

CHAPTER 2

Blown-down and Seared Zones



Surviving fireweed emerges from blast and tephra near Ryan Lake (August 20, 1980).

How the blown-down zone formed

The charisma of the first 1980 eruption of Mount St. Helens, once a perfect stratovolcano called the Fuji of North America, derives from having broken many rules. The initial blast was directed across the landscape. Soon after the volcano started to awaken (March, 1980), an administrative red-zone, centered on the cone, was implemented, designed to protect the public. Its shape was based on expert opinions. In retrospect, it was too small and people beyond the closure zones died and the blast transcended the closed areas.

This unusual eruption might have been anticipated. In the weeks before May 18, a prominent bulge, caused by magma moving up the throat of the volcano, developed on the north face of the cone. By May 17, it was growing by an astonishing 1.5 meters a day and the north face had moved up and out by 135 m. Several hints of what was to come might have been noted. In 1847, Canadian painter Paul Kane sketched a small eruption centered at this spot. This clue foreshadowed the lateral eruption to come. In 1955, the volcano Bezymianny (*unnamed* in

Russian) experienced a lateral blast. Bezymianny is similar in size, shape and age to Mount St. Helens, and its eruption formed an amphitheater-like crater similar to the iconic one on Mount St. Helens. Its inaccessibility in a remote part of Kamchatka, intensified by restricted access due to Soviet military activities, assured that little was made of its eruption. So, precedent and clues to suggest that a lateral blast was imminent on Mount St. Helens were obscured.

The inevitable blast extended over an arc of 170° centered to the north. It bashed and seared trees beyond 28 km from the cone (Fig. 2.1). Near the crater, this blast removed all vegetation, and subsequent eruptive processes covered the naked landscape with pumice (see Chapter 4). The seared and blown-down zones, where forest trees were killed, provide interesting ecological lessons and contrasts to sites more distant from the crater, where tephra and lahar deposits also impacted the landscape.

Blown-down forests resulting from storms

While a lateral volcanic eruption is unusual, other natural



Fig. 2.1. Aerial view of the blast zone, showing the 170° arc of the blast. Scorch and blown-down forests can be seen in the foreground. Abundant clear-cuts and the Muddy River Lahar are also prominent (July 30, 1980, from a commercial airplane).

forces create massive swaths of jumbled forest remnants. For example, hurricanes devastate coastal areas, flattening forests, leaving behind impenetrable thickets. While damage decreases from the coast, it increases with the stature of the forest. Stems are broken and trees are uprooted. Topography can protect parts of the forest, to form a mosaic of damage. Hurricane Katrina (2005) killed 320 million trees along 5 million coastal acres. The decaying forest pumped as much carbon into the air as was absorbed by all U.S. forests that year. Forests can recover from hurricanes in many ways, including crown sprouting, so that the secondary succession is relatively rapid.

An intense windstorm in 1997 toppled a swath of forest in northwest Colorado. Salvage logging led to a barren weed-infested and eroded landscape. This management practice produced more damage by killing many seedlings that had survived the windstorm. The naturally recovering blown-down forest was more diverse and recovery quicker than the areas from which logs were removed. In general, when forests are toppled by storms, natural recovery is rapid. The soil remains intact and most understory species survive, as do smaller individuals of the dominant species. We know much about recovery from such disturbances, primarily because they are related to commercial forestry.

Historical directed blasts

In 1914 (Taisho 3), Japanese scientists on the island of Kyushu warned that another eruption of the chronically restive volcano Sakurajima (Cherry Blossom Island) would occur, but that it was safe to remain on the island. People living on the slopes, attending to folk wisdom and recent memory, thought otherwise and fled. Others left

after earthquakes killed many people. The subsequent pyroclastic flows, lahars and lava flows were concentrated to the east, and killed those who did remain. The massive lava flow bridged the gap to the mainland, which is why this “island” is today a peninsula. Today, there is a monument to the fallen that admonishes, in part, “*Do not trust scientists*”. I hope that after 100 years or so, volcanologists have learned enough to issue reliable warnings.

The directed blast on Bezymianny volcano was uncannily similar to that of Mount St. Helens; a bulge formed on the southeastern slope, then 0.5 km³ of the cone collapsed, unleashing a debris avalanche, a directed blast and then pyroclastic flows. The blown-down zone extended up to 25 km. A classic Plinian eruption ensued. The debris avalanche and the blast covered an area similar to that of Mount St. Helens, about 500 km². A new dome started to develop within the crater soon thereafter. However, virtually no biological work has occurred owing to the extreme isolation, among other reasons. When I visited the region in 1999, it remained accessible only by helicopter.

