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AN ECOLOGICAL FRAMEWORK FOR ENVIRONMENTAL IMPACT ASSESSMENT IN CANADA

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hope to use the project results in evaluating their impact assessment procedures. It is evident, for example, that substantial changes are required in assessment guidelines if major difficulties are to be resolved.

(d) The content of this report is expected to provide some direction for governments and industrial proponents in planning long-term co-operative programmes of environmental research and monitoring.

(e) The results of the project may be incorporated into environmental impact assessment courses given at various universities and community colleges across the country. Requests have already been received for specific material and information, and the demand is expected to increase.

(f) The report should be of value to various public interest groups which take an active role in the environmental assessment process.

Obviously, not all of these potential user groups will have equal interest in all aspects of the project. However, the report has been designed and written to be of use to a broad audience through a balance between technical details and implications for environmental assessment in a broader perspective. While the general text contains material of interest to the full range of target audiences, we have directed specific recommendations to those groups that we believe should bear the major responsibility for implementing them.

DEFINITIONS OF TERMS

Numerous common and technical terms are used within the report in very specific contexts. In this section we define several of these terms in order to clarify their use in this report.

Environmental Impact Assessment (EIA)

This term is used synonymously with *environmental assessment* and *impact assessment*, and it refers to a process or set of activities designed to contribute pertinent environmental information to project or programme decision-making. In doing so it attempts to predict or measure the environmental effects of specific human activities or do both, and to investigate and propose means of ameliorating those effects.

Environment

The term *environment*, in the context of the environmental impact assessment, has come to include the social and economic milieu of development proposals as well as the natural (biophysical) environment. This report recognizes the importance of all three elements, but deals only with matters of environmental assessment that pertain to the natural environment.

Ecological Principles and Concepts

Ecological principles and *ecological concepts* refer to basic truths, theories, or working hypotheses about the relationships of organisms or groups of organisms with their environment. In the report, principle is used in the positive sense, concerned with scientific concepts, rather than in the normative sense which is concerned with moral or ethical value judgements (Norton and Walker, 1982). Such positive principles or ecological concepts may range from general statements that are basic to the science of ecology, to detailed principles as developed within specialized scientific disciplines. We refer the reader to a recent paper by Walker and Norton (1982) for a preliminary set of some 30 positive ecological principles that are of use in designing and conducting environmental impact studies.

Ecological Approach vs Ecosystem Approach

An *ecological approach* to environmental impact assessment is one that makes optimal use of ecological principles and concepts in the design and conduct of assessment studies and in the prediction of impacts. An *ecosystem approach* to impact assessment is one in which impact studies and predictions concentrate on phenomena and variables at the community and ecosystems levels. In advocating the former, this report simultaneously endorses a systems approach to environmental assessment, and recognizes the critical importance of ecosystem theory and principles in adopting an ecological approach. We caution against the exclusive use of an ecosystem approach as defined above on the grounds that environmental impact assessment will likely achieve its greatest influence on project or programme decisions through information about species populations for which there is public or professional concern or both.

Social Scoping vs Ecological Scoping

Social scoping refers to a very early activity in an impact assessment in which an attempt is made to identify the attributes or components of the environment for which there is public or professional concern, or both, and to which the assessment should primarily be addressed. On the other hand, *ecological scoping* is defined as an exploration of the possibilities for studying and predicting the effects of a planned action on the attributes or components so defined. Thus, social scoping establishes the terms in which impacts should be expressed, and ecological scoping establishes the terms under which the impacts can be studied and predicted.

Valued Ecosystem Components

Each of the environmental attributes or components identified as a result of a social scoping exercise is referred to as a *valued ecosystem component*. These may be determined on the basis of perceived public concerns related to social, cultural, economic or aesthetic values. They may also reflect the scientific concerns of the professional community as expressed through the social scoping procedures (i.e., public hearings, questionnaires, interviews, workshops, media reports, etc.).

