S&E SCIENCE AND THE ENVIRONMENT BULLETIN S&E
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SMOKE ON THE WATER

Ask cottagers the last place they would choose to swim, and most will say the local marina, where motorboats leave shiny pools of oil on the water's surface and clouds of blue exhaust in the air. The old-style, two-stroke engines that power the vast majority of Canada's approximately three million watercraft are major environmental polluters, fouling the marine environment and spewing large amounts of pollution into the atmosphere each year.

Emissions from non-road sources, such as power boats, lawn and garden equipment, and construction vehicles, comprise approximately 20 per cent of all smog produced by mobile sources in Canada. Unlike cars, however, marine engines have never been subject to emissions regulations and, as a result, are considerably less clean and efficient. According to estimates, a 70-horsepower (hp) two-stroke outboard emits the same mass of hydrocarbon pollution in one hour as a new car does driving 8 000 kilometres.

Lighter, relatively inexpensive, and long-lasting, two-stroke engines have remained essentially unchanged since the 1940s. What makes them so inefficient and dirty is that the exhaust ports in the cylinders remain open for a short period of time while a charge of fuel and air flow into the combustion chamber from the intake port. This design results in some fuel exiting the cylinder before the exhaust port closes. As a result, the engine exhausts, unburned, as much as 40 per cent of its fuel. Another problem with two-strokes is that they require a mixture of oil and gasoline — so some of the exhausted fuel is raw oil.

Although outboard motors exhaust their emissions into the water, recent studies of their impacts on lakes revealed that most hydrocarbon compounds in the water migrated into the air within six hours, and that samples taken about a metre below the surface showed no contamination. However, heavier hydrocarbons, such as oil and grease, remain on the surface for a longer period of time and may affect the health of microscopic organisms.

To get a clearer picture of the content of marine engine emissions, Environment Canada's Environmental Technology Centre (ETC) in Ottawa began testing outboard exhaust for total hydrocarbons, nitrogen oxides, carbon monoxide, carbon dioxide, oil and grease, and BTEX (benzene, toluene, ethylbenzene, xylenes) — carcinogenic or mutagenic aromatic hydrocarbons formed through the combustion process.

ETC's tests showed that two-stroke outboards produce 12 times as much BTEX as four-strokes, and five times as much oil and grease. Further comparisons of the exhaust emissions from a light-duty van, a 9.9-hp two-stroke outboard and a 9.9-hp four-stroke outboard showed that the two-stroke produced 50 per cent more carbon monoxide than the four-stroke and nearly 60 times more than the van. The two-stroke also emitted 15 times more unburned hydrocarbons than the four-stroke, and nearly 125 times more than the van.

Comparisons such as these shed light on the disparity between the emissions from on-road vehicles and outboard engines. On-road vehicles have been subject to emissions standards in Canada since the mid-1970s, which led to more advanced emissions control technologies being developed and applied. A significant reduction in emissions from these engines has been the result.

To address the issue of air pollution from marine engines in the near-term, Environment Canada and the Canadian Marine Manufacturers Association (CMMA) announced a Memorandum of Understanding in January of this year to voluntarily introduce cleaner outboard engines and personal watercraft (PWC) into the Canadian marketplace.

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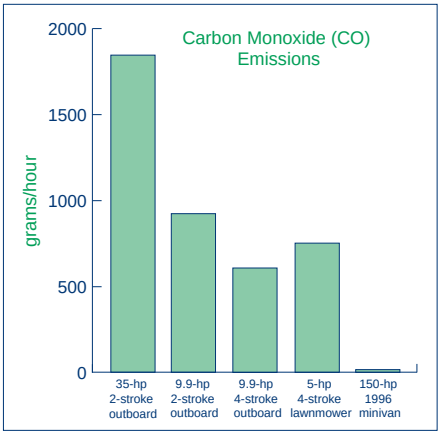
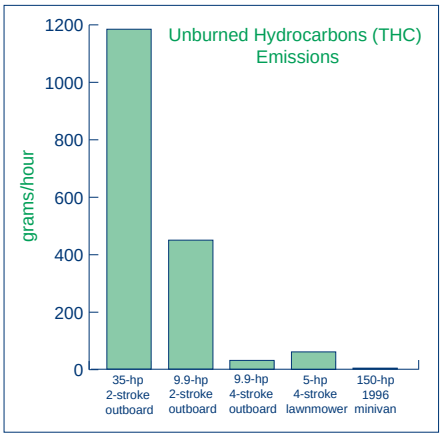
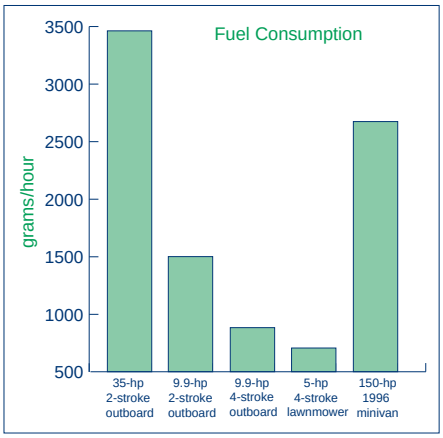






