S&E
SCIENCE AND THE ENVIRONMENT
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DNA HELPS SOLVE THE MIGRATION MYSTERY

The loss of just a few habitats far from Canada can threaten populations of migratory birds that depend on those sites when they migrate there each winter.

When critical habitat is preserved, migratory bird populations can maintain healthier numbers. To preserve habitat effectively, it is important to understand migratory paths of differing populations. Charting the migration is made all the more complicated because many populations look very much like one another, and show little difference in body measurements.

Photo: Tony Beck *Semi-Palmated Sandpiper*

Environment Canada scientists, working with colleagues from the United States Department of the Interior and several American universities, have demonstrated the feasibility of tracking different species of birds using modern DNA analysis techniques. These techniques are fast, simple, and inexpensive, and much more effective than traditional methods of marking birds and relying on recapturing them or resighting them.

The scientists studied nine shorebird species from five families. They analysed DNA from birds at five different Arctic breeding locations and four temperate migration/wintering sites in North America, to link breeding populations with their migration patterns.

Among their findings was the discovery that most migrants were more closely associated with breeding populations to the west of them rather than to the east. For example, Hudsonian godwits on fall migration in Saskatchewan were genetically more similar to birds from the Mackenzie Delta than from Churchill, Manitoba. Similarly, red-necked phalaropes captured on fall migration in Saskatchewan were more closely linked to birds from Prudhoe Bay, Alaska, rather than Churchill. The same was true of dunlin on spring migration in Saskatchewan.

The scientists also found that, within species, birds such as the dunlin, Hudsonian godwit, and semi-palmated sandpiper, that tend to have several different breeding grounds, showed the greatest genetic differentiation.

RANGE OF THE SEMI-PALMATED SANDPIPER

This project represents an international effort to gain a better understanding of large-scale migratory shorebird population movements. The knowledge gained through it will assist in conservation planning on a global scale.

I N S I D E

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THE GRASSHOPPER EFFECT
AND TRACKING HAZARDOUS AIR POLLUTANTS

Toxic chemicals that are banned or severely restricted in Canada make their way into our environment every day through a cycle of long-range air transport and deposition known as the "grasshopper effect." Scientists are now able to figure out the source of some of these chemicals, and even how old they are.

20 YEARS OF COSEWIC

Careful research, monitoring and compiling of data are needed to determine the status of endangered species. In Canada, there are many dedicated scientists working for governments, universities and other organizations who spend long hours at this research, and devising ways to help recover dwindling wildlife populations.

Established in 1978, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) comprises members from federal, provincial, and territorial government wildlife agencies, three national conservation organizations (World Wildlife Fund Canada, the Canadian Nature Federation and the Canadian Wildlife Federation), chairs of six scientific subcommittees and the chair of COSEWIC.

For 20 years, COSEWIC has produced the official Canadian list of wildlife at risk. The Committee commissions status reports which contain summaries of the best available information collected by field researchers, academics, students, museum biologists, consultants and volunteer naturalists. COSEWIC carefully assesses information about population numbers and threats to habitat to determine the status of species. They may then be classified as extinct, extirpated (no longer existing in the wild in Canada), endangered, threatened or vulnerable. Such a listing can prompt the design of recovery plans for many species. COSEWIC is involved in assessing the de-listing of species, as well.

http://www.ec.gc.ca/cws-scf/hww-fap/endanger/endanger.html

Persistent and volatile pollutants—including certain pesticides, industrial chemicals and heavy metals—evaporate out of the soil in warmer countries where they are still used, and travel in the atmosphere toward cooler areas, condensing out again when the temperature drops. The process, repeated in "hops," can carry them thousands of kilometres in a matter of days.

Canada's cold climate puts it at the receiving end of this process, with measurable concentrations of DDT, toxaphene, chlordane, PCBs and mercury found in both the Great Lakes and the Arctic. Ingested by fish and other species, the chemicals travel up the food chain, accumulating in the fatty tissue of predatory animals, including people. Some of these pollutants are linked with developmental and reproductive impacts on wildlife, and may have similar effects on humans. The consequences may be serious for Native people in the North, whose traditional food sources are being contaminated.

