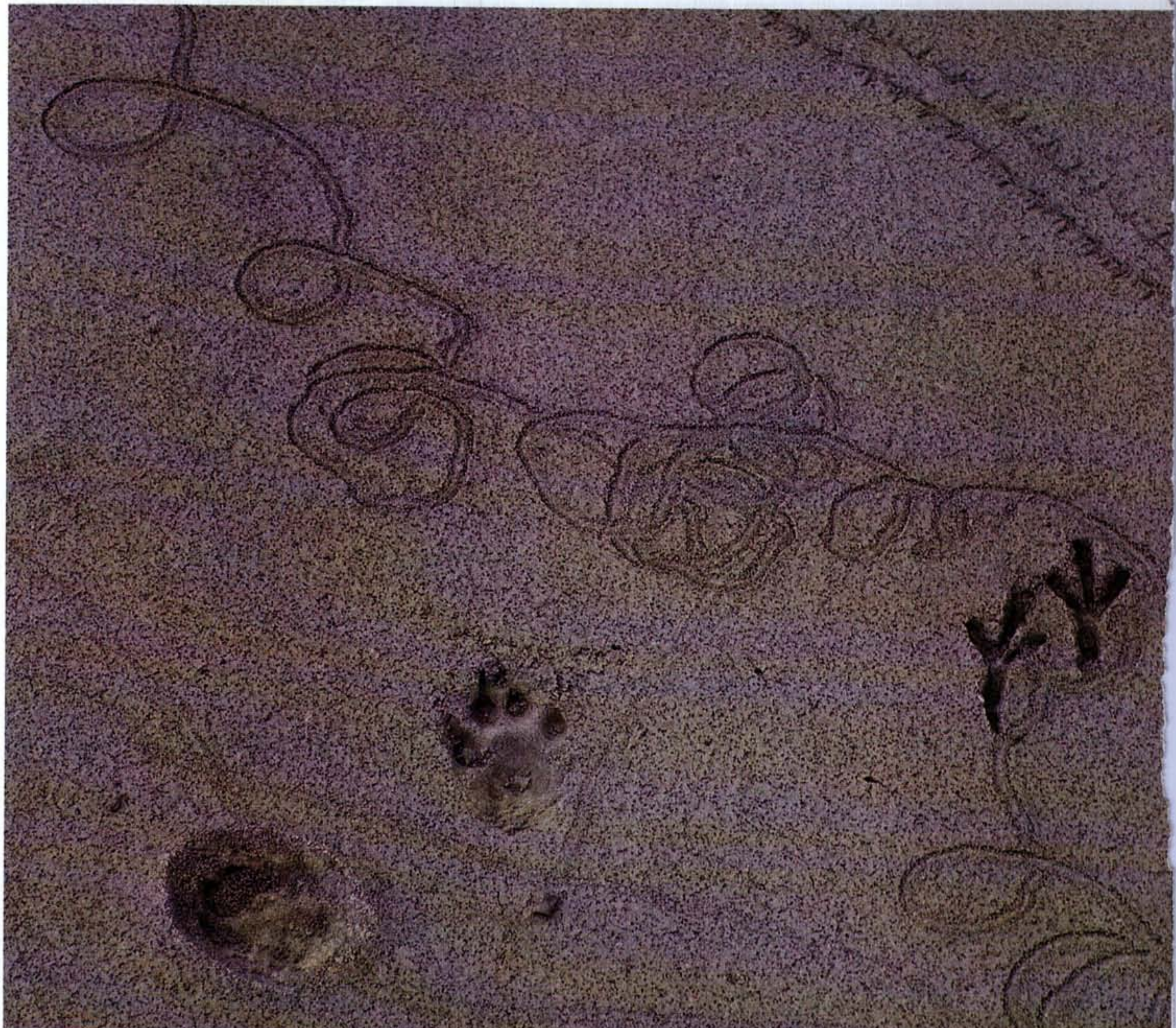
The differences between recovery due completely to immigration and that abetted by residual vegetation will be documented in permanently marked plots at Abraham Plains and Pine Creek. Questions about succession under stressful conditions will be addressed. Do survivors and immigrants belong to the same species? Or, as in the case of Abraham Plains, is the habitat so severe that pioneers are the only species capable of survival? Are differences in species composition due to dispersal failures or simply to the absent species' inability to grow in unaltered mudflow material? Answers to such questions can be applied to the future reclamation of derelict

Soon after the eruption, herbaceous vegetation began returning to recent clear-cuts within the blast zone. The pink flowers of fireweed, a colonizing species of disturbed areas, were a common sight.

In what was once a large meadow covered with huckleberry bushes, a lone spotted frog, right, rests next to a dying bush. To support this amphibian, the meadow must still have some permanent water source.

James A. MacMahon

Mammals, birds, and insects have left records of their wanderings in the ash and mud, below. Where the crust is hard, the tracks of large animals provide traps for seeds and suitable sites for germination.



John Marshall

lands in volcanic regions of the Pacific Northwest.

