

Research & Development and Related Science Activities in Environment Canada

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Science Policy Branch
Environment Canada

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Environnement Canada

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Les **documents de travail** sont des rapports intérimaires sur le travail effectué par la Direction de la politique scientifique, Environnement Canada. Ils n'ont été examinés que de façon limitée. Ces rapports sont distribués en nombre restreint pour diffuser les études, promouvoir la discussion et favoriser la réalisation d'autres études d'orientations.

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**Science Policy Branch
Environment Canada**

Global Change Strategies International Inc.

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Purpose of This Report

The Working Group on R&D Priority Setting and S&T Capacity, a subgroup of Environment Canada's S&T Advisory Board, requested a synopsis of the types and amounts of major research and development (R&D) and related science activities (RSA) in each of the Department's four business lines. This information can be used to provide advice to the Deputy Minister on the balance between R&D and RSA in Environment Canada, where any gaps need to be addressed, and relative priorities. This work forms part of the Advisory Board's role in championing S&T for the Department and contributing to Environment Canada's R&D agenda.

To meet this need, the Science Policy Branch of the Ecosystem Science Directorate retained GCSI — Global Change Strategies International Inc. — to develop this synopsis report. The report that follows provides some background on the Department and its science and technology components and challenges, indicates the key R&D and RSA areas and their estimated resource allocations for 1999-2000, and offers commentary on how this information can be used.

Goals of Environment Canada

Mission and Mandate

Environment Canada's mission is to help Canadians live and prosper in an environment that needs to be respected, protected and conserved. This involves approximately 4,200 employees, a budget of over half a billion dollars, and activities that go on around the clock in over 100 communities coast to coast.

The Department's mandate (under the Department of the Environment Act) covers preservation and enhancement of the quality of the natural environment, renewable resources (including water, migratory birds and other non-domestic flora and fauna), meteorology, enforcement of the rules of the Canada-U.S. International Joint Commission, and coordination of federal environmental policies and programs. Departmental activities, including R&D and RSA, are conducted to support legislative requirements and obligations, as well as to meet expectations by Canadians and the international community. These include:

Legislative framework:

- Department of the Environment Act
- Canada Water Act
- Migratory Birds Act
- Emergency Preparedness Act
- Weather Modification Information Act
- Statutes which require EC to support other federal departments

International and transboundary obligations:

- UN World Meteorological Organization
- Vienna Convention for the Protection of the Ozone Layer
- UN/ECE Convention on Long Range Transboundary Air Pollution

- North American Agreement on Environmental Cooperation
- International Boundary Water Agreements (e.g., Lake of the Woods)
- Canada-U.S. Air Quality Agreement
- International Joint Commission
- Great Lakes Water Quality Agreement
- Convention on Biodiversity
- Accord for the Protection of Species at Risk
- UNFCCC and Kyoto Protocol
- International aviation, defence and Coast Guard agreements
- Bilateral forums and agreements (e.g., Russian Federation, China)

Science and Technology

EC is a science-based department, using both R&D and RSA to fulfil its mandate. S&T activities allow the Department to identify the extent of environmental issues and speak with credibility, while building consensus on solutions to these issues. Specifically, science and technology provides the capability to:

- Identify scientific research needs for environmental issues and direct resources toward addressing those needs;
- Carry out research (experimental design, data collection and analysis) and apply new science-based knowledge to environmental issues (research may include both natural sciences and socio-economic sciences);
- Build consensus on problems and potential solutions; and
- Develop and adapt tools to address environmental issues (regulations, guidelines, standards, technologies, etc.).

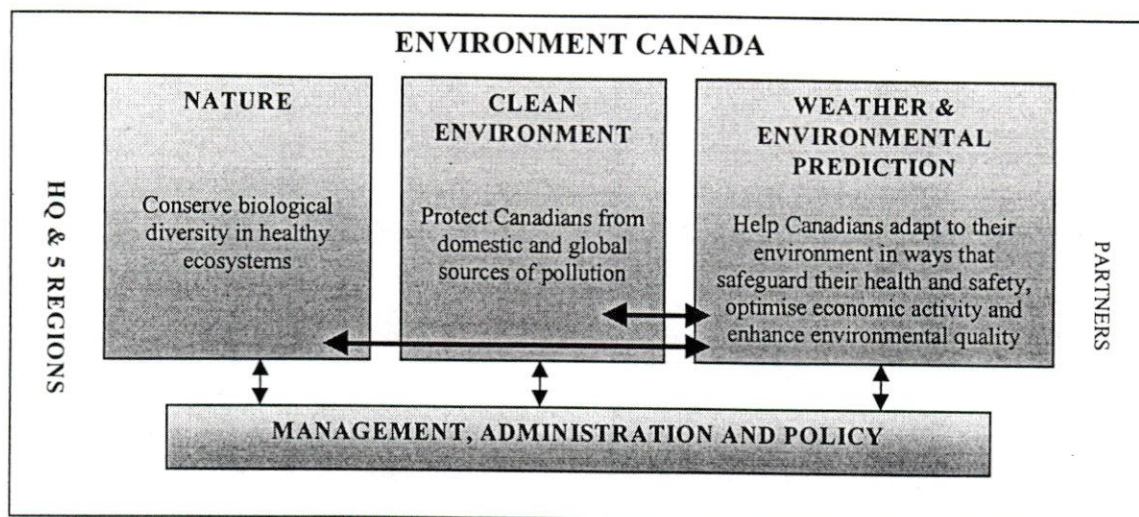
Fundamentally, science and technology acts to ensure that the Department has the knowledge and information needed to make responsible decisions regarding the environment, now and in the future.

The heart of the Department's S&T work is R&D. Research and development is used to identify and understand existing and emerging problems, support the development and application of solutions, and provide some of the knowledge needed to make sound decisions on policies and control options. Environment Canada's R&D activities support essential services, such as national weather warnings, which are relied on every day by Canadians and Canadian businesses. These R&D activities also support technology development, including new techniques for improving environmental prediction, environmental quality assessments and remediation of environmental pollution. The Department's research and monitoring activities are extensively partnered with Canadian universities, provinces and the international scientific community.

Context for R&D and RSA

Business Lines and Research Agendas

EC is structured around four business lines for internal management and external reporting. While the organizational regions and services of EC are where the day-to-day decisions are made, the business lines are forums for setting national direction, ensuring national coherence in program delivery, establishing clear accountabilities for results across organizations, and tracking and reporting on performance.



R&D and RSA are underway in each business line. R&D under the Clean Environment business line is primarily oriented toward protecting Canadians from domestic and global sources of pollution. Under the Nature business line, R&D generates new knowledge to support policies and management activities that ensure the sustainability of Canada's biodiversity and ecosystem health. Within the Weather and Environmental Prediction business line, R&D is oriented toward minimizing risks from natural and human-induced environmental hazards to the health, safety, property and environment of Canadians. R&D in the Management, Administration and Policy (MAP) business line targets social science areas in order to broaden our understanding of sustainable development (SD) and deepen our understanding of a variety of environmentally linked issues.

To provide a clear link between research and development programs and business line results, each business line is currently developing a "Research Agenda" that sets out the strategic research issues to be pursued over the next five to 10 years.¹ One of the key functions of the Research Agendas is to assist in determining departmental

¹ In the Research Agendas, research is defined as the combined activities of scientific hypothesis-based research; science assessment (integration and interpretation of existing data/results to understand impacts of human activities on the environment); and monitoring and reporting activities that provide feedback on the results of environmental conservation programs and identify emerging research needs.

requirements to support research, as capacity needs and priorities can be fully assessed only after key science areas have been examined.