Environment Canada scientists measure and monitor concentrations of these toxic chemicals to learn more about how they are exchanged among air, land and water. Similar studies being carried out in Russia—both by Canadian scientists and by Russian colleagues using analytical equipment Canada donated several years ago—are yielding useful data for global comparisons, and providing additional insight into the grasshopper effect and the impact on shared resources such as the Arctic Ocean.

An important breakthrough has been the recent development of a technique for identifying the age and source of some of these chemicals. Certain persistent organic pollutants (POPs) have right- and left-handed molecules that are mirror images of one another. While new formulations tend to have equal amounts of both, differences in the way these molecules are metabolized by microbes and enzymes in the biological system change this ratio as the chemical ages. The tracers show the grasshopper effect quite clearly. By separating them, it should be possible to determine how long they have have been travelling, and whether they have spent time on

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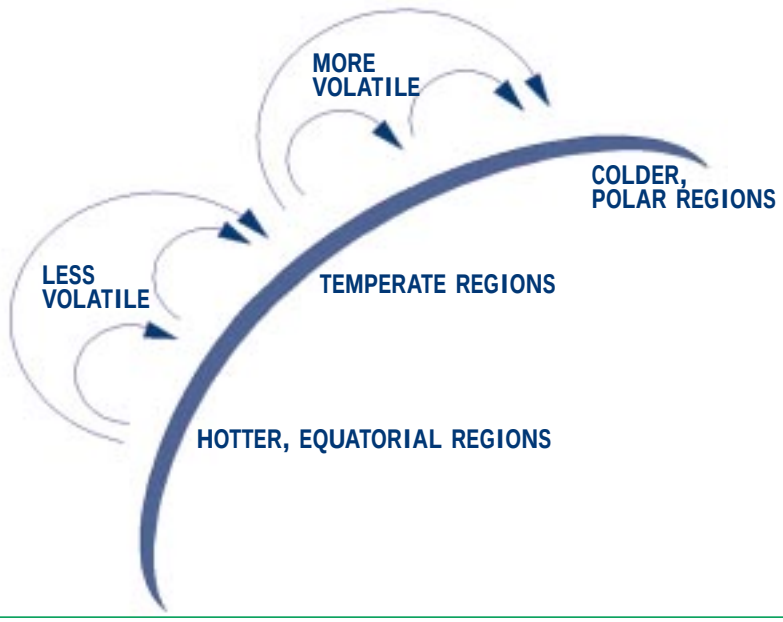
land or in water. By matching them with weather records, scientists should also be able to find out where the chemicals are from.

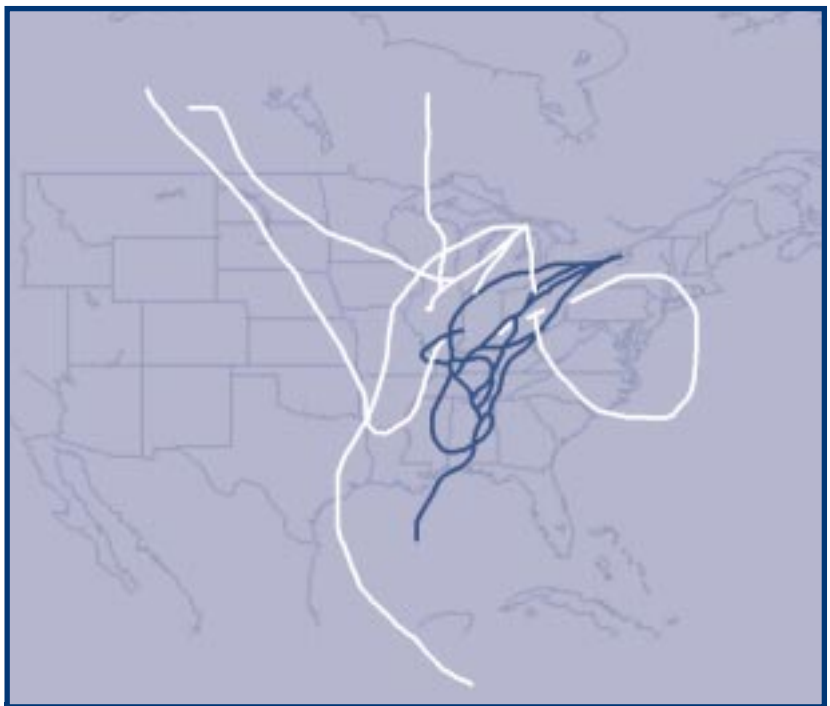
In the figure below, approximately 10% of the highest cases of p,p'-DDT (a component of DDT) arriving at two Integrated Atmospheric Deposition Network stations on the Great Lakes are tracked back to potential sources in the south using weather records.

