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Lakeshore Restoration

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Lakes have a relatively long history of restoration work, and many restoration techniques have been developed over time. But as the papers in this section demonstrate, many basic restoration methods remain experimental. Methods remain experimental partly because results can be inconclusive or can vary from one site to another, and partly because new technology produces opportunities to experiment with new techniques that might improve upon older methods. The topics discussed in these papers also indicate that familiar lake quality problems remain central to restoration research: controlling eutrophication and water quality, shoreline erosion, and invasive species such as Eurasian water milfoil (*Myriophyllum spicatum*) are at the core of restoration discussions as they have been for decades. Because of the inextricable relationship of lake biota and water quality, biological and chemical/physical problems are often two sides of the same coin. A single lake restoration project might be approached from either angle. Controlling Eurasian water milfoil, for example, can be treated as a biotic problem (benthic and native species suffer from the milfoil growth), or as a water quality problem (milfoil expansions can indicate excessive phosphorus loading and result in eutrophication, turbidity, and oxygen depletion).

A perennial issue in lake restoration is nutrient loading. Nutrients from both urban and agricultural lands surrounding a lake can contribute to turbidity, eutrophication (excessive plant growth and raised water temperatures), and weed invasions. The ultimate remedy for nutrient loading is generally off-site control of nutrient production, that is, diverting or cleaning up runoff from yards, streets, and fields. Restoration must often be carried out on-site, however, because controlling on-shore land uses is difficult or impossible. On-site nutrient removal techniques include precipitation, dredging and harvesting. Phosphorus, the principal focus of nutrient control, can be precipitated out of the water column by adding alum or other materials that bond to available phosphorus ions. Sediments can then be dredged to remove nutrients (Klein). Principal problems of dredging include turbidity as sediments are stirred up, and finding suitable sites for on-shore disposal of nutrient-laden sediments, which can also be laced with toxic substances. Macrophyte harvesting can also remove phosphorus bound up in plant tissue. However the volume of phosphorus removed is usually minimal. Neither of these techniques introduces foreign substances, but both have only temporarily effects.

Innovative approaches such as iron complexing and biomanipulation are also being developed to control nutrient levels. Iron complexing is an experimental technique that could prove relatively effective and affordable. Powdered iron released in a lake bonds readily with phosphorus ions and precipitates out of the water column, increasing water clarity and reducing algae populations.

Initial tests suggest that iron complexing could provide relatively successful long-term benefits. Removing the iron- and nutrient-rich sediments raises restoration costs, but Melchior suggests that even with removal expenses iron complexing appears to be less expensive than herbicide treatments. Biomanipulation is another relatively new approach to controlling eutrophication in small, shallow lakes through increasing populations of algae-consuming plankton (Riedel-Lehrke). Biomanipulation was designed as an ecologically based alternative to standard nutrient management such as precipitation, which is ineffective in shallow lakes where biotic activity retains sediments in the water column, and stormwater diversion and sediment removal (dredging), which remove stressors but cannot restore lake water quality. Plankton populations can be enhanced by removing fish. Most often fish removal entails killing fish with rotenone or introducing fish predators or parasites. The success of zooplankton stocking is not well documented, especially in the long term. Initial successes appear promising but may not persist after several years. Riedel-Lehrke indicates that biomanipulation by itself may not be effective, but it might increase the success of other nutrient management methods.

Many lake restorations require handling multiple problems simultaneously. Shoreline restoration, for example, requires integrated erosion control and revegetation. Plants require erosion control to take root, but once established, vegetation helps reduce erosion by moderating wave and rainfall impact. Historically straw mulch, paper, and burlap were among the materials used to help control soil movement on recently seeded sites. Knapp reviews the strengths and weaknesses of a variety of mulches, meshes, blankets and mats, as well as structural features such as riprap and gabions. Combination materials such as pre-seeded blankets, pre-vegetated mats, and sprayed hydro-mulches containing a mix of seed, fertilizer, and stabilizing mulch, appear to be a promising method of establishing plants and controlling erosion simultaneously. Hardstem bulrush (*Scirpus acutus*) is specialized shoreline revegetation-stabilization problem reviewed by Shuttleworth. Hardstem bulrush normally takes advantage of seasonal drought to establish new stands on exposed mud flats, but artificially maintained water levels have reduced restoration opportunities in many lakes. This case demonstrates the importance of good site selection where other conditions may be beyond control: bulrush, for example, establishes best on gently sloping shorelines with protection from wind and waves. Shuttleworth also points out problems with acquiring propagules. Commercial bulrush rhizome sources, she notes, are often poor quality and have low survival rates. They are also often collected from natural sites, raising ethical issues of depleting an intact vegetative community in order to restore or create another.

Some restoration projects remain stubbornly difficult despite decades of work and research. A notorious case is Eurasion watermilfoil, which has aggressive colonization and growth patterns. In fact no successful removal has been documented to date (Melchior). As with water quality restorations, there are both mechanical and biotic approaches to controlling milfoil. Harvesting, lowering water levels to desiccate plants, and herbicide applications are all used regularly, but each of these methods has its drawbacks. Harvesting can encourage growth; water drawdown is only useful in reservoirs; and herbicides decimate native vegetation as well as milfoil. Introducing milfoil-eating weevils could be a cheaper and safer alternative, but in test cases it has been only marginally successful. Lake acidification is another intractable problem with only temporary on-site solutions as long as the stressor, air-borne nitrates and sulfates from industrial sources, remain. Liming, application of powdered calcium carbonate, has been used for more than 20 years in Europe and North America to reduce acidity and restore game fish populations. Temporary improvements have been demonstrated, but long-term restoration requires reducing industrial emissions (Lease).

In general, nutrient removal is often central to lake restoration because excess phosphorus levels contribute to both eutrophication and weed invasions. As in any restoration effort, understanding and mitigating the source of disturbance or stress is as important as any restoration effort. In many lake contexts the source of disturbance is partly or entirely nutrient-laden runoff. But because of institutional constraints most restorations appear to focus on on-site solutions. For each type of restoration problem there are both biotic and abiotic (mechanical or chemical) experimental solutions. In most cases a combination of techniques may be necessary, but combined efforts have received relatively little research attention.