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The Role of Science in Environmental Impact Assessment: Workshop Proceedings

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Introduction

A workshop on The Role of Science in Environmental Impact Assessment, sponsored jointly by the Canadian Circumpolar Institute and the Canadian Studies Program of the University of Alberta, was held in the Stollery Centre at the University of Alberta in April, 1992. In this document we present an introduction to the issue of the role of science in environmental impact assessment (EIA), the texts of the presentations by the four invited workshop speakers, and a brief summary of discussions among workshop participants.

In the 1990's there have been great upheavals in the Canadian EIA process. In the west, fresh from the disappointments of the Rafferty–Alameda and Al–Pac EIA's, we were greeted with the news of the Oldman Dam report. In all three cases, the environmental public hearing panels provided clear direction for decisions by policy makers, but their recommendations were deflected in a variety of ingenious ways. Bill C-13, the extensive set of revisions to the federal EIA process, received Royal Assent during the summer of 1992, leading industry, environmentalists and government officials to speculate on the outcome. Most view the legislation as an improvement over the old regulations, but it falls short of resolving some of the major practical issues in the EIA process.[1]

One of these issues is the proper role for science in EIA. What should scientists contribute to the EIA process? The answer is obvious, at least on the surface. When a large project such as a pulp mill or a dam is constructed, there are bound to be impacts on ecosystems, as well as on current social, political and economic arrangements in communities. Conflicts arise over whether the benefits brought by the project will outweigh the harm it will cause. When governments make decisions about projects, they strive not to be, or at least not to appear to be, biased in favour of one or another of the strong interest groups (corporate, community, environmental, etc.) that form around the project. The government agency charged with the inquiry into the impacts of the proposed project seeks the help of objective, value-free methods of arbitrating among the interest groups. For this purpose, science presents itself as the best source of information by predicting the effects of large projects on such things as water and air, and human and animal health. It does this by appealing to empirical data and widely accepted scientific principles. Armed with this unbiased information, governments can make decisions that transcend the conflicting interests of various groups.

This is the position represented, for example, in a Government of Canada report, according to which the environmental public hearing is "a forum in which expert opinion on technical subjects as well as value judgments or the choices of society may intersect and merge."[2] The clear implication of this statement is that value judgments come from society, and expert opinion and technical advice are offered by scientists. This view accords well with widely held beliefs about the function of science in contemporary society: science provides reliable information about the world, which can then be used in

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[1] Gibson, Robert B., "The New Canadian Environmental Assessment Act: Possible Responses to its Main Deficiencies," *Journal of Environmental Law and Practice*, vol. 2 (1992) pp. 223-255.

[2] Study Group on Environmental Assessment Hearing Procedures, *Public Review: Neither Judicial, Nor Political, But an Essential Forum for the Future of the Environment*, A Report Concerning the Reform of Public Hearing Procedures for Federal Environmental Assessment Reviews (Ottawa: Supply and Services Canada, 1988), p. 12.

political and social decision-making processes. This is often called the *traditional view* of science.

When questions are raised about the role of science in EIA, the issues usually reflect this traditional view. If the role of science is questioned, it is usually for two reasons: quantity and quality. In the first matter, many complain that shortfalls in EIA occur when there is not enough science to go around, or that there are insufficient data to cover a specific subject. This is a common complaint. There is scarcely ever enough money and time to collect data sufficient to support scientific conclusions. For example, questions are often raised about whether there is enough baseline data, that is, information about the condition of the affected ecosystem prior to construction of the project, to determine the impacts it actually has once it goes into operation. The second complaint has to do with the quality of scientific information. A distinction is sometimes made between 'assessment science' or 'mandated science' and 'real science.'[3] To work well, scientists must be given time and resources to carry out their work, respecting not the special interests of a mandate to produce a report in a short time, but the demands of the problem itself. When scientific work is compressed to fit the needs of a specific project, quality suffers.

There is an obvious and often repeated solution to the problems of both quality and quantity—spend more money on science. In this way, at least the problem of quantity could be resolved, and headway could be made on quality. There are at least two difficulties with this proposal, one practical and the other conceptual. Is it realistic to presume that large amounts of money will flow to assessment science? Assuming that adequate resources are made available, will more science lead to markedly better EIA's? We know the answer to the first question, at least for the immediate future. The second question is discussed in various ways by the four invited workshop speakers, and dominates the discussion among workshop participants, who begin to question the traditional view of science. Husain Sadar reminds us that EIA is still in its infancy. His paper (coauthored with John McEwen) contains a detailed inventory of issues confronted by the EIA process in Canada, and a series of recommendations for reforming the role of science. Fred Roots, one of the architects of the Federal Environmental Assesment Review Office (FEARO), reflects on EIA as an art requiring wisdom, as well as a science. He makes a clear case for considering the social context of science in EIA. EIA, accordingly, is a process of "social learning." Val Geist writes on the shortcomings of many environmental scientists at the front lines, taking into consideration the demands on scientists presenting data to judicial or quasi-judicial bodies. Andy Hamilton's paper promotes the idea of long-term monitoring projects, and asks what long-term goals, especially educational ones, will be necessary to support the new EIA legislation. He provides an important warning: too much attention to EIA's can divert attention from earlier stages of ecological planning. His paper, is, in effect, a plea for considering the larger context of EIA.

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[3] See, for example, Salter, Liora, *Mandated Science: Science and Scientists in the Making of Standards*. (Dordrecht, Holland: Kluwer Academic Publishers, 1988) and Schindler, David W., "The Impact Statement Boondoggle," *Science*, vol. 192, no. 4239, 7 May, 1976, p. 509.

1. Some Concepts and Issues Surrounding the Place of Science in Assessment of Impacts on the Environment

E.Fred Roots

What is Environmental Assessment?

Many definitions have been given, some broad, some very narrow; but all carry the idea of an *estimate in advance* of a value or magnitude, or a change of value or magnitude, of the single or collective set of natural characteristics or processes generally understood to constitute the environment.

An assessment is not a judgement or a measurement. The word and the idea come from the legal system of the Roman Empire, where an assessor (one who sits) is a person who sits as a legal advisor to a judge, but has no power of making judgements.

As used in the present Canadian context, environmental assessment applies to the effects that deliberate human-caused or human-triggered actions impose on the environment in ways other than the direct intended result of the actions themselves. There is an important, but sometimes subtle, difference between environmental *effects*, and environmental *impacts*. (If a tree falls over in the forest for any reason, it has an environmental effect; but the consequences of cutting down a healthy tree to make lumber would be an environmental *impact*.)

Environmental assessment becomes environmental impact assessment when the focus is on estimates of the changes that may be imposed on the environment as a result of a deliberate human action or behaviour.

Kinds of Environmental Impact Assessment

There are many types and gradations of environmental impact assessment, and it is useful to keep them in mind as a background or context for considering more formalized and institutionalized assessment.

- There is *informal or intuitive assessment*, based on experience and accumulated knowledge. This is, for example, the stock-in-trade of every good farmer, who considers a range of activities—where and when to plow or seed, what crops and how much, what tillage, what pest control practices, etc.—and who estimates in advance the likely impact of these activities on the natural environments from which he makes a living. Some of those impacts will be desirable, some not. He makes decisions and acts on the basis of his environmental assessments.

- There is *organized planning and selection of techniques* and practices according to their likely (estimated) environmental effects. An example of this is good engineering practice—especially geotechnical engineering.

Every road-builder who designs and installs an adequate culvert to handle the disruption in surface drainage that he will cause by building a road is practising and acting on environmental impact assessment.

- There are *environmental protection laws and regulations*, for which advance environmental impact assessment has been or is fundamental. From the first modern environmental protection legislation, the Alkali Acts of the eighteenth century, or the Smoke Abatement Regulations designed to prevent fouling of the air over the estates of the wealthy, an assessment in advance of the likely impact that a continued human practice would have on the natural environment has been a part of government decision-making.

- The broad public and political concern over preservation of natural resources and natural beauty that arose in several countries in the nineteenth century, and led to the conservation movement and the establishment of national parks, employed another aspect of environmental impact assessment—an *estimate or anticipation of what humans and human institutions would do to the natural world* and its resources if decisions were not made in advance to control or conserve. Behind the lofty statements of national parks of most countries—"to preserve natural values for the enjoyment and benefit of present and future generations"—lies more than a century of broadly accepted environmental impact assessment.

These are examples of environmental impact assessment that provide the broad context into which institutionalized environmental impact assessment, as a specific decision-making activity in the modern context, should be fitted. All require (i) a *base of knowledge and understanding* of environmental processes, (ii) an *ability to relate the effects of human action* to that environmental knowledge, and (iii) an *identified means for making decisions*.

Formal Practices of Environmental Impact Assessment

Purpose

Environmental impact assessment as practised in Canada today is an institutionalized, structured activity, designed to identify and estimate the effects that a proposed human action or series of actions are likely to have on the physical environment, the ecosystem(s), and, through these effects, on human health, well-being, or prosperity.

To carry out this purpose, environmental impact assessment must be:

i. organized within the societal system—(it must not be purely bureaucratic, but have public input);

ii. consistent and systematic in its concepts and operations — (and be seen to be so);

iii. comparable with other assessments so that alternatives and options can be considered—(there can be no absolute standard — judgements must depend on comparisons).

Requisites

Successful environmental impact assessment can be achieved only if some basic factors are in place:

i. a generally accepted concept of what the "environment" is and how it functions;

ii. agreement on what the action or project is whose impact is being assessed, who is responsible for it, and what are its primary purposes or objectives;

iii. a generally accepted set of values, shared by those in authority and those affected by a possible change in the environment, of what is good and what is bad among the things that might happen to the environment (or a shared feeling about what future generations might find good or bad); and some agreement on a means of measuring or rating changes in values. This is very hard to achieve, and lies in the area of wisdom, rather than science.

iv. a method of making decisions, so that the estimate of likely environmental impacts can influence the actions whose impacts are being assessed.

