S&E SCIENCE AND THE ENVIRONMENT BULLETIN S&E
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CURBING THE EFFECT OF WASTE ON CLIMATE

While most Canadians are aware that the burning of fossil fuels in their cars and homes produces emissions that contribute to climate change, few realize that the garbage they carry out to the curb every week is also a culprit. In fact, the waste sector accounts for 3.5 per cent of the nation's total greenhouse-gas emissions.

Although recycling and composting in Canada currently divert about 29 per cent of solid waste from disposal, the other 71 per cent is typically dumped at landfill sites or burned. Both of these options result in the release of greenhouse gases into the atmosphere that trap and retain heat from the sun, creating a warming effect on Earth.

Compacting waste at a landfill site. Landfilling is one of six options compared in a recent Environment Canada study on the impacts of waste management on greenhouse-gas emissions.

Landfills are responsible for the lion's share of these emissions, and nearly one quarter of the total methane emissions produced in Canada. Methane is created when organic material buried deep under layers of waste and earth decomposes without oxygen, or anaerobically. While burning waste does not produce methane, it pumps out nearly one per cent of the nation's total carbon dioxide and nitrous oxide emissions.

Although carbon dioxide is the most prevalent greenhouse gas, methane and nitrous oxide are much more potent—with 21 and 310 times as much global-warming potential, respectively. All three are targetted for reduction in the Kyoto Protocol, which is aimed at reducing greenhouse-gas emissions in the world's most industrialized nations by 2010. The other eggs in the Kyoto basket are the highly potent and persistent hydro-fluorocarbons, perfluorocarbons and sulphur hexafluoride, which are used primarily for various industrial purposes.

Emission reductions associated with waste diversion are not directly accounted for in Canada's greenhouse-gas inventory, so they do not contribute to meeting Kyoto commitments. However, such activities can have a significant impact on minimizing the effects of waste management on climate change. In order to assist municipalities and others in achieving this end, Environment Canada has developed a life-cycle assessment of the impact of different waste-disposal options and waste materials on greenhouse-gas emissions. The six options are source reduction, recycling, composting, anaerobic digestion, combustion, and landfilling, while the materials include papers, metals, glass, plastics, and organics.

Net greenhouse-gas emissions were determined by totalling the emissions associated with the management of each material, both upstream and downstream of waste disposal. These included energy-related emissions from the extraction of raw materials and manufacturing processes involved in producing the materials. Subtracted from this were any factors that offset these emissions—including increases in carbon stored in forests and soil (which reduces the quantity of carbon dioxide in the atmosphere), and recovered energy that displaces the burning of fossil fuels.

The study revealed that the choice of downstream management methods—such as landfilling, combustion and

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	Source Reduction (Current Mix of Inputs)	Recycling	Composting	Anaerobic Digestion	Combustion
Newsprint	(2.40)	(1.46)	NA	0.85	0.98
Fine Paper	(6.66)	(4.17)	NA	(1.34)	(1.27)
Cardboard	(5.15)	(3.48)	NA	(0.37)	(0.40)
Other Paper	(5.83)	(3.77)	NA	(0.79)	(0.82)
Aluminum	(1.40)	(1.93)	NA	0.00	0.01
Steel	(1.59)	(0.90)	NA	0.00	(0.78)
Glass	(0.29)	(0.07)	NA	0.00	0.01
HDPE	(1.77)	(1.40)	NA	0.00	2.39
PET	(2.72)	(2.82)	NA	0.00	1.89
Other Plastic	(2.00)	(1.11)	NA	0.00	2.27
Food Scraps	NA	NA	(0.74)	(0.91)	(0.76)
Yard Trimmings	NA	NA	0.36	0.11	0.32

Greenhouse-gas emissions of five municipal solid-waste management options relative to a sixth option, landfilling. Figures represent tonnes of carbon-dioxide equivalent per tonne of material. Those in brackets represent negative amounts.

anaerobic digestion—has significant implications for paper, plastics, and organics, but virtually none for metals and glass. It also proved, not surprisingly, that avoiding the production of a material in the first place is the single most effective way to avoid emissions at all stages of its life cycle. Reusing materials also diverts waste from disposal, at least temporarily. For materials that have already been produced, recycling can have a large impact on reducing greenhouse gases, because it replaces some of the raw materials used in the manufacturing process. Using recycled material not only reduces emissions produced during the extraction of raw materials used to produce these products, but also the energy required for manufacturing. For materials that require intensive primary processing, such as steel, plastic, and aluminum, recycling can reduce emissions by about two tonnes of carbon dioxide equivalent per tonne of product. Paper recycling also increases carbon storage because it leaves more trees growing in the forest.

