

# Environment Canada's Science Plan



## A Strategy for Environment Canada's Science



Environment  
Canada

Environnement  
Canada

Canada



# **Environment Canada's Science Plan**

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# Message from the Assistant Deputy Minister

This Science Plan represents a significant step in a continuing effort by Environment Canada to strengthen the role of environmental science in helping the Department support environmental quality, human health and safety, and economic prosperity.

In November 2004, the Deputy Minister's external Science and Technology Management Review Panel made two major recommendations to improve the planning and management of science at Environment Canada: the establishment of a Science and Technology Branch to strengthen the Department's overall management of environmental science; and a commitment to long-term science planning in the Department to ensure that we have in place the high-quality science we need to address current and emerging challenges.

The first step in responding to the Review Panel's recommendations came in September 2005, with the establishment of the Science and Technology Branch, bringing much of Environment Canada's science and technology under one Assistant Deputy Minister.

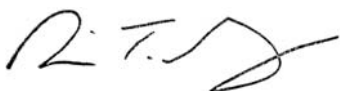
With the Science Plan – which, with time, will be integrated with the Department's Technology Plan – we have taken the second major step. This Plan provides the first strategic look at a major activity that cuts across the full range of the Department's activities. It will bring a more integrated and collaborative approach to environmental science within Environment Canada and with our external partners. And it will ensure that we continue to effectively apply our science resources – our excellent staff, infrastructure and funds – to the priorities of Canadians.

Collaboration is a fundamental requirement of high-quality science, and so too has it been with the development of the Science Plan. We have greatly benefited at every step from the perspectives and ideas of our own scientists and managers, and of our colleagues in other federal departments, other jurisdictions, academia and the private sector. Early on, we brought together 45 scientists, managers and policy makers to look at major themes and critical interdependencies for the Department's science. As the Plan developed, we held information sessions across the country with more than 500 individuals. Finally, we asked our world-class External Science Review Panel members for feedback on the content and direction of the Plan. The final result truly represents a shared effort among many individuals and organizations that care about our environment and about high-quality environmental science in Canada.

On behalf of Environment Canada, I want to express my sincere appreciation to our staff and to all of those who participated in developing the Science Plan.

No matter your discipline, jurisdiction or organization, I invite you to read this Plan – and to think about the challenges and directions it sets out for environmental science in Canada. I also want to let you know that developing the Plan is only the beginning – we will continue to seek your collaboration and ideas as we move forward to implement the Plan and strengthen the role of environmental science in the years ahead.

I look forward to working with you.



**Brian T. Gray, Ph.D.**

*Assistant Deputy Minister, Science and Technology Branch*





## Executive Summary

### Purpose of the Science Plan

Environmental science has a strong role to play in helping society attain and enhance environmental quality, human health and safety, and economic prosperity. This Science Plan sets out a vision for managing and conducting Environment Canada's science over the next 10 years.

The Plan will:

- Ensure that Environment Canada's science activities continue to contribute to government and departmental priorities;
- Create opportunities for greater integration of science within Environment Canada and improved collaboration with science partners outside the Department;
- Promote the highest standard of scientific excellence to help the Department deliver on its program, policy and service responsibilities;
- Ensure that the Department uses its science resources – people, infrastructure and funds – effectively; and
- Help the Department's corporate-wide functions (such as human resources and finance) better support science.

**This Science Plan sets out a vision for managing and conducting Environment Canada's science over the next 10 years.**

### The Mission

The Science Plan sets out the following mission for Environment Canada's science:

*To deliver the high-quality knowledge, information and data that enable the Minister, the Government, the Department and other decision makers to enhance the health and safety of Canadians, protect the quality of the natural environment, and advance Canada's long-term competitiveness.*

### Challenges and Opportunities for Environment Canada's Science

What environmental science will be needed over the coming years – what are the challenges where we will need to apply our scientific resources and experience, facilitate the development of new science and influence others?

In the area of *environmental sustainability*, major challenges for environmental science include: strengthened predictive models, conserving natural capital, cumulative risks, and resilience of ecosystems and the water supply.

In the area of *weather and environmental services*, major challenges include: environmental prediction capability; cumulative impacts, risks and vulnerabilities; and adaptation and resilience.

Finally, in the area of *environmental protection*, major challenges for environmental science include: improved predictive models, cumulative risks, integrated risk management tools, and emission reduction tools and mitigation science.

## Strategic Directions for Environment Canada's Science

The Science Plan outlines three long-term directions to guide the Department and its science partners as we work together towards the vision of *environmental sustainability as a means of improving human and environmental health and promoting long-term competitiveness*.

### 1. Developing an Integrated Environmental Monitoring and Prediction Capability

Better understand the changing state of the environment through the development and use of a multidisciplinary environmental monitoring and prediction capability.

Environment Canada's science should focus on:

- Moving to more comprehensive and integrated environmental prediction models and environmental monitoring systems;
- Moving to finer time and spatial scales for predictions and analyses of environmental systems; and
- Expanding lists of environmental parameters to be measured on finer time and spatial scales.

### 2. Understanding Cumulative Risks

Develop and implement strategies and tools to anticipate, understand, characterize and communicate:

- the cumulative impacts on, and risks to, human and ecosystem health and security from multiple stressors interacting over time; and
- the risks to, and opportunities for, Canada's long-term competitiveness resulting from a changing environment.

Environment Canada's science should focus on:

- Understanding past and present trends, future projections and scenarios for environmental change, and the sensitivities of various ecosystems, societal needs and economic sectors to those changes;
- Developing tools to increase our ability to assess the cumulative risks and opportunities arising from existing environmental stressors;
- Developing a capacity to systematically identify and characterize the impact of individual and cumulative threats to human and ecosystem health and long-term competitiveness – before they occur; and
- Strengthening our capacity to communicate the results of our science to various user groups, including policy analysts, and to transfer science, technology and information to providers of essential services.



Canada's delicate Northern ecosystems are particularly sensitive to environmental stressors.

### 3. Managing Risks, Optimizing Opportunities and Building Resilience

Help clients reduce risks and take advantage of opportunities arising from the changing environment, while building greater resilience in Canada's environment, communities and key economic sectors.

Environment Canada's science should focus on:

- Developing knowledge-based approaches and systems to assess priorities for action and recommend interventions and risk management strategies;

- Understanding the costs and benefits of the various risks, and assessing the opportunities and barriers to implementing risk management strategies;
- Increasing the capacity to apply real-time weather and environmental predictions to meet the short- and long-term needs of Canadians;
- Developing the full-spectrum approach of adaptation science at local, national and international scales; and
- Fostering science and technology (S&T) to support innovation on remedial actions that will reduce risks and build resiliency.

