Environment Canada | Environnement Canada

Planning and Finance Service
Occasional Paper No. 4

The Development and Practice of Environmental Impact Assessment Concepts in Canada

P.J.B. Duffy

THE DEVELOPMENT AND PRACTICE OF ENVIRONMENTAL IMPACT ASSESSMENT CONCEPTS IN CANADA

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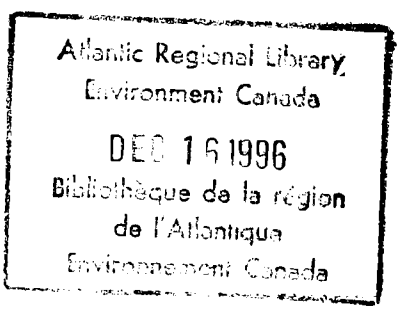
by P.J.B. Duffy

Résumé en français



Environment Canada
Planning and Finance Service
Occasional Paper No. 4
Ottawa, 1975

Issued under the authority of the
Honourable Jeanne Sauvé
Minister, Environment Canada

Information Canada
Cat. No. En-515/4-1975
Ottawa, 1975

Code No. 500-KA305-4-5011-3·75
Contract No. OKT4-2206
Kromar Printing (1969) Ltd.

ABSTRACT

This paper reviews the subject of environmental impact assessment with emphasis on the definition of environmental impact, on the description of the state of the art of environmental impact assessments, and on the description of several relevant Canadian studies.

The Canadian development of concepts of environmental impact assessment is traced to distinguish it from the evolution of similar developments in the United States. Concepts and methods of assessment are described with emphasis on those which have proven to be practicable. Several Canadian environmental impact studies are referred to in the hope that the published reports will find wider use by Canadian readers.

The methodology of environmental impact assessment is still in its infancy in spite of accelerated activity both in research and in practice. There is a need for more practical methods, particularly those which permit related impacts to be correlated or integrated for the purposes of accurate description of effects in quantitative terms.

RÉSUMÉ

L'exposé porte sur les évaluations environnementales, en particulier sur la définition de l'effet environnemental, et rend compte de l'état des connaissances dans ce domaine ainsi que de plusieurs études canadiennes pertinentes.

On y fait l'historique du développement des concepts sur l'évaluation environnementale au Canada afin de le distinguer d'une évolution analogue aux États-Unis. Il y a une description des notions et méthodes d'évaluation, surtout de celles dont l'efficacité a été établie. On mentionne plusieurs études canadiennes sur l'évaluation environnementale dans l'espoir que les rapports déjà publiés seront lus davantage par les Canadiens.

La méthodologie de l'évaluation environnementale en est encore à ses débuts et ce, en dépit d'une activité accélérée tant du côté de la recherche que de l'application. On a besoin de méthodes plus pratiques, surtout de celles qui permettent de faire correspondre ou d'intégrer des répercussions connexes afin d'obtenir une description quantitative précise des effets.

CONTENTS

ACKNOWLEDGEMENTS

Several scientists and administrators have contributed over the past few years to the development of Canadian environmental impact assessment concepts and procedures. They served with government agencies, universities and consulting firms. Although these workers are too numerous to mention here, the author wishes to acknowledge their contribution to the subject through their papers, seminar presentations and personal communications. The development of the Canadian approach to environmental impact assessment is a product of their efforts. While the author assumes responsibility for this paper, he does not claim originality for the concepts and procedures described.

P.J.B. Duffy*

Introduction

The purpose of this paper is to review the subject of environmental impact assessment with emphasis on the definition of environmental impact, to describe the state of the art of environmental impact assessment, and to describe several Canadian studies which are either under way or have been completed.

What is the Problem?