Information obtained through these and other Canadian studies is the foundation of international negotiations for global bans on certain of these toxics. Canada is playing a leadership role in these efforts. They include the recent negotiation of protocols for POPs and heavy metals under the United Nations Economic Commission for Europe—to be signed this June—and other initiatives are now being launched with other parts of the world through the United Nations Environment Programme.

Canada's work in the Great Lakes and Arctic provides powerful evidence that persistent toxic pollutants are travelling long distances, and the efforts have raised global awareness of an important issue.

GRASSHOPPER EFFECT OR GLOBAL DISTILLATION





p,p'-DDT (a main component of DDT) arriving at the Point Petre (white lines) and Burnt Island (blue lines) stations of the Integrated Atmospheric Deposition Network, tracked back to potential sources.

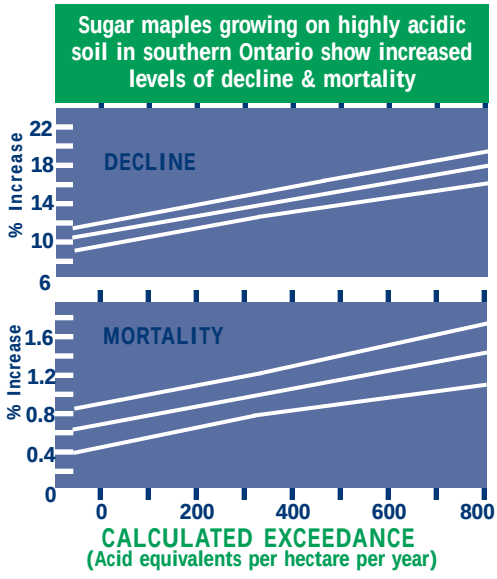
FACTS & FIGURES

- ***COSEWIC encourages species status reports from all sources, and will use such unsolicited reports to make a listing determination if they contain sufficient and reliable information.***
- ***RENEW is the committee on the Recovery of Nationally Endangered Wildlife. It works with governments, stakeholders, organizations and individuals on plans to protect or recover species that are at risk.***
- ***There are now 31 recovery planning teams active under RENEW, directly involving at least 197 members from 65 countries.***

ACID RAIN & CANADA'S FORESTS

Acid rain is still a problem, and its impact on Canadian forests may have been underestimated. According to the *1997 Canadian Acid Rain Assessment*, forests are affected by acid rain more than previously believed.

Decades of acid deposition have depleted forest soils of nutrients that are essential for forest growth. Previous studies had estimated that natural processes replace nutrients faster than they are displaced by acid precipitation. There is mounting evidence that this is not the case. More than 30 years of meticulous measurements from the Hubbard Brook Experimental Forest site in New Hampshire have concluded that more than half the available pool of plant nutrients (e.g., calcium, magnesium, potassium) has disappeared from soils. Nutrient losses are also evident in observations from Ontario and Quebec. The result is reduced forest growth and, years later, more visible signs of damage such as die-back and higher mortality.



Sugar maples growing on highly acidic soil in southern Ontario show increased levels of decline & mortality

The Assessment shows that some lakes in eastern Canada have made only modest improvements in spite of significant progress in reducing emissions of sulphur dioxide, the main pollutant responsible for acid rain. Acid levels have remained stubbornly high in acidified lakes. Only in central Ontario, where emissions from local smelters have been reduced by more than 80 per cent, have acidity levels shown a significant decrease.