R&D and RSA Challenges

Environment Canada's ability to carry out its mandated activities satisfactorily in the areas of science and technology may be challenged by the retirement of its workforce. In 1997, more than half of all scientific and technical employees in the Public Service were aged 45 years or older. By 2002, 20% of the 1997 science and technology workforce is projected to depart, including 26% of the Environment Canada R&D workforce. Retirements alone are expected to result in 65% of these estimated departures (Source: *Estimates of Hiring Potential: Scientific and Technical Community 1998-2002*). These crucial resources need to be replenished and developed to ensure work continues in the needed areas. This will involve both hiring and specific training to acquire and develop scientific knowledge and skills for research, technology and related information systems.

In terms of capital infrastructure, the Department operates 15 research institutes and laboratories, and over 4,600 air, climate and water monitoring stations in all regions of the country. However, this infrastructure is currently "rusting out." Environment Canada estimates that \$246 million is needed to bring its capital asset base up to acceptable industry standards, as determined by NATO, CPI and Treasury Board. This includes scientific facilities, scientific equipment, information technology and other infrastructure assets required for program delivery. Additionally, Environment Canada estimates an ongoing requirement of \$52.1 million annually to maintain its asset base at the level suggested under these standards. Indicators of the present state of Environment Canada's asset base are that 40% of the Atmospheric Environment infrastructure is beyond its expected operational lifetime (weather stations, water gauging stations, etc.). Similarly, the age of more than 60% of Environment Canada's overall scientific equipment base is beyond the applicable standard. In addition, EC's aging facilities base of specialized laboratories requires \$22.8 million to address health and safety code compliance and modernization needs (Source: *Capital Rust-Out of Federal Crown-Owned Assets*, April 1999).

Overall, the growing demands placed on the Department, coupled with the decreasing availability of resources over the last several years, have led to a gap in the Department's ability to meet emerging priorities and future needs.

Several initiatives are underway to address these gaps and to ensure that scarce resources are used to address defined program needs. These initiatives include the government-wide Program Integrity Exercise, the development of the Research Agendas, and the Science Capacity Study. Additional resources have been requested for departmental programs and infrastructure through a number of program-specific Memoranda to Cabinet and through the Long-Term Capital Plan.

Definitions of R&D and RSA

Before information can be provided on the types and amounts of R&D and RSA undertaken in EC, clear definitions are needed to indicate what was considered under each category.

Research and development (R&D) is defined as follows:²

- Creative work undertaken on a systematic basis to increase the stock of scientific and technical knowledge and to use this knowledge in new applications (this includes both basic and applied research).
- The central characteristic of R&D is an appreciable element of novelty and of uncertainty — new knowledge, products or processes are sought.
- The work is normally performed by, or under the supervision of, persons with postgraduate degrees in the natural sciences or engineering.
- It may include in-house R&D, contracts, grants and contributions, research fellowships, and capital expenditures.

Related science activities (RSA) are defined as follows:

- Activities that support or facilitate R&D work, or are an application of an R&D result.
- There are a number of categories for such activities (some specific to Environment Canada and some considered standard by Statistics Canada) including scientific and environmental assessment, production (e.g., forecasts and predictions), monitoring infrastructure, monitoring and reporting, information services, testing and standardization, feasibility studies, museum services, education support, pollution prevention, emergencies, enforcement, and technology transfer. (See Annex A for further details on each of these areas.)

While every attempt was made to follow these definitions when reporting the information below, this was not always possible due to the nature of the information available or how others interpreted the category of activity.

Types of R&D and RSA in Environment Canada

The following table lists the main R&D and RSA areas for each business line, result and sub-result. Many of these categories are quite detailed and pertain only to that single sub-result (e.g., understanding causes and effects of poor air quality), while others are more generic and apply to a number of results areas (e.g., monitoring).

Detailed resource information is not consistently available for the information provided at this level. Research and development activities discussed in this report are detailed

² Statistics Canada, "Guide to Assessment of Science and Science-Related Activities," catalogue 5-4900-421.

and generally well costed due to the availability of the R&D Activity Lists provided by Regions and Services. Detailed information on RSA (e.g., individual activities and their costs) were not readily available, even though RSA are more numerous and account for a much larger portion of the departmental budget than R&D activities. As a result, broad, aggregating categories were used for the analysis of RSA in this report. Nevertheless, this table does provide a good overview of the types of R&D and RSA underway in the Department, and shows how these activities contribute to achieving specific results.³

It should also be noted that there are significant interactions between R&D and RSA within the Department that can lead to a blurring of the distinctions between the two and cause difficulties in compiling a report like this. For instance, routine data collection for monitoring atmospheric conditions and preparing weather forecasts and predictions is deemed to be RSA. However, the subsequent use of the same data for purposes of understanding climate variations, or in relating weather events to pollution from human impacts, is categorized as R&D. Further, the interactions become more complicated because the infrastructure assets needed to carry out the monitoring and data collection, and the budgetary expenditures for their upkeep, are designated as R&D expenditures, despite serving both RSA and R&D initiatives.

³ Where provided, Business Line Plan designations of activities by RSA and R&D type were adhered to. Where this information was not available, the earlier StatsCan definitions were used in assigning activity types.

TABLE 1: TYPES OF R&D AND RSA BY BUSINESS LINE RESULT IN ENVIRONMENT CANADA

Business Lines	Results	Areas of Work	R&D Areas	RSA Areas
1. Clean Environment	1.1 Human Impact on atmosphere and air quality is reduced	1.1.1 Climate change	<ul style="list-style-type: none"> • Understanding impacts of climate change on aquatic ecosystems and hydrology • Technology development to reduce greenhouse gases 	<ul style="list-style-type: none"> • Science assessment • Monitoring and reporting
		1.1.2 Air quality	<ul style="list-style-type: none"> • Understanding sources, fates and threats from particulate matter • Understanding causes and effects of poor air quality (smog) • Improved ambient air-sampling technologies 	<ul style="list-style-type: none"> • Science assessment • Monitoring and reporting
		1.1.3 Acid rain	<ul style="list-style-type: none"> • Understanding domestic emissions and atmospheric processes • Impacts on aquatic ecosystems • Sources and fates of acidifying pollutants 	<ul style="list-style-type: none"> • Science assessment • Monitoring and reporting
		1.1.4 Hazardous air pollutants (HAPS)	<ul style="list-style-type: none"> • Identifying HAPs of concern, source regions and environmental changes • Sources, fates and impacts of POPs, PAHs, metals • Long-range transport and deposition of POPs and metals • National guidelines 	<ul style="list-style-type: none"> • Science assessment • Monitoring and reporting
		1.1.5 Stratospheric ozone	<ul style="list-style-type: none"> • Impacts of reduced production and consumption of ozone-depleting substances • Impacts of UV-B on aquatic ecosystems 	<ul style="list-style-type: none"> • Science assessment • Monitoring and reporting
	1.2 Threat posed by toxic substances is prevented or reduced	1.2.1 Virtual elimination of PBT substances	<ul style="list-style-type: none"> • Limits of quantification • Action of heavy metals and endocrine disruptors on ecosystem health • Impacts of POPs and metals (Hg) 	<ul style="list-style-type: none"> • Science assessment • Monitoring and reporting
		1.2.2 Understanding new substances	<ul style="list-style-type: none"> • Improving understanding and prevention of environmental and health impacts from toxics • Laboratory methods • Effects of priority substances, effluents and endocrine disruptors on aquatic ecosystems 	<ul style="list-style-type: none"> • Science assessment • Monitoring and reporting • Testing and standardization