Recently there has been a growing recognition that the resources of the earth are limited and that careful management of them is vital. With the increased tempo of development, the quality of the environment is prone to degradation because of a lack of foresight in planning. The empirical relationships between economic growth and environmental quality are becoming clearer. The exploitation of resources has resulted in the disturbance of natural ecosystems and the disruption of physical and biological processes which are essential to the maintenance of ecosystems. At present there is a demand by the world-wide public for improved husbandry of resources and of the environment, based on a more complete understanding of the natural systems which support them. MacNeill (15) states "In the near future effective environmental management strategies will have to reconcile economic growth with a progressively improving level of environmental quality".

Many development projects and activities have not been well planned and have had harmful effects on the environment. If environmental assessments were conducted at all, it was after the project was completed. It is now clear that the potential environmental effects of an undertaking need to be taken into account in initial concept planning, project design, and in the construction and operation of the development projects and activities. Assessment is needed to determine whether the activity should proceed as planned (feasibility), and also to serve the planning process after a decision has been made to proceed (planning and design). *The problem is to insure that the environmental consequences of projects and activities are taken into account early in the planning stages.*

Environmental factors need to be considered together with economic, social and political ones in such undertakings. A systematic approach is necessary in order to prepare an adequate description of environmental effects. This has not been well done in the past.

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One central activity in the development of effective environmental management is that of environmental impact assessment. This activity has to do with identifying, studying and assessing the environmental effects of human actions (policies, programs, projects and operations) with potential to have a significant effect on the environment. There is a need to have environmental management and design include provision for the prediction of the positive and negative effects of major undertakings and, at the same time, to ensure that the design or planning of such undertakings takes into account the mitigation or elimination of the harmful effects.

The subject of environmental impact assessment is developing rapidly because of the recognition of the importance of environmental quality and because many scientific and other disciplines have been stimulated to learn more about natural systems and of predicting the consequences of human actions.

What have been the Recent Developments?

The present concern for environmental quality in Canada seemed to have its start in the late 1950's during a time when developments in the United States were centered on the Wilderness Bill controversy. The Canadian public was becoming better informed on environmental and conservation matters and interventions began to appear in the 1960's, particularly on large projects. Examples are the lobby to defeat a proposal to stage the 1972 Winter Olympic Games in Banff National Park (1966), the Quetico Park and Algonquin Park controversies (1970), the Spadina Expressway development in Metropolitan Toronto (1971), and the decision on Village Lake Louise (1972). This increase in public concern coupled with the creation of the program of environmental impact assessment under the National Environmental Policy Act (NEPA) in the United States created pressure for a similar assessment program in Canada.

The experience in the United States has been closely watched in Canada and has influenced Canadian preparations to deal with the problem. An increasing number of major Canadian projects have been examined for environmental effects. These studies have been aimed at improving the overall design to minimize undesirable effects, and, in some cases, to establish whether or not a project should proceed. Studies aimed at the mitigation of undesirable effects have been undertaken for the Mackenzie Valley Pipeline Corridor, the James Bay Hydro Project, the Come-by-Chance Port Facility, and the Lorneville Industrial Complex. Studies have been made to assist in the decision of whether or not to proceed with the Village Lake Louise Development Studies and the Squamish Coal Port Facility (British Columbia).

At the present time almost all major Canadian physical projects are coming under some form of scrutiny to determine environmental effects. Provincial legislation in Quebec (Environment Quality Act, 1972) and in Alberta (Land Reclamation and Rehabilitation Act, 1973) provides for environmental assessments to be undertaken. A federal program requires environmental impact assessments for major federal actions with potential to affect the environment (House of Commons Debates, March 14, 1974). These provincial and federal governmental decisions are presently being implemented.

Even though the environmental consequences of most Canadian projects are being examined, the procedures that are being employed are highly variable. More consistent methods are required to ensure that all environmental effects are adequately described together with alternatives to the proposed project or action.

A suggested procedure for federal government projects calls for all proposals to be examined at the preliminary stage of planning prior to taking the decision whether or not to proceed. If necessary, the project may again be the subject of a detailed assessment at the time of project design, pending overall approval.