## Implementing the Plan and Measuring Our Progress

### Leadership and Governance

Effective leadership is essential to realizing the mission for Environment Canada's science. Using the Science Plan as a tool for engagement, the Department will mobilize the national and international science needed to provide solutions to important Canadian environmental issues.

**Using the Science Plan as a tool for engagement, the Department will mobilize the national and international science needed to provide solutions to important Canadian environmental issues.**

### Management Support

Environment Canada will provide strong and effective management support for environmental science in several key areas:

- To ensure the Department can continue to attract and retain excellent scientific professionals and support staff, Environment Canada will develop an S&T human resources plan, and will take steps to develop its cadre of potential science managers.
- Recognizing the increasing importance of all types of collaboration to sound science, the S&T Branch will lead in streamlining the Department's collaboration policies to encourage S&T partnering.
- The S&T Branch will develop a stronger relationship with the Department's real property, information technology and capital allocation enabling groups to address the unique infrastructure needs of environmental science.
- Recognizing that transmitting new scientific knowledge to decision makers is a key role of government science, the S&T Branch will promote more effective communication between scientists and decision makers. The Branch will also standardize and streamline the process within the Department to support scientists as they proceed through the peer-review process into print.
- The S&T Branch, in partnership with relevant departmental groups, will contribute to improved access to, and management of, scientific information, including data management.

### Strengthening the Plan

The Science Plan will evolve over the coming years in response to new scientific knowledge and data, changing environmental concerns and government priorities. To ensure that the Plan remains relevant and effective, the Assistant Deputy Minister S&T will undertake periodic reviews of priority issues, and conduct a comprehensive review of the entire Plan every five years. Periodic audits of the Science Plan will also be undertaken.

The Science Plan's performance measurement framework will provide information to monitor progress, inform future editions of the Science Plan, and ensure a process of continuous improvement within Environment Canada's science.



# Introduction to the Science Plan

## The Need for a Science Plan

This Science Plan sets out a vision for managing and conducting Environment Canada’s science over the next ten years. It presents the strategic directions for environmental science in the Department so that the highest standards of science are maintained and Canadians can continue to benefit from the Department’s scientific skills and resources.

The Plan has been prepared for individuals and organizations with an interest in environmental science in Canada, including scientists and managers within Environment Canada, and the Department’s many science partners and clients within Canada and internationally, such as those in other federal departments, other governments, academia, the private sector and civil society.

The Plan strongly reflects and contributes to Environment Canada’s mandate to:

- Preserve and enhance the quality of the natural environment, including water, air and soil quality;
- Conserve Canada’s renewable resources, including migratory birds and other flora and fauna;
- Conserve and protect Canada’s water resources;
- Enforce the rules made by the Canada – United States International Joint Commission relating to boundary waters;
- Carry out meteorological research and predictions; and
- Coordinate environmental policies, regulations and programs for the federal government.

Science and technology (S&T) play a significant part of Environment Canada’s efforts to carry out this mandate, accounting for more than 70% of the Department’s budget and two-thirds of its employees. The Department’s scientific expertise and interests cover a wide range of areas – water, atmospheric, wildlife, technology and risk assessment. About one-third of the Department’s scientific activity focusses on research and development (R&D). The balance covers a variety of non-research science activities, including weather forecasting, risk assessments, regulatory activities, data collection and environmental monitoring, emergency preparedness, and S&T knowledge brokering.

Figure 1 illustrates the complexity of human-environment interrelationships, and the centrality of environmental science to understanding and influencing those interactions. In carrying out its mandate, Environment Canada recognizes that many major public policy challenges – such as air and water quality, transportation and health care – cut across scientific, economic and social disciplines, and are intricately connected with one another. Some environmental pressures, such as changes in land use and release of toxins, result from human activities;

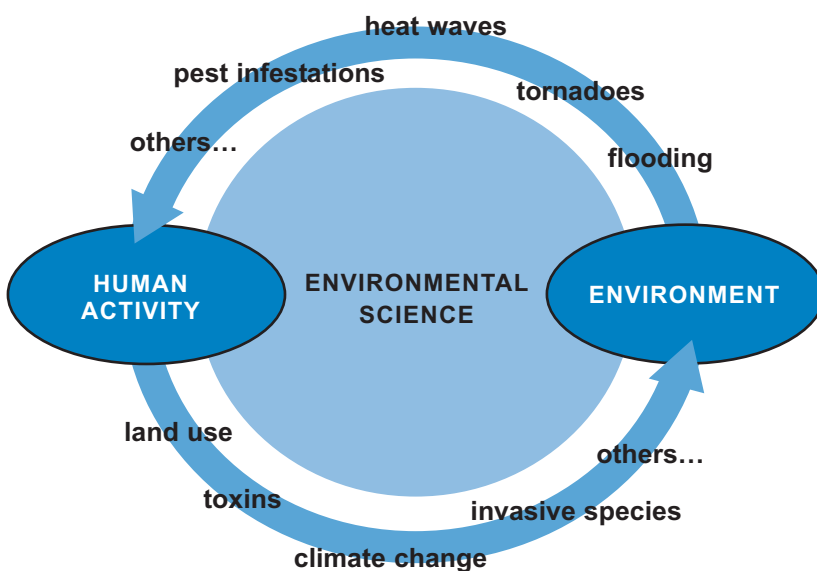


Fig. 1. The role of science in understanding and influencing human-environment interactions.

others flow from natural variations. At the same time, human activities are dependent on the environment, and can be affected by variations such as extreme weather, pest infestations, climate change and invasive species. These pressures and variations can be altered by changes in behaviour by governments, the private sector, and other organizations and individuals.

In the past, Environment Canada has prepared science plans for issue-, region- or discipline-specific parts of the organization. Now there is an opportunity, through this Science Plan, to apply a more comprehensive and integrated approach to the strategic planning of its various natural and physical science activities. This type of integrated approach reflects the reality of responding to today's complex and interrelated environmental challenges.

This integrated approach also reflects and strongly supports the Department's primary planning and reporting mechanism. The recently established results management structure links all departmental activities to results in three priority areas: ecosystem sustainability, weather and environmental services, and environmental protection.

## Objectives of the Science Plan

The Science Plan seeks to provide strategic direction for those undertaking, applying and managing science in the Department. The focus of the plan is on the natural and physical sciences, including both R&D and other scientific activities.

Specifically, the Plan will:

- Ensure that Environment Canada's science activities continue to contribute to government and departmental priorities;
- Create opportunities for greater integration of science within Environment Canada and improved collaboration with science partners outside the Department;
- Promote the highest standard of scientific excellence, to help the Department deliver on its policy, regulatory, program and service responsibilities;
- Ensure that the Department uses its science resources – people, infrastructure, and funds – effectively; and
- Help the Department's corporate-wide functions (such as human resources and finance) better support science.

