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From Fragmentation to Coordination: Ensuring Canada's Environmental Research Meets the Country's Needs

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Executive Summary

Background

Environmental research is a broad term that includes a wide variety of activities that seek to create knowledge about the biotic and abiotic environment. These activities include everything from studying the habitat of a particular animal to determining water quality through a series of chemical analyses or studying urban design to determine how to minimize cities' impacts on their surrounding environments. Involved in such pursuits are a number of players, generally within the categories of researchers, research users or research funders. Environmental researchers in Canada are found principally in the federal government and the higher education sector (universities, colleges and technical institutes), though a significant number of scientists work for other organizations like provincial governments, hospital consortiums, business enterprise and advocacy groups. Research users, including governments at all levels, business enterprise, academia, the media, non-governmental organizations, advocacy groups, citizens' coalitions and individual Canadians, are the largest group. A research use of key importance to the country is that of governments, who need science to fulfill their policy, regulatory, and legislative mandates. Environmental research funders are a smaller, though equally diverse group. Large portions of environmental research funding come from the federal government and the granting councils, with smaller portions from provincial governments, business enterprise and non-governmental organizations.

The coordination challenge

Within Environment Canada, the idea of coordinating environmental research has been around for some time and has most recently taken the form of the Canadian Environmental Sciences Network (CESN). CESN, along with environmental researchers, have been actively engaged in increasing collaborative efforts across the environmental sciences. Programs like the Networks of Centres of Excellence have also contributed to greater collaboration in environmental research. However, despite these collaborations and partnerships between individual researchers, environmental research as a whole remains largely fragmented. Funding structures generally do not promote research across disciplinary or sectoral boundaries, making collaborative projects more difficult to get off the ground.

Were environmental sciences presented with unlimited resources, such a lack of coordination might not be a problem. As it is, though, resources in this area are very tight and the issues environmental research must seek to address are ever-increasing. For example, the Canadian public is increasingly demanding action on the environment, especially where environmental factors are thought to be affecting people's health. Additionally, governments are using environmental research not just as an end in itself, but also as a piece of the larger sustainable development picture. International pressures also place demands on Canadian environmental research, meaning that new science must be produced for not only multiple audiences, but also for multiple purposes.

Coordination would provide a way to more effectively channel resources to meet these growing demands. As it stands currently, it is very difficult to determine exactly who is doing what in the area of environmental research and how much money they are spending on it. One of the reasons for this is the ambiguity of environmental science: not a traditional discipline of its own, it often escapes traditional classification and reporting systems. Because there is little front-end coordination, either in academia or government and only round-about, best-guess ways to determine output, pinning down what Canada is doing by way of environmental research is a difficult task. Meeting the needs of the multiple audiences and multiple purposes mentioned above is, then, a quite obviously piece-meal, fragmented process. Increased coordination would allow these needs to be met in a more strategic fashion and allow researchers to work collaboratively on long term approaches to significant environmental challenges.

Achieving this type of coordination, however, would require a process that presents its own set of questions. The first is a dual question of who would be involved in such a process and what its aims might be. Equally important are issues like what kind of mechanism might ensure coordination, how funding would be aligned with coordinated goals and how the supply and demand sides of environmental research could be integrated. Careful consideration of different choices associated with these questions would be a necessary precursor to establishing a successful coordination exercise.

Optional approaches

There are several different ways in which a process to increase coordination in Canadian environmental research might be designed. The first would be to promote existing linkages and research agendas. This could involve fostering partnerships and collaborations as they occur and increasing efforts to integrate research agendas developed by extant networks working in areas of environmental science. Another process would involve mechanisms of central coordination. These could include an environmental research agenda for the entire federal government, or perhaps harmonization through the Canadian Council of Ministers for the Environment. An effective tool in this effort would be funding coordination, either at the government level or with involvement from the granting councils in a more widespread initiative. An expert mediated process, on the other hand, would involve focusing effort on researchers' input to a coordination effort. A more inclusive view of what it means to be an expert could bring research producers, users and funders to the table as an advisory council that would guide a coordination process. Lastly, a stakeholder centered process could involve either direct stakeholders such as funders, users and producers of environmental research, or it might be expanded to include broad public input.

Recommendations

Combining several optional approaches to increasing coordination yields the most effective way to help the environmental science community address the challenges with which it is faced. A national summit supported by an expert advisory council, backed by a coordinated funding mechanism, and preceded by a renewed effort in the area of federal research coordination would be an effective way to coordinate research.

Summit participants would represent a broad range of constituencies and disciplines and would work towards identifying key research directions or goals to be achieved through a research strategy that would encompass a range of research themes. The expert advisory council, composed of members drawn from these key constituencies, would take the lead in identifying and recruiting appropriate summit participants. Building in inclusiveness to every part of the process would assist in the development of a more truly national research system. Continuing with the idea of inclusiveness and adding to it openness and transparency, the proposed research directions developed at the summit should be open for comment to the research community and general public for a set period of time. Following the receipt of those comments, the expert advisory council would finalize the directions and strategy and then act as a steering committee for the strategy as it unfolds. Increased funding coordination within the federal government and a new pot of money for environmental research administered through the granting agencies would help operationalize work towards identified priorities.

Introduction

Environmental research fulfils several essential roles in Canada: informing political decisions, developing new green technologies, and creating knowledge that helps Canadians better understand and protect their environment. On a national level, however, the science that makes the fulfilment of these roles possible faces a number of ongoing pressures—including increasingly complex environmental problems and decreasing resources with which to address them—none of which show any signs of abating. The scope of this challenge makes it a significant policy problem, as governments across the country work to piece together the science they need from a fragmented system. As a step forward in addressing this problem, this paper will first develop an overview of the current state of environmental science in Canada and take a more thorough look at the challenges facing the country's uncoordinated environmental research system. Following that, it will discuss why coordination would help address these challenges and canvass several options for initiating a move towards greater national research coordination. A more detailed description of one course of action that has the potential to address many of the challenges inherent in such a large-scale activity will conclude the paper.

These options and recommendations will act as a starting point for discussion about the best way to proceed with better national research coordination at a time when the federal government is receptive to such an idea. In the Speech from the Throne on October 5, 2004, the Governor General spoke of the government's interest in keeping Canada among world leaders in environmental research and innovation. Canada's Environment Minister, speaking on September 10, 2004, said that "Canada needs to find ways for all partners to work together to address our economic and environmental challenges in a coordinated way" (Dion, section 3), including a more collaborative focus on science and technology.

The development of a new National Science Advisor position is a tangible sign that the federal government is ready to focus on S&T and work on new ways to realize its potential in Canada. One of the National Science Advisor's principal roles is "to bring about a fuller integration of the Government's substantial in-house science and technology activity" ("Speech from the Throne", 2004, p. 4). Within Environment Canada, the latest version of the "Competitiveness and Environmental Sustainability Framework"[1] (EC, 2004a), which will be a guiding document for the department's operations in the coming months, calls for an overhaul to the current system, to be replaced by "an integrated approach to set national priorities, develop research agendas and focus research on Canada's sustainability objectives" (p. 12). This momentum provides an excellent opportunity for environmental researchers and the users and funders of that science to work together to create a more effective, efficient system of environmental research for Canada.

[1] This is the latest title of a document known previously as the "Framework for Integrating Environment and Economic Policy", referred to commonly as the Environment and Economic Framework or EEPF.

Background

What is environmental research?

For the purposes of this paper, the term *environmental science* refers to:

> *all scientific and experimental studies aimed at analyzing the physical, biological and chemical processes forming the environment, as well as the relationship between human activities and these biotic and abiotic processes"* (Observatoire des sciences et des technologies [OST], 2002, p. 2).

