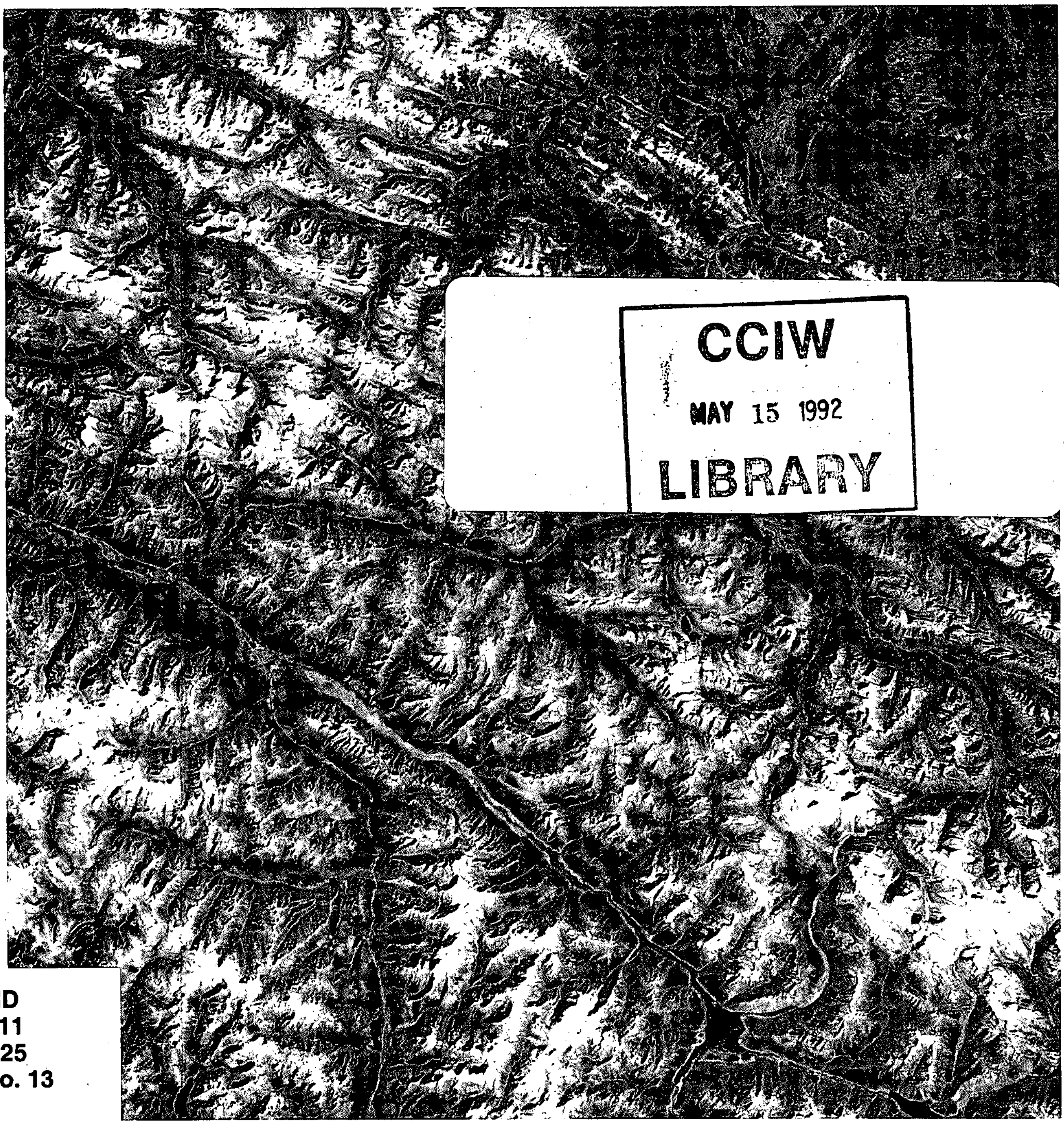
Federal Environmental Assessment and Review Process

# ECOLOGICAL LAND SURVEY GUIDELINES FOR ENVIRONMENTAL IMPACT ANALYSIS







Land Classification Series, No. 13

Canada

# ECOLOGICAL LAND SURVEY GUIDELINES FOR ENVIRONMENTAL IMPACT ANALYSIS

Ecological Land Classification Series, No. 13
Federal Environmental Assessment and Review Process

ENVIRONMENTAL CONSERVATION SERVICE TASK FORCE

Lands Directorate
Environment Canada

Federal Environmental Assessment
Review Office (FEARO)

Cover: A false-colour composite image of the site of the Columbia River Reservoir in southeastern British Columbia. This image of the Big Bend area was recorded by the LANDSAT satellite on 15 September 1973, prior to flooding.

# PREFACE

The Environmental Conservation Service the Federal Environmental Assessment Review Office (FEARO) play an important role in efforts aimed at conservation and management of renewable resources, enhancement of environmental quality, and reduction of negative environmental impacts associated with major federal projects. Based on experiences with the Environmental Assessment and Review Process (EARP), it was felt that guidelines for the collection of baseline information would not only be useful to the proponent, but also to other participants in the Process as well as to facilitate the functioning of EARP.

Ecological Lands Survey (ELS) has a major advantage over the other types of field surveys, that is, a wide variety of interpretations can be derived from a single data base. In addition, the hierarchical nature of ELS provides for general as well as detailed data gathering, analysis, and interpretation. This feature of ELS is of direct application to environmental impact analysis in general and to the stages of the Environmental Assessment and Review Process in particular.

In addition to providing requisite environmental baseline information, an ELS serves as a data base for project planning and management. It also forms a framework for environmental monitoring of project operations. Reduced survey costs result from integrated remote sensing and field work activities which characterize this type of data gathering from traditional single discipline surveys. These features lead to substantial savings of time and funds.

The guidelines outline such questions as why an ELS is needed, how to carry out such a survey, and how to use the data.

The report has four parts:

1. A description of the Federal Environmental Assessment and Review Process and of Ecological Land Surveys.

2. How to plan an ELS.

3. How to conduct the survey.

4. How to use an Ecological Land Survey Data Base.

The first, second, and fourth parts are directed mainly to project planners; the third part is aimed at the project manager and will assist in the setting of national standards for collecting ecological land data.

These are preliminary guidelines ready to be applied to environmental impact assessments of major projects. The task force responsible for this version is made up of specialists from the Department of the Environment, Environmental Conservaton Service and from the Federal Environmental Assessment Review Office. The task force seeks comments from users in order to improve and update future revisions.

Assistant Deputy Minister
Environmental Conservation Service

Executive Chairman
Federal Environmental Assessment Review Office

# ACKNOWLEDGEMENTS

This report was prepared by a task force representing the various regions and directorates of The Environmental Conservation Service and the Canadian Forestry Service, Environment Canada: G. Beanlands, J.L. Belair, P. Duffy (FEARO), H. Hirvonen, D. Lacate, W. Speller, J. Thie (Chairman), D. Welch, G. Wickware, E. Wiken, and S.C. Zoltai. The proposal to prepare the guidelines originated with G. Beanlands, P. Duffy, H. Hirvonen, and N. Lopoukhine. Discussion drafts were prepared by E. Wiken, D. Welch, J. Thie, C. Rubec, W. Speller, P. Duffy, and G. Ironside, with critical review by the Task Force. The report was typed by M. Poulin.

# TABLE OF CONTENTS

# PART 1
# ECOLOGICAL LAND SURVEYS FOR ENVIRONMENTAL IMPACT ASSESSMENTS

## 1.1 FEDERAL ENVIRONMENTAL ASSESSMENT AND REVIEW PROCESS

The Federal Environmental Assessment and Review Process, established by Cabinet Decision on December 20, 1973 and amended by Cabinet on February 15, 1977, embodies Canada's policy on environmental assessment as it relates to the activities of the federal government. The Process is a means of determining in advance the potential environmental impact of all federal projects, programs and activities. The ultimate responsibility for decisions resulting from the Process rests with the Minister of the Environment and the Cabinet.

The purpose of the Process is to ensure that the environmental effects of federal projects, programs and activities are assessed early in their planning, before any commitments or irrevocable decisions are made. Activities with potentially significant environmental effects are submitted to the Minister of the Environment for formal review by an Environmental Assessment Panel.

Federal projects are considered to be those initiated by federal departments and agencies, those for which federal funds are solicited and those involving federal property. This definition includes projects that may originate outside the federal government, but involve a particular federal department through funding or property considerations.

The Process focusses on the need for consideration of environmental factors as well as economic, engineering and social factors in the planning and implementation of projects and programs. The Process is illustrated in Figure 1.1 and is described in detail in "Revised Guide to the Federal Environmental Assessment and Review Process" which is available together with "Guide for Environmental Screening" and "Guidelines for Preparing Initial Environmental Evaluations" from the Federal Environmental Assessment Review Office (FEARO), 13th Floor, Fontaine Building, Hull, Quebec, K1A OH3, Telephone: (819) 997-1000.

Many major federal projects which are under review have several common characteristics. Large areas of land and water are often involved. The projects have multiple development aspects; for example, a hydro-electric development may involve dam construction, preparation of an impoundment area, river diversion, the construction of new or improved access routes and transmission rights-of-way, and new settlements. Projects are often located in remote areas for which there is only limited information on the resources and dynamics of land, water and climate. Experience shows that some projects are undertaken on a tight time schedule with the expenditure of substantial funds and other resources.

Proponents of major projects need to gather baseline information within limited time frames. From such data, the environmental assessment is prepared. Experience over the past ten years has shown that Ecological Land Survey methods have provided a balanced and integrated information base for this purpose.

These Guidelines are for application in environmental assessment and review, specifically to assist project planners, managers and specialists to gather and analyze environmental data using integrated and cost-effective methods. Appendices A and B provide information on ecological land survey methods and sources of maps, reports and publications which are of use in the preliminary planning process.

## 1.2 ECOLOGICAL LAND SURVEY, ITS USEFULNESS AND MERITS

There are many approaches available to acquire environmental baseline information and each has its own particular usefulness. With an Ecological Land Survey (ELS), land is perceived in a holistic manner — as such, an ecosystem. Land, thus, comprises five main components: terrain, hydrology, climate, flora and fauna and the relationships which exist among them. This focus shows that an ELS is well-suited to those circumstances which call for a broad base of environmental data.

Ecological Land Survey refers to the entire process of examining and evaluating the environment of an area for project planning and management in a way which is compatible with that environment. ELS includes the rationale for undertaking a survey, for organization, data collection, data storage,

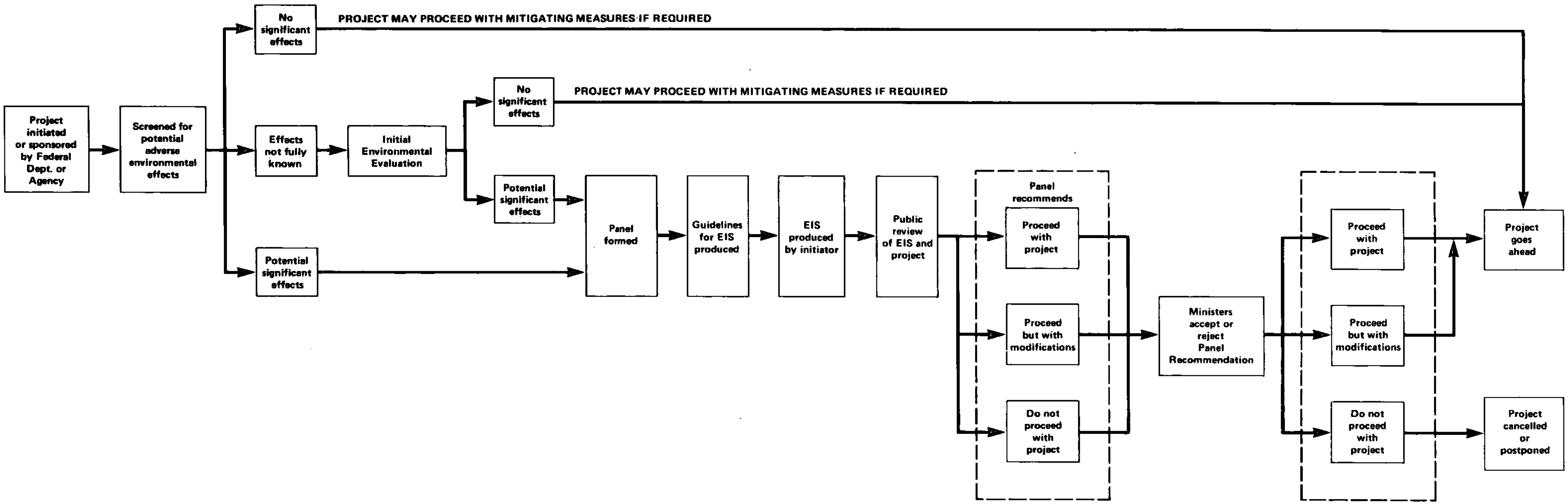



FIGURE 1.1 SCHEMATIC DIAGRAM OF THE FEDERAL ENVIRONMENTAL ASSESSMENT AND REVIEW PROCESS

interpretations, and recommendations for action.

This integrated, ecological approach to classifying land has numerous advantages over conducting a series of single discipline surveys of an area. Because ELS accepts and follows the interactive ways of nature, impacts from disturbances of one area or characteristic can be predicted more easily and accurately in relation to others. This follows partly from mapping and description of ecologically significant portions of the land surface (Figures 1.2 and 1.3), and partly from the close working relationships developed by scientists in collecting this information. An ELS is also preferred over separate single sector surveys because:

(i) Basic descriptive data can be interpreted for a wide variety of applications;

(ii) An integrated team minimizes the costs and resources used in completing several parallel surveys;

(iii) A single set of map units and descriptions allows easy retrieval of data, efficient comparisons of different characteristics, and a high degree of flexibility in making interpretations and modelling alternate impact or planning scenarios. The alternative is a series of maps, with non-concordant boundaries with varying levels of detail and legends - all of which make integrated interpretations quite difficult.

(iv) An ELS is primarily used to measure stable environmental phenomena which reflect on-going processes; therefore, the survey maintains its utility for future applications (e.g. flood regime remains the same over many decades whereas present discharge depends on the year or even day and hour of survey). However, dynamic phenomenon, such as vegetation cover and wildlife occurrence, are also included for current applications and long-term monitoring;

(v) An ELS establishes environmental baseline information which provides a basic reference for future environmental monitoring and can also help to pinpoint locations for permanent monitoring stations (e.g. vegetation plots, stream gauges, weather stations, and fish and wildlife sampling points);

(vi) The information is assembled in one package; and

(vii) An ELS uses a hierarchical approach to land classification, so that information can be assembled at various levels of detail, according to the needs of the proponent.

## 1.3 APPLICATION TO PHASES IN EARP

Ecological Land Survey can be directed toward the conceptual and planning phases of project development and the Screening, Initial Environmental Evaluation (IEE), and Environmental Impact Statement (EIS) phases of EARP. Each phase will have different, though related, requirements in detail, scope, time, and cost.

An exploratory ELS should be carried out in the conceptual and planning stages of the project to allow early incorporation of environmental considerations in the project design. Such a survey may lean heavily on existing information in the area and emphasize integration of information sources, relationships between disciplines, and the filling-in of specific gaps in the data base. The benefit of this approach is that significant impacts may be avoided in the design phase, and an IEE or EIS may no longer be required. This "planning" stage ELS would tend to be a relatively low cost, short-term "overview" survey, providing a flexible data base for interpretations and analysis, and assisting in the earliest stages of project planning. It allows, through effective screening, the early identification of areas of potential impacts, and therefore reduces the cost and time of the more detailed surveys that may be required for an EIS.

An ELS which is carried out at the IEE stage can be tailored by information obtained at the screening stage in order to identify the type of potential impact (physical-chemical, biological, aesthetic, or social), and the time of impact as it relates to the principal phases of project development (e.g. site investigation, construction, operation, and maintenance). At this stage the objective of the ELS can be more specifically related to the project and to its potential impacts and problem areas identified through the screening. The level of ELS detail required should be such that the potential impact can be rated as significant or not significant, according to criteria listed in the "Guidelines for Environmental Screening".

