Ecosystem Resilience

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Three decades out, the pulse of research quickens on the volcano that kicks butt.

Seismographs never flatline. But the six that monitor Mount St. Helens (MSH) National Volcanic Monument were calm enough on 18 May, registering only the routine burps and jitters of geosurveillance and a temporarily placid crater.

It was the 30th anniversary of the eruption, and if the geology was stilled, there was plenty of other activity. Dozens of cars wound their way upslope to the Johnston Ridge visitor center for the occasion, carrying survivors, relatives of victims, aging Boy Scouts whose camps disappeared in the blast zone, congressional staffers, and scientists, among others.

Kids jumped hard on the floor next to the demonstration seismometer, joined at one point by a crew of tattooed bikers who moved the needles more emphatically. Everyone tried to glimpse the great St. Helens crater, almost too big for the picture windows and shrouded much of the time under intractable fog.

For science, some features of the mountain's ecosystem also remain outsize and obscure, despite hundreds of studies and findings that have been called "paradigm shifting." About 50 projects are currently active, in what one administrator says is "a tremendous resurgence. One would have to characterize research at Mount St. Helens as vibrant."

The eruption in 1980 resulted in "a grand experiment that you could never have gotten anybody to fund," says Forest Service ecologist Charles Crisafulli. "Everything's new. It's a new landform." Unlike most misbehaving volcanoes, this one provided an accessible laboratory right along the Interstate 5 corridor, with the research infrastructure of major universities nearby.

Charles Crisafulli surveys the recovering aquatic ecosystem at Spirit Lake. Photograph: US Department of Agriculture Forest Service.

Subsequent jockeying among private landowners, local business, timber interests, government, environmentalists, and scientists created the 43,300-hectare MSH national monument, administered by the US Forest Service and preserved for research and low-impact recreation.

Disturbance happens

In the restrained locution of ecology, what occurred in 1980 was a "disturbance." It instantly recast the serene Fuji-form symmetry of the volcano and its lush forests; meadows; and clear, snow-fed lakes into a stark dead gray blank slate, extending northward around a gaping, side-blown crater.

The eruption's first phase was the largest avalanche in recorded history, much of which quickly moved 23 kilometers at speeds up to 70 meters per second to bury a wide area. This was followed within seconds by a 250-degree Celsius stone-filled lateral blast cloud that quickly outpaced the avalanche, scouring, scorching, or toppling nearly everything over a 600-square-kilometer arc.

Over the ensuing nine hours the vertical component of the blast elevated a cubic kilometer of matter up to 27 kilometers into the sky, a column that rained ash over 11 states. Mudflows began almost immediately, hurling more than a hundred million cubic meters of liquefied sand, gravel, rock, and earth entrained with cut logs and other human-made debris down the North Fork Toutle River Valley, some of it eventually reaching the Columbia River, 120 kilometers distant.

Pyroclastic material flowed for five hours from the main vent, covering more than 15 square kilometers of the already transformed landscape with superheated, incandescent volcanic

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material up to 40 meters thick. Fifty-seven people were killed.

Among the first organisms visible a few days later on this still-active landscape were scientists. They included Virginia Dale, now of the Oak Ridge National Laboratory. She had mounted the defense of her doctoral thesis in mathematical ecology at the University of Washington the day the mountain started rumbling, and by the time it erupted a few weeks later, she and some colleagues had a research proposal in hand.

"There was a lot of interest in how life was going to return to the area," she says now. "A general sense was that life had been wiped out in the blast zone, so a big question was, what's going to be the progression of life coming back?" The field of disturbance ecology gauges a wipeout's impact. The comeback is called "succession."

Chance features of the general chaos can influence what develops afterward in surprising ways, researchers discovered. Because this eruption happened to occur in spring, snow still covered some of the mountain, providing a mantle of protection for a few deeply buried plants and animals that allowed them to regenerate. The crater's slopes weren't paved with lava; they were instead blasted with loose volcanic material, and in these deposits, seeds can sprout and buried plants emerge.

Dead or living remnants of the prior ecosystem are "biological legacies," such as a stick; a root; some gophers left alive under earth and snow, a patch of soil, or a flattened forest. When a disturbance of this size resets natural history to something near zero, the legacies are thought by some to be more important than the disturbance itself in determining what happens next.