Composting is an option available only for food scraps and yard waste. Because it involves aerobic decomposition, composting does not generate any methane emissions, and only releases a small amount of carbon dioxide. Since the material is plant and tree derived, however, this is considered part of the natural carbon cycle, and not an added emission. Some carbon storage also occurs when compost is applied to soil.

Although there are very few operational examples in Canada, anaerobic digestion facilities speed the decomposition of solid organic waste—including papers and cardboards—without the presence of oxygen. Like landfills, which undergo a similar process at a much slower rate, this process creates methane. This gas is then collected and used as energy, thereby displacing the burning of fossil fuels. A small amount of carbon storage occurs when the decomposed matter is added to soil.

Incineration is a less common disposal method for all forms of solid waste that results in emissions of both carbon dioxide and nitrous oxide. Since materials derived from plants are part of the natural carbon cycle, only the emissions produced from fossil-derived products are counted. Combusted waste can displace the burning of fossil fuels by producing electricity or displacing the use of fossil fuels in nearby industries.

Landfilling is the most common waste disposal method and, in many cases, the one that produces the most emissions...

Landfilling is the most common waste disposal method and, in many cases, the one that produces the most emissions when there is no landfill-gas capture system in place. When paper and other organic matter is landfilled, a portion decomposes anaerobically, releasing methane. Although 41 landfills in Canada recover the gas and flare it or use it to generate electricity, most methane emissions are released into the atmosphere. Some long-term carbon storage occurs because not all of the organic matter decomposes, and the metals and plastics don't break down.

The emissions factors developed through Environment Canada's life-cycle assessment are based on national averages, and should not be used to calculate greenhouse-gas reductions for specific municipalities. However, they are very useful for a general comparison of current and alternative waste-management scenarios. For example, recycling one tonne of aluminum instead of landfilling it would result in emissions savings equal to approximately two tonnes of carbon dioxide—as much as would fill a hockey rink to the top of the boards. With fine paper or cardboard, the savings would be about twice as great. On the other hand, for plastics, landfilling comes out ahead compared to incineration—saving about two tonnes of carbon-dioxide equivalent per tonne of material disposed.

Although the values for each option and material are only estimates, it is clear that upstream methods—such as source reduction and recycling—that divert waste from disposal hold the greatest potential for reducing greenhouse-gas emissions. Simply sustaining its current diversion rate would enable Canada to reduce its emissions by 2.9 million tonnes of carbon dioxide equivalent by 2010, while increasing it to 50 or 75 per cent would boost this total to 5.1 million and 6.9 million tonnes, respectively. Waste diversion also improves air quality and reduces water pollution, toxics, land used for landfills, and disposal costs.

Whatever the mix of materials involved or the range of options available, these life-cycle assessments will help the waste sector develop better, more integrated approaches to waste management that will reduce its impact on climate change and our environment as a whole. S&E