Even though environmental impact assessments are being made for major development projects and physical works, there is not yet evidence that the same type of studies are being made for new legislation, policy proposals, and operational plans. At present the Canadian procedures are mainly for major physical projects. There is, however, the recognition that it would be desirable to scrutinize all major actions for their potential environmental effects.

What is Environmental Impact?

The construction and operation of an international airport (an activity) may cause an increased noise level (an effect) which may interrupt the sleep of nearby residents or may interrupt the feeding and nesting habits of migratory birds by destroying scarce habitat to which some species are restricted (an impact). Thus environmental impact can be viewed as part of a cause-effect relationship. From an analytical view-point environmental impact may be seen as the difference between the condition of the environment as it would exist *with* a proposed project and condition that would exist *without* the proposed action. The baseline condition is that which is *without* the proposed action and is not necessarily the present condition. Other actions or activities may cause the baseline condition to be significantly altered (positively or negatively) from the present condition.

Environmental impact has been defined as the "sum of short- and long-term effects of any action (or failure to act) by man on the physical, biological, and socio-economic environments, including the effects of policies, legislative proposals, programs, projects, and operational practices". In the United States, attention is paid to "significant adverse effects on the quality of the human environment including both those that directly affect human beings and those that indirectly affect human beings through adverse effects on the environment".(6)

The examination of environmental impact can be undertaken in the following sequence:

1. The *identification* of the impact (e.g. noise from a highway in an urban area).
2. The *measurement* of the impact (e.g. noise levels) and its effect (e.g. population affected by noise) including its effect when taken in conjunction with other impacts.
3. The *evaluation* of the impact in terms which permit it to be compared with and aggregated with other impacts. This is useful in deciding how important the impact is to the decision-maker.

The subject of environmental impact assessment is undergoing refinement as a result of discussion and debate, particularly on the question of what environmental impact includes and what it excludes. A description of environmental impact should cover all obvious and hidden factors, both negative and positive.

Descriptions of environmental impacts are required for an *environmental impact assessment*, the results of which are given in an *environmental impact statement*. At present the contents of these statements vary greatly in Canada because the guidelines for their preparation are not yet consistent between the provincial and federal government agencies which require them. In the United States the statement, as required under the National Environmental Policy Act of 1969 (Section 102, 2 [C]), has specific subject requirements (6).

"All agencies of the Federal Government shall include in every recommendation or report on proposals for legislation or other major Federal actions significantly affecting the human environment, a detailed statement on:

(i) the environmental impact of the proposed action,
(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
(iii) alternatives to the proposed action,
(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."

(The National Environmental Policy Action of 1969, Public Law 91-190. January 1, 1970. [42 United States Code 4321-4327]. For text see: *Council on Environmental Quality, Third Annual Report, 1972, pp. 352-357).*

Environmental impact assessment is a predictive activity. Some impacts are essentially conjectural, some are partially predictable, and some are almost totally predictable. At the present time there is a need for more objective methods which permit the identification and measurement of all relevant environmental impacts. The importance which is attached to impacts also needs more attention. Ultimately it will be important to understand how to integrate the impacts of an action into an expression which describes the sum of the effects. The methods which are available now fall short of these properties, particularly that of the integration of impacts.

Environmental Impact Assessment Methodology - the State of Art

In recent years there has been an acceleration in efforts to develop adequate methods to assess environmental impacts of different kinds. A number of methods have evolved with specific orientations. For instance, large water resource projects and transportation facilities have come under close study, as have proposals for siting industrial and electric power installations. At present the methodology is project-oriented rather than being applicable to policies, programs and management practices. The environmental effects of such practices seem to be more difficult to define that those of specific construction projects, such as highways, hydro-dams, and airports.

At the present time the state of the art of environmental impact assessment is in its infancy. Only a few methods are being given wide application. Substantial research and development will be required to support the development of environmental impact assessment on a variety of actions in Canada.

Methods for environmental impact assessment should possess some or all of the following characteristics, as identified by Drobney*. A method should:

1. Permit a comprehensive review of a proposed action.

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*Personal communication, 1973, from N. Drobney, Battelle-Columbus Laboratories, Columbus, Ohio, U.S.A.

