37 The Canadian Land Inventory System

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I. INTRODUCTION

When the world's human population was smaller than it is now, it was possible for nations, particularly those of the New World, to place no restraints on land development on the assumption that land and resources were inexhaustible. This approach to resources was indicative of the thinking in Canada well into the 1950s and early 1960s.

It became apparent in recent years that Canada's agricultural community was in serious trouble both economically and socially because the land base could not support all the demands made upon it. The situation warranted a reappraisal of agricultural land-use practices and the application of modern scientific technology to produce satisfactory economic and social benefits.

To develop good land management practices, an understanding of the physical nature of the land resource's capability to sustain and support the agricultural industry was required. An inventory of Canada's lands suitable for agricultural use and the identification of possible alternative land use opportunities was the first step; thus, the Canada Land Inventory (CLI) program—a comprehensive survey of land capability and use designed to provide a basis for resource and land use planning—evolved. The CLI included assessment of land capability for agriculture, forestry, recreation, and wildlife. An inventory of present land use and pilot land use planning projects in each of Canada's ten provinces were essential parts of the program.

To place the Canada Land Inventory in perspective, the first part of the chapter provides a sketch of Canadian land settlement and, as a prerequisite to integrated land use planning, the factors which led to the development of a land resource information base.

The chapter proceeds to describe the objectives, organization, and content of the CLI program. A brief outline of the classification methodology is developed for each sector. The chapter concludes with examples of how the Canada Land Inventory information is applied to integrated land use planning situations.

Planning the Uses and Management of Land.

II. THE CANADA LAND INVENTORY PROGRAM: A NATIONAL SYSTEM FOR COLLECTING RESOURCE DATA

A. Historical Background

Although Canada's total area is estimated at slightly over 9.8 million km^2, the population and associated land use activities are concentrated largely in the southern one-third of the country; the people are historically linked to an agrarian way of life and the exploitation of renewable resources.

Physical constraints such as climate have imposed limitations to further northward extension of particular land use options such as agriculture; however, major land use problems emerging today arise from intense sociological and technical changes taking place in the settled areas of Canada (Maxwell, 1972).

During the period of initial land settlement, which started in eastern Canada, very little technical information existed to guide the settlers. A wide range of soils and land types were occupied and, if settlement occurred on good agricultural land, it was more often by accident rather than design. The first cycle of farm abandonment began when pioneers found themselves located on unproductive land. Once established, however, farming communities tended to perpetuate and enlarge mainly through family association or through the arrival of new immigrants of the same ethnic stock as the original settlers.

Toward the end of the nineteenth century, certain agricultural areas in eastern Canada had developed to the point where significant surpluses of grain and forage products were being produced. These surpluses provided an important export trade in agricultural products. In the early 1900s particularly this trade began to assume a position of prime importance in the national economy as the farm commodities from the newly settled areas of western Canada entered the flow of agricultural exports. Unlike the slower settlement processes experienced in eastern Canada, the agricultural settlement of the prairie lands and mountain valleys of western Canada was large scale, swift, and dramatic. It occurred primarily in the first decade of the century and was commercially oriented and dependent upon the products of technology—above all the railroad.

By the 1920s, the contemporary land settlement pattern of the country had emerged. At this time, the status of the agricultural industry was marked by comparative stability and modest prosperity in eastern Canada, and by growth, considerable prosperity, and optimism in western Canada.

The 1930s brought a series of events that were to produce revolutionary changes in the agricultural industry and in land management practices generally. These events unleashed forces which were to generate social problems of national significance that have continued to the present time.

The Great Depression of the 1930s coincided with an unprecedented dry spell on the Canadian Prairies and on the central plains of the

neighbour to the south. Drought and associated wind erosion converted much of the short-grass prairie country, which had been placed in cereal production, into a vast dust bowl. Only later was it recognized that the precipitation regime of the semiarid territory made it unsuited for cereal-crop production.