The Plan also supports and complements more detailed operational plans developed by the Department to guide annual operations and specific initiatives.

## Organization of the Science Plan

The Science Plan consists of the following four elements:

- *Mission for Environment Canada's Science* – a clear statement of what we want to achieve through the science activity of the Department, and how this mission reflects and supports the core roles and principles of federal science;
- *Challenges and Opportunities* – a review of where we are now and what the current and emerging needs are for the Department's environmental science;
- *Strategic Directions for Environment Canada's Science* – a description of where we want to go in order to respond to the challenges and achieve our objectives; and
- *Implementing the Plan and Measuring Our Progress* – an overview of how we are going to implement the Plan, including measuring our progress and adapting our activities to achieve the Plan's objectives.

## **What Do We Want to Achieve?**

### **The Mission for Environment Canada's Science**

#### **The Mission**

The Science Plan sets out the following mission for Environment Canada's science:

*To deliver the high-quality knowledge, information and data that enable the Minister, the Government, the Department and other decision makers to enhance the health and safety of Canadians, protect the quality of the natural environment, and advance Canada's long-term competitiveness.*

#### **The Role and Principles of Federal Science**

The mission for Environment Canada's science is founded on the core roles and principles of federal science as established under the *Framework for Federal Science and Technology*.<sup>1</sup>

The essential character of federal science is *science for the public good*. That is, it must focus on protecting and advancing Canada's public interests. The Framework identifies four core roles for federal science:

- Support for decision making, policy development and regulation;
- Development and management of federal and international standards;
- Support for health, safety and security, and environmental needs; and
- Enabling economic and social development.

High-quality, relevant and accessible science undertaken by Environment Canada contributes to all four of these roles. Environment Canada's scientific professionals provide highly credible data and knowledge needed in policies, regulations, enforcement, and federal and international codes and standards. They conduct R&D to better understand important ongoing and emerging problems in wildlife, biodiversity, water, air, soil, climate, environmental prediction science and environmental technologies. They undertake environmental monitoring to understand what is changing and to detect and evaluate emerging threats. And they provide essential services that safeguard human health and safety, security and environmental quality.

**Science includes both research and development and other scientific activities. It is the use of investigative, analytical and experimental methods to measure, assess, interpret, predict and respond to changes in environmental parameters and processes, indicators of environmental health, and human interactions with the environment, using physical, chemical and biological principles.**

Environment Canada's science – like all federal science activities – is founded on three principles established under the federal S&T Framework:

#### **Alignment**

*Federal S&T must reflect and support the priorities of Canadians*

Under this principle, our scientific activities must be designed and undertaken to advance our departmental mandate and the broader priorities of the Government. We must be prepared to adjust these activities when needed to remain focussed on issues of concern to Canadians, while continuing to meet

our ongoing and long-term commitments. We also must understand the priorities of Canadians and the full range of demand for Environment Canada's science. Other governments, Aboriginal peoples, communities, citizens and industry use the results and products of our science to help them understand the factors affecting their health, safety, livelihood and environment. To better serve these users, the Department must work to understand what they need, and whether it is the most appropriate science provider to respond to those needs.

More broadly, the Department has a leadership role to play on this issue, ensuring that national capacity in environmental science is directed toward national priorities.

## Linkages

*Federal S&T must be built on effective, collaborative relationships*

Environment Canada's science cannot achieve its mission in isolation. Solutions to many complex, global environmental problems must involve the scientific community across disciplines and outside departmental and government boundaries.

For Environment Canada, the principle of linkages requires building strong and sustained collaborative relationships to foster better integration of science across the federal government. It involves working with researchers and scientific groups within Canada and internationally in universities and colleges, industry, civil society, the granting councils and funding programs. It means finding ways to work more efficiently together through co-location of facilities, shared financial resources, training opportunities, adjunct professorships and international cooperative agreements. And it means maintaining effective relationships between science and those who need the results of our work: policy makers, regulators, service providers, citizens and others – communicating our knowledge and advice in language they can understand and use.



Photo: Julie Suzanne Pollock

*For 25 years, colonial waterbird biologists from the Great Lakes area have met in two working groups to discuss the past year's research findings on this group of birds. In autumn of 2006, 26 researchers convened the 25<sup>th</sup> annual meeting of the Great Lakes Area Colonial Waterbird Working Group, representing at least 12 different agencies from Canada and the United States. A new working group was also established, the Western Great Lakes Colonial Waterbird Working Group, including 25 researchers from 15 different agencies.*

## Excellence

*Federal S&T must incorporate the highest standards of excellence*

Environment Canada must produce the highest-quality, leading-edge, credible and unbiased environmental science relevant to support sound policies, effective regulations and informed decision making. We must promote innovation and encourage creative options for addressing a wide range of environmental challenges. Above all, we must demonstrate transparency and openness in how we conduct our scientific activities, adhering to scientific principles and continuing to use proven quality assurance methods such as international standards, peer review and expert external advice.



## Where Are We Now?

### Challenges and Opportunities for Environment Canada's Science

If we are to achieve our mission for Environment Canada's science, we must begin with a clear understanding of our current position. This section of the Plan provides an assessment of what environmental science will be needed over the coming years – those challenges where we will need to apply our scientific resources and experience, facilitate the development of new science and influence others. The assessment is based on extensive consultations with Environment Canada's scientists and science managers, as well as with external experts.<sup>2</sup> Challenges and opportunities are grouped under the Department's three primary responsibility areas:

- Ecosystem Sustainability;
- Weather and Environmental Services; and
- Environmental Protection.

#### Ecosystem Sustainability

##### Departmental Strategic Outcome

*Canada's natural capital is restored, conserved and enhanced*

**Between now and 2050, Canada's Gross Domestic Product is expected to increase by up to 2.7% per year. This pace of economic growth likely will increase pressures on the environment.**

##### Key Challenges and Opportunities

Between now and 2050, Canada's Gross Domestic Product is expected to increase by up to 2.7% per year.<sup>3</sup> This pace of economic growth likely will increase pressures on the environment from urbanization, industrialization, resource extraction, habitat conversion to agriculture, invasive alien species and pollution. These pressures will challenge the ability of Environment Canada to monitor and understand changes to Canada's natural resources and ecosystems, as well as our capacity to identify, anticipate and reduce the risks to human health, safety and security.

Looking ahead then, Canada must improve its monitoring systems and develop the knowledge and data to promote environmental sustainability. We must ensure our capacity to develop more comprehensive and integrated policies to protect ecosystems. We will need to better understand the cumulative nature of human impacts on the environment. And we will need to strengthen science-based practices in such areas as species recovery and stewardship.