However, rainwater and snow remain more acidic than natural levels. Sulphate concentration has gone down in tandem with decreases in sulphur dioxide emissions, but there has also been a reduction in elements such as calcium and magnesium, that help buffer rain acidity. The end result is that rain is still abnormally acid.

The loss of soil nutrients and the lack of lake recovery are likely to continue as long as acid deposition continues to exceed the ecosystem tolerance levels. The Assessment estimates that, even after full implementation of Canadian and U.S. emission controls, large parts of Ontario, Quebec, New Brunswick and Nova Scotia will continue to receive twice the amount of acid that they can tolerate.

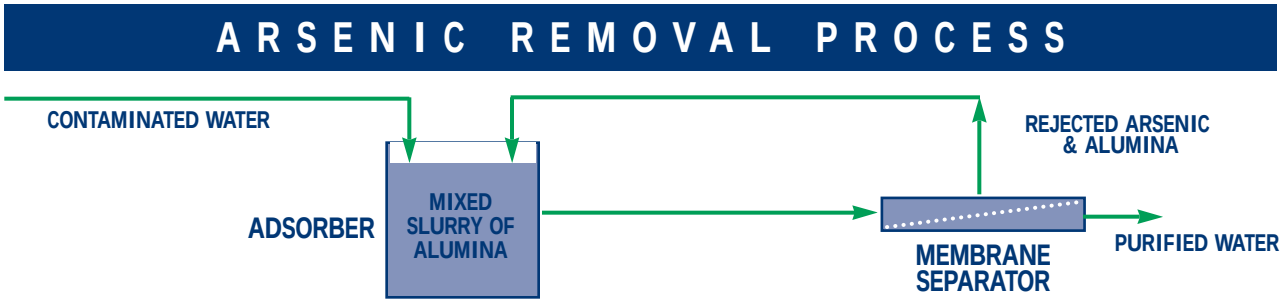
Modest reductions in lake acidity do show up in southeastern Canada. Of the 202 lakes that have been monitored, 33 per cent have recorded reduced acidity, 56 per cent have shown no change, while 11 per cent have become more acidic. The most striking improvements have been seen in the Sudbury area, a result of very substantial reductions in sulphur dioxide emissions from local smelters, while the least improvement has occurred in the Atlantic provinces.

Environment Canada is working with the provinces to reach agreement on a new Canada-Wide Acid Rain Strategy for Post-2000. This strategy is due to be finalized in 1998.

Photo credits:
Top– Dernier espoir by Lynn Potvin
Bottom– Fall Breezes by Brenda Kieswetter

REMOVING ARSENIC FROM WATER:
IMPROVING THE PROCESS

Environment Canada scientists have developed a new way to remove arsenic from water, using a process that is both cost-efficient and easily portable.



Their work provides hope to communities in countries such as Sri Lanka and Bangladesh, where arsenic in drinking water causes "blackfoot disease." Sufferers of this condition have to have their limbs amputated.

The scientists, working in partnership with Canada's ZENON Environmental Inc., were able to use extremely small particles of alumina, a form of aluminum oxide that is a white powder. Arsenic-laden water is fed into a tank reactor, where the molecules of arsenic are held on the surface and in the pores of the alumina through a process called adsorption, in much the same way that water is held in a sponge. The water/alumina mixture then moves to a membrane unit for microfiltration. Water travels through the membrane, but the particles, and the arsenic, are rejected, and are returned to the tank so the alumina can be reused.

The process was originally developed to remove arsenic from mining effluents and wastewater, but can also be used to make drinking water safe. It has been shown to be effective at removing 99.99 per cent of the arsenic from mining effluence with a concentration of 100 parts per million (ppm) of arsenic. The technology is most effective, however, at removing arsenic in concentrations of 4-5 ppm, or 4,000-5,000 parts per billion (ppb). In comparison, the acceptable level of arsenic for discharge is 50 ppb, and for drinking water, 25 ppb.

