Experimental Lakes Area

Protecting the Health of Canada's Lakes

Introduction

In the picturesque shield country of northwestern Ontario, midway between Kenora and Dryden, lies a unique facility. It has gained an international reputation as one of Canada's most innovative and successful commitments to freshwater research. This facility, the Experimental Lakes Area, or ELA, has served for more than thirty years as a natural laboratory. Scientists come here from around the world to study the lakes and streams, and their watersheds, and the effects of various pollutants or stressors on these living systems.

Operated by the Central and Arctic Region of Fisheries and Oceans Canada, the ELA was established by mutual agreement of the federal and provincial governments. The facility consists of 58 small lakes and their watersheds, and a year-round field station capable of accommodating up to 50 researchers. A broad range of government agencies, universities and private corporations participate in the research.

Bird's-eye view of an ELA lake showing the typical terrain of the Canadian Shield. Most ELA lakes remain in their natural state. Experimentally altered lakes must be returned to a natural condition.

Before the ELA program began in 1968, most evidence of the effects of pollutants on lakes, and especially the life they contain, came either from laboratory experiments or from monitoring lakes that had been polluted for many years. Laboratory experiments have major limitations. Most natural ecosystem interactions cannot be reproduced under lab conditions and living organisms often

do not behave naturally. Results cannot be applied confidently to whole ecosystems. Studies on long-polluted lakes are also open to question when little scientific information about the lakes is available for the period before pollution occurred. The true extent of damage cannot be assessed reliably. Often, several pollutants or stressors act together to damage an ecosystem. The effects of a single pollutant cannot be measured accurately.

The field station kitchen and dining hall. Full accommodations are provided for up to 50 researchers. More than $300 thousand are expended at local businesses each year.

The experimental studies at the ELA provide controlled measurements of the effects of various pollutants or stressors on aquatic ecosystems and on the organisms that live in them. These results can be used to plan ecologically sound management schemes for large, economically important bodies of fresh water.

At any particular time, only a few of the lakes at the ELA are undergoing experimental manipulation. Most of the lakes remain in their natural states, providing valuable reference systems against which the experimental studies can be compared.

Research Achievements

Over a period of more than three decades, the ELA researchers have conducted hundreds of studies. The following are a few of the major research achievements:

Eutrophication

During the 1960s and early 1970s, rapid increases in algal growth were causing deterioration of the water quality and the fisheries of Lake Erie and other lakes in North America and Europe. Laboratory studies suggested that several nutrients were responsible, primarily phosphorus, nitrogen and carbon. ELA studies showed that rather than controlling all of these nutrients, this problem of nutrient pollution, or *eutrophication*, could be controlled successfully by restricting the input of only one element, phosphorus.

The two basins of this lake were separated by a plastic curtain. The lower basin received additions of carbon, nitrogen and phosphorus; the upper basin received carbon and nitrogen only. The bright green colour is from a surface scum of algae resulting from phosphorus additions.

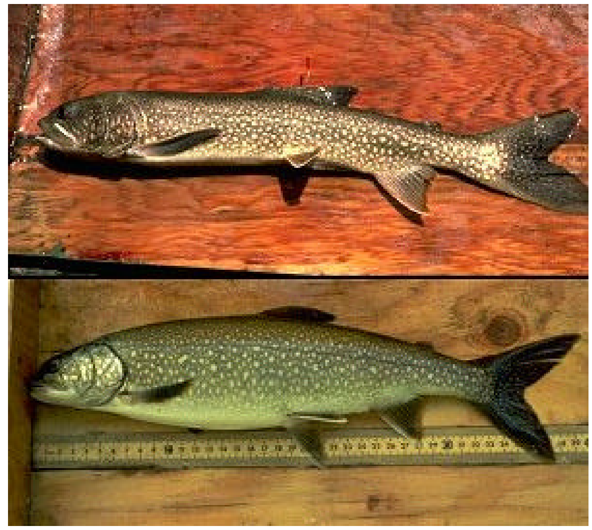
While control of multiple nutrients is not practical, several cost-effective methods can control or remove phosphorus. These findings, along with monitoring studies by Ontario’s Ministry of the Environment, led Canada to become the first country to ban phosphorus from laundry detergents. These detergents supplied over 50% of the phosphorus to many eutrophic lakes. Canada also was first to require that phosphorus be removed from municipal sewage discharged into the Great Lakes. Many of the American states bordering the Great Lakes followed Canada's lead. Lakes Erie and Ontario have now significantly recovered significantly from eutrophication.