In response to this crisis, the Canadian Government passed the Prairie Farm Rehabilitation Act of 1935. This Act and later amendments to it enabled the conversion of cultivated semiarid lands to permanent grassland, the establishment of community pastures, the resettlement of the affected populations, the provision of agricultural land management services, and the development of large irrigation systems and water control projects.

A land capability survey formed part of this program. Although limited to the assessment of the land's physical capability for sustaining cereal crop production, this survey represented the first large-scale attempt in Canada to apply a scientific approach to assessing land use capability; it was an important predecessor of the Canada Land Inventory.

B. Prelude to Inventory

The decades of the 1940s and 1950s were momentous ones for Canadian agriculture. Science-based technology was applied by the industry on a grand scale. A scarcity of labor and spiralling costs made mechanization mandatory for viable farm operations. Changes in market patterns and conditions contributed to increased crop specialization.

Although these forces presented opportunities for increasing the efficiency, productivity, and income of farms, certain prerequisites were necessary before advantage could be taken of the new opportunities; the farm must be located on reasonably productive land suitable for mechanized operation; it must have access to sufficient capital for underwriting investments in machinery and other necessary farm inputs; it must contain sufficient acreage to spread the costs of labor and machinery and thereby keep these unit costs at competitive levels. Finally, farm operators must be skilled in farm-management business practices and in the application of new products of science and technology such as inorganic fertilizers, pesticides, and herbicides.

Unfortunately, many Canadian farm operations could not meet these exacting conditions. As a result, large numbers of farms located on poor soils and even small farms on good soils were unable to adjust to the new economic climate. This situation initiated a new round of farm abandonment which is still continuing. In the 1960s, it is estimated that the number of farms in Canada declined at the rate of 10,000 a year. Although many people who gave up farming were able to find alternative employment in the industries of the growing urban centers, thousands of farm people could not find viable employment opportunities, and poverty conditions emerged in many of the country's rural areas.

The Canadian Government responded to this situation by passing the

Agricultural Rehabilitation and Development Act of 1961 (later renamed the Agriculture and Rural Development Act). This Act, known by the acronym ARDA, enabled the federal government to undertake farm enlargement and consolidation programs, land improvement schemes, and land use adjustment projects in cooperation with provincial governments.

As the ARDA programs were being formulated, it became evident that a rational approach to land use adjustment and planning could not be undertaken without knowledge of the land's capability to support agriculture and other feasible alternative uses. To provide this knowledge the Canada Land Inventory project was launched in October 1963.

C. Objective and Organization

The Canada Land Inventory is a comprehensive survey of land capability and land use designed to provide a partial data base for broad-scale resource and land use planning. It includes assessment of land capability for agriculture, forestry, recreation, wildlife, present land use, and pilot land use planning projects. It was established as a cooperative federal/provincial program administered under the Agricultural Rehabilitation and Development Act (ARDA) of June 1961 (Environ. Canada, 1970a).

Under the aegis of ARDA, comprehensive resource management and social planning programs took shape along with provincial government ventures in the sphere of regional development planning. It became increasingly apparent, however, that without a land capability inventory any programs of land adjustment and regional economic development would be based on subjective judgements made in the absence of essential resource information. The Canada Land Inventory was designed to respond to this information need, with the underlying objective to provide a basis for land use planning.

The project, started in 1963, was essentially completed in 1975–76. It covered the settled parts of Canada and the adjacent forest fringe—an area of approximately 2.6 million km^2 (Fig. 1). Data are provided on maps at three scales for each sector. Field maps are prepared at the 1:50,00 scale and published maps at the 1:250,000 and 1:1,000,000 scales. In addition, because of the volume of data produced (20,000 maps at the 1:50,000 scale and 1,200 at the 1:250,000 and 1:1,000,000 scales), a computerized data bank known as the Canada Geographic Information System (CGIS) was developed to facilitate storage, retrieval, and analysis of information.