Unless all these factors are in place, environmental impact assessment cannot succeed. But none of these is fully achieved or fixed; and indeed many of them change during the course of environmental impact assessment itself. In that respect, environmental impact assessment is very much an activity of *collective social learning*. It is the difficulty and irregularity of this learning process that makes environmental impact assessment a difficult, often frustrating, and sometimes controversial or even counter-productive process.

The Role of Knowledge, Science, and Research

Each of the above critical factors of successful environmental impact assessment requires *knowledge*—knowledge of many kinds, of the environment and its processes, of technologies and their effects, of humans and their behaviour, of institutions and policies that may produce actions and responses different from the intentions of those who created them. Sometimes what is necessary is to pull together, in new ways, scientific knowledge that already exists; but sometimes a lot of new knowledge is needed—knowledge that does not exist, or is not easily available or agreed upon, for environmental impact assessment raises issues that go beyond and overlap traditional scientific disciplines, jurisdictions, and scales of time or space.

But knowledge alone is not sufficient for successful environmental impact assessment. There must be the *understanding* and *capability,* in decision-makers and in influential citizenry, to absorb and use that knowledge. And there must be a system of communication or interpretation that can connect the knowledge and assessment with the understanding of the decision-maker and of the citizens who must accept the decisions. To bring this about, the successful environmental impact assessment system must have a *suitable structure* and its practitioners must have *art* as well as *science* in using the structure.

If *science* is organized knowledge of any kind, we may ask: what kinds of science are needed for environmental impact assessment in the modern context? In almost every case it will be found that the range and depth of science required for environmental impact assessment is different, and usually broader, than that required by the activity being assessed, simply to carry out its own operations to achieve its primary goals. This is an important reason why the proponents of an activity often find that the business of environmental impact assessment is an expense, a nuisance, and a distraction which may, if imposed too late, defeat the original project. (If Moses had been required to go through an assessment of the environmental impact of parting the waters of the Red Sea when he came to the shore, he surely would have been caught by the Egyptians. But because he filed his Environmental Impact Statement [EIS] well in advance, the waters parted and he got across in the nick of time.)

Research, of course, is just the organized and deliberate pursuit of knowledge. However, knowledge gained through research is of no value in environmental impact assessment unless it increases *understanding,* which is knowledge with value added in terms of its integration and applicability to the subjective estimates that must be made.

The Importance of "Understanding"

There are *two kinds of understanding* based on knowledge and research that are essential to successful environmental impact assessment:

1. Understanding of the *characteristics of the natural environment,* and the working of environmental processes, and of how those characteristics and processes will be affected by the activity; and of how important the effects are likely to be for those affected by them.

   This kind of understanding must be based on traditional scientific observation, data, information, and research in the relevant disciplines in environmental sciences, environmental economics, and social and behavioral sciences.

   The major problems in achieving adequate understanding in these areas are:

   - difficulties in bridging disciplines;
   - shortcomings because we have only a primitive ability to predict or to deal with increasing complexity— (mathematical simulation models, although complex to us, are gross simplifications of the workings of nature);
   - problems of integration of scales over space and time.

2. Understanding of the *processes and practices of environmental assessment itself*—how to make it more effective, not only in an administrative and institutional sense, but as a societal learning process.

   This requires research of a different sort, to obtain new knowledge on the goals of society, and how society resolves legitimate conflicts among goals; the values of citizens, investors, and decision-makers—how they are expressed, and justified, how they conflict with one another, and how they

are held in surrogate for others, for future citizens, for non-humans; how decision-making, implementation and enforcement of decisions themselves affect the values placed on decisions; and how external environmental and socioeconomic factors interact with the assessment process.

It is a sobering fact that most of our major difficulties with environmental impact assessment in the last decade have had a basis in problems of understanding of the second type, related to inadequacies of knowledge about the nature and the issues of the assessment process itself, rather than being the result of lack of environmental scientific knowledge leading to the first type of understanding. Yet the overwhelming preponderance of our science and research effort has gone toward information and knowledge that applies to the first type.

Continuing Difficulties in the Application of Science to Environmental Impact Assessment

Some major difficulties in using what scientific knowledge we do have to achieve effective environmental impact assessment relate to:

- the integrated nature of environmental issues versus the artificial division or fragmentation of areas of responsibility, knowledge, and action;
- reluctance to deal with the difficult problem of relating natural processes over a range of time and space scales (see Figure 1);
- the "practical" need to ignore "ripple effects" or "nibble" effects which, in sum, may control the net environmental response; assessment of cumulative effects of many projects will begin to address this problem;
- the inability of the present economic and political system to take into account benefits and costs to other jurisdictions, to the future, to the disenfranchised;
- the tendency to substitute observation and data for understanding and wisdom (see Figure 2);
- the reluctance, at times amounting to a modern cultural taboo, to challenge the "sacred cows" of our society in assessment of environmental values. Some of western society's sacred cows which are very difficult to challenge or ignore without upsetting the whole system, but which make environmental assessment difficult are: that continued economic growth is not only desirable but necessary for future well-being; that there is no optimum scale for enterprises or for the size and distribution of population, and that "economies of scale" mean that larger is expected to be more efficient; that human biological impulses and instincts are different from those of other organisms and that individual freedom means minimum restraint on acting according to animal impulses; that individual rights take precedence over collective rights except in extreme cases; and that democracy means that each person has a right both to eat his or her cake and have it too, no matter how many of us there are and whether we live in an environmentally productive or marginal region, or whether the environmental support system has been maintained or destroyed.

All of these difficulties become apparent, over and over again, in the attempts to apply scientific knowledge to environmental impact assessment. A list of the major areas of research addressed by the Canadian Environmental Assessment Research Council (CEARC), 1984–91, shows some areas in which the scientific community has attempted to deal with them in specific subject areas:

- Cumulative effects assessment;
- Social impact assessment;
- Assessment of health impacts of environmental change;
- Assessment of environment/economy relationships;
- Assessment of the environmental effects of government policies;
- Assessment of environmental factors in urban and rural settlements, and assessment of the factors and controls that are necessary to achieve "sustainable" communities;
- The application of traditional environmental knowledge to environmental impact assessment;
- Integrated resource planning;
- Monitoring of effects of environmental decisions based on implementation of Environmental Impact Assessment (post-assessment audits).

The Canadian Environmental Assessment Research Council has ceased to function. But the issues it addressed remain. Each of them requires science and research to produce the new knowledge and improved understanding of our environment and of ourselves that is essential if environmental impact assessement is to be a positive and productive tool to help humans live on the planet in a prosperous and sustained manner.

The need for carefully conceived and directed, new and imaginative science, and for pulling together what we already know about the environment, about management and about human behaviour in relation to environmental impact assessment has never been greater. But science alone is not enough. Scientists and citizens at large, together, have a responsibility to insist and ensure that our knowledge and understanding are applied in a constructive way to our decisions and to our awareness and acceptance of changes. This is what enviromental impact assessment is all about.

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EARTH SYSTEM PROCESSES: CHARACTERISTIC SPACE AND TIME SCALES

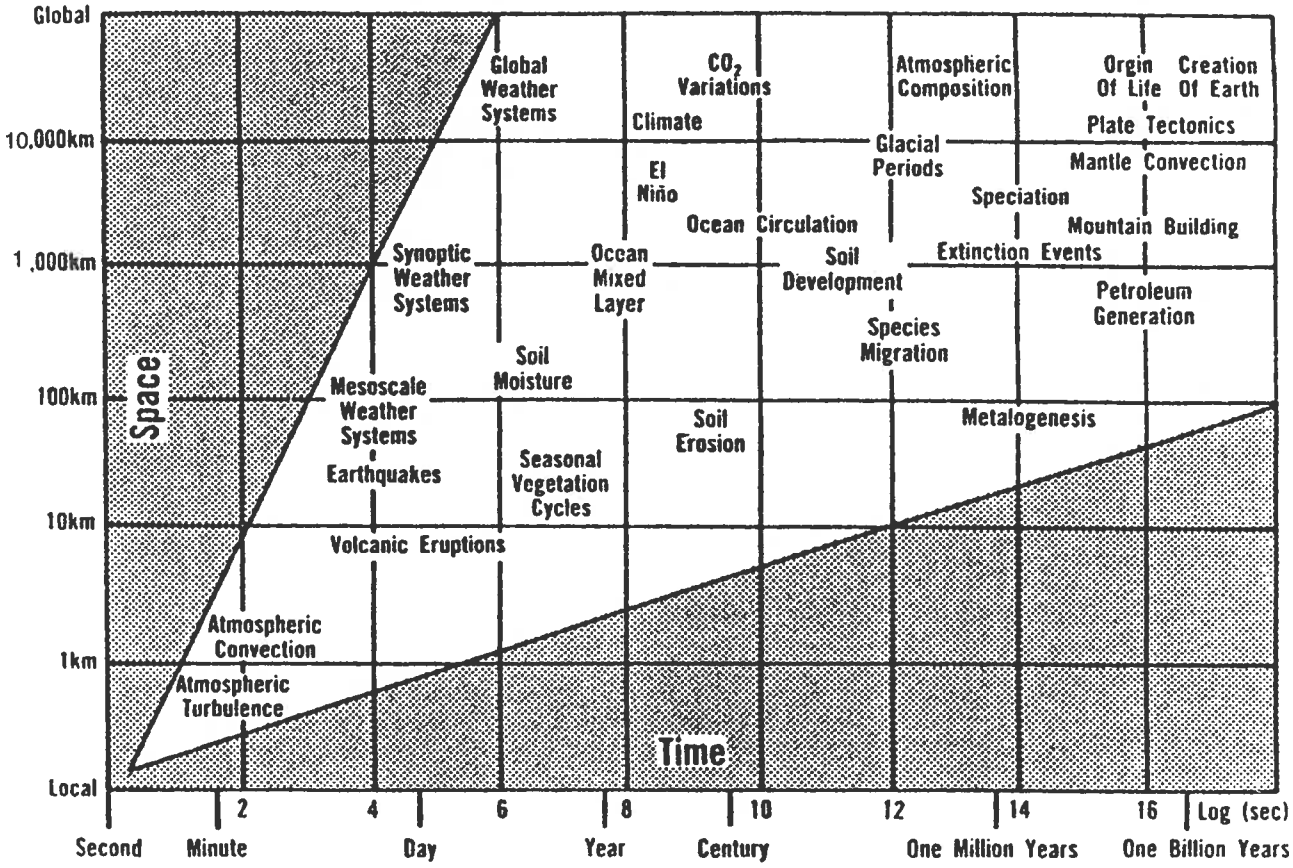

FIGURE 1 (From Bretherton, 1986)