2. Be flexible and therefore applicable to a wide range of actions.
3. Be objective and repeatable.
4. Permit the input of available expertise and information.
5. Employ definite criteria and rationale.
6. Permit the assessment of impact magnitude and total effect.
7. Identify environmentally sensitive areas.
8. Permit the integration of different impacts towards a total impact for the action.

At the present time, there are no methods which fully satisfy all of these characteristics, though some do provide for more integrated and comprehensive assessments than others.

Environmental impact assessment is based on the analysis of field studies and background information. The assessment statement is reviewed for its implications for decision-making on whether to proceed with an action, modify it, or stop it. Through the sequence of study, assessment, and review there is a need for methods to identify, measure and evaluate the impacts which accompany a given action. Approaches to environmental impact assessment methods can be categorized for the purposes of discussion. The following categories are not mutually exclusive and there is some overlap between them:

1. Task force organization.
2. Inventory of assessment factors.
3. Factor integration and interaction.

Task Force Organization

The method provides for a task force of experts in relevant disciplines to carry out the joint study of a proposed project plan and of its environment. Characteristically each discipline conducts a study of the environmental consequences of the action on the sector. For instance, in the case of a hydro-electric development with water impoundment, separate studies might be undertaken by experts in fresh water biology, river geomorphology, land use, fisheries, forestry, wildlife, and recreation. A variety of methods might be employed in making the individual assessments, and as a result the study could be made up of separate reports. Thus, where there is a multi-disciplinary task force as opposed to an inter-disciplinary one, the approach lacks the integrating features of other methods. An advantage of the method is that a rapid assessment of potential environmental impacts can be obtained through the solicitation of expert opinion.

Inventory of Assessment Factors

This category gives emphasis to the identification and listing of environmental factors associated with a given action. One method is the two dimension matrix which provides for the identification of possible impacts which stem from individual phases or

activities associated with a given action. An example is a United States Geological Survey (USGS) matrix, Leopold *et al* (14), which was developed for the examination of a wide range of actions for their primary ecological and physical-chemical impacts and some social and indirect impacts. Economic and secondary impacts are not addressed in the USGS method.

"The heart of the system is a matrix which is general enough to be used as a reference checklist or a reminder of the full range of actions and impacts on the environment that may be related to proposed actions. The marked (completed) matrix also serves as an abstract of the text of environmental assessment to enable the many reviewers of impact reports to determine quickly what are considered to be the significant impacts and their relative importance as evaluated by the originators of the impact report.

This comparatively simple system is intended as a guide for the many people who are faced with the evaluation and preparation of environmental impact reports before the results of these studies have been completed. It should be borne in mind that there presently is no uniformity in approach or agreement upon objectives in an impact analysis and this generalized matrix is a step in the direction."(14)

One of the main uses of the USGS method is as a checklist. Most potential impacts are identified in the matrix. The total impact can be promptly described in subjective terms. However quantitative estimates of impacts cannot be made using this matrix. The method does provide for the assessment of the magnitude of the impact (degree, extensiveness, or scale) and/or the importance of the impact (including consideration of the consequences of changing a particular condition on other factors in the environment). The importance rating requires more of a value judgment from the analyst that does the rating of the magnitude.

A modified USGS matrix was employed to identify four categories of impact in a preliminary study of the environmental impacts of the James Bay Development Project (10). Impacts were classified as important, moderate, minor or temporary. Probable impacts were also classified as important, moderate, minor or temporary. Probable impacts were also identified on the basis of sparse existing information. All phases of the development of the project were examined.

In a comparative review of methods, Warner and Preston (23) noted that assessments made with the USGS method are subjective. The man-year and the funding requirements of the approach are very flexible. The approach was not developed for any specific type of project and it may therefore be broadly applied with some alterations.

