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Science

FINDINGS

“Science affects the way we think together.”
 Lewis Thomas

THE RULE OF TIME AND CHANCE: MOUNT ST. HELENS AND ITS LEGACY OF KNOWLEDGE

“Succession is far too complex to be susceptible to singular explanations.”

Robert P. McIntosh, 1980

Ten days after Mount St. Helens blew off its upper north side, researchers from the Pacific Northwest (PNW) Research Station were on site, trying to make sense of what had happened. Ferried by helicopter into an apparent wasteland, they had no idea of what they would find alive, if anything. They had even less idea of how many surprises were in store for them in the next two decades.

Since the May 1980 eruption, many scientific theories—about succession, survival,



A *The northern pocket gopher was one of the most successful animal survivors within the impact areas. After the eruption, they facilitated plant recovery by mixing the nutrient-poor volcanic material with the former nutrient-rich forest soil as they tunneled through the ground in search of food.*

disturbance regimes, erosion, geomorphic effects on ecology, and chance as an environmental agent—have gone the way of the mountaintop.

“Mount St. Helens provided us with a context for seeing a range of disturbance conditions, from total obliteration at the crater, to trees cast down like matchsticks, to standing dead trees, to standing live trees heavily coated with ash, to a light dusting of ash,” says Charlie Crisafulli, an ecologist with the PNW Research Station who has worked on Mount St. Helens since the eruption.

Formerly forested sites, lakes, streams, and meadows are now in each of these disturbance states. “This gradient of disturbance has allowed us to move along that simplified spectrum and tease out individual aspects of survival and succession that are normally tangled up in much more complex systems.”

“The myriad stories that have emerged have created new perspectives on the way we view disturbance, and have helped reshape a number of management strategies,” says Fred Swanson, a research geologist with the PNW Research Station. “Conventional wisdom has been challenged on many fronts, particularly in the area of species ecology.”

Swanson was one of the first onto the mountain after the eruption. Calling himself a “disasterologist” and closet volcanologist, he recognized in Mount St. Helens the granddaddy of all opportunities to study disturbance, from the ground up.

IN SUMMARY

When Mount St. Helens blew in 1980, it took with it some old ideas that have surprised scientists over the intervening 20 years. Traditional wisdom about ecological succession, survival, and disturbance regimes was moved aside by discoveries of the power of time and chance as environmental agents. Theories about recovery and restoration also have been revised in the wake of many unsuccessful attempts to return the area to its former state.

For it seems the nature of living legacies left behind after disturbance plays a far more important role than previously understood. This finding also has important implications for timber management strategies as they relate to other values: what we leave behind may be more important than what we take.

Researchers have further established that the geologic underpinnings of an area dictate many of its ecological responses, and physical processes have their own kind of succession, not unlike those of the ecological realm. The findings from Mount St. Helens, a global beacon of learning, have affected subsequent management of Pacific Northwest forests, and contributed to strip mining recovery projects in Wyoming.

THE ROLE OF RANDOM EVENTS

Ecosystem response has been a remarkable and challenging mix of the expected and the surprising. But perhaps the most dramatic finding has been the role of time and chance in recovery from disturbance.

"Stochastic, or unpredictable, processes play a very important role during and following disturbance," Crisafulli explains. "Chance events such as timing of the disturbance, both seasonally and even within a 24-hour period, strongly influence survivorship and recovery. For example, if it had been late summer, there would not have been late-lying patches of snow to protect subalpine vegetation, or ice-covering lakes, which shielded aquatic organisms from lethal volcanic forces. If it had been at night, the nocturnal animals would have been in the line of fire."

There were various species responses to the apparent ecological disaster: some perished, others declined, and still others increased. Survival, Crisafulli says, was generally favored by species with some or all of certain attributes: small size, multiple life history stages, nocturnal, broadly distributed in the landscape, large population size, burrowing, or lake dwelling. Species requiring closed-canopy forests are not expected to return for decades or longer. Some survived and will spread only through ecological time. Others took advantage of unoccupied habitat and spread rapidly.

To a great extent, biological legacies made the difference. The oases of survivorship provided by frozen lakes, packed snow, burrows, downed dead trees, and living trees that protected some understory from the worst of the volcanic forces directly affected the trajectory of recovery and accelerated its rate.

Perhaps the most pervasive legacies were dead trees, standing or down. Crisafulli points out that they provided nesting and foraging sites for birds, fungi substrates, hiding cover for small mammals, and time-release carbon and nutrient sources for the developing soil.

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KEY FINDINGS



- Unpredictable processes play a significant role during and after disturbance. Chance events such as timing of disturbance strongly influence survival and recovery.
- Biological legacies, both living and dead, greatly accelerate the rate of recovery and substantially influence recovery trajectory. Surviving organisms served as refugia that helped in recovery of bird and small mammal assemblages.
- Erosion, often viewed as a detrimental process, was in some circumstances an important positive force at Mount St. Helens. It exposed buried plant parts, which could then grow and spread.
- Many plant and animal species believed to have specific requirements associated with late-successional forests have been among the most successful species, even in severely blasted areas.