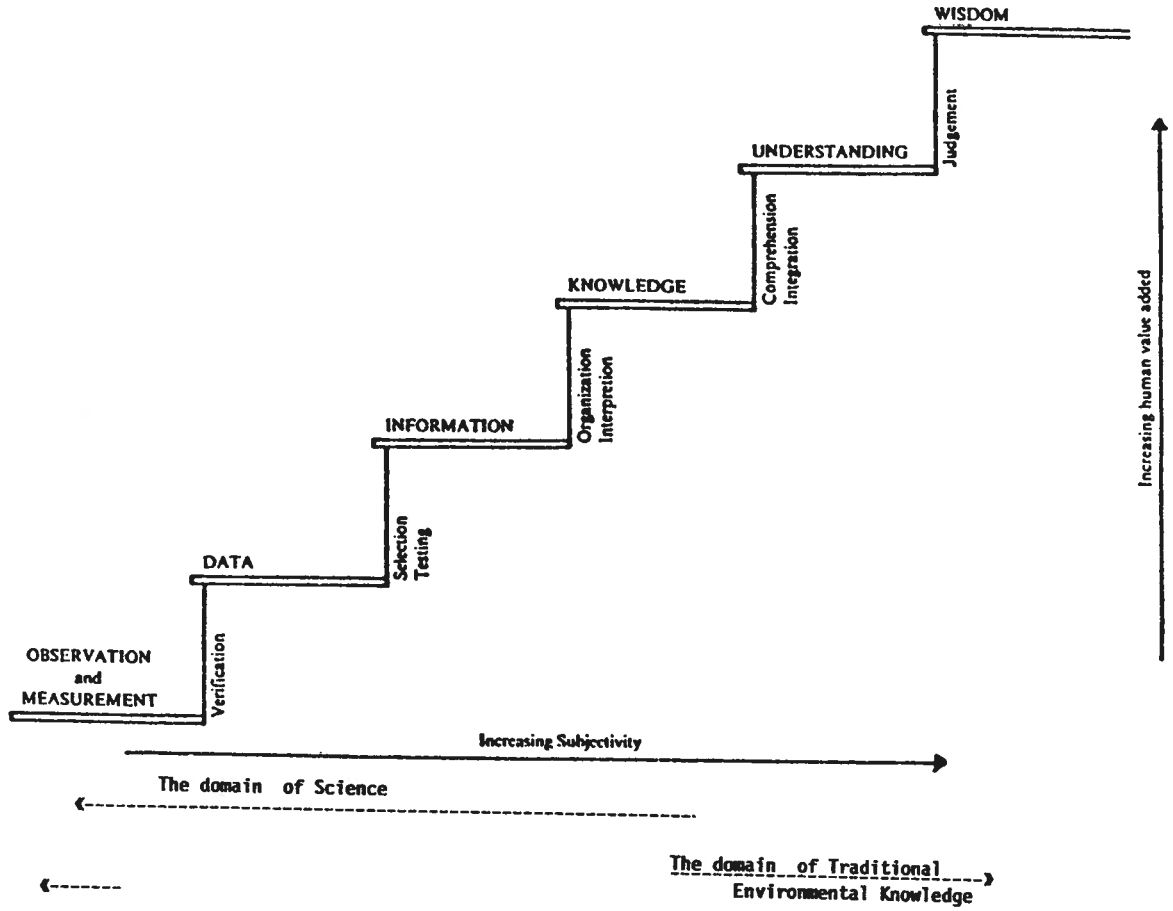

FIGURE 2 THE STAIRCASE OF "KNOWING" (adapted from Roots, 1992)

2. Reflections on the Potential for Science and Scientists to Contribute to Environmental Assessment Processes

Andrew L. Hamilton

Setting and Context

Environmental issues are finding their way to the top of government agendas. The public is increasingly concerned over environmental quality, and both the media and the public are more aware of the systemic (or ecosystemic) aspects of environmental issues. The environment is news and the media have played an important role in building an informed public constituency that is concerned about ecological limits and ecological imperatives. This public awareness and support has made "ecological security" a political priority and indeed a political imperative.

There is general uneasiness that the scale of resource development and resource extraction activities in Canada is now of such a magnitude that the integrity, health and sustainability of local and regional ecosystems and resources are at risk. Aquatic ecosystems and aquatic resources are integrators of land-based resource development, and it is not surprising that they often show the cumulative effects of earlier developments.

Recent court decisions on the role of the federal government of Canada in the environmental assessment process have helped to crystallize a variety of environmental issues. Canadians are clearly looking to the federal government to play a significant role in assessing the environmental implications of policies and projects that could impinge on areas of federal jurisdiction.

These recent decisions can be interpreted as being a reflection of a broad public demand to take environmental assessment seriously and to make the process more meaningful. One way of ensuring that the process becomes more meaningful is to initiate the process before the critical developmental decisions have already been taken.

Several federal initiatives are helping to set the stage for constructive change in the business of environmental assessment research. Bill C-13, the act to establish a federal environmental assessment process, will specifically require consideration of the "cumulative environmental effects" of projects. The Department of Fisheries and Oceans' "Policy for the Management of Fish Habitat" also provides a potentially powerful mandate. The policy objective to "increase the natural productive capacity of habitats for the nation's fisheries resources, to benefit present and future generations of Canadians" and the guiding principle of "no net loss of the productive capacity of habitats" both clearly require significant fisheries science input into developmental decisions. To date, this input has been limited.

Canada's Green Plan calls for many initiatives that are consistent with the overall objectives of an environmental assessment process. Considerable emphasis is

given to "environment-economy linkages," and "sustainable development." In fact, the need to carry out adequate ecosystemic planning and environmental assessment is both explicit and implicit throughout much of the document.

A Time for Choices and Decisions

The science-based departments and the federal government will all have a major role to play in addressing the need for substantive environmental assessments. The Department of Fisheries and Oceans has numerous responsibilities with respect to the production and management of fish and fish habitat. The objective of the Fish Habitat Policy to "increase the natural productive capacity of habitats for the nation's fisheries resources" is both commendable and onerous. **It cannot be achieved without the presence of a well-supported nucleus of scientists with licenses to do long-term research on the relationships between human activities, aquatic ecosystems and aquatic resources.** Unless there is a mandated, well resourced, continuing program to address these fundamental issues, then there is no realistic reason to believe that developmental decisions will be made within the context of ecological reality. Similarly, Environment Canada scientists have a major responsibility to contribute to a wide range of "green" initiatives and "green" policies.

Part of this challenge, made especially difficult in "times of restraint," is to make wise decisions for the allocation of resources between *urgent*, legally mandated but reactive operational obligations, and more *important* (in the long-term), proactive strategic research. In the case of the environmental assessment process it is essential that affected departments have a significant presence when departmental interests are at stake. It is even more important that departments act quickly to make the strategic long-term decisions that are essential to encourage the development of the knowledge and expertise that will give substance and credibility to the process.

Environmental assessment processes are a means of putting a spotlight on the later stages of developmental decisions. Typically the process is project-driven, but it does provide a means of forcing some reflection on the environmental implications of developmental decisions. In most instances, the process is likely to have considerable public input and even though it tends to occur rather late in the planning process it will, one hopes, prompt developers to give more, and earlier, consideration to the environmental implications and costs of their projects.

The recent inception of joint federal and provincial panels to carry out environmental assessment reviews of major projects is a particularly relevant development. It will provide further impetus to the growing public awareness of the long-term ecological consequences of developmental decisions. Another important change is the requirement to assess the cumulative impact of proposed projects. This requirement is contained in the federal legislation (Bill C-13). If cumulative impact is taken seriously, as it eventually must be, then it will lead to new research approaches and it is likely to fundamentally change the nature of the environmental assessment process.

For managers in government, it is relatively easy to defend the allocation of resources to meet specific statutory obligations. However, it is much more

difficult to defend allocation of resources to the long-term development of the knowledge and expertise that is essential if responsible agencies are to shift to a more proactive approach to reducing negative environmental consequences and environmental risks. In short, the immediate takes precedence over the long-term and, unfortunately, this all too often means that the urgent takes precedence over the important. The longer this situation prevails the more we compromise the future and the more inevitable it becomes that we will be left with little choice other than to adopt a "knee-jerk" response to crises that will increase in both frequency and intensity. The choices aren't easy and the immediate pressures on federal managers will always be to emphasize and justify short-term steps to address the immediate responsibilities arising from federal environmental assessment processes. It will take courage and foresight to find a way of emphasizing and mandating the kinds of strategic long-term research that will eventually provide the basis for more informed and responsible decision-making on matters affecting departmental and shared responsibilities.