When significant impacts are predicted, a comprehensive analysis of environmental effects should be carried out. When a project is referred to the Federal Environmental Assessment and Review Office, then an Environmental Assessment Panel is formed. This Panel issues guidelines for the

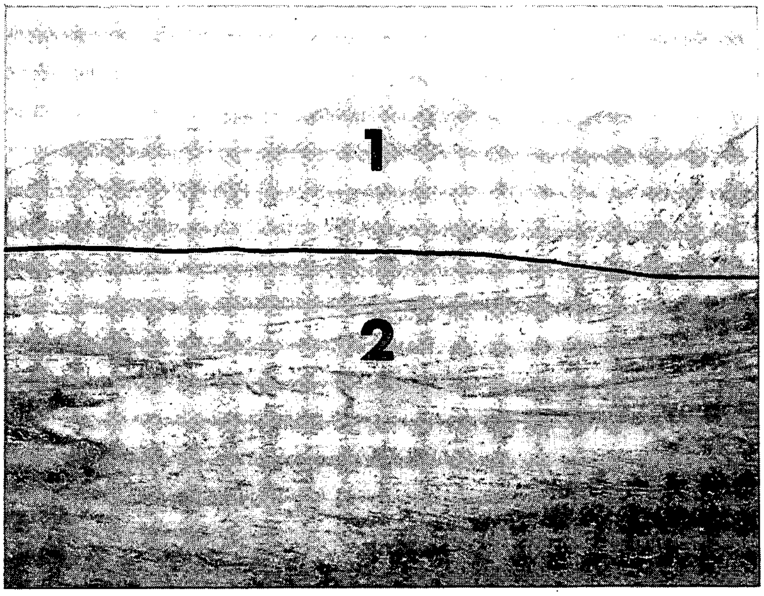



Figure 1.2: Two large and ecologically distinct areas of land each with characteristic slopes, vegetation, drainage and materials. Thus, each has distinct concerns and opportunities for planning, management and impact analysis.

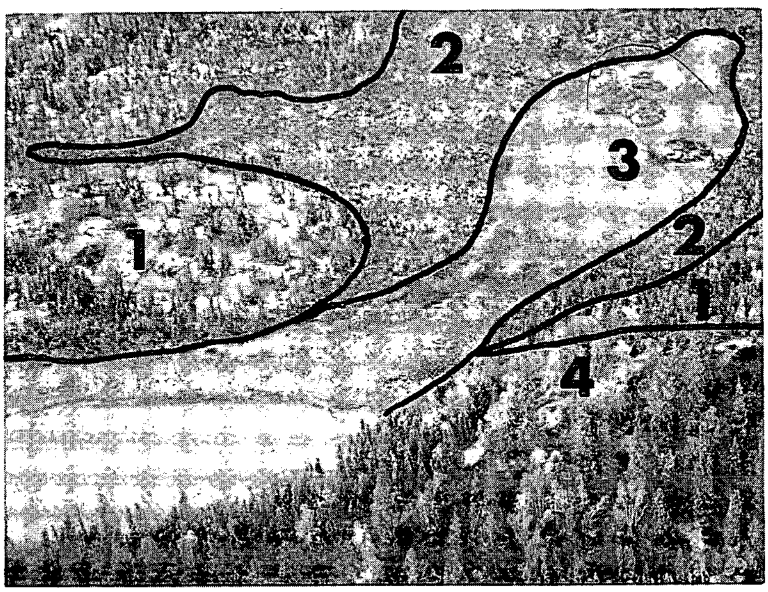



Figure 1.3: Detailed Ecological Land Survey is also possible where resource use, nature of impacts and phase in EARP require it. In this case, a lichen open woodland on outwash (1), a lichen woodland on an organic bog (2), a sedge covered fen (3), and a low shurb mixed woodland community on an esker (4) are all distinguished. In a more general survey, 2 and 3 could be grouped into one unit; likewise 1 and 4.

preparation of an Environmental Impact Statement (EIS). Subsequently, the Panel arranges for the technical and public review the EIS and, ultimately, reports to the Minister of the Environment on the adequacy of the environmental planning on the project. At this stage the ELS provides basic information in a format that is useful to the proponent's planners, the members of the panel, and to the public.

In addition to providing a general environmental perspective, the ELS focuses on locational and design alternatives and identifies potential impact areas. Emphasis is placed on integration of environmental information with the description of ecological relationships, and causes and effects. The ELS can provide the flexibility required to answer additional questions that may be raised by the planners, panel members, and the public.

# PART 2
# PLANNING AN ECOLOGICAL LAND SURVEY

## 2.1 INTRODUCTION

To organize an ELS, the proponent should consider the need for, objectives of, time frame for, and budgeting and use of the ELS data. He should be able to justify the approach and investment in the survey as a benefit to the planning and implementation of his project.

As a first step, during the earliest stages of project planning, the existing environmental data and information base should be assessed for their use in the project planning as well as for a possible Initial Environmental Evaluation (IEE) and Environmental Impact Statement (EIS).

Based on the knowledge of what information is needed, what is feasible (in terms of costs and time), and what is available, specific objectives and technical specifications can be written for an ELS. Such an integrated environmental survey would provide baseline information for the widest possible range of uses (interpretations) and the lowest possible cost to the proponents.

## 2.2 ESTABLISHING THE OBJECTIVES

### 2.2.1 General

The general objective of an ELS is to provide an integrated environmental information base for project planning, upon which environmental screening, evaluation, or assessment can be based. Specifically, the objectives are directed to the phase of the EARP which they service (Part 1), the nature and phase of the project, the environmental information needs for project planning, and time and resource constraints. These are important because the result of the ELS and its usefulness to the proponent depends heavily on the careful definition of the objectives and a clear term of reference (particularly where work is contracted out to other agencies, and opportunities for modifying the survey are limited).

### 2.2.2. Establishing Information Needs

As briefly discussed earlier, project managers and planners or their consulting specialists can identify potential impacts and information needs through the environmental 'Screening' process. Using the FEARO guide on screening, and in particular Table 2.1 in this report, the type of environmental impact can be cross-referenced with the stage of project development in which it occurs. The screening process establishes what information is required (if any) and when, particularly for the IEE. Guidelines for preparation of IEE, were issued by the chairman of FEARO in a 1976 report. The guidelines cover:

1. Oil and gas exploration and production;
2. Linear transmission: highways, railways, power transmission lines, and oil and gas pipelines;
3. Hydro electric and other water development projects;
4. Fossil fuel power generation;
5. Nuclear power generation;
6. Airports;
7. Ports;
8. Mining developments; and
9. Industrial developments.

If the screening or IEE established significant impacts, FEARO will have to be consulted; a FEARO panel will then identify detailed information requirements and prepare detailed guidelines for a project's EIS.

The nature of the project, the type and complexity of the environment, and the existing data base control the information needs. The total area of survey, spatial resolution, level of detail, accuracy of information, and selection of areas for intensive study have to be decided. The total area to be considered for the survey can be very large (as with oil and gas exploration and hydro developments) or relatively small (as with airports, nuclear power generating stations, and ports). The survey is often two pronged: (1) synoptic information for large areas, to assess implications of over a large area; and (2) detailed information for specific sites, to answer site-related problems or to study representative ecosystems or relationships identified by the broad survey. For example, in highway development projects, the synoptic view provides information for the selection of a best corridor, at the outset, or consideration of alternate routes, or route modification in further stages of project planning or impact assessment. Detailed studies would address critical environmental or construction sites.

For large areas (over 12,000 $km^2$), exploratory or reconnaissance surveys are recommended to obtain information on ecoregions, ecodistricts and ecosections at a scale of 1:125,000 or smaller. This will provide the environmental perspective of the area, and allows evaluation of alternative locations and designs. Representative ecosystems, which may be affected by the development (selected through the initial survey) should be surveyed at greater detail. These local studies may require scales of information between 1:50,000 and 1:10,000, and sometimes as large as 1:1,000. Cost increases significantly with an increase in scale. By using the ELS hierarchy, field work can be concentrated in areas of representative ecosystems and in sensitive areas. At the same time, the ELS approach provides an effective framework for extrapolation of field data to non-sampled areas using photo-interpretation and remote sensing techniques. Gathering of data in field is usually one of the most expensive parts of environmental surveys, particularly in areas with poor accessibility. Significant cost-savings can accrue to the proponent using hierarchical ELS sampling schemes and more efficient logistics. Table 2.1 provides a guide to the application of ELS levels of mapping for environmental impact assessment.

### 2.2.3 Establishing Constraints

The scope and objectives of an ELS are controlled not only by the natural setting but also by the money available, time limit, and manpower resources; time limit in turn is strictly controlled by conceptual, planning, and implementation phases of the proposed project. Though most ecological land surveys are limited by project time and money restraints, inadequate surveys may delay projects if satisfactory IEE and EIS cannot be made. If environmental concerns are not adequately considered, or if budget or time is unrealistically restricted, poor project planning and design may result. It may even necessitate the carrying out of a full EIS when otherwise a proper IEE may have been satisfactory.

Based on experience, it is recommended that the proponent establish a full-time interdisciplinary coordinating and management team to design, supervise, and analyse the ELS; the actual survey itself, however, can be contracted out to the private sector. The advice of such contractors, however, can be usefully solicited at later stages for more effective data interpretation. Part of the guidelines in Part 3 can be used (adapted to the project) as contract specifications. Specialists from Environment Canada are available to advise and participate in the coordinating/ management team.

## 2.3 GATHERING AND ASSESSING EXISTING ENVIRONMENTAL INFORMATION

### 2.3.1 Sources of Information

Before an ELS is started, the existing base of environmental information must be evaluated. This includes reviewing maps, research reports, environmental statistics, and publications available for the area (and for ecologically similar areas) and environmental effects of similar projects. Potential information sources (ordering addresses are presented in Appendix B) include:

(i) Topographic maps
(ii) Hydrographic charts
(iii) Canada Land Inventory critical area maps
(iv) Canada Land Inventory land use and land capability maps
(v) Ecological (biophysical) land surveys
(vi) Geological and terrain maps
(vii) Soils maps
(viii) Aerial photographs and mosaics
(ix) Satellite images, maps and mosaics
(x) Provincial forest inventory maps
(xi) Northern Land Use Information Series maps
(xii) Arctic Ecology Map Series
(xiii) River basin and watershed studies
(xiv) Migratory bird information
(xv) ALUR reports
(xvi) Provincial and national atlasses
(xvii) Flood risk maps
(xviii) Water resource data
(xix) Climate data

### 2.3.2 Advisory Services

Environment Canada offices are available to provide advice and assist in designing an ELS. FEARO should be consulted early in the project planning stages. Some consultants also are building up their expertise in this area. Regional offices of Environment Canada can also provide advice on ecological land surveys and environmental impact assessment. These include:

a) Headquarters

Executive Chairman, Federal Environmental Assessment Review Office
13th Floor — Fontaine Building
Hull, Quebec
K1A 0H3

Table 2.1 A Guide to the Selection of Mapping Levels for Environmental Impact Assessment

| | | STAGES IN ENVIRONMENTAL ASSESSMENT REVIEW PROCESS* | | |
|---|---|---|---|---|
| PROJECT PHASE | EXAMPLES OF ACTIVITIES | SCREENING | INITIAL ENVIRONMENTAL EVALUATION (IEE) | ENVIRONMENTAL IMPACT STATEMENT (EIS) |
| CONCEPTION | Reconnaissance of resource opportunities; consider general design, magnitude and potential of activities | *Ecoregions*** for Wide Areas | N/A | N/A |
| GENERAL PLANNING | Select resource areas, corridors, etc. Consider related activities | *Ecodistricts* for Project Area | N/A | N/A |
| DETAILED PLANNING | Design specifications; detailed route/site selection, and detailed site design | *Ecodistricts* for Project Area | *Ecodistricts*** for Disturbed Locations | *Ecosections*** for Project Area; *Ecoelements* for Disturbed Sites |
| DEVELOPMENT | Construction - e.g. roads, excavations | *Ecosections* for Project Area | N/A | *Ecosites* for Project Area; *Ecoelements* for Disturbed Sites |
| OPERATION AND MAINTENANCE | Mining, traffic, product storage, monitoring | *Ecosites* for Project Area to select monitoring *Ecoelements* | N/A | *Ecosites* for Project Area; *Ecoelements* for Disturbed Sites |
| ABANDONMENT | Staging of shut-down; Dispose of, remove or abandon equipment | *Ecodistricts* for Project Area | *Ecosections* for Project Area | *Ecosections* for Project Area; *Ecoelements* for Disturbed areas |

* For use of data in planning and management activities, more detailed levels and wider areas are recommended. This table assumes the project is to be determined as described in FEARO documents.
** Preferred mapping levels according to EARP requirements.

Director, Pacific Region
FEARO
789 West Pender Street, Room 700
Vancouver, B.C.
V6C 1H2

Canada Committee on Ecological (Biophysical) Land Classification
Secretariat
Lands Directorate
Environment Canada
Ottawa, Ontario
K1A OE7

b) Regional Screening and Coordinating Committees

B.C. and Yukon — Secretariat — Regional Screening and Coordinating Committee
Pacific Region
Environmental Protection Service
Environment Canada
Kapilano 100, Park Royal
West Vancouver, B.C.
V7T 1A2

| | | |
|---|---|---|
| Prairies and N.W.T. | Secretariat — Regional Screening and Coordinating Committee<br>Northwest Region<br>Environmental Protection Service<br>Environment Canada<br>9942 - 108th Street<br>Edmonton, Alberta<br>T5K 2J5 |
| Ontario | Secretariat — Regional Screening and Coordinating Committee<br>Ontario Region<br>Environmental Protection Service<br>Environment Canada<br>25 St. Clair Avenue East<br>Toronto, Ontario<br>M4T 1M2 |
| Maritimes | Secretariat — Regional Screening and Coordinating Committee<br>Atlantic Region<br>Environmental Protection Service<br>Environment Canada<br>45 Alderney Dr., Queen's Square<br>Dartmouth, Nova Scotia<br>B2Y 2N6 |
| Quebec | Secretariat — Regional Screening and Coordinating Committee<br>Quebec Region<br>Environmental Protection Service<br>Environment Canada<br>1550 Maisonneuve Blvd., Suite 410<br>Montreal, Quebec<br>H3G 1N2 |

## 2.4 DESIGNING THE INTEGRATED ELS

### 2.4.1 Survey Requirements

After establishing information needs, the phase of EARP to be served, and the constraints, one defines the type and format of data that are required and the time frame. The review of the existing data base has indicated what information is available. The ELS for a project should be tailored to fill the gap.

Existing data are available in a variety of formats, scales, and disciplines, and usually with incompatible accuracies. In most instances, information was gathered for a specific purpose, and consequently information is not integrated. The incompatibility of information, lack of integration and gaps in the data base make environmental management and planning difficult even in populated areas*. For northern areas, a reasonable data base is usually non-existent. Therefore, environmental impacts, causes-and-effects, and side effects cannot be predicted or adequately analysed. Integration of data bases 'after the fact' (at the end of surveys) has consistently proved to be technically and organizationally very difficult. Integration of information is therefore part of the ELS from the earliest stage.

This report discusses the ELS in support of environmental impact assessment; however, ELS's support all aspects of environmental management: planning, environmental impact assessment, implementation of plans, operational management, and monitoring.

The ELS should be designed to:

(1) integrate existing information, (if possible);
(2) fill gaps in the data base and fulfill particular information needs of the project;
(3) emphasize interactions between disciplines and environmental elements;
(4) provide an ecological perspective (through integrating biological and physical components) which can be used at various levels of project development and planning and which serves as a basis for extrapolation of impact assessments;
(5) present the complex information in a single data base (as simple a format as possible);
(6) define and designate critical areas;
(7) provide the framework for more detailed selected studies and/or environmental monitoring sites and stations;
(8) provide the framework for evaluation of project design alternatives; and
(9) provide a basis for extrapolation of assessment of impacts.

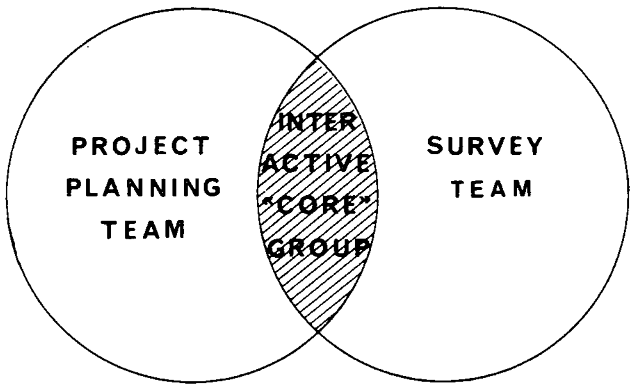
### 2.4.2 The ELS Survey Team

Selecting the team to carry out or manage the ELS is a critical step. Environmental information supplied by the ELS must not be handled as an afterthought. Team selection therefore should emphasize the survey requirements, and the user requirements. The team should be able to competently carry out the survey, communicate information to the users, and participate in both the evaluation and interpretation of environmental facts and the design of alternative plans. Figure 2.1

---

* Canada Committee on Ecological Land Classification. 1977. Ecological (Biophysical) Land Classification in Urban Areas: Proceedings of a Workshop. November 1976, Toronto. Cat. No. EN 73-3/3. Lands Directorate, Environment Canada, Ottawa. Price $4.00 (Canada).

shows schematically the relations of the planning and survey teams.