Further insight into recovery mechanisms will come from observations of revegetation in sites on the periphery of the directed blast. The ridges and glacial valleys in these areas escaped the debris flow and pyroclastic activity. On ridges above the South Fork of the Toutle River, for example, the few lodgepole pines at timberline were killed by the scorching blast, but the lush herbaceous vegetation that normally dominates these ridges, including the yellow penstemon (*Penstemon confertus*) and the broadleaf lupine, returned with no apparent ill effects. On the other hand, the glacial valleys below the ridges, scorched by the directed blast or scoured by mudflows resulting from melting glaciers, lost most of their vegetation. Normally, these valleys support plants different from those on the more exposed ridges, but ridge vegetation is now the most likely source of seeds for the newly exposed terrain. Mountain glaciers such as the ones that formed these valleys ordinarily retreat slowly enough for valley vegetation to keep pace. When Mount St. Helens erupted, however, the rapid melting of the glaciers not only exposed large areas for the first time in more than a century but also washed away most vegetation below the glacier. Thus, in the absence of species specifically adapted to the valleys, ridge species may expand their habitat and create novel assemblages in the valleys.

Mount St. Helens is so young and its environment so harsh that even under normal conditions only the more generalized and stress-tolerant plants can survive. All plants common to the upper slopes display adaptation to unstable or chronically disturbed environments: deep taproots, buried growing points, large storage reserves, and good dispersal mechanisms. Therefore, although ridge-dwelling plants may under normal circumstances be competitively inferior to valley dwellers, they may be physiologically capable of surviving in the valleys. I plan to monitor the development of the upper glacier valley vegetation to see whether plant communities composed of ridge species do develop. Their existence in the valleys would be strong, although indirect, evidence for the importance of competition in stressful environments.

Of all the regions on the mountain, the most severely affected was the blast zone immediately north of the crater, including Spirit Lake. Every type of volcanic behavior displayed by the mountain has assailed this terrain. All life was seemingly obliterated. Trees were pulverized and soil vaporized. Yet, even here, life is returning. Forest recovery will be slow, but it will happen. Soil development will require the establishment of mushrooms, lichens, and pioneering herbs. Seed and spore sources are scarce but a few pockets of vegetation remain. A protected ridge beyond Abraham Plains, on the eastern edge of this area, for example, supports some silver firs and a few areas of herbaceous vegetation.

Higher terrestrial life may be scarce in the blast zone but dead organic matter is abundant, and such a resource is never unexploited for long. Here, where many humans died, where entire ecosystems ceased to exist in a matter of seconds, Dave Hosford of Central Washington State College has found a mushroom, *Autracobia melaloma,* growing from the ash, slowly decomposing organic matter found there, and beginning a terrestrial succession.

Most of the biological action in the blast zone, however, is taking place in lakes. Spirit Lake, once a pristine and clear body of water and now as appealing as a sewage lagoon, teems with microscopic life. Bob Wissmar of the University of Washington, who is conducting a systematic survey of the affected lakes, has pointed out that the water in Spirit Lake was totally removed by the force of the debris flow and replaced by a hot, muddy slurry of ash and debris. Thousands of trees, blown off the mountain and washed into the lake, have provided the basis of a new aquatic food chain on the clogged water surface. As the water cooled, blue-green algae and bacteria were the first active organisms, but decomposing anaerobic bacteria and protozoans now dominate the biota. The slowly dissolving organic matter has reduced the oxygen content of the lake and continues to release prodigious quantities of sulfur dioxide, the smell of which permeates the pyroclastic zone.

Many years will pass before Spirit Lake and other profoundly altered lakes return to a semblance of their preeruptive state. Recovery will be faster in smaller, higher lakes, which were more thoroughly protected by the snowpack. Higher lakes not hit by debris flows or mudflows were primarily affected by ash fallout and received only limited amounts of organic matter.

Ephemeral lakes, laden with organic debris and silt, pockmark the debris flow that settled into the North Fork of the Toutle River. These lakes were quite warm throughout last summer, and decomposition in them was rampant. A witch's brew of phenolic acids and tannins, smelling strongly of creosote and turpentine, is still draining from them. Tracks of elk, deer, and coyote are frequently encountered on the debris flow where little food is evident, suggesting that the animals may well be in search of water. Unfortunately, the quality of the water in ephemeral and permanent lakes is suspect. On one occasion, I found a dead deer mouse, apparently poisoned by the tannin-blackened water in Castle Lake, which formed when the May eruption dammed Castle Creek.

As I write, the winter rains cleanse the forest of ash, and snow falls on the mountain slopes, restoring to Mount St. Helens a pristine appearance. The volcano will undoubtedly rumble for several years, however, and minor damage is likely to continue, particularly on the north slope. In such areas, the biological recovery clock may restart several times, providing future opportunities to observe several stages of succession simultaneously.

Recovery on the mountain will go on for many years. At first, physical changes will predominate: wind will remove the dust, mud will erode, glaciers may recover somewhat. Many lakes and streams should recover quickly, although the persistence of heavy sediment loads will probably retard the recovery of fish. In the higher forests, snow-protected small trees will form the next generation and provide a forested look to much of the blowdown area within fifteen to twenty-five years. Above timberline, as surviving vegetation emerges from beneath mudflows and ash, only subtle differences from preeruption conditions will be evident. Where high-elevation vegetation was destroyed, however, revegetation will be slow and dependent on long-distance dispersal.

Foresters, ecologists, soil scientists, limnologists, entomologists, and other biologists have coordinated their studies of the biological aftermath of the 1980 Mount St. Helens eruptions. In our efforts to understand how ecosystems recover from such fundamental disturbances, we build on the work of pioneers. What we learn may, in turn, help us develop judicious ways to cope with future natural catastrophes. No one wishes to experience further Cascade eruptions, but should they happen, we will be better prepared to encourage rapid and effective ecosystem recovery techniques. □

With the afternoon sun obscured behind a ridge, fireweed blossoms scatter their luminous message of life among the stumps of an earlier clear-cut operation four miles west of the peak of Mount St. Helens.

Ralph Perry