Another fundamental consideration is the roles to be played by federal scientists in the environmental assessment process. A large proportion of Canada's overall capability to assess the environmental implications of proposed developments rests with scientists in departments such as Environment, Fisheries and Oceans, Agriculture, Health and Welfare, and Energy Mines and Resources. Is their expertise to be filtered through senior departmental officials who provide the official position or are individual scientists going to be encouraged to participate in their "personal and professional" capacity—as citizens, as members of their scientific associations or even on behalf of environmental non-governmental associations?

If We Are Serious

There is growing evidence that the environmental rhetoric of the 1960s and 1970s has given way to the ecosystem approach and ecosystem integrity of the 1980s and perhaps to sustainable development and environment/economy round tables in the 1990s. The commitments in Canada's Green Plan, the Department of Fisheries and Oceans' policy for the management of fish habitat, the *Canadian Environmental Protection Act* and Bill C-13 (to establish a federal environmental assessment process) are all examples of moving beyond the rhetoric. Each of the above initiatives contains important elements that require long-term research commitments. At the same time, each agency of government will have to develop its own means of rationalizing and justifying a research program.

In departments such as Fisheries and Oceans and Environment Canada, there is a recognition that some research is required in order to meet statutory obligations. Yet, there is no clear mandate for research unless it can be justified on the basis of a program responsibility. The former Fisheries Research Board of Canada did have an explicit mandate for fisheries research. Without such a mandate it can be very difficult to defend long-term strategic research in the face of demands for resources to respond to current environmental crises. It is often relatively easy to use current political and departmental priorities as a basis for justifying current and proposed activities—provided these activities give promise of quick returns and that they do not sound like research. This is a demoralizing position for research practitioners, especially when many of them,

for good reasons, believe that "band-aid" responses to current statutory requirements are wasteful, inefficient and in the long-term, likely to be counter-productive.

Is the current response to the federal environmental assessment process based on a need to meet statutory federal obligations, or is it motivated by a genuine desire to further the stated purpose of legislation such as the environmental assessment act or of policies such as the policy for the management of fisheries habitat? Clearly the former objective is much less onerous and can probably be met through providing scientific input at appropriate stages in the environmental assessment process. It might be appropriate and practical to contract most of the requirements to consulting firms that have developed some expertise in meeting the needs of the process. Indeed, many consultants have developed considerable competence at synthesizing and re-packaging information from a variety of sources. They do not, however, provide a means of generating new knowledge, nor are they equipped to provide an overall assessment of the state of ecosystems that are likely to be affected.

If governments are serious about tackling obligations such as cumulative impact assessment, there are few defensible shortcuts. Without long-term commitments to address such very difficult but essential questions it is clear that science can only play at the margins. **Now is an opportune time for a major governmental effort to develop a cohesive research-based strategy to meet federal obligations with respect to the federal environmental assessment process.** More importantly, the strategies could be aimed at positioning federal departments to play a much larger "information" role in influencing decisions that individually and collectively pose a significant threat to Canadian ecosystems and Canadian resources.

Positioning to Make a Difference

A Conceptual Model

Figure 1 is a generic model of the respective roles of an environmental assessment process and environmental assessment research in the making of resource development decisions. The model is a simplified attempt to "tease out" the major opportunities to influence the decisions affecting the use and development of resources. For the most part, "feedback" loops have been omitted because they add complexity and might divert us from addressing the key opportunities for making some important strategic gains by positioning federal science-based departments to play a more important role in decisions affecting the environment.

The major assumptions underlying the model are:

1. Scientific knowledge and understanding should be important inputs to decisions affecting the use of ecosystems, habitat and resources.

2. Scientific knowledge and information can be thought of as flowing through three channels:

    a. A public channel where this information mixes with and modifies public perceptions, public values, public behaviour, and the decisions

of individuals. This channel is facilitated by the media and a modest proportion of university research flows through this channel;

b. A government channel where the information flows through government bureaucracies and governmental processes for the purposes of governance. This channel caters to the need for equity, regulation and the allocation of costs, benefits and resources. Most government research has generated information that has been targeted and justified on the basis of this channel;

c. An industrial channel that is largely shaped by market-place forces where the research has usually been funded by the industrial sector for the purpose of meeting governmental requirements (such as environmental assessment requirements) or for gaining a competitive advantage in the market place.

3. There is a filter in each channel through which scientific information flows. These filters serve the important purpose of making the information relevant and useful to the sector or client that receives the information. This synthesis and tailoring of information to meet sector or client needs is an extremely important element in the "big picture." Information is power and information brokers have a strategic role to play in influencing decision-makers. Private consultants play a significant role as information brokers, particularly with the government and industrial channels. Non-governmental organizations and the media are more active in the public channels.

4. Environmental assessment processes are governmental processes which occur rather late in decision-making processes and networks. They are unlikely to have more than a marginal influence on the projects and proposals that are actually being assessed. However, they are important for several reasons including:

   a. The presence of environmental assessment processes is likely to influence the project planning carried out by the proponent so that the project will have less difficulty in the environmental assessment process;

   b. Environmental assessment processes open up the decision-making process and provide a setting where public, proponent and government interests become clearer;

   c. Environmental assessment processes create a strong demand for information that is relevant and understandable;

   d. Environmental assessment processes contribute significantly to the general awareness of the nature, extent and significance of environmental issues.

5. Environmental assessment research contributes directly to the pool of scientific knowledge and understanding. Research by the Freshwater Institute on the diversion of the Churchill River into the Nelson River provides an excellent example of how an environmental assessment process was used to generate information that enabled us to make better decisions concerning the use and management of northern rivers. The acid rain research at the Experimental Lakes Area had different origins, but the result of that work provided powerful evidence that helped stimulate decisions and action on the acid rain issue.

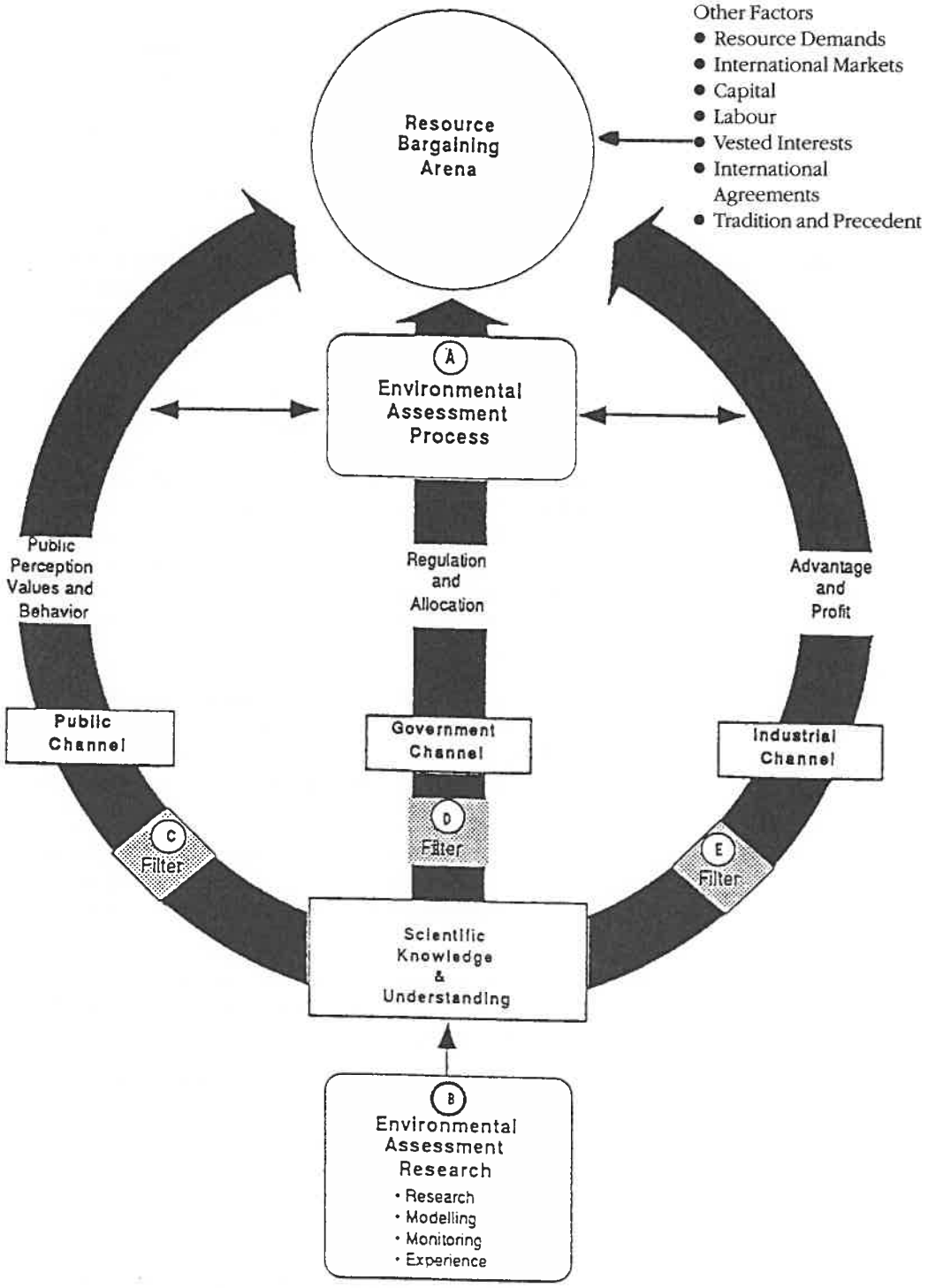

Figure 1: A simplified generic model of the respective roles of environmental assessment research, and the environmental assessment process in the making of resource development decisions.