ELS SURVEY TEAM = INTERACTIVE CORE GROUP + SURVEY TEAM

Figure 2.1

Project planning is an in-house function of the proponent; however, since environmental impact statements often require specialists who are not readily available in the proponent's organization, much of the ELS work is contracted out to consultants. If this is the case, special care should be taken to assure that the ELS information is effectively integrated in the project planning work. For the larger projects in particular, the proponent should establish a core management group to interact with the project planners. This group should design and manage the ELS and assure that the survey results are useful for and used in project planning. The group should be interdisciplinary and should be representative of a broad range of general expertise and interests. Effective generalists usually require academic training in one discipline and sufficient work experience so as to understand the needs and limitations of several disciplines. The actual composition of the survey team should reflect the goals of the project and the ELS. It should also reflect the particular gaps in the existing data. The size of the team may vary significantly, depending on the scope of the proposed project. However, a team should have a base expertise that covers:

(1) terrain (soils and landforms);
(2) water (lakes, rivers, wetlands, etc.);
(3) climate (regional climate and microclimate);
(4) vegetation;
(5) fish and wildlife;
(6) ecological integration;
(7) land use (past, present and potential);
(8) user interaction (data interpretation, presentation, and communication); and
(9) management of survey (including planning, logistics, organizational integration, user liaison).

Having this range of expertise does not necessarily mean one individual for each of the above specializations. In small surveys one individual could be responsible for one or more; on the other hand, large survey operations may need a team of specialists to cover one specialization.

To achieve effective integration of disciplinary information, the ELS team must occupy one set of offices and its members should operate on a full-time basis. Part-time secondment of specialists, particularly when spread over a number of locations, has demonstrated significant problems related to communication, analysis, and integration of information. For large projects, a special team with full-time seconded or term staff is recommended.

In most surveys, fieldwork constitutes the major expense, especially in the north. Thus, the survey team must have a good knowledge of air photo-interpretation and remote sensing techniques. Aerial photographs and other remote sensing imagery provide the basis for stratifying the sampling population, selection and timing of sampling and monitoring sites, mapping of ecologically uniform areas, extrapolation of field information, and impact assessments.

### 2.4.3 Cost Considerations

Cost varies greatly depending upon the detail of the survey, accessibility to the area, complexity of the survey, etc. In most cases, however, the fieldwork phase is both critical and expensive. In northern, remote areas, for example, field expenses may take 70% of the total survey budget. Typical cost for general overview surveys is in the order of \$4-8 per square kilometre. Poor accessibility and difficult logistics (as in the Arctic) could easily double these costs.

Most surveys provide information for project planning. Although some environmental effects may be predicted, selected detailed surveys usually should be carried out to define impacts more accurately — the cost of detailed surveys may be \$40-800 per square kilometre. However, the ecological framework and hierarchy of the ELS allow significant reductions in the number and size of detailed surveys. The above estimates do not apply to site-specific or special studies. Costs for these could be considerably higher.

# PART 3
# CONDUCTING AN ECOLOGICAL LAND SURVEY

## 3.1 INTRODUCTION

### 3.1.1. Major Steps in the ELS

There are three major steps in operational surveys (Figure 3.1). The initial step has been covered in Part 2, and the latter will be dealt with in Part 4. Part 3 emphasizes data gathering — an integrated process which includes the description, comparison, and synthesis of data related to the biological and physical characteristics of the land. As such, it is geared mainly to field workers who are concerned with the methodology for ecologically classifying land.


Figure 3.1: Major steps in an ecological land survey

Conducting an ecological land survey (ELS) is largely governed by the conditions which are established in the initial planning step. For the survey to be successful, both the user's needs and the doer's constraints must be well understood. Failure to do so will likely inhibit the provision of the range of desired interpretations in the tertiary step. Since these conditions vary somewhat from one project to another, the manner in which an ELS is carried out will also differ slightly. Considering this, only an overall and generalized model of how to conduct an ELS is presented. The appropriate aspects can be extracted from the model to match the circumstances under which the survey must operate.

### 3.1.2 Purpose of Data Gathering

Data gathering in an ELS is an integrated procedure. Instead of stressing an isolated component of the system, it focusses on several components, especially the basic framework and relationships which sustain natural or man-modified ecosystems*. The most immediate purpose of data gathering is then to delineate and describe areas of land which have ecologically significant and recognizable similarities. The characteristics generally used to determine similarity are the more stable and collective characteristics displayed via soils, geomorphology, climate, vegetation, hydrology, and fauna. This procedure standardizes the characterization of land ecosystems and provides functional units which can be evaluated in ecological terms for various land uses.

### 3.1.3 Levels of Generalization

To what degree do areas of land have to be similar before they constitute a discrete land ecosystem? In part, the answer, like beauty, rests in the eye of the beholder. Depending on the perspective taken, it could cover large area generalizations such as the short-grass prairies or the arctic tundra through to small area generalizations such as bogs or estuaries. Each of these generalized forms of ecosystems has distinctive biological and physical land characteristics associated with it. However, they differ in the degree of overall similarity as the larger ecosystems tend to be more variable and diverse in terms of their characteristics. These different levels of generalization can be linked hierarchically. Units recognized at one level furnish the constituent parts of the next higher level. An example would be generalization such as the prairies, a unit which could include lower order generalizations such as the short-grass prairie, the tall-grass prairie, and the mixed prairie.

Since these differences in perceived similarity often correspond to the needs of various orders of land use planning and management, the ELS is hierarchically arranged according to different levels of generalization. Examples of planning and management tasks and their approximate match with levels of generalization have been presented in Table 2.1.

The names for the levels of generalization vary in the literature; for this publication, the names used by the Ecological Land Classification and Evaluation Division (Lands Directorate) are adopted. Table 3.1 provides definitions for each of the more common levels. Collectively, they could be considered as designations for areas of land of differing orders of generalization, each possessing a recognized common identity based on their inherent and unified pattern of biological and physical characteristics. To further assist in their identification, the criteria

* The term is often qualified as land ecosystem to avoid the confusion with other terms such as aquatic ecosystem, animal ecosystems, etc. Land is used in the holistic sense — including components such as soil, bedrock, surficial deposits, lakes, streams, etc.

Definitions for the levels of generalization.

ECOPROVINCE - an area of the earth's surface characterized major assemblages of structural or surface forms, faunal realms, vegetation, hydrological, soil and climatic zones.

ECOREGION - a part of an ecoprovince characterized by distinctive ecological responses to climate as expressed by the development of vegetation, soils, water, fauna, etc.

ECODISTRICT - a part of an ecoregion characterized by a distinctive assemblages of relief, geology, geomorphology, vegetation, soils, water, and fauna.

ECOSECTION - a part of an ecodistrict throughout which there is a recurring assemblage of terrain, soils, vegetation,

ECOSITE - a part of a ecosection in which there is a relative uniformity of parent material, soil, hydrology, and vegetation

ECOELEMENT - a part of an ecosite displaying uniform soil, topographical, vegetative and hydrological characteristics.

| LEVEL OF GENERALIZATION Common map scale* | EXAMPLES OF COMMON BENCHMARKS FOR RECOGNITION | | | | | |
|---|---|---|---|---|---|---|
| | Geomorphology | Soils | Vegetation | Climate | Water | Fauna |
| ECOREGION 1:3,000,000 to 1:1,000,000 | Large order landforms or assemblages of regional landforms | Great groups or associations thereof | Plant regions or assemblages of plant regions | Meso or small order macro | Large water basins | Assemblages of faunal communities. |
| ECODISTRICT 1:500,000 to 1:125,000 | Regional landform or assemblages thereof | Subgroups or associations thereof | Plant districts or assemblages of plant districts | Meso or large order micro | Drainage pattern; water quality | Faunal community or some specialized specialized habitat. |
| ECOSECTION 1:250,000 to 1:50,000 | Assemblages of local landforms or a local landform | Family or associations thereof | Plant associations or assemblages thereof | Large order micro to small order micro | River reaches lakes and shoreland | Specialized habitat within a community or a lower order community. |
| ECOSITE** 1:50,000 to 1:10,000 | A local landform or portion thereof | Soil series or an association of series | Plant association or community | Small order micro | Subdivision of above | Portions of a community or total habitats of some small species. |
| ECOELEMENT 1:10,000 to 1:2,500 | Portion of or a local landform | Phases of soil series or a soil series | Parts of a plant assoc. or sub-association | Small order micro | Sections of small streams | |

* Map scales should not be taken too restrictively, as they will vary with the setting and objectives of the survey

** More so than others, this level is frequently subdivided into phases to indicate a passing or temporary state (eg seral)

Table 3.1: Levels of ecological generalization proposed by the Canada Committee on Ecological (Biophysical) Land Classification.

generally used to recognize a particular level are also noted in Table 3.1; and the general telescoping perspective associated with these levels is illustrated in Figure 3.2. As these levels of generalization are hierarchically nested, a lower order generalization (e.g. ecosection) is a subset of a higher order (e.g. ecodistrict), and therefore contains its characteristics as well. Examples of these levels of generalization are presented at the end of this section.

## 3.2 THE PROCESS OF ELS

Table 3.2 lists some of the considerations for each of the three major activities of an ELS.

Table 3.2: General Summary of the ELS Process

PREFIELD ACTIVITIES

(A) Establish What Work Is Desired
- select project leader
- define goals and objectives clearly
- identify manpower, time, and monetary constraints
- develop initial work schedule

(B) Field Preparation
- in depth background research and review
- select and consult field team
- consult known expertise
- obtain work materials, equipment, and permits
- choose standards for description
- pretype land ecosystems
- plan for field sampling (timeliness, locations, etc.)
- arrange field support (aircraft charter, lodging, fuel caches, etc.)

FIELD ACTIVITIES

(A) Preliminary Overview and Review
- obtain a general overview of area
- evaluate sampling strategy

(B) Field Sampling
- collect data and modify pretyping where necessary.

POSTFIELD ACTIVITIES

(A) Analysis and Compilation of Data
- analyze and sort the data

(B) Classification of Data and Ecological Generalizations
- establish and describe the range of different land ecosystems
- refine map boundaries

(C) Storage of Results
- set up of storage system (report/map/computer)

(D) Evaluation of Data Base
- provide interpretations and generate plans and management programs

### 3.2.1 Prefield Activities

These activities are perhaps the most important. It is here where economies of money and time spent on classification can most often be achieved. As the next stage in the ELS process — field activities — is usually the more costly of the three, any effort which would curtail duplication or extraneous efforts in the field would make data gathering more effective and efficient. Consideration here would also ensure that critical times for certain types of data collection would be identified. Much of this work should be the responsibility of the field project leader — an individual with abilities to coordinate and appreciate interdisciplinary studies.

(A) Establishing What Work is Desired

The project's terms of reference govern the preparations for field work. Although there is some repetition of what has been said in Part 2, it is critical to obtain a clear set of references which indicate:

- the objectives and goals of the survey based on the proponent's needs;
- the intensity and degree of detail sought;
- the limitations in relation to time and manpower resources;
- the restrictions imposed by accessibility, current knowledge, field operations, etc.;
- and the needs of the assessment panel.

If these terms of reference are hazy, they should be clarified; discussion with the proponent of the work is usually the most expedient method.

(B) Field Preparation

Once the terms are set, the project leader can prepare a work schedule commensurate with the needs and constraints. The schedule should be flexible to allow modification as the ELS process progresses. Next, the project leader should establish what data must be collected, plus how, where, when, and by whom. The field support and equipment needed should also be arranged or considered.

(i) Background Research and Review

While a cursory review of existing data and information was done when the survey was being organized, greater depth is desirable at this stage. Collecting, analyzing and summarizing existing documents and maps indicates gaps in the environmental baseline, and the kind of survey team that should be selected. Known expertise should also be consulted — their knowledge frequently provides valuable insights. After this background evaluation, the difference between the existing and desired environmental baselines should be the information to be provided by the ELS. The availability of benchmark studies (vegetation chronosequences, environmental dynamics, sensitivity to land uses, etc.) should also be indicated.

(ii) Selection of Field Survey Team

The selection of a survey team depends largely on the existing baseline material, the size of the study area, the objectives, the intensity of the work and the nature of the environmental setting. However, under most circumstances at least a nucleus of crossdisciplinary professionals (refer to part 2) should be present. The general concept behind selecting a field survey team is to ensure that the group is collectively capable of respecting the needs and concerns of several disciplines rather than any one in particular. The team should, where possible, be kept together throughout the work to allow the integrated perspective of the environment to develop as fully as possible.

It cannot be overemphasized that data-gathering in an ELS is not simply the aggregation of a number of separate disciplines; rather, it is an integrative approach which develops best when a variety of team professionals maintain communicative contact.

(iii) Obtain Working Materials, Field Support, and Permits

As soon as the team has been picked, or in cases prior to this, the necessary materials and field equipment should be reviewed and secured. This includes the acquisition of remote sensing imagery (aerial photographs, LANDSAT, etc.), base maps, equipment (stereos, testing kits, etc.), and the arrangement for fuel caches, field camps, lodging, and transportation. Much of this hinges upon the nature of the work itself. For instance, detailed field work in an urban fringe may require items such as a truck, 1:25,000 air photos, a 1:25,000 topographical map and no base camp; exploratory work in remote areas may, however, require items such as LANDSAT images and small scale air photos, field camps, 1:500,000 and 1:250,000 topographical maps, and a helicopter and a fixed wing aircraft for transportation.

Permits may be required to conduct field work. In the Yukon and Northwest Territories, for example, a license for scientific activity should be obtained. Equally, regulations such as the Yukon's 'remote camp policy' should also be checked.

(iv) Pretype Imagery and Planning Field Checks

Appropriate remote sensing imagery (e.g. conventional air photos and LANDSAT images) should be pretyped to generate preliminary mapping units for the desired level(s) of generalization. Depicting these units at this stage is principally geared to observable differences in topography, drainage, erosion, tone, texture, and pattern. These differences in turn infer certain characteristics about the terrain, plant cover, and faunal habitats. These observations can be coded and placed on the individual map units and thus provide the initial start on a map legend. As there are many good texts on the subject of air photo interpretation, greater detail on how to make observation based on the various kinds of imagery can be rendered from them (e.g. American Society of Photogrammetry. 1975. Manual of Remote Sensing, Ed. by R.G. Reeves, A. Anson, and D. Lander. 2 vols. Amer. Soc. Photogram. Falls Church, Virginia).

A map unit may contain one or more distinctive land ecosystems. The reason for having composite map units is primarily related to cartographic convenience in that it may not be practical for the mapper to separate the individual entities in areas where changes take place over relatively short distances. At the ecosection level of mapping, for instance, it may be impractical to separate individual ecosections which occur within a complex consisting of eskers, kames and organics. Consequently, these type of occurrences tend to be enclosed by one map unit; the symbol used to code these map units usually indicates the relative percentage of each occurrence. Figures 3.3 and 3.4 show example composite-type map units and two different ways of coding them.