Under this definition, environmental science includes studies performed in the specialties of ecology, environmental engineering, meteorology and atmospheric science, water resources, health and environmental toxicology, environment-related social sciences and the catch-all category of general environment.

The term *research and development* (R&D) will be used as defined by Statistics Canada (2003):

> "*Creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of humans, culture and society and the use of this stock of knowledge to devise new applications. R&D requires the acquisition of knowledge and not just information. New knowledge involves the integration of newly acquired information into existing hypotheses, the formulation and testing of new hypotheses or the re-evaluation of existing observations* (p. 114).

Combining these two definitions leads to a very broad definition of environmental research. The process of acquiring new knowledge about the environment—essentially what environmental research is defined as—necessitates a range of actors including those who use that knowledge, those who create it, and those who provide the resources for it all.

Researchers

Environmental science is often, and accurately, referred to as the environmental sciences, as its problems are usually of an interdisciplinary nature and often require complex and innovative solutions. As such, the number of researchers potentially involved in addressing any one environmental problem is enormous: they may be from government, academia, industry or a non-governmental environmental group; have a national, regional, provincial, territorial or local base; work in the natural, physical or social sciences; and be interested in long-term or immediate problems with international or local scope. Additionally, as environmental science is not yet a discipline in and of itself, it remains difficult to identify who might be performing research with environmental applications. Unlike traditional academic disciplines, environmental science can be performed under any number of labels and is therefore a difficult field to survey.

A multitude of departments, agencies and Crown Corporations within the federal government are actively engaged in environmental research. At the departmental level, Environment, Fisheries and Oceans, Agriculture and Agri-food, Natural Resources, and Health are among the largest performers of environmental research (Statistics Canada,

2003). The ADM S&T Integration Board[2] is working towards greater coordination in the science and technology activities of these and other science-based departments, but it remains a largely unaccomplished initiative.

Institutions of higher education round out the list of principal performers of environmental research in Canada, contributing over two-thirds of Canada's total environmental research output. Provincial governments, research centres, industry, hospitals and some large advocacy groups also play an important, though smaller, role. Interestingly, the main players in Canadian environmental research already recognize the potential for combining their resources; all top ten producers collaborate with one another and with smaller research producers (OST, 2002). For these collaborative ventures to occur, however, researchers need to know who else might be interested in a problem on which they are working: information which is currently very hard to access.

Top 10 Producers of Environmental R&D

1. Environment Canada
2. Fisheries and Oceans Canada
3. University of British Columbia
4. University of Toronto
5. McGill University
6. University of Alberta
7. University of Waterloo
8. University of Guelph
9. Agriculture and Agri-Food Canada
10. Natural Resources Canada

Source: OST, 2002.

Funders

Hundreds of millions of dollars are spent annually on environmental research and development in Canada. Much of that funding is funnelled through departmental allocations within the federal government; however, many projects, especially those taking place in institutions of higher education, rely on funding from three major granting councils: the Natural Sciences and Engineering Research Council (NSERC), the Social Sciences and Humanities Research Council (SSHRC) and the Canadian Institutes of Health Research (CIHR). Increasingly, new funds are coming through agencies like Genome Canada and the Canada Foundation for Innovation (CFI). Other significant funding comes from business enterprises, non-governmental organizations, private trusts, provincial and municipal governments, and even some unlikely organizations like hospital consortiums and the media (see Appendix 1 for examples of funding). These different funding organizations employ a wide range of funding processes. Governments and business enterprise tend to fund science that will create knowledge around a narrowly constrained issue. Granting councils are almost always solely concerned with the scientific integrity of a given project. Other funding bodies have various aims—for instance, supporting a particular position or developing a body of knowledge around a broad theme—and may tailor their funding criteria accordingly.

[2] The role of the ADM S&T Integration Board is "to catalyze and nurture S&T initiatives that draw together and integrate expertise in federal departments and agencies, as well as that of other performers of S&T where appropriate, to help fulfill federal responsibilities on cross-cutting issues of national interest" ("S&T Management Map - Organizations", ADM S&T Integration Board page, 2004).

Users

Environmental research in Canada is largely produced by the federal government and universities, with smaller contributions from provincial and municipal governments, business enterprise, research centres and citizen scientists. However, the results of this research are used by many different organizations and individuals for a multitude of reasons. These research consumers include governments at all levels, business enterprise, academia, the media, non-governmental organizations, advocacy groups, citizens' coalitions and individual Canadians. As consumers, these groups and individuals are positioned to pick what they need from the research products available to them. For example, a recent City of Toronto report on alternative uses of organic waste used research from the Ontario Ministry of the Environment, Environment Canada, several academic sources and private consultants (City of Toronto, 2002) to supplement the city's own limited environmental research capabilities.

This type of use, however, is not the only kind. The federal, provincial and territorial governments make extensive use of environmental research to inform policies, legislation and regulations. Advocacy groups use it to more convincingly argue their positions or to inform their future priorities. Individual Canadians use environmental research to decide what fridge to buy and to determine what kinds of risks their drinking water may pose. This huge variety in the type of environmental research demanded by its users means that research suppliers must devise ways to be attentive and responsive to these increasing and diverse needs.

The challenges facing environmental science

Environmental problems facing Canada and the world continue to grow but, despite important investments in components of Canada's environmental S&T system, the supply of S&T with which to address these complex problems is not keeping up with demand. Exacerbating this challenge is the increasingly fragmented nature of our environmental S&T efforts. Extensive S&T partnerships and collaborations, while a step in the right direction, do not address the more fundamental problem of a lack of cohesion across the system as a whole. Even within the federal government, departments often work on S&T issues in isolation from one another, thereby missing the chance to more effectively link science to policy, to focus on key priority areas and to identify potential gaps before they occur. At the national level, there is a marked lack of coordination of S&T between levels of government, among funding channels, across academic disciplines and institutions and between government and industry. As a result of these oversights, there is growing concern that there are critical gaps in our S&T efforts and that Canada risks losing out in some highly promising technology niche markets. Governments at both the federal and provincial/territorial levels are also facing an increasingly difficult challenge as they try to locate the science they need across a fragmented system. Without a collective vision for S&T, greater institutional leadership and more cohesion across the environmental S&T system as a whole, Canada risks falling even further behind in this area.

Existing coordination

In Environment Canada, the idea of greater national coordination has been around for some time, most recently taking shape as the Canadian Environmental Sciences Network (CESN). Early in 2001, a paper on CESN identified the following priorities:

1. *The need to raise the profile of, and re-build "investor confidence" in, Canadian environmental science. Investors comprise the public and private sectors, and include institutions managing resources used to fund and conduct science.*
2. *The need to increase the mobilization and collective direction of existing resources within the Canadian environmental science system* (Science Policy Branch [SPB], p. 20).

The idea of CESN as an umbrella network of interconnected thematic and regional networks grew out of those expressed needs.

Since its inception, the CESN has been involved in a number of different initiatives, including working with partners on national research development, conducting background studies and building communications within the network. These efforts have laid the groundwork for greater research coordination in a number of areas. For example, as part of its work towards a more coordinated environmental research system the CESN has been supporting regional and thematic networks and facilitating knowledge sharing among them. A number of thematic networks are well-established and the regional networks are becoming increasingly so. In 2003, in response to a request from CESN, the Atlantic Environmental Sciences Network (AESN) created a lessons learned document to help other networks through their formative stages.