In 1995, the Soufrière (French = sulfur outlet) Hills volcano on Montserrat produced a small lateral blast, several lahars and intense pyroclastic flows. This volcano remains active and dangerous; understandably, little ecological work has occurred. The town of Plymouth was evacuated in response to accurate forecasts before it was destroyed by pyroclastic flows and the directed blast. While several deaths occurred from the multiple events, greater understanding of the potential danger from such volcanoes proved invaluable. Therefore, while directed blasts are unusual, they do recur sporadically. Remarkable, only that of Mount St. Helens has been studied intensively from the biological perspective.

Importance of the blown-down zone

Large-scale blow down events inform succession theory (Lindemann and Baker, 2001). The impact of the blast was felt differently by different species and by different size classes. Most large trees were killed, but young ones, often of different species survived and quickly grew. Thus, the recovered forest often has different dominants than the previous one. The timing of the event relative to the growing season influences recovery patterns because timing determines which species and which life stages are vulnerable. Local environmental conditions are often altered. Species adapted to open habitats, with rapid growth, gain the establishment advantage over forest understory species. Many animals survive such events and

are crucial to forest community recovery, for example as dispersal agents and by churning up soil. Birds and some mammals import seeds of species destroyed by the event.



Fig. 2.2. Scorch zone, demonstrating the characteristic russet color of dead conifer needles (September 8, 1980).

Burrowing animals create disturbances that promote seedling establishment by forming empty spaces, mixing soil and bringing nutrients to the surface.

Blown-down and seared zones on Mount St. Helens

The blast zone has three regions. Within 10 km of the crater, most vestiges of vegetation were removed (tree removal zone; see Chapter 4). More distant, trees were killed, but snow protected understory vegetation in localized patches. This outer part of the blast zone includes two regions dominated by forest remains: the blown-



Fig. 2.3. Standing dead zone along FR-99. A. Standing dead and toppled trees with slide alder and grasses (July 30, 2004); B. After 31 years, many stems have toppled as the standing dead zone is being transformed into a zone where the fallen stems are gradually incorporated into the soil (August 15, 2011).

down zone and the seared zone of standing dead trees. Outer boundary of the blast zone is irregular, responding to topographic factors. The seared zone, however, has a surprisingly regular width to form the transition between toppled trees and the tephra fall zone. The seared zone occupies about 110 km² of forest where the force of the blast neither toppled most trees nor even removed the leaves, but the heat of the blast killed needles and buds (Fig. 2.2). These dead needles soon turned russet, but



Fig. 2.4. Ryan Lake was devastated by the blast: Top. Surrounded by toppled trees and dense covering of tephra (July 8, 1980); Bottom. Scattered forbs are pushing through the ash, aided by summer rains. Note the elk tracks in mud (August 20, 1980).

could persist for several years. Dead standing snags persist in many places to the present although many have since fallen (Fig. 2.3). This landscape can be eerie, so much so that it was used in the 2009 film *The Road*, a story set in a “post-apocalyptic” America (see Sidebar 2.1).

The blown-down zone is closer to the crater and occupies about 370 km². It is characterized, logically enough, by the many thousands of trees that were snapped off within 10 m of the surface or that were uprooted (Fig. 2.4). When viewed from the air, they can look like so

many pick-up sticks somehow forming regular patterns on the ground.

Sidebar 2.1. The Road

During the summer of 2008, traffic along the FR-99 was blocked beyond Bear Creek Lookout by a landslide that collapsed half of the road for several hundred meters. Although the road was passable, the public was excluded by a locked gate. We had permission to enter, and that was a lonely summer. On our last trip, we were shocked to find a large tent pitched just off the road. Later that day, we met the location manager for a film crew shooting a movie. She said the movie was “a post-apocalyptic tale of a man and his son trying to survive by any means possible,” based on Cormac McCarthy’s novel. Her crew and star Viggo Mortensen were there, but they were just filming “atmosphere.” We went about our business. That evening, we were slowly driving up the narrow “Trail of Terror” (see Sidebar 8.1) when a guy flagged us down and asked us politely to find a turn out. Such things scarcely exist on this extension of FR-99, but, as if by magic, one appeared. As we waited, we were dumbfounded to see two (!) large boom trucks, lumbering slowly down towards the Pumice Plain. In places, they had less than 10 cm clearance. They must have made it back because I recognized a few landscapes in the movie. The young women in my group that year could talk of nothing except about seeing Viggo at the commissary tent. The young men, and me too, lamented that the co-star, Charlize Theron, was not there.