Ecologist Jerry Franklin, now of the University of Washington (UW) and a key organizer of the posteruption research campaign, has said that he and other ecologists sometimes "got their scientific butts kicked" in pursuing it. "Backed up into a corner, we might have said yeah, I'm sure there are some things that are still alive out there, but the whole notion that they were going to play the major role in recovery was not something that we were thinking about."

"This is a totally unique resource," Dale says. "There's no other site in the world with this 30-year history where you've had hundreds of scientists learning the role of legacies, which we didn't understand before. That was not a concept that was even in the literature before the eruption."

Nothing succeeds like succession

Mount St. Helens has helped revise one of ecology's oldest preoccupations: trying to recapitulate the story of how communities of plants and animals assemble themselves over time—how one suite of species succeeds another. The tabula rasa of the blast zone "created a great template to evaluate that," Crisafulli says.

It's a given that life ultimately reappears if it is erased by disturbance. "Nothing succeeds like succession," as ecologists say. But the stories in their heads at the time were based on studies of only a few disturbed ecosystems, especially abandoned farm fields in the eastern United States.

Logical rules had been laid out from these studies: Simple organisms arrive first, giving way to more complex ones. Certain species are pioneers, evolved to capitalize on early postdisturbance opportunities. After intermediate phases of competition, a suite of "climax species" such as long-lived trees arrives to establish a mostly stable, enduring scene.

At MSH, those succession scripts began to fall apart. "It turns out, there were lots of surprises," UW community ecologist Roger del Moral says. "The process is much less deterministic than those diagrams in textbooks might suggest."

Supposed late-successional species arrive early. Simple organisms like mosses show up late, or not at all. Cascade lupine and prairie lupine aren't expected to occupy the same kinds of habitat, "yet there they are, often in the same square meter," del Moral says, flowering in their thousands over broad areas of the mountain. Unanticipated juxtapositions, arrivals, and departures have characterized succession on MSH.

Overall, del Moral's statistical analyses find that environmental factors such as soils, temperatures, moisture, and elevation don't predict much at all, especially in the early years after a disturbance. Instead, chance dominates: which seeds might be blown or carried in, what species are nearby or distant, and the "biological legacy" factors that survived the disturbance.

"We are now coming to believe that just because it happens in a particular way does not mean it must happen in that particular way," he says. "There are alternative pathways that can get you from A to G by going through different intermediate steps—say A to E to G or A to C to G—without going through all the stages. Succession is not nearly as deterministic as we thought."

If science aspires to the discovery of general rules for how nature works, the posteruption research at MSH has often done more to catalog fascinating particularities—landing closer to natural history at times and further from theory. Disturbance ecology and succession studies have "struggled to find generality" and do not accurately interpret events at MSH, an overview of the research has concluded. "Properties of

Roger del Moral says chance dominates phases of new life on posteruption St. Helens. Photograph courtesy of Roger del Moral.

Charles Crisafulli and Virginia Dale, second and third from left, lead high school students who are pursuing research at the volcano. Photograph: Peter Haydock, National Geographic: The JASON Project.

succession are difficult to incorporate into mechanistic models."

Dale says she feels no disappointment about that, even after decades of intensive research at a large-scale, well-protected site. "Ecological thought has been challenged, and people have debated for a long time that we don't have any grand unified theory of ecology as we do in physics, no periodic table as in chemistry," she says.

"I think that's the way it is, and I think ecologists need to recognize this complexity. I'm working a lot with economists now. They are constantly giving us their little supply-demand curve, and we're saying that doesn't always work. There are always exceptions.... As a scientist, I keep seeing the exceptions, and MSH played that out because it was the chance events that were really important."

Franklin concurs: "Ecology is a science that lacks exceptionless empirical laws and deterministic general theories. Fundamentally, you need to know the natural history of the ecosystem and organisms to predict responses to a specific event such as an eruption.

"That is a great trauma to a lot of biologists and to a lot of ecologists who work so hard to create theory, and then almost inevitably the theory they create has to do with special cases. It's not general theory at all."

Postcatastrophe prescriptions

Theory aside, researchers say MSH and its research programs have taught crucial lessons for how, and how not, to manage big disturbed landscapes. These are not in short supply. The anniversary at the volcano also marked the fourth week of another catastrophic eruption, which was adding a roughly estimated 9.5 million liters of oil to the Gulf of Mexico ecosystem each day.

