Chemical and Biological Status of Killarney Park Lakes (1995-1997): A study of lakes in the early stages of recovery from acidification.

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Abstract

For nearly thirty years, Killarney Park has been one of Canada's principal study sites for research into the ecological effects of acidification. Results of university and government-based research at Killarney contributed to major environmental improvements in North America including for example, the Clear Air Act Amendments. The area is now, once again, providing research opportunities unparalleled in the world. Only in the greater Sudbury area which includes Killarney, are acidified lakes showing substantial chemical and biological recovery as a result of implemented pollution control programs. In response to these opportunities, the Co-op Unit has initiated three major monitoring and research programs:

1. Killarney Biodiversity Survey;
2. EMAN designation for global change monitoring; and,
3. Canadian/Norwegian Joint Study of Biological Recovery

Recent Inventory and Monitoring

An inventory of water quality and biological communities was recently undertaken for the lakes and ponds of Killarney Provincial Park. Killarney Park is a 48,000 hectares wilderness area containing about 600 waterbodies (0.03-810 hectares). This report describes the methods, summarizes the data and presents some initial interpretation from this inventory work conducted from 1995 to 1997. The inventory project was supported as a partnership between university, government, industry and non-government organizations. It was designed not only to establish the current state of the park environment, but also as a baseline for future research, monitoring, restoration and educational programs.

Killarney Park is well known as a site of significant environmental damage from acid deposition. Bedrock geology and location relative to pollution sources combined to create this situation. The park is dominated by the La Cloche Mountain Range, a geological formation composed mainly of orthoquartzite, highly erosion-resistant bedrock that provides little buffering against acid precipitation. Killarney is located 40-60 km southwest of the large sulphide ore smelters in Sudbury, Ontario and within a continental zone of high acid deposition (> 20 kg/ha SO_4) originating from a vast array of long-range industrial sources. Not surprisingly then, the Killarney lakes were some of the first lakes in North America to be acidified by atmospheric pollutants. By the late 1970s, most Killarney lakes were damaged. This damage resulted in the loss of thousands of individual populations of fish, plankton, benthic invertebrates and amphibians.

In recent decades Killarney has again been noteworthy, but this time as a site where substantial recovery from acidification has been observed as a result of major reductions in emissions at local and long-range sources. The evidence of recovery was the principal reason for initiating a park-wide inventory of current conditions.

Water samples were obtained from 154 lakes (87.7% of lakes by surface area) in the eight major drainage basins, with most sampling occurring in the winter of 1996 and generally a single sample used to characterize the chemistry. The lakes exhibited a broad range in pH (4.3-7.6 with a median of 5.2). There was historic evidence that pH had risen by about 0.5 units for a well-studied set of 14 lake trout lakes. However, a large number of lakes remain acidic (110/154 lakes with pH < 6.0) and vulnerable to acidification (61/154 lakes with tip alkalinity < 0 mg/L).

Metals mobilized from acid deposition on watershed soils (Al, Mn, and Zn) were present in high concentrations in low pH lakes. The concentration of nickel (range 0-20 ug/L), a metal presumably deposited as particulates from the area smelters, showed elevations above expected background levels but was low relative to provincial water quality guidelines.

A special feature of the La Cloche Mountain lakes is their exceptional clarity. Relative to other Ontario lakes, an unusually high proportion (43/153) of Killarney's lakes have a dissolved oxygen content (DOC) measurement of less than 2 mg/L. There was a strong negative correlation between DOC and Secchi depth and the depth of the late summer thermocline. Low DOC, high clarity (Secchi depth up to 30 m) lakes are generally located on the Lorrain and Bar River Formations. High DOC, brown-coloured waters (Secchi depth as low as 1.1 m) exist primarily in lowland lakes with wetlands.

Biological surveys targeting specific groups or indicator species – rather than attempting complete coverage – were completed on 119 lakes. Some methodological testing of gear and sampling intensity to detect rare specimens was conducted, but most lakes received a rather standard assessment using a broad range of proven sampling techniques for assessing species presence as opposed to abundance.

A total of 28 species of fish were caught during the survey. The two most common fish species were pumpkinseed and yellow perch. The ten species that were caught in at least one third of the lakes and accounted for 90.6% of the total catch by number were: bluegill, brown bullhead, golden shiner, largemouth bass, northern pike, pumpkinseed, rock bass, smallmouth bass, white sucker, and yellow perch. The most acid-tolerant species, as suggested by their occurrence in lakes with pH < 5.0, were bluegill, brown bullhead, brook trout, golden shiner, pumpkinseed, and yellow perch. Fish found only in lakes with pH $\geq$ 6.0 were blackchin shiner, blacknose shiner, finescale dace, johnnie darter, mimic shiner, rainbow smelt and slimy sculpin.