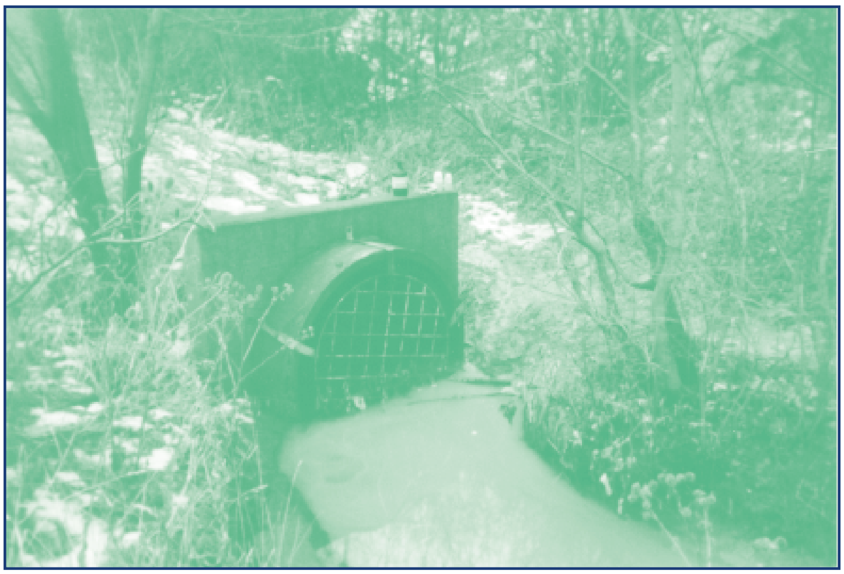
TACKLING URBAN WATER POLLUTION

When raw sewage is accidentally discharged into rivers and lakes, it can pollute the water with such high levels of fecal coliform bacteria and other pathogens that local beaches may have to be closed. Yet in some Canadian cities, sewage discharges occur many times each year—not by accident but by design.

In wet weather, rainwater running off streets, roofs and parking lots enters combined sewers, which collect and move both stormwater and municipal sewage. These sewers were standard engineering practice until the Second World War and are still found in the older parts of many Canadian cities—including Vancouver, Edmonton, Winnipeg, Toronto, Ottawa, Montréal, Quebec City and Halifax. When the sewer capacity is exceeded, or high flows would threaten downstream parts of the system (such as the sewage treatment plant), excess combined sewage is allowed to escape via combined sewer overflows (CSOs) into nearby receiving waters.

The discharged mixture of rainwater, raw municipal sewage and scoured sewer sludge pollutes receiving waters. Along the Toronto Waterfront, for example, discharges of combined sewage are the main reason for closing public beaches during and immediately after rainfall. In the Great Lakes region, this pollution is a major obstacle to restoring Areas of Concern such as Hamilton Harbour. The cost of solving the problem using traditional methods, such as sewer separation, are prohibitive—estimated at over $3 billion for Toronto alone.

Research scientists at Environment Canada's National Water Research Institute have teamed up with the Great Lakes Sustainability Fund and other partners to help Great Lakes municipalities find innovative CSO abatement strategies that will protect their receiving waters at minimal cost. So far, these partnership arrangements are in place in Windsor, Toronto, Niagara Falls and Welland, and negotiations are under way in Hamilton.



The outflow from this combined sewer located in an older residential area of Hamilton, Ontario, discharges into a small creek that flows into the Cootes Paradise area of Hamilton Harbour.

The work begins with an assessment of the problem in each location. In Niagara Falls, for instance, early indications are that the pollution can be controlled by a high-rate treatment method that would cost some 80 per cent less than sewer separation. A laboratory study of this method, which involves the use of chemicals to treat the discharge and promote settling, is currently in progress to determine the best coagulants and flocculants to use in this case.

In Toronto, studies of high-rate chemical treatment indicate great potential for savings on abatement costs. Already, an inexpensive retrofit of the North Toronto facility greatly improved its treatment capacity, while detailed computer modelling of the North Toronto facility identified structural measures that could further increase the plant's treatment capacity and improve efficiency. In field tests of high-rate treatment, researchers are examining the optimal chemical dosing for the efficient treatment and environmental safety of the treated effluent. Savings on CSO control by high-rate treatment were also confirmed in Windsor, where chemical use will result in smaller, cheaper facilities.

To enable municipalities to make their own decisions about treatment methods that will best meet local objectives and constraints, the research team is creating a catalogue of CSO-treatment technologies. This tool, combined with the team's laboratory and field studies, will provide scientific and technical guidance for the successful abatement of CSO pollution in the Great Lakes region and will ultimately help protect aquatic ecosystems across Canada from the effects of municipal pollution. S&E

WHEN OIL AND WATER DO MIX

The old adage about oil and water may hold true for salad dressing, but it doesn't always apply to oil spilled at sea. Under certain conditions, in fact, the two can combine to create an almost solid mat of toxic sludge that is more than triple the volume of the original oil.