The CLI is designed primarily for planning rather than for management. It is of a reconnaissance type; it provides information essential to land development planning at the municipal, provincial, and federal levels of government. It does not provide the detailed information required for individual parcels of land or for land planning in small watersheds, local government units, etc.

The broad objectives of the Canada Land Inventory are to classify lands according to their present use and capabilities, to obtain a firm estimate of the extent and location of each land class, and to encourage use

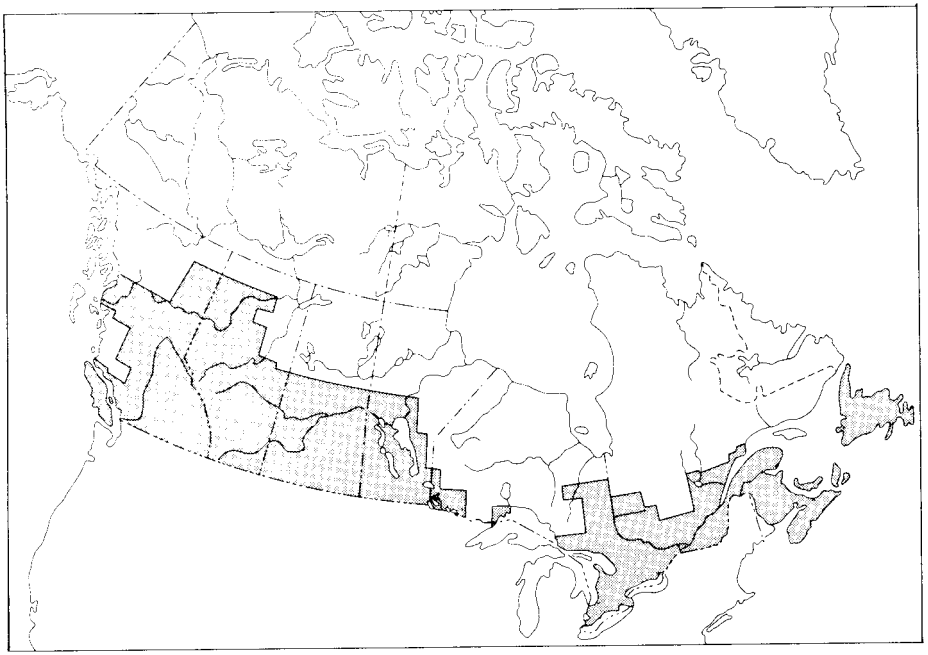

Fig. 1—Areas covered by the Canada Land Inventory.

of the CLI data in land use planning and decision-making. These objectives can be refined further in the following three program activities:

1) *Activity Number 1*—To classify and map lands according to their capabilities and present land use. The CLI establishes a common base for data description and presentation; it provides for the physical generation of maps and related data covering present land use, and land capability for agriculture, forestry, recreation, and wildife—ungulates and waterfowl. In addition, supplemental programs in Sport Fish Capability and Agroclimatology were implemented in some provinces.

The role of the federal government was primarily one of enabling and coordination. Thus, the Government of Canada financed all incremental costs incurred by the provinces in the conduct of the Inventory. It also directed the development of national capability classification systems and provided coordination services to ensure their consistent application.

The provinces carried out the work within their own jurisdictions and they were, therefore, responsible for the planning of provincial programs and the preparation of capability maps. Inventory committees, chaired by a provincial CLI coordinator, were established in each province to direct this work which was carried out by federal and provincial resource agencies, university groups, and private consultants.

2) *Activity Number 2*—To obtain a firm estimate of the extent and location of each land class. The CGIS (Environ. Canada, 1976a; Tomlinson et al., 1976) was established to apply the processing and data handling capabilities of large-scale computers to the difficult task of reducing, tabulating, manipulating, and analzying the volumes of data collected by CLI. Because

of the great mass of data to be generated it was obvious that an automated system of data handling would be an indispensable tool.