In addition to establishing formal networks, researchers often come together across sectors on an ad hoc basis in areas where they have similar research goals. Many examples exist of Environment Canada researchers collaborating with university researchers and students on research activities where they stand to gain from each other's expertise (Science Policy Branch [SPB], 2004). It is also becoming more common for governments and universities, and universities and industry to co-locate research facilities, thus making resource sharing not only easier but essential. This idea of sharing expertise and resources has found resonance with the Networks of Centres of Excellence, of which there are currently four in the area of Natural Resources and the Environment. These networks are another way in which researchers are able to work across traditional sector and discipline boundaries on themes of common interest (NCE website, Sept. 13, 2004).

Another important instance of collaboration takes place at the political level through the Canadian Council of Ministers of the Environment (CCME). The CCME "works to promote effective intergovernmental cooperation and coordinated approaches to interjurisdictional issues such as air pollution and toxic chemicals" (*CCME website*, July 23, 2004). Although most of its work is in the policy arena, the CCME is a valuable model of developing shared goals and provides a forum for issues that cut across jurisdictions.

In another excellent example of stakeholder networking, a set of two *Workshops on Sustainability and Environment* in the spring of 2004, hosted by York University, brought together representatives from nine universities, two granting councils, Environment Canada, the National Round Table on the Environment and the Economy, and the Canadian Institute for Environmental Law and Policy. These workshops allowed environmental researchers, policy makers and the people who support them to connect with one another and discuss areas of common interest and options for moving forward with environmental research in Canada ("Workshop Notes", 2004). Initiatives such as these—developed and initiated by researchers who have seen the need for greater coordination—may well act as a blueprint for a much larger exercise of the same type.

Along with networking, funding is another principal area through which environmental science might reasonably be expected to achieve greater coordination. Despite the potential for research coordination offered by the concentration of funding in the federal government and central granting agencies, the reality of this system has been less kind to the environmental sciences. One challenge for both granting agencies and researchers is that environmental research often spills over the borders of any one granting agency's domain. This means that even if environmental research is planned with an interdisciplinary component, it may have to be broken down into traditional academic discipline-components for funding purposes. A similar problem presents itself in the federal government, where any given department may only be mandated to look a small piece of a large environmental issue and funding to address that issue is likewise spread in small bits across government.

As part of their efforts to develop greater coherence around environmental research in Canada, representatives of the CESN have been working with both the Canadian Institutes of Health Research and the Social Sciences and Humanities Research Council, with SSHRC taking the lead on a tri-Council (CIHR, SSHRC and NSERC) strategy for environmental research. CESN is also beginning work with NSERC on their strategy for environmental research and has made preliminary contact with the National Research Council and the Canadian Foundation for Climate and Atmospheric Sciences. Genome Canada and Environment Canada co-hosted a workshop on Comparative and Environmental Genomics last fall, which led to an agreement that this is an important area for further research supported by Genome Canada (Environmental and Comparative Genomics Workshop notes, 2003). These initiatives, if fully realized, would be an important step towards greater coordination of environmental sciences.

Emerging concerns about lack of coordination

A recent review of Canada's current approach to environmental science leaves little doubt as to the necessity of a new system. Environment Canada's Environment and Economic Policy Framework (EEPF) describes Canada's current approach as "fragmented between and within jurisdictions, regions, and sectors; characterized by antagonistic relationships between key stakeholders; and takes a short-term, issue-by-issue approach and fails to focus on long-term outcomes" (EC, 2004b, slide 20). While numerous examples certainly belie the universality of such claims, if they are even

partially true, they make a strong case for an increased emphasis on coordination among the environmental research community.

These concerns have been heard from other corners as well. Internationally, the Organisation for Economic Co-operation and Development (2003) recently published a study showing that member countries are increasingly moving towards better coordination of research within government and greater collaboration among researchers from all sectors. These reforms are largely in response to an increasingly diverse set of stakeholders, all with their own set of demands on research; a desire to exploit emerging opportunities; and the need to sustain the research enterprise in the long-term.

Within Canada, environmental researchers, seeing the need for greater coordination, have started to develop regional and thematic networks that allow them to work collaboratively towards common research aims while simultaneously increasing the profile of the environmental sciences. One example of this is the Upper Lakes Environmental Research Network (ULERN). A non-profit network with membership from government (federal and provincial), industry, universities, and First Nations groups, ULERN was developed to help researchers share "resources, expertise and equipment...allow[ing] everyone to do more with less money" ("ULERN: Origin & History", 2004, paragraph 6). Also in an attempt to deal with the issue of fragmentation, a group of natural and social scientists from four Canadian universities met earlier this year to discuss, among other concerns, ways in which environmental science could benefit from greater connections between social, natural, and physical scientific disciplines ("Workshops on Sustainability and Environment", 2004).

Industry, too, is cognizant of the challenges presented by fragmentation and the potential offered by greater coordination of environmental research. For example, the Oil Sands Environmental Research Network (OSERN) brings together industry and several university partners to develop reclamation science and technologies. The oil sands industry is looking for cohesive, coordinated science that will allow it to predict costs and determine long term impacts of its operations (OSERN, 2004).

The problem of fragmentation, then, is becoming an increasing concern for the Canadian government, international governments and research communities, and the environmental research community and the people who support it here in Canada. Many groups of environmental scientists and those who use their research products have begun to coordinate their activities in recognition of the synergies and efficiencies to be achieved by working more closely together. Looking at the pressures environmental science is faced with in Canada and the fragmented resources with which it must attempt to address those pressures adds to the feeling that there must be a better way to organize environmental research.

The challenges

One of the main pressures facing Canada's environmental science system comes from the public; Canada's environment is truly a shared resource, meaning that interest in

and influence of environmental research extends far beyond those who perform it. Groups ranging from governments to citizens, industry to academia and Aboriginal peoples to people outside of our national borders have an important stake in environmental science, though their priorities in this area may be markedly different. For instance, one area in which many citizens' groups have been particularly active is local environmental exposures to pollutants. Citizens' concerns over pollutants in their communities have frequently pushed environmental research items forward on the political and funding agendas. One recent example is the new funding announced in the spring of 2004 for the Sydney Tar Ponds and Coke Ovens remediation. While the remediation itself is not necessarily a research activity, public pressure in this area has driven environmental research able to address the problem of heavily contaminated sites. Although this may be helpful in terms of identifying public priorities, these pressures strain a research system already pushed beyond its capacity.

Pressure on environmental science is also increasing as a result of increased efforts in related areas. At the national level, environmental issues are increasingly being framed as part of the bigger picture of sustainable development and environmental research is expected to inform the sustainable development effort. Environment Canada's commitment to a coordinated national research effort is outlined in its "Sustainable Development Strategy 2004-2006"(2004d): "Environment Canada contributes to a strong, integrated environmental science system in Canada that supports sustainable development" (p. 8). This commitment to integration and support of sustainable development means that environmental science must not only accomplish its own ends, whatever those might be, but also those of a larger agenda. This pressure is felt most acutely in government, which must find new ways to ensure that Canada is producing the environmental research necessary to support the sustainable development agenda.

Doern and Rosenblatt (2001) note that framing environmental research in terms of sustainable development immediately changes a number of things about its parameters (p. 13). For one, sustainable development demands a research agenda that is even more interdisciplinary and multi-sectoral than that which environmental issues would require. A sustainable development approach is also more preventative in nature and takes an inter-generational rather than short or medium-term view of problems and their solutions. These types of parameters, while they may ultimately be helpful in developing a successful environmental science strategy, also demand things of such a strategy that, as of yet, the fragmented environmental science community is ill-prepared to deliver.