Guidelines associated with the method are minimal and several important ambiguities are likely in the definition and separation of impacts. The reliance on subjective judgment, without guidelines, reduces the replicability of the approach. The chief advantage seems to be its usefulness as a means of identifying project impacts and as a display format for communicating results of an analysis. One disadvantage is that the matrix is not easily applicable to a large undertaking composed of many projects developed simultaneously or in sequence.

Schlesinger and Daetz (21) developed an environmental assessment matrix approach for use at various stages of planning and design of a project (sketch-level, first-cut level, draft level, and final design). Descriptions are made of the importance of several matrix parameters and their application in other matrix approaches. These parameters are (impact) identification, magnitude, importance, duration, interrelationships, probability, sensitivity, and mitigation.

The Brubaker environmental logic matrix serves as a general approach in the search for possible effects of an action on different environmental sectors (4). The method is a conceptual one and it permits a broad overview of the environmental and social effects of a wide range of actions. The matrix focuses on the gravity of a given environmental problem and on appropriate approaches to minimize or eliminate undesirable effects. For example, future technological development can and will affect ecological systems and life-support systems through cumulative effects, some with major potential. The effects may be discernible immediately and continue for generations over areas of wide magnitude. To mitigate such effects, national and even global management strategies may be required. Economic measures (taxes or subsidies) may be found useful and several institutional approaches may be necessary to bring about an alteration of the effects. Technological approaches to the mitigation of effects may include containment of the impact or of the effect at its source. The Brubaker matrix offers a broad orientation to the identification of such effects and their significance as well as broad strategies to cope with them.

For coastal zone planning, Sorenson (22) developed matrices for the analysis of environmental impacts caused by a wide range of activities. The matrices provide for a description of both the initial and the consequent conditions (i.e. before and after a given activity is launched). The possible environmental effects are described, together with the corrective actions or control measures necessary to minimize or eliminate undesirable effects. Separate

matrices are presented for four broad types of development possibilities in coastal zone areas. They are:
1. Residential, commercial, agriculture.
2. Recreational.
3. Extractive.
4. Industrial, transportation.

This system is basically a tool for identifying the sources and types of environmental impacts and to assist an analyst to insure that, as much as possible, all potential impacts have been checked.

Mapping overlays have been widely used in resource management and land use planning. The method is one of superimposing a map with one type of information (e.g. zoning for land use) on another map with another type of information (e.g. land instability) for the purposes of site, project or regional planning (e.g. the location of a facility or the use of land). This method has been applied in the land capability analysis program of the British Columbia - Canada Land Inventory. The optimum use of land is mapped on the basis of productivity or usefulness under a given sector (agriculture, forestry, recreation, wildlife). The inventory also provides information on physical hazards associated with land development. Such land capability survey results serve as an important basis for environmental impact assessment (20).

A map overlay technique for regional development has been described by McHarg (16). The method employs map transparencies of environmental characteristics overlaid on a regional base map. In a highway route selection problem, a location was chosen which provided the maximum social benefit (including environment) at the least social cost. The McHarg system is valuable in the screening of alternative project sites or routes for a variety of project types.

Limitations of the McHarg system include the lack of provision for the identification and quantification of possible impacts and the difficulties encountered in giving weights to the environmental characteristics. The system does not predict environmental impact but it does identify the areas of greater or lesser impact. The man-year and the funding requirements of the method are not demanding but a high degree of skill and training is required to derive and prepare the map overlays. The approach seems to be most useful as a "first-cut method" for identifying and selecting alternative project sites or routes, prior to detailed studies of environmental impacts.

Factor Integration and Interaction

Several methods have been developed which stress the weighting of the environmental impact of a given action, either by

subjective assessment or by quantitative measurement. The USGS matrix method provides for separate rating of the relative *magnitude* and importance of impact, each on a scale of 1 (least) to 10 (greatest). The ratings are subjective and are therefore prone to analyst bias.