Fig. 2.5. Clearwater blown down zone: Fireweed dominates the immediate plant response to the blast in the (August 20, 1980).

Owing to protection offered by distance, topography and snow, many plants and animals survived (Means et al. 1982). Tree saplings survived to begin the recovery as soon as snow melted. Along the Clearwater Drainage, where logging had been rampant, there was a readily visible transition from blown-down to an intact forest (Fig. 2.5). Here, weeds were abundant prior to the eruption, and the recovering vegetation to be dominated by fireweed.

The distance from the crater to the edge of the blown-down zone varied with topography. The force of the blast was attenuated to the east and west of the main direction of the blast. Thus, on Pine Creek Ridge, on the eastern blast boundary, trees died, but remained standing, and the snow protected a lush understory. In August 1981, Cascade lupines and bear grass formed a dense understory that protected the slopes from further erosion (Fig. 2.6).



Fig. 2.6. Near the eastern boundary of the blast, on Pine Creek Ridge, trees were killed, but the understory of Cascade lupine, bear grass and sedges recovered quickly (August 12, 1981).

Today, the standing dead forest is starting to topple as supporting roots rot and can no longer support the boles. However, downed trees of the blown-down zone still remain visible but somewhat obscured by understory vegetation and soil development. They are gradually being buried by soil build up, by compression from winter snow



Fig. 2.7. Near Norway Pass, the forest is in recovery; downed trees provide erosion control and habitat for a variety of plants, mammals, birds and insects (August 16, 2011).

and by deterioration from relentless wet-dry cycles. As they decay, they make great nurse logs. Seedlings of many species can establish their claim while mosses form a dense seedbed. Although dead, they continue to perform valuable ecosystem services and retard erosion. The recovering forest is now luxuriant jumble of forest understory species, sun-adapted pioneer species such as fireweed and growing saplings that survived the eruption (Fig. 2.7).

Little was known about vegetation recovery from directed volcanic blasts until the eruption of Mount St. Helens. The lateral blast created impacts on the forest that decreased with distance. These impacts are superimposed on existing topographic heterogeneity, variable species composition and variable snowpack during the eruption, so every site is unique. Topography and variable snow depths added complexity to the pattern.

South facing slopes in this region are generally expected to recover from disturbances more slowly than north facing ones due to greater drought and exposure to wind. On Mount St. Helens, they were also fully exposed to the blast and had the least snow to protect the ground layer vegetation. These sites remain impoverished (Fig.



Fig. 2.8. Exposed sites remain dry much of the summer, stunting recovery (August 17, 2011).

2.8). Nearby, on north facing slopes, deep snow offered more protection and the blast was less intense. Small saplings and most understory species survived, so that these sites have developed quickly (Fig. 2.9). Of course, after the blast, most sites also received deep tephra deposits (see Chapter 1). Wind and water erosion was crucial to expose the original surfaces, promoting recovery. The many recovery patterns have helped ecologists understand the relative importance of recovery mechanisms.

Many plants and animals survived the eruption in the

blown-down and seared zones; many more soon returned. While most trees died, saplings covered with snow often survived. If they occupied steep, north-facing slopes, their survival odds were good. Similarly, many species of shrubs and the ground layer survived, at least in sites protected by snow or topography. Surviving mammals were generally small species such as deer mice, chipmunks, shrews, moles, voles, pocket gophers and ground squirrels. These mammals persisted in ground burrows and occasionally in tree hollows. Amphibians survived near lakes; and many insects survived. Large animals, including deer, elk, mountain goats, bears and mountain lions perished, as did most mid-sized mammals (e.g., coyote and beaver). Because understory vegetation persisted in this zone, most of these species, as well as birds, soon returned (Crisafulli et al. 2005a).