The CGIS is operational and has a scale capability of 1:500 through 1:1,000,000 for input of map data. Presently, the bulk of the data in the data base is at a scale of 1:250,000. In addition to CLI data, maps showing present land use, census enumeration areas, and administrative, watershed, and shoreline boundaries serve as source documents. This cartographic information, along with the associated classifications, is traced and prepared for input into the geographically organized data bank. The information, coded and placed on magnetic tape, permits economic and easy retrieval of detailed or general information. For each separately designated area (map face) on a CLI map, the data bank contains: (i) an identifying number; (ii) the shape and location of boundaries; (iii) the classification data; (iv) the calculated area; and (v) the location of a central point by latitude and longitude.

Maps of a similar type (e.g., all present land-use maps or all recreation maps) are grouped together to form a coverage. Each coverage will comprise all the mapped land in Canada.

Raw or analzyed data for selected geographic areas may be retreived either in map format (graphic) or in tabular format.

Any coverage described in area units may be added to the system. Special coverages, other than those contained in the data bank, may be entered after consideration of such factors as applicability, resources available, time, and cost.

3) *Activity Number 3*—To encourage use of CLI data in land use planning. In November 1967, the CLI program was extended to cover pilot projects in land-use planning.

It was realized that the maximum usefulness of the Inventory could be achieved only by developing and evaluating applications of the data in the planning process. The objectives were twofold: to provide opportunities for the assessment of the adequacy of data in development planning and to familiarize those engaged in land resource planning and management with the data.

It is anticipated that the pilot projects could promote greater cooperation and coordination among resource sector specialists in developing multidisciplinary approaches to land planning. Under this program the federal government underwrote the costs of a provincially proposed and sponsored pilot-scale, land use planning study.

As few restraints were imposed by the federal government, maximum flexibility was achieved in the use of the data and in the design and organization of studies to meet the variety of needs across the country.

III. THE CLI LAND CAPABILITY CLASSIFICATION SYSTEMS

One of the major challenges of the CLI Program was the development of national land capability classification systems. Initially, the task appeared formidable because of the geographical diversity of Canada and the

number and complexity of factors which determine a viability of a particular land use at a given time and location.

It quickly became apparent that, if a data base having a viability over a reasonably long period of time was to be produced, the more dynamic socioeconomic determinants of land use could not be considered. For this reason, such factors as present land use, vegetative cover, accessibility, tenure, and market conditions were excluded from the assessment process. Although these factors are critical in determining the highest and best use of land at any given time and location, it was decided that consideration of them should take place only at the time when land use plans are being prepared and implemented. The elimination of these factors permited lands to be evaluated strictly on the ability of their inherent physical characteristics to support specified uses under current technological conditions and good management practices.

The five land capability classification systems developed for the CLI project, although dealing with different land uses, are similar in the following respects:

1) All are interpretive classification systems in which soils or land types are grouped into one of seven classes on the basis of their capability for production. The systems, therefore, are comparable in a relative but not necessarily in an absolute sense.
2) With the exception of the recreation sector, which presents details of the positive features of the landscape, all systems list the limiting factors which downgrade land units from the highest capability.
3) All systems are national in character; thus, a class assigned to an area in eastern Canada has the same meaning as a similar class either in central or western Canada.
4) All site factors are incorporated into the capability rating.
5) Only physical factors are assessed—not locational, economic, or accessibility factors.
6) The systems are meant to serve as a basis for land use planning, but not for land management.

A. Soil Capability for Agriculture

The capability classification for agriculture (Environ. Canada, 1969a) was the first system to be developed; it is based on a system originally designed by the Soil Conservation Society of America. The classification work conducted by the federal and provincial soil survey organizations is based on the interpretations of the data provided by soil survey maps and reports prepared by the National Soil Survey. Since the Survey was established in 1921, soil reports cover most of the settled areas of Canada. Through interpretation, the soils are mapped by land units having homogenous characteristics according to their general ability for the production of common field crops; it takes into account the effects of climatic and soil limitations in a system of mechanized farming.