TABLE 1: TYPES OF R&D AND RSA BY BUSINESS LINE RESULT IN ENVIRONMENT CANADA

Business Lines	Results	Areas of Work	R&D Areas	RSA Areas
		1.2.3 Understanding and managing existing substances	<ul style="list-style-type: none"> • Occurrence, persistence, fate and effects of toxics on aquatic ecosystems • Development of pollution prevention and toxic control technologies • Assessment and remediation of contaminated sites • Environmental assessment priorities 	<ul style="list-style-type: none"> • Pollution prevention • Emergencies • Technology transfer
2. Nature	2.1 Biological diversity is conserved	2.1.1 Recovery of species at risk	<ul style="list-style-type: none"> • Ecological requirements and research on species at risk • Approaches for species recovery • Understanding biodiversity and effects by human activities 	<ul style="list-style-type: none"> • Species assessment, species at risk legislation
		2.1.2 Sustaining and increasing targeted populations	<ul style="list-style-type: none"> • Wildlife research and surveys • Wildlife toxicology • Ecological requirements of migratory birds, and population dynamics of birds, caribou and polar bears • Recovery of species/endangered species • Northern ecology • Wildlife ecology 	<ul style="list-style-type: none"> • Amendments to existing legislation • Monitoring • Enforcement • Implementation of 1998 update of NAWMP
		2.1.3 Habitat stewardship	<ul style="list-style-type: none"> • Impact of habitat loss on wildlife • Preservation and restoration of critical habitats • Initiatives and plans for recovery of ecosystems 	<ul style="list-style-type: none"> • NAWMP joint ventures • Designation of national wildlife areas and migratory bird sanctuaries
		2.1.4 Biodiversity conservation		<ul style="list-style-type: none"> • Information and reporting systems, and performance measurement for Canadian Biodiversity Strategy

TABLE 1: TYPES OF R&D AND RSA BY BUSINESS LINE RESULT IN ENVIRONMENT CANADA

Business Lines	Results	Areas of Work	R&D Areas	RSA Areas
	2.2 Priority ecosystems are conserved and restored	2.2.1 Ecosystem initiatives	<ul style="list-style-type: none"> Protecting and conserving ecosystem health and diversity in distinct areas — St. Lawrence, Atlantic coast; northern communities; Peace, Athabasca and Slave rivers; Georgia Basin; Great Lakes New assessment and conservation approaches 	<ul style="list-style-type: none"> S&T policy and management instruments, decision support systems Pollution prevention Community projects
		2.2.2 Water resources (freshwater)		<ul style="list-style-type: none"> Development of a federal freshwater strategy Development of Canada-wide approach to prohibit bulk water removal
		2.2.3 Capacity building		<ul style="list-style-type: none"> Innovative tools for sound ecosystem and environmental decision making
	2.3 Human impacts on ecosystems are understood and reduced	2.3.1 Current state of ecosystem health	<ul style="list-style-type: none"> Aquatic ecosystem health, stressors, and new threats (e.g., endocrine disruptors) Cumulative impacts of environmental stressors on freshwater ecosystems 	<ul style="list-style-type: none"> National environmental indicators Ecological monitoring and assessment Environmental effects monitoring
		2.3.2 Understanding human impacts	<ul style="list-style-type: none"> Sources, fates and effects of toxics on aquatic ecosystems Wildlife and ecosystem impacts of PBTs — lindane and mercury 	<ul style="list-style-type: none"> New ecosystem health indicators Decision-making tools and codes of practice to minimize impacts of land management activities on water resources
		2.3.3 Reducing human impacts	<ul style="list-style-type: none"> Identifying remediations and restoration approaches for ecosystem health National guidelines, standards and indicators of ecosystem health 	<ul style="list-style-type: none"> Information services

TABLE 1: TYPES OF R&D AND RSA BY BUSINESS LINE RESULT IN ENVIRONMENT CANADA

Business Lines	Results	Areas of Work	R&D Areas	RSA Areas
		2.3.4 Management of S&T capacity, infrastructure	<ul style="list-style-type: none"> • Laboratory operation for research support 	<ul style="list-style-type: none"> • S&T policy and management instruments
			R&D Areas	RSA Areas
3. Weather and Environmental Prediction	3.1 Reduced impact of weather and related hazards on health, safety and the economy	3.1.1 Extreme weather and related hazards 3.1.2 Climate change and variability 3.1.3 Ice 3.1.4 Water quantity 3.1.5 Air quality	<ul style="list-style-type: none"> • Numerical weather and hydrologic models • Cloud and precipitation physics • Data assimilation • Severe weather research • Nuclear and volcanic modelling • Technology development • Forecast techniques 	<ul style="list-style-type: none"> • Prediction of severe weather events and related hazards • Advice on nuclear accidents and volcanic eruptions • Advice on floods and surges • Remote and ground-based sensing • Outreach, education and consultation
	3.2 Adaptation to day-to-day and long-term changes in atmospheric hydrologic and ice conditions	3.2.1 Weather and environmental applications 3.2.2 Climate change and variability 3.2.3 Ice 3.2.4 Water quantity 3.2.5 Air quality	<ul style="list-style-type: none"> • Numerical weather, climate and hydrologic models • Stratospheric studies • Climate processes • Climate trends • Carbon cycle • Climate research network 	<ul style="list-style-type: none"> • Environmental prediction and information • Remote and ground-based sensing • Climate trends and data analysis • Science assessment • Outreach, education and consultation • Socio-economic impacts and adaptation • Development of applications to human health, biodiversity, pollution prevention • Maintain world's tropospheric ozone archive

TABLE 1: TYPES OF R&D AND RSA BY BUSINESS LINE RESULT IN ENVIRONMENT CANADA

Business Lines	Results	Areas of Work	R&D Areas	RSA Areas
4. Management Administration and Policy	4.1 Strategic and integrated policy, priorities and plans	4.1.1 Socio-economic and policy research	<ul style="list-style-type: none"> • Broaden understanding of SD in a domestic and international context, including barriers to SD implementation, solutions for better integrating SD considerations into the policy process, and research gaps Research surveys on: importance of nature to Canadians; Industrial Water Survey and Municipal Water Survey; value of avoiding the morbidity effects of air pollution; Importance of maintaining water quality in Canadian communities • Environmental Valuation Reference Inventory (EVRI), a database of environmental economic values • Air Quality Valuation Model (AQVM) that estimates the value of avoiding the health effects of air pollution • Case studies: benefits of controlling three chemical substances • Natural Capital —valuing Canada's natural assets 	
	4.2 A well-performing organization, supported by efficient and innovative services			

Expenditures on R&D and RSA

Departmental Resources

The following table estimates the expenditures on R&D and RSA for each business line result area. Please note that the various pieces of information originate from different sources. Thus, references are provided for each number, and all are included to show the variance. The table on the following page breaks out the expenditures further, based on key areas of work (specific R&D and RSA areas for each are described in Table 1).