Environment Canada's science, in collaboration with national and international partners, will be needed on several fronts in the area of ecosystem sustainability:

- *Strengthened predictive models:* Our science can help better understand, quantify and predict the influences of biological, physical and chemical influences on biodiversity, ecosystem function and water availability;
- *Natural capital:* We can help develop a comprehensive framework to restore and enhance Canada's natural and physical environment, while balancing the real value of natural resources and ecosystems, biodiversity, human health, quality of life, and economic development;
- *Cumulative risks:* We need to identify, monitor, predict and communicate cumulative impacts and risks, particularly with respect to ecosystem function and water availability; and
- *Resilience of ecosystems and the water supply:* Our science must contribute to an adaptive management framework to help improve the resilience of ecosystems and Canada's water resources to large-scale environmental changes arising from industrialization and urbanization.

## Weather and Environmental Services

### Departmental Strategic Outcome

*Weather and environmental predictions and services reduce risks and contribute to the well-being and security of Canadians*

### Key Challenges and Opportunities

Every day, citizens, communities, governments and industry must make short- and long-term decisions affecting their health and wealth and the quality of the environment. For example, based on U.S. estimates,<sup>4</sup> about 30% of Canada's Gross Domestic Product is sensitive to weather and climate that create inherent inefficiencies in the economy, especially in key sectors such as agriculture, forestry, construction, transportation and tourism. In addition, the risks to Canada's public infrastructure will increase due to the changing climate.<sup>5</sup>

The importance of atmospheric and related environmental prediction and adaptation science increases as Canadians become more vulnerable to weather, climate and environmental conditions. The vulnerability has increased, in part, because of population concentrations in urban areas, increasing dependency on electricity, aging of Canada's essential infrastructure, and greater integration into the global economic community.



Photo: Douglas A. Walker

*A shelf cloud over a canola field in southern Saskatchewan during a derecho (a warm-weather violent windstorm with thunderstorms).*

In recent years, Canadians have become more aware of these risks and potential opportunities, such as wind power. Their awareness has driven the demand for environmental prediction science, adaptation science and decision-making tools enabling them to prevent the preventable, optimize the opportunities, reduce adaptation and mitigation costs, and risk manage the rest.

Environment Canada's science, in collaboration with national and international partners will need to address three major challenges:

- **Environmental prediction capability:** We need a multidisciplinary environmental prediction capability that supports policy and decision making on key government issues such as clean air, clean water, clean land, energy, health and safety, and economic competitiveness. The objective is to provide highly reliable and useful predictions of weather, climate, atmospheric transport, water resources and other environmental conditions at various scales for different users;
- **Cumulative impacts, risks and vulnerabilities:** We need to improve our understanding of the cumulative impacts, risks and vulnerabilities of high-impact events (such as floods, droughts, ice storms, hurricanes and poor air quality) and of climate change and variability, on human and ecosystem health and long-term competitiveness; and
- **Adaptation and resilience:** We need to develop the full spectrum of adaptation science, including methodologies, approaches and tools to help decision makers minimize the risks and optimize opportunities (e.g., green energy) while improving the resilience of their social, economic and environmental systems to high-impact events and our changing climate.

## Environmental Protection

### Departmental Strategic Outcome

*Canadians and their environment are protected from the effects of pollution and waste*

### Key Challenges and Opportunities

Canadians need a safe and healthy environment to sustain their high quality of life. At the same time, their lifestyles generate and release into the environment a wide range of chemical, biological and physical substances. Some of these substances can significantly stress human and environmental health. We need to do a better job anticipating these new stresses and identifying and managing the resulting risks to acceptable levels.

In the past, governments tended to react to pollution threats, and ended up having to play costly “catch-up” after years of neglect. Today, we know that protecting human and environmental health is much more effective through proactive and integrated science-based approaches. This means taking an integrated approach to existing stressors and taking preventative action on new and emerging issues. We are now using these approaches to manage a variety of existing and emerging complex threats, such as chemical substances (including those linked to climate change), nanotechnology, new pathogens and urbanization.

We need to continue to use our scientific resources and skills to look ahead and anticipate possible threats to human and environmental health. This foresight will give policy makers, regulators and industry sufficient lead time to develop and implement effective initiatives to reduce these threats.

Environment Canada’s science, in collaboration with national and international partners, will need to address several challenges in the area of environmental protection:

- *Improved predictive models:* We need to understand and model, on appropriate time and spatial scales, the processes that are influencing emission, transport, fate, effects and risks of existing and emerging chemical, biological, physical and genetic pollutants within and across all environmental media;
- *Cumulative risks:* We need to better understand, predict and communicate the cumulative risks of chemical, biological, physical and genetic pollutants on human and ecosystem health;
- *Integrated risk management tools:* We need to develop tools, standards and advice to help governments and others proactively manage the human, socio-economic and environmental risks of chemical, biological, physical and genetic pollutants; and
- *Emission reduction tools and mitigation science:* We need to develop comprehensive knowledge-based approaches, methodologies and tools to help Canadians reduce existing emissions of chemical (including greenhouse gases), biological, physical and genetic pollutants.

## Where Do We Want to Go?

### Strategic Directions for Environment Canada's Science

Where do we go from here? How can the mission for Environment Canada's science be achieved?

Building on the understanding of the current and emerging challenges and opportunities to environmental science, this section of the Science Plan outlines three long-term directions to guide the Department and its science partners as we work together towards the vision of *environmental sustainability as a means of improving human and environmental health and promoting long-term competitiveness*.

The strategic directions are just that – guideposts that can help direct our scientific resources and activities over the coming years. The strategic directions, as illustrated in Figure 2, below, are:

1. Developing an Integrated Environmental Monitoring and Prediction Capability
2. Understanding Cumulative Risks
3. Managing Risks, Optimizing Opportunities and Building Resilience

As a foundation, integrated environmental science monitoring, research and analysis helps build understanding of the fundamental processes at work in the environment. From this knowledge comes an understanding of the cumulative impacts and risks of the environmental pressures and stressors. Building on this understanding, integrated environmental prediction systems are developed to help decision makers determine how current policies and programs are affecting the environment and what changes are needed to improve environmental quality, health and safety, and competitiveness. In this way, high-quality environmental science becomes part of decision support systems that help various actors better manage risks, take advantage of opportunities and build greater resilience into environmental, social and economic systems.