And the pressures do not stop at Canada's borders. In addition to pursuing its own national environmental research interests, Canada must also consider how it will fulfill international obligations and expectations. International environmental agreements, such as the *Convention on Biological Diversity*, push environmental research in certain directions by identifying priorities. Furthermore, Canada must often deal with environmental problems, such as climate change or persistent organic pollutants, that transcend political borders. Even in the absence of formal obligations, Canada sees itself among the world leaders in its approach to the environment and such a position

requires a solid foundation of environmental research. Given the country's rather dismal performance on initiatives like the *US-Canada Air Quality Agreement* (see Appendix 2), it is obvious that achieving such a goal will require a more concerted, focussed effort.

Inadequate means to address the challenges

A main impetus for coordinating Canadian environmental research efforts is to make the best possible use of limited resources to address the pressures with which the system is faced. Exactly what these resources are, however, is difficult to determine given the disjointed nature of environmental research funding: many different government departments and agencies as well as several public granting councils share responsibility for funding the bulk of public environmental research in Canada. Furthermore, defining exactly what constitutes environmental science can also be difficult as the definition varies from department to department, discipline to discipline (Impact Group, 2003).

While many funding organizations publish accounts of the research they fund, unless specific keywords are included in the project title or description, it is often impossible to tell what projects might fall under the category of environmental science. This means that there is no reliable way to quickly assess what research is being performed and hence what gaps or areas of overlap might exist. Even absent formal mechanisms of coordination, knowing what areas of research are being funded would help Canada address its challenges and obligations in this area.

In terms of actual dollars currently devoted to environmental science, some rough estimates of the federal government's funding of its own environmental research can be drawn from expenditure by socio-economic objective data, collected by Statistics Canada. From 1998 to 2001, the federal government spent an average of $215 million per year on Pollution, Protection and Conservation of the Environment R&D and $249 million per year on Exploration and Exploitation of the Earth R&D, the two socio-economic objectives of which environmental research is a main component. Agricultural Production and Technology R&D, a portion of which is dedicated to examining the environmental effects of forestry and agriculture, accounts for a further $552 million a year, on average (*Statistics Canada*, 2003, p. 100). Small portions of other socio-economic objective R&D funding including, notably, that for Public Health, are also apportioned to environmental research, though exact figures are hard to come by. This lack of certainty in funding levels makes it difficult to determine gaps in current research as there is no way to tell what kind of research is being funded (see Appendix 3 for some estimates of funding).

Most often it is the government, federal, provincial, or territorial, that is expected to respond to demands for science from the public, the international community and other initiatives such as sustainable development. Logical building blocks for a national environmental research agenda would, therefore, be federal and Environment Canada (EC) research agendas. Currently only the latter exists, though a federal environmental

policy framework, currently under construction, may be an important first step towards a coordinated federal environmental research strategy.

Environment Canada's research agenda is organized around the department's key priorities of reducing the health and safety impacts of environmental threats, sustaining our natural environment, and addressing climate change (EC, 2002). Within each of these priority areas, the department has identified numerous research thrusts. Another important aspect of EC's research agenda is an explicit imperative for the department to collaborate across sectors and jurisdictions, though mechanisms for achieving this collaboration are not identified.

At the federal level, there is an acknowledged need for a coordinated approach to all environmental activities, including research. The department's "Framework for Integrating Environment and Economic Policy" (EC, 2004c) proposes "strengthen[ing] mechanisms for collective priority-setting and decision-making among federal departments and agencies so as to better align federal S&T efforts" (p. 12). For the time being, however, the lack of a coordinated federal approach to environmental research means that an important segment of Canada's environmental research, and the segment over which Environment Canada might reasonably be thought to have the most influence, remains disjointed.

At the national level, environmental research efforts are fragmented to an even greater degree than those in the federal government. Despite promising efforts in networking and collaboration among researchers, the overall environmental science system remains disjointed to an extent that makes it a system in name only. This fragmentation takes place on several different planes: researchers are not connected to one another, nor are they connected to research users. This makes it difficult not only to ensure that all relevant areas of research are being canvassed, but also to identify those relevant areas of research. On the flip side, with a poor connection between the demand and supply sides of environmental research, the opportunity for emergent science to inform policy directions is lost.

Benefits of increased coordination

As evidenced by the challenges outlined above, greater coordination could mean many things for Canadian environmental research. These benefits might include improved capacity to address priorities in a strategic way, the creation of synergies by pooling people and resources, and a stronger voice with which to promote environmental research. These kinds of benefits would allow Canadian environmental science, and indeed the federal and provincial governments, to address increasing demands for research from within and outside the country. As well, greater coordination among producers, users and funders of environmental research would lead to a more efficient use of resources and help inform the development of more useful research products and sound policy and regulation.

A process facilitating the achievement of such goals would be invaluable for both performers and users of environmental research. One key advantage of greater

coordination would be the increased extent to which the environmental science system as a whole could focus on longer term problems. In the current system, researchers, especially those in government who are performing mandate-driven science, are often forced to concentrate on immediate problems. This leaves bigger, longer term environmental issues only partially addressed, setting up even greater challenges for environmental research in the future. Increasing coordination across the system would decrease areas of overlap to more effectively use research resources and would also increase researchers' ability to collaborate, making their individual projects part of a larger collective effort.

Successful coordination in other jurisdictions suggests Canada may be well positioned to improve its own environmental science performance through some measure of coordination. In Australia, for example, an extensive consultation process led to the development of seven Priority Goals for the national research Priority of "An Environmentally Sustainable Australia" ("An Environmentally Sustainable Australia", 2003). In the UK, the Environment Research Funders' Forum (ERFF) allows "public sector sponsors of environmental science to identify and take strategic action on any gaps in environmental research and training [and] also shape future science direction" (ERFF, 2002). Such exercises have helped address the very challenges with which Canada is currently faced.

Challenges to increasing coordination

In developing a path towards greater coordination, there are a few issues that will need to be addressed. In its "Science Advice for Government Effectiveness" report, the Council of Science and Technology Advisors (1999) proposed six general principles for science and technology advice (see Appendix 4). As ideas, these principles are as equally applicable to a prioritization process as they are to a research endeavour. These principles—early issue identification, inclusiveness, sound science and science advice, uncertainty and risk, transparency and openness, and review—run as a common thread throughout the issues inherent in designing a process of coordination. More specific questions include things like how representative experts or relevant stakeholders might be chosen to participate in a coordination exercise; conferring voice on some people and not on others has consequences. While questions like this may appear at first glance to address details of little import to the big question of what Canadian environmental researchers should spend their time doing, they hint at the underlying foundation of challenges upon which, successfully or unsuccessfully, depending on how well they are answered, a research strategy must be built.

One overarching question that must be addressed prior to undertaking any kind of coordination exercise is the end product desired of that exercise. Though the answer—an agenda, strategy or direction as the case may be—seems self-evident, the reality has a few more layers. First, what will coordination look like, to whom will it be applicable and how will consensus be built within that group? Secondly, in what way will it be applicable: through coercion, persuasion, or as an information tool? And of course the scope of coordination could range anywhere from a few all-encompassing themes to a multitude of detailed research programs. All of these questions feed into

the larger issue of the conceptual framework in which the process occurs. As noted by Doern and Rosenblatt (2001, p.5), such a process could be used as a way to position the environmental sciences to receive greater political attention, to communicate environmental values, to rank research priorities or for any number of other aims. The extent of the exercise also speaks to Canada's commitment to early issue identification and sound science and science advice, both of which would be facilitated by a comprehensive coordination exercise.