TABLE 2: NET BUDGETARY EXPENDITURES IN ENVIRONMENT CANADA (99/00)				
Business Line	Result	Total \$M	R&D \$M	RSA \$M
Clean Environment		134 ⁴	16 ⁷ -35 ⁸ (27 ⁴)	39 ⁸ -69 ⁴ (68 ⁵)
	Human impacts on atmosphere and air quality are reduced	62 ⁴	9 ⁷ -13 ⁴ (12 ⁸)	16 ⁸ -29 ⁴
	Threats posed by toxic substances are prevented or reduced	72 ⁴	7 ⁷ -23 ⁸ (14 ⁴)	23 ⁸ -40 ⁴
Nature		137 ⁴	38 ⁷ -40 ⁴	60 ⁴
	Biological diversity is conserved	45 ⁴	11 ⁴ -14 ⁷	28 ⁴
	Priority ecosystems are conserved and restored	52 ⁴	5 ^{4,7}	22 ⁴
	Human impacts on ecosystems are understood and reduced	40 ⁴	19 ⁷ -24 ⁴	10 ⁴
Weather and Environmental Prediction		150.8 ⁸ (167 ⁴)	27 ⁸ (23 ⁷ -32 ⁴)	123.8 ⁸ (109 ⁵ -111 ⁴)
	Reduced impact of weather and related hazards on health, safety and the economy	106.4 ⁸ - 119 ⁴	11.6 ⁸ (10 ⁷ -14 ⁴)	94.8 ⁸ (83 ⁵ -88 ⁴)

⁴ Estimates from 1999-2000 ARLU — Pivot Table Activities

⁵ Business Line Plans

TABLE 2: NET BUDGETARY EXPENDITURES IN ENVIRONMENT CANADA (99/00)				
Business Line	Result	Total \$M	R&D \$M	RSA \$M
	Adaptation to day-to-day and long-term changes in atmospheric, hydrologic and ice conditions	44.4 ⁸ - 48 ⁴	15.4 ⁸ (13 ⁷ -18 ⁴)	29 ⁸ (23 ⁴ -26 ⁵)
	Management Administration and Policy	94 ⁴	1 ^{4,8}	
	Strategic and integrated policy, priorities and plans	51 ⁴	1 ^{4,8}	
	A well-performing organization, supported by efficient and innovative services	43 ⁴		
TOTAL DEPARTMENTAL		532⁴	78⁷/100⁴/102⁸ (100⁶)	223⁸/237⁵/240⁴ (252⁶)

TABLE 3: ESTIMATED NET BUDGETARY EXPENDITURES ON R&D AND RSA BY BUSINESS LINE RESULT IN ENVIRONMENT CANADA (Estimated from 1999-2000 ARLU Pivot Table Activities)				
Business Lines	Results	Areas of Work	R&D Expenditures	RSA Expenditures
1. Clean Environment	1.1 Human impact on atmosphere and air quality is reduced	1.1.1 Climate change	\$5 M	\$6 M
		1.1.2 Air quality	\$2 M	\$11 M
		1.1.3 Acid rain	\$3 M	\$3 M
		1.1.4 Hazardous air pollutants	\$2 M	\$4 M
		1.1.5 Stratospheric ozone	\$1 M	\$5 M
	1.2 Threat posed by toxic substances is prevented or reduced	1.2.1 Virtual Elimination of PBT Substances	\$3 M	\$2 M
		1.2.2 Understanding new substances	\$4 M	\$3 M

⁶ Science Addendum (1999/2000)

⁷ R&D Activity Lists provided by Regions and Services

⁸ Notes from Business Line Planners (for WEP, based on 2000-2001 budgets; does not include senior management, support services, policy development or unallocated items)

TABLE 3: ESTIMATED NET BUDGETARY EXPENDITURES ON R&D AND RSA BY BUSINESS LINE RESULT IN ENVIRONMENT CANADA (Estimated from 1999-2000 ARLU Pivot Table Activities)				
Business Lines	Results	Areas of Work	R&D Expenditures	RSA Expenditures
		1.2.3 Understanding and managing existing substances	\$7 M	\$35 M
2. Nature	2.1 Biological diversity is conserved	2.1.1 Recovery of species at risk		\$4 M
		2.1.2 Sustaining and increasing targeted populations	\$7 M	\$11 M
		2.1.3 Habitat stewardship	\$4 M	\$13 M
		2.1.4 Biodiversity conservation		
	2.2 Priority ecosystems are conserved and restored	2.2.1 Ecosystem initiatives	\$5 M	\$14 M
		2.2.2 Water resources		\$4 M
		2.2.3 Capacity building		\$4 M
	2.3 Human impacts on ecosystems are understood and reduced	2.3.1 Current state of ecosystem health	\$4 M	\$5 M
		2.3.2 Understanding human impacts	\$3 M	\$2 M
		2.3.3 Reducing human impacts	\$3 M	\$2 M
		2.3.4 Management of S&T capacity and infrastructure	\$14 M	\$1 M
3. Weather and Environmental Prediction	3.1 Reduced impact of weather and related hazards on health, safety and the economy	3.1.1 Extreme weather and related hazards	\$5.8 M	\$80.0 M
		3.1.2 Climate change and variability	\$2.7 M	\$1.6 M
		3.1.3 Ice	\$0 M	\$2.5 M
		3.1.4 Water quantity	\$0.7 M	\$10.2 M
		3.1.5 Air quality	\$2.4 M	\$0.5 M
	3.2 Adaptation to day-to-day and long-term changes in atmospheric hydrologic and ice conditions	3.2.1 Weather and environmental applications	\$3.8 M	\$20.9 M
		3.2.2 Climate change and variability	\$10.9 M	\$4.9 M
		3.2.3 Ice	\$0 M	\$0.6 M
		3.2.4 Water quantity	\$0.1 M	\$2.5 M
		3.2.5 Air quality	\$0.5 M	\$0 M

TABLE 3: ESTIMATED NET BUDGETARY EXPENDITURES ON R&D AND RSA BY BUSINESS LINE RESULT IN ENVIRONMENT CANADA (Estimated from 1999-2000 ARLU Pivot Table Activities)				
Business Lines	Results	Areas of Work	R&D Expenditures	RSA Expenditures
4. Management Administration and Policy	4.1 Strategic and integrated policy, priorities and plans	4.1.1 Socio-economic research	\$1 M	
	4.2 A well-performing organization, supported by efficient and innovative services			

New S&T Resources

In addition to the expenditures noted above for ongoing program requirements, there have been two significant new sources of funds for R&D and RSA in Environment Canada over the last couple of years.

1. Toxic Substances Research Initiative

The Toxic Substances Research Initiative (TSRI) is a program within the Environmental Health Directorate of Health Canada that provides funding for applied toxic substances research. This initiative supports research projects from both within and outside the federal government and promotes partnerships between researchers in both sectors.

The key objective of the TSRI is to enhance the knowledge base needed to define and reduce the risk of adverse effects of toxic substances on Canadians and their environment. This includes knowledge needed to conduct risk assessments, develop risk management strategies, evaluate risk management options, and provide Canadians with sound science on which to base their own decisions. The TSRI complements other federal activities on toxic substances by supporting multidisciplinary team research, both within and outside government, into priority areas and emerging issues not adequately addressed by other programs.

Research proposals are funded annually following a technical peer review, directed by a Science Management Committee (SMC) comprising of senior scientists (co-chaired by Environment Canada and Health Canada). A total of 81 research projects were selected for funding over the 1999-2000 fiscal year, allocating \$10.94 million toward the first phase of research projects under the TSRI. Forty percent of the funds were allocated to the federal government (\$4.3 million).