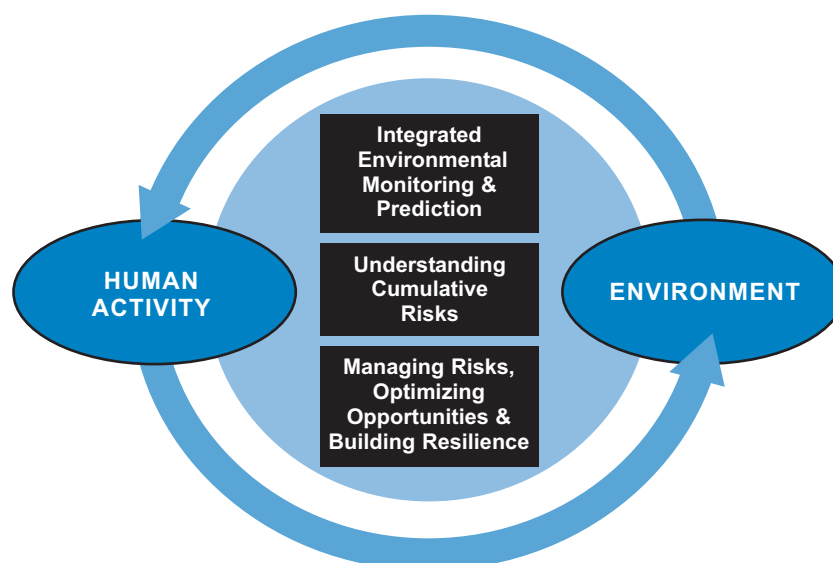


Fig. 2. Strategic directions for Environment Canada's science.

For each of the strategic directions, the Science Plan identifies a goal, provides a brief rationale, and proposes areas where Environment Canada's science should focus.

#### Strategic Direction 1

##### Developing an Integrated Environmental Monitoring and Prediction Capability

###### Goal

*Better understand the changing state of the environment through the development and use of a multidisciplinary environmental monitoring and prediction capability.*

## Rationale

Whether the challenge is damaging weather, biodiversity loss or water availability, solutions to today's major environmental issues require integrated and multidisciplinary approaches. We can no longer treat smog, climate change, water quality or biodiversity issues individually, because we know that the physics, chemistry and biological aspects of these issues interact. Rather than existing as isolated issues, these concerns form a complex web of interrelated issues at the local, national and international levels. For example:

- Science has linked emissions from energy production and use to climate change, acidification, smog and mercury in the environment;
- Climate change and variability, in turn, affect land use, ecosystem function, water supply and weather extremes;
- Changes in land use affect water quality, community planning, habitat availability, biodiversity, animal migration routes and climate; and
- Changes in water quality, habitat and other environmental factors can affect the global spread of diseases that can transfer to humans.

To understand one environmental issue, then, science has to examine several interrelated issues at any one time. Science must also ensure a solution to one problem does not make another worse. In addressing this intricate web, science must take a holistic, "earth system" approach. Instead of monitoring and predicting weather or water quality, for example, we must move toward monitoring and predicting an integrated state of the earth's systems – its air, water, living organisms and land, creating linked and responsive decision support systems.

**Whether the challenge is damaging weather, biodiversity loss or water availability, solutions to today's major environmental issues require integrated and multidisciplinary approaches.**

## Areas of Focus

In addressing this long-term strategic direction, Environment Canada's science should focus on:

- Moving to more comprehensive and integrated environmental monitoring systems and prediction models;
- Moving to finer temporal and spatial scales for predictions and analyses of environmental systems; and
- Expanding lists of environmental parameters to be measured with greater spatial and temporal resolution than is currently available.

## Strategic Direction 2 Understanding Cumulative Risks

### Goal

*Develop and implement strategies and tools to anticipate, understand, characterize and communicate:*

- the cumulative impacts on, and risks to, human and ecosystem health and security from multiple stressors interacting over time; and
- the risks to, and opportunities for, Canada's long-term competitiveness resulting from a changing environment.

## Rationale

We must improve the efficiency and effectiveness of existing reactive systems that identify, understand and communicate risks. For example, we need to better understand, within a reasonable time, the individual toxicity of many thousands of existing chemical, biological, genetic and physical pollutants. But we also need to comprehend the aggregate risks from *multiple* stressors. For example, two chemical pollutants may be relatively benign on their own, but their toxicity could be very high when combined. Similarly, we must understand the cumulative risks to water availability and biodiversity in a specific ecosystem from such trends as acidification, increased exposure to ultraviolet radiation, and climate change.

These examples deal with reacting to something already in the environment. But we must do more than react. As we improve the effectiveness of existing reactive systems, we should build science-based systems that are more proactive and pre-emptive. This approach will give decision makers time to intervene, reducing the risk to acceptable levels before the issue develops, and avoiding a potentially expensive reactive, catch-up response.

Finally, the risks to, and opportunities for, Canada's long-term competitiveness arising from a changing climate are not well understood. We need to do a better job of anticipating, understanding and communicating the vulnerabilities of, and risks to, ecosystems and human health from climate change.

## Areas of Focus

In addressing this long-term strategic direction, Environment Canada's science should focus on:

- Understanding past and present trends, future projections and scenarios for environmental change, and the sensitivities of various ecosystems, societal needs and economic sectors to those changes;
- Developing tools to increase our ability to assess the cumulative risks and opportunities arising from existing environmental stressors, particularly those dealing with urbanization, industrialization, forestry, agriculture, power generation and climate change;
- Developing early-warning foresight systems, screening methods, scenarios, physical indicators and key indicator species to systematically identify and characterize the impact of individual and cumulative threats to human and ecosystem health and long-term competitiveness – before they occur; and
- Strengthening our capacity to communicate the results of our science to various user groups, including policy analysts and decision makers, and to transfer science, technology and information to providers of essential services.

## Strategic Direction 3

### Managing Risks, Optimizing Opportunities and Building Resilience

#### Goal

*Help clients reduce risks and take advantage of opportunities arising from the changing environment, while building greater resilience in Canada's environment, communities and key economic sectors.*

#### Rationale

The previous strategic direction seeks to improve our understanding of the risks arising from environmental changes. The next step is to help Canadians act on this understanding – to guide management of the risks at an acceptable level, take advantage of opportunities and build resilience against future risks.

We know that changing environmental quality affects the health and safety of Canadians, and the economic productivity and competitiveness of the country's economy. We also know that as Canadians try to sustain this quality of life and improve the level of productivity, there will be impacts on the environment. Where is the balance point? What risks are acceptable? Science can help us reduce risks through innovative mitigation and adaptation strategies that can, at the same time, build greater resilience into Canada's natural, social and economic systems.

### Areas of Focus

In addressing this long-term strategic direction, Environment Canada's science should focus on:

- Developing knowledge-based approaches and systems to assess priorities for action and recommend interventions and risk management strategies (e.g., expert teams and networks able to pull together quickly to address an environmental crisis or emergency);
- Understanding the costs and benefits of the various risks, and assessing the opportunities of, and barriers to, implementing risk management strategies;
- Increasing the capacity to apply real-time weather and environmental predictions to meet the short- and long-term needs of Canadians;
- Developing the full-spectrum approach of adaptation science (behavioural, institutional, regulatory, analytical and technological) at local, national and international scales; and
- Fostering S&T to support innovation on remedial actions that will reduce risks and build resiliency (e.g., using catchment areas as natural buffers to protect communities from floods and droughts).



