

# ATMOSPHERIC NITROGEN DEPOSITION IN THE NORTH AMERICAN ROCKY MOUNTAINS

*Ecological change in remote, high-elevation lakes.*

**HIGH-ELEVATION LAKES** in the western U.S. are highly valued for their remarkable water clarity and trout fisheries. The watersheds of many of these lakes have experienced little land use change, and as a result, these lakes appear pristine. However, during the last century, rates of atmospheric nitrogen deposition have increased across the West, threatening the water quality, transparency, and biological integrity of these remote lakes. Although nitrogen deposition rates are lower in many parts of the western U.S. compared to the east, biological production in western high elevation lakes is limited by nitrogen. This renders them susceptible to the enrichment effects of N deposition, which increased biological production and reduces water clarity.

Early ecological effects of nitrogen deposition on western alpine lakes can be assessed using changes in diatom community structure. Diatoms are a class of microscopic algae that are sensitive to environmental changes and have cell walls that are frequently well preserved in lake sediments (Photo 1). Changes in diatom community composition provide early indications of ecological perturbations, whether by acidification, nutrient enrichment, or climate change. These changes can be understood through paleolimnological investigations coupled with experimental approaches.



Photo 1: The diatom *Asterionella formosa*.



**Research** in the Diatom Ecology Laboratory in the Climate Change Institute has demonstrated that, in fossil diatom assemblages spanning from 1700 to 2000 in the Greater Yellowstone Ecosystem, rapid changes occurred after 1980 (Saros et al. 2003; Saros et al. 2005; Figure 1). Results from nutrient enrichment experiments reveal that these rapid changes in diatoms are the result of nitrogen enrichment from atmospheric sources (Saros et al. 2005; Michel et al. 2006). Specifically, increases in two diatom species, *Asterionella formosa* and *Fragilaria crotonensis*, are used as indicators of nitrogen enrichment. These results were used to determine a critical load of nitrogen to high-elevation lakes. A critical load is defined as the threshold below which observable ecological effects do not occur.

Based on the fossil diatom records, a critical nitrogen deposition load of  $1.4 \text{ kg ha}^{-1} \text{ yr}^{-1}$  was determined for the Greater Yellowstone Ecosystem (Saros et al. 2010). With a current nitrogen deposition rate of  $1.8 \text{ kg ha}^{-1} \text{ yr}^{-1}$ , this ecosystem currently exceeds this critical load.

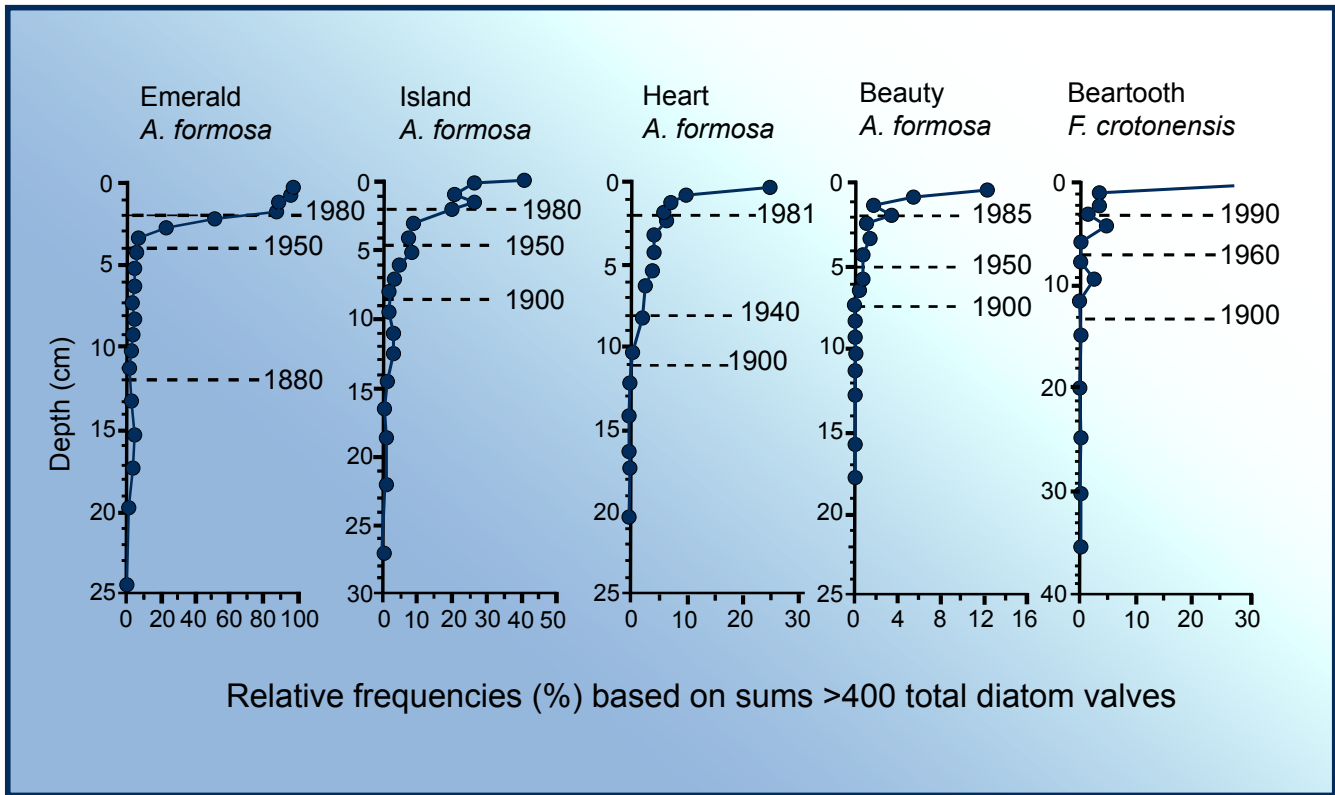


Figure 1. Changes in the relative abundances of key diatom species (*Asterionella formosa* and *Fragilaria crotonensis*) in lakes of the Greater Yellowstone Ecosystem over the past few centuries.

## Selected References

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