Study Tactics and Study Strategies

We have borrowed two terms from military usage, as suggested by Bella and Overton (1972), for describing levels of study organization in environmental assessment. A *study strategy* is considered an overall plan used to co-ordinate various individual activities and sources of knowledge in seeking answers (e.g., predictions or hypothesis tests) concerning specific effects on valued ecosystem components. A *study tactic* represents a component study within the strategy which contributes specific, partial knowledge toward the answer sought. Examples include distribution and abundance surveys, laboratory experiments and simulation modelling exercises.

Ecological Characterization

"An *ecological charaterization* is a description of the important components and processes comprising an ecosystem and an understanding of their functional relationships", (Hirsch, 1980; emphasis added). Such a characterization should include information on the biotic resources important to man (including important features of their habitat) and key biotic processes (e.g., climate, and transport mechanisms). An ecological characterization is an early step in an environmental assessment, and it depends primarily on information from reconnaissance surveys and the published material, co-ordinated by a conceptual modelling exercise.

Baseline

We use the term *baseline* to mean a description of conditions existing before development against which subsequent changes can be detected through monitoring, (after Hirsch, 1980). To fulfill this role, baselines normally must consist of statistically adequate descriptions of the variability inherent in the valued ecosystem components prior to the onset of the planned action. As such, the baseline study itself is not a predictive tool, although it does describe the condition from which a valued ecosystem component is predicted to change.

Prediction

Combining definitions from a few common dictionaries, we define *prediction* as an assertion based on calculation, knowledge, or shrewd inference from facts or experience, in advance of proof. The term *forecast* can be used synonymously, although it often implies on assertion based on transparent conjecture, that is, its basis in opinion is publically disclosed. We have not differentiated between a prediction and a forecast in this report. In the context of environmental impact assessment, we submit that a prediction or forecast is incomplete without an explanation of the basis upon which it was made.

Monitoring

Monitoring simply means repetitive measurement. In the general context of environmental impact assessment, it usually refers to the measurement of environmental variables after a development proposal has been initiated (the baseline constituting such measurement before project initiation). In the specific context of ecological investigations within impact assessment (i.e., the context of this report), our use of the term monitoring refers to repetitive measurement of specific ecological phenomena to document change primarily for the purposes of (i) testing impact hypotheses and predictions and (ii) testing mitigative measures.

Conceptual Modelling and Quantitative Modelling

We use the term *conceptual modelling* to refer to an organized exercise of: (i) identifying the relevant system components, (ii) qualitatively identifying the system structure, and (iii) developing a flow diagram of the system. The main purpose for the conceptual model is to explicitly organize the preliminary understanding of ecological structure and function (i.e., components and processes).

On the other hand, *quantitative modelling* is used to refer to the construction and use of mathematical representations of ecological phenomena and relationships. As such, it may involve statistical analyses, simulation modelling, and several other forms of mathematical manipulation of data.

We emphasize that conceptual modelling and quantitative modelling are not mutually exclusive; in fact, they are often fused into a modelling exercise that progresses from the former into the latter (e.g., Holling, 1978). However, conceptual modelling usually connotes an earlier, qualitative effort at systems understanding, whereas quantitative modelling connotes a later, more detailed numerical exercise.

Indicator of Change

The term *indicator* is used to denote either (i) a biophysical component or variable which is monitored to detect change in that component or variable or (ii) a calculated index of the condition of all or part of an ecosystem. Such indicators are considered to be generally unrelated to the valued ecosystem components identified for the assessment. Biophysical components or variables that are related to, and used to indicate the condition of, the valued ecosystem components have been termed *surrogates*.

There are, however, some underlying themes which appear to be fundamental to a consideration of ecological significance. First, it may be argued that ecosystems have no intrinsic value; they are ascribed a value in the context of the extent to which they are used or required by man. Admittedly, this may be an overly restrictive view of ecological significance. Yet, the conservation ethic expressed by the general public in the environmental impact assessment process can most often be traced to a concern for the continued welfare or survival of people.