The general pattern of recovery in the blown-down and seared areas was evident in the earliest studies (e.g., McGee et al. 1987). Understory cover was about 3% where a snow pack had existed during the eruption and barely measurable in sites on warmer slopes and at lower elevations. Typically, plots had eight species compared to two in snow-free sites. Recovery was more rapid at increasing distances from the crater where tephra deposits

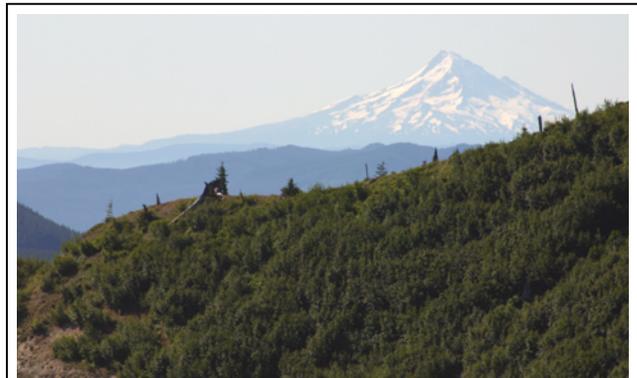


Fig. 2.9. Rapid recovery of saplings and understory vegetation was common on protected, north facing slopes such as this slope above Bean Creek (August 16, 2011).

were thinner. Herbaceous vegetation in riparian zones recovered quickly because most plants were dormant and tephra was rapidly rinsed from the creek margins.

I established line of ten plots up a ridge that divides the two forks of the Toutle River. The goal was to describe recovery up the slope and to other sites. Monitoring continued from 1981 to 1997, after which time it was abandoned due to logistical constraints that included road washouts. The plots ranged in elevation from 1280 m to

1430 m on this northwest-facing ridge. At these elevations, existing forest was sparse, and after the eruption only denuded saplings persisted. A few larger trees were smashed to the ground (Fig. 2.10). Much of the soil was blasted away slowing the early plant response. However, some soil was retained and a few species with strong rhizome systems persisted. Richness declined with elevation (Fig. 2.11A). Cover percentage was low after two years in all plots, then gradually increased. By 1997, cover had stabilized in all plots, and, like richness, decreased with elevation (Fig. 2.11B).

Species composition changed little over time and even though plots were widely separated in space, their species composition was becoming more similar to each other (Fig. 2.12). At first, each plot had different surviving species. By 1997, species composition, if not cover, appeared to have stabilized. At this time, the vegetation cover percentage declined with elevation from 33% to 14%, while richness declined from 26 to 11 species per plot. Composition was similar along the transect and was dominated by bentgrass, prairie lupine, desert parsley, yarrow, pussypaws and beardtongue. The lower elevation plots had many species that did not extend up the slope, including pinemat manzanita, Cascade aster, dunhead sedge and strawberry. Mosses were rare and did not appear until 1994.

This small study suggested that recovery from the blast can be rapid when there are survivors. Despite removal of the sparse canopy, much soil remained and the many species adapted to open conditions could recover. However, the intensity of the blast, compared to that in forested zones to the north, meant that it will take many decades for this vegetation to fully develop.

Ecological effects in blown-down areas

Effects of downed trees. The blown-down zone occupies an extremely rugged landscape. Toppled trees provided two post-eruption benefits to the recovering biota. First, downed trees reduced erosion significantly by allowing more water to infiltrate the fine-textured tephra surface. Second, they provided stable habitats that protected plants emerging through the tephra and allowed seeds to become established. Trees that died slowly gradually dropped their leaves to provide surface organic matter. Erosion during the first several years often uncovered buried surfaces and allowed regeneration of surviving plants. Willows and many perennial herbs dominated recovery wherever tephra had been removed (Swanson and Major 2005). Recovering vegetation was concentrated in gullies created by erosion. In contrast, erosion in the seared zone was substantially reduced compared to the

blown-down zone. Litter (primarily dead leaves that fell during the summer) formed a protective barrier against rain and tephra deposits were thinner and conformed to



Fig. 2.10. Lower Toutle Ridge on the transition from blast zone to blown down zone. Site was on the west edge of the blast, but within 2 km of the crater. Conifers were young and flexible, so most resisted the blast, but their needles and branches were stripped. Snow cover was limited; so much of the understory was also removed (August 10, 1981).

the undulating topography of the ground.