Environment Canada had 21 projects approved for 1999-2000 (i.e., where EC is the principal investigator), for a total of \$3 million over three years. These include the following project amounts, broken down in terms of research priorities:

• Persistent Organic Pollutants (POPs)	\$700,000
• Metals	\$810,600
• Endocrine Disrupting Chemicals (EDCs)	\$850,000
• Air	\$300,000
• Cumulative Effects	\$350,000

EC is also a partner in about 14 other TSRI projects.

2. Climate Change Action Fund

The Climate Change Action Fund (CCAF) was announced in the 1998 federal budget, where \$150 million was allocated over three years to support the development of an implementation strategy to meet the commitments made in Kyoto on climate change and to facilitate early action to reduce greenhouse gas emissions.

Activities under the CCAF have been divided into four components:

- Foundation Analysis by Issues Tables
- Technology Early Action Measures
- Science, Impacts and Adaptation (SIA)
- Public Education and Outreach (PEO)

Environment Canada had net budgetary expenditures of over \$17 million for the various CCAF components in 1999-2000, drawn from the following allocations:

- \$10 million per year for three years for PEO — most of which is provided to external outreach projects;
- \$3 million per year for SIA — much of which was provided to external and partnered research projects;
- \$2 million to help support and participate in the Issues Tables; and
- \$2.6 million for the Climate Change Bureau.

The current CCAF sunsets in March 2001.

External S&T Resources

Also, the Department is very successful at obtaining additional resources from external sources and partnerships for S&T work. Three main types of leveraging take place in EC:

1. Revenue credited to vote (VNR), which is often used for RSA and other non-S&T work, and is planned or estimated annually. This totalled about \$70 million in 1999-2000 (see breakdown in table below for all VNR, not just S&T spending). This amount of revenue amounts to around 11% of gross spending, and reduces the Department's net expenditures from around \$620 million to less than \$550 million..
2. Special-purpose accounts, which are often used for R&D work as part of specific joint projects on particular areas. This totalled about \$3.2 million in 1999-2000; split between Nature (43%), Clean Environment (37%), and Weather and Environmental Prediction (20%). This amount varies from year to year, as projects are negotiated annually.
3. Work sharing, which is in-kind leveraging of resources for S&T work. While difficult to quantify, it is a very important part of the work in all S&T areas and enables EC to build long-term relationships with academia, industry, other government departments, provinces and other countries to address common priorities. For example, the Environmental Technology Centre estimates that it levers about \$10-15 million per year in work-sharing arrangements. As further information on work-sharing amounts and types are not available through departmental systems, directors of research institutes would need to be contacted directly for more details.

Table 4: Estimated Breakdown of Vote Net Revenue (VNR) in Environment Canada

(Source: Environment Canada, *Report on Plans and Priorities*, 1999-2000 Estimates)

Business Line	Gross Planned Spending (\$M)	VNR (\$M)
Clean Environment	134	5.8
Human impacts on atmosphere and air quality are reduced	62	3.1
Threats posed by toxic substances are prevented or reduced	72	2.7
Revenue Areas: <ul style="list-style-type: none"> • Information Products • Scientific and Professional Services • Regulatory Services • Realty (Accommodation) • Miscellaneous 		Breakdown: <ul style="list-style-type: none"> 3.7 1.3 0.4 0.1 0.3
Nature	137	7.6
Biological diversity is conserved	45	0.7
Priority ecosystems are conserved and restored	52	1.1
Human impacts on ecosystems are understood and reduced	40	5.8
Revenue Areas: <ul style="list-style-type: none"> • Information Products • Scientific and Professional Services • Regulatory Services • Realty (Accommodation) • Miscellaneous 		Breakdown: <ul style="list-style-type: none"> 4.1 1.4 0.2 0.2 1.7
WEP	167	56.5
Reduced impact of weather and related hazards on health, safety and the economy	110	42.8
Adaptation to day-to-day and long-term changes in atmospheric, hydrologic and ice conditions	57	13.7
Revenue Areas: <ul style="list-style-type: none"> • Information Products • Scientific & Professional Services • Regulatory Services • Realty (Accommodation) • Miscellaneous 		Breakdown: <ul style="list-style-type: none"> 50.3 2.3 0.6 0.6 2.7
MAP	94	0.015
Strategic and integrated policy, priorities and plans	51	0
A well-performing organization, supported by efficient and innovative services	43	0.015
Revenue Areas: <ul style="list-style-type: none"> • Miscellaneous (Administrative Services) 		Breakdown: <ul style="list-style-type: none"> 0.015
TOTAL REVENUE		69.9

While the table above includes VNR for all departmental activities, the following provides an idea of which S&T areas receive the largest sources of external revenue (i.e., over \$1 million):

In Clean Environment:

- | | |
|--------------------------------|---------------|
| • Ocean Disposal | \$1.3 million |
| • Program on Energy R&D (PERD) | \$2.6 million |

In Nature:

- | | |
|-----------------------------------|-------------|
| • Operation of Research Buildings | \$3 million |
| • PERD | \$1 million |

In Weather and Environmental Prediction:

- | | |
|-----------------------------------|--------------|
| • Weather Services | \$36 million |
| • Ice Services | \$11 million |
| • Water quality/quantity Services | \$6 million |
| • Climate | \$2 million |
| • PERD | \$2 million |

The Science Addendum, compiled by Statistics Canada, indicates that revenues specific to S&T activities total around \$57 million (about 80% of total revenues). This means that about 16% of departmental spending on S&T comes from external sources.

The Science Addendum also provides information on the major sources of external revenues for S&T. It has noted the following trends in revenues to Environment Canada over the last three years:

- The departmental budget accounts for about 84% of the total S&T funds;
- Revenues from other federal departments account for about 7% of the total S&T funds;
- Revenues from business enterprises account for about 7% of the total S&T funds; and
- Revenues from provincial governments account for about 2% of the total S&T funds.

Analysis and Conclusions

Considerations

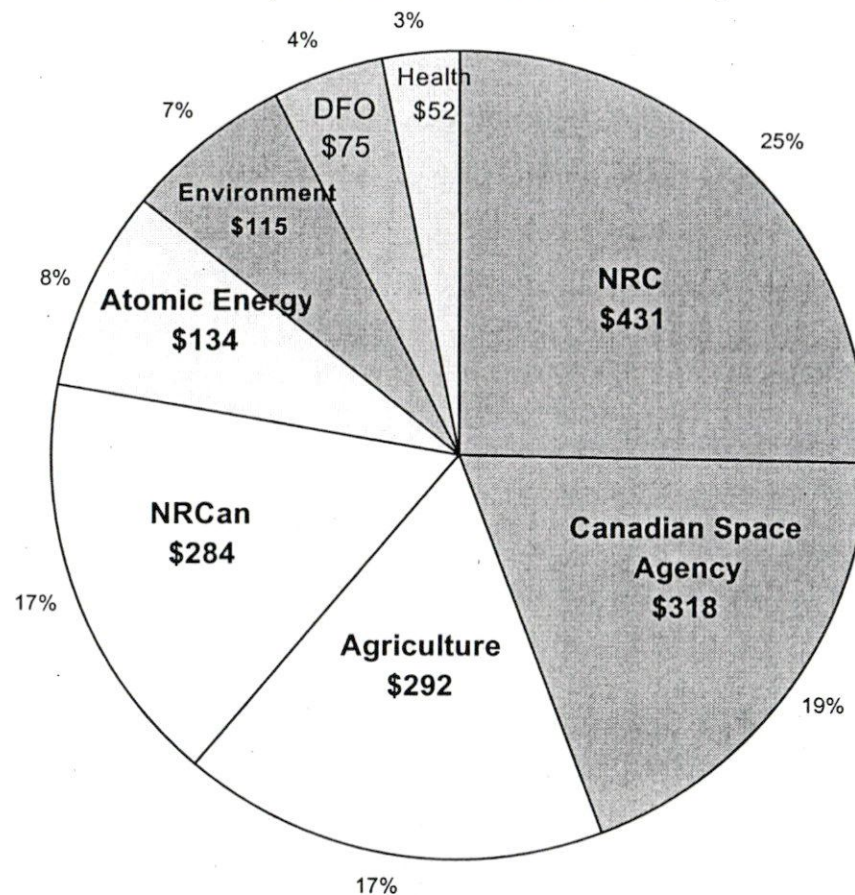
Determining the types and amounts of R&D and RSA underway in the Department is not a simple exercise. As Environment Canada uses a results-based management approach, information is available either on a results basis or by organization/responsibility centre. The financial and planning systems do not currently code functions as either R&D or RSA; and therefore, considerable interpretive effort is necessary when compiling such information, and cross-checking with other sources of information (at varying levels of detail) is also required.