In a review of the evaluation of environmental intangibles, Coomber and Biswas (5) described the problems of quantifying environmental parameters and the subsequent weighting or aggregating of this information for the purposes of decision-making. Different approaches to weighting environmental impact have been proposed by Orlob *et al* for river planning (19), by Dearinger for small streams near urban areas (7), by Odum for highway development (18), and by Dee *et al* for water resource planning (8). As with the USGS matrix, the weighting techniques are useful but approximate means of estimating environmental impact. The techniques do not provide for the measurement of the impact and its effect on the environment. The main disadvantage of weighting is analyst subjectivity.

If the pursuit of environmental assessment is going to lead to a fuller understanding of the "irreversible and irretrievable commitment of resources resulting from a proposed action" and if the cumulative and long-term effects of the action are to be described, it is not sufficient to identify, measure, and evaluate individual effects. Methods are also required which permit the aggregation and addition of impacts. Where it is practical to do so, the integration of impacts should be undertaken to describe the total effect of an action.

The need for an understanding of the relationships which exist in a given environment is particularly important in the ecological category of environmental impacts, as illustrated in an assessment method developed by Dee and Drobney (9). The complex nature of interrelationships between environmental components was described using four categories (physical/chemical, ecological, social, and aesthetic). Apparent relationships were shown but the means by which one environmental parameter was affected by another were not given. This aspect of the analysis of environmental impact continues to be a complex and unresolved one, partly due to the fact that present knowledge of natural systems and the physical and biological processes which operate in them is inadequate. Bella and Overton (3) noted:

"Man is faced with an environmental predicament which can be stated as follows: Man's ability to modify the environment will increase faster than his ability to foresee the effects of his activities. This predicament rests not on man's lack of interest in his environment (though this is a contributing factor) but on his

relative inability to understand complex organized ecosystems, i.e. the environmental predicament rests ultimately on man's capacity rather than on his will. Failure to recognize this predicament can occur because of the engineer's underestimating of the relative complexity of ecosystems and the ecologist's overestimation of the relative complexity of man-made systems. As an illustration of this predicament consider the basic manuals available to both the engineer and the ecologist. There are no ecological manuals comparable in simplicity, generality, utility and availability to the engineering design manual (e.g. Manual of Steel Construction, the Reinforced Concrete Design Handbook) and there will likely never be such manuals, not because ecologists are backward or unimaginative, but because ecological systems are too complex. It is extremely unlikely that a major breakthrough will occur in the environmental sciences such that the environmental predicament will be removed. Thus, environmental strategies must be based on a recognition of this predicament."

There are no hard examples of environmental impact assessment methodologies that deal with the integration of effects which stem from a single action. The technology which is available to deal with synergistic effects appears to be lacking, particularly for major physical projects and programs.

The Need for Integrated and Comprehensive Background Studies

The planning and execution of major projects are not always smooth and predictable activities. For instance, large hydroelectric and transportation projects are designed and built to meet industrial or domestic demands. Such projects are often in hinterland locations for which planners have only limited environmental and resource data. This presents a major hindrance to adequate environmental impact prediction. In the past these environmental studies have tended to be hurried "fire-fighting operations" carried out to meet a construction deadline with little effect on project planning or the decision on whether or not to proceed with the project.

In order to prepare adequately for future projects in similar locations it is necessary to stress comprehensive environmental and resource planning. This requires that the inventory and planning of resources for development be carefully scheduled and integrated. This is the preferred route to follow because major environmental and resource problems can be avoided by an examination of alternative schemes. Better decision-making on environmental questions will follow from this approach. Examples of comprehensive studies are the

Alberta Foothills Land Use Study and the British Columbia Land Capability Analysis Program.

Integrated Surveys

Land resource and water resource surveys do give valuable background information to the regional and environment planner, particularly if they are undertaken by inter-disciplinary teams using integrative methods. These methods have become more common recently and have begun to replace traditional sector surveys of geology, soils, climate, resource use, and land use.

Canadian examples of integrated surveys which have provided comprehensive background information to the resource and environment planner include:
Canadian Wildlife Service ecology surveys for portions of the Yukon and Northwest Territories.
Biophysical Land Classification Surveys in British Columbia, Manitoba, Quebec, and Newfoundland.
Canada Land Inventory (CLI) maps of land capability for agriculture, forestry, recreation, and wildlife.