In deciding to whom a national research agenda might apply—the inclusiveness of the end product of coordination—there are a few factors to consider. Making federal researchers the primary focus of such an agenda may simplify implementation but then the goal of truly national coordination is lost. If governments and institutions of higher education buy-in to common directions, then the process is closer to being national but would also require much more extensive consultations and would likely become a framework of general research themes rather than anything more specific. Thus, the risk of thinking too small is undermining the idea of a national strategy, while thinking too big will potentially lead to a set of broad and unwieldy visions that will remain unimplemented. The former problem, though perhaps unavoidable in such a large system, has been encountered in the United States, where federal research is directed towards specific goals, but the extensive university, business enterprise and foundation-supported research communities are only nominally consulted about what federal goals should be or how researchers outside the federal government might help to support them (Voyer, 2003). The latter problem has been encountered to some degree in Sweden, where most proposed programs involving universities, business enterprise, and international research centres failed to accomplish the original lofty goals of a coordinated funding agency, though the agency and environmental science performers have largely addressed this problem now (Persson, 1999).

Closely linked to the question of who will contribute to coordinated research goals is the way in which those goals will be implemented. Some jurisdictions, like the United Kingdom and the United States, have opted to monitor and control government departments' compliance with common directions. Others, like Sweden, use control-based implementation within government, but supplement it with funding external researchers working in priority areas (Voyer, 2003). Research agendas built through extensive consultation and consensus within their research communities have occasionally, as in the case of the National Occupational Research Agenda[3], been able to leverage researchers' common vision into general acceptance of and adherence to their goals.

Tied to the issues of who and how is the what of a direction-setting process. Environment Canada's "Framework for Integrating Environment and Economic Policy" (or Environment and Economic Policy Framework, EEPF) calls for the "establish[ment

[3] A "framework to guide occupational safety and health research into the next decade" ("About NORA", n.d.) spearheaded by the National Institutes of Occupational Safety and Health. Development of the agenda included consultation with over 500 organizations and individuals working in the field of occupational safety, and resulted in the identification of 21 research priorities.

of] an integrated approach to set national priorities, develop research agendas and focus research on Canada's sustainability objectives" (2004c, p. 12). This suggests that the current approach of disparate, uncoordinated research goals is not working. Focussing environmental research, however, could mean anything from articulating a broad vision to determining key themes to detailing priority research programs. Persson (1999) makes the case that all—vision, program goals and project priorities—are necessary to solve environmental research questions, but some of those elements may be better suited to informal development by individual research teams to allow for a more flexible and responsive system of research (p. 325).

Funding these visions, program goals and project priorities in a concerted way is likely essential to their achievement. Going back to the use of the word *priorities*, these types of priority rankings are already made through resource allocations. In fact, Stewart (1995) suggests that in many cases, priority setting and resource allocation may be one and the same process (p. 117). For successful implementation of newly determined priorities, funding would have to follow these new priorities rather than the other way around. This could involve substantial changes to the ways in which federal departments allocate research dollars and would also require the buy-in of both the research councils and the researchers they fund, in order to effectively direct resources towards national priorities. If, however, this funding coordination could be achieved, it would significantly strengthen the likelihood of successfully coordinating environmental research.

A key determinant in assigning funding and hence priority is the demand for environmental research. While many academic researchers perform work for what it will add to the overall environmental knowledge base, government and private sector scientists are expected to provide demand-based research products. Increasingly, all sectors are expected or, at the very least, encouraged to develop research that will meet a market demand as well. If even government scientists, whose primary role has always been to perform science that will inform sound decision making, are encouraged to "seize opportunities that might have commercial applications" (Keough, 2002, p. 6), then market demand must certainly be considered, along with demands inherent in federal departments' mandates, when setting an environmental research agenda. Another key demand is that of policy makers and decision makers at all levels of government, who use science to inform regulations, policy and legislation. The necessity of considering both the supply and demand sides of research—not to mention the funding aspect—has implications for whose input would be required in an agenda-setting process.

Deciding who should be included in a strategy-design process from the general categories of researchers, funders and research users presents a bit of a challenge. Include too few people and you risk alienating vital members of the implementation exercise. Include too many and you risk crippling the process with a surfeit of opinions. Chrislip (1995) defines relevant stakeholders as "people who, if they were to reach an agreement, could act together to achieve real results" (p. 25). Certainly this definition would be useful for a process employing wide or even focussed consultation, though for

a less inclusive process, some additional criteria would be necessary. For any process, regardless of scope, a small, highly credible group of people who are representative of the larger community—in this case the community of producers, users and funders of environmental research—act as initiators (Chrislip, 1995; p. 24). This indicates that a small, carefully selected[4] committee, able to ensure the idea of inclusiveness was built in to the process, might be a useful way to begin the coordination exercise no matter what form it takes.

Optional approaches

Why EC should take the lead

Environment Canada is the largest institutional performer of environmental science in the country and also the primary collaborator of the other most important national performers of this type of research. As such, it is in a unique position to take the lead on the development of a more coordinated national research system. Moreover, the *Department of the Environment Act* states that "The Minister... shall coordinate programs of the Government of Canada that are designed to provide to Canadians environmental information in the public interest" (5. a) iii), giving EC a mandate to coordinate federal environmental S&T and certainly an interest in external S&T. The Canadian Environmental Sciences Network (CESN), an umbrella network of the environmental sciences currently coordinated out of EC, is similarly suited to this task.

For Environment Canada, a department that directs 70% of its funding and human resources towards science and technology (Statistics Canada, 2003), environmental research is of key importance. The demand for the scientific information necessary to effectively fulfill the department's mandate has often been such that EC has relied on science from outside the department—either from other science-based departments and agencies, institutions of higher education or often citizen-scientists—to meet it. EC's environmental science capacity has been very much affected by challenges like not knowing who is performing environmental science and the lack of a federal agenda in that area. The idea of greater connectivity between performers of environmental research has, for that reason, particular resonance within Environment Canada.

Discussion of options

Canadian researchers have found innovative ways, through networks and partnerships, to deliver the science demanded of them. The changing nature of the scientific enterprise, made possible by electronic technology, has allowed researchers to accomplish work across previously insurmountable barriers of time and space. However, with a static and sometimes shrinking resource-base, inclusion in the forward agenda of sustainable development and an increasing demand for high-quality research, the environmental sciences in Canada need a new approach if all these challenges are to continue to be met. Having renewed its efforts to develop the building

[4] There is, of course, another layer of questioning attached to the issue of who is selecting this small, credible group, but between Environment Canada and people connected to the CESN, there is a broad enough view of the environmental sciences community in Canada to allow for a defensible selection process.

blocks for national research coordination in the past few years, EC is now in a position to move forward with that goal. Using the relationships it has developed, the background research that has been done, current networks and partnerships and the communications structure developed by the CESN, the department is well placed for the next step.

Although the options below are far from an exhaustive list of ways in which environmental research directions might be determined, they include models that have been used successfully in other jurisdictions or for other types of research. The options are arranged according to the scope of the process involved. It should be noted that not all of the options listed below explicitly include working with all or even many stakeholders, though those linkages might well have to occur, at least informally, regardless of the option selected.

Promote existing linkages and agendas

There is the possibility that existing, implicit research directions need no further coordination and that promotion of existing linkages and partnerships is adequate in the way of assuring collaborative research. If this is the case, an ongoing inventory of research being undertaken in different thematic areas might be a useful way to identify gaps, as defined by users of environmental science, in current research. In 1990, the CCME produced a "National Inventory of Research and Development Projects". While compiling this inventory represented a substantial amount of work, it might more easily be undertaken now using government and funding council databases, Statistics Canada data and possibly a bibliometric study (Impact Group, 2003, p. 23). This option has the advantage of avoiding a number of potential challenges such as deciding who should be involved in a coordination exercise or revamping funding mechanisms, though it also minimizes the chances of achieving the significant benefits a more thorough process could engender.