Strategy Options

There are a number of major "points of entry" that could be used to enhance the scientific communities' ability to influence decisions affecting ecosystems, habitats and resources. These same "points of entry" are also a means of improving a governmental agency's performance in meeting its statutory responsibilities. Major points of entry as illustrated in Fig. 1 are:
A. Environmental assessment processes; B. Environmental assessment research; C. Information filter in the public channel; D. Information filter in the government channel; E. Information filter in the industrial channel.

The strategic options outlined below are directly related to the relative importance assigned to each of these "entry points". The following scenarios reflect four different strategic approaches that could be developed.

Option 1: The Minimalist Approach

The underlying philosophy of this approach is that the federal environmental assessment process is an obligation that is largely irrelevant. In times of severe resource constraints the most appropriate approach is to meet the letter of the law by limiting a department's involvement to providing necessary input at the required times in the process ("entry point" A). The input from the federal science community would, as in the past, be opportunistic and occasional. Indeed, under this approach, one could argue that most of the federal input could be contracted out to consulting firms. Resources to address specific assessments would be justified and sought on a case-by-case basis.

Option 2: The Incrementalist Approach

The philosophy underlying this approach is that the federal responsibilities for playing a larger role in environmental assessment processes, coupled with increasing public expectations, can be used as a basis for justifying new resources for meeting the requirements of the process. The tendency would likely be to concentrate attention on making direct input to the process ("entry point" A). This approach, like that of the minimalist approach, would be largely reactive. However, more resources would be sought, and the continuing need would be emphasized and the case-by-case approach down-played. The incremental approach would also have room for marginal improvements in the information filtering role (especially "entry point" D) and in the gradual development of a targeted environmental assessment research capability. This incrementalist approach, if mandated and supported, could eventually lead to the development of significant expertise that could be directed at meeting environmental assessment obligations and in influencing future decisions affecting ecosystems, habitats and resources.

Option 3: The Proactive Mandated Approach

The philosophy underlying this approach is that the current mandated obligations of the federal government, including those related to the federal environmental assessment process, provide an excellent opportunity to significantly enhance the ability to influence decisions affecting ecosystems,

habitats and resources. In this approach, the federal government would clearly assume a leadership role and would be making the strategic decision to position the government and its scientists to be major players.

Federal departments would continue to meet regulatory obligations ("entry point" A) but would mandate a comprehensive targeted research program that would do much more than contribute to the pool of scientific knowledge and understanding ("entry point" B). Such a program should also be actively engaged in synthesizing and tailoring information to meet the needs of the clients in each of the three channels ("entry points" C, D and E). In addition, the program should have the capability of providing expertise and expert witnesses to help meet the immediate needs of environmental assessment processes, whether they be federal or provincial ("entry point" A).

This approach would require significant new resources but it would also represent a meaningful and serious attempt to assume a leadership role in addressing mandated responsibilities and policy objectives. There would be some immediate "pay-off", although the major "pay offs" would be in the mid- and long-term and would significantly improve the major decisions affecting Canadian ecosystems.

Option 4: The Proactive Collaborative Approach

The philosophy behind this approach is that existing institutional arrangements are wholly inadequate to meet the challenge presented by modern environmental problems and that present systems of governance cannot cope with today's global ecological crises.

Another underlying assumption is that the best hope for generating the global awareness that will help bring about constructive change lies with developed middle-power countries. Canada, Australia, New Zealand, The Netherlands, and the Scandinavian countries are well positioned to lead in addressing the "tragedy of the global commons." The opportunity to "lead by example" could justify the search for new and creative ways of approaching complex environmental issues.

The proactive collaborative approach would clearly require working with others to ensure that decisions about resource development are ecologically sustainable and that development that is inconsistent with maintaining the integrity of the ecosystems on which we all depend is simply unacceptable. Such an approach would clearly signal a commitment to ensure that the options of future generations would not be compromised.

This approach, like the previous approach, would clearly require significant input at each of the "entry points" outlined in Fig. 1. It would mean a commitment to a substantive environmental assessment research program and a substantial commitment to see that the information generated was interpreted and used to influence the decisions that counted. Long-term ecological research and monitoring programs would go a long way towards meeting statutory obligations called for under environmental assessment legislation. They would also provide the basis for making more informed and more responsible decisions concerning the use and abuse of Canadian ecosystems. An added bonus is that the knowledge and expertise developed through such programs

would help to position Canada to continue to play a leading role in conceiving and designing a more sustainable biosphere.

Summary of Strategic Options

The four strategic options outlined above are summarized in Table 1. The federal government has a number of different ways of approaching its responsibilities relative to the federal environmental assessment process. In times of fiscal restraint, it may be tempting to adopt an approach that will require minimal expenditures. However, a great deal is at stake and the longer we take to address fundamental questions associated with developmental decisions the fewer options we leave to future generations. In my view, it is essential that the federal government and the scientific community both work toward a more proactive approach. Ideally the federal government science departments should develop new and creative ways of working collaboratively with one another and with others.

Table 1:
Strategic options for addressing the obligations and opportunities arising from the federal environmental assessment process. Capital letters = major input at this point of entry; lower-case = minor input at this point entry. Points of entry are as illustrated in Fig. l.

Points of Entry **Strategic Options**	A. Environmental Assessment Process	B. Environmental Assessment Research	C. Information Filter Public Channel	D. Information Filter Gov' t Channel	E. Information Filter Industrial Channel
1. The Minimalist Approach	A	b	-	-	-
2. The Incrementalist Approach	A	b-B	c	d	-
3. The Proactive Mandated Approach	A	B	C	D	e
4. The Proactive Collaborative Approach	A	B	C	D	E

3. The Role of Science in Environmental Impact Assessment*

M. Husain Sadar
and
John McEwen**

Introduction

Environmental Impact Assessment (EIA) is generally defined as an activity designed to predict, interpret and communicate the impacts of a proposed action on the well-being of ecosystems upon which human health and survival depend.

Interest in the environmental consequences of human activity is relatively recent. Public concern about the deterioration of the natural environment exploded in the late fifties and early sixties. The resultant public pressure made its way through the corridors of political power only recently. The ensuing restructuring, reorganization and creation of government and public institutions gave us various departments and agencies now assigned the role of protecting the environment. It is important to remember that most of these entities are still in an early developmental stage.

EIA as a planning tool and as an instrument for improved decision-making is, therefore, a recent phenomenon. With only 20 years or so of experience in this field, it is little wonder that EIA-related practices, procedures and methodologies are still in their infancy. However, EIA has been generally accepted as an aid to prudent and sustainable development planning. The real challenge is to strengthen the scientific, methodological and procedural basis of EIA in order to institute equity, fairness and transparency in economic development planning.

Public Concerns about Decision Making Processes

Since one of the principal objectives of conducting environmental impact assessment is to make better decisions through adequate public input, it is important to understand the reasons behind growing public concerns about the environmental consequences of economic development proposals.

Up to the time of the Hippie Revolution (i.e. the early to mid sixties), the general public in the developed world, and especially in the United States and Canada, was quite content with the way things were going. The top decision makers in both the public and private sectors were constantly fuelling the engines of

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*The views expressed here are strictly the authors' own and do not necessarily reflect those of their employer.

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economic growth to meet increasing consumer appetite. The exploitation of natural resources for increased productivity in energy, transportation, mining, forestry and other sectors went on unchecked and unquestioned. It is difficult to recall any significant public opposition to the construction of new nuclear power generation plants, hydroelectric dams and hydrocarbon extraction facilities prior to the late fifties. The process of shedding light on the costs of catering to an excessively consumptive society really began after that. For example, Rachel Carson's book, *Silent Spring*, informed the general public about the stress on the natural environment which resulted from the indiscriminate use of insecticides.

Now, public concerns about the environmental consequences of development continue to grow because:

- Development initiatives are often large in scale and involve technologies which are complex and difficult to comprehend.

- The level of ecological knowledge is very low. Our understanding of inter-relationships among various components of any ecosystem can be described as primitive. Hence, assessing total stress on an ecosystem and designing appropriate mitigative and monitoring measures is rarely possible. This adds to the public's lack of confidence in the EIA process.

- The areas of technical expertise and scientific specialities needed in large scale development proposals are mind boggling. As examples, Tables 1 & 2 contain partial lists of specialized areas of knowledge which may need to be covered in the Grande Baleine and Nuclear Fuel Waste Disposal concept EIA reviews respectively. Discussion of such specific subjects usually does not involve the general public. Moreover, experts often disagree among themselves, which adds more confusion.

- The distribution of benefits and risks associated with development proposals is often uneven. The benefits go to a few outsiders but the risks are borne by the local population.

- Public concerns are magnified through media attention. Perceptions about anticipated negative impacts may be based on fear or lack of availability or understanding of facts.

- There is a long history of adversarial relationship between the proponents and the opponents of such projects as nuclear power generators. Both sides, therefore, strive to get the public on their side in order to enhance their power base.

- There is a growing concern about the fragile nature of planet Earth and the cumulative effects of various activities on the local and global environment. Public discussion regarding environmental impacts of a particular proposal ultimately leads to a discussion of the consequences of the addition of stresses to an already stressed environment.

Additional Issues in Assessing Environmental Impacts of Economic Development Proposals

Economic planners are guided by trends in the global economy and international markets, in addition to other important considerations such as the use of modern technologies for cost efficiency and improved competitiveness. Documentation for large projects is voluminous and complex, containing many assumptions and technical terms, and a great deal of background information. In order to understand fully the nature and scope of the environmental and related social and economic impacts of such proposed projects, the public is required to comprehend all these assumptions and technical terms as well as economic arguments about the attendant costs and benefits.