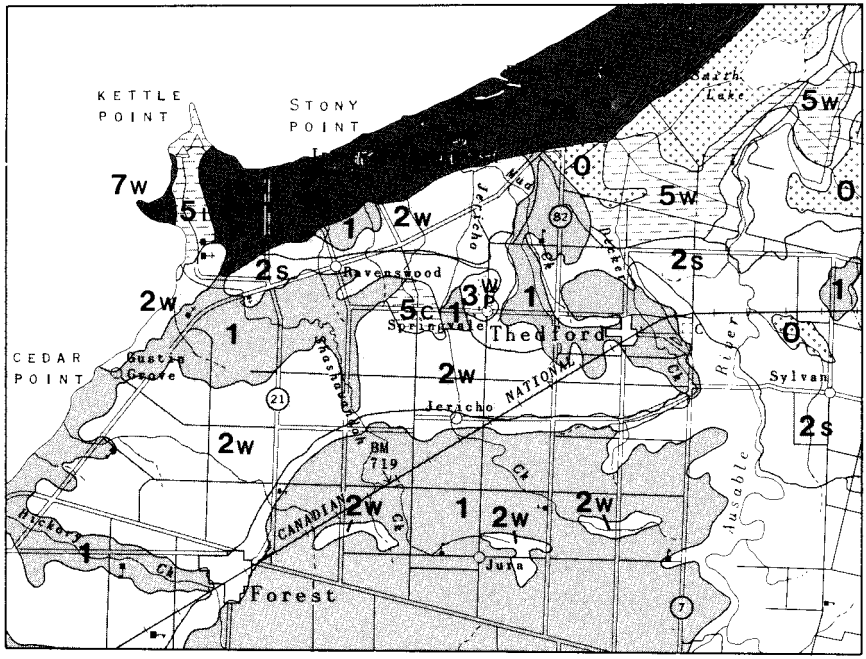

Fig. 2—Agriculture. Symbol 3_P^W indicates Class 3 land unit with wetness (W) and stoniness (P) as limitations.

1. CAPABILITY CLASSES FOR AGRICULTURE (FIG. 2)

In this classification the mineral soils are grouped into seven classes depending on the degree of limitation and into thirteen subclasses according to the kinds of limitation. Class 1 soils have no significant limitations and, together with Classes 2 and 3, are considered capable of sustaining production of common field crops. Class 4 soils are physically marginal for sustained arable agriculture. Soils in Class 5 are unsuitable for annual field crops but suitable for forage production and improved pasture. Those in Class 6 are restricted in their use of native grazing. Class 7 is unsuitable for agricultural use. Organic soils are not included in the classification but are shown separately on the maps.

The classification system is based on the following criteria:

1) Soils will be well managed and cropped using a largely mechanized system.
2) Land requiring improvements (including clearing) that can be made economically by the owner is classified according to its limitations or hazards in use as if the improvements have been made. Land requiring improvements deemed beyond the means of the individual owner is classed according to its present conditions.
3) These factors are not considered: distance to market, type of roads, location, size of farm, type of ownership, cultural patterns, skill or

resources of individual operators and hazard of crop damage by storms.

The classification does not include capability of soils for trees, fruit trees, small fruits, ornamental plants, recreation, or wildlife.

The classes are based on intensity rather than on the type of agricultural limitations which they display. Each class includes many kinds of soils; many soils in a class require different treatment and management.

2. SUBCLASSES

Subclasses are divisions within classes that have the same kind of limitations for agricultural use. Thirteen different kinds of limitations are recognized at the subclass level such as (C) denoting adverse climate for crop production as compared to the 'median' climate or (E) denoting soils where damage from erosion is a limitation to agricultural use.

3. ORGANIC SOILS

The interpretative capability classification is not applied to organic soils since usually there is insufficient information on organic soil areas to make an interpretive judgement. Organic soils are designated by the letter O.