Photo: Bill Bowman

*Wetlands and the animals that call them home, like this leopard frog, face cumulative risks arising from stressors such as changing land use patterns, climate change, and pollution.*

## How Will We Get There?

### Implementing the Plan and Measuring Our Progress

The Science Plan has set out a mission to guide Environment Canada's science. It has identified broad areas where that science will be needed in the coming years, and outlined three strategic directions to realize the mission and contribute to departmental and government priorities.

The final element of the Science Plan involves putting the ideas into practice.

This concluding section outlines how the Plan will be implemented. It presents Environment Canada's commitments to support the Plan in terms of leadership and governance, and to provide the enabling management support in key areas such as human resources, capital and infrastructure, and communications. Finally, it articulates the Department's clear commitment to achieving our Science Plan mission over the coming years by measuring progress and maintaining open communications with our departmental scientists and managers, and our partners and clients.

### The Science Capacity Challenge

If Environment Canada is to become more proactive over the coming years, then it needs to refocus its science activities to better address the increasingly complex and interrelated nature of environmental issues. The following approaches are particularly relevant to this effort to strengthen science capacity in the Department:

- *A multidisciplinary approach* that includes the social sciences and economics is needed to effectively monitor and predict changes in the earth system. Climate, air quality, water, environmental and weather modelling, and prediction systems are becoming more closely interconnected, moving to more refined spatial and time scales, and relying on complex systems for merging information from observations and models.
- *A consultative and collaborative approach*, including domestic and international decision makers, practitioners and researchers, is needed to better coordinate research and monitoring strategies and address environmental challenges spanning sectoral and political boundaries.
- *Adaptive solutions* that can match a solid foundation of adaptation science with strong partnerships are needed to improve Environment Canada's capacity to address challenges relating to human health and safety (e.g., heat alerts and air quality warning systems), economic competitiveness (e.g., forestry, construction and agriculture), Canada's critical public infrastructure, Canada's water resources, and resilience in natural ecosystems.
- *Environmental foresight* is needed to better identify and characterize environmental threats before they occur. This involves developing comprehensive, fine-scale models; the capacity to deploy expertise rapidly in the event of emergencies; and supporting infrastructure such as national, multidisciplinary networks and databases.

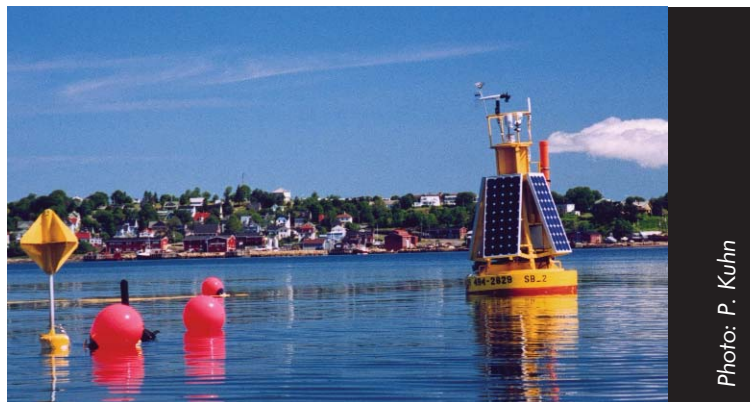


Photo: P. Kuhn

*A solar-powered ocean monitoring buoy gathering data in Lunenburg Bay, N.S., as part of a Centre for Marine Environmental Prediction (CMEP) storm surge prediction project. CMEP is a multidisciplinary collaboration between Dalhousie University, Fisheries & Oceans Canada and EC.*



## Leadership and Governance

### Leadership

Effective leadership is essential to realizing the mission for Environment Canada's science. For science within the Department and the federal government, "leadership is an essential ingredient to success. Leaders can articulate federal S&T goals, establish ethical standards, motivate others, engage partners, and promote S&T success stories."<sup>6</sup>

A key aspect of leadership for Environment Canada is its role in delivering the credible, high-quality science needed to address environmental priorities, and in mobilizing national and international science capacity. As the largest institutional performer of environmental science in Canada, the Department has a responsibility to act as a catalyst for environmental science within the country and internationally.

The Assistant Deputy Minister (ADM) S&T has functional responsibility for implementing the Science Plan. The ADM S&T will communicate key elements of the Science Plan to the Department's Executive Management Council at the beginning of the planning cycle each fall to inform the Department's strategic priority-setting process and encourage active participation from all Branches.

*Environment Canada's Commitment:*

- Developing the Science Plan is a major step for Environment Canada in terms of leadership in mobilizing national and international science needed to provide solutions to important Canadian environmental issues. Using the Science Plan as a tool for engagement, the Department will involve external partners in further collaboration, with the aim of building a strong, integrated environmental science system directed towards national and global challenges.

### The Results Management Framework and the S&T Branch

The key governance mechanisms for the Science Plan are the Department's Results Management Boards and the S&T Branch.

Environment Canada governs and delivers on its roles and responsibilities through its Results Management Framework. The Framework enables the achievement of departmental strategic outcomes and results by establishing mechanisms and tools to provide a consistent, transparent planning and reporting process department-wide, and to link people and resources to results.

To ensure that the Science Plan contributes to Environment Canada's planning and operational decisions, the Plan's strategic directions and initiatives will be integrated with the Department's Results Management Framework through the Priority Management and Enabling Boards.

The S&T Branch, which consolidates a significant portion of the Department's science into one group, facilitates the integration of science. It also encourages coordination of science management, as with development of this Science Plan. Within the S&T Branch, other governance mechanisms such as the S&T Branch Executive<sup>7</sup> and the S&T Branch Management Council<sup>8</sup> are ensuring that the Department's science resources contribute to departmental priorities.

*Environment Canada's Commitment:*

- The S&T Branch Executive will continue to work closely with the Results Management Boards to implement, monitor and review the Plan and its impacts. The S&T Branch will also continue to work with Environment Canada's Finance and Corporate Branch to adjust the Results Management Tool to include sections about science and science-related activities.
- S&T Branch Executive will work with the Results Management Boards to use the Results Management Tool to track science activities in the Department and help project leads align those activities with the Science Plan. This will also allow the S&T Branch Executive to assess the scope and breadth of Environment Canada's science activities periodically, and identify synergies across the Department.

- In recognition of the Science Plan's central role in creating a coordinated approach to fulfilling Environment Canada's science responsibilities, a new external Science Advisory Board will be established to provide advice to the ADM S&T. The Board will be asked to advise on where the Department's science activities should be headed and on the content of future versions of the Science Plan.