Effects of snow. Halpern et al. (1990) studied blown-down clear-cut sites. Snow covered and snow-free sites were compared in each. Blown-down forests with a snow cover during the eruption had the most vegetative cover while the clear-cut areas had the least. Perennial forbs dominated in the blown-down forests where no snow was present during the eruption, while similar sites with a snow cover were floristically and structurally more diverse. All sites had been invaded by fireweed from the clear-cuts and by grasses sown by the U.S. Soil Conservation Service. These exotic species dominated the clear-cut and were common in the other sites except where snow helped to retain a cohesive understory. Here, understory species re-sprouted. The floristic development in each habitat was distinctive. Because of the invasion by pioneer species, blown-down sites were becoming floristically more like the clear-cuts.

The early recovery rate of these forests was slower than what typically occurs on landslides and clear-cuts followed by burning in this region. Widespread clear-cuts provided a lavish source of weeds, thus altering trajectories. Because colonists affect development in many ways, it is unlikely that these forests will come to resemble their pre-eruption characteristics. The deposition of up to 50 cm of ash also inhibited the recovery of many ground-layer species, but the survival of gophers in some of the

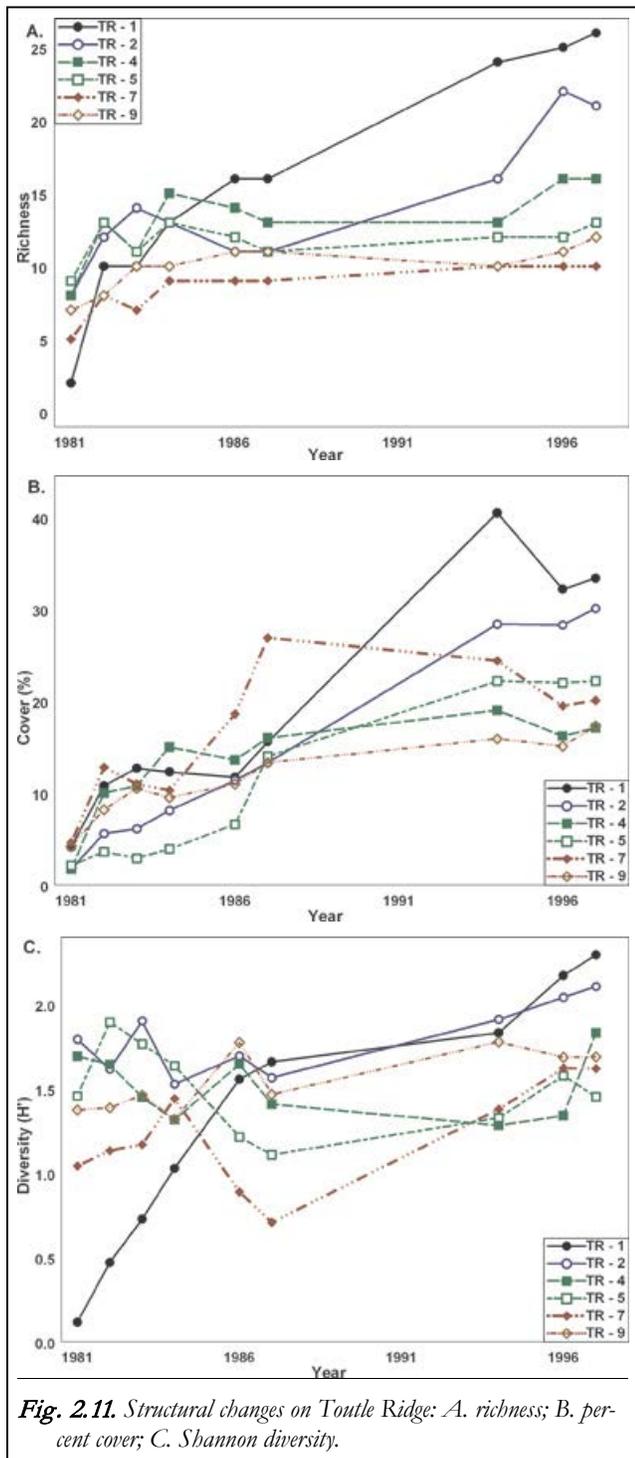


Fig. 2.11. Structural changes on Toutle Ridge: *A.* richness; *B.* percent cover; *C.* Shannon diversity.

area caused the tephra layer to be disrupted, redistributed nutrients and facilitated mycorrhizal infections (Allen et al. 1992). Water penetrated into the soil more readily, reducing erosion, and roots were exposed to more oxygen. Elk also improved soil conditions by churning up soil, but

browsing and trampling by these brutes may have retarded vegetation development.