While there is a significant level of detail on current R&D activities and spending, due to a recent Science Policy Branch exercise soliciting such information, this is not yet complete and there is relatively little direct information on RSA spending. In some business line plans (e.g., WEP and Clean Environment), resource totals by R&D and RSA can be surmised; however, there are varying interpretations of what fits into each category across the Department (e.g., WEP includes science assessment as an R&D activity, rather than as RSA). Finally, while the government-wide Science Addendum, compiled by Statistics Canada, does provide an R&D/RSA breakdown, it is at a departmental or organizational level and thus is most useful for interdepartmental comparisons, rather than for illustrating Environment Canada's specific priorities. Nevertheless, in reviewing Table 2 it can be seen that the totals estimated through review of the available information, including Business Line Plans, R&D Activity Lists and the 1999-2000 ARLU Pivot Table Activities, are in close agreement with the aggregate departmental numbers provided in the Science Addendum (1999/2000). Although the numbers from various sources are similar, each should be considered notional, rather than absolute, and they should be used to indicate a relative and approximate level of effort, rather than a definitive sum.

Conclusions

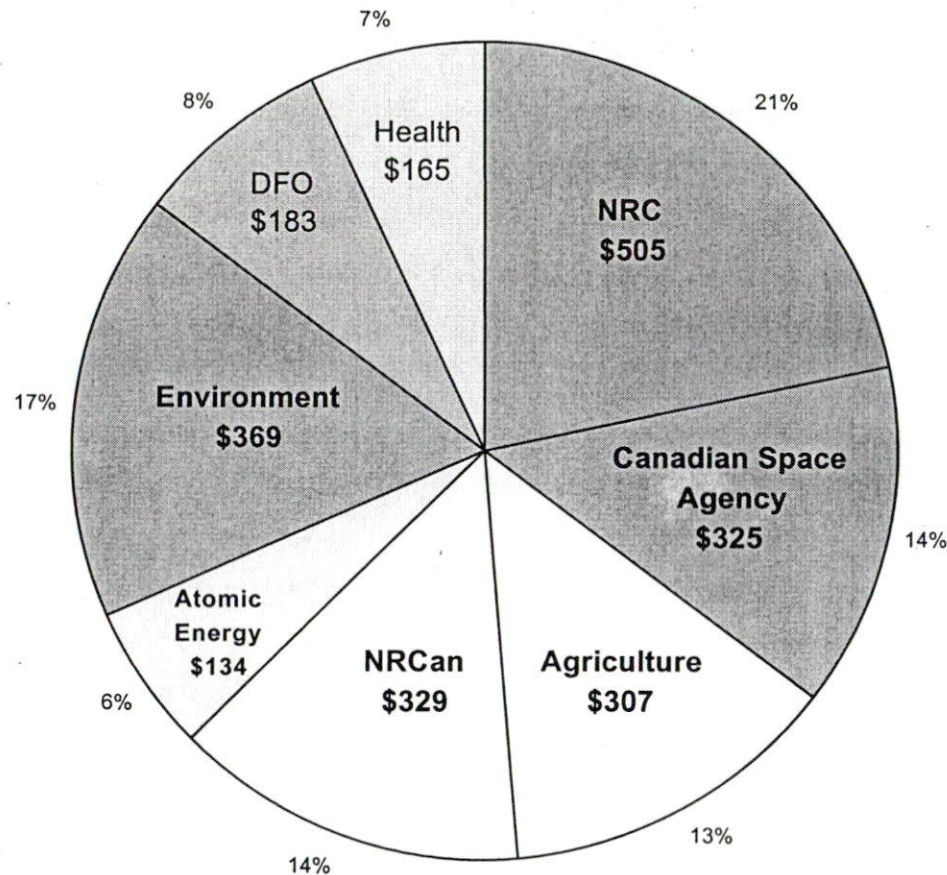
Environment Canada is truly a "science-based" department. EC ranks sixth in terms of total expenditures on R&D by major performing federal departments and agencies, behind the National Research Council (NRC), the Canadian Space Agency, Agriculture and Agri-Food Canada, Natural Resources Canada, and Atomic Energy Canada, but ahead of Fisheries and Oceans and Health Canada (Source: *Science Capacity Study*, May 18, 1999). Environment Canada ranks second, behind only NRC, when considering total S&T expenditures, due to the fact that the Department has the highest expenditures in RSA. *It should be noted that, while generally in agreement, the Environment Canada R&D and S&T expenditures documented in this study are not identical to those provided in the Science Addendum (1999/2000) or those surmised from the other sources used in this exercise.*

**Federal Expenditures on R&D
by major performing department or agency
(1998/99 constant \$million)**



Source: "Science Capacity Background Data, May 18, 1999: a study by the Impact Group"

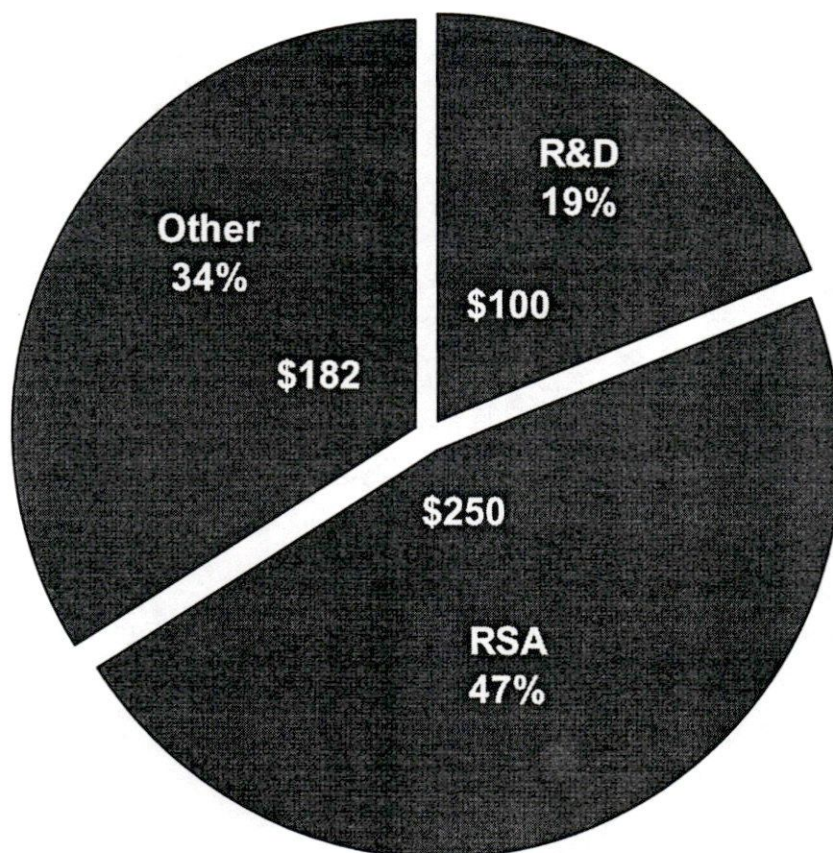
**Federal Expenditures on S&T
by major performing department or agency
(1998/99 constant \$million)**