The extensive use of technical data, modelling techniques and favourable predictions in economic development proposals is only one side of the coin. The other side is societal values, the degree of public acceptance of the proposal, and alternate means of achieving similar socio-economic goals.

There are a number of major obstacles in applying EIA in a fair, credible and efficient fashion. Current EIA processes are still in an early developmental stage. There is still a considerable degree of confusion and lack of understanding of procedural matters on the part of those responsible for applying the process, and on the part of the intervenors and other participants. Additional difficulties include jurisdictional conflicts and ongoing disputes about authority over natural resources among various levels of government, and an abundance of EIA-related processes and regulations as applied by governments and regulatory bodies such as the National Energy Board and the Ontario Municipal Board.

There is also a lack of understanding of the role of various departments and agencies at each level of government in the EIA process. The general public and especially the proponent of a proposal are not fully aware of the exact roles of federal departments such as Health and Welfare, Environment, and Fisheries and Oceans in EIA review processes, particularly those conducted by independent panels and boards. This lack of awareness applies equally to departments and agencies of provincial governments.

There is a lack of baseline information about valued ecosystem components. This serious lack of information exists even though Canada's economy is heavily dependent upon exploitation of its vast natural resources.

Furthermore, the allocation of resources for the development of EIA-related sciences and methodologies is inadequate. There is a lack of adequate public and private sector cooperation for promoting EIA-related sciences and research. Prior to the creation of the Canadian Environmental Assessment Research Council (CEARC), there were few focal points for identifying and promoting EIA-related sciences and research.

There is a definite lack of knowledge about the relationship between changes in the environment and those who inhabit the changed environment.

Although there is a requirement for multidisciplinary participation and institutional support for an effective EIA process, academic institutions, research

institutions and funding agencies have traditionally been developed and operated on different lines.

Public consultation and public participation are considered to be the corner-stone of any EIA process. However, major sources of knowledge and expertise funded by public moneys are controlled by governments and are not generally accessible to the public.

Past experience indicates that most development proposals affect segments of Canada's aboriginal population. Their traditional knowledge of the environment and understanding of valued ecosystem components has been neither systematically documented nor used in EIA's.

Finally, since the ultimate purpose of an EIA process is to protect the integrity of the ecosystems upon which human health and well-being depend, one needs to identify and understand the linkages between human health and the biophysical environment. This area clearly deserves more attention from human health related institutions and professionals.

The Role of Science in Environmental Impact Assessment

It does not take genius to conclude that the global environment is under heavy stress. If the current rate of destruction and depletion of earth's resources goes on unchecked, the very survival of the human race could be threatened. People around the globe have recognized the need to change the old ways of doing things in order to preserve and protect precious environmental capital for our future generations. Environmental assessment is one of the tools available for prudent development planning and for making informed decisions. The effectiveness of EIA as an aid to decision makers depends on numerous factors, the most important of which is the commitment at the political level for passing appropriate legislation and ensuring its effective implementation.

A second factor is the resolve of decision makers in both the public and private sectors to scrutinize all policies, programs and proposals for their environmental implications. The federal and all provincial governments in Canada have performed reasonably well in this area.

Predicting environmental and related social impacts of any proposed action requires the following:

- baseline data about all the valued ecosystems (VEC's) likely to be impacted;
- knowledge of components of an individual VEC as well as mutual interdependency of VEC's;
- understanding of all scientific, technical and socio-economic features of the proposal;
- ability to establish clear linkages among environmental impacts, socioeconomic impacts and human health effects;
- knowledge and understanding of the social conditions, cultural traditions and the aspirations of the people living in the impacted area.

Table 3 contains 8 steps suggested by the World Health Organization for conducting Environmental Health Impacts Assessment (EHIA). It is obvious that if EIA is to serve as an effective planning tool it must contain clear procedural steps and credible scientific and technical components.

EIA-related processes and procedures are now reasonably well developed. Science, however, has yet to find its legitimate place in these processes. This seems ironic since it was sciences and scientific discoveries that initiated EIA in the first place. Some of the reasons are as follows:

- Scientific input into EIA requires the blending and integration of knowledge and data generated by specialists in numerous subjects.

- Disciplines used by the developers such as engineering, economics, and law are well-developed and have accumulated an enormous knowledge base. EIA-related sciences, however, have no such advantages.

- EIA methodologies are largely at primitive stages of development, and resources allocated for such development are woefully inadequate.

- Academic institutions and educational systems have not fully caught up with the need for EIA expertise and experts.

  In fact, the Canadian academic community has so far been unable to provide intellectual leadership in this area. There are numerous reasons for this failure, some of which are beyond the control of this community. University administrators usually follow governments in creating faculties and institutes of environmental studies for developing EIA-related methodologies and manpower.

- An adversarial relationship among the developers and environmental advocacy groups prevents an ongoing exchange of the experience and expertise needed for improving the efficiency and cost effectiveness of EIA procedures.

- There is an acute shortage of baseline data to determine the state of the undisturbed natural environment. This is essential for measuring the significance of predicted impacts.

- Research results and other knowledge generated by institutions funded and controlled by governments are not generally accessible or helpful to the public or the proponent.

- Decision makers are heavily influenced by economic, engineering and other short-term gains rather than scientific evidence.

- Scientific experts often create confusion and uncertainty by disagreeing among themselves or by inflating their claims.

- Scientists have generally been unsuccessful in influencing policy and decision makers.

Conclusions

There is need for:

1. developing clear strategies for directing scientific research and development, especially in the areas related to natural resources;

2. providing long-term funding support to academic and research institutions for conducting EIA-related research and policy analysis for guiding public and private sector development plans;

3. establishing EIA databases for providing objective and integrated sustainable development information to the public;

4. revising governmental policies regarding the use and distribution of scientific information generated by departments responsible for protecting natural resources;

5. greater cooperation and collaboration among the public and private sectors and the academic community for the exchange of EIA-related information and know-how;

6. providing funding and incentives to young Canadians for pursuing careers in environmental sciences and research;

7. establishing EIA centres of excellence and research chairs at major Canadian universities;

8. conferring awards and other forms of recognition for those who have made significant contributions to EIA-related practices, process, sciences and methodologies;

9. promoting the compilation and use of traditional or aboriginal knowledge in EIA;

10. creating greater awareness about the importance of scientific input into decision-making processes for solving problems facing technologically-dominated societies.

Table 1: Partial List of Expertise Which May Be Needed in a Watershed Modification Proposal such as Grande Baleine

1.	**ECOLOGY** • – Boreal Ecology • – Wetland Ecology • – Estuarine Ecology • – Marine Ecology • – Limnology
2.	**BIOLOGY** • – Marine Mammals • – Marine Fish • – Freshwaster Fish • – Fur Bearers • – Ungulates • – Migratory Birds
3.	**WILDLIFE** • – Species, Habitat, Commercial and Cultural Importance
4.	**TERRAIN/LAND USE AND CONDITIONS** • – Permafrost Soils • – Geology • – Mineral/Archeological Resources
5.	**AQUATIC (FRESH)** • – Nature of Watershed(s) • – Hydrological Conditions of Each Watershed/River • – Water Uses • – Seasonal/Climactic Conditions
6.	**AQUATIC (MARINE)** • – James Bay/Hudson Bay Ecology/Limnology • – Fisheries/Marine Resources • – Canada's Commitment/Roles Regarding Laws For Protection of Seas
7.	**WATER QUALITY** • – Heavy Metals • – Monitoring
8.	**FORESTRY RELATED ISSUES**

9.	**ENGINEERING** • – Design/Construction • – Safety • – Infrastructure/Access Roads • – Site Preparations • – Heavy Equipment Movement, Storage and Use
10.	**ECONOMICS** • – Need • – Cost/Benefit Analysis • – Alternatives • – Local Economy
11.	**SOCIAL/CULTURAL** • – History/Heritage • – Anthropology • – Population Movement/Displacement • – Lifestyles/Culture In The Impacted Area
12.	**NATIVE ISSUES** • – Native Fish and Wildlife Harvesting • – Native History • – Nature of Relationship(s) With Governments • – Land Claim Issues • – Native Heritage
13.	**BROADER ISSUES-PROJECT'S POSSIBLE LINKS WITH:** • – Long Term Climatic Changes • – Greenhouse Effect • – Cumulative Impacts

Table 2: Partial List of Discipline Requirements for the Environmental Assessment Review of the Nuclear Fuel Waste Disposal Concept

1.	**ETHICAL AND MORAL ISSUES** • Human Dimension • Environmental Dimension • Philosophical Differences
2.	**HEALTH** • Human • Other Biota • Radiological and Non–Radiological Aspects • Psychological Aspects
3.	**ABORIGINAL ISSUES** • Cultural and Philosophical Differences • Traditional Resource and Land Use
4.	**SOCIAL AND ECONOMIC ISSUES** • Public Participation • Communication • Heritage • Lifestyles and Demography • Cumulative Impacts
5.	**ENGINEERING** • Rock Excavation Techniques • Disposal Vault Stability • Disposal Vault Sealing Techniques • Materials Performance Testing • Materials Corrosion – Chemical, Microbial and Radiological Aspects • Contaminant Migration
6.	**GEOSCIENCE** • Rock Mass Structure • Seismic Risk and Hazard • Groundwater Movement and Groundwater Age • Heat Flow • Contaminant Migration • Geosphere Modelling
7.	**BIOSCIENCE** • Aquatic, Terrestrial and Atmospheric Aspects • Contaminant Pathway Analysis • Bioaccumulation/Bioconcentration • Cumulative Impacts • Biosphere Modelling