Results of emissions tests carried out at ETC on a 35-hp two-stroke engine, 9.9-hp two-stroke and four-stroke engines, a 5-hp four-stroke lawnmower and a 150-hp 1996 minivan. All quantities are represented in grams per hour.

Under the terms of the Memorandum, new outboards and PWCs sold in Canada beginning with model-year 2001 must comply with United States Environmental Protection Agency (EPA) emissions standards for marine spark-ignition engines, and must come with an emissions warranty. The U.S. federal emissions standards seek to reduce levels of hydrocarbon emissions from gasoline outboards and PWC engines by 75 per cent over pre-control levels. These rules, which establish increasingly stringent emissions standards, have been gradually phased in since 1998, and will be fully implemented by 2006.

According to the CMMA, the Memorandum will ensure that newer, more efficient technologies will make it to the Canadian market, and that Canada won't be a dumping ground for non-compliant, older technology that is not certified for sale in the United States or other countries with emissions regulations. Consumers will see a significant change in the product line-up as a result. This new generation of engines and watercraft will be not only cleaner, but also more efficient — thereby reducing the consumption of fossil fuels and the creation of greenhouse gases that contribute to climate change.

In order to meet the EPA regulations, most outboards of less than 90 hp will likely employ four-stroke technology in the future. In comparison to two-strokes of the same horsepower, four-strokes consume about 30 per cent less gasoline at full speed, and as much as 80 per cent less when idling. They also produce less than 20 per cent of the pollution, and run more smoothly and quietly.

The reason for the increased efficiency and lower emissions is that the intake valve on a four-stroke opens to admit the air-fuel mixture only after all the exhaust valve at the top of the cylinder has closed. Also, because the lubricating oil is contained in an isolated reservoir, similar to that in automobiles, the design prevents this oil from entering the air-fuel mixture. This, in turn, prevents oil from being exhausted into the environment.

Two-stroke outboards aren't out of the picture, however, as several two-stroke Direct Fuel Injection (DFI) systems have been developed that eliminate the emission of unburned fuel from the combustion process. DFIs use high-pressure pumps to blast precisely timed bursts of fuel directly into the engine's combustion chambers after the exhaust port is closed. More complex and costly than regular two-strokes, DFIs have been on the market for some four years, but have generally been limited to models over 100 hp and to larger, more cost-effective markets. Although the engines haven't been the subject of emissions testing at the ETC yet, manufacturers claim they meet the 75 per cent hydrocarbon reduction target, and are 35 per cent more fuel-efficient than their conventionally carbureted two-stroke predecessors.

Both four-strokes and DFIs are more expensive than old-style two-strokes, but savings in fuel costs mean that buyers will quickly recoup their investments. Manufacturers have also developed small catalytic converters for use on outboards that show emission reductions of 73 per cent in some cases. However, because of engineering challenges, these devices have not yet seen widespread application. Diesel outboards also show a great deal of potential in terms of reduced emissions and greater fuel economy, but represent a very tiny percentage of the total market at present due to their higher cost and the lack of filling stations.