One reason for the rapid phosphate ban in Canada was the availability of a phosphorus substitute, nitrilotriacetic acid (NTA). Originally, scientists were concerned that incomplete bacterial breakdown of NTA in water might cause toxic products to build up. The possibility was tested at the ELA, and NTA was shown to be safe.

Acidic Precipitation

In 1976, scientists began acidifying a small ELA lake. In the first three years, enough sulfuric acid was gradually added to the lake to be comparable to 20 years exposure in an industrially impacted area. A surprising number of changes occurred in the lake, even during the early stages of the experiment.

The minnow, *Pimephales promelas*, and the freshwater shrimp, *Mysis relicta*, disappeared at pH levels of 5.6 to 6.0, while the alga, *Mougeotia*, began to cover the lake bottom. Toxic metals, including aluminum, began to diffuse from bottom sediments. This proved aquatic ecosystems are damaged at much higher pH values than first believed. As the pH was lowered to near 5.0, more species disappeared from the lake. The lake trout (*Salvelinus namaycush*) population stopped reproducing and the remaining individuals began to slowly starve. The ecosystem was severely impacted above pH 5.0 – a finding that proved important in negotiating a reduction in acid-causing sulphur dioxide emissions with the United States.



The skinny lake trout in the upper photo was captured in an acidified ELA lake at pH 5.1. It was slowly starving because most of its food had disappeared from the lake. When the lake was permitted to recover from acidification, the trout were able to obtain food and their condition improved dramatically (lower photo).

Beginning in 1982, another experiment compared the acidifying effects of sulfuric and nitric acids. While sulfuric acid is more common in acid rain now, nitric acid is expected to be more plentiful in precipitation in the future. The results of this study show that, while sulfuric acid is a more potent acidifier of lakes, nitric acid is a significant source of lake acidification and nitrogen oxide emissions should be reduced. Subsequent work in this lake has examined acid-caused changes to the shallow water communities, including the growth of thick algal mats. It has also shown how controlled nutrient additions, by stimulating algal growth, can generate alkalinity and help to reduce acidification of the lake.

Whenever researchers experimentally pollute or modify a lake at the ELA, they are obliged to return it to its natural condition. These recovery studies are often as valuable as the original experiments in helping us to understand how these complex systems work. For instance, when they began to let the acidified lakes recover, scientists noted that these systems have internal biological processes that generate alkalinity. These processes permit many acidified lakes, once acid input is reduced, to recover chemically on their own.

Currently, most ELA acidification study sites have returned to natural conditions. The others are well into their recovery phases, and careful monitoring is continuing.

Heavy Metals and Radionuclides

A technician working in one of the ELA field station laboratories. While the field station has well-equipped and newly renovated labs, the primary laboratories at the ELA are the lakes and their watersheds.

In 1976, 1977, and again in 1989, small amounts of radioactive metals were added to two small lakes. The goal was to study the geochemical pathways of these materials and their effects on the food chain. Almost all of these radioisotopes had rapid decay rates and would disappear from the lakes in a few years. Most isotopes were similar to those coming from nuclear power stations and radioactive fallout. Some isotopes of common metal pollutants, such as mercury, were also chosen.

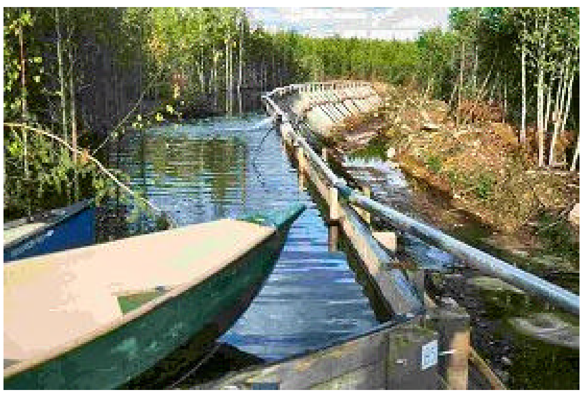
The use of ultra-sensitive radiation detectors required that only tiny amounts of radioactive material be used. These detectors were so sensitive that, to give accurate results, they had to be shielded from naturally occurring radioactive materials in concrete and local bedrock. At no time did radioactivity in the lakes exceed safe drinking water standards.