B. Land Capability for Forestry

The national land capability classification for forestry (Environ. Canada, 1970b) was developed on the basis of completed pilot projects conducted in each province, and a subsequent regional and national meeting of provincial, federal, and university specialists. Basic data for classification were available in most provinces in the form of soil survey and forest inventory maps and reports. Interpretation of these data, together with new field survey data, permitted the system to be developed.

Fully compatible with the other sectors, the forestry capability classification system serves to indicate those lands on which intensive management practices might be justified. In this classification all mineral and organic soils are grouped into one of seven capability classes according to their ability to grow commercial timber. Capability is in terms of mean annual increment per hectare, expressed in cubic meters for indigenous tree species growing as full-stocked stands and assuming good management practices.

1. CAPABILITY CLASSES FOR FORESTRY (FIG. 3)

Classes 1 to 3 lands range from those having no important limitations to the growth of commercial forests with productivity over 7.8 m^3/ha per annum to lands having moderate limitations with productivity down to 4.9 m^3/ha. Classes 4 and 5 lands have moderately severe to severe limitations;

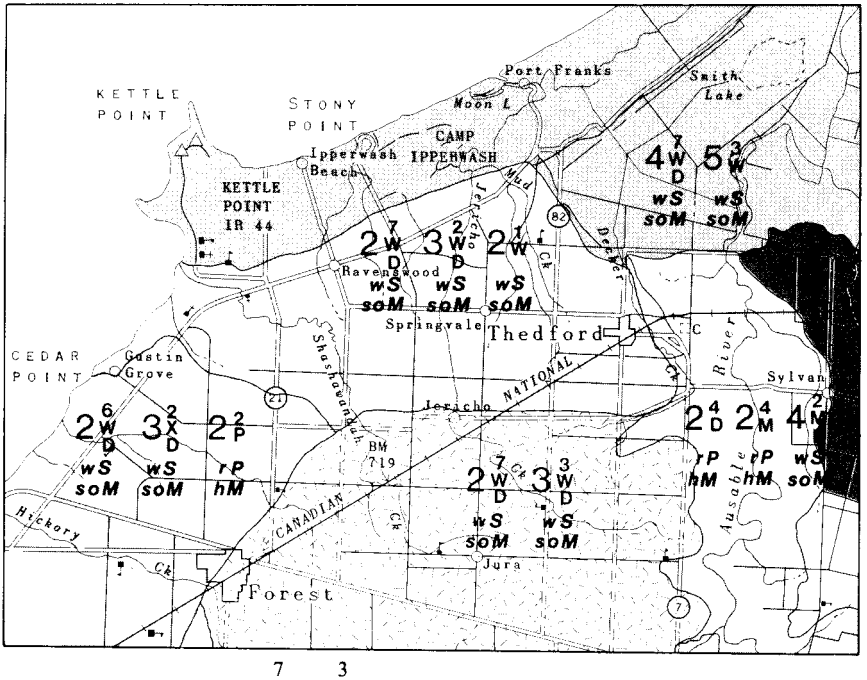

Fig. 3—Forestry. Symbol $\frac{7}{4W}\ \frac{3}{5W}$ D wS soM wS soM

This complex unit indicates 70% Class 4 land with moisture (W) and compactness (D) limiting soil factors, white spruce (wS) and soft maple (soM) dominant species; 30% Class 5 with moisture (W) limiting factor and same species.

productivity ranges from 4.8 down to 2.2 m^3/ha. Class 6 have very severe limitations; whereas, Class 7 have limitations so severe as to preclude growth of commercial forests. Productivity is usually less than 0.7 m^3/ha per annum.

Associated with each capability class is a productivity range based on the mean annual increment of the best species or group of species adapted to the site at, or near, rotation age. Productivity ranges are expressed in gross mechanical cubic meter volume and for tree diameters to a minimum of 10.16 cm. The productivity ranges are for 'normal' or fully stocked stands. Since only well-stocked stands are measured to indicate the capability class, the implication is that only good management produces such stands.

