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Response and Recovery of Lakes
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18.1 Introduction

The 1980 eruption of Mount St. Helens devastated vast forestlands, triggered massive landslides and mudflows, and emplaced timber and volcanic debris in nearby lakes. Tephra and pyrolyzed forest debris rained down on dozens of subalpine, oligotrophic lakes scattered across a fan-shaped area affected by the lateral blast of the May eruption. This blast area, which encompasses the debris-avalanche, pyroclastic-flow, blowdown, and scorch zones, covers roughly 570 km$^2$ north of the volcano. An additional, extensive zone northeast of the blast area received tephra fall.

Runoff from melting glaciers and snowfields on the flanks of the volcano generated enormous mudflows. Quickly gathering momentum, the debris surged into river valleys radiating out from the volcano’s base. The massive debris avalanche that swept down the North Fork of the Toutle River blocked tributary streams on either side of the river with an estimated 2.5 km$^3$ of water-saturated sediment. Dammed at their confluence with the main stem of the river, tributary valleys began to fill with water and formed new lakes. Some of these were small ponds that eventually disappeared; others persisted. But two of the lakes, named Coldwater and Castle, became prominent, established bodies of water in less than a year.

At Spirit Lake, the debris-avalanche deposit blocked the lake’s only outlet, the North Fork Toutle River. The lake was thereafter impounded in a closed, hydrologically unstable basin by a debris dam 150 to nearly 200 m thick. To stabilize the lake and to prevent it from breaching or overtopping the dam, water was artificially withdrawn and discharged downstream, first by pumping and later through a newly constructed tunnel 2600 m long (U.S. Army Corps of Engineers 1987).

Four major factors determined the extent of limnological disturbance:

- Location of the lakes relative to the trajectory of blast materials;
- Abundance of terrestrial organic matter deposited in lakes;
- Emplacement and alteration of mineral deposits; and
- Subsequent in-lake biogeochemical processes

(Wissmar et al. 1982a). Although most lakes inside the blast area were abruptly and substantially altered, some were affected much less, especially those that were shielded from the brunt of the eruption by ice cover or intervening ridges. The few lakes located outside the blast area along the south and west slopes of the volcano all received tephra fall of 5 to 25 cm.

The eruption provided a rare opportunity to study lake response and recovery in the wake of volcanic disturbance. Scientists predicted that recovery (broadly defined as the return to preruption chemical and biological conditions) would require up to 20 years (Wissmar et al. 1982a,b). Information about lake response and recovery in other volcanically impacted regions was scarce, consisting largely of posteruption studies of Lake Asabatchye on Russia’s Kamchatka Peninsula (Kurenkov 1966) and of several lakes in southwestern Alaska (Eicher and Rounsefell 1957). But these studies, limited in scope and duration, were of little help in reliably predicting the recovery of lakes at Mount St. Helens.

Our objectives were threefold:

- To characterize the initial posteruption limnology of lakes within and outside the blast zone;
- From this baseline, to track lake response and recovery over several years; and
- To document the limnological development of the two newly created lakes, Coldwater and Castle, with emphasis on biological colonization.

This chapter reports our findings and addresses three important questions: (1) What was learned about the response of lakes to a large-scale, infrequent disturbance? (2) What factor(s) contributed most to lake recovery? And (3) what was learned about colonization of the new lakes?

We distinguish among four categories of lakes, as shown in Figure 18.1: (1) Spirit Lake, which received a variety of volcanic impacts, including lateral blast, debris avalanche, pyroclastic flows, and tephra fall; (2) the newly created lakes,
Coldwater and Castle; (3) lakes in the tree-blowdown zone and along the periphery of the scorch zone; and (4) lakes outside the blowdown and scorch zones that were barely affected morphologically, but periodically received tephra fall. Lakes in Category 3 (in the blowdown and scorch zones) include Boot, Fawn, Grizzly, Hanaford, Meta, Obscurity, Panhandle, Ryan, Shovel, Snow, St. Helens, and Venus. Category 4 lakes (Blue, June, McBride, and Merrill) were used as reference lakes because they received minimal volcanic impact.

18.2 Preeruption Limnology of Mount St. Helens Lakes

In 1980, Mount St. Helens was surrounded by 35 to 40 subalpine lakes of glacial, landslide, and volcanic origin. Lake-surface elevations ranged from 475 to 1500 m (above mean sea level, msl). Lakes at the higher elevations were ice covered 5 to 8 months of the year.

Preeruption limnological information for Mount St. Helens lakes is scarce (but see Bortleson et al. 1976; Dethier et al. 1980; Wissmar et al. 1982a; Crawford 1986). The data consist mostly of a few physical and chemical measurements. Information about phytoplankton, periphyton, other aquatic plants, zooplankton, and other aquatic invertebrates is almost nonexistent. Planktonic and benthic organisms in Spirit Lake in 1937 were described as “sparse”; dissolved oxygen concentrations at the surface and at 53 m were 6.7 and 7.4 mg l$^{-1}$, respectively; Secchi-disk transparency was 9.2 m; and surface pH was 6.8 (Crawford 1986). Size of lakes examined varied considerably, ranging from Elk Lake (area = 12 ha; maximum depth = 14 m) to Spirit Lake with an area of 530 ha and a maximum depth of 58 m when it was measured by Wolcott (1973).