Water-in-oil emulsion, known as "chocolate mousse" for its visual similarity to the frothy dessert, is a clean-up nightmare. Changes in the physical and chemical properties of the oil that result from the emulsification process cause evaporation and biodegradation to slow and prevent soluble components from dissolving in water. Too thick to disperse, recover with skimmers, or burn, it either has to be broken down, using heat or chemicals, or collected manually and landfilled as hazardous waste.

Knowing the exact conditions under which emulsions form enables scientists to develop more effective and cost-efficient methods for preventing and remediating spills.

Little was known about water-in-oil emulsions until Environment Canada began studying them more than 15 years ago. After carrying out hundreds of laboratory experiments and analyzing spill samples from around the world, scientists at the department's Environmental Technology Centre (ETC) unlocked the secret of how and why such emulsions form. Over the past two years, their findings were confirmed in "real-life" situations through large-scale tank tests conducted with the United States Minerals Management Service.

Emulsification is the process by which one liquid is dispersed into another in the form of tiny droplets. Water droplets enter oil when they are forced by the wave action of the sea—much like they combine temporarily when you shake a bottle of salad dressing. If the oil is too viscous, that is, too thick and slow-flowing, the water won't be able to penetrate. If it is not viscous enough, the two will mix but will quickly separate again.

The other factor that strongly affects emulsification is the quantity of asphaltenes and resins present in the spilled oil. These gummy constituents of oil, which are attracted to water, help stabilize emulsions by bonding the two components together. The longer the water is held inside the oil by its viscosity, the more likely this chemical bonding is to occur, although a high percentage of aromatics (another class of chemicals found in oil) in the emulsion can reduce this effect by stabilizing the asphaltenes and resins before the bonding process takes place.

Researchers create a "chocolate mousse" in the laboratory at the Environmental Technology Centre to study the process by which water-in-oil emulsions form during oil spills at sea.

Unlike diesel oil, which has both a low viscosity and low asphaltene-resin content, crude oil and intermediate fuel oil are more viscous and contain higher levels of these bonding agents—making them more likely to form emulsions if they are spilled. In 1999, one of the most devastating spills since the *Exxon Valdez* occurred off the coast of France, when the tanker *Erika* released some 15 000 tonnes of intermediate fuel oil into the ocean, creating a massive volume of water-in-oil emulsion.

The ETC scientists discovered that water and oil mixtures take four different forms. First, a small portion of water may dissolve completely in oil, creating a permanent solution that contains up to one per cent water. Second, if viscosity is appropriate but insufficient asphaltenes and resins are present, the mixture can become an unstable emulsion, held together by viscosity alone for a few minutes or hours. Third, a semi-stable emulsion occurs when the oil's asphaltene-resin content is at least three per cent by weight and its viscosity is sufficient. This kind of emulsion has a viscosity 20 to 80 times greater than the original oil, and usually breaks down within a few days. A portion of these semi-stable emulsions may also become stable emulsions—the fourth form of water and oil mixture. Stable emulsions require at least eight per cent asphaltenes and are 500 to 1000 times as viscous as the original oil. These near-solid emulsions can take months or years to break down naturally.

In addition to developing a better understanding of how water and oil mix, Environment Canada's spill experts are exploring other important parts of the puzzle, including the effects of salinity and temperature on the formation of emulsions. S&E

DESIGNER GENE ARRAYS AID TOXICOLOGISTS

Environment Canada scientists in Vancouver are using microscope slides spotted with genes of interest to examine the effects of toxic compounds in agricultural runoff, industrial effluent and municipal wastewater on aquatic organisms.

The same way genes influence characteristics such as eye colour and height, they also affect how all bodily systems—from respiration to reproduction—function. If certain genes are exposed to toxics at a critical stage of development, it can affect the way they are "expressed," or in other words, the process by which their encoded information is transferred to the organism's cells.