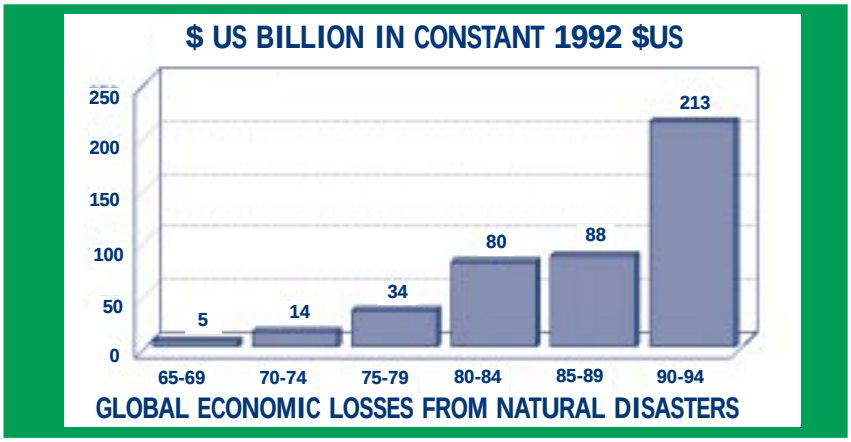
The process is also self-regenerating. When sufficient quantities of arsenic and alumina have been rejected by the membrane, an alkaline solution is added to the reactor that causes the arsenic to separate, or de-absorb, from the alumina. The mixture then travels to the membrane again, and the concentrated arsenic flows through, while the rejected alumina is regenerated and reused. The apparatus used to carry out this process is small and self-contained, and can be transported on a trailer. This makes it particularly effective for developing countries, where arsenic poses a hazard to drinking water. Areas of Canada and the United States also must deal with this problem. In Canada, naturally ocurring arsenic is found in rocks in Nova Scotia, and leaches into water. In the United States, some remote communities in New Mexico and Arizona have to bring in drinking water by truck because of arsenic in the local water.

Previous methods of removing arsenic used larger particles of alumina, and this slowed down the adsorption time. Environment Canada scientists and their partners have patented their discovery in both Canada and the United States, and are currently examining whether the technology can be adapted to remove lead and selenium from water.

GLOBAL WARMING:

A POSSIBLE FACTOR BEHIND AN INCREASE IN EXTREME WEATHER EVENTS

The number of floods, droughts, storms, hurricanes and other extreme weather events that have taken place around the world in the past two decades raises some serious questions about the current and future state of the global climate. Is this a long-term trend, or just a temporary aberration? Are these events the result of purely natural forces, or linked in some way to climate change caused by the buildup of greenhouse gases in the atmosphere?



According to Munich Re, one of the world's largest re-insurance firms, economic losses from natural disasters worldwide increased by a factor of 43 between the mid-1960s and mid-1990s—dwarfing the growth rate for wealth and population. By far the largest part of this increase is because of weather-related events. Recent studies have also identified significant regional climate trends—including a decrease in many parts of the world in lower temperature extremes, a tendency toward heavier rainfall in the northern hemisphere, and more frequent droughts in parts of Africa, Chile, Peru and Australia. In 1998, the Montréal area and eastern Ontario were hit by the single most destructive weather event in Canadian history—a winter ice storm that knocked out power lines for weeks, left 25 people dead, and caused an estimated $2 billion in damage.

Global **Climate Change**

Although the natural variability of the climate and such normal occurrences as volcanic eruptions, fluctuations in the intensity of the sun's radiation, and the periodic appearances of El Nino, can cause short-term changes in the weather, extremes that persist point to a fundamental shift in climate behaviour. Global warming may be a key cause of just such a shift. Scientists estimate that about a third of the warming the world has experienced since 1970 may have been caused by a natural increase in the sun's output. There is growing evidence, however, that the human-induced greenhouse effect is responsible for the rest.

How can global warming increase the frequency and intensity of extreme weather? For one, a

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change in the distribution of heat disrupts the flow of energy through the climate system, altering the circulation patterns of the atmosphere and oceans, and modifying the earth's hydrologic cycle. For another, higher temperatures not only increase evaporation and transpiration, but also raise the air's capacity to hold moisture, making more available in the atmosphere to fall as rain and snow.