In order to foster greater connections between performers and users of environmental sciences, additional efforts could be made to encourage cross-sectoral research collaborations, such as those between government and universities, or universities and associated spin-off companies. Such collaborations would continue to ensure that environmental research speaks to the needs of a number of its users simultaneously, addressing implicit rather than explicit research priorities. Similarly, interdisciplinary research should be encouraged and fostered where it occurs. Speaking of their experiences with the Eco-Research Program, designed to encourage such linkages, many people involved with the program spoke of discovering a richer, more rewarding arena in interdisciplinary research, from which they have never looked back (Whetstone Group, 2004b). Again, this option avoids the issues associated with a more active coordination effort but does not direct research in any meaningful way.

Coordinating or consolidating existing strategies—from thematic, regional or local networks, or individual academic disciplines—into an all-encompassing agenda for environmental research would allow the achievement of general directions without revamping existing priorities. For example, the Atlantic Environmental Sciences

Network (AESN) has identified Climate Change as one of its cooperative themes (AESN, 2003, p. 8). Many researchers working within that AESN theme are likely also involved in the activities of Canadian Climate Impacts and Adaptation Research Network, and a more formal way of coordinating the specific research goals of the two networks could only help them to achieve the kind of collaborative synergy that is the goal of both. Important to note however, is that this type of strategy has no mechanism for identifying gaps in Canada's environmental research, which may fall between areas in which networks have formed. This possibility imperils the principle of early issue identification and does not allow for the most complete science advice to flow to government or other research users.

Central coordination

In the federal government, five departments—Environment, Fisheries and Oceans, Agriculture and Agri-food, Natural Resources and Health—conduct significant amounts of environmental research. Federal government departments account for roughly a third of all Canadian environmental R&D (OST, 2002, p. iv). A formally articulated research agenda for the combined environmental research outputs of the federal government alone would successfully coordinate a substantial portion of the country's environmental research. While mechanisms such as the ADM S&T Integration Board are in place to help foster coordination in federal S&T initiatives, the development of specific environmental research objectives would ensure that all federal players were working towards the same goals regardless of their level of interdepartmental coordination. While such an effort would be a valuable first step in a national strategy for the environmental sciences, its lack of inclusiveness would make it only one component piece of a truly national plan.

Looking beyond the federal government, the CCME is in a unique position within Canadian environmental science because of its inherent interjurisdictional approach. Using this approach, it could potentially develop research directions for Canadian environmental sciences. With coordinated environmental management as one of its main current initiatives, the CCME has both the body of expertise and authority, in the area of harmonizing environmental matters across the country (*CCME*, n.d.). In addition to bringing this expertise to bear, the CCME would be able to provide the interaction between levels of government necessary for a truly national plan in a federated state (Voyer, 2003, p. 10). Despite the nation-wide view of the CCME, however, it still only represents the federal and provincial governments as stakeholders and would have to address the gaps in such a plan that would result from the missing perspectives of universities, private non-profit organizations, business enterprise and all other performers, funders and users of environmental research.

Perhaps the most effective way to centrally coordinate national environmental research directions would be to coordinate their funding. Currently, major public funding for environmental research comes from federal government departments and the granting councils, especially the Natural Sciences and Engineering Research Council. A first and not insignificant step towards coordinated research funding would be to strategically invest government funding allocated to internal research. Following that, a renewed

effort at developing a tri-council (NSERC, SSHRC and CIHR) initiative on environmental research would further channel funding into priority areas, though an accompanying method of determining those priorities would be necessary.

An interesting funding coordination model is that of the Environment Research Funders' Forum in the UK, which brings major funders of public research together to strategically address gaps in the country's environmental research (ERFF, 2002). Another useful model comes from here in Canada. Between 1994 and 1997, an environmental research support program, involving NSERC, SSHRC and the Medical Research Council (now CIHR), dedicated $27 million to cross-disciplinary environmental research initiatives (Whetstone Group, 2004a). The Eco-Research Program administered research grants, funded research chairs and awarded doctoral fellowships as part of its activities, all with a view to better fostering the cross-disciplinary linkages often necessary for environmental research. Combining this type of strategy with a more inclusive priority-setting mechanism would make it more likely that stakeholder support and significant resources would be directed towards the same general areas of research.

Expert mediated process

Another common model of setting direction involves relying on the knowledge of people conducting environmental research to shape the priorities of that research. This follows the model of most granting agencies in Canada and elsewhere, for which scientific credibility of a research proposal is the main, and usually sole, criteria for funding. In such a model, it is assumed that those with expertise in environmental research are best placed to determine what research-produced knowledge is needed at any given time. This type of approach encourages the development of sound science, as research projects are judged on their scientific credibility. A wide range of scopes is possible within this approach, including either university-produced environmental research, government-produced environmental research or a truly national program. For this model, funding coordination, as discussed above, would be necessary in the absence of a new, devoted source of funding for environmental research.

One of the most interesting examples of this type of model is the Canadian Institutes of Health Research (CIHR), formed in 2000 to fund health research in Canada. Of its $662 million (2004-05) annual funding, the CIHR devotes 70% to purely investigator-driven research and 30% to strategic initiatives, with all funding channelled through 13 Research Institutes, charged with leading investigations in their thematic areas and helping to network researchers working in those areas (*CIHR*, n.d.). An important part of the CIHR's formation was an extensive consultation process with researchers across the country (Doern & Rosenblatt, 2001, p. 23). It is telling, however, that this process is most often used where the funding organization itself does not have any particular knowledge needs. Adopting such a model to government or industry, where the needs of research users are often quite specific, would be far more difficult. However, it might usefully be made part of an overall funding strategy that would include focussed funding for specific research needs.

Taking a slightly different approach to an expert-led process might entail assembling a panel of experts: a relatively efficient way to develop national research directions. Similar in make-up to the Department of Environment's Science & Technology Advisory Board[5], perhaps with representation from federal government scientists as well, such a council would bring together selected experts in environmental sciences with the aim of developing goals for Canadian environmental research. So as to increase buy-in from constituents outside the selected few council members, the role of such a council could be to distil overall research themes from more specific research questions developed by a wider range of interested parties. This council might also usefully serve as an oversight body for the selected research themes, ensuring their continued relevance and reviewing progress towards them.

Following a round of public consultations, Australia formed an expert advisory committee to consider possible government research priorities suggested by the public. This committee was headed by the President of the Australian Academy of Science and developed its recommendations to government from close to 200 suggested research priorities submitted by members of the public (Voyer, 2003, p. 12). One of the four overall research themes, with seven associated Priority Goals, that emerged from this process addressed the environment, and the process is instructive from the Canadian environmental research perspective. Drawing from this experience but adapting it slightly might mean Canada could form an expert council made up of researchers (as in Australia) as well as research funders and users. This would ensure a broader view of environmental research, make the process more inclusive, and hopefully allow for greater coordination between the supply and demand sides of research.

Stakeholder centered process

Moving towards even greater inclusivity, a national summit is one way to bring together researchers, policymakers and funding sources from a number of different constituencies. Lobbyists and other interested parties might also be invited to participate in the summit, depending on the balance of openness and effectiveness desired. Ideally, a one or two day summit would allow for dialogue around already-developed ideas, brought forward by thematic or regional networks, organizations with policy needs, or any other stakeholder in this process. This type of format would allow for more focussed discussion at the summit itself and identify areas of overlapping interest that might usefully be combined into shared research directions.