## Management Support

Sound science is a fundamental step to fulfilling Environment Canada's mandate. Environment Canada will provide strong and effective management support for this science in several key areas.

### People

Committed, talented people in both scientific and support positions are the core of Environment Canada's scientific strength. They are the single most important contributor to the success of the Department and the Science Plan.

Managing a scientific and technical workforce involves many different elements: successfully recruiting well-trained people, retaining them in positions useful to the Department, offering them career-enriching learning and development opportunities, and planning ahead to retain needed skills and knowledge within the Department when individuals retire or move to other opportunities.

For many scientific disciplines, Environment Canada faces significant competition from other organizations in recruiting and retaining scientific talent. The same difficulty is experienced in other federal science-based departments and agencies. The federal S&T community has responded to this concern through several interdepartmental initiatives led by the Science ADMs Advisory Committee on Human Resources (SAAC).<sup>9</sup>

Within its S&T workforce, Environment Canada must also encourage individuals to develop the skills needed to move into management positions. Several federal S&T community initiatives are addressing the developmental needs of aspiring science managers. For example, the SAAC and the Privy Council Office have launched the *Scientists as Leaders* initiative, designed to help selected scientists become excellent leaders. This program complements other interdepartmental learning initiatives that help make the transition to management easier for those scientists interested in pursuing leadership roles. Similarly, because science is so integral to the Department's policy and regulatory development processes, Environment Canada needs to facilitate the movement of scientific professionals into policy and regulatory development roles.

#### *Environment Canada's Commitment:*

- To ensure the Department can continue to attract and retain excellent scientific professionals and support staff, Environment Canada will develop an S&T human resources plan through collaboration between the S&T Branch and the human resources enabling team. This plan will address the Department's S&T human resources needs and integrate the continued commitment to federal S&T community human resources initiatives. The plan will also consider ways to help facilitate the movement of scientific professionals into the policy and regulatory arenas.
- The S&T Branch will also take steps to develop its cadre of potential science managers. The Branch will create a management training program, working closely with Environment Canada's human



Photo: B. Trapp

*McMaster University summer student Lisa Melymuk and EC technologist Tara Nelson sample water quality as part of the Hamilton Harbour lakebed sediment stability project.*

resources enabling team, and taking full advantage of the *Scientists as Leaders* initiative. This training program will encourage scientists to consider earlier in their careers a possible future in management, through gradual development of competencies they need to become successful managers. The Department will continue to encourage Environment Canada scientists to take advantage of the many interdepartmental management development programs available. Other developmental options, such as mentoring programs, will also be explored.

## Collaboration

Science collaborations – partnerships, relationships, networks and multidisciplinary approaches – are essential to address today’s complex, interrelated environmental issues. Collaboration can help stimulate innovation and maximize the value of limited resources. Collaboration involves working with colleagues within the Department and its partners across scientific disciplines, organizational structures, cultures and physical locations. New S&T tools and approaches are proving to be significant drivers of collaboration. For example, new computational modelling tools bring together climate and landscape modellers, and ecosystem management approaches help integrate the work of many scientific disciplines.

Environment Canada recognizes the value and necessity of these science partnering relationships and has worked with others to provide opportunities and incentives for greater collaboration.<sup>10</sup> In addition, collaboration is the primary concern of the ADM S&T Integration Board,<sup>11</sup> which will launch a coordinated effort around several integration themes and develop a unified picture of all federal S&T to help identify potential areas for collaboration. The Board has also supported the work of the interdepartmental *Overcoming Barriers to S&T Collaboration*<sup>12</sup> initiative developed to identify how federal departmental financial systems, management regimes, human resources policies, and other corporate initiatives can support greater S&T collaboration.

**Science collaborations are essential to address today’s complex, inter-related environmental issues.**

### *Environment Canada’s Commitment:*

- Recognizing the increasing importance of all types of collaboration to sound science, the S&T Branch will lead Environment Canada in simplifying and streamlining the Department’s collaboration policies to encourage S&T partnering. It will focus on better integrating science efforts across the Branch and the Department and will develop a strategy for evaluating collaborations with a view to improving the policies. The Department will also continue to work with the federal S&T community to address government-wide barriers to collaboration.
- Building on the work done by EC’s Audit & Evaluation Branch in their *Evaluation of the Co-location of Science Research Centres on University Campuses*,<sup>13</sup> the S&T Branch will continue to explore ways of effectively co-locating research facilities and scientific equipment with external partners.

## Capital and Infrastructure

The importance of infrastructure to science cannot be overstated. Environment Canada recognizes that “world-class research is dependent on exceptionally functional and well-equipped work places for scientists.”<sup>14</sup> Buildings and equipment, tools, facilities, environments and support staff are all essential to excellent science. Moreover, S&T infrastructure contributes to making S&T work in the government attractive to highly qualified potential employees.

Environment Canada’s science has special needs for capital and infrastructure. As a result, procedures around forecasting requirements, purchasing, maintaining and managing equipment, facilities and information technology resources should be geared to meet the particular needs of a science culture. For example, competitive bidding processes for procurement may be neither efficient nor effective when specialized scientific equipment is produced by only one supplier.

Environment Canada's science programs also depend on equipment and infrastructure to a greater degree than elsewhere in the Department. A delay in acquiring new specialized equipment or infrastructure is more than an inconvenience – it could mean a delay in critical research and operational activities planned in anticipation of the new equipment.

*Environment Canada's Commitment:*

- Recognizing that infrastructure and capital assets are uniquely important to Environment Canada's science, the S&T Branch will develop a stronger relationship with the Department's real property, information technology and capital allocation enabling groups. Management mechanisms will be created to help ensure these groups receive proactive and timely advice about science infrastructure and equipment needs. As a first step, the S&T Branch will review the mandate and membership of the Laboratory Coordinating Committee to help contribute to the development of an integrated S&T infrastructure planning capacity.
- The Branch will also continue to support interdepartmental efforts in this area, including work done through the Overcoming Barriers to S&T Collaboration initiative and the S&T infrastructure assessment led by the Treasury Board Secretariat, recognizing that an issue of this scope is best dealt with collaboratively.

## **Financial Resources**

Financial resources and effective financial control mechanisms are fundamental to supporting scientific activities in the Department. More than just a level of funding, adequate financial resourcing of S&T means ongoing, stable funding, with processes to accommodate the long-term nature and needs of science programs and facilitate collaborative scientific work within and beyond the Department.

The question of financial resources has long generated considerable interest among federal science-based departments and agencies and their science partners. Within the federal government, the goal is to have in place financial management mechanisms for S&T that are both accountable and flexible.