Climate studies show that warming increases both heavy rainfalls and average global precipitation—meaning more flooding, more property damage from high winds and thunderstorms that accompany heavy rainfalls, and more frequent droughts due to increased evaporation. Higher humidity levels and hotter temperatures also mean more dynamic, electrically charged storm clouds, and more heat waves and extremely hot days.

Further scientific effort is needed to study severe weather as a feature of climate and to increase our understanding of future risks. In the meantime, improving our adaptation to present hazards—through expanding flood-control systems, tightening land-use regulations, and reinforcing buildings and other structures—will help lessen the dramatic economic, human and ecological costs that even a slight increase in extreme weather would mean to society.

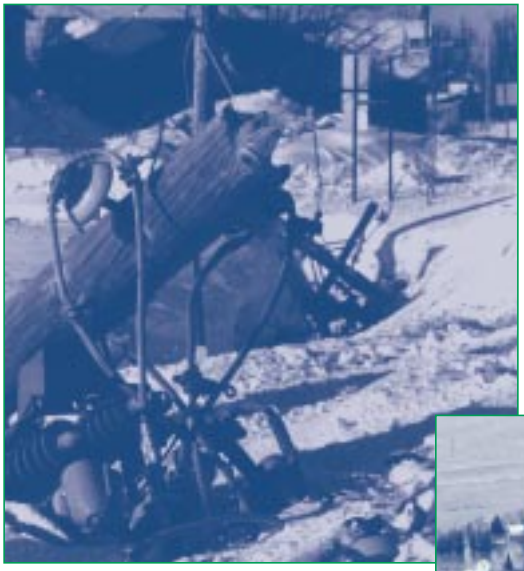

Photo by Jacques Lavigne

Photo by Department of National Defence

Struck by beauty/Frappé de beauté by Pierre Trudel

FACTS & FIGURES

- ***During 1998-99, Environment Canada and World Wildlife Fund Canada are funding 38 projects under the Endangered Species Recovery Fund. Among species that will benefit are the Swift Fox, Prothonotary Warbler, Harlequin Duck, Bottlenose Whale and Blue Racer Snake.***

- ***The most recent data show a population increase in the endangered St. Lawrence beluga whale. Aerial surveys put the population at around 705 in 1995, compared with 525 in 1992.***

WEATHER AND SONGBIRDS

Bad weather along the travel route has hindered many a snowbird, and it may have an effect on real birds as well. An examination of the North American Breeding Bird Survey and weather records from for the past 30 years reveals some interesting findings.

Blackpoll Warbler by J.R. Graham, Parks Canada

Migration flights over land or ocean make a difference. Songbird population declines were found mostly in the eastern North American populations that migrate over the ocean to winter homes in South America. Between 1980 and 1990, eastern species flying between 250 and 800 km to winter quarters experienced a median *decline* of 0.6 per cent, while western species experienced a median *increase* of 1.3 per cent. Songbirds from the western part of the continent travel overland to get to their winter homes in Mexico.

The long-distance travelers were also among the most affected, such as the Blackpoll warbler, which flies close to 4,000 km from the Maritimes to South America each autumn. The chance of encountering unfavourable weather during migration was four times greater for birds flying long distances than for those flying shorter distances.

Scientists in Environment Canada's Pacific Wildlife Research Centre also found the period with the greatest declines was 1986 to 1990, a time with unusually high numbers of storms in the southwest Atlantic. Chances of encountering unfavourable weather during this period were twice as high as between 1966 and 1970, when there were just one third the number of stormy days over the same area. Survival rates among the migrating songbirds were much higher in the calmer period.

Perhaps the most important factor for the decline in songbird populations is the loss of habitat. However, the correlations from this research (not cause and effect) note that storm activity in the Atlantic and Gulf of Mexico is linked to changes in water temperature in the Pacific. This research implies that songbird populations in eastern North America might be affected by global climate change in the Atlantic and Caribbean.

FACTS & FIGURES

- ***Canada, the United States and other countries work together under a number of different agreements to protect endangered species such as the whooping crane and piping plover.***

- ***Peregrine falcon populations have been re-established in every geographic region of Canada that historically had peregrines. There are estimated to be 400 pairs in the Northwest Territories and the Yukon, and 85 pairs across southern Canada.***