Traditional environmental toxicology determines toxicity based on such end points as mortality, reproductive success, growth and behavioural responses. Genomic studies, on the other hand, provide evidence of the potential deleterious effects of a chemical on an organism at the molecular or functional level.

Although the field of toxico-genomics has existed for more than two decades, until recently it was not practical to apply information learned and methodologies developed through the process of mapping the human genome to environmental toxicology. But now entire genomes of many organisms have been mapped and thousands of other gene sequences are available for use. Scientists, once limited to monitoring a small number of genes at a time, can simultaneously monitor hundreds of genes.

Since 1999, scientists at the department's Pacific Environmental Science Centre, in collaboration with the universities of Victoria and Waterloo and the Prostate Centre at the Vancouver General Hospital, have been using the latest advancements in genomics to study the effects of endocrine-disrupting chemicals on rainbow trout and bullfrogs in the Fraser River Valley. These chemicals, which include pesticides and sterol compounds, disrupt the regulatory functions of the immune, nervous and endocrine systems by mimicking or inhibiting natural hormones. Fish and frogs are particularly vulnerable to such disruptions because they live in an aquatic environment, and so may be exposed to chemical effluents during critical developmental stages in their lives.

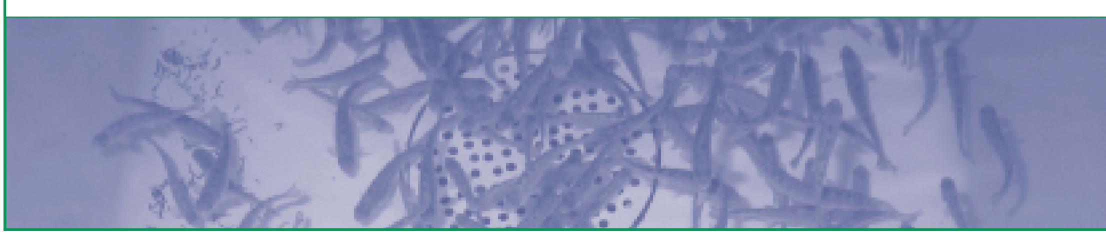
Collections of genes called gene arrays are used to monitor the effects of these chemicals. While gene arrays for most studies in environmental toxicology are randomly selected, this Environment Canada project focuses on specific families of genes—such as those dealing with cancer, tumour suppression and endocrine functioning—that belong to key systems affected by these chemicals. The specially designed array of genes for bullfrogs includes over 450 genes, and the one for rainbow trout about 150.

Testing is carried out in the laboratory using effluent obtained from sites or mixed to concentrations measured in the receiving environment. The fish are exposed from the time the eggs are fertilized until the fry begin feeding on their own—a period of about two months. The frogs are exposed from the time the tadpoles hatch until they turn into froglets. Some studies have involved exposing yearling trout to effluent to gauge differences in impact at this later stage in their life cycle.

The gene array consists of genes of interest taken from the organism or created from known gene sequences, and then immobilized on a microscope slide. Nucleic acids from the exposed tissue are then extracted and labelled with fluorescent dye. When the nucleic acids from the exposed tissue are applied to the slide, they adhere to the immobilized genes that have the same deoxyribonucleic acid (DNA) sequence—a phenomenon known as hybridization.

When the hybridized slide is fed into a scanner, the different light patterns created by the dyes indicate whether the exposed genes are over or under expressed in comparison to the normal genes. Such differences may indicate that the organism has been affected by the chemical.