Mount St. Helens research is now a source of data for those who must cope with the aftermath of both natural and human-caused disturbances, Crisafulli says. "Early on we were ridiculed. People said, it's part of a stamp collection, it has no value or relevance to other places, but indeed it does."

Four hundred miles to the south of MSH, in southern Oregon, research data became part of an acrimonious debate over whether to salvage-log some of the 200,000 charred hectares of the Siskiyou National Forest in the wake of a 2002 wildfire, the state's largest and costliest in at least a century. Crisafulli was consulted by a Texas company doing reclamation work on Western strip mines, including a problematic site in Washington. His analysis of its climate, soil data, and available nutrients suggested that native lupines would be good to consider for land cover. The US Geological Survey contacted him to ask how a formerly inundated landscape might evolve when an old dam was removed from the Elwha River near Washington's Olympic National Park.

"We do know enough to make sensible suggestions for management," says Dale, the lead author of a research paper titled "Ecosystem Management in the Context of Large, Infrequent Disturbances." One of its more salient prescriptions: The more legacy left on the landscape, the more rapidly a diversity of life forms returns. Another lesson: Messiness is good. "We've learned that you don't necessarily need to clean things up" after catastrophic change, Dale says.

For example, despite strong opposition from many ecologists, state, federal, and private foresters removed millions of board feet of dead logs that were part of the "biological legacy" of the eruption at MSH. The timber was taken out for its economic value and also, proponents argued, to forestall wildfires and a potential explosion of tree beetle populations. Subsequent research at unsalvaged areas of MSH found that these fears were not realized. Salvaged areas have recovered more slowly, with comparatively impoverished biological diversity.

Just after the eruption, a controversial and expensive aerial reseeding program sowed exotic grasses on steep slopes. Sheet erosion quickly washed away many of the seeds. The attempt was made in the wrong season, too, so germination was minimal. Clouds of the seeds sometimes drifted elsewhere downslope, however, causing mouse populations to explode. When this food supply was exhausted, the hungry mice gnawed tree bark, suppressing forest recovery and diversity, studies found.

Snags and debris were cleared from slopes and streams—another instructive error, as things turned out. "Many times when we have these large disturbances money is spent because that's what we know how to do," Dale says. "We don't always spend it in a very wise fashion. We often spend it to clean up things. Nature's not clean.

"Leaving a big jumbled-up mess led to quicker recovery because pockets of vegetation could get started, seeds could get established, it was wetter," she says. "That messiness is a part of nature." Research on cleanup efforts following hurricanes has led to the same conclusion, she adds.

Data from MSH have also profoundly affected the national debate over clear-cut timber harvesting, Franklin says. As one of the architects of the Clinton-era "spotted owl" settlement, the Northwest Forest Plan, he brought volcano-generated experience to the negotiations. "It gave us the whole notion that instead of trying to totally sweep clean, as we do with clear cutting, if we're interested in things like biological diversity and other kinds of ecosystem processes besides timber production, maybe we'd better rethink our concepts."

Replanting privately held forest acreage at MSH has mostly yielded stands of trees for wood production. "It comes at an ecological cost," Crisafulli says. "We're seeing that at St. Helens when we look at mammal diversity and herb diversity."

Hot spots for research

Near the end of a hypercaffeinated PBS documentary that aired the week before the anniversary of the eruption, viewers were assured that "today, the slopes of the mountain are a living testimony to the miraculous ability of nature to return from the dead." Symphonic brasses swelled under the libretto.

Although miraculous returns from the dead do not appear in the research literature, scientists have indeed seemed awestruck by the exuberant and ingenious reestablishment of willows, microbes, elk, balloon spiders, rock wrens, horned larks, salmon, trout, and thousands of other species.

Franklin, a career-long devotee of old-growth forests, is delighted by the productivity of this infant landscape. "It has finally forced us to look candidly at this period between an intense disturbance and when the forest canopy again closes, and trees resume dominance over the site. You have ecosystems that are characterized by a diversity of plant life forms: herbs, shrubs, and trees are scattered through that. Reptiles, amphibians, mammals, birds, and of course larger ungulates, like elk, and their predators are all favored by that condition."