8.	**CHEMISTRY** • Geochemistry • Groundwater Chemistry • Radiochemistry • Biochemistry • Atmospheric Chemistry
9.	**RISK AND PERFORMANCE ASSESSMENT** • Risk Criteria and Analysis • Risk Perception and Communication • Quality Assurance and Control • Natural Analogues • Risk and Performance Modelling • Validation • Uncertainties
10.	**OTHER ISSUES** • Transitional Processes, e.g. Earthquakes, Isostatic Rebound, Climate Change – Short and Long Term, Biological Changes, Meteorite Impacts • Long Time Frame (> 10,000 Yrs.) • Alternatives

Table 3: World Health Organization Suggested Procedures for EHIA

STEP 1	Assessment of Primary Impacts on Environmental Parameters	Regular EIA Process
	↓	
STEP 2	Assessment of Secondary or Tertiary Impacts on Environmental Parameters Resulting from the Primary Ones	Regular EIA Process
	↓	
STEP 3	Screening of Impacted Environmental Parameters of Recognized Health Significance (EH Factors)	Epidemiological Knowledge
	↓	
STEP 4	Assessment of Impacts on the Magnitude of Exposed Populations for Each Group of EH Factors	Census, Land–Use Planning
	↓	
STEP 5	Assessment of Impacts on the Magnitude of Risk Groups Included in Each Group of Exposed Population	Census
	↓	
STEP 6	Computation of Health Impacts in Terms of Morbidity and Mortality	Result from Risk Assessment Studies
	↓	
STEP 7	Definition of Acceptable Hazards (or of Significant Health Impacts)	Trade–Off Between Human and Economic Requirements
	↓	
STEP 8	Identification of Efficient Mitigation Measures to Reduce Significant Health Impacts	Abatement of EH Factors, Magnitude Reduction of Exposed Popultions, Protection of Risk Groups

4. Science in Public Policy and Decision Making

Valerius Geist

Abstract

The following observations are based on two decades of experience as an environmental scientist, and as the founding programme director of a graduate-level environmental science programme. I have taken a broader perspective than Environmental Impact Assessment (EIA), as disputes in which environmental science is relevant are also dealt with in courts and public hearings, or are relevant to white papers and policy proclamations issued by governments. I have taken the role of a scientist confronted with documents of this type and have enumerated the flaws and difficulties encountered in them. I conclude that environmental scientists must break with conventional systems of referencing in science and adopt those that are practiced in the humanities and law to avoid fundamental difficulties arising from judicial processes. Appeal to authority should be abandoned in favour of detailed, documented exposition. Also, inadequate scoping is common and arises for several reasons, one being advocacy to push a proponent's "paradigm." Other problems include inadequate scholarship, such as is also encountered in academic studies (faulty literature reviews, mathematics, experimental design, controls, and methodologies), and poor interdisciplinary comprehension and skills. There are also errors of omission and commission, one being an overemphasis on analytical studies, when pilot studies to gain know-how and train man-power are required. There is a paucity of comprehension of design solutions. Environmental studies invariably have regulatory and legal implications and need to be screened for such implications. The high standards demanded by courts of science and scientists have a salutary feedback on the disciplines. Finally, the training of environmental scientists based on an academic mix of undergraduate courses is inadequate to prepare students for the demands extracted from environmental scientists in professional practice.

Introduction

I shall proceed with a critique of science in public policy and decision making from the perspective of a scientist frequently called upon to examine policy documents, draft legislation, Environmental Impact Statements, depositions to courts, judicial or less formal public hearings, investigative reports in police investigations of breeches of environmental legislation, and correspondence pertaining to public policy. For over two decades, I have screened such documents pertaining to wildlife conservation policy and management, disputes over native treaties, industrial and military activity with environmental ramifications, and major planning and engineering designs affecting landscapes.

After listing the weaknesses and strengths discovered, I shall illustrate these with a few case histories, identify the causes of some of the problems, and comment

on several inevitable conclusions drawn from this experience, as well as on the training of environmental scientists.

Common Flaws

1. *Referencing systems*

Reading major documents for scientific content is rarely a pleasure, but there are exceptions, in particular, the meticulous submissions by The Fund for Animals in several court cases. The strengths of these interventions resided not only in meticulous research, but also in the abandonment of scientific referencing in favour of a classical footnote format. Scientific referencing, for example "(Joe Blow, 1987)," is an imposition on the reader, which we accept in research, where time is not of the essence. However, a judge cannot be expected to wait weeks for a library search to be completed. It is up to the intervenor to present the supporting evidence to the judge in an accessible fashion, and the footnote system of classical scholarship, which includes extensive quotations from reference texts (unless they are in the body of the document) is infinitely superior to the referencing system scientists normally use. The latter encourages bad habits of inadequate scholarly research. An example of how the classical system of referencing works in science is given by Roe's (1971) book on the North American buffalo, which I highly recommend.

An exception is the excellent Lanka et al. (1990) report, a submission to court, prepared as a conventional science report. However, it contains a large, detailed set of appendixes which support the conclusions presented.

2. *Presumptuousness*

Closely allied to poor referencing is the presumption that the conclusions drawn by a scientist are not only correct, but supported beyond dispute—and the reader better adopt the verdict. In part, this impression arises even where unfounded because scientists present matters referenced so as to be essentially inaccessible, at least in the short term. Supporting evidence may be inaccessible in the long term as well due to scientific jargon, argot or quantitative formulations mysterious to the uninitiated. In short, a text may seem presumptuous because little care has been taken to make the evidence explicit. Such writing can be—and in critical cases should be—dismissed.

Occasionally, the writing is truly presumptuous, in which case technically inadequate matter is presented as the pinnacle of current scientific thought. Intellectually undigested or obsolete theories and deductions from them may be involved. One of the worst examples of such presumptuousness is found in statements by the California Fish and Game Department in court submissions pertaining to a challenge of bear hunting, and in EIA's pertaining to deer management. Bad science, haughtily presented, is offensive to the technically versed, including well educated, astute laymen who have become acquainted with a subject matter and have mastered it. Such laymen can ask pertinent questions that not only embarrass experts, but destroy their credibility.

Veterinary medicine extended to wildlife, and therefore entering the unfamiliar arenas of wildlife ecology and ethology, contains examples of professional misjudgments publicly proclaimed. A current example is Agriculture Canada's

policy of guaranteeing the health of wildlife species ranched commercially. In fact, not only peer reviewed literature, but also expert witness submissions in court (i.e The Lanka report, 1990, and trial transcripts in the John Dorrance III cases in Wyoming in 1991), which are publicly exposed to hostile cross examination, have made the point that one cannot prevent the transmission of many diseases borne by wildlife, for technical reasons. The regulatory failures of Agriculture Canada in the repeated outbreaks of bovine tuberculosis in Canada on deer ranches east and west, have proven Lanka et al. (1990) and earlier critics (Holmes 1982; Tessaro 1986; Samuel 1987; Geist 1988) correct. Unfortunately, the belief by some Agriculture Canada policy makers that wildlife is "just livestock," ludicrous as it is in practice, has taken hold firmly and evidence to the contrary is simply ignored. I shall dwell on failures of this type, paradigm failures, later.

3. *Inadequate scoping*

Inadequate scoping may occur when scientific evidence is selectively applied to promote a particular viewpoint favorable to the proponent. This is *advocacy*, not science, as it violates the tenets of impartiality in scholarship basic to science. There is a narrow line between regrettable advocacy and unconscionable fraud.

The most blatant types of advocacy are attempts by one party to intimidate the other with libel threats; attempting to persuade editors of academic journals not to publish the opposite point of view; preventing the release to the public of documents containing a critique of the scientific inadequacy of advocacy positions; and maligning and blackmailing scientific critics. In all such cases, in my experience, the advocacy position does not have scientific or scholarly merit, and these behaviours are signs that the offending paradigm will be pursued at the political level.

Inadequate scoping may also arise out of failure of scientists to have acquainted themselves with history, and therefore accepting as novel and promising ideas that have failed in the past. An example of this failure is an ahistoric approach to wildlife management, which has led in part to current problems. In particular, there is a lack of comprehension of market forces and their consequence to management of public resources. Current problems, such as the struggle over control of wildlife between public and private entrepreneurs, have arisen in the past as well, (Geist 1988), and history is ready to teach penetrating lessons—provided it is given a chance. However, there is little evidence that this is happening. Science is normally taught as a platonic abstract.

Inadequate scoping may also be due to the neglect of areas not normally considered within the scope of science, for instance, customs of native people. Feit (1987) has shown in an anthropological classic how similar are the practices of wildlife management by Labrador Cree and classical wildlife management. Also, an analysis of root policies of North American wildlife management (Geist 1988), and those of a native culture in Feit's (1987) account, shows striking similarities. So do current practices by natives where they are able to exert real control over wildlife management in Canada (Dueck 1990).

4. *Flawed technical background*

There are inadequacies of a more innocent nature traceable to various factors. One of these is inadequate familiarity with technical matters. This may be due to:

- failing to do comprehensive literature searches of a field,
- failure to research *original* references due to undue reliance on second hand referencing or trust in literature reviews,
- deliberate avoidance of historical literature on the mistaken assumption that recentness of publication date is synonymous with quality of publication,
- intrusion into well-developed disciplines by the author, without proper comprehension, which can lead to amateurish mistakes,
- blockages attributable to inadequate understanding of foreign languages, mathematics included,
- misapplication of statistics and inadequate experimental design,
- lack of or inadequate controls in experimental work.