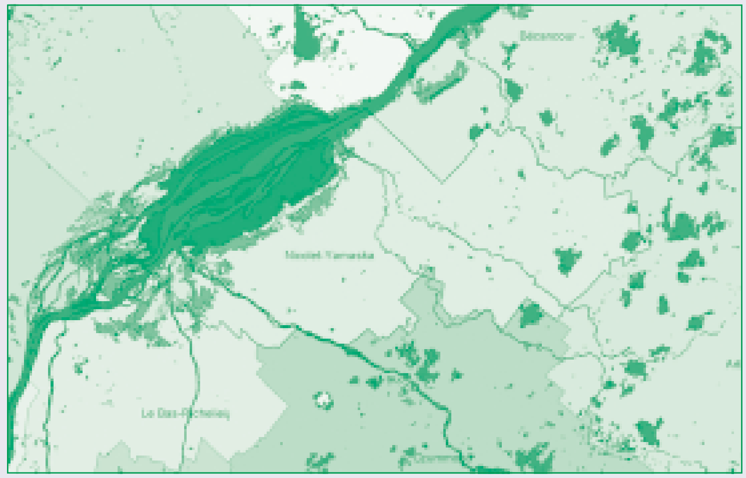
This evidence will not only help decision makers set standards to control the entry of harmful substances into the environment, but also help to prevent genetic abnormalities from being passed on to future generations. S&E



Rainbow trout are exposed to effluent in laboratory tanks in order to determine how exposure to toxic chemicals at critical developmental stages in their life cycle affect them at the molecular level.

WHERE THE BOGS ARE…

Like rainforests, wetlands are among the most productive ecosystems in the world. Their abundant supply of food and water and diverse ecological niches support hundreds of different species of plants and animals. Wetlands also act as natural filtration systems, purifying the water that flows into our lakes, rivers and wells, and provide opportunities for recreation.



Close-up of a map in the Wetland Conservation Atlas of the St. Lawrence Valley *showing the distribution of flooded forests, marshes, fens and bogs around the Lake St-Pierre Biosphere Reserve.*

Over the past century, however, the intensification of agricultural activities has resulted in the degradation or loss of 80–98 per cent of the wetlands in rural Canada. In the intensively farmed region of southern Quebec, over 4000 hectares of marsh habitat along the St. Lawrence River have been damaged or destroyed. In other parts of the St. Lawrence Valley, 45 000 kilometres of waterways have been straightened, and over 1.5 million hectares of land have been drained.

Knowing where Canada's remaining wetlands are located is crucial to conserving these vanishing habitats in human-dominated landscapes. As such, Environment Canada, the Canadian Space Agency, Ducks Unlimited, and Wildlife Habitat Canada have been working together since 1999 to develop the first *Wetland Conservation Atlas of the St. Lawrence Valley*.

The research team used a new classification method—known as hierachical tree analysis—to combine images taken by the Landsat and RADARSAT satellites with digital hydrological and topographical data and information from field observations, forestry maps, vegetation studies and other sources. The resulting 1:50 000-scale maps blanket the agricultural landscape of 68 regional municipalities in the St. Lawrence and Ottawa valleys—an area of over 40 000 square kilometres.

In addition to pinpointing the location of some 20 000 wetlands, the on-line atlas (which will be available on Environment Canada's Green Lane) will indicate the size, shape and type of each—from peatbogs, marshes and swamps to shallow water and flooded agricultural land. It will also provide definitions of the various wetlands and their roles, statistical and descriptive data for specific areas (number of wetlands, categories, average areas, etc.) and conservation options, and allow users to create their own maps from the original database.

Scheduled for launch in February 2003 at the National Conference on Canadian Wetlands Stewardship in Ottawa, the atlas will help land managers at the provincial and municipal levels and non-governmental organizations make informed decisions related to the use and conservation of wetlands in southern Quebec, and will open the door to a national wetlands inventory for the whole country. S&E

WHAT'S IN A NAME?

Boggled by the difference between a bog and a fen? Mystified by the meaning of "marsh"? Here's the low-down on which wetlands are which, based on the Canadian Wetland Classification System:

Bogs are wetlands with acidic waters that occur at or near surface level, over a thick accumulation of peat deposits. They are dominated by poorly decomposed sphagnum, low shrubs and, occasionally, wild flowers. **Fens** are similar to bogs, but support a greater number and diversity of plant species.

Swamps are wetlands associated with rivers, lakes and waterways. They have forest or shrub cover over at least 30 per cent of their surface and support a wide variety of plant species. **Marshes** are the most common wetland habitat in North America. They have a thin layer of surface water that varies in depth according to tides, floods, evapotranspiration and water flow and are made up of a mosaic of tiny stands of vegetation, open-water areas and muddy spaces.