Although the built environment's effects on physical and mental health is a much narrower and less developed area of scientific inquiry than are the environmental sciences, lessons can nonetheless be drawn from the process created by the Centers for Disease Control (CDC) for developing a research agenda in that area. In 2002, the CDC responded to the paucity of studies examining the relationship between the built environment and human health by inviting researchers from a wide variety of disciplines, from air pollution to architecture to social marketing, to a one-day

[5] A multidisciplinary board of external experts drawn from academia, industry, the media, NGOs and other levels of government to provide advice on science and technology to the department (S&T Management Map, SBDA's S&T Advisory Boards page, Sept. 15, 2004).

conference to determine essential research questions. Participants were each asked to bring two research questions from their area of expertise, questions which were then discussed, amalgamated, and refined into components of an overall research agenda (Dannenberg et al., 2003). While the scope of environmental research is much larger and the potential questions therefore much more numerous, the basic design of bringing together experts from a variety of fields to develop overarching research objectives is still valid. Involving funders and users of environmental research as well as researchers themselves could only help develop more nationally-relevant research directions.

Perhaps the most complex way of developing national environmental research directions is to directly involve the Canadian public in the process. Such consultations could be conducted through town hall meetings, focus groups or individual surveys. As various objectives could be achieved using this process, it would be important to identify the goals of the consultation prior to its beginning. For example, town hall meetings might be most effectively used to vet a pre-determined set of possible research directions while individual surveys could identify areas of concern to Canadians from which research priorities could be developed. Public consultation could, of course, be combined with any of the more expert-centered options listed above, as a step towards transparency and openness in a comprehensive process.

Including public consultation in the development of research directions is not without precedent, both within Canada and extra-jurisdictionally. For example, the American National Institute of Environmental Health Sciences (NIEHS) uses Town Meetings as a forum for public concerns, which are then used to inform NIEHS research opportunities as a way to give communities affected by environmental health issues a voice (O'Fallon et al., 2003). When Australia sought to shape its environmental research agenda, it used public consultations as a way to develop a preliminary framework delineating the way in which Australians wanted priorities set (Voyer, 2003, p. 12). Sweden also used public input to determine its environmental policy objectives, using goals identified through public consultations to develop overall objectives (Voyer, 2003, p. 4). Following such models, Canada might want to recognize the Canadian public as the ultimate user of much of its environmental science and include public representatives as essential stakeholders—and indeed experts on the subject of their own research needs—at various stages of the coordination process.

Recommendations

While many possible options exist for a process to coordinate national environmental research, a national summit supported by an expert advisory council, backed by a coordinated funding mechanism, and preceded by a renewed effort in the area of federal research coordination offers the best chance for the Canadian environmental science community to create common research directions that will help it address the many challenges with which it is currently faced. The summit participants would be tasked with identifying key research directions or goals to be achieved through a research strategy that would encompass a wide range of research themes. Summit participants would include not only public-sector, academic and private sector environmental researchers, but also social scientists working in potentially

environmentally-relevant areas (e.g. economics, sociology, political science, anthropology, etc.), users of environmental research and people in charge of resource allocation for environmental research. A key activity of the expert advisory council, composed of members drawn from these key constituencies, will be identifying and recruiting appropriate summit participants. This will ensure that a wide range of stakeholders continue to be involved in the development of a more truly national research system. Following the summit, the proposed research directions and strategy should be open for comment to the research community and general public for a set period of time, at the end of which the expert advisory council will finalize the directions and strategy and then provide advisory support to the strategy as it unfolds. The council will also oversee the administration of a coordinated funding mechanism for environmental research. The reasons behind this set of recommendations are outlined below.

A National Summit

The "Framework for Integrating Environment and Economic Policy" calls for an integrated, focused and national approach to environmental science and says that:

> *The first step towards achieving these goals is to bring together the many funders, practitioners and users, including individuals and networks to take part in an external review of our collective S&T efforts to identify our national needs and identify current and future gaps with a view to developing a national environment and sustainability research agenda* (EC, 2004c, p. 12).

Given the framework's importance to the way Environment Canada will do business in the future, initiating a process in line with the framework's recommendations makes sense from the department's point of view. Also, as Bell and Tunnicliff (1996) point out, when seeking to develop future directions, "a broad spectrum of different viewpoints and interests is required to provide a full picture of future possibilities" (p. 14). For EC, building consensus around research directions outside of the department will also be essential in ensuring the department's continued access to the science it needs to fulfil its mandate. And as a benefit to environmental research as a whole, the design of such a summit will ensure that research users are informing research directions and that funding organizations are able to work together to direct resources to key areas.

Representing many disciplines

There is a need for a national summit to include not only natural scientists, themselves from any number of different traditional academic disciplines, but also social scientists with a valuable contribution to make to the understanding of what kinds of environmental research Canada will need in the future. Stern (1997) argues that an important line of environmental research, not being adequately pursued at present, is "understanding the economic, social, cultural, and institutional processes that set anthropogenic environmental changes [e.g. climate change, loss of biodiversity or other such environmental threats] in motion" (p. 2). In addition to conducting research into the causality of environmental problems, social scientists can also help bridge the divide between environmental research and public (or political) understanding and use of that research (Boardman, 2002, pp. 177-8). Such connections will help to foster early issue identification and link science advice to decision making. Including social scientists at

the beginning of the direction-setting process along with their natural science counterparts will increase the odds, though admittedly not necessarily guarantee, that an interdisciplinary bias is built into the strategy that will emerge from this process.

Informed by diverse perspectives

Though ensuring that a wide range of research disciplines are represented is a good first step in building an innovative, responsive and eventually successful strategy, attention must also be given to ensuring that all perspectives on environmental research have a voice at the summit. This means including researchers, research-users—itself a broad category including policy workers, decision-makers, private sector interests and researchers in related areas, among others—and research funders. This comes back to Chrislip's (1995) definition of relevant stakeholders as "people who, if they were to reach an agreement, could act together to achieve real results" (p. 25). The cooperation of research performers, users and funding organizations is necessary if a new environmental research strategy is to move past the stage of being a vision for one of these groups and on to being a reality for all three. To this end, positioning the process results as directions to be achieved by a research strategy allows stakeholders with diverse perspectives to agree first on long-term goals for environmental research and then work backwards to the potentially more contentious strategy of how to achieve those goals.

Supported by an expert advisory council

Valuing diverse perspectives must include looking beyond Environment Canada and the federal government as a whole, despite the presence within government of all three relevant groups: funders, users and performers of research. People associated with the CESN will likely display a wide range of perspectives, but are still principally natural science researchers, members of only one of the stakeholder groups an inclusive process would hope to tap into. Inviting well-respected members of different constituencies from a variety of backgrounds to initiate the recruitment of summit participants would ensure that diverse values and viewpoints are represented in the direction-setting process. Also, despite the respect generally enjoyed by Environment Canada in the environmental sciences community, it still has, and is seen to have, a very definite agenda of its own. Vesting ownership of the national direction-setting process in an expert advisory council would help move the new national strategy to arms length of Environment Canada and thus likely increase stakeholders' sense of ownership in it. Following an opportunity for interested members of the public to comment, for the sake of openness and transparency, the expert advisory council will be able to draft a final version of the direction and strategy with the advantage of the diverse perspectives represented on the council, ensuring a broad national view at all points in the process. Equally important will be the council's continued oversight role of the research strategy, fulfilling the principle of review, as it unfolds.

Backed by a coordinated funding mechanism

Some degree of funding coordination is essential to ensuring that resources are aligned with research priorities. An ambitious undertaking as it is, this mechanism only seeks to coordinate major sources of public funding, in recognition of the fact that coordinating all

smaller funding sources would be too unwieldy a task. Taking a two-pronged approach, then, such a mechanism would combine federal environmental research funds into a notional common pot to be used strategically towards identified priorities. While individual departments would keep their respective research funds, the ADM S&T Integration Board would play a role in ensuring that departments pool resources (funding, people and capital assets) where appropriate. The second funding prong would be along the lines of the Eco-Research Program, with a new pot of money dedicated to environmental research administered through the granting councils. Although not capturing all environmental research funding, this two pronged mechanism would effectively direct a large portion of Canada's environmental science spending to priority research areas in a coordinated way.