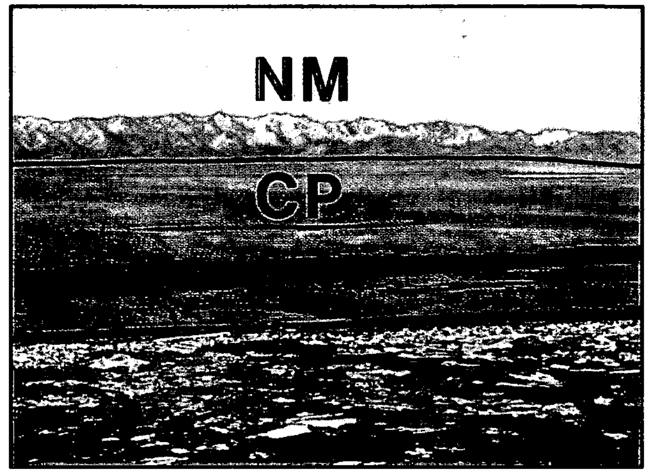
During air photo interpretation, the available literature and baseline material for the project area as well as other professionals in the team should be consulted. This photo-interpretion should be done primarily by the staff who are going into the field; some of the more repetitive and routine aspects of photo-interpretation can be delegated to competent technicians. After the boundaries of map units have been drawn on the imagery, the lines should be transcribed onto a base map (topographical map or airphoto mosaic); this will give the field team a better impression of the continuity of their mapping and an idea of the range and diversity of units. The scale for the base maps should correspond or be

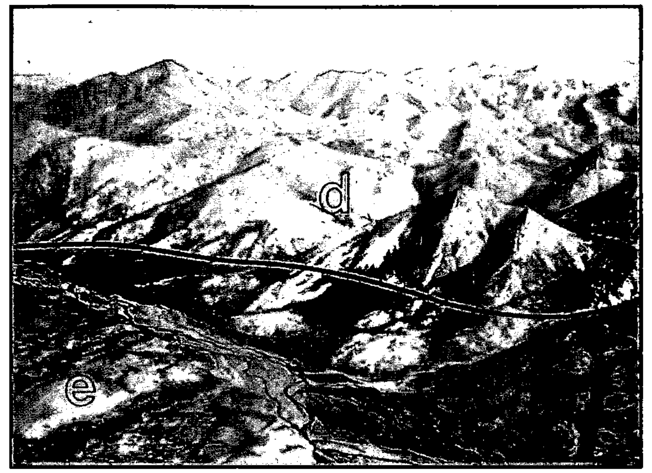
*FIGURE 3.2*

# ECOLOGICAL LAND CLASSIFICATION

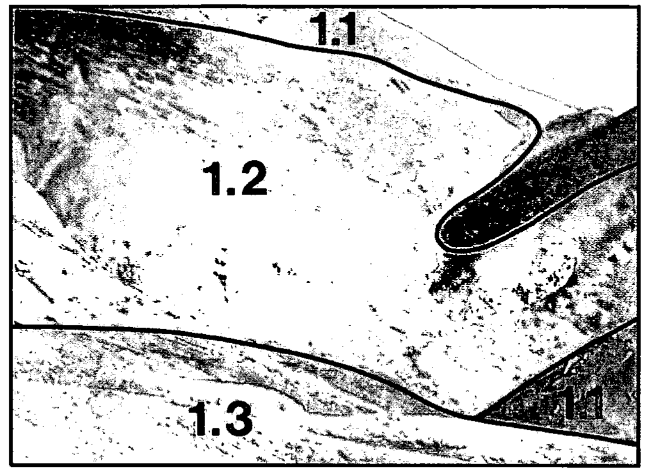
## ECOREGION — ECODISTRICT — ECOSECTION — ECOSITE — ECOELEMENT

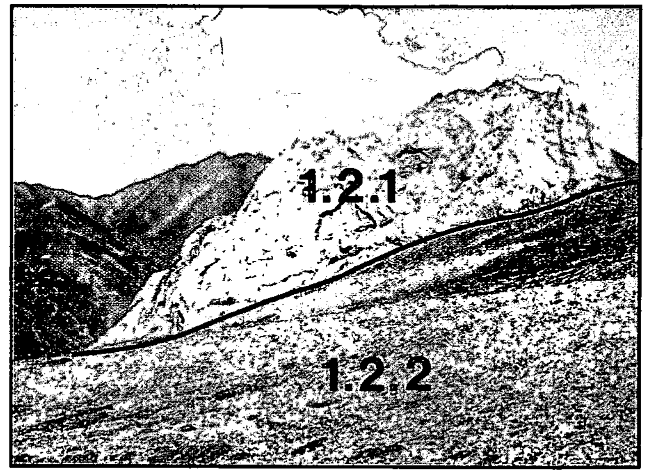
REPRESENTATIVE OBLIQUE PHOTOGRAPHS








BRIEF DESCRIPTIVE TEXT

| | |
|---|---|
| Ecoregion | CP NM |
| Ecodistrict | d e |
| Ecosection | d.1 d.3 |
| Ecosite | 1.1 1.2 1.3 |
| Ecoelement | 1.2.1 1.2.2 |

**Ecoregion:** A small portion of two *ecoregions* is shown on the above oblique photograph. In the foreground, the Coastal Plain (CP) ecoregion, a gently inclined surface, extends along the coastal areas of Alaska, Yukon and Northwest Territories. Wet soils, tussocky and almost continuous sedge-trailing shrub communities, and a foggy and cool maritime climate prevail through much of this region. The Northern Mountains (NM) ecoregion is contrastingly sparsely vegetated, rugged and mantled by colluvial detritus. Below, the ecoregion boundary is portrayed on a 1:1,000,000 topographical map.

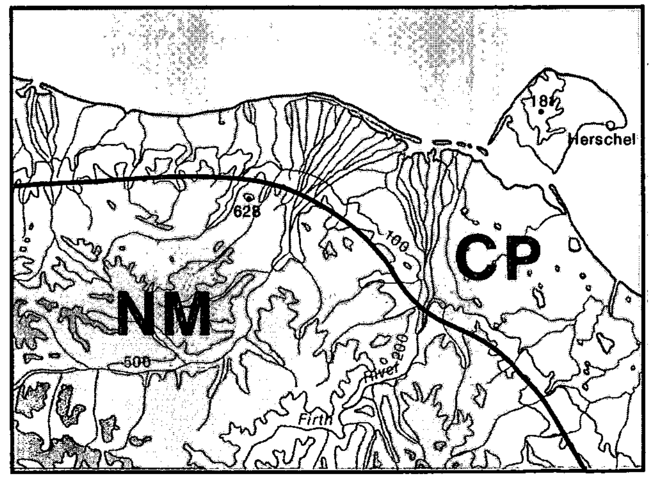
**Ecodistrict:** Each ecoregion can be separated into *ecodistricts*. The bold and outline letters are used to designate ecodistrict units (below on LANDSAT image) along a portion of the Coastal Plain and Northern Mountains ecoregions boundary. Above, the "d" in outline depicts a particular ecodistrict comprised of a chain of angular limestone formations which are mantled by rubbly debris and covered by sparse alpine vegetation. The letter "e" represents the margin of another ecodistrict that consists of low, rounded hills. Bedrock is largely shale; vegetative cover is fairly continuous and consists of sedges and low shrubs.

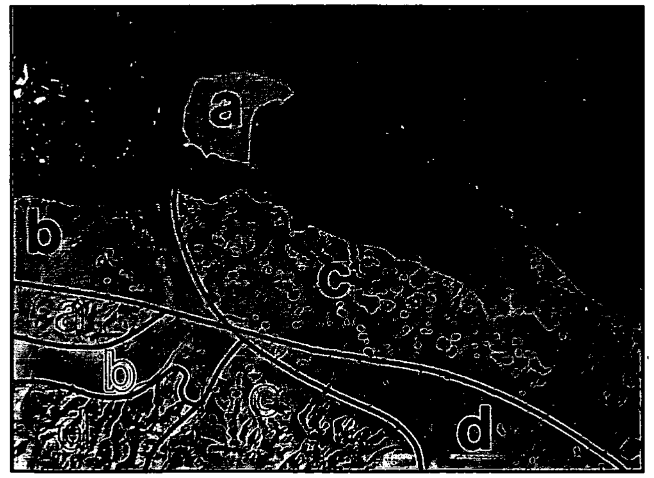
**Ecosection:** *Ecosections* are subsystems of ecodistricts—in this case, a portion of ecodistrict "d" (outline) has been subdivided into its respective ecosection map units. The units "d.1" and "d.3" are indicated on an oblique photo and below on a 1:50,000 conventional black and white aerial photograph. Within each unit there is a distinct assemblage and range of soils, local land forms, plant communities, hillslope hydrology and bedrock. Less perceivable is the micro-climatic association for each unit.

**Ecosite:** Ecosections such as d.1 can be further refined into yet other subsystems termed *ecosites*. In this case, they are noted via decimals of the integer 1. Ecosite map unit 1.1 is associated with shedding hillcrest positions; soils are poorly developed in this actively turbated limestone colluvium; the alpine plants provide sparse and discontinuous cover. Downslope, ecosite 1.3 represents a more stable medium in which there is greater variety and coverage of plant species; soil weathering is more marked in the colluvium. The map units are portrayed below on a 1:25,000 topographical base.

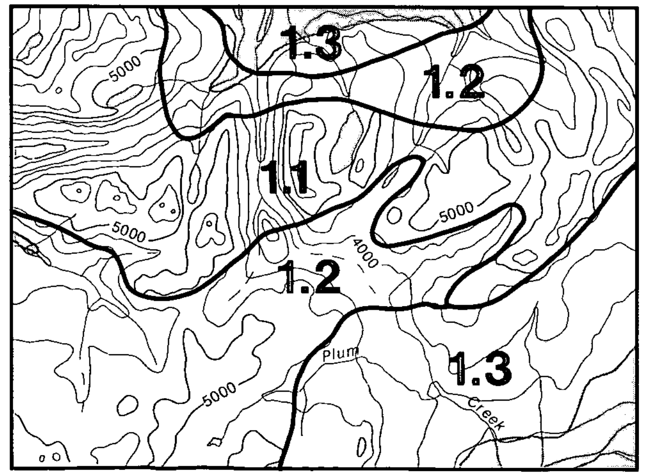
**Ecoelement:** *Ecoelement* represents the lowest level in the classification system. For illustration, ecosite 1.2 has been subdivided into ecoelements 1.2.1 and 1.2.2. The first map unit coincides with the crustose lichen community which covers pinnacles of limestone; these units are favored raptor nesting areas. Unit 1.2.2 is an exposed and windswept colluvial slope colonized by a mountain avens-saxifrage community; permafrost is near to the surface and soils are actively cryoturbated. Below, these two units are mapped on a 1:5,000 topographical base.

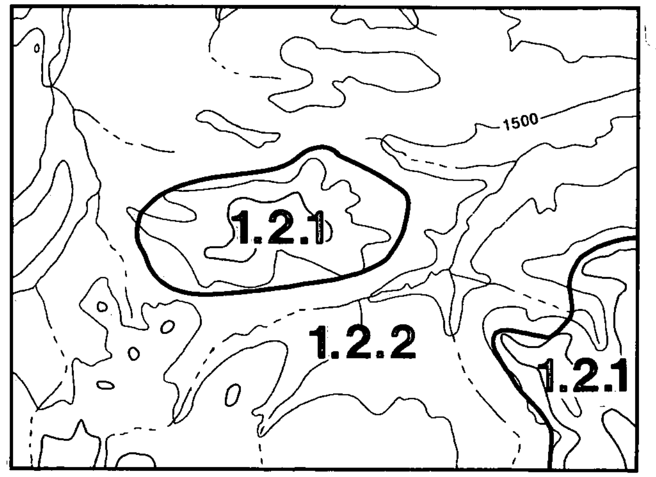
EXAMPLE BASE MAP FORMATS







commensurate with the level of generalization being treated.

In some cases, time may not permit the whole area to be pretyped; however, the imagery should be reviewed and some pretyping should be done to familiarize the team with the area and to allow a sampling strategy to evolve.

The mapping units drawn must be field checked. Even when much of the desired data and information already exists from previous single disciplinary studies, the accuracy of the work must be assessed and, if needed, upgraded. Where little base knowledge is present, the field checks provide the descriptive data.

The pretyping of the survey area assists in designing an efficient strategy for field checks. It relates the diversity of land ecosystems present and representative locales for sampling. Planning the shortest and most convenient route between these sampling spots minimizes field time and transportation costs and maximizes the gathering of significant descriptive characteristics for the range of land ecosystems identified.

Planning field checks can have other advantages. Previous experiences of the field crew on other field studies often reveal areas which are likely to receive the greatest impact as a result of the proposed development; more field checking could be planned for these vicinities.

(v) Choosing Standards for Descriptions

Beginning with at least the pretyping, the biological and physical characteristics of the land must be described. However, what standards should be chosen, and, more importantly, why?

Standardized systems for describing land characteristics provide for ease of understanding; without standardized terms, the works of others may not be fully understood or appreciated. Standardized systems are also important for producing compatible baseline material; as securing environmental baseline material may require building upon or extending the existing base, the job is simplified if the material is compatible. Also, impacts of projects often transcend jurisdictional boundaries; if each jurisdiction were to acquire baseline material following different systems of description and then had to reach a mutual agreement on action, the common denominator would be removed.

There are many systems for describing terrain, soil, vegetation, climatic and hydrologic characteristics. The standards proposed here, however, have been tempered through national efforts or currently seem most appropriate. Each system is somewhat flexible and should not be considered as an imposed straight-jacket. To avoid lengthy elaboration, they are only briefly discussed; the reports which explain these systems more fully are noted.

(a) Terrain

Terrain usually refers to the physical characteristics of the ground. This is the most permanent and enduring component of land. Terrain is synonymous in many cases with 'landform'. As most terrain mapping in Canada has developed at the 1:50,000 to 1:250,000 map scales, the present system of classification has concentrated on 'local landforms'. The system to classify these was developed by the Geological Survey of Canada in conjunction with the Canada Soil Survey Committee. It uses names which convey the geomorphic origins of materials, the dominant process involved and the form, thickness and texture of the material. The first reference presents the basic elements of the systems, and the second and third references provide a more detailed version. The fourth applies specifically to organic terrain.

Canada Soil Survey Committee. 1978. Landform Classification, Chapter 17 in: The Canadian System of Soil Classification. Can. Dep. Agric. Publ. 1646. Available from: Supply and Services Canada, Hull, Quebec K1A 0S9. (Catalogue No. A53-1646/1977, price $9.00).

ELUC Secretariat. 1976. Terrain Classification System. 55 p. Available from: Publications, Resource Analysis Branch, Ministry of the Environment, Parliament Bldgs., Victoria, B.C., V8V 1X4.

Fulton, R.J. and N.F. Alley. 1974. Terrain Analysis Legend Used In British Columbia. in ELC Series No. 0. pp. 15-21. Lands Directorate, Ottawa, K1A 0E7.

Zoltai, S.C., F.C. Pollett, J.K. Jeglum and G.D. Adams. 1973. Developing a Wetland Classification For Canada. in Proc. 4th North Am. For. Soil Conf., pp. 497-511.

A system for describing 'regional' landforms (represented on maps of scales of approximately 1:500,000 to 1:1,000,000) or what is commonly referred to as 'physiographic separations' is not as well documented in Canadian literature. They would include such

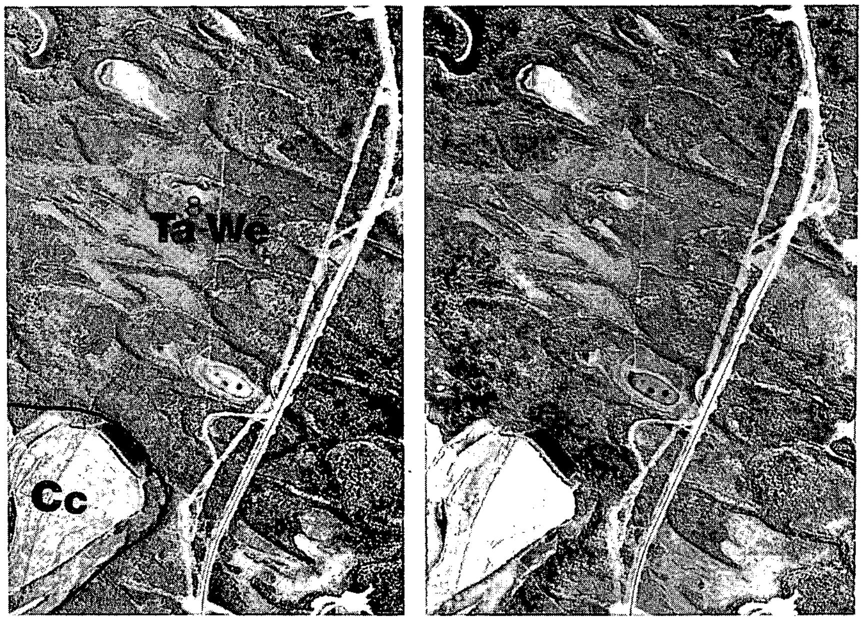



Figure 3.3: Map unit Ta-We contains an intricate mixture of vegetated barchane dunes and organic terrain; it would be considered a composite map unit. The superscripts indicate the relative percentages (i.e. 80% and 20% respectively). Cc is a simple map unit.

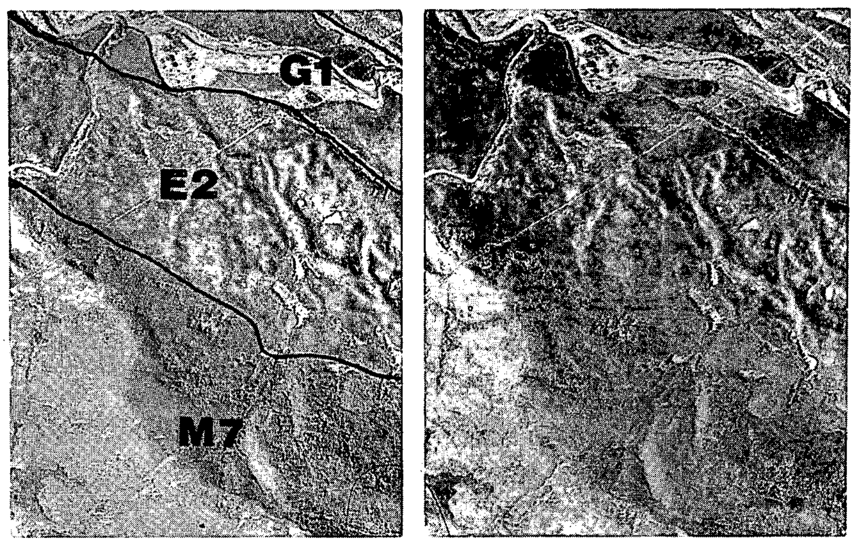



Figure 3.4: In this stereo photo-pair, map unit G1 is a simple unit. The other two units, E2 and M7, are composites. In this case, map convention does not require notation of either component part or the relative percentage of each since these are given in the text of the report.

phenomena as drumilinized till plains, interior plateaux and basins, etc. — landforms which would correspond to fourth and fifth order forms. Suggested references are:

Hammond, E.H. 1954. Small-Scale Continental Landform Maps. Ann. Assoc. Amer. Geog. Vol. 44:33-42.

Fairbridge, R.W. (ed.). 1968. The Encyclopedia of Geomorphology. Reinhold Book Corp., New York, N.Y. 1295 p.

