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Biological Legacies: A Critical Management Concept from Mount St. Helens

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Introduction

Studies of early successional recovery of communities following catastrophic disturbance generally give little attention to influences of the pre-disturbance ecosystem. For example, the role of migration or reinvasion of organisms is typically emphasized while surviving organisms are largely ignored.

Increasingly, disturbances are recognized as ''editing'' processes which, however, leave behind varying levels of organisms, structures and patterns. These biotically derived legacies from the predisturbance ecosystem can have important influences on the paths and rates of succession. Further, since there is a continuum of disturbance intensities, similar gradients exist in these legacies.

As defined here, biological legacies refer to: living organisms that survive a catastrophe; organic debris, particularly the large organically-derived structures; and biotically derived patterns in soils and understories. The living legacies may take a variety of forms, including intact plants and animals, perenating structures (e.g., rhizomes) and dormant spores and seeds. Important biotically-derived structures include dead trees (snags) and down logs, large soil aggregates and dense mats of fungal hyphae. These structures are increasingly appreciated for their role in ecosystem functioning, such as the importance of large woody structures as animal habitat (Harmon et al. 1986, Maser et al. 1988). Pattern legacies include those created in soil properties—chemical, physical, and microbiological—through the action of plants and their litter, and patterns in understory vegetation associated with variations in canopy light conditions.

In this paper, I outline the role that the 1980 eruption of Mount St. Helens played in the rediscovery of the importance of biological legacies in ecosystem recovery. The research conducted there provided clear evidence of the importance of both living and dead organic legacies following natural catastrophe. It stimulated a re-examination of the recovery processes following other natural catastrophes, including wildfire and windstorm, and a comparison with recovery following human disturbances, particularly clearcutting. The recognized importance of biological legacies in ensuring rapid redevelopment of compositionally and structurally diverse ecosystems is being strongly reflected in the development of management systems for natural resources with improved abilities to maintain ecological values.

Recovery in the Mount St. Helens Ecosystem

The eruption of Mount St. Helens on May 18, 1980 devastated more than 125,000 acres (50,000 ha) of mountainous forest lands and associated streams and lakes in the southern Washington Cascade Range (Franklin et al. 1985, 1988). Ashfall covered a much larger area. The 1980 eruption was, in fact, a complex series of events with multiple and varied impacts. Major volcanic habitats created within the blast zone by the eruption included debris avalanche, pyroclastic flows, lahars or mudflows, blast-downed forest and scorched forests. Environmental conditions, such as nutrients and moisture, and levels of biological legacies varied widely across this spectrum of habitats.

Mechanisms by which living organisms survived were highly varied (Franklin et al. 1985). Vascular plants most commonly survived by having reproductive structures, such as buds, in protected locations beneath the ground surface. Vertebrate and invertebrate animals also survived the eruption below ground. Deposits of ash were typically sufficiently thin and friable that many plant shoots could penetrate them and animals could free themselves from their burial. Conditions for surviving animals varied from moderately favorable to poor depending upon food availability, susceptibility to abrasive effects of the ash and tolerance of environmental extremes.

Ten years later levels of recovery are highly variable throughout the devastated zone (Franklin et al. 1988). The most important variable in recovery has been the level of biological legacies. Most of the other important variables—type of volcanic disturbance, type of pre-eruption ecosystem, snow conditions at the time of eruption, and post-disturbance erosion—have affected recovery primarily through their influence on numbers and kinds of surviving organisms and levels of organic debris.

The type and intensity of volcanic disturbance(s) at a given location were important variables that affected survivors and subsequent recovery processes. Most of the devastated zone was subjected to the blast and to ash fall. Such sites had survivor levels that largely reflected the pre-eruption community. For example, the legacy of large organic debris was very abundant on sites of blast-downed forest and included large numbers and volumes of logs and, in some cases, snags. Significant numbers of herbs, shrubs and fossorial animals also survived on these habitats. Areas subjected to pyroclastic flows, which were deposited at temperatures of up to 850°C, had almost no biological legacy of either living or dead material. The occurrence of live surviving plants on the debris avalanche was limited to transported plants or parts of plants (e.g., a piece of rootstock) that came to rest on the surface of the flow: the debris avalanche deposits were far too deep to allow buried organisms to emerge. The biological legacy on lahars was highly variable with locale, but did include viable plants and organic debris carried along with the lahar and plants that survived inundation or coating by the flow.