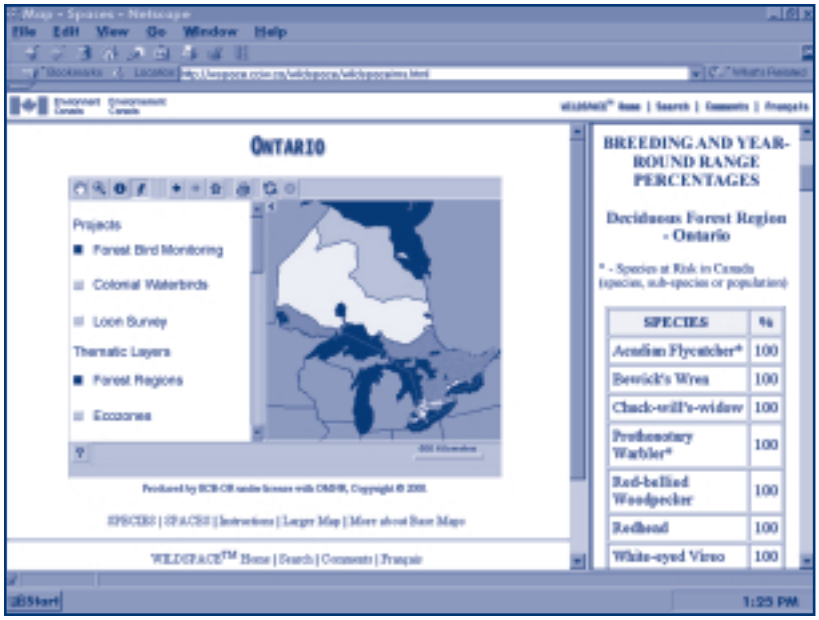
Policy experts and scientists at Environment Canada are currently developing a vehicle, engine and fuel action plan to address air pollution from mobile sources as one of a number of steps toward improving air quality in Canada. This plan, which will include input from stakeholders, will identify emission control programs, including regulations, and will be implemented over the next 10 years. The Memorandum of Understanding on marine engines will not only help bring Canada's marine industry into step with the most progressive jurisdictions, but also prepare it for the possible introduction of more stringent control programs in the future. SE

TAKE A WALK ON THE WILD SITE

Some of the most important wildlife and habitat research Environment Canada scientists in Ontario have conducted over the past 50 years is the foundation of an interactive web site that enables users to explore species and spaces — particularly birds and their habitats — by combining different thematic layers of information on digital maps.

The dynamic new web site is the latest offshoot of Project *WILDSPACE*™ — an effort launched by the Canadian Wildlife Service (CWS) in 1996 to pull its diverse data holdings together into an information management system. The site, which has been under development since 1998, enables users to learn about some of this research, and provides access to a wealth of information on wildlife.

Visitors to the site can search from either a species or spaces perspective. A species search provides links to detailed information on 431 species of Canadian birds, including colour photos, life history, sound bytes of calls, range and breeding area maps, and research activities. Limited information is also available on a number of reptiles, amphibians and mammals. A spaces search gives the user the option of choosing from maps of the Western Hemisphere, Canada or Ontario, and then selecting from a list of geographically referenced themes, such as ecozones, ecoregions, provinces, and research projects to query for information. It is even possible to generate correlations between themes and species, such as the percentage of a bird's breeding range that falls within a certain geographic area.



Computer screen showing interactive mapping capabilities on the Project WILDSPACE™ Internet site.

The web site is a more visual, simplified and condensed version of some of the data used by the *WILDSPACE*™ decision support system (DSS), an analytical, planning and management tool that enables scientists, resource managers and decision makers to carry out more complex queries on the temporal and spatial distribution of wildlife. The DSS, which currently has access to more than half of the 60 data sets compiled to date, can instantly calculate changes in bird populations, breeding densities and other spatial information, factor in other attributes, such as political boundaries, and transfer the resulting summary onto a thematic map. This ability to highlight trends or anomalies makes it an invaluable tool for environmental assessment and management.

The creation of the information management system, DSS and web site, is an ongoing effort involving expertise from across the Department and cooperation with a wide range of government and non-government partners. CWS's role is to identify and gather data sets through questionnaires and interviews with scientists, ensure that all taxonomic references are standardized, and format the information for the system — a major undertaking for some older data, which are handwritten on file cards. Experts at the National Water Research Institute developed the decision support system that generates knowledge from these diverse research efforts and techniques, while the Meteorological Service of Canada provided digital base maps, created hundreds of static maps and an interactive mapping system for the web site, and is responsible for ensuring that all the data in the database are correctly referenced on global coordinates.

Since its inception as a primarily Ontario-based project, *WILDSPACE*™ has expanded to include information on all Canadian breeding birds and a variety of CWS projects beyond the province's borders. Organizers hope that more detailed information on other animal species will soon be added, along with data on habitats and projects across Canada. In the meantime, plans are under way to post photos of typical breeding habitats of birds, as well as their nests, eggs and young, and to devise a way for volunteer wildlife monitors to input observations directly to the web. In the future, the multi-media site could feature everything from video clips to interviews with experts. Visit *WILDSPACE*™ at [http://wildspace.ec.gc.ca]. S&E

THE ARCTIC: CLEAN OR CONTAMINATED?