(b) Soils

The Canadian Soil Classification System regards soils as natural bodies which reflect processes of soil genesis and environmental factors. This hierarchic system has five levels: order, great group, subgroup, family, and series. The order is the most abstract.

Soils are primarily described on the basis of diagnostic horizons and their inherent properties. Data accumulated typically include depth and/or thickness of horizons, texture, colour, temperature, stoniness, drainage, soil structure, pH, etc. The terrain classification system mentioned earlier is adopted for soils as well. Two references are appropriate for soil classification.

Canada Soil Survey Committee, 1978. Manual For Describing Soils In The Field. Available from: Agricultural Land Resource Research Institute, Central Experimental Farm, Ottawa, Ontario, K1A OC6.

Canada Soil Survey Committee, 1978. The Canadian System of Soil Classification. Can. Dep. Agric. Publ. 1646, 164 p. Available from: Supply and Services Canada, Hull, Quebec. K1A OS9. (Catalogue No. A53-1646/1977), price $9.00.

(c) Vegetation

Several systems of vegetation classification have gained a following in Canada. No one system appears to be acceptable in all respects, as regional biases are very apparent. The vegetation data, regardless of the system followed, should consider various plant groupings* in terms of their physiognomy, floristics, arrangement and probable successions. These data should be abstracted to parallel the land ecosystem generalization in question. Although the terms may differ, this could include highly abstract plant groupings such as 'plant regions' (e.g. arctic tundra) or more specific groupings such as plant associations (e.g. Ponderosa pine/blue bunch wheatgrass association). References include:

Oosting, H.J. 1956. The Study of Plant Communities. W.H. Freeman and Co., San Francisco. 440 p.

Daubenmire, R. 1968. Plant Communities: A Textbook of Plant Synecology. Harper and Row Publ., New York. 300 p.

Jurdant, M. et al. 1977. Analyse De La Végétation. Chapter 6 in: l'Inventaire du Capital-Nature. Ecological Land Classification Series No. 2. Available from: Supply and Services Canada, Hull, Quebec. K1A OS9, Price $7.00.

Descriptive data cards for vegetation normally cover:

- a location reference (e.g. air photo number, Mercator coordinates, sample number, date, altitude, aspect, etc.)
- present cover
- dominant species, codominants, etc.
- degree of variability or diversity
- development stage and probable succession
- life form and structures
- seasonality of dominants
- age, heights, and productivity of stands
- cover classes
- disturbance and intensity

(d) Climate

Owing to the dearth of weather stations in some areas in Canada, climatic classifications are usually made by inference from the vegetation or soil characteristics, or from such phenomena as permafrost. This is especially so in the north and with higher elevational areas in mountainous regions. In other cases, they can be derived by extrapolating data from existing short- and long-term weather stations. Whether generated by inference or by extrapolation, climatic classifications are commonly termed 'ecoclimates' in ELS studies. Macro, meso, and micro scale regimes of ecoclimates should be described where necessary to match the level of detail being sought. Data such as precipitation, radiation, and temperature can be extremely useful. While a specific ecoclimate classification system will likely evolve later through the Canada Committee on Ecological Land Classification, there are useful references:

* Vegetation 'grouping' is used here in a general sense.

Hare, F.K. and M.K. Thomas. 1974. Climate Canada. Wiley Pub. of Can. Ltd. Toronto. 256 p.

Oliver, J.E. 1973. Climate and Man's Environment. John Wiley and Sons Ltd. Toronto. 517 p.

Tosi, J.A. 1964. Climatic control of terrestrial ecosystems: a report on the Holdridge model. Econ. Geog. 40:173-181.

(e) Hydrology

Hydrology refers to the description and study of the properties, distribution and circulation of water on the surface, in the soil and underlying rocks, and in the atmosphere. This topic has been dealt with in several ecological or related type of land surveys. These approaches are summarized and analyzed in:

Welch, D.M. 1978. Land/Water Classification. Ecological Land Classification Series, No. 5. Available from: Supply and Services Canada, K1A OS9. Price $4.50

(f) Fauna

Wildlife and fish data should be collected. Census counts are not normally made in the data gathering step of an ELS. Census statistics are achieved mainly through complementary or additional studies. However, the range, distribution, and habitats of species can often be inferred from other baseline data (e.g. soils, vegetation, water, climate, etc.). This material can itself be used to indicate such things as ecological diversity, productivity, dynamics and interactions, etc. of the various land ecosystems.

Canada Committee on Ecological Land Classification. 1980. Land/Wildlife Integration Ecological Land Classification Series No. 11. Lands Directorate, Environment Canada.

### 3.2.2 Field Activities

Within this second major part of the ELS process, the study area is overviewed and the necessary data are gathered.

(A) Preliminary Overview

Before sampling, it is advantageous to gain a general perspective of the area to be surveyed. In small area studies, this can be done by touring the area by vehicle; in large area studies, an overview may involve the use of aircraft. This overview can serve several purposes:

- it familiarizes the field crew with the natural setting;
- it provides an opportunity to evaluate and adjust the field sampling plan; and
- it allows the field crew to review the pretyping.

(B) Field Sampling

The number and location of field samples will vary from one project to the next. They are determined by factors such as desired data, available resources (time, money, man-years) for the survey, existing baseline material, required map scale and level of generalization, and the complexity of the natural setting. Much of this is taken into account in the initial planning step of an ELS.

Field sampling is designed to permit the field crew to characterize the different land ecosystems identified, either through site-specific or transect investigations. As the sampling is an interdisciplinary effort, at least the nucleus of disciplines should be present to describe and discuss the areas chosen for field investigation. A 'nucleus' is stressed because often transport and time logistics may prevent the entire field team from going to the selected field sampling locations. To ensure that the desired data are collected at each sampling location, it is useful to have field data cards prepared before going into the field. Once a location is sampled the coordinates should be noted or the spot marked on air photos. A geographical reference will be useful for referencing of collected data.

### 3.2.3 Postfield Activities

In this final part of the ELS process, the field data must be compiled, reviewed, finalized and organized. Also, the levels of ecological generalization (e.g. ecoregion, ecodistrict, etc.) generated must be reviewed and organized. The format employed to arrange the data and generalizations should be compatible for both the intended user/and or interpretations. Although considered as part of the Postfield Activities, the aspect of generating interpretations will be discussed separately in Part 4.

(A) Compilation of Data

Some aspects of data collection cannot be readily compiled in the field. The analyses of soil and water samples as well as the identification of some plant species are examples. These raw data sets usually require analysis in the postfield step.

Data arising from complementary surveys also may be integrated at this time. Under normal field operations, seasonal dynamic phenomena such as the climatic or hydrological regimes are inferred because of the short field investigation time. In certain circumstances, the user may wish to have more exacting knowledge of these regimes and this means that complementary surveys would have to be set up to provide the additional data. The topic of collecting complementary sets of data is amplified in section 3.3.

(B) Classification of Data and Ecological Generalizations

Classification does not suddenly begin here; rather, there should be some consciousness of this goal throughout the three phases, with much of it culminating at this point.

The classification of raw data sets into a hierarchy of ecological generalizations may invoke dichotomy of thought. To some, 'classification' means that land ecosystems of one level of generalization are derived by logical division of more generalized levels; others feel that they are derived by assembling from more detailed levels. For example, an ecodistrict could be formed either by dividing ecoregions or by assembling ecosections. In practice, there is often a little of both, as each route tends to substantiate or modify the results of the other.

Though many meanings are offered, a classification is basically the recognition of similarities and the subsequent grouping of phenomena according to their likeness. For ELS, the phenomena in question are 'land ecosystems' — areas of land which demonstrate ecological unity. These areas are recognized on the basis of observable or inferred characteristics (e.g. data on soils, landforms, vegetation, hydrology, fauna, climate, etc.) which are collectively associated with a tract of land. Where these collective characteristics differ significantly, boundaries are drawn. These lines demark continua from one unit to another, rather than absolutes in change. This transitional gradient may be a relatively narrow zone (as in many mountainous settings), or it may be fairly broad (as in a plains setting).

When the data base is completed or near completion, the appropriate descriptions and maps can be generated. This descriptive phase will be based on the results of the field study and on material available from other investigations of the project area.

For purposes of description, the primary concern is to identify and to characterize the various land ecosystems which occur within the project area. Land ecosystems can be identified by names (e.g. Beaver River Ecoregion or Gull Lake Ecodistrict); numbers or letters, alone or in combination (e.g. Ecoregion 1, Ecoregion D, Ecoregion D1 or Peak Mountain Ecoregion D1); or by other means. The system followed should be easy for the user to understand. When the project involves the mapping of two or more different levels of generalization, the system should also allow for ease in seeing the relationships which exist between levels.

When characterizing land ecosystems according to their biological and physical characteristics, both summaries <u>and</u> detailed text are helpful; this gives the reader the option for a quick general characterization or a more detailed one. Summaries can be in the form of representative photographs of the area, a table of dominant characteristics, or a diagram. Within the text, the individual components and relationships should be discussed.

Following or in conjunction with description of land ecosystems, the pretyped lines should be refined and the base map having these transcribed lines should be finalized. Each map unit should then be symbolized to indicate to which land ecosystem it corresponds. If, for mapping convenience, the map unit encloses two or more land ecosystems, each should be indicated. Map unit symbols can range from simple conventions (e.g. a numerical reference code) to complex conventions which provide abridged descriptions of the unit.

(C) Storage of Results

The results of the field work and the ecological generalizations can be stored on maps, in reports, on computer tapes, or a combination of these. What is used will depend on the nature of the survey. For small order projects, a map with an expanded legend may suffice; for a large order project, such as the Mackenzie pipeline study, computer storage may be emphasized for ease of retrieval and manipulation. The format chosen for data storage should principally have the user in mind. It should readily allow pertinent data or information to be extracted, both for general knowledge and for specific evaluations.

(D) Evaluations of Data

Part 4, which follows, outlines more fully the interpretations of the information base for various land uses. In addition, it illustrates how the base can be employed to produce plans and management schemes. The important thing to associate with evaluations of data is both to meet the needs of planners and managers and to render the baseline information onto a format which can be readily understood by the audience at hand.

## 3.3 COMPLEMENTARY FIELD SURVEYS

The data gathered through an ELS may need to be complemented by data collected via sectorial-oriented surveys. As these are not normally considered as part of the field activities of an ELS, they are treated separately in Part 3. Nonetheless, complementary surveys should be considered during the planning of an ELS and should be integrated, where possible, with ELS activities.

Complementary field surveys are designed to secure data and information on environmental components which vary, often dramatically, over short periods of time; these fluctuations cannot be readily detailed from limited field investigation. for example, weather conditions, hydrological regimes, water quality characteristics, and limnological conditions follow daily or annual cycles; also, fish and wildlife populations fluctuate due to daily or seasonal movements and migrations, climatic or hydrological conditions, changing habitat conditions, intrinsic biological factors, etc. Although these variations make data collection difficult, the proponent often needs information on these environmental components. This is particularly true when developments may have impacts on hydrological regimes, water quality, climate and fish and wildlife populations, or when these may affect the development.

The methods used in complementary field surveys must consider the nature of seasonal conditions. Fish and wildlife, for instance, must be censused at times of year when the habitats are being used if reliable population estimates are to be attained. Similarly, data on climatic and hydrological extremes can only be obtained during appropriate seasons and over several years.

# PART 4
# HOW TO USE AN ECOLOGICAL LAND SURVEY DATA BASE

## 4.1 INTRODUCTION

### 4.1.1 Project Phases and Activities

Projects typically evolve through a number of phases, as outlined, most with some degree of environmental impact. The activities which give rise to impacts (described in FEARO's "Guide for Environmental Screening") are listed beside the appropriate project phases. These terms are used throughout this Part.

| Project Phases | Activities which lead to environmental impacts |
|---|---|
| Conception ------- | Not Applicable |
| Planning --------- | Investigation |
| Development------- | Construction |
| Operation--------- | Operation and Maintenance |
| Abandonment------- | Dismantling, Disposal, Removal of Safeguards |
| Spinoff Projects-- | Future and Related Activities |

### 4.1.2 Assessment Criteria and the Need for Environmental Data

The "Guide for Environmental Screening" lists the following six criteria that can be used when making a decision as to the environmental effect of an activity.

| Screening Criteria | Euphemism or Explanation |
|---|---|
| Magnitude --------- | severity |
| Prevalence -------- | cumulative effect (spatial) |
| Duration and Frequency -------- | cumulative effect (temporal) |
| Risks ------------- | probability of occurrence |
| Importance -------- | an area's value or uniqueness, etc. |
| Mitigation -------- | available solutions that can be designed into the project. |

These criteria are not limited to environmental screening; however, they apply to all levels of impact analysis. In the first five criteria, impact assessments can be made only by interweaving knowledge of the project's activities with that of the environment — the land, its ecology, and its resources. 'Mitigation' may also require environmental information, as when streams are to be rerouted, or when sand or gravel is excavated.

## 4.2 APPRAISING AN ECOLOGICAL LAND DATA BASE

### 4.2.1 Introduction

Where an ecological land data base is to be used, the project planner(s) must always decide whether it meets the project's objectives. This 'appraisal' step applies in three situations:

- where a survey was conducted for the particular project and its environmental impact assessment,
- where a survey was conducted as part of the project's conception and planning, and
- where a previous survey is available to the project's planners.

In the second and third instances, the project planner may also wish to use the ecological land data for the various stages in the Environmental Assessment and Review Process. The early availability of these data may save much time and money by foretelling deleterious effects, and by encouraging alternate designs and mitigation in the conceptual and planning phases of a project. Sources for this and other environmental data are listed in Part 2. In all three situations, the proponent should appraise the ecological land survey by considering the following:

- area to be covered
- level of generalization
- amount of information for each mapped unit, and
- the reliability given to mapping and information content.

### 4.2.2 Area

Direct and indirect environmental impacts arise from the interaction of certain activities (see the FEARO's "Guide for Environmental Screening") with certain elements of the land and people (see the FEARO's "Guidelines for Preparing Initial Environmental Evaluations"). Potential impacts are not limited to a construction site; they may also arise from resource extraction (e.g. mining or logging), disposal (e.g. mine tailings or thermal discharge from power stations), and access (e.g. dust and noise associated with highways). Impacts may also be indirect, as when a transportation corridor generates hunting and fishing for many kilometres on either side, or when a dam reduces downstream water levels and alters the ecology and productivity of floodplains, marshes, and lakes.

#### 4.2.3 Level of Generalization

The levels of generalization of ecological land survey range from the relatively broad ecoregion to the detailed ecoelement. The choice of a more detailed level at which to evaluate impacts follows from increases in several of the assessment criteria: (a) the magnitude of impacts, (b) the risk of impacts, and (c) the importance of the area. Conversely the use of a more general level may be favoured by increased degrees of (a) the prevalence and (b) the duration and frequency of impacts.

Also affecting the choice of level are the phase and related activities reached by the project. A proponent may wish to anticipate impacts even at the conceptual phase of a project. To do this, the general information of the ecoregion level will be useful. For development, operation and abandonment phases, however, environmental impact analysis should be quite detailed, (e.g. at the ecosite level). For planning and future activity, an intermediate level, such as the ecodistrict, may be satisfactory.

Whether using an existing data base or sponsoring a new one, there are thus several tendencies, each with its own components, to be balanced when selecting a level of generalization for environmental impact assessment. To define rigid guidelines to make this choice is not practicable. Instead, the proponent should consider these factors and arrive at a reasoned choice — there are, after all, no more than four, and often only two or three, mapping levels from which to choose. When only a broad ecological land survey has previously been conducted, these same judgements should be used for deciding whether to infill or add to the existing data base by additional survey. The choice of level for impact analysis, using ecological land data, may be guided by Table 2.1. The FEAR Office may also be required to give specific guidance, taking into account the nature of the project and the many factors listed here.

#### 4.2.4 Information Content

Do the existing land data contain an adequate range of information for the impact analysis? Despite the concept of an ecological, integrated, land classification method, the science is still developing. To date, most surveys have featured landforms, soils, and vegetation, whereas water, wildlife, land use and climate data are usually lacking. The proponent may have to sponsor the addition of this information. This is especially true for fish, wildlife, and water surveys, where much more emphasis is on dynamic phenomena occurring at specific locations. Ecological Land Survey alone should not be expected to provide this information, although it may help in planning strategies to collect it.

It may or may not be easy to integrate extra thematic material into existing, partial land data bases. Integrated classification and mapping of the environment depends partly on the number of disciplines involved. It may arise, for example, that additional data, such as on water or wildlife, do not fit well into existing map units or legends. The proponent must be ready for this. Problems of integrating additional disciplines may be resolved through consultation between the proponent, the team that conducted the existing land survey, and a complementary single-discipline team.

#### 4.2.5 Reliability

Reliability means the degree to which a particular ecological land survey can be relied upon to provide the data and answers needed by the proponent or planner. In this general sense are contained several notions. For example, does the survey fill the information gaps established during the organization phase? Are the data collected in a way guaranteed to minimize error? Does the data collection methodology meet standards acceptable to the appropriate disciplines? Was the survey conducted at the right time(s) and places(s)? etc. In short,

- are they the right data, and
- are the data right?