The CLI Land Capability Analysis maps for British Columbia and Quebec represent more advanced versions of integrated resource and environment information of vital usefulness to the individual or agency responsible for environmental impact assessment. The maps and the background information used in their preparation serve as an important source of relevant data.

Recent efforts to mount integrated surveys have been concentrated in Quebec (James Bay and Lac St. Jean), Yukon and Northwest Territories (MacKenzie Valley pipeline studies) and in British Columbia (Canada Land Inventory). However some of these and other Canadian surveys fall short of being fully integrated land resource surveys with the following characteristics:

1. Accommodation of the user or client agency in the planning of the survey and in the implementation of the results of the study.
2. Multi-disciplinary teams of scientists working concurrently on the project.
3. The use of a common mapping unit such as the land system of the Biophysical Land Classification System (17).
4. Heavy dependence on aerial photo interpretation.

Scenarios

Emphasis has been placed recently on the development of scenarios to anticipate better the environmental impacts of some actions, particularly those with regional implications. These descriptive documents have been developed for such activities as

off-shore drilling (Atlantic Seaboard) and for river and estuarine developments (Mackenzie Valley and Beaufort Sea). Such outlines of possible major activities serve to alert the environmental impact assessment specialists and analysts to the obvious impacts of an undertaking as well as to identify information gaps or areas of unusual uncertainty.

Conclusions

In spite of the fact that most major projects in Canada are receiving attention in their planning stages as to the expected environmental implications, the technology is relatively new and development is rapid. With the installation of formalized procedures by provincial and federal agencies, guidelines for environmental studies will be put into practice. In the meantime, research is required on reactions of different ecosystems to project development. Procedures are also required to collate information on these effects and to alter project planning so as to minimize environmental disruptions and, ultimately to enhance the quality of the environment.

Canadian Examples of Environmental Impact Studies

Several Canadian environmental impact assessment studies have been undertaken which illustrate the use of one or more methods. In some cases the studies were undertaken before the decision was taken to proceed with the project; other studies were after-the-fact and formed a retrospective and follow-up review of *what happened* after a project was completed.

James Bay

An environmental impact study was made of the proposed James Bay Development by a Joint-Provincial Task Force 1971 (10). The task force was charged with "the making of a preliminary appraisal of the impacts upon the environment that can be anticipated due to the development of the James Bay project".

The report is a digest of a variety of working papers and reports contributed by four study teams, their associates and advisors. The region and the proposed hydroelectric project are given summary description. Then the predicted ecological impacts and necessary corrective actions are described under the categories of minerotrophy (geology, geomorphology, hydrology, meteorology, water), phytotrophy (plant life, both aquatic and terrestrial), zootrophy

(fish, animal and bird life), and human resources (natives, tourism and archeology).

The USGS matrix was used to illustrate the actions associated with the project which affect the environment and also the natural characteristics of the environment which will be susceptible to impact. It was not possible to evaluate the magnitude and importance of the impacts. However four rough levels of significance were used in a limited evaluation of impacts (important, moderate, minor and temporary). Probable impacts were also identified. The USGS matrix served to raise questions requiring answers and it continues to do so as environmental studies are continued on the James Bay Project.

The study outlined the expected environmental impacts and the proposed studies and actions which would help to reduce the undesirable effects. The combination of task force and the USGS matrix resulted in a comprehensive overview of the impacts being obtained. However, it was not possible to add up or to integrate the impacts using these methods.

Peace-Athabasca Delta Study

The Peace-Athabasca Delta area was the subject of an environmental impact assessment based on a cooperative interdisciplinary study by the governments of Canada, Alberta and Saskatchewan (2). The study was to investigate and report on the extent of low water levels in Lake Athabasca, their cause, and their effects on the Delta and upon the local people. The report covered the findings and the recommendations of the study including alternative solutions for the restoration of water levels.