White snow as far as the eye can see, clean cold water, an uncontaminated haven in a polluted world — this is how people like to picture Canada's North. But these images have been challenged by an increasing body of research showing the presence of contaminants throughout Arctic ecosystems, sometimes at surprisingly high levels.

Roy Neureuther of NWRI excavating a 4-metre-deep snowpit at Amituk Lake, Cornwallis Island, NWT. Snow samples are collected for the measurement of organochlorine contaminants in the lake basin.

Researchers from Environment Canada's National Water Research Institute (NWRI) are working with other experts in Canada and around the world under the Arctic Monitoring and Assessment Programme (AMAP) to learn more about the extent of these contaminants and their biological effects. NWRI's research has focused on the scientific assessment of persistent organic pollutants (POPs) in the circumpolar Arctic. These chemicals from agricultural and industrial activities in the south are transported north mainly by atmospheric processes, and enter aquatic ecosystems when snow and ice melt in spring.

POPs enter the food chain when they are consumed by aquatic species, and because they are slow to degrade, they bioaccumulate in their tissue. When these species are, in turn, eaten by others further up the food chain, concentrations magnify dramatically. The process is a cause for concern not only because of potential effects on Arctic wildlife, but because of possible impacts on northern peoples, who may be exposed through consumption of traditional foods like fish, marine mammals, birds and caribou.

In 1997, AMAP released a report presenting all available data on organic pollutants in Arctic air, seawater, sediments, and terrestrial, freshwater and marine biota, and gave governments of the eight Arctic countries a clearer picture of the state of the Arctic environment. It also identified gaps in knowledge and recommended further actions to identify sources of pollutants and determine biological effects. Work to address these gaps through further collaborative research has been ongoing ever since.

In Canada, for example, NWRI researchers have begun studying POPs in landlocked char fish in Resolute and Char lakes in the central Canadian archipelago, and are planning to collect annual samples to follow changes over time. In another study, lake sediment cores are being collected along a north-south transect in the Canadian Arctic to learn more about the sources, long-range transport and impacts of new and old organic pollutants and of mercury, a toxic metal increasing in concentration in the Arctic.

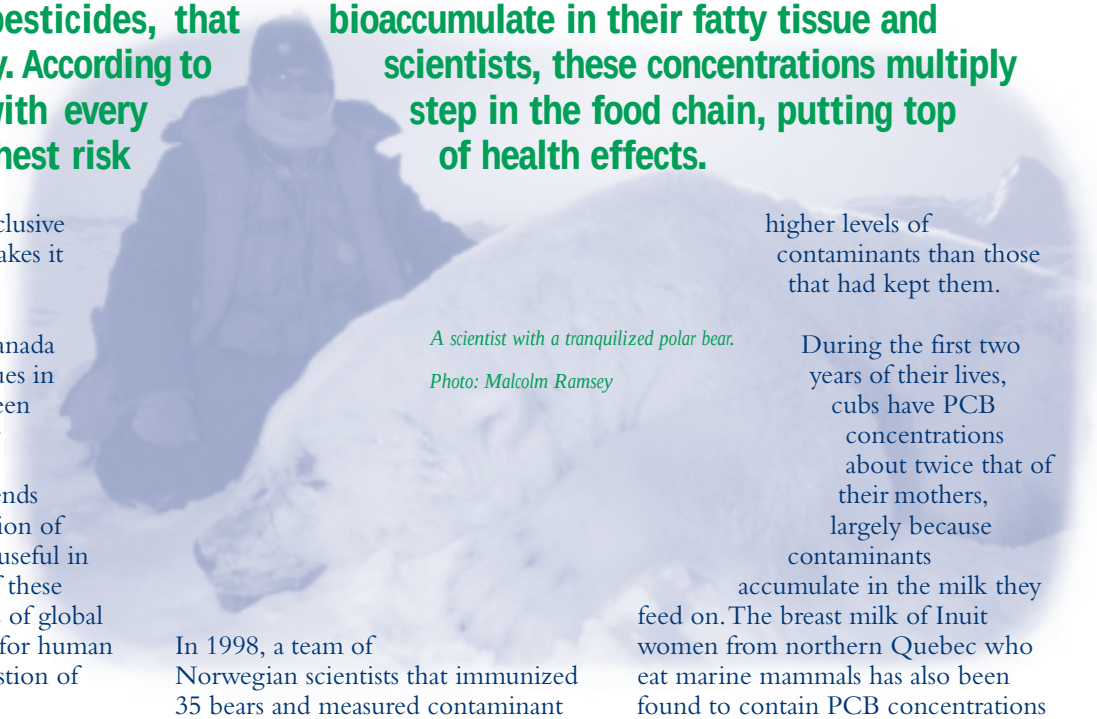
Other work focuses on achieving a better understanding of the behaviour of contaminants in high Arctic lakes. Researchers developed a model that took the unique characteristics of these lakes into account and applied it to Amituk and Char lakes. Their results suggest that Arctic lakes act as conduits, not sinks, for chemicals. Most contaminant loading comes from snowmelt and most is exported from the lake, leaving minimal amounts in the sediment. This finding provides important insights into the potential exposure of aquatic biota to contaminants in lake ecosystems.