Shallow waters are humid areas transitional between wetlands and open water with a deep-water zone.

RESEARCH CENTRE'S NEW LOCATION TO BOOST COLLABORATION WITH ACADEMIA

More than 50 Environment Canada staff, 500 000 wildlife specimens, and millions of dollars worth of laboratory equipment have moved from cramped quarters in a historic Hull building to a custom-built facility on the campus of Carleton University in Ottawa.

The National Wildlife Research Centre's (NWRC) five-level, $15-million building is almost twice as large as the centre's former home, with nearly 6000 m^2 of space—over half of it devoted to laboratories. The campus location was chosen to help foster closer collaboration with Carleton scholars by providing them with ready access to data, equipment, and specimens and by creating opportunities for NWRC scientists to mentor students. The new facility is linked physically with the university's biology department and equipped with office space for 24 graduate students.

Created in 1976, the centre is the largest wildlife toxicology laboratory in Canada. It is the federal government's principal source of knowledge and expertise on the impact of toxic substances on wild organisms and the use of certain species as indicators of environmental quality. Through data reviews, observational field-work, sample collection, and laboratory analyses and tests, scientists identify the toxic chemicals found in selected wild species, track their sources, and predict and measure their impacts from the physiological to the population level.

While much of the field work happens at regional sites, most laboratory work requires NWRC's sophisticated analytical equipment. Laboratory staff identify and quantify trace chemical residues—such as pesticides, industrial pollutants, and metals—and biological measures of effects in the tissues and organs of specimens collected in the field or in laboratory studies where the organisms (usually fertilized chicken eggs) have been exposed to controlled amounts of contaminants of interest.

The facility at Carleton features $2.2-million worth of new equipment, including a greenhouse and growth chambers for studying the fates and effects of herbicides. However, its most distinctive resource remains the wildlife specimen bank—a collection of primarily avian bodies, bones, organs, wings, blood, and eggs along with other tissue from amphibians, reptiles, mammals (particularly arctic), and plants. Built up over the past 25 years, the bank allows scientists to assess temporal and spatial trends in environmental quality as reflected by changes in types and levels of contaminants in wildlife.

The massive walk-in freezers where the specimens are stored (at a chilly -40°C) are 50 per cent larger in the new facility than in the old, to accommodate the more than 6500 new specimens that are added to the collection each year. To ensure that certain chemical processes that occur at higher temperatures are stayed until the tissues have been analyzed, some tissues are stored in ultra-low-temperature chest freezers or in special liquid nitrogen chambers, where the mercury dips to -196 °C.

Another important part of NWRC's work is conducting research and surveys on migratory bird populations—including seabirds, shorebirds, geese, and landbirds. Environment Canada biologists travel across the Western Hemisphere to study and monitor species' nesting and wintering sites, predation, and breeding and other behaviours. Their efforts have yielded important information on population trends, ecology, and climate change. The centre also administers and coordinates all of Canada's bird-banding projects and acquires and maintains data obtained from major national population surveys, including the National Harvest Survey and the North American Breeding Bird Survey.

The National Wildlife Research Centre's new quarters at Carleton University.

The National Wildlife Research Centre publishes the results of its studies in a variety of scientific and technical documents. By providing information and advice on factors that affect the health of wild species and ecosystems, the centre promotes conservation and protection and provides the scientific basis for policies and programs that prevent, mitigate, and redress the ecological effects of toxic substances. The opportunities for collaboration that will arise at the centre's new location will help to ensure that its resources are used to their fullest to further knowledge and expertise in these critical areas of study. S&E

SUPPORTING SUSTAINABLE DECISION MAKING

Canadians' understanding of the impacts human activity has on the environment has grown since the *Canadian Environmental Assessment Act* came into force in 1995. Today, an assessment process similar to that required under that act for major federal projects is being applied to some federal policies, plans and programs.