The proponent/planner must here rely on his in-house expertise to evaluate the survey in terms of the specifications drawn up in the organization phase.

In the event that a proponent finds that previous ecological land survey work has been done, there is another aspect of reliability that must be evaluated before the data are adopted for use. Ecological land surveys can be conducted at any of several degrees of reliability, being either exploratory, reconnaissance, or detailed at any of the levels of generalization. This reliability is usually chosen according to whether or not specific projects have been formulated for an area, the extent of the area, and whether or not further, more detailed land classification is anticipated. Within this context, the reliability of ecological land data depends on the design and amount of supporting field work, the quality of the team and the expertise of the individuals.

The proponent must be careful not to apply data that was collected at a level of generalization or a degree of reliability less than that required for the project. For example, conception and general regional planning of recreation or conservation often require exploratory or reconnaissance data. More direct use of resources generally needs more reliable data. For hydroelectricity development, for example, this could mean detailed work at the ecosection mapping level, whereas for forest management, detailed standing crop data at the ecosite level is essential. Although it has indeed been tried in the past, simple enlargement of a map is an inadequate and deceptive way of providing data at larger scales.

## 4.3 INTERACTION BETWEEN THE PROPONENT AND THE SURVEY TEAM

### 4.3.1 Responsibility of the Proponent

A skilled ecological land survey team could interpret their data in many ways. Nevertheless, the proponent must specify the activities for which impacts are to be assessed. With this knowledge, the practitioners (land survey team) or the proponent with in-house expertise can select from the data appropriate information, can compare the relevant data, and can predict what, where and how much impact may occur.

In particular, there are occasions when the required information may appear trite or not relevant to the survey team, and so they do not consider reporting it. This happens because planners and surveyors each have their different backgrounds and expertise, and cannot accurately guess the needs of each other. Again, therefore, the proponent must assume the responsibility of clearly specifying his projected activities and information needs.

A previous section of these Guidelines discussed the organization of an ecological land survey. A part of this is the establishment of a "core-group", or single person in the case of small projects, which can liaise between proponent and practitioner. This core-group should work closely with the survey team to devise and report on interpretations of the ecological data base. Normally this core-group would provide a continuation to the Screening and Initial Environmental Evaluation functions already undertaken by the proponent.

### 4.3.2 Responsibility of the Survey Team

Ecological land survey data often appear complex at first glance. Each map unit may have fifteen, twenty or more numbers or letters attached to it, plus index cards and written descriptions, summarizing a number of specialist views of the unit of land. This mass of data may intimidate a planner, especially one who is not familiar with the multidisciplinary nature of ecological land data. Thus, there is a clear responsibility on the part of the practitioner to fully explain his methods and results to the planner. The mechanism for this is the core-group as discussed in Part 2.

While conducting an ecological land survey the team may find features of special interest, such as unique landscapes, unusual vegetation, fish or wildlife, sensitive ecosystems, and so forth. The practitioner has a responsibility to report on these, even if not specifically asked to do so. Such information may be reported through letters, special reports, appendices, etc.

### 4.3.3 Communication

To assure these interactions between planner and surveyor may require several workshops and training sessions. Face-to-face consultations are a must, even to the extent of being in the field together or sharing in overflights. If the practitioner is from private industry, or a cost-recovery governmental agency, then the proponent must expect to pay for this interaction. This expense, however, is one of the most important single factors that help assure the success and sound application of an ecological land survey.

## 4.4. DATA ANALYSIS

### 4.4.1 Introduction

Data analysis refers here to all those retrieval and interpretive activities that begin with a completed ecological data base and end with one or a series of data sets describing opportunities, limitations, and other special qualities of land within the ecological land survey area.

To date, most ecological land surveys have produced a map base of contiguous units of land, an extended legend, ten to twenty characteristics per unit, and text descriptions of ecoregions, ecodistricts, processes, special features, human occupation, etc. The maps provide a spatial reference and allow comparison with other spatial data such as geology and climate maps. For large data bases, overlays and analyses of this nature may be facilitated through the use of computer geographic information systems. Advice on this subject may be obtained from:

Canada Land Data System Division
Lands Directorate
Environment Canada
Ottawa, Ontario, K1A 0E7
Tel: (819) 997-2510

The legends, characteristics and classes are the basic data which provide for comparisons between units of land for a variety of attributes, both observed and interpreted. On the other hand, the textual descriptions, along with the choice of the legend's contents, help to formulate the manipulation of the data. A broad knowledge of an area, an understanding of its ecology, plant dynamics, water regimes, etc. permits meaningful and consistent interpretations. Often these interpretations are best worked out by the ecological land survey team itself; having conducted a survey, they are the ones with the best overall ability to devise the varied scenarios for impact analysis. Where appropriate, however, the in-house liaison group may best be qualified to handle the data instead.

### 4.4.2 Retrieval of Basic Data

Ecological land survey is an integrated, interdisciplinary method of mapping and describing unified tracts of land. This holism often creates the impression of complicated units which are somehow difficult to visualize or understand. This need not be the case, however. Although each map unit portrays an ecological entity, its descriptive information still contains basic data organized along disciplinary lines. A useful beginning to the analysis of ecological land data is to retrieve some of these single criteria. When a number of these basic data retrievals are done, the commonality of map units becomes clear. This is one of the strengths of ecological land classification - avoidance of conflicting, cluttering overlays of maps, and the easy recognition of the ecological relationships among environmental components. Certain characteristics are identified directly from air photos or topographic maps and are recorded for each mapped unit. They commonly include many of the following:

(i) Landforms
- physiography, (hills, plains, mountains, etc.)
- elevation above sea level
- local relief
- slope
- thickness of surface materials
- modifying processes
- surface expression, (slopes, local forms, etc.).

(ii) Vegetation
- general vegetation type (e.g. Arctic tundra, mixed hardwood forest, etc.)
- cover
- fire and other disturbances

(iii) Lakes
- lake size and shape
- lake cover
- land ecosystems bordering large lakes
- insulosity
- drainage condition (i.e. open, restricted, or closed lakes)
- backshore slope
- shoreline material
- shoreline pattern
- shoreline processes
- offshore slope

(iv) Rivers
- channel pattern
- rapids, obstructions, etc.
- size of streams and rivers
- erosional and depositional features
- abundance of small streams

(v) Land Use
- resource use
- engineering works, buildings, etc.

Depending on the staffing and support given to the ecological land survey team, and depending on the nature of the study area and the type of development, these characteristics may vary in their detailed breakdown (classes). Hence, no rigid set of classes is proposed here. A few examples of actual ecological land classification legends are included in Part 3.

There are other characteristics available apart from those listed above. These additional data relate information which was observed directly at various reference sites on the ground, and which can be keyed into air photo interpretation characteristics and extrapolated for each map unit. For example, a combination of climate at the ecoregion level, altitude, surficial materials and vegetation physiognomy can be interpreted for soil association or vegetation chronosequence. These 'derived' basic characteristics include:

(i) Landforms
- genetic origin of surface materials
- texture of surface materials

(ii) Soils
- depth
- pedogenesis, association
- stoniness, texture
- pH, fertility
- permafrost, turbation
- water regime in soils

(iii) Vegetation
- species, phytosociology
- abundance, percent
- structure, dominance
- chronosequence
- regeneration

(iv) Fish and Wildlife
- habitats (potential, critical, or specialized)

- possible species

(v) Lakes
- water quality
- lake origin
- depth class
- shoreline processes

(vi) Rivers
- water regime
- sediment load and bedforms
- bank stability
- channel type (substrate materials)

(vii) Ecoclimate- an amalgam of soil and plant conditions

For both of these lists of basic ecological land data, the limit to their availability is set by the limits of funding, man years, elapsed time and expertise available. These limits are more critical for the second list, however, as it is based on the number of field checks and supporting logistics, which are the more expensive parts of an ecological land survey. Nevertheless, the extent of the lists reflects the flexible, and hence, cost-effective nature of ecological land classification, as compared to independent surveys to procure each factor separately.

Apart from helping to give overviews of a project area, retrieval of basic data is sometimes of direct use in impact analysis. Certain activities can be predicted to have adverse effects on certain natural conditions of land. Examples are heavy vehicles moving across steep slopes, septic tanks in shallow soils, embankments across flood plains, and sand and gravel extraction from stabilized beaches. They rarely require manipulation of more than one or two characteristics of the map legend, and don't need the weightings and comparisons involved in producing interpretations such as lake productivity, trafficability, risk of erosion, etc. Ecological land surveys therefore provide an easy method of predicting Prevalence, Risks and Importance of many types of environmental impact.

### 4.4.3 Interpretations

The preceding paragraphs show that basic data can be retrieved for certain types of impact analysis, namely those activities having a predictable impact on certain natural conditions of the land. These predictions are generally based on the recognition of a well-defined threshold, below or above which environmental impacts are known to occur. Examples are critical slope angles for slope failure, texture of surface materials for surface run-off and erosion, and the physiognomy of vegetation for the risk of fire, etc. These kinds of predictions relate mainly to the FEARO Screening criterion of Prevalence of an Impact, since the resulting interpretation will generally be a map showing the distribution and extent of units of land possessing certain sensitivities.

Many other impact analyses demand the prediction of degree as well as of kind. These predictions are largely related to the FEARO Screening criteria of Magnitude and Importance. Information on several kinds of impact is sought out through this predictive work. They are:

(i) Direct Impacts - measured by the degree (Magnitude), of sensitivity, trafficability, etc., or by the probability (Risk), etc.,

(ii) Indirect Impacts - either:
positive, such as unwanted or unplanned activities following a project, an example being hunting brought about by introducing roads into a hitherto inaccessible area; or
- negative, such as the preclusion of alternate land uses when a reservoir floods potentially productive agricultural or forest land.

Viewed in this way, proper impact analysis converges with integrated resource planning, since spinoff and related projects may spur natural resource developments in their own right, or impinge upon present land uses or preclude future ones. Ecological land surveys can be interpreted to predict and plan for many of these factors. The following list shows this flexibility of interpretation.

(i) Agriculture
- soil capability according to limiting factors
- soil capability for a diversity of crops
- soil erosion risk
- management problems, such as the need for irrigation, drainage, flood hazard, etc.

(ii) Forestry
- productivity potential, e.g. by $m^3$/ha/year
- potential for diverse species
- preferred species for replanting
- replanting cost
- production costs of plantations, e.g. cost/benefit
- trafficability for heavy machinery
- windthrow risk
- fire hazard
- potential for natural regeneration
- natural regeneration after clear-cutting, e.g. which species
- natural regeneration after fire
- potential for increasing stream sediment loads

(iii) Outdoor Recreation
- landscape attractiveness
- surrounding vistas, panoramas, etc.
- exceptional features
- river navigability for canoes
- sportfish potential, e.g. species, catch limits

(iv) Wildlife
- land capability for ungulates, e.g. moose, caribou, etc.
- capability to support waterfowl
- land capability for fur-bearers, e.g. beaver, otter, marten
- land capability for plants used by wildlife

(v) Rivers and Streams
- risks of bank erosion or deposition, bed scour, etc
- fordability
- fish spawning and migration areas
- flood risk, magnitude and probability
- tolerance to increased flows
- tolerance to water level regulation and/or reduced sediment
- tolerance to thermal discharge

(vi) Lakes
- potential productivity
- tolerance to nitrates and phosphates, thermal discharge, etc.
- risk of shoreline erosion
- relative depth of freezing

(vii) Engineering
- potential for aggregate materials
- type of soil to support foundations, piles, etc.
- risk of thermal collapse
- trafficability as a function of soil surface
- trafficability as a function of slopes and local relief
- thickness of overburden

### 4.4.4 Data Reduction

All of these interpretations require that one or several characteristics be compared and combined according to their relative importance for the particular activity and impact. The selection, relative weighting, and method of combination must be done with due considera tion for the reference data collected in the field by the survey team, the existing methods of measuring potentials and limitations such as for the Canada Land Inventory, or along the lines used by several ecological land surveys. These latter rank land according to whether or not a map unit possesses certain attributes, or alternatively, combine several characteristics after weighting them, and then sum the weighted class values to produce a numerical scale of potential, risk, sensitivity, etc. Whatever method is chosen to produce interpretations, the interpreter (proponent's in-house group, or the survey team) must clearly specify the method used, according to:

- which characteristics were used, and why?
- how do these characteristics relate to each other in importance or interaction?
- how do the class intervals affect the (interpretation?)

Good interpretations may depend on consultations with members of local communities; local knowledge provides a kind of field check tested over many years. Whenever a final evaluation of impact is achieved, it is desirable to express this in a limited number of impact classes, usually from three to seven (e.g. high risk, moderate magnitude, etc.). Such final interpretations are understandable to a wide variety of disciplines and to the general public, especially if the public has been involved in designing the method of interpretation.

### 4.4.5 Examples of the Analysis of Ecological Land Data

#### 4.4.5.1 Introduction

There are several methods of analysing ecological land data. Among these are:

- Single-factor: the use of only one characteristic;
- Added-factor: the progressive adding of characteristics according to increasing limitations, potentials, risk, etc.;
- Sorted-factor: the use of several characteristics, treated in a step-wise manner somewhat like a binary key although not restricted to yes/no decisions; and
- Weighted-factor: where several characteristics are combined arithmetically to reflect the relative importance of each.

#### - 4.4.5.2 Single Factor Analysis

This is the simplest of the four methods. It uses only one characteristic and is essentially the retrieval of basic data as referred to above (4.4.2). The characteristic can be transformed into two or more classes, depending on the need of the user. For example, at the ecosite level, organic terrain usually eliminates land for purposes of building; simple yes/no, presence/absence classes are all that are necessary.

Single-factor analysis is illustrated in

Figure 4.1a with data from the northern Yukon ecological land survey (Wiken et al, 1978). Here, the presence of icings is taken to mean that a unit of land has significance for overwintering of fish (Table 4.1a and Figure 4.1a). Some evaluations, however, can relate to a scale of values. For example, opportunity for float-plane landing, useful for developing a forest fire-fighting strategy, could be based on various classes of lake size. The number of evaluation classes is limited only by the number of classes in the basic data. This method is particularly useful for introducing a user to the flexibili ty of ELS data or in situations where clear-cut opportunities/limitations, etc. exist.

#### 4.4.5.3 Added-Factor Analysis

This approach to land evaluation was used by the Canada Land Inventory. It is useful where limitations or capabilities change according to the presence or absence of an increasing number of features. It is also useful where relatively few units are to be considered (e.g. less than 200), so that complex computing facilities are not justified. Thirdly, it has significant benefits when users are familiar with the Canada Land Inventory, since results and recommendations are more acceptable when the user (the public or a proponent) understands how conclusions are developed.

One example of the additive approach is in evaluating wind erosion potential from land clearing operations. Wind erosion risk might increase progressively as more and more appropriate conditions occur in an area, such as clay or silt soils, level terrain, dry soils and high winds. In another example. (Table 4.1b and Figure 4.1c) pipeline construction might be hindered by high local relief, muskeg, unstable slopes, moist soils, many lakes, many river crossings, and the absence of valley flats. As more of these occur together, construction difficulty increases. Note, however, that some characteristics are sufficient to increase construction difficulty more than several others combined. In this example, the absence of valley flats is deemed to create "many limitations". Thus, although the scale is additive, it is not uniformly progressive.

#### 4.4.5.4 Sorted-Factor Analysis

This approach is similar to the keys used frequently in identifying plants, rocks or minerals. As shown by Table 4.1c, each unit falls into a specific class according to the value of each several characteristics. In this example, four characteristics are considered, one of them with three divisions, the others with two. The sequence of factors does not matter; more important is the final evaluation class assigned to each "pathway". This is an arbitrary decision and requires good ecological knowledge to give valid interpretations.

Another caution: the method produces many "sets" of factors, but many of these should have the same evaluation class since some factors cancel out vis-à-vis land capability, sensitivity, etc. In the example used here, land erosion potential during pipeline construction, 24 "sets" are assigned only seven classes of erosion potential.

With these cautions in mind, we recommend the use of a sorted factor approach when a large matrix of basic data (many characteristics and many units) must be analyzed without computing facilities. Clear-cut decisions can be quickly achieved manually without the need for a great deal of memorization.

#### 4.4.5.5 Weighted-Factor Analysis

The final method presented here is recommended for use only with detailed field work upon which to base selection and weighting of variables, and with large sets of data whereby use of computers can be taken for granted as a means of handling data. These situations might arise in regional surveys for resource development, corridor planning and selection, or national studies of policy or program impacts using, for example the Canada Land Inventory or the Northern Land Use Information Series.

Like sorted-factor analysis, several variables are considered for each and every unit and evaluation class. However, based on field work and other background knowledge, each variable is "weighted" according to its relative importance to the evaluation. For the example here, disturbance to waterfowl during operation of an all-weather road (Table 4.1d and Figure 4.1d), the area of lakes is considered to be more important than elevation by a ratio of 30:20 (percentages are easiest to deal with).