Researchers involved in northern contaminant research not only publish their work in scientific journals and reports, but also bring this information back to the North to share it with those who are directly affected by contaminants in their environment. Recently, NWRI scientists participated in a tour of hamlets in the Eastern Arctic to make presentations on POPs and metals in marine mammals and birds collected near each community.

These and other studies contribute to Canada's efforts to reduce contaminants in traditionally harvested foods, and help provide the scientific foundation for international agreements to control environmental contamination. Environment Canada experts were in Germany this March for the fourth of five negotiating sessions to develop a global convention on POPs. Canada is one of more than 100 countries involved in the effort, which is aimed at eliminating or reducing emissions of 12 toxic substances linked to health issues in the North. S&E

POLAR BEARS AT THE TOP OF THE POPs

Wild prey provide predators with plenty of protein and energy, but they also pass along persistent organic pollutants (POPs), such as polychlorinated biphenyls (PCBs) and chlorinated pesticides, that bioaccumulate in their fatty tissue and degrade very slowly. According to scientists, these concentrations multiply five- to tenfold with every step in the food chain, putting top feeders at the highest risk of health effects.



A scientist with a tranquilized polar bear.

Photo: Malcolm Ramsey

The polar bear's almost exclusive diet of fatty ringed seals makes it one of the most highly contaminated of all Arctic mammals. Environment Canada scientists and their colleagues in other polar nations have been monitoring bear tissues for more than two decades to determine geographical trends in the type and concentration of POPs. This information is useful in determining the sources of these pollutants, the effectiveness of global controls, and the potential for human exposure through the ingestion of wild foods.

PCBs and other toxins can mimic, block or disrupt the function of naturally occurring hormones in both humans and wildlife, and have been implicated as a causative factor in cancer, embryonic malformation, sterility, growth retardation, immunologic dysfunction, and reproductive abnormalities. Relatively high levels of PCBs and compounds related to the pesticide chlordane have been found in polar bears — with concentrations in the order of 10 parts per million (ppm) in the Canadian Arctic and up to 100 ppm in the European Arctic, likely due to pollution from sources in Europe, Asia and North America.

There is increasing evidence that PCBs and other organochlorines may affect the immune systems of wildlife, even at very low concentrations. Studies of harbour seals that were fed PCB-contaminated fish showed that immune suppression occurred at a much lower level than other effects — and at levels similar to those found in polar bears in some areas of the Arctic.

In 1998, a team of Norwegian scientists that immunized 35 bears and measured contaminant concentrations in their blood found that bears with higher levels of PCBs had lower levels of a group of proteins that function as antibodies. The study was repeated in 1999 with Canadian polar bears, and the data are currently being analyzed.

Organochlorine levels have not changed much since the beginning of accurate polar bear population assessments in the early 1970s, so reproductive effects are difficult to determine. PCBs, DDT or their methylsulfone metabolites are suspected of causing reproductive failure in grey and ringed seals in the Baltic Sea, but at much higher concentrations than in the Arctic. The fact that POPs relocate to target organs when fat reserves are used makes it likely that female bears, fetuses and cubs are at the highest risk from toxic effects because the females fast for up to seven months of the year. Although this theory remains to be proven, a recent study showed that females who had lost cubs sometime during the first year after birth had higher levels of contaminants than those that had kept them.