▲ *The Roosevelt's elk sustained complete mortality within a 150-square-mile area north of the volcano. However, because of their high mobility, the rapid development of preferred forage, and the absence of hunting, the herds have rebounded at an astonishing rate. Today about 1,200 elk roam throughout the new landscape.*

The mountain has forced ecologists to look at timing as an element in ecological succession, he says, a very random element that has little to do with what has been seen as "the natural order of things." Seasonal timing selected which organisms had a chance to survive and which would subsequently provide that chance to others.

So whatever happened to the simple successional pathways on which ecologists have built their theories and models for decades?

"A lot of old dogma has been laid to rest. Lessons learned from Mount St. Helens have demonstrated our lack of understanding of many species' habitat relations, dispersal capacity, and general ecology," Crisafulli says.

Purpose of PNW Science Findings

To provide scientific information to people who make and influence decisions about managing land.

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NEW IDEAS ON SUCCESSION

Examples abound of opportunistic thriving. The mountain bluebird population exploded within several years of the eruption. The birds could nest in the broken tops of trees or use woodpecker cavities, and they thrived on the open ground left after the blast for their food-hunting ground sallies. An entire assemblage of scavenging and predatory beetles and spiders was living evidence of a “rain” of insects carried by the wind and deposited on the barren substrates. Once high flows flushed volcanic sediments from streams, thereby exposing critical cobble habitat for aquatic bugs, fish that had survived in ice-protected headwater lakes successfully colonized stream systems.

Amphibians, long considered highly susceptible to even modest environmental change, survived under ice- and snow-covered lakes and in thermally-buffered seeps. Surprisingly, each of the 12 surviving species have persisted, and some have flourished in the landscape over the past 20 years.

During the eruption, 120 new ponds were created, representing a 5-fold increase in the amount of pond habitat available in the landscape. The red-legged frog, pacific tree frog, western toad, and northwestern salamander crossed several kilometers of volcanic debris to colonize these new habitats within a few years of the eruption and currently have established large breeding populations.

“Small areas of survival deep within the disturbed zone minimized or even negated the importance of dispersal capability,” Crisafulli explains. In other words, if you were already there, you had a jump on creatures coming in from the outside, which would have to cross an expansive and often hostile environment working against their survival.

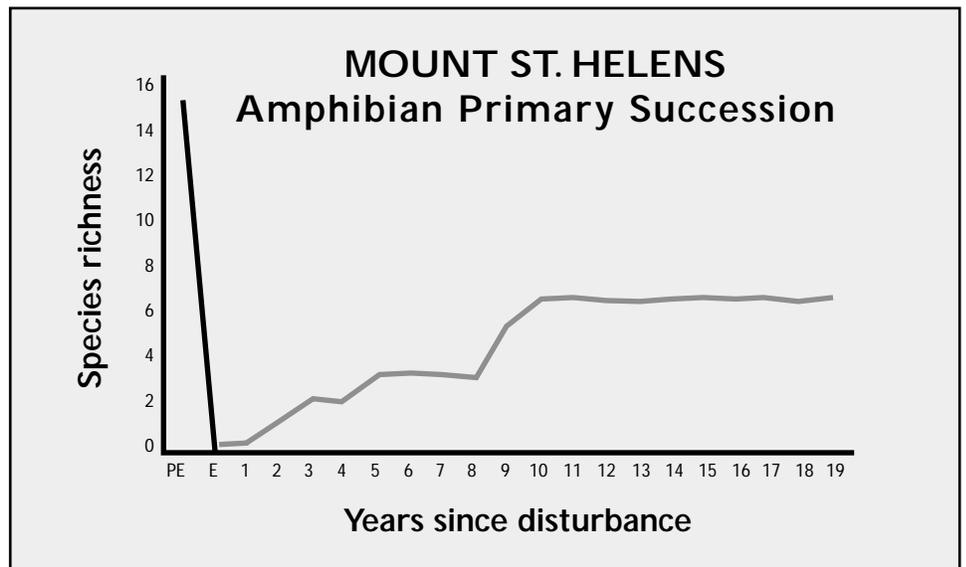
Ideas on recolonizing bare areas also have been forced to change. “Literature on migration and establishment of ecosystems on bare areas has emphasized dispersal and establishment of new individuals as the critical process in recovery,” Swanson says. “But



LAND MANAGEMENT IMPLICATIONS



- What we leave at a harvest site may be just as important as what we take. For example, snags specifically attract certain cavity-nesting species based on how many are left per hectare after harvest.
- Given the right conditions, introduced species can have catastrophic effects on populations of native species.
- Knowing the geological history and structure of an area is important to understanding how it can and might respond to disturbance.
- Efforts to restore ecosystems on the west side need to carefully consider that these ecosystems will naturally recover from disturbance.