The information from these experiments will be useful when decisions are made concerning nuclear waste disposal and discharge. Results for isotopic mercury and selenium studies have been helpful in interpreting problems connected with mercury pollution at several locations on the Canadian Shield.

Flooding by Reservoirs

Many hydro-electric projects in northern Canada and elsewhere require large reservoirs that commonly flood large areas of vegetation. During the 1990s, A major ELA experiment is now underway to investigated the effects of flooding wetland vegetation. The experiment had two purposes: to study the formation, effects and mitigation of methyl mercury in the flooded ecosystem, and to measure the production and release to the atmosphere of the greenhouse gases, carbon dioxide and methane.

Methyl mercury is highly toxic to humans. It is produced in flooded reservoirs and increases with each level of the food chain. When people regularly eat fish from these systems, they may receive toxic doses of methyl mercury. It has also been found that, when flooded, wetland vegetation and accumulated peat, when flooded, decay and release large quantities of carbon dioxide and methane. These are gases that, in the atmosphere, act like a greenhouse to trap the sun’s heat and promote climate change.



A portion of the wooden dyke containing one of the reservoirs created for the Flooded Upland Dynamics Experiment. Flooded vegetation produces toxic methyl mercury and releases large amounts of carbon dioxide and methane.

The ELA study at ELA demonstrated huge increases in the production of both methyl mercury and greenhouse gases following flooding. It examined in detail how the methyl mercury is produced, and showed that large reservoirs can contribute significantly to climate change, if they flood large areas of vegetation. A follow-up experiment is now examining the same factors when upland areas are flooded. The results of this research are already influencing site selection and design of future reservoirs.

Toxic Contaminants

Recently, much of the ELA research emphasis has moved to toxic contaminants, particularly to substances that mimic natural hormones, and to a renewed focus on mercury.

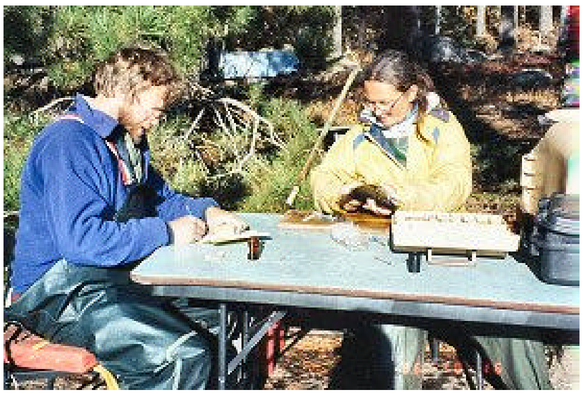
Human technology is producing many substances that are chemically similar to the natural hormones that control life processes. Increasingly, evidence indicates that these manufactured substances are interfering with these natural processes. A synthetic estrogen, used in birth control pills, is being released to natural waters through sewage treatment plants and may disrupt normal reproduction in fish and other aquatic species. One new ELA experiment will add small concentrations of this estrogen to the water of a study lake to determine its effect on fish reproduction.

Mercury is falling from the sky, and is widely recognized as the most common contaminant of aquatic systems in Canada. Even fish populations in remote lakes have unacceptably high concentrations of this toxic metal, resulting in human consumption advisories. A second new experiment wouldwill add tiny amounts of traceable mercury to an ELA lake and its watershed. Using sophisticated techniques, an international team of researchers will monitor the production and movement of mercury within this ecosystem to determine whether the newly added mercury is an important source of the mercury contamination in fish populations.

Biological Manipulations

Various ELA studies have tested the effects on ecosystems of harvesting or introducing important species.

Growth rates of commercially important fish species following cropping have been studied in several lakes. Other studies are testing food chain responses to the introduction of previously absent top-predator fish. Improvements in aging of fish, mark and recapture methods, and other aspects of fisheries methodology have been and are being developed and tested.



Researchers studying fish in an ELA lake. Fish are live-trapped, measured and tagged for future, then returned live to the lake.

Many cottagers and shoreline residents dislike having rooted aquatic plants, or "weeds", growing in front of their properties, and regularly remove them. Beginning in 1996, ELA researchers mechanically removed half of the rooted vegetation from the shallow water of a small lake. Within three years, this removal of vegetation had caused major changes to the lake’s food web. The numbers of northern pike, *Esox lucius*, were decreasing, while the pumkinseed sunfish (*Lepomis gibbosus*) population had exploded, clearly demonstrating the importance of these plants for maintaining stable fish populations.