During the first two years of their lives, cubs have PCB concentrations about twice that of their mothers, largely because contaminants accumulate in the milk they feed on. The breast milk of Inuit women from northern Quebec who eat marine mammals has also been found to contain PCB concentrations 2 to10 times higher than that of women in the southern part of the province.

Last year, Environment Canada and researchers at the University of British Columbia carried out tests to determine whether testosterone metabolism in male bears is affected by increased concentrations of enzymes in the animals' livers induced by high levels of PCBs. The Department is also working with Carleton University in Ottawa to test the hypothesis that hydroxy PCB metabolites found in polar bear blood may be interfering with the transport of Vitamin A and a thyroid hormone in blood.

By improving our understanding of the effects of persistent toxic pollutants on human and wildlife health — and determining geographic and temporal trends in contamination levels — the results of these and other studies will help policy makers identify priorities and effective strategies for controlling airborne toxics. S&E

WHAT'S GOOD FOR THE GOOSE?

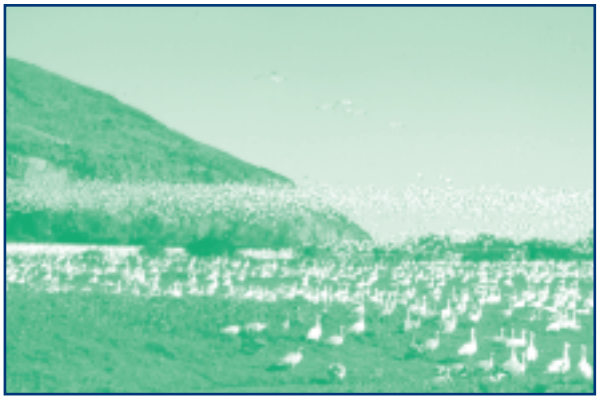
Every spring, giant flocks of Greater Snow Geese stop along the banks of the St. Lawrence River to rest and refuel on their annual migration to their breeding grounds on the Arctic tundra. The sights and sounds of a sea of white geese feeding in a field are a marvel to visitors, but a nightmare to Quebec farmers — who suffer nearly a million dollars in crop damage each year as a result.

In the early 1900s there were only a few thousand Greater Snow Geese in Canada, but the creation of refuges, the introduction of laws prohibiting spring hunting, and the banning of sport hunting in the United States before 1975 enabled the population to take off. The species' count jumped to 20 000 by 1940 and almost 70 000 by the end of the 1960s, by which time the geese had already begun feeding on farmland. A decade later, agricultural regions of the birds' staging area east of Quebec City were being plagued.

Boosted by this abundant new source of food, the birds' reproductive success increased. This, combined with a drop in the number of hunters and the goose's lack of popularity as a game bird in the U.S., caused the population to explode tenfold over the past two decades. By the spring of 1999, the species numbered just short of a million, and had expanded its staging area from 80 to approximately 400 kilometres of land along the St. Lawrence River.

Environment Canada scientists in Quebec became involved in the issue in the early 1990s, when the provincial and federal agriculture departments began compensating farmers for goose-caused crop damage. Effective intervention was needed to avoid the kind of acute habitat destruction caused by the overpopulation of the Lesser Snow Goose — a mid-continental sub-species that is destroying its breeding habitat on the west coasts of James and Hudson bays, and causes up to $3 million damage to farmland each year. This extensive degradation is affecting numerous other bird and animal species.

In 1996, the Canadian Wildlife Service in Quebec formed a multi-stakeholder Greater Snow Goose Committee made up of wildlife and agricultural managers at all levels of government, scientists, farmers, birdwatchers, conservationists and tourist operators in order to find ways to tackle the issue, while at the same time maintaining economic spin-offs from tourism and hunting that generate about $21 million a year in Quebec.



Snow Geese feeding on farmland.