And preceded by increased federal coordination

As the principal user, producer and funder of environmental research in Canada, the federal government can and should play an important part in the determination of national research directions. Coordinating federal environmental science to a greater degree, or at least developing a clearer idea of all departments' environmental research activities, would allow the federal government to more effectively participate in the subsequent national direction-setting process.

Conclusion

While the time has never been wrong for moving towards greater coordination within Canadian environmental research, it is particularly right at the moment. Droughts, floods and other extreme weather events have re-focused public attention on climate change and the need to better understand it. Environmental health incidents like Walkerton and the increasing frequency of smog warnings in Canadian cities have made air and water quality issues impossible to ignore. The newly created position of National Science Advisor, to which the former president of the National Research Council was appointed only months ago, speaks to a political will for ideas and initiatives that will better the quality of Canada's science system. And within Environment Canada, the call for national coordination of environmental research is being heard time and again. Finally, after having nurtured the idea of greater coordination for quite some time, EC and the CESN are ready to act "to increase the mobilization and collective direction of existing resources within the Canadian environmental science system" (SPB, 2001, p. 20).

Ways to choose that collective direction—itself a goal with many different interpretations—range from continuing to foster partnerships and collaborations to undertaking Canada-wide consultations. Several of these options are well documented as a result of having been tried in different contexts or jurisdictions and all could have value for Canadian environmental research. Regardless of the type of process chosen, several issues must be addressed at its outset. These include questions about who will be involved in the process, what their goal will be, how chosen directions will be applied, and how the process might address current funding structures. The most appealing

process would be one that speaks to issues such as promoting early issue identification, inclusiveness, sound science and science advice, and transparency and openness.

Given the potential range of options and their accompanying issues, Environment Canada and the CESN would do well to use parts of several options and convene a national summit of participants suggested by an expert council chosen from a wide range of constituencies. Summit participants would develop overall environmental research directions or goals and a strategy to move towards those goals. Following public input, the expert council would finalize, oversee, and coordinate funding directed towards the country's selected research directions. By using these tools, Canadian environmental science should be able to head towards a well-coordinated future in which its research is better positioned to address the country's most pressing environmental challenges.

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Appendix 1 – Examples of environmental research funding

The following numbers are based on R&D expenditures for the socio-economic objectives of "Pollution, Protection and Conservation of the Environment" and "Exploration and Exploitation of the Earth". These two socio-economic objectives encompass a large part, though not all, of Canada's environmental research.

Ontario: $5 million for "Pollution, Protection and Conservation of the Environment" and $2.5 million for "Exploration and Exploitation of the Earth" in 2002-2003. 14% of the Government of Ontario's R&D in the natural sciences and engineering is conducted in-house. Over 50% is conducted by the higher education sector.

Alberta: $18 million for "Pollution, Protection and Conservation of the Environment" and $0 for "Exploration and Exploitation of the Earth" in 2002-2003.
40% of the Government of Alberta's R&D in the natural sciences and engineering is conducted in-house. Another 40% is conducted by the higher education sector.

British Columbia: $3 million for "Pollution, Protection and Conservation of the Environment" and $0 for "Exploration and Exploitation of the Earth" in 2002-2003.
14% of the Government of British Columbia's R&D in the natural sciences and engineering is conducted in-house. Close to 50% is conducted by the higher education sector.

Canadian Foundation for Innovation: $13 million for "Pollution, Protection and Conservation of the Environment" and $6 million for "Exploration and Exploitation of the Earth" in 2000-2001.

Natural Sciences and Engineering Research Council: $73 million for "Pollution, Protection and Conservation of the Environment" and $23 million for "Exploration and Exploitation of the Earth" in 2000-2001.

Environment Canada: $89 million for "Pollution, Protection and Conservation of the Environment" and $38 million for "Exploration and Exploitation of the Earth" in 2000-2001. Environment Canada conducts 85% of its research in-house.

Federal Government (including granting councils): $255 million for "Pollution, Protection and Conservation of the Environment" (56% in-house) and $253 for "Exploration and Exploitation of the Earth" (82% in-house) in 2000-2001.

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Appendix 2 – Canada's performance in meeting domestic and international air pollution commitments

Organisation for Economic Co-operation and Development (2004). *OECD Environmental Performance Reviews: Canada*. Paris: Author.

Appendix 3 – Estimates of environmental science funding

From 1995-98, 5.4% of Canada's overall R&D funding was devoted to the environmental sciences (OST, 2002). During that time, Canada's gross domestic expenditure on R&D (GERD) was $12.1 billion per year, on average (OECD, 2003b). If, in fact, these figures can work together (see below), then annual environmental spending should be roughly 5.4% x $12.1 billion, or ~$654 million. While the estimate of $654 million per year may be accurate, it most likely overstates environmental sciences spending because the GERD figure includes spending by industry, whose research is often not published in peer-reviewed journals, from which the 5.4% figure for environmental R&D is drawn. As industry generally has little incentive to produce environmental research not required of it by regulatory regimes, 5.4% of total R&D spending is likely a more accurate estimate of university and government environmental R&D spending than it is of industry's.

Another way to estimate spending on environmental R&D is to use spending towards the socio-economic objectives of "Pollution, Protection and Conservation of the Environment" and "Exploration and Exploitation of the Earth" as a proxy measure of total spending. All available (government only) figures for 2000-2001 indicate that R&D spending on these two objectives was approximately $534 million (Statistics Canada, 2003). This figure includes spending in the federal government, including the granting councils, as well as the provinces of Ontario, Manitoba, Saskatchewan, Alberta and British Columbia. This figure is likely an underestimate of spending because it does not take into account environmental R&D for socio-economic objectives such as "Agricultural Production and Technology" and "Public Health". It also only accounts for government spending, and even there data is only available for five provinces.

Although these two estimates are both very approximate, with one too high and one too low, they seem to indicate that spending on environmental R&D was between $550 million and $650 million a few years ago. Adjusting those figures to 2004, an estimate on the high side of that range seems likely.

Observatoire des sciences et des technologies (2002). *Bibliometric Profile.* Science Policy Branch Working Paper Series, no. 16.

OECD (2003). Table A.2.2. Gross domestic expenditure on R&D (GERD). *OECD Science, Technology and Industry Scorecard 2003.* Retrieved May 27, 2004, from http://www1.oecd.org/publications/e-book/92-2003-04-1-7294/Annex_tables_excel/At2.2_e.xls.

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Appendix 4 – Principles of Science Advice

The Council of Science and Technology Advisors (CSTA) developed a set of principles and guidelines to help government effectively use science advice in policy and regulatory decision making. These principles are also useful in talking about ways in which science advice and policy and regulation can inform one another. The principles are also a valuable tool with which to evaluate the ideas behind the issues surrounding coordination of environmental science in Canada. For example, Guideline II-1 states that "Departments should seek science input and advice from a wide range of sources, and decision makers should consider the multiple viewpoints received" (p. 5). This guideline speaks to the principle of inclusiveness, and really gets at the idea that the formulation of science advice benefits from a wide range of input. This idea is transferable to a coordination exercise, to which a broad range of constituencies should be invited to comment.

The following document is excerpted from:

Industry Canada (2000). *A Framework for Science and Technology Advice: Principles and Guidelines for the Effective Use of Science and Technology Advice in Government Decision Making.* Retrieved July 22, 2004 from http://strategis.gc.ca/pics/te/stadvice_e.pdf.

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