*Environment Canada's Commitment:*

- The Overcoming Barriers to S&T Collaboration initiative, under the direction of the ADM S&T Integration Board, has been used to engage the Treasury Board Secretariat in re-examining its financial management policies in light of the S&T community's unique needs. The S&T Branch will persevere in this interdepartmental process on behalf of Environment Canada's science and will work with the Department's finance enabling team to create as much flexibility as possible within financial management rules.
- The S&T Branch recognizes that funding for science will only be assured if the science serves the needs of the Results Management Structure. Therefore, the Branch will continue to focus on ensuring strong linkages between the Department's priorities and its science activities.

## **S&T Communications and Knowledge Brokering**

Environment Canada directs S&T communications and knowledge brokering activities toward three principal audiences: decision makers, the scientific community and the public. These audiences usually have different information needs and prefer to receive information in different ways.

Decision makers typically have very different training than scientists. They use different vocabularies, work on different timelines, and can have different priorities. This means that a specialized approach is needed for knowledge transfer at the interface of science and policy. From the science side, the S&T Branch must understand the priorities of users of scientific information – policy managers, program managers and municipal government officials, for

**A specialized approach is needed for knowledge transfer at the interface of science and policy.**

example – so that science advice can be tailored to user needs. This calls for people who can act as information brokers and integrators, able to effectively translate knowledge from the scientific community to the policy community and back again. Within the Department, only a small number of people carry out these tasks on a formal basis.

Expert review of scientific publications is a cornerstone of the scientific process. It helps to uphold standards of excellence within Environment Canada and maintain our credibility with external partners. Scientific publications are also one of the principal methods the Department uses to share its science with other scientists, opening up possibilities for collaboration and new avenues of research. Scientific publications are very different from other kinds of government communication products in terms of their audience, content and purpose.

With respect to public audiences, science communications can foster an S&T culture in Canada by contributing to public understanding of S&T issues. This understanding, in turn, can enhance public confidence in government decision making. These communications can also inform Canadian youth about S&T, developing science literacy and encouraging future scientists. Finally, S&T communications to the public can provide direct information services such as extreme weather warnings.

#### *Environment Canada's Commitment:*

- Recognizing that transmitting new scientific knowledge to decision makers is a key role of government science, the S&T Branch will promote more effective communication between scientists and decision makers. In particular, the Branch will develop practices based on how, where and why scientific information is used in the policy development process.
- Recognizing that scientific publishing is a vital science activity, the S&T Branch will standardize and streamline the process within the Department to support scientists as they proceed through the peer-review process into print. The S&T Branch will generate a policy and process for S&T publications that will clarify how the Department approaches these unique communication tools and speed up the process for S&T staff. The Branch will also work with the Intellectual Property group in the Department as it develops a new policy to ensure that Environment Canada's scientific intellectual property is used appropriately.
- The S&T Branch, in partnership with relevant departmental groups, will contribute to improved access to, and management of, scientific information, including data management, through new and effective policies to manage the process.

## **Strengthening the Plan**

Environment Canada is committed to ensuring that the Science Plan remains a vibrant and relevant guide for our scientists and science managers, all branches of the Department, and our science partners and clients. We will review the Plan on a regular basis and apply a performance measurement framework to ensure that Environment Canada's science remains of the highest calibre and continues to contribute to departmental and government priorities.

### **Reviewing and Revising the Science Plan**

The Science Plan will evolve over the coming years in response to new scientific knowledge and data, changing environmental concerns, responsibilities to Aboriginal peoples, and government priorities. To ensure that the Plan remains relevant and effective, the ADM S&T will lead management actions, including undertaking reviews of priority issues as required and conducting a comprehensive review of the entire Plan every five years.

These reviews will include input from the relevant Results Management Boards and project leads, as well as advice from external experts. Final decisions on changes to the Plan will be made by the Department's Executive Management Council, taking into account recommendations provided by the S&T Branch Executive.

Periodic evaluations of the Science Plan will also be undertaken. These are expected to focus on: specific aspects of Environment Canada's current environmental science activities and long-term science needs; the effectiveness of science management practices; and the effectiveness of the Plan itself. The ADM S&T will seek the advice of the Science Advisory Board on these issues.

## Measuring Progress

Performance measures are an essential component of strategic plans. In the context of the Science Plan, performance measures will provide information to monitor progress, inform future editions of the Plan, and ensure a process of continuous improvement within Environment Canada's science. Performance measures can also be used to promote success within the Department, demonstrating its achievements in a measurable and unbiased manner.

In addition to comprehensive reviews and periodic evaluations of the Science Plan, the ADM S&T will present quarterly reports on the Plan to the Department's Executive Management Council. These reports will assess EC's progress towards the Plan's three long-term strategic directions and towards its commitments under leadership and governance, and management support. The quarterly reports will be rolled up into an annual report for the Executive Management Council. In addition, the S&T Branch Executive will present semi-annual reports on progress in specific science and science management areas to the appropriate Results Management Board.

### Principles

The progress reports, comprehensive reviews and other performance measures for the Science Plan will be based on the three principles of federal S&T: alignment, linkages and excellence.

Environment Canada will consider these types of questions in monitoring progress of the Science Plan with respect to the principle of *alignment*:

- Does Environment Canada's science contribute to the Results Management Boards' strategic outcomes and the Department's mandate?
- Is the Science Plan effectively adapting to emerging scientific, environmental and policy issues?

The following types of questions will be applied in monitoring progress of the Science Plan with respect to the principle of *linkages*:

- Is there an effective feedback loop between the Science Plan and the Priority Management and Enabling Boards?
- Does Environment Canada's science operate as an integrated whole?
- Does the Department collaborate effectively with federal, provincial, territorial, municipal, Aboriginal, national and international partners to deliver the science Environment Canada needs?

Finally, the Department will consider the following types of questions in monitoring progress of the Science Plan with respect to the principle of *excellence*:

- Is Environment Canada performing demonstrably excellent science according to recognized international measures of scientific excellence?
- Does the Department have adequate mechanisms in place to solicit external advice on the excellence and relevance of its science?

**"Planning 10–20 years ahead is necessary for a science-based organization to ensure cutting edge science is available to the decision makers and operators."**

**Environment Canada Science and Technology  
Management Review Panel Report<sup>15</sup>**

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## Endnotes

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- 7 S&T Branch Executive consists of the ADM and Directors General of the S&T Branch, as well as the Director of the Environmental Technology Centre.
- 8 S&T Branch Management Council consists of senior scientists, science managers and policy advisors from the S&T Branch.
- 9 For more information: [http://intranet.sciencetech.gc.ca/ScienceTech/initiatives/hr\\_initiatives\\_e.shtml](http://intranet.sciencetech.gc.ca/ScienceTech/initiatives/hr_initiatives_e.shtml) (Federal government access only).
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