The type of pre-eruption ecosystem has had a significant influence on path and rate of recovery over much of the devastated zone. Areas clearcut prior to the eruption generally recovered more rapidly than adjacent areas of forests blown down by the blast. This is because clearcuts were generally dominated by communities composed of species such as fireweed (*Epilobium angustifolium*), thistle (*Cirsium* spp.) and pearly everlasting (*Anaphilis margaritaceae*). These were essentially preadapted weedy communities that vigorously sprouted after their aerial parts were destroyed. Herb and shrub species in the old-growth forests were generally not as well adapted to disturbances and the penetration of ash layers; surviving plants of these species were most often found on steep surfaces of root wads of windthrows.

Presence of snow was another important contributor to distinctive and rapid patterns of vegetative recovery. A patchy spring snowpack was still present at middle elevations and was continuous at high elevations at the time of the eruption. Plants or parts of plants enclosed within the snowpack were protected from the effects of the blast. Furthermore, the ash layers were disrupted and wetted by the melting snowpack; this facilitated penetration by fragile species. As a consequence, many high-elevation meadow communities appeared to have survived the eruption almost completely intact. Another important effect of the snowpack was survival of seedlings and saplings of coniferous tree species, such as mountain and western hemlocks (*Tsuga mertensiana* and *Heterophylla*) and Pacific silver fir (*Abies amabilis*). Because the native conifers are incapable of sprouting, conifers would have been eliminated throughout the devastated zone without the protection of snowpacks.

Erosion of ash and other sediment is the most important posteruption variable affecting recovery and, again, it has operated primarily through its influence on levels of biological legacies, particularly on the number of surviving plants. Generally, erosion of the ash mantle to the surface of the old soil has favored greater numbers and growth rates of surviving plants. Erosion freed plants from the mechanical impediment of burial. Deposition of additional sediment by landsliding, fluvial and volcanic processes has, on the other hand, strongly retarded vegetative recovery.

Management Application of Biological Legacies

One of the surprising lessons from Mount St. Helens was the importance of biological legacies—surviving organisms and organic debris—in the process of ecosystem recovery. The abundance of plant and animal survivors and their early importance were unexpected given the lunar appearance of the landscape immediately following the eruption.

This experience stimulated ecosystem scientists in the Pacific Northwest to look again at the processes of ecosystem recovery after other catastrophic disturbances, including clearcut logging. It was immediately apparent that, while most natural catastrophes, such as wildfire and windstorm, typically convert many trees from living to snags and down logs, very little organic material is actually removed (*see*, e.g., Spies et al. 1988, Maser et al. 1988). Furthermore, many of the plant and animal species found in the forest survive; this often includes mature specimens of the tree species. The result is that recovering ecosystems receive very large legacies of both living organisms and organic structures; compositional and structural diversity is, therefore, often high even in young natural forests.

Biological legacies are typically much lower following clearcut logging of forests. While many of the original plant species may survive, the level of living legacies is strongly and negatively influenced by the intensity of the management practices (*see*, e.g., Halpern 1988, 1989). Legacies of large organic structures, such as snags and down logs, are very drastically reduced under most current silvicultural practices, which include both harvest and slash disposal operations. The result is that the young forests that develop following traditional clearcut practices are typically much simpler in composition and structure than those which develop following natural disturbances.

The lesson of biological legacies is proving to have major relevance to development of forest management systems which attempt to better integrate ecological values, including wildlife, and commodity production (Franklin et al. 1986, 1989). These approaches are sometimes referred to as "New Forestry." Structural diversity is particularly important to a variety of forest functions, including provision of wildlife habitat. Therefore, silvicultural systems are being designed that provide for higher levels of structural diversity at all stages in managed forest stands. Some specific practices include provision for a continuous supply of large snags and down logs, development of compositionally and structurally diverse managed stands and maintanence of large green trees on cutover areas by substituting partial cutting practices for clearcutting.

Biological legacies is a concept with broad relevance to the management of ecosystems for higher levels of genetic and structural diversity. It is obviously applicable to commodity forests and rangelands where harvest or other management techniques may reduce diversity. It is also a useful concept in considering management objectives and techniques in natural landscapes, such as National Parks and Wilderness.

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