

Long Range Transport of Atmospheric Pollutants

Effects of "Acid Rain" on Lakes

By the mid 1970's, funding for the eutrophication studies at the ELA was declining. David Schindler realized that new initiatives were needed to fully utilize the capabilities of the ELA facility. Encouraged by Dr. Dick Beamish, who had recently completed thesis work on acidified lakes near Sudbury, Ontario, Dr. Schindler initiated in 1974 a research program to investigate the effects of acidification (acid rain) on lake ecosystems.

Lake 223 was selected as the site of the first whole-ecosystem experimental acidification study. Following two years of background monitoring and pilot studies, technicians began adding sulfuric acid (see photo) to Lake 223 in 1976.



A field technician adds acid to experimental Lake 223 to regulate the acidity of the lake water.

Additions were carefully planned and carried out to achieve predetermined target pH levels.

Results were monitored in detail.

The experimental design called for the lake to be gradually acidified over a period of years. Each year, a "target" pH (acidity level) was selected and sufficient acid added to maintain surface water acidity at, or near that target. By 1981, the pH had been reduced from the natural 6.7 to near 5.0. During this 5-year experimental period, major changes in the ecosystem were observed. Several key species, including Mysis shrimp, crayfish, and fathead minnows, disappeared entirely from the lake. The lake trout and white sucker populations began to experience reproductive failure. By 1981, many of the remaining adult lake trout were slowly starving (see photo).



**A starving lake trout captured in acidified Lake 223 when the pH was 5.1.
Most of the trout's food supply had been killed off by the acid.**

Even though the pH had never gone below 5.0, the lake's natural food chain was clearly disrupted and modified. Biodiversity had declined. It was obvious that the trout and suckers would disappear in a few years if something wasn't done.

The scientists decided, in 1984, to begin a controlled recovery phase, in which the amount of acid being added would be reduced to permit the pH to gradually increase (*ie.* the acidity to gradually decrease). Almost immediately, the lake ecosystem began to respond. The pH began to rise without addition of lime. The white suckers successfully reproduced and the adult trout were able to feed on the young suckers. The condition of the trout improved markedly (see photo). Soon, the trout as well were successfully reproducing.



**A healthy lake trout captured in recovering Lake 223 when the pH had risen back
above 5.4.
Young white suckers were again plentiful in the lake, serving as food for the trout.**

While the chemical conditions in the lake recovered spontaneously in response to reduced acid additions, the biological responses were not all as rapid. Some of the extirpated species returned to the lake, but many others, have not yet re-appeared. While conditions should now be favorable for them, it is not always easy for species to re-invade isolated lakes. The pH of the lake water has returned to normal and no acid has been added since 1994. The lake trout population has almost completely recovered,

but the slimy sculpin has not yet returned to the lake. We continue to monitor the biological recovery of the Lake 223 ecosystem.

Several other whole ecosystem acidification and recovery experiments were carried out at the ELA during the 1980's and 1990's. The largest of these was a double-basin experiment in Lake 302, in which one basin received additions of sulfuric acid while the other basin received approximately equivalent additions of nitric acid. Over a five-year period, the nitric acid proved to be about two-thirds as effective as the sulfuric acid as a lake acidifying agent. This demonstrated that nitric oxide emissions from automobiles and other sources can be potent sources of lake acidification.

The basin of Lake 302 receiving sulfuric acid was subsequently acidified to a pH of 4.5, a level several times more acidic than anything experienced in Lake 223. During this study, considerable attention was paid to the littoral community and the effects of acidification on the algae and other food chain components of this community.



Filamentous green algae growing from the stems of lily pads in acidified Lake 302. These masses of algae are commonly found in acidified lakes.

Among other results, the work on Lake 302 demonstrated that acidification has dramatic effects on the littoral community and that spontaneous recovery from acidification to pH 4.5 is much slower than it was from pH 5.0 in Lake 223. No acid has been added since 2001. Currently, the pH in Lake 302S has returned to pre-acidification levels, and the biota are gradually recovering. We continue to monitor this recovery.