▲ *Amphibian numbers dropped dramatically immediately after the eruption, but they rapidly filled new habitat openings and thrived in following decades.*

surviving organisms played by far the major role at Mount St. Helens by providing established individuals and indigenous sources of seed.”

Crisafulli notes the importance of natural history in being able to understand and predict how various surviving creatures responded to the blast, and also subsequent patterns of colonization.

“If you have a reasonably good understanding of an organism’s natural history, you have a powerful predictive tool for knowing how

it will respond under certain conditions. For example, by 8:32 a.m. on May 18, the nocturnal deer mouse was safely into a log or burrow. An elk, on the other hand, was out and active, and had no place to hide, so we lost a large number of them, but their mobility means that they can still recover quickly, coming into the hostile environment for fodder, but also leaving it with ease.” Simply by virtue of their stature, the former kings of the landscape—elk and Douglas-fir—were extirpated from the blast zone.

WRITER’S PROFILE

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BOOM AND BUST ON THE MOUNTAIN

Tracking succession since the blast has often seemed more akin to detective work with constantly changing characters than applied field ecology. Crisafulli loves to tell the willow story, which incorporates many components of events on the mountain since it blew 20 years ago.

In the first 10 years of recovery, vegetation consisted largely of surviving understory species such as huckleberries and other opportunistic forbs such as fireweed that colonized from wind-dispersed seeds, from less-disturbed lower elevation sites. Willows and alder were also slowly recolonizing along streams but remained scant in the first decade.

“Once willow reached about 2 meters, however, and had spread in verdant lines of green through the blowdown zone, we had what is known as a ‘cusp event,’” he explains. Willow is a keystone species, meaning its establishment heralds the preparedness of an ecosystem for the next group of species to move in. These new species are reliant on



▲ *Streams in the blast zone received enormous quantities of trees from the surrounding ancient forests as the powerful lateral blast uprooted, snapped off, and leveled trees in a 150-square-mile area north of the mountain.*

the presence of the keystone species and are vulnerable should the keystone species decline or be eliminated.

RETHINKING SPECIES MANAGEMENT

Many species, including both plants and animals, that were believed to have limited dispersal capabilities or specific requirements associated with old-growth forests, have been among the most successful species in even the most severely affected locations. “We have learned that we need to look not just at the fact that some creature thrives in old-growth forest,” says Crisafulli. “We need to look at why, at what it’s specifically seeking in the forest habitats, and whether it might find that in other places as well.”

There are significant implications for crafting the standards and guidelines by which public lands are managed. For example, the Washington State Department of Ecology recently wanted to set its regulations for stream temperature at very low levels to protect tailed frogs, Crisafulli says. “But Mount St. Helens has provided new insights regarding their ability to thrive in warmer waters than previously thought. Optimal growth may result from somewhat elevated water temperatures that result in large standing crops of periphyton, the primary food of larval frogs. Additionally, this species

likely operates at small spatial scales in very complex streams and water temperature alone may not be the best parameter alone to set standards by,” he explains.

Similarly, posteruption findings have helped clarify an approach to snag management. Some species cue on the presence of large numbers of snags, others on very few snags. The important thing in designing standards and guidelines, Crisafulli says, is to recognize that the number of snags left relates directly to the number of potential assemblages of snag-using birds they will attract.

In a new spin on exotic species, the Washington Department of Fish and Wildlife has been working with the Forest Service to assess the impacts of introduced fish species on native amphibians. “We have found that introduced trout have had a significant impact on amphibians—the northwestern salamander was an order of magnitude more abundant in lakes without trout. Exotic species such as brook trout can be very successful and tenacious in their new environments and can profoundly influence native biota. It is believed that brook trout have had a greater impact on

Sure enough, the number of birds along streams increased dramatically: mostly the Neotropical migrants such as yellow and orange crown warblers, warbling vireos, and willow flycatchers. Willow habitat also invited specialized small mammals, ushering in the successful establishment of Richardson’s vole and water shrew.

“Enter the exotics. The willow stem-boring beetle larvae created tunnels in the stems within 1 meter of the ground. This compromised the integrity of the wood; the willow shrubs collapsed, and thus lost their structural value to birds and mammals. Faunal collapse came next,” Crisafulli continues. “Meanwhile beavers were having a field day, chewing down the willow and creating dammed ponds that encouraged amphibian habitat along the edges and provided ideal egg-laying habitat for salamanders in the downed willow.”

The willow story highlights the game of ecological musical chairs, a boom and bust cycle that emerged regularly as flora and fauna jockeyed for position.