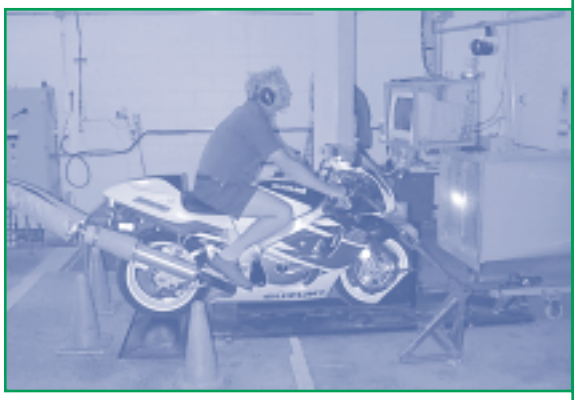
Canadian and American scientists with the Arctic Goose Joint Venture gathered information on the species' population dynamics, and recommended stabilizing the population by 2002. To achieve this, the group recommended doubling the current rate of harvest to about 24 per cent of the population per year by implementing a spring conservation hunt, increasing quotas, and permitting the use of electronic calls, baiting, and lure crops. As a result, Canada, the U.S. and Mexico agreed to amend regulations in staging and wintering areas to allow the species to be controlled for conservation purposes.

The multi-stakeholder committee supported the decision to implement a spring hunt in 1999 for the first time since 1916, when Canada and the U.S. signed the migratory bird treaty. Although organizers expected some 5 000 hunters to register, the total topped nearly 14 000, with 44 000 birds harvested between mid-April and the end of May. Combined with the previous fall harvest and the American harvest over the same period, that total came to about 250 000 Greater Snow Geese, or almost 24 per cent of the fall population — as hoped.

In 1999, agricultural losses in green crops were down 45 per cent over 1998, with a 38-per-cent reduction in the number of hectares affected. However, there was a 24-per-cent increase in grain crop damage, despite the fact that the number of hectares affected was similar in both years.

While the hunt takes place again this spring, Environment Canada will complete a document detailing other work that needs to be done on the issue — including more scientific research into and monitoring of the carrying capacity of wintering, staging and breeding habitats, and studies of the socio-economic and ecological problems associated with overabundance. S&E

TAPPED TAILPIPES HELP PROFILE PARTICLES



Motorcycle emissions testing at Environment Canada's Environmental Technology Centre.

When vehicles burn fossil fuels, they emit a mixture of gaseous chemicals and particulate matter into the air. Some of these chemicals — such as oxides of nitrogen (NO_x), sulphur dioxide and volatile organic compounds (VOCs) — also form fine particles when they react in the atmosphere. Studies suggest that the smaller these particles are, the deeper they can be inhaled into the lungs and the greater their effect on respiratory and other health problems.

Although scientists have been measuring the mass concentration of particles in the air for more than a decade, growing interest in developing air quality standards for this form of pollution has spurred the need for more specific information about how it is formed, what it is made of, and where it comes from.

To answer these questions, scientists with Environment Canada (EC), Health Canada, the National Research Council and Natural Resources Canada launched a three-year project in 1998 to study fine particulate matter from the transportation sector — the largest human-made source of NO_x and VOCs in Canada. The project, which focuses on cars and trucks, was recently extended for another four years with plans to include other transportation sources such as off-road vehicles.

The project is aimed at developing detailed emissions profiles — including chemical make-up and size distribution — of fine particulate matter emitted from motor vehicles. By also collecting and analyzing ambient air samples, scientists can then use these profiles to calculate what percentage of atmospheric particle loading in populated areas is due to transportation, and what percentage of this is formed through atmospheric reactions. This knowledge is being used to develop models for forecasting how atmospheric loading would change as a result of different policies on transportation or transportation fuels.

Environment Canada developed sample collection and chemical analysis methods for both the source and ambient particulate matter, and spent last year testing these techniques in the lab and in the field. The Department's Environmental Technology Centre collected emission samples in its Ottawa lab from cars, light-duty trucks, buses and, for the first time, motorcycles. The Centre's technicians also spent five weeks in Vancouver measuring particle and gaseous emissions from more than 75 in-use vehicles at the BC Air Care Centre. The vehicles, which ranged from 1978 to 1998 models, were also checked for differences in the grade, brand and sulphur content of their gasoline.

Early results indicate that, in general, older cars emit more particles than newer ones, that oil-burning vehicles produce very high quantities of particles, and that well-maintained vehicles emit less than others. This year, the team will concentrate on completing analyses of the data collected last year, and has proposed collecting samples from new low- and ultra-low-emission vehicles as well.

Air-quality experts from EC's Meteorological Service of Canada tested their ambient air collection and chemical analysis techniques in studies in Toronto and southern Ontario last summer, and will be doing similar studies in Toronto and Vancouver over the next two years. One part of the Vancouver program will be a tunnel study, in which the ambient air at the entrance and exit of road tunnels is analyzed and results are used to determine particles and other chemicals emitted over a certain time or distance by a given number of vehicles. The Department is also working with atmospheric chemists from several Canadian universities, who are developing new sampling and analysis technologies and studying the transformation of gaseous chemicals in the atmosphere.