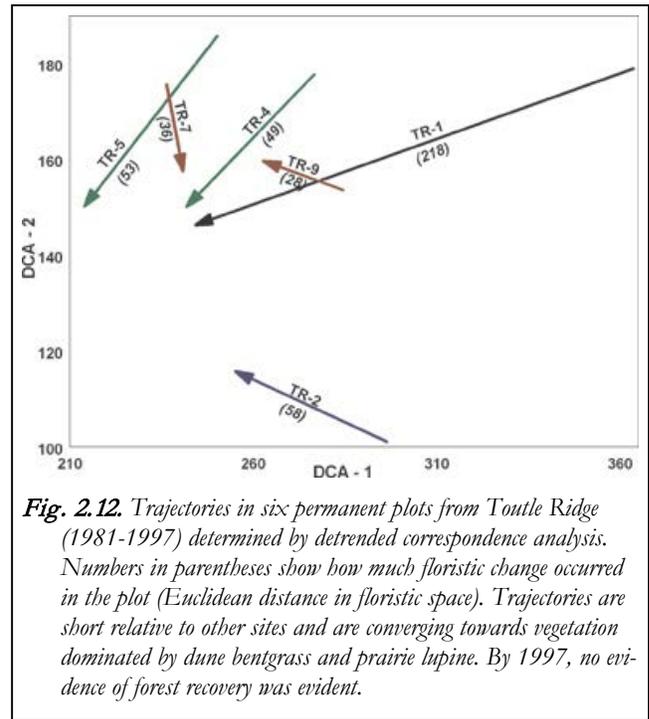


Fig. 2.12. Trajectories in six permanent plots from Toutle Ridge (1981-1997) determined by detrended correspondence analysis. Numbers in parentheses show how much floristic change occurred in the plot (Euclidean distance in floristic space). Trajectories are short relative to other sites and are converging towards vegetation dominated by dune bentgrass and prairie lupine. By 1997, no evidence of forest recovery was evident.

Snow deposition patterns were crucial in determining early recovery. This reinforced the idea that chance plays a large role in subsequent recovery. A late summer eruption would have been far more devastating and recovery would have been much slower. While there was convergence due to the initial abundance of pioneer species in each habitat, these forests began to diverge from clear-cut areas as trees began to mature. Forest recovery, in terms of cover development, was more rapid where deep snow protected small tree shrubs and herbs. It was slowest in clear-cuts because plant survival was limited. The seared zone and snow-free blown-down sites appear to have recovered at about the same rate.

The importance of downed logs. Even after trees are toppled, they still provide important ecosystem services (Fig. 2.13). Studies reported by Swanson and Major (2005) confirmed that toppled trees reduced runoff and permitted infiltration, both phenomena inhibiting erosion and siltation. Logs also provided havens for many plant and animal species. In clear-cuts, or where the trees withstood the blast, erosion of the tephra deposits was intense. Gullies formed which eventually became streams lined by willows and other wetland shrubs. However, as with windstorms, the sudden appearance of huge volumes of wood on the ground was irresistible to commercial interests. Removal of downed logs, followed by replanting with one



Fig. 2.13. Nurse effects from destroyed trees have lasted decades. Here, on an exposed ridge, the remnant of a subalpine fir provides protection, enhance fertility and greater moisture for invading species that include slide alder, paintbrush, wood rush, waterleaf and various grasses.

species of conifer, was authorized and quickly accomplished, leaving replanted sites open to substantial erosion. The importance of downed timber to overall ecosystem development extends well beyond erosion control. Titus and Householder (2007) compared a blown-down forest near Meta Lake with an adjacent area that had been salvage logged during 1981 and 1982. All forests had been covered by old trees before the eruption and all sites had received 30 cm of tephra after the blast. The salvage-logged area was replanted with Noble fir between 1982 and 1984. The salvaged area had 75% as much litter, 20% as much woody debris and but few snags. The understory included 2.5 times as much bare soil and only 50% as much plant cover. Species richness of the salvaged area understory was 50% unsalvaged site and significantly diversity was much lower. Although the sites had similar environments, the composition of the ground layers was distinct. Salvaged sites had more species characteristic of dry sites (e.g., alpine buckwheat) while unsalvaged sites were characterized by ferns, dwarf bramble, woodrush, mountain ash and mosses, all species found in moist sites. Weeds were more abundant in the salvaged area. Unsalvaged sites lacked noble firs, suggesting that the planting choice was inappropriate. There was, instead, a diversity of conifers and broadleaf trees at low density, eventually capable of supporting a more diverse fauna. Only the planted noble fir was abundant in the planted area, but after 20 years, the plantations remained open, with less than 25% tree cover. This may reflect the substantially lower soil fertility found in salvaged sites. Succession was substantially retarded and ecosystem values had been compromised in the salvage logged sites. These replanted

sites did not provide biodiversity refuges, a fact that should be considered when clear-cut areas are replanted.