▲ *View of the Mount St. Helens volcano from the north, looking south across the Spirit Lake basin. The eruption on May 18, 1980, removed the top 1,300 feet of the volcano and created a large horse-shoe-shaped crater.*

the salamander than the devastating eruption,” he explains.

The mountain’s management lessons have spread beyond the Northwest as far as former strip-mining sites in Wyoming, where plans to restore the natural shrub-steppe environment lean heavily on the new knowledge of disturbance.

DEVELOPING MULTIPLE LINKS

Striking and unexpected also was the speed with which organisms of all kinds developed functional links.

"Although the landscape looked sparse and simple, many and elaborate links quickly reestablished between physical processes, plants, and animals," Crisafulli notes. "These included woody debris in streams, fish recovery, the role of nitrogen-fixing species such as lupines as centers for establishment of other plants and animals on nitrogen-poor sites, and interactions between animal tracks, seed accumulations, and seedling establishment."

Pocket gophers, for example, stimulated vegetation recovery. Owing to their subterranean existence, these small mammals survived in many locations within the devastated area. As they burrow through the soil, they mix old, nutrient-rich soil with fresh ash, producing a combination with higher water-holding capability and higher concentrations of nitrate, organic carbon, and phosphate than the raw ash, Crisafulli says. The

mixing of the substrates also brings seeds, bulbs, underground stems, and mycorrhizal fungus spores to the surface, thereby promoting vegetation development.

Deep in the realm of the unexpected lies the geomorphological links to ecological processes. "Erosion, often viewed as a detrimental process, was observed to be a very important positive force in parts of the Mount St. Helens landscape," Swanson explains. "Water erosion cut through ash and pumice deposits, exposing buried plant parts. These plants exposed in the first few years after the eruption responded by putting on aerial growth and spread, first longitudinally in the channel and later laterally. This was a pervasive and exceedingly important mechanism of plant survival and reestablishment."

The recovery on the mountain also revealed that the ecological story cannot be understood unless the underlying geological story is straight. Whether the slope is steep or shallow, stable or unstable, with deep soils

or exposed rock, or facing the sun directly affects the types of refuge and the kinds of succession likely after disturbance. Thus, Crisafulli notes, much of the Cascade Range is living with the ghost of volcanoes past.

Further, physical processes turn out to have their own kind of succession, not unlike that of the ecological realm. For example, Swanson explains, small gullies formed on blast zone hillslopes after the first heavy rains, allowing the flow of water into preeruption soils. Surface runoff was reduced, but shallow landsliding increased in subsequent years.

"The continued high rate of sediment production has sustained very unstable stream channels, limiting for decades the recovery of riparian vegetation along the more unstable channels," he says. "What we see is a sequence of interacting physical processes affecting the landscape, just as plant species exhibit sequential properties in their reoccupation processes."

JUST ADD WATER

Overwhelmingly, the posteruption picture alludes to the resilience of nature, its ability to bounce back from what seem appalling knocks to revive and thrive again.

Aquatic ecosystems give some of the most stunning examples of recovery. Spirit Lake was moved 200 meters up the mountain-side by the initial avalanche. In the course of that event, it was filled with detritus and sediment. As a closed system, it rapidly became completely anaerobic, a warm, foetid shadow of its former self.

"However, within a mere 6 years, this lake—among the most severely disturbed in the world—had rebounded to a condition typical of west-side high-altitude lakes. Today it contains clear, cold, well-oxygenated water that supports a healthy plankton community, the base of a complex food web that includes aquatic insects, numerous amphibian species, and rainbow trout."

Various restoration efforts attempted to repair "damage" at Mount St. Helens: seeding hillsides for stability, lowering lake levels or providing escape channels to drain those dammed by blowdown, and replanting former plantations. Aside from the tree plantings that went deep enough to get

roots into mineral soil, efforts at restoration seem mostly for naught.

"I will go so far as to say that in west-side Cascade Range forests, rarely do areas warrant active restoration. The planning, implementation, and monitoring is very expensive and not always effective. After all, nature is very tenacious: it's been at it for millions of years, and it's gotten very good at it!"

In fact, in our mild, temperate, and moist climate, he suggests that the best response to disturbance is already built into the climate: just add water. Invasion by exotic species may be the only case in which aggressive action is warranted.

At the 20-year anniversary of the eruption, a field workshop scattered seasoned researchers across the mountain to take benchmark measurements. In part, this "pulse" of information gathering and sharing was to bolster their own research and analysis, partly to pass the baton to the next generation, and partly to contribute to the Mount St. Helens database, now established on the Web. A synthesis book is expected to be published within 2 years.

"When we first got to the mountain, we didn't need to bring color film. It was all grey and black."

Roger del Moral

FOR FURTHER READING

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SCIENTIST PROFILES



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