By synthesizing this information into computer models that simulate the formation and deposition of fine particulate matter and forecast the effects of possible changes in policies and transportation use, Environment Canada's scientists are helping identify effective strategies for controlling the formation of particles and ground-level ozone. The next area that needs to be looked at is stationary sources such as incinerators and coal-fired power plants, and their relative contributions to particulate matter and other forms of urban air pollution. SE

STUDY EXAMINES AIR POLLUTION IN PRISTINE AREAS

Bison at Elk Island National Park.
Photo: Charles Ebbs

A wild landscape of trembling aspen groves and rough fescue grasslands, Elk Island National Park is a refuge for many rare species in Alberta — from elk and bison to Trumpeter Swans. Its location just 35 kilometres downwind of Edmonton and its proximity to Fort Saskatchewan Industrial Park and rural farming operations makes this parkland susceptible to pollution from beyond its borders.

Concerned over the impact of urban emissions on human and environmental health, and the transport of human-made pollutants to pristine areas, Environment Canada launched an air quality study in the park in the summer of 1998. With the help of scientists from Parks Canada, the Department installed special air-monitoring equipment to measure fine particulate matter in the park's air. Fine particles (called $PM_{2.5}$ because they are 2.5 microns or less in diameter) are a major health concern because they are small enough to be inhaled, and have been linked to respiratory problems in human beings.

Proposed industrial development in the Fort Saskatchewan area has also generated interest in a cooperative process to address these concerns. The Fort Air Partnership, a multi-stakeholder group made up of representatives from industry, government, and non-government organizations, is establishing a network of air quality sampling stations in the region to monitor these effects, and Elk Island will be one of its key sites.

Preliminary measurements of $PM_{2.5}$ at Elk Island show concentrations only slightly lower than in Edmonton. While this is still lower than in most major cities in Canada, such as Montréal and Toronto, it is three times the level measured at clean rural locations. Analysis of the wind speed and direction confirmed that the city is the main contributor, while the industrial park and agricultural regions are secondary sources.

Although a great deal of work has been done on pollutants in areas like Toronto and Vancouver, little has been carried out at latitudes above 50^0 North. The Elk Island project provides an opportunity to study the generation of fine particles under climatic conditions that are unique to this northern latitude.

Data gathered at the park show particulate concentrations increase at both warm and cold temperatures. In winter, increased use of fossil fuels for transportation, heating and power generation from urban and industrial sources appears to be part of the reason. Scientists also noted a daily increase in fine particulate matter around 9 a.m. and again from 6-7 p.m. throughout the year, due to rush-hour traffic. This made it possible to calculate the speed of atmospheric transport from Edmonton to Elk Island at about two hours.

The next step in the project will be to install ozone-measuring and chemical analysis instruments at Elk Island this summer. This will enable scientists to determine the relative contribution of urban, industrial and agricultural sectors and different activities within them to fine particulate mass in the park's air. Tracking pollutants to their sources — whether they be coal-fired power plants or motor vehicles — will help Edmonton and other cities with similar concerns plan more effective energy-efficiency or clean-air campaigns.

Another aspect of the Elk Island project will be to investigate the respiratory health of the bison in the park to determine the effects of low-level continuous exposure to fine particulate matter and ground-level ozone. Efforts are currently focused on finding a way to attach air quality monitors to several of the animals when they are rounded up for their annual medical examinations this fall.

The information gathered through these efforts will not only serve as a baseline for gauging the impact of future development, but also improve efforts to protect pristine areas of the country from the effects of urban air pollution. S&E

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SCIENCE AND THE ENVIRONMENT BULLETIN

is a bi-monthly publication produced by Environment Canada to provide information on leading-edge environmental science and technology to Canadians.

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For more information on a subject, you can search all of the on-line resources available from Canada's four natural resource departments — including *S&E Bulletin* — by using the CanExplore search engine at [www.canexplore.gc.ca].

Media representatives and others interested in conducting further research may obtain contact information from the *Bulletin*'s editor, Paul Hempel, at Paul.Hempel@ec.gc.ca, or (819) 994-7796. Readers' comments and suggestions are also welcome.