The second major theme relates ecological significance to the irretrievable loss of ecosystem components within specified time and space boundaries. Examples of this, in increasing biological importance, include the loss of a population, a reduction in genetic variability (gene pool), or the loss of a species. As Cooper and Zedler (1980) noted, the destruction of a population can result in the loss of genetic material that may have great survival value for the species, or that may have great value in plant or animal breeding and improvement. Time and space limitations must be imposed to separate anthropogenic losses from normal evolutionary processes. Embodied in this theme is the notion of stewardship of nature which philosophically may be contradictory to the theme that ecosystems have no intrinsic value.

Unlike the loss of a gene pool or a species, which is absolute, the significance of the loss of a particular population must be qualified according to certain time limitations. Such limitations (recovery times) are seldom discussed in any detail in environmental impact studies. The literature notes our limited understanding of compensatory responses of populations under stress, even of commercial fish species which have been extensively studied and managed for some time (Buffington *et al.*, 1980). Indeed, the population focus for environmental impact assessment may be the result of biologists transferring concepts of population dynamics and maximum sustained yield from fisheries and wildlife management (Sharma, 1976). On the other hand, it may be a reflection of the general level of public awareness and interest in certain species, the so-called "representative and important species" (Christensen *et al.*, 1976).

The loss of a population or species may imply an irreversible change in the structure of an ecosystem; however, as pointed out by Buffington and others (1980), "It is not certain how many species can be lost, nor how their role can be replaced by species already in the community picking up the function, without risking collapse of a community." This idea of the functional integrity of an ecosystem was raised by a number of workshop participants as another interpretation of an ecologically significant impact. However, the concept of function often implies the organization of species at the more complex community and ecosystem levels and, not surprisingly, discussions relating impact significance to changes in ecosystem functioning were often couched in generalities such as a disruption of the food chain, a simplification of complex systems or changes in assimilative capacity.

There was some general support for the idea that impacts which result in irreversible reductions in primary productivity (the concentration of energy through the production of organic material) should be considered as potentially significant since it represents an erosion of one of the primary life support systems for species at higher trophic levels. Some of the literature on the biological significance of impacts (e.g., Longley, 1979) also reflects this focus on reduction in primary productivity. Unfortunately, neither the literature nor the workshop participants provided any guidance on how rigorously this definition should be applied; for example, is *any* reduction in primary productivity to be considered as significant? Certainly in marine and aquatic systems primary productivity is related to phytoplankton blooms which are so variable under natural conditions that only gross man-induced changes can be detected (Anonymous, 1975). It seems clear, however, that a reduction in primary productivity is one area in which the effects of incremental losses are to be guarded against, especially as they may affect the functioning of aquatic ecosystems.

"All or any impact that tends to reduce production of a desirable species is serious."

"If you accept first of all that a decrease in primary productivity is a significant negative impact, then I think that it strengthens your case."

"I consider a significant negative impact one which irreversibly destroys an ecosystem, or destroys it beyond its ability to self-correct."

"There are three issues involved when considering the capability to evolve in impact significance. One is the immediate survival of the population. The second one is the persistence of vigour and evolutionary adaptation of a population in the face of a changing environment; in other words, the adaptability already within the population. The third one is the continued creation of evolutionary novelty."

SOCIAL IMPORTANCE

Any consideration of the significance of environmental effects must acknowledge that environmental impact assessment is inherently an anthropocentric concept. It is centred on the effects of human activities and ultimately involves a value judgement by society of the significance or importance of these effects. Such judgements, often based on social and economic criteria, reflect the political reality of impact assessment in which significance is translated into public acceptability and desirability. Some authors (e.g., Andrews, 1973; and Buffington *et al.*, 1980) preferred to separate the concept of significance of impacts from public acceptability, while others such as Longley (1979) and Cooper and Zedler (1980) equated the two. In the words of Longley (1979), "Significance is a determination that links estimations of magnitude made by impact assessment analysts with environmental policies."

In this context, the ecological implications of a proposed development usually get translated into effects on physical and biotic resources valued by man for commercial, recreational or aesthetic purposes. From the perspective of an ecologist, more profound changes to the intrinsic structure