Source: "Science Capacity Background Data, May 18, 1999: a study by the Impact Group"

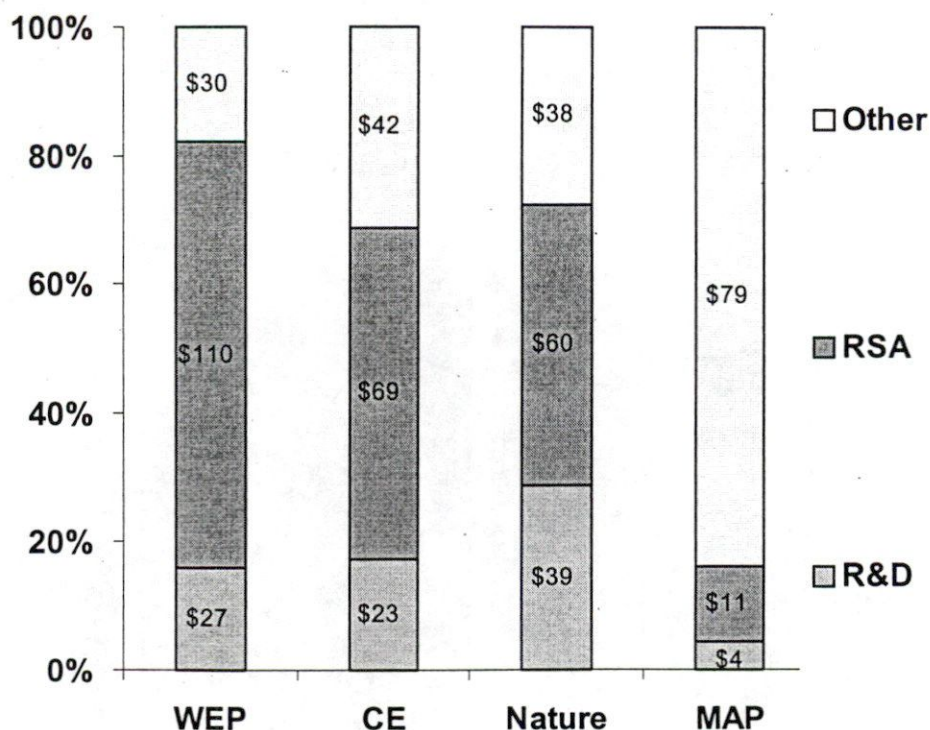
Of Environment Canada's \$532 million overall budgetary expenditures for 1999-2000, about 66% are for S&T activities — around \$100 million for R&D (19%) and \$250 million for RSA (47%). The rest of the expenditures (34%) are mainly for activities that run across all business lines including policy work, management and planning, and support services (administration, human resources, informatics, finance).

**Environment Canada
Expenditure
1998/99 (\$million)**



R&D and RSA expenditures vary considerably by business line, with most of the S&T activity taking place in the WEP and Nature business lines (82% and 72%, respectively), and most of the policy and support work taking place in the Clean Environment and MAP business lines (33% and 84%, respectively). This is consistent with the function and mandate of the various business lines. The largest chunk of R&D resides in the Nature business line, due to its responsibility for several of the major research institutes. The largest chunk of RSA resides in the WEP business line, for the extensive weather forecasting and production functions.

Environment Canada Expenditure Allocation by Business Line (\$ millions)



Breaking down the R&D/RSA expenditures into the various categories of research, the highest R&D expenditures are in the following areas (not including infrastructure):

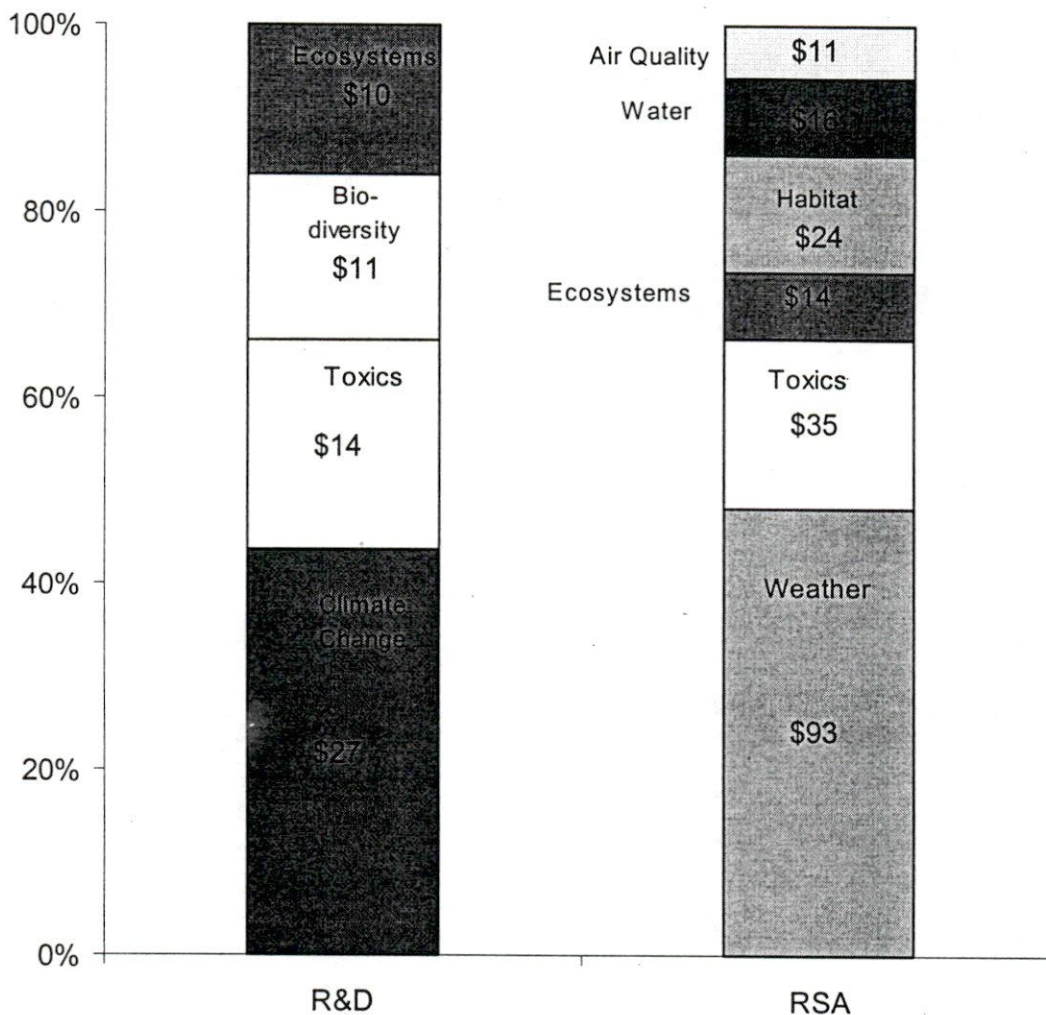
- Climate Variability, Climate Change and Adaptation \$27 million
- Toxic Substances \$14 million
- Biodiversity \$11 million
- Ecosystem Health \$10 million