The study is an example of an after-the-fact investigation for the purpose of recommending actions to reduce the impacts caused by the lower water levels. The study team followed the task force approach to designing and executing a wide range of projects (about sixty in number) the results of which were collated to form a basis for recommendations. Other methodologies were not specified in the summary report. However a degree of integration was achieved by consultation between teams of workers. In addition, a number of important guidelines were given for the conduct of future ecological studies of similar complexity and magnitude.

The Impact on the Environment of Surface Mining in Alberta

Several inquiries have been made by the Environment Conservation Authority (ECA) into the impacts of resource development in Alberta. The results of the inquiries are given as advice for the Lieutenant Governor-in-Council on preventive and reclamation procedures to assure that these resource developments would go forward

without permanent environmental damage. The report on surface mining (13) describes the general impact of surface mining in the Alberta plains and in the foothills. It also summarizes the proceedings of public hearings held at several centers in coal mining regions.

The ECA report does not specify methodologies but the summary report and the proceedings from the hearings represent a comprehensive treatment of environmental impacts of the industry.

Lorneville, New Brunswick

The New Brunswick Development Corporation has put forward a proposal that the Lorneville Harbor be developed as a port facility to serve supertankers and bulk cargo carriers, a crude oil transfer terminal, an asphalt refinery and various other industries. An oil-fired thermal generating station is also proposed for nearby Coleson Cove. The environmental impacts of these developments were examined by a coordinated task force of federal and provincial specialists. The main sources of impact were seen to be vessel traffic, gaseous emissions, and thermal discharges.

An appraisal of the environmental consequences of these developments was reported as a basis for the environmental planning aspects of the development.

Alberta Highway No. 40 (Kananaskis)

A 30-mile section of a proposed 700-mile all-weather, multi-purpose highway in Alberta was the subject of an environmental impact statement (1). Several Alberta Government agencies participated in the assessment in a task force organization. The USGS matrix was used to inventory and to rate all impacts in terms of magnitude and importance. The main effects were described by sector and therefore it was not possible to provide for the integration or addition of impacts.

The Kananaskis Highway study offered recommendations on measures to minimize adverse effects on the environment during highway location and construction phases.

Nanaimo Port Alternatives

A lumber shipment facility has been proposed for the Nanaimo area on Vancouver Island (British Columbia). A task force investigated the environmental disruption which would be caused by the construction and operation of such a facility. A number of alternative development sites were assessed. Each one was examined for potential environmental effects and all sites were ranked as to their preferability on environmental grounds (12).

Each sector was given study for environmental impact (fisheries, birdlife, vegetation, etc.). The interactions between the components of the environmental system were identified. Many two-link dependency chains were identified. A short example (crab dependency on upland vegetation) was given to illustrate the fact that "one cannot alter or modify any of the components of an environmental system without causing ripples of effects to occur throughout the entire system". The food web was used to illustrate the interdependence of components in an estuarine system.

The estimate of environmental disruptions on first-order dependencies was made by assignment of weights for "almost negligible", "slight impact", "moderate", and "catastrophic impacts" (weighting). These assignments were in "an environmental component interaction matrix" which stressed the need to identify and describe primary, secondary, and higher-order impacts. This method permitted interdependencies to be described. At present there are no methods available to describe the importance of the interdependencies. Therefore weights cannot be given to the interdependencies and information cannot be collated on the amount of disruption caused by each alternative development site.

The Nanaimo Harbor task force had representation from such sectors as wildlife, fisheries, marine sciences, land use planning and environmental protection. The group prepared a component interaction matrix identifying the dependencies between the environmental variables. First order dependencies were also shown graphically to illustrate the complexity of the relationships and also to indicate the degree to which the environmental system is dependent on its marine components, which support roughly twice as many of the interdependencies as the non-marine components.

A large number of interdependencies were identified although the magnitude or importance of the interactions was not measurable. Until environmental scientists can measure these factors accurately, environmental assessments will be restricted to qualitative assessments.

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