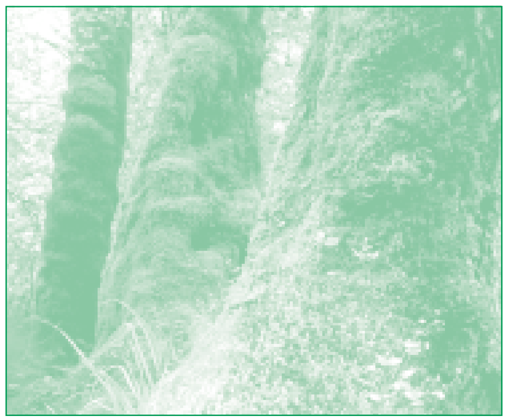
Known as strategic environmental assessment (SEA), this process is driven by a 1999 government directive that requires SEAs for all proposals with potentially significant environmental effects that are going to Cabinet or an independent Minister for decision. Examples include policies, plans and programs dealing with such issues as waste management, resource consumption, environmental conservation, land management and the regulation of pollutants.

Strategic environmental assessments help to improve decision making by identifying the environmental effects of a proposal at its conceptual stage, so it can be modified to accentuate benefits and mitigate negative impacts. In addition to reducing environmental damage, SEAs protect human health and well-being, reduce the costs of remedial action and streamline project-level assessments by identifying and addressing generic issues.

Over the past year, Environment Canada (EC) has been honing its SEA process to better support both the objectives of its *Sustainable Development Strategy* and its goals in priority areas such as clean air, water and biodiversity. EC is unique among federal departments in that all of its activities are aimed at protecting and enhancing Canada's environment. As such, it leads about 20 SEAs per year, in addition to providing analyses and advice to other departments and agencies. The department has completed SEAs on the proposed *Species at Risk Act*, the *Great Lakes 2020 Action Plan,* and oil and gas development in the Kendall Island bird sanctuary in the Arctic, to name a few.

Key Steps of an SEA

1. Identify the key environmental and other issues involved and their possible implications. Determine what information is required for the assessment and who should be involved.
2. Identify the options, including the status quo as a benchmark.
3. Assess the likelihood and magnitude of the effects of each option on the aquatic, terrestrial and atmospheric environment, including wildlife and human health.
4. Determine what can be done to enhance the positive effects of these options and to avoid or reduce the negative effects. Also, determine what potential environmental effects could remain after mitigation.



Strategic environmental assessments help to improve decision making by identifying the environmental effects of a proposal at its conceptual stage.

At Environment Canada, SEAs are carried out by small teams with expertise in such areas as policy, operations and science. Information is collected through research, original studies and consultations with external advisors, stakeholders and members of the public. Science plays a vital role in analyzing and predicting effects, supporting claims, developing sustainability indicators, and devising the latest mitigation and enhancement measures.

In formulating a policy on oil and gas development in the Kendall Island bird sanctuary, for example, Environment Canada considered effects on sensitive arctic habitat, migratory birds and the quality of water, air and land. It also examined indirect economic and social impacts resulting from environmental impacts, including the cost of habitat restoration and effects on the traditions and livelihoods of local hunters and communities.

Although SEAs play a vital role in shaping policies, plans and programs before they are implemented, these products should continue to evolve over their life cycle. Post-assessment monitoring and follow-up can help to evaluate the validity of impact predictions and the effectiveness of mitigation measures, and to identify any changes that would improve environmental benefits.

Environment Canada is publishing an updated manual, training CD-ROM, brochure, and poster on SEA—all of which will be available by the end of 2002. These tools will help to ensure that environmental considerations remain a priority at the highest levels of decision making. S&E

S&E Bulletin

This bi-monthly newsletter provides information on Environment Canada's leading-edge science and technology.

Find out more about the subjects in this issue and previous ones by visiting our S&E Web site at [www.ec.gc.ca/science]. Many departmental publications mentioned in the *Bulletin* are posted on Environment Canada's Green Lane at [www.ec.gc.ca], or can be ordered from the Inquiry Centre at 1-800-668-6767.

Scientific contacts may be obtained from the *Bulletin*'s editor at Amanda.Cahoon@ec.gc.ca, or (819) 953-6846. Comments and suggestions are also welcome.

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