These ills, of course, are also found in academic literature, where, however, they may not have dire consequences. While interdisciplinarity is essential to the solution of environmental problems, it does increase the risk of errors. This has to be accepted as inevitable and corrections need to be applied quickly and without acrimony when discovered.

5. *Mathematics misapplied*

Mathematics ought to be considered as a language, to be studied before one applies it to real-world problems. The application of quantitative methods in science requires much more consideration than a "cookbook" approach, no matter how complex the statistical machinery applied. The complexity of a statistical approach does not guarantee its correctness of application to a given problem - "garbage in is garbage out."

For example, inappropriate pooling of variances came to light in ethological studies when it was shown that entering multiple samples derived from individuals into one common data pool greatly underestimated the true variance. It gave statistically significant results at low sampling frequency due to an underestimate of variability. In taxonomy, comparative morphometrics, long sanctioned by uncritical use, also pools unrelated variances and thereby confounds genetic, epistatic, environmental and true statistical variances (Geist 1991a, b). In these cases, inappropriate quantification creates "misplaced concreteness," because no taxonomic conclusions can be drawn from comparative morphometrics. Unfortunately, taxonomy is today a vital legal element in conservation legislation and subject to court actions, as well as regulatory hearings (Geist, 1992).

6. *Experimental design and controls*

A common problem with original EIA research is the lack of sound experimental design and the use of inadequate controls. As this is not an uncommon malaise even in avant garde basic research (Duesberg 1991), it should not come as a surprise that it surfaces in EIA's. The necessity of involving a statistician, right at the beginning of any experimental treatment, is not well appreciated. Sometimes, of course, one must sample what one gets by good fortune. In such cases a disclaimer is needed to warn the reader. Such data may be still very convincing and needs to be reported, but the onus is on the original author to clearly state the limitations of the data.

7. *Non-repeatable studies*

The methodological section of reports and studies bears careful reading and assessment to determine whether the experiments described can be repeated. Not uncommonly, the methodology is inadequately described and there is no hope of repeating the study.

8. *Sins of omission and commission: pilot projects, not base–line studies*

The foregoing has dealt entirely with flaws in science in the narrow sense. That is, it has looked at the quality of science applied. There is also the question of omissions to do science when its use is appropriate, as well as the inclusion of irrelevant studies. When reading submissions to environmental hearing panels, one may stumble upon instances in which the proponent failed to do work, but where prudence dictates that investigations should have been done.

Conversely, an EIA may be loaded with irrelevant studies, which take up time, but in no sense contribute to a resolution of the problems at hand. There may be extensive descriptive studies which fail to help resolve the issues. These may masquerade as "base line studies" without being such in practice. For example, in some instances of strip mining, no landscape rehabilitation can possibly return the landscape to the original condition, forcing a search for acceptable alternatives. Strip mines for coal in the foothills of Alberta can be restructured, for instance, with the tall walls left in place as prime bighorn sheep habitat (MacCallum 1988). The original ecological state prior to mining is irrelevant to the new end-state. Thus, descriptive studies are not helpful in this case.

Irrelevance is a costly waste of resources. In the instances familiar to me, amateurish work by consultants could be traced to inadequate familiarity with the field at hand.

One problem of irrelevance is putting studies in place of pilot projects that aim at developing operational solutions and the training of the necessary manpower. For instance, one may need pilot studies in order to successfully return landscapes to productivity after massive surface disturbance. Research on pre-disturbance ecological conditions will deal with ecological conditions that can no longer exist and may have little relevance. It is crucial to know when to stop analyzing, and get on with hands-on experimental work that exposes weaknesses in theory, planning, management, design and implementation, and can lead to solutions prior to full-fledged implementation of mitigative measures.

9. *Paucity of design*

A common thrust in mitigation is the aim to rehabilitate areas to the original ecological condition. This is, given the current training of ecologists, no surprise. It is, however, a handicap to thinking about alternatives, in particular, developing *design interventions*. The fencing of the Trans-Canada highway in Banff National Park, for instance, was opposed by skeptical ecologists. The suggestion to fence arose from the high kill of large mammals by traffic on the highway. A fence could reduce the number of animals killed, but it would also disrupt movements within the park. The appropriate solution was to include underpasses and overpasses that were designed to allow the skittish cervids to pass in safely and with a minimum of fright. The fence had thus to be designed to meet the security requirements of these ungulates. A presentation to this end was made to the hearing panel by a class of graduate students from the Faculty Environmental Design taking a course in wildlife management. As fate would have it, two students from this class were able to put the designs into practice. It has worked well for the cervids, but the fence became a trap for mountain sheep when coyotes learned to corner them against the wire mesh.

My point here is that EIA's, written by scientists, may be unduly neglectful of *design solutions*.

10. *Legal and regulatory inadequacies*

Environmental interventions are, in essence, regulation driven. Consequently, competent environmental science must fulfill not only the spirit of science, but also the spirit, as well as the letter, of environmental laws and regulations. However, there may also be legal implications to studies, depending on how the subject matter is presented, particularly if the scientific findings may be used to allocate blame. I mentioned the matter of taxonomy, where the formal labeling of taxa has profound consequences on the welfare of the biota cited (O'Brian and Mayr 1991; Geist 1992). There are not only conservation implications to formal labeling, but it also structures the legal avenues open to private citizens in dealing with wildlife. There may also be formal treaty and law-enforcement implications. An environmental scientist should not be oblivious to these.

There may be legal opportunities or traps buried in environmental science studies. Consequently, screening reports with experienced environmental lawyers, can be revealing and a most positive learning experience.

11. *Feed-back on science*

Science in the public domain, particularly if it becomes subject to public hearings and hostile cross examination before courts, leads to a detailed scrutiny of the disciplines involved. This process does reveal bad science and leads to corrections (Geist 1991a, b).

On Training Environmental Scientists

Environmental science rigorously developed in the spirit of classical scholarship, and judiciously structured so as to be understood by decision makers, can be a powerful tool. How does one train practitioners for this task?

I do not intend to develop this complex subject in detail, but want to point out some relevant points overlooked all too frequently in structuring curricula in environmental studies, particularly at the undergraduate level.

What are the individuals expected to do when they graduate?

They are expected not only to be well versed in a given science, but also to know the regulatory climate; have tangible skills to offer that make their science useful; interact productively with other disciplines by virtue of understanding modes of operation other than those practiced in science, and of group processes as well as professional conduct and responsibility; and they are expected to have some acquaintance with business practices.

These are demanding expectations. They cannot be fulfilled by shuffling undergraduate courses into an "environmental studies major", taught by academics without practical experience, nor by revamping, for instance, existing engineering curricula. It requires a much bolder approach, one that should be pursued only by an independent body of scholars with specific professional and academic goals of their own, and an independent system of career evaluation. Even such a unit, formally recognized, with its own budget, with its own dean on equal footing with others, might not survive the institutional conflicts within a university setting, but it has at least a fighting chance.

To prepare Canada for the decades ahead there will be a need for many more such units than are now in place.

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Summary of Workshop Discussion

In the afternoon, those attending the workshop were divided into two groups, each of which was asked to discuss three items: current problems encountered in EIA; suggestions for a research agenda; and practical proposals.

The groups had no difficulty in articulating problems with the role of science in EIA. Participants examined not only the problems of quantity and quality, but went on to discuss the need for cumulative impact analysis, and the development of site specific regulations, and to challenge the traditional view of science. They asked whether science and scientists can really be objective or value free with respect to all competing interests in society. Would that even be a good thing? When estimates must be made, for example, how do scientists determine whether to err on the side of safety, or on the side of economic or other perceived benefits? Who are the experts? Is anecdotal evidence about local conditions to be discounted in favour of rigourous demonstrable conclusions which may not take account of local conditions?

Questions were raised about whether science is producing the kind of knowledge we need to create and sustain an ecologically responsible society. The problem here is not that there is too much or too little science, or that it is poorly done (although those criticisms were sometimes made as well). Rather, the last half of the twentieth century is marked by an exceptional fusion of industrial development and scientific expertise. This has cemented a way of viewing the world according to principles of efficiency, progress, accelerated pace, and instrumental rationality, which together are sometimes called the *scientific* or *technical worldview*. The worry expressed by some workshop participants was that scientific knowledge has run over other forms of knowledge to such an extent that we are blinded simultaneously to the weaknesses of scientific knowledge and to the strengths of other forms of knowledge about the way the world works. In the case of EIA, scientific knowledge too often displaces common sense and community based wisdom. It eliminates the possibility of aboriginal knowledge playing a decisive role in hearing processes, or attempts to subject such knowledge to scientific validation. In taking on such a powerful role, bolstered by the authority of experts, science becomes the dominant discourse of the EIA process. Participants talked about how the EIA process would operate if we took people's experience and local knowledge more seriously.

Another worry was that EIA processes do not include mechanisms for post-assessment monitoring. There is no commitment or mechanism for following up on promises and predictions made during EIAs. The suggestion was made that research be done to determine which EIAs have been most successful in that what was predicted actually did come to pass, so that it could be determined what EIA processes are most effective.

A good deal of discussion centered on the role of universities to train environmental scientists who could meet the challenges posed by environmental impact assessment. Science faculties typically produce specialists, whereas what is needed is people with broader, inter-disciplinary training. One suggestion was that universities set up projects and include in their curricula questions about global effects of our current practices, such as climate change, soil erosion, and extinction of species. Another suggestion was that government and industry set up internship programs with universities in the

area of environmental impact assessment. Finally, since ecosystem research is expensive, and more money is not likely to be forthcoming in the near future, it will be important for scientists to learn to communicate to the public in a two-way fashion—to communicate the results of their research in an intelligible way, and to learn from local people what they have learned about the natural attributes of their region.

About the Workshop Presenters

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