The reassembly of the former old-growth evergreen forest ecosystem could take hundreds of years. It may not recur at all. Wild cards such as exotic invasive species or more eruptions may generate a different outcome. Global warming might bring a more open, pine-dominated forest instead. "In this time, unfortunately, you can't be sure," Franklin says. "Any time you put an ecosystem through a wringer like that, it may not come back."

Resources for further reading:

Ecological Responses to the 1980 Eruption of Mount St. Helens. Dale V, Swanson F, Crisafulli C, eds. Springer, 2005.

Ecosystem Management in the Context of Large, Infrequent Disturbances Ecosystems 1: 546–557.

Recommendations of the Mt. St. Helens Advisory Committee. 2009. *www.skamaniacounty.org.*

Laws, Theories, and Patterns In Ecology by Dodds W. University of California Press, 2009.

Jerry Franklin talks about lessons learned in managing natural landscapes from a surprising volcano. Photograph: US Department of Agriculture Forest Service.

Meanwhile, exotics seem to be playing a surprisingly modest role so far, Crisafulli says, and MSH has become a biological hot spot for the whole Cascade range, from California to British Columbia. There is no equivalent area in the Cascades with the number or the diversity of bird species, for example. And there is far more biological diversity at MSH today than before the eruption.

All the same, some near neighbors have decidedly mixed feelings about the science enterprise at MSH. Maintaining it as a research laboratory for the observation of natural forces has meant keeping human influences at bay, at least to some extent. Off-trail hiking, off-road vehicles, hunting, fishing, horses, dogs, and camping are banned or restricted in some sections. Proponents of more tourism have advocated easing those restrictions and building a new highway to link the eastern and western sides of the monument.

The area's congressional delegation convened a task force of local elected officials and stakeholders to investigate the issue, and its report was formally presented in the weeks before the anniversary. The report recommended forming a committee "to vet recreational opportunities while maintaining a scientific conscience." But it concluded that more recreational access of all kinds is of "paramount importance to the public," and in pursuing more of that, the current Forest Service administration was considered a better bet. A proposed conversion of the monument to a national park, under the supervision of the National Park Service, was rejected.

"I can see where they're coming from," Dale says. "Land is locked up, and people always want access to land." But the region is already rich in environmentally compromised areas that can be used for recreation, she adds. "Large research land is rare, especially where we know what's happened for 30 years. There are no other examples.... Think they'd buy that?"

Learning to see the next big log

The tumult of constant change on a young landscape sets the research agenda for the next decades. More complex food webs are developing. Living things, rather than rocks, air currents, minerals, or moisture, are beginning to dictate the direction of succession, researchers say.

As plants multiply, so do the ranks of plant-eaters such as elk and insects. "It's generally thought that it's plants duking it out for resources, nutrients, light, space," Crisafulli says. Herbivores are now exerting enormous influence too, he says. The transformation from herbaceous to woody vegetation will catapult further change toward more shade-tolerant plants and the small mammals and birds that are adapted to life in trees.

Wolves, whose reintroduction powerfully altered the Yellowstone ecosystem, are likely to move into this landscape in the next decade or so, Forest Service researcher Frederick Swanson predicts. "What will their presence do here?" he asks.

Frederick Swanson is watching for wolves as well as new research recruits and new ideas. Photograph: US Department of Agriculture Forest Service.

Mount St. Helens can be viewed as an analog to global warming—another possibility for future research. The eruption's replacement of a damp, cool, fir forest with a much drier, warmer, and windier environment may prefigure similar changes in other areas as the global climate shifts.

Another natural process is also under way as the years pass. "A generation of scientists who cut their teeth here are moving close to retirement now, so we need to bring on the next cohort," Swanson says. Part of that recruitment effort pulls interdisciplinary teams of scientists and others to MSH every few years, including this one. Veterans and younger researchers camp, work together, mind their research plots, generate new ideas about what to study, then "test them with one another around the campfire and some beer in the evening," he says. The process, begun by Franklin a generation ago, addresses another of his concerns: that ecologists, and others, not be "blind-sided by their own preconceived notions."

Franklin saw plenty of rotting logs during his first years in forestry research, never guessing their ecological significance as providers of shade, moisture, soil nutrients, and shelter. Their importance became apparent at MSH. "If you can overlook something as big and common as that, then we're still not seeing everything. What big log is lying out there on the forest floor that I'm not seeing now? I'm still having revelations, and I've been at this for 50 years."

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