See the blown-down and standing dead forests:

The best-developed blown-down and scorched sites are concentrated to the north and northeast of the crater. Many examples may be seen along FR-99 road, or along short walks leading from this road. You may also approach the blast zone from the north, via FR-26. You should use a recent map to the National Volcanic Monument and check on-line for current road and trail conditions. Landslides and road washouts are common.

Good locations for the blown-down zone include:

Meta Lake: Located near FR-99 near its junction with FR-26. A short paved interpretive trail is situated in dense vegetation recovering from the blast that blew down many trees in this vicinity.

Ryan Lake: Located along FR-26 at the northern extension of the blown-down forest with the remains of scorched forests nearby. Short interpretive loop trail provides vistas of standing dead, blown-down forest and the crater. Old tephra layers are visible in cuts along the trail.

Norway Pass: Located 1.2 miles north of the junction of FR-25 and FR-99, you reach the trailhead and views of blown-down and scorched vegetation. Take the Boundary Trail #1, which connects to Trail #227A. You will have vistas of Spirit Lake and the cone.

FR-99: Several locations, including Independence Pass, Harmony, Donnybrook, Smith Creek Picnic area (where the effects of pre-eruption logging remain evident) and Windy Ridge, all provide views of the recovering blown down zone. You can also see out to the Pumice Plain. East of FR-99, sites near Independence Pass, along Bean Creek and Clear Water Creek all show replanted Nobel firs in sites from which logs were salvaged.

SR-504: There are many excellent views of the blown-down zone (as well as other features) to be seen along the road. You may find interpretive help from the Science Center at Coldwater, the Johnson Ridge Observatory and Loowit Viewpoint,

Sidebar 2.2. *It takes a cab-full to survive the 99*

FR-99, or the 99 road as we called it, was paved to MP 10, then oiled gravel to Windy Ridge, then gravel down to the Truman Trail. Going up the road early one August morning in 1983 meant we were free from all the tourists in their cavernous RVs. In those days, the U.S. Army Corps of Engineers was building the tunnel to drawdown Spirit Lake, so oil for generators was trucked in, and empty trucks barreled out. Salvage logging had recently been authorized and several logging companies were at the height of removing blown down trees outside the monument. Logging trucks and the occasional oil tanker used the early morning, tourist-free time to career down the 99 road, the loggers trying to make two salvage runs in a day. Our little white pickup truck would stand no chance if we met one of them on a curve. Those were the days of CB radio and we were assigned the emergency channel. Dave Wood had the wheel; Chris Clampitt kept a sharp vigil up the road from the shotgun seat and I watched the odometer and called out our position on the CB (“White pickup at mile 2”). It was foggy this particular early July morning and very quiet. No one responded to my calls, thankfully. “...white pickup passing mile 2.5.” Still no responses and no trucks. I began to think that the egress of trucks had ended for the day. “White pickup at mile 3” and immediately: “LOGGER AT MILE 3, PULL THE *%#& OVER”! Chris seconded the command and Dave miraculously, simultaneously, swerved onto the providentially present shoulder and slammed to a stop as the fully loaded log truck careened around the hairpin turn and missed us...barely. Several minutes later, my BP down to manageable levels, the blood back into my face, and each of our hearts back in its rightful place, we took off again. “White pickup at mile 3.5.” I miss those old CB radios.

Summary

Even where vegetation was not obliterated, the directed blast provided an impacts ranging from sites where trees were flattened and soil removed to places where trees were killed by the heat, but remained standing while keeping their dead foliage. The understories of these sites have recovered to various degrees. Because many species survived the blast, recovery was relatively quick and the degree of floristic change small compared to other impact types. The presence of downed logs in the blown-down zone provided habitat to facilitate the recovery of a wide range of species. Nearby sites in the blown-down zone from which logs were removed were less diverse and