Long-Term Monitoring

One of the most important contributions of ELA research is the long-term monitoring of natural ecosystems. This detailed record, covering more than thirty years for some lakes, has contributed tremendously to our understanding of how natural ecosystems work, and how various stresses affect them.

For each experimentally manipulated ELA lake, there is one, or more, being studied in its natural state. These natural lakes are used for comparisons with the manipulated lake systems. In addition, several ELA lakes have been selected as long-term ecological monitoring (LTER) sites, and are routinely monitored for a range of natural variables. They are valuable indicators of natural ecosystem variability and useful for detecting large-scale environmental changes, such as climate change. Data from these lakes are being compared with similar data from other North American sites to examine regional similarities and differences.

The ELA serves as a south-central Canadian reference site for atmospheric monitoring. Meteorological data have been provided to the Atmospheric Environment Service since 1969. Sophisticated air and precipitation sampling equipment has been operating since 1980, providing data for various provincial, national and international programs.

The data from these various monitoring programs have become invaluable for assessing the implications of climate change. Currently, the long-term effects of climate change on water supply and water quality are being assessed using these historical ELA data.

Scientific Excellence

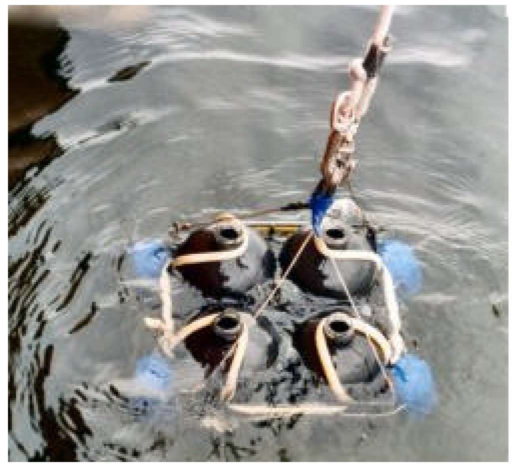
An agreement for the ELA, updated in 2000, provides for joint federal-provincial management of the facility. Various government agencies, private corporations, and more than 20 universities from across Canada, the U.S. and elsewhere have participated in ELA research. Scientists provide expertise in ecology, limnology, fisheries biology, water chemistry, geochemistry, radiation science, physiology, microbiology, toxicology, meteorology and hydrology.

Numerous undergraduate and graduate students assist with research programs to further their scientific training. More than 80 Masters and Doctoral theses have been published on research from the ELA. These graduates are now conducting research, and training new students, in many parts of the world.

Restriction of Public Access

The whole-lake experiments often use expensive scientific equipment that must be kept operational for several years to properly execute the experiments. Such equipment may be submerged, without surface floats, because wave action disrupts its operation. Accidentally striking this equipment with a watercraft, entangling it with a fishing line, or otherwise interfering with its normal operation, could prevent the clear interpretation of an entire experiment.

Likewise, removal of experimentally tagged fish, or the accidental damage of fishing gear, could cause costly problems. Recreational fishing by ELA staff is severely restricted. Many of the lakes are closed to all angling by order of Ontario's Minister of Natural Resources.



Sensitive equipment floating in the experimental lakes could be damaged by unaware or careless visitors. Public access to these lakes is discouraged.

Entry of waste or unknown pollutants to the lakes, even in small amounts, could confuse the interpretation of controlled experiments. Human-caused wildfires could have disastrous effects for the entire ELA program. For these reasons, road access to the ELA is restricted, and persons other than ELA staff are discouraged from accessing the watersheds and study lakes. However, none of the lakes presents any unusual health hazards to humans.

For Further Information

Individuals or groups interested in the ELA program can obtain more information on the studies, or arrange tours of the facility, by contacting the Communications office or the ELA project leader at Fisheries and Oceans Canada’s Freshwater Institute in Winnipeg

An ELA scientist explains an experimental study at Lake 115 to a visiting tour group. Group tours of the field station and accessible field sites can be arranged on request.

Scientific staff also give lectures on findings from the studies to schools, universities, public groups and government agencies, when schedules permit. A listing of more than 700 scientific publications from the dozens of ELA studies is available on request. Copies of most publications may be obtained through the Eric Marshall Aquatic Research Library at the Freshwater Institute.

"Ecosystem research is essential to the health of our lakes."