The next step is to convert all variables used to a scale of 0-10, with higher values having greater potential for disturbance. It is extremely important that all variables are scaled in <u>the same direction</u>, otherwise some high and low evaluations will cancel out. Some basic data scales may have to be inverted; some qualitative scales (e.g. soil or plant types) may have to be assigned values very carefully.

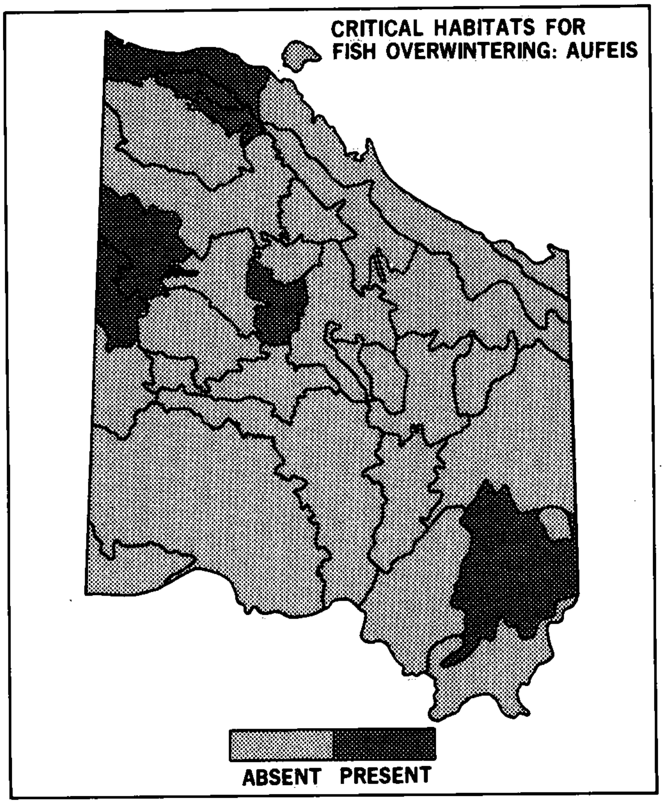



**FIGURE 4.1a: SINGLE FACTOR**

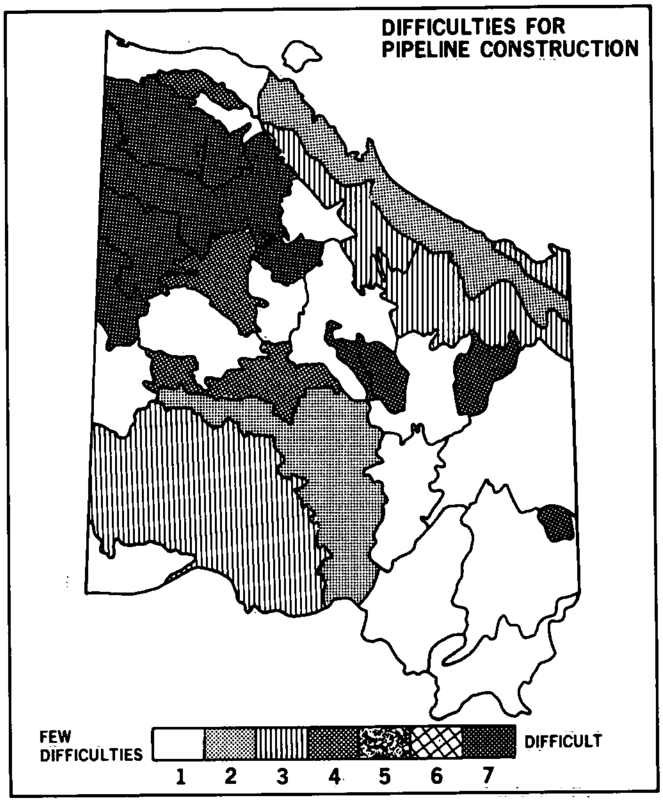



**FIGURE 4.1b: ADDED FACTORS**

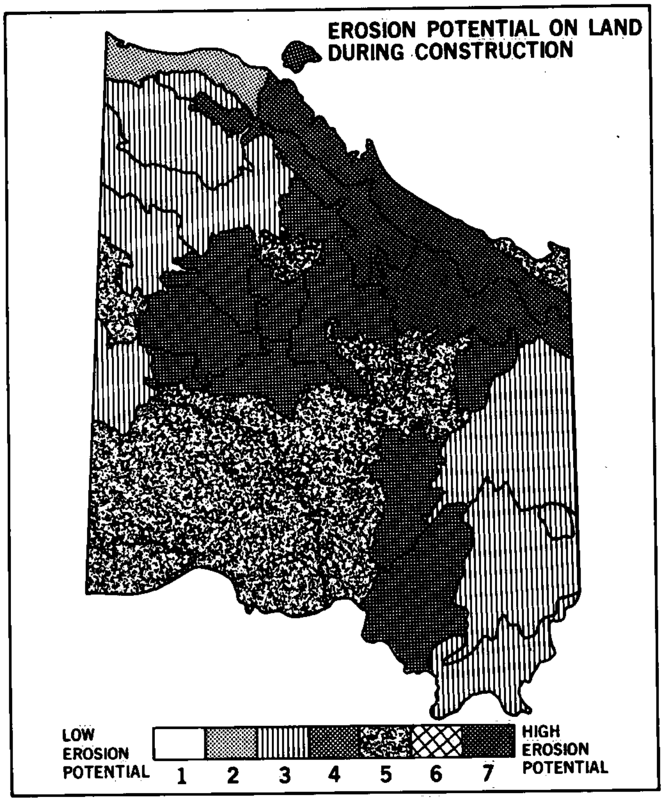



**FIGURE 4.1c: SORTED FACTORS**

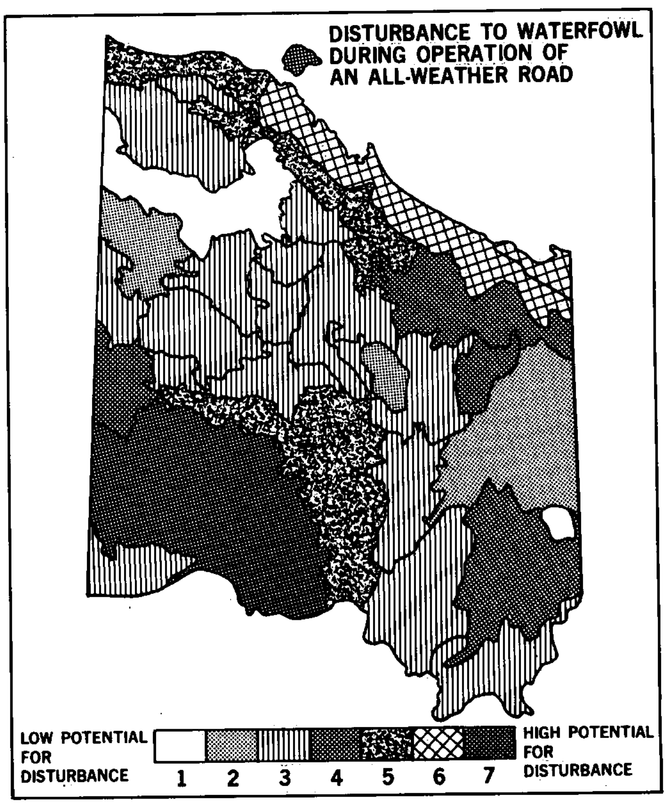



**FIGURE 4.1d: WEIGHTED FACTORS**

TABLE 4.1a: SINGLE-FACTOR ANALYSIS: CRITICAL HABITAT FOR FISH OVERWINTERING

Factor ....... presence of icings (aufeis) in the unit
Variable ..... Drainage type
Class ........ Braided with aufeis

Result ....... each ecodistrict evaluated as being with or without aufeis.

TABLE 4.1b: ADDED-FACTOR ANALYSIS: DIFFICULTY FOR PIPELINE CONSTRUCTION

| FACTOR | VARIABLE | CLASS |
|---|---|---|
| Relief | Local Relief | > 500 metres |
| Muskeg | Genetic Materials | Organic |
| Slope Instability | Modifying Process | Mass-wasting |
| Soil Water | Free Water | Saturated for very prolonged periods |
| Lakes | Lake Cover | > 30% |
| River Crossings | Drainage Density | > 0.5 per kilometre |
| Narrow Valleys | Drainage Type and Local Relief | Gravel bed streams and < 300 metres relief |

DIFFICULTY CLASSES BASED ON OCCURRENCE OF ABOVE CLASSES AS PRIMARY OR SECONDARY IN THE AREA

Class 1: No Serious Limitations .... No limits due to relief, instability or narrow valleys, and none or only one limit due to the remaining factors.
Class 2: Few Limitations ........... Limits due to only two of the following: muskeg, soil water, lakes and river crossings.
Class 3: Moderate Limitations ...... Limits due to three or four of: muskeg, soil water, lakes and river crossings.
Class 4: Many Limitations .......... Difficulty due to many narrow valleys.
Class 5: Great Difficulty .......... Narrow valleys and one or more of muskeg, soil water, lakes and river crossings.
Class 6: Severe Difficulty ......... Narrow valleys and high relief.
Class 7: Extreme Difficulty ........ Narrow valleys and unstable slopes, or narrow valleys and high relief and any other factors.

TABLE 4.1c: SORTED-FACTOR ANALYSIS: EROSION POTENTIAL ON LAND DURING CONSTRUCTION

| Slope SURFACE EXPRESSION | Materials TEXTURE | Soil Water FREE WATER | Active Layer DEPTH TO PERMAFROST | POTENTIAL |
|---|---|---|---|---|
| | Clay and Silt | Saturated | < 30 cm | 7 |
| | Diamicton | frequently | > 30 cm | 7 |
| Steep | Fibrous | Usually water | > 30 cm | 6 |
| Slumps | Mesic | free | < 30 cm | 5 |
| Fan | Blocky | Saturated | < 30 cm | 6 |
| Apron | Rubbly | frequently | > 30 cm | 5 |
| | Gravelly | Usually water | < 30 cm | 4 |
| | | free | > 30 cm | 3 |
| | Clay and Silt | Saturated | < 30 cm | 7 |
| | Diamicton | frequently | > 30 cm | 6 |
| Inclined | Fibrous | Usually water | < 30 cm | 5 |
| Rolling | Mesic | free | > 30 cm | 4 |
| Terraced | Blocky | Saturated | < 30 cm | 5 |
| | Rubbly | frequently | > 30 cm | 4 |
| | Gravelly | Usually water | < 30 cm | 3 |
| | | free | > 30 cm | 2 |
| | Clay & Silt | Saturated | < 30 cm | 6 |
| | Diamicton | frequently | > 30 cm | 5 |
| Level | Fibrous | Usually water | < 30 cm | 4 |
| | Mesic | free | > 30 cm | 3 |
| Horizontal | Blocky | Saturated | < 30 cm | 4 |
| | Rubbly | frequently | > 30 cm | 3 |
| | Gravelly | Usually water | < 30 cm | 2 |
| | | free | > 30 cm | 1 |

TABLE 4.1d: WEIGHTED-FACTOR ANALYSIS: DISTURBANCE TO WATERFOWL DURING OPERATION OF AN ALL-WEATHER ROAD

| FACTOR | VARIABLE | WEIGHT % | SCALE |
|---|---|---|---|
| Elevation | Average Elevation | 20 | 1-10 |
| Landform | Genetic Materials | 25 | 1-10 |
| Vegetation | Plant Districts | 25 | 0-10 |
| Lakes | Lake Cover | 30 | 0-10 |

Each class of each variable is transformed to a common scale of 0-10, or 1-10 where no "absent" class applies; then it is multiplied by its weighting, then summed for each unit. The scale of 0-100% is then divided equally into 7 to arrive at Classes "1" (high likelihood) to "7" (low likelihood of disturbance).

The scaled value of each variable is then multiplied by its weighting, and all such products are then summed for the unit. The results will be a series of values from 0% to 100%. This 0-100 scale is then divided uniformly into the desired number of evaluation classes.

This method is the most complex of the four discussed here, and should only be used as mentioned above. Without proper field knowledge, it is the most subject to arbitrary decisions and user error. With proper knowledge, it is ideally suited to electronic data processing of large-area, large-scale surveys. It has been used successfully, for example, in the James Bay ecological land survey.

#### 4.4.5.6 Summary of Analytical Methods

Several methods have been set out here. One is not recommended over any other in terms of ecological or environmental principles. Rather, each has a role to play, depending on the volume of data, the back-up data handling facility, and the practical needs of the user. As a rule, the data handling/analysis method should be kept simple, since the more complex it becomes, the more subjective it is also. Each evaluation should aim at no more than 5-7 classes; over-elaborate methods can produce a false sense of objectivity, since each method contains several subjective decisions within it.

#### 4.4.5.7 Combining and Comparing Evaluations

In an operational setting, one of the above methods for analyzing a data base would be used. A large number of potential hazards, impacts and capabilities likely would be examined and maps such as those in Figure 4 derived. The critical step then becomes to effectively overlay these derived maps together manually or with the computer. This step of combining and comparing data base interpretations is essential; it permits a final evaluation of the optimal routing of a road or pipeline, for instance, based on reliable environmental interpretations.

The complexity and quantity of data derived in ecological land survey governs whether a computerized data base or other type of file system will be established. A well-designed analysis system can allow interpretation of the environmental data suitable to a wide spectrum of users. In summary, effective evaluations of a data base of ecological information can prove to be a highly useful tool for environmental impact assessment.

# APPENDIX A
# SELECTED REFERENCES


Alberta Energy and Natural Resources. 1978. Biophysical Analysis and Evaluation of Capability, Castle River Area. Alberta ENR Report No. 64. 72 p. and maps. An example of an ecological land survey for an intermediate size area.

Canada Committee on Ecological (Biophysical) Land Classification. 1980. Land/Wildlife Integration (Comp. and ed. by D.G. Taylor). Proceedings of a technical workshop to discuss the incorporation of wildlife information in ELS. Lands Directorate, Environment Canada ELC Series No. 11. 160 p.

Canada Committee on Ecological (Biophysical) Land Classification. 1979. Applications of Ecological (Biophysical) Land Classification in Canada. (comp. and ed. by C.D. Rubec). Lands Directorate, Environment Canada. Proceedings of second meeting CCELC, Victoria, B.C. ELC Series No. 7. 396 p.

__________ 1979. Revised Working Paper on Methodology/Philosophy of Ecological Land Classification. (comp. by J.S. Rowe). A discussion and proposal of concepts in the ecological classification and mapping of land. pp. 23-30 in Proc. 2nd. meeting CCELC. ELC Series No. 7.

__________ 1977. Ecological (Biophysical) Land Classification in Urban Areas. Lands Directorate, Environment Canada, ELC Series No. 3. 167 p. The proceedings of a workshop on the use of ecological data for planning and management in urban areas. ELC Series No. 3. EN73-3/3, $4.00.

Canada Committee on Ecological (Biophysical) Land Classification. 1977. Ecological (Biophysical) Land Classification in Canada. (comp. and ed. by J. Thie and G. Ironside). Lands Directorate, Environment Canada. Proc. first meeting CCELC, Petawawa. ELC Series No. 1. 269 p. These proceedings of the first meeting of the CCELC include a wide range of reports on ecological land surveys and related activities across the country.

Environmental Management Service. 1979. An Ecological Land Survey of the Saint John Airport New Brunswick. Environment Canada and Transport Canada. Halifax, N.S. 66 p. and maps.

Gimbarzevsky, P., N. Lopoukhine and P. Addison. 1978. Biophysical Resources of Pukaskwa National Park. Canadian Forestry Service Report No. EMR-X-106, 129 p. Contains many air photo stereograms showing map units.

Jurdant, M., J. Bélair, V. Gerardin and J.P. Ducruc. 1979. L'Inventaire du Capital-Nature. Lands Directorate, Environment Canada, 202 p. ELC Series No. 2. The method for a relatively detailed ecological land survey of a large area is described. Included are many examples of interpretive maps. No. EN73-3/2F, $7.00.

Oswald, E.T. and J.P. Senyk. 1977. Ecoregions of Yukon Territory. Canadian Forestry Service Pub. No. BC-X-164, 155 p. and map. An account of a large area reconnaisance survey, with many photos illustrating ecological relationships.

Subcommittee on Biophysical Land Classification. 1969. Guidelines for Bio-physical Land Classification (comp. by D.S. Lacate). Canadian Forestry Service Pub. #1264. 61 p. These guidelines, a predecessor of these present ones, represent a first step toward a national approach to Ecological Land Survey.

Wiken, E.B. 1981. Ecological Land Classification: Analysis and Methodologies. Lands Directorate, Environment Canada. ELC Series No. 6. A review of the history of ecological land classification, and a comparison of various methodologies.