The highest RSA expenditures are in the following areas:

- Weather (forecasts, warnings, extreme events, information products, data processing, network planning and standards, etc.) \$93 million
- Managing Toxic Substances (pollution prevention, emergencies, enforcement, environmental assessment, technology transfer) \$35 million
- Habitat and Wildlife Stewardship (migratory birds, wildlife enforcement, management plans and wildlife areas, etc.) \$24 million
- Water/Ice (monitoring, modelling, network planning and standards, network inspection, support and maintenance, etc.) \$16 million

- Ecosystem Initiatives (community/ecosystem projects on toxics, air, water quality and conservation, biodiversity, governance, etc.) \$14 million
- Air Quality (science assessment, monitoring, etc. for smog and other air toxics) \$11 million

Environment Canada S&T Expenditure 1998/99 (\$millions)



This report does not make conclusions on the appropriateness of the funds spent in different results areas. However, the information provided in Table 3 illustrates, for use by the S&T Advisory Group, the balance between R&D and RSA spending, and the level of effort in the key program areas, thereby alluding to the funding priorities of the Department.

It is widely recognized that the Department is under-resourced in almost every program area. Emerging environmental issues (e.g., endocrine disrupting

substances) and the high priority of current issues (e.g., climate change, biodiversity, toxics) place an increased demand on finite resources required to meet legislative and other obligations. The challenge for Environment Canada, and for the S&T Advisory Group in advising the Department, is to balance these needs and resources in a way that best "helps Canadians live and prosper in an environment that needs to be respected, protected and conserved." The aim of this report is to provide some background information to help in this task.

Other initiatives are underway, both with the S&T Advisory Committee (e.g., Impact Group report on "Strengthening Environmental Research in Canada") and within the Department (e.g., Research Agendas) to identify the key future S&T needs, and to identify and analyse gaps. This work will be important to ensuring that planning and resources are allocated to the highest research priorities now and in the future.

Annex A: Definition of Key RSA Functions

Education Support — grants to individuals or institutions on behalf of individuals, which are intended to support the post-secondary education of students in technology and the natural sciences.

Emergencies — all activities to anticipate, prevent and reduce the frequency, severity and consequences of accidental releases (risk management), including preventive measures, preparedness initiatives, response advice, and negotiation and implementation of international, national and regional agreements, principles and standards.

Enforcement — activities that enforce the Canadian Environmental Protection Act and specific sections of the Fisheries Act, including inspections, investigations, and measures to compel compliance (tickets, court orders).

Environmental Assessment — activities ensuring compliance with the Canadian Environmental Assessment Act, including provision of expert advice, marketing procedures and methodologies, management of information and advocating the sustainable use of resources, the conservation of biodiversity and the protection of ecosystems.

Feasibility Studies — technical investigations or demonstration of proposed engineering projects to provide additional information required to reach decisions on implementation.

Information Services — all work directed to recording, classifying, translating and disseminating scientific and technological information. Included are the operations of scientific and technical libraries, S&T consulting and advisory services, the Patent Office, the publication of scientific journals and monographs, and the organizing of scientific conferences. Grants for the publication of scholarly works are also included.

Monitoring and Reporting — providing data for predictive models and for reporting, and providing feedback to guide policy development and fine-tuning of program delivery. Management tracking is also included in this function, as it too provides data for modelling (scenario building) and reporting, and provides feedback. Scientific monitoring captures activities related to the systematic collection of data about the environment, for example:

- Baseline monitoring to determine the nature and ranges of natural variation;
- Effects monitoring to measure changes that can be attributed to a departmental intervention;
- Compliance monitoring to ensure that regulatory requirements are observed and standards met (surveillance and inspection may also form a part of this activity but need not necessarily involve measurement); and
- Evaluation studies to determine the effectiveness of policies and programs.

Monitoring Infrastructure — continuous and systematic observations of the environment, including data gathering, quality assurance, archiving, data management, instrument maintenance, and network planning and standards.

Museum Services — the collecting, cataloguing, and displaying of specimens of the natural world or of representations of natural phenomena. The scientific activities of natural history museums, zoological and botanical gardens, aquaria, planetaria and nature reserves are included.

Pollution Prevention — the use of processes, practices, materials, products or energy that avoid or minimize the creation of pollutants and waste, and reduce overall risk to human health or the environment. Pollution prevention activities include:

- Promoting pollution prevention to industry and other stakeholders, including participation in international fora;
- Demonstration projects and seminars at federal and industrial facilities;
- New Substances Notification;
- Assessing biotechnology;
- Implementing the pollution prevention provisions of the Canadian Environmental Protection Act and the Fisheries Act; and
- Pollution prevention planning for international air and water.

Production — assimilating and analysing data, including running numerical models, interpreting model outputs, and generating products to meet the timing and information needs of clients.

Science Assessment — identifying the risk to physical, chemical and biological processes within ecosystems, and shedding light on the connections between these things. Any work detailing exposure, effects or entry falls into the science assessment function.

Technology Transfer — activities intended to bridge the gap between the understanding of an environmental problem and the action required to achieve environmental results, including the demonstration, evaluation, commercialization and deployment of Canadian environmental technologies domestically; as well as international cooperation on pollution abatement.

Testing and Standardization — work directed toward the establishment of national and international standards for materials, devices, products and processes, the calibration of secondary standards and non-routine quality testing.

Voluntary Agreements — activities directed toward implementation of specific agreements to reduce environmental impacts (e.g., ARET [Accelerated Reduction and Elimination of Toxics], motor vehicle emissions), including training, communication, monitoring and tracking.

Annex B: Key Sources of Information

1. *R&D Summaries by Business Line and Result* — which includes comprehensive but incomplete information on the broad research areas across the Department, as well as associated resources for 1998-99 and 1999-2000.
2. *Departmental Science Addendum* — which rolls up the Department's level of effort in R&D and RSA areas each year for Statistics Canada. This information provides an overall picture of the expenditure of resources, but does not provide detail on which research areas these resources support.
3. *Departmental Science Capacity* — which includes various bits of information on science capacity in Environment Canada, such as issues, gaps and recommendations for a long-term framework; demographics of the S&T workforce; overall expenditures on S&T and R&D; and bibliometric analysis of research publications.
4. *Federal Science Capacity Study* — which was completed in 1999 and compares federal expenditures on S&T, R&D and RSA by department for 1998-99.
5. *Atmospheric Environment Service Alternative Delivery Study* — which includes specific capacity analyses for this section of the Department.
6. *Environment Canada's ARLU Pivot Table (1999-2000)* — detailing departmental expenditures by result and activity.
7. *Departmental Business Line Plans*.
8. *Statistics Canada "Guide to Assessment of Science and Science-Related Activities."* Catalogue 5-4900-421. Provides definitions for use in designating science-based activities as R&D or RSA.
9. *Discussion with Business Line Planners*.



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