The number of fish species per lake ranged from 0 to 14, with a mean of 4.1 and a median of 3.0. The species richness of lakes with pH > 6.0 was similar to that of non-acidified lakes in other parts of Ontario. Among the major drainage basins, the median species richness varied from 0 (Chikanishing River) to 6.5

(Howry Creek). Thirty-six percent (43/119) of the lakes did not have fish. All of the fishless lakes (pH 4.3 - 5.9) have watersheds underlain primarily by the Lorrain and Bar River Formations. The estimated number of fish populations lost from 55 of the biologically surveyed lakes (pH < 6.0, surface area > 3.4 ha) was 262.

The smallest waterbody in the province known to contain a native lake trout population - Teardrop Lake, 3.4 hectares - was discovered. It's lake trout population is notable for its unique gene assemblage and extremely slow growth rates. This lake is located on top of a ridge in the Bar River Formation and, unlike all other lakes situated on that bedrock type, was protected from acidification by an exposed vein of olivine diabase. The lake supports an undisturbed community of a wide variety of other native species, for example *Hyalella azteca, Stenonema femoratum*, and slimy sculpin, that may become the source of colonizers for nearby recovering lakes.

Natural recolonization by smallmouth bass and northern pike emigrating from neighbouring lakes was documented in Johnnie and Freeland Lakes. Evidence was also found in other lakes of successful restoration by recent stocking. The transfer of wild adults re-established a self-sustaining smallmouth bass population in A.Y. Jackson Lake and spawning by introduced hatchery-reared lake trout was documented in three lakes. A largemouth bass population was established in Great Mountain Lake by an unauthorized introduction. In 1997 smallmouth bass were reintroduced into George Lake.

We observed 11 species of amphibians, 24 species of aquatic or fish-eating birds, six species of reptiles, and five species of aquatic mammals.

Four crayfish species were captured. *Cambarus robustus* and *C. bartoni* were found in the most acidic lakes (pH 4.3-7.3). *Orconectes propinquus* and *O. virilis* were restricted to lakes with more moderate pH (5.2-7.6). The most common crayfish found in the 48 streams that were surveyed were the two *Cambarus* species. Only three streams, all in the lowlands, contained *Orconectes*. Natural recolonization by immigration of *Orconectes* has occurred in three recovering acid-damaged lakes.

Acid-sensitive species of mayflies and amphipods were generally restricted to the lowland lakes. Their absence from most high-elevation (i.e., > 250 m) lakes was probably due to acidity. The amphipod *Hyalella azteca* was found in 51 lakes (pH range 5.6-7.6), including some recovering acidified lakes. The most acid-tolerant mayfly species *Eurylophella temporalis* and *Leptophlebia* were found in lakes with pH as low as 5.0. Mayflies of the family Baetidae were not found in lakes with pH < 6.2. Moderately acid-sensitive species *Stenonema femoratum* (pH $\geq$ 5.6) and *Stenacron interpunctatum* (pH $\geq$ 5.3) were found in some recovering acidified lakes, indicating that natural recolonization is taking place. Invertebrate sampling of the Chikanishing River revealed that mayflies, absent in 1981, have recolonized the lower river in response to improving water quality.

The Killarney Biodiversity study is a partnership between: Ontario Parks; Ontario Ministry of Natural Resources (OMNR); Ontario Ministry of Environment and Energy (MOEE); INCO Ltd.; Falconbridge Ltd.; Laurentian University and Friends of Killarney. The study is designed to assess the species and genetic biodiversity

of fish, major invertebrates and waterfowl that survived the decades of acid-damage. Over the past three years (1995-97) chemical studies have been conducted in 150 lakes and biological studies have been conducted in 115 lakes. The GIS managed data from the surveys – organized by watersheds – will be used to create a web-site and other interpretive visitor service information on biological recovery and recolonization processes. Comparison of modern to post-glacial colonization events is planned.

As a newly established (1997) national Ecological Monitoring and Assessment Network (EMAN) site, our hope is that Killarney will become a long-term monitoring site for the study of biological recovery of disturbed ecosystems. EMAN also recognizes the site as having special status for the study of global changes in climate and UV-B for example, because it contains some of the clearest waters in Canada and is prone to El Nino and ozone depletion effects.

A cooperative project began with Norwegian University and government agencies in 1997 to study the details of recovery of acid-sensitive biota in Killarney as a surrogate site for European monitoring issues. Initial results of the assessment and modeling projects will be presented at the first Killarney Biodiversity Workshop, scheduled for Laurentian University on February 18, 1998. Finally, a World Wildlife Fund project is underway in Killarney to establish genetic refuge sites for endangered fish stocks such as Iroquois Bay lake trout, and OMNR continues to support research on species interactions to assist with fish community rehabilitation efforts. An overview of the scientific, management policy, visitor service and public education significance of the above studies will be presented.