Wiken, E., D. Welch, G. Ironside, D. Taylor and J. Thie. 1978. The Northern Yukon: An Ecological Land Survey. A report prepared for Parks Canada by Lands Directorate. Environment Canada. Ottawa. 323 p. and maps.

# APPENDIX B
# SOURCES OF INFORMATION

The following sources of maps, reports, and other publications will be of considerable importance in the preliminary planning process.

(i) National Topographic System (NTS) Maps

Topographic maps are available at various scales from:

Canada Map Office
615 Booth Street
Ottawa, Ontario
K1A 0E9 Tel: (613) 995-4510

Indeces to the NTS maps are available free of charge but maps cost $1.50 plus 50 handling if ordered by mail. The following documents are also available from the Canada Map Office:

a) Lists of aeronautical charts dealers for each province
b) Lists of topographic map dealers for each province
c) A list of Surveys and Mapping publications
d) The table of contents of Canada's National Atlas
e) A catalogue of Canadian Aeronautical Charts
f) Indices of Canada Land Inventory maps
g) An index to the maps in the Northern Land Use Information Series

(ii) Hydrographic Charts

These charts are available at various scales from:

Marine Information Centre
Canada Centre for Inland Waters
Box 5050
Burlington, Ontario
L7R 4A6
Tel: (416) 637-4337

Charts cost $3.00 each and indices are available from the same address for $1.00 each. Hydrographic charts can also be purchased locally from government booksellers, local marine dealers, and through the Canada Map Office, Ottawa.

(iii, iv) Canada Land Inventory (CLI) Land Capability Maps, Reports, and Critical Area Maps

The CLI map series classifies a large portion of Canada as to the land's capability to support activities in the sectors listed below.

| | Map Scale | | |
|---|---|---|---|
| Sector | 1:50,000 | 1:250,000 | 1:1,000,000 |
| Agriculture | A | A | A |
| Forestry | A | A | A |
| Recreation | A | A | A |
| Ungulates | A | A | A |
| Waterfowl | A | A | A |
| Sport fish | N/A | N/A | A |
| Present land use | A | A | N/A |

A - available N/A - not available

CLI maps at 1:50,000 are available from the provinces as ozalid prints usually. Maps at 1:250,000 and 1:1,000,000 and indices to the CLI maps are available from either:

Supply and Services Canada
Printing and Publishing
Hull, Quebec
K1A 0S9
or
Canada Map Office
615 Booth Street
Ottawa, Ontario
K1A 0E9

Various reports and national summaries of the CLI program are available free of charge through the ECS Information Team, Environment Canada, Ottawa, Ontario. K1A 0E7 Tel: (819) 997-6611.

(v) Ecological Land Surveys

Information on completed studies and surveys underway or planned can be obtained from:

Secretariat
Canada Committee on Ecological Land Classification
Lands Directorate
Environment Canada
Ottawa, Ontario
K1A 0E7 Tel: (819) 997-2320

or on a regional basis from the various Lands Directorate Offices listed below:

Pacific and Yukon Region
1001 West Pender Street
Vancouver, B.C.
V6E 2M7
Tel: (604) 666-3161

Quebec Region
C.P. 10100
Ste-Foy, Quebec
G1V 2L8
Tel: (418) 694-3965

Atlantic Region
45 Aldereney Drive
Dartmouth, N.S.
B2Y 2N6
Tel: (902) 426-4196

Ontario Region
Box 5050
Burlington, Ontario
L7R 4A6
Tel: (416) 637-4552

(vi) Geologic and Terrain Maps and Open Map Files

This information is available from the Geological Survey of Canada (GSC). Maps, reports, and open files can be obtained through the GSC offices listed below:

Headquarters
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario
K1A 0E8 Tel: (613) 995-4089

British Columbia Office
Geological Survey of Canada
1001 West Pender Street
Vancouver, B.C.
V6B 1R8 Tel: (604) 544-1529

Institute of Sedimentary and Petroleum Geology
3303-33rd Street N.W.
Calgary, Alberta
T2L 2A7 Tel: (403) 284-0110

Atlantic Geoscience Centre
Bedford Institute of Oceanography
Box 1006
Dartmouth, N.S.
B2Y 2A2 Tel: (902) 426-2367

A monthly circular is available detailing new publications and open files obtainable from these offices.

(vii) Soil Surveys

These maps and reports are available from each province, however, map indices and ordering information can be obtained from Agriculture Canada, Land Resource Research Institute, Neatby Building, Ottawa, Ontario K1A 0C6 or the following regional offices:

Agriculture Canada
Research Station
6660 N.W. Marine Drive
Vancouver, B.C.
V6T 1X2 Tel: (605) 224-4355

Alberta Soil Survey
14605-118 Avenue
Edmonton, Alberta
T5L 2M7 Tel: (403) 545-2518

Department of Soil Science
John Mitchell Building
University of Saskatoon
Saskatoon, Saskatchewan
S7N 0W0 Tel: (306) 665-4061

Ontario Institute of Pedology
Blackwood Hall
University of Guelph
Guelph, Ontario
N1G 2W1
Tel: (416) 824-4120 ext 2483

Department of Soil Science
Ellis Building
University of Winnipeg,
Winnipeg, Manitoba
R3T 2N2 Tel: (204) 474-8153 ext 130

Équippe Pedalogique
Département d'Agriculture
Université de Laval
Ste-Foy, Québec Tel: (418) 694-7730

Atlantic Soil Survey
Box 550
Truro, Nova Scotia
B2N 5E3 Tel: (902) 902-1571 ext 158

(viii, ix) Aerial and Satellite Imagery

Air Photos
These are available from the:
National Airphoto Library (NAPL)
615 Booth Street
Ottawa, Ontario
K1A 0E9 Tel: (613) 995-4560

Standard 10" x 10" contact prints cost $1.40 plus $2.00 handling. Index maps overlaid on NTS map sheets are also available for $1.50 each. Provincial aerial photography librairies also exist; a list of these is available from NAPL.

Satellite Imagery

LANDSAT imagery and products are available from:
Satellite Receiving Station
User Services
Box 1150
Prince Albert, Saskatchewan
S6V 5T2 Tel: (306) 764-3602
(306) 764-4259

Standard LANDSAT 1:1,000,000 paper format, black and white prints cost $9.00, while colour prints cost $16.50.

Film transparencies at this scale cost $11.00 and $20.00 respectively. Imagery from NOAA, Skylab, and SEASAT are also available here.

Colour and black and white aerial photographic mosaics of many areas are currently available from NAPL. Colour LANDSAT mosaics are also available from NAPL for each province and all NTS quadrangles south of 60° North.

Further assistance with remote sensing technology and products can be obtained from the Canada Centre for Remote Sensing (CCRS). This Centre was established in 1972 as a key element in a national remote sensing program. CCRS user services include a computerized technical information system called RESORS permitting access to the remote sensing literature. Computerized and microfiche catalogues of satellite imagery are also available providing a geographic listing of LANDSAT scenes in all Canadian areas, annotated by the degree of cloud cover and image quality.

Inquires should be directed to:

User Assistance and Marketing Unit
Canada Centre for Remote Sensing
717 Belfast Road
Ottawa, Ontario
K1A 0Y7 Tel: (613) 995-1210

(x) Forest Inventory Maps

These maps can be obtained by writing to the various provincial departments of forestry. The reader is referred to the Environment Source Book from which addresses for such provincial agencies can be obtained. This book is obtainable from the Enquiry Centre, Information Services Directorate, Department of the Environment, Ottawa, Ontario. K1A 0H3.

Further national and regional forestry information can be obtained from the Canadian Forestry service at the following addresses:

Headquarters
Canadian Forestry Service
Place Vincent Massey
Hull, Quebec
K1A 0E7 Tel: (819) 997-1454

Forest Pest Management Institute
Canadian Forestry Service
Environment Canada
1219 Queen Street East
P.O. Box 490
Sault Ste. Marie, Ontario
P6A 5M7 Tel: (705) 949-9461

Regional Director
Pacific Forest Research Centre
Canadian Forestry Service
Environment Canada
506 West Burnside Road
Victoria, B.C.
V8Z 1M5 Tel: (604) 566-3811

Regional Director
Northern Forest Research Centre
Environment Canada
5320-122nd Street
Edmonton, Alberta
T6H 3S5 Tel: (403) 435-7210

Regional Director
Maritimes Forest Research Centre
Environment Canada
Box 4000
Fredericton, N.B.
E3B 5P7 Tel: (506) 452-3508

Regional Director
Great Lakes Forest Research Centre
Environment Canada
1219 Queen Street East
Box 490
Sault Ste. Marie, Ontario
P6A 5M7 Tel: (705) 949-9461

Centre de Recherche Forestière des Laurentides
Environnement Canada
1080 route du Vallon, C.P. 3800
Ste-Foy, Québec
G1V 4C7 Tel: (418) 694-3957

Newfoundland Forest Research Centre
Environment Canada
Box 6028
St. John's, Newfoundland
A1C 5X8 Tel: (709) 737-4683

(xi) Northern Land Use Information Series

These maps covering part of the Yukon Territory, Mackenzie Valley, and part of the western N.W.T. are available from the Canada Map Office, Department of Energy Mines and Resources, 615 Booth Street, Ottawa, Ontario, K1A 0E9, Tel: (613) 998-9900. The maps provide information on renewable resources and related human activities. Request for additional information should be directed to:

Environmental Protection Branch
Indian and Northern Affairs
Ottawa, Ontario
K1A 0H4 Tel: (819) 997-9090

Land Data and Evaluation Branch
Lands Directorate
Environment Canada
Ottawa, Ontario
K1A 0E7 Tel: (819) 997-2240

(xii) Arctic Ecology Map Series

Limited numbers of these map folios are available through the Canadian Wildlife Service at the following address:

Distribution Section
Canadian Wildlife Service
Environment Canada
Ottawa, Ontario
K1A 0E7
Tel: (819) 997-1686

These maps are a first attempt to map critical wildlife habitat over an extensive area of the Yukon, Northwest Territories and high Arctic.

(xiii) River Basin and Watershed Studies

Information on completed and ongoing studies is available from regional offices of the Inland Waters Directorate, Water Planning and Management Branch. The addresses of these offices are listed below:

Ontario
Inland Waters Directorate
Environment Canada
35050 Harvester Road
Burlington, Ontario
L7N 3J1 Tel: (446) 637-4220

Atlantic
Inland Waters Directorate
Environment Canada
45 Alderney Dr., Queen's Square
Dartmouth, Nova Scotia
B2Y 2N6 Tel: (902) 426-6050

Quebec
Inland Waters Directorate
Environment Canada
Box 10,100
Ste.-Foy, Quebec
G1V 4H5 Tel: (418) 694-3921

Pacific
Inland Waters Directorate
Environment Canada
Room 502
1001 West Pender Street
Vancouver, B.C.
V6E 2M9 Tel: (604) 544-3357

Western and Northern
Inland Waters Directorate
Environment Canada
1901 Victoria Avenue
Regina, Saskatchewan
S4P 3R4 Tel: (306) 569-5319

(xiv) Migratory Bird Information

Inquiries in this field should be directed to either Canadian Wildlife Service Headquarters or the appropriate regional office.

Headquarters
Canadian Wildlife Service
Ottawa, Ontario
K1A 0E7

Regional Offices

Atlantic Region
Canadian Wildlife Service
Environment Canada
Box 1590
Sackville, New Brunswick
E0A 3C0 Tel: (506) 536-3025

Quebec Region
Service canadien de la faune
Environnement Canada
1700 boulevard Laurier
C.P. 10 100
Ste.-Foy, Québec
G1V 4H5 Tel: (418) 694-3685

Ontario Region
Canadian Wildlife Service
Environment Canada
5th Floor
Aselford-Martin Building
1725 Woodward Drive
Ottawa, Ontario
K1G 3Z7 Tel: (613) 998-4693

Western and Northern Region
Canadian Wildlife Service
Environment Canada
1000, 9942 - 108 Street
Edmonton, Alberta
T5K 2J5 Tel: (403) 425-5889

Pacific and Yukon Region
Canadian Wildlife Service
Environment Canada
5421 Robertson Road
Box 340
Delta, British Columbia
V4K 3Y3 Tel: (604) 946-8546

(xv) Arctic Land Use Research

These reports, published by the Northern Environmental Protection Branch, Indian and

Northern Affairs, aim at providing important information for land use decisions in the Yukon and N.W.T.

Inquiries should be directed to:

Director
Northern Environmental Protection Branch
Les Terrasses de la Chaudière
Ottawa, Ontario
K1A 0H4 Tel: (819) 997-9090

(xvi) Atlasses

Numerous excellent national and provincial atlasses with natural resources information exist. A few of those usually available include:

The National Atlas of Canada. 1974. 4th Edition. Dept. Energy, Mines and Resources, Ottawa. M61-1E1974. 254 p.

Canada's Special Resource Lands. 1979. by W. Simpson-Lewis et al. Lands Directorate, Environment Canada, Ottawa. EN73-3/4. Price $12.00. 232 p.

Hydrological Atlas of Canada. 1978. Environment Canada Publication No. EN37-26/1978. Price $35.00.

Atlas of Resources: British Columbia. 1956. B.C. Natural Resources conference. ed. by J.D. Champman et al.

Atlas of Alberta. 1969. Government of Alberta and the University of Alberta. Edmonton. 158 p.

Atlas of Saskatchewan. 1969. Edited by J.H. Richards and K.I. Fung. University of Saskatchewan. Saskatoon. 236 p.

Atlas of the Prairie Provinces. 1971. ed. by T.R. Weir and G. Matthews. Oxford University Press.

Economic Atlas of Manitoba. 1969. Manitoba Dept. of Industry and Commerce. Winnipeg.

Economic Atlas of Ontario. 1969. ed. by W.G. Dean and G.J. Matthews. Univ. Toronto Press.

Gulf of St. Lawrence. 1973. Geographical Paper 73. Lands Directorate, Environment Canada. Ottawa. EN36-506/53 Price $3.75.

Climate Atlas: Part One Quebec. 1971. Canadian Meteorological Service. Cat. No. T57-6/11-1. Price $5.00.

Atlas Régional (a) Bas St. Laurent (b) Gaspé (c) Iles de la Madeleine. 1966. Bureau d'Aménagement de l'Est du Québec.

Resource Atlas: Island of Newfoundland. 1974. Dept. of Forestry and Agriculture and Canada Land Inventory, St. John's, Newfoundland.

Atlas of the Northwest Territories. Canada. 1966. Advisory Commission on the Development of Government in the Northwest Territories. Ottawa.

Environmental Atlas: Environmental Impact Assessment. Vol III: Mackenzie Gas Pipeline Route. 1974. Environmental Protection Board.

An Arctic Atlas: Background Information for Developing Marine Oilspill Countermeasures. 1978. Environmental Impact Control Directorate, Environment Canada Report EPS-9-EC-78-1.

(xvii) Flood Risk Data

Information on ongoing and completed studies is taking the form of maps and brochures and is available through the Director, Inland Waters Directorate, Environment Canada, Ottawa, Ontario. K1A 0E7.

(xviii) Water Resource Data

The Water Resources Branch of the Inland Waters Directorate produces data compilations and maps at specified intervals documenting various parameters of surface water and sediment loads in Canadian watersheds. For information contact the director, Water Resources Branch, Environment Canada, Ottawa, Ontario. K1A 0E7. Tel: (819) 997-2098.

Also available are the services of the Water Resources Document Reference Center (WATDOC). This is a data base with full bibliographic citations, keywords and abstracts to documents published and unpublished dating from around 1970 on Canada's water resources and related topics. For information contact:

WATDOC
Inland Waters Directorate
Environment Canada
Ottawa, Ontario
K1A 0E7 Tel: (819) 997-2324 or 997-1238

Responsibility for Water Resources Management in Quebec has been a provincial responsibility since 1964. Inquiries should be addressed to:

Hydrometric Services
Water Branch
Department of Natural Resources
Quebec, Quebec. Tel: (418) 643-4553

(xix) Climate Data

Information on climate data, reports and summaries can be obtained from:

Information Unit
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario
M3H 5T4 Tel: (416) 667-4723

Pacific Region
Atmospheric Environment Service
Suite 700
1200 West 73rd Avenue
Vancouver, B.C.
V6P 6H6 Tel: (604) 732-4673

Western Region
Atmospheric Environment Service
Argyll Centre
6325-103rd Street
Edmonton, Alberta
T6H 5H6 Tel: (403) 437-1250

Central Region
Atmospheric Environment Service
Room 1000
266 Graham Avenue
Winnipeg, Manitoba
R3C 3V4 Tel: (209) 949-4380

Ontario Region
Atmospheric Environment Service
23 St. Clair Avenue East
Toronto, Ontario
M4T 1M2 Tel: (416) 966-5624

Quebec Region
Atmospheric Environment Service
Third Floor
100 Alexis Nihon Blvd.
Ville St. Laurent, Quebec
H4M 2N6 Tel: (514) 333-3000

Atlantic Region
Atmospheric Environment Service
P.O. Box 5000
Bedford, Nova Scotia
BON 1BO Tel: (902) 835-9328