In a capability class, factors such as location, access, distance to market, size of units, ownership, or present state are not considered. Classification is based on the natural state of the land without improvements such as fertilization, drainage, or other ameliorations. Improved forest management may change the productivity range.

2. CAPABILITY SUBCLASSES

Subclasses, when shown, always represent a limitation to growth and are used only when the limitations affect the class level. Such factors as climate, soil moisture, permeability and depth of rooting zone, and soil factors which individually or in combination adversely affect growth are identified. These factors in the classification of a land unit are related to the indigeneous species which can be expected to yield the volume associated with each class.

C. Land Capability for Wildlife

The Wildlife Sector of the Canada Land Inventory has some unique aspects, particularly the great diversity of wildlife species, their different environmental requirements, their mobility, and other behavioral attributes. One national series of maps cannot effectively represent the capability of land to produce or support all species of wildlife. For this reason, the current capability inventory is restricted to two main groups of species which occur across Canada: ungulates, which are the responsibility of the provincial governments, and waterfowl, which by treaty are the responsibility of the federal government. The classification system (Environ. Canada, 1969c) is the same for both groups, with slight modifications due to their different environmental requirements.

Criteria for capability mapping were developed by officials of the Canadian Wildlife Service and the Provincial Game Agencies. The mapping program for waterfowl capability was implemented by Canadian Wildlife Service officials, while ungulate capability mapping was carried on by Provincial officials. Categories used in the classification system are: the capability class, the capability subclass, and, for ungulates, the indicator species.

All environmental factors are taken into consideration when assigning a capability class to a unit of land. The class boundary is determined by physical characteristics of the land which are significant to ungulates and waterfowl. Thus the capability class is an expression of the environmental factors that control the numbers of ungulates or waterfowl produced and supported on a unit of land.

In general, the needs of all wildlife are much alike: each individual and species must be provided with a sufficient quality and quantity of food, protective cover, and space to meet its needs for survival, growth, and reproduction. The ability of the land to meet these needs is determined by the individual requirements of each species or group of species under consideration, the physical characteristics of the land, and those factors that affect the plant and animal communities.

In an interpretative land classification system for wildlife, criteria and procedures must be the same for the system to be uniform. All wildlife

capability maps were prepared as follows:

1) The separation of the land surface into homogeneous units for classification is on the basis of physical characteristics that are significant from a wildlife standpoint.
2) The assignment of a class to each unit of land is on the basis of all known or inferred relevant information about the unit, including parent material, soil profile, depth, moisture, fertility, landform, climatic factors, and vegetation which reflect the quality and quantity of food and cover available to wildlife.
3) Classifications are based on the natural state of the land under good wildlife management practices. Management practices which are practical and feasible are assumed.
4) Factors such as location, access, ownership, distance from cities or roads, or present condition of a land unit are not considered in assigning a capability class. Present cover and production in an area are used only for additional information. Excessive or insufficient hunting pressures do not limit the capability of the land and are not used in assigning classification values.
5) The degree of limitation determines the class designation. The subclass is the factor which causes the limitation. The limitations and the class may be changed by the advent of new and improved management techniques; it is unlikely that significant changes can be made except by costly and continuing practices.

1. CAPABILITY CLASSES FOR WATERFOWL (FIG. 4)

The basic unit of the classification system is the capability class which denotes the ability of land or water to support or produce waterfowl. The capability class level is determined by the degree of limitation which affects either the quality or quantity of habitat for waterfowl. Classes 1 to 3 range from lands having no significant limitations to the production of waterfowl (where soils are fertile with good water-holding characteristics and good wetlands) to areas having slight limitations due to occasional droughts, climatic conditions, or the physical conditions of the land that affect the quality and quantity of the habitat. Classes 4 and 5 lands have moderate to moderately severe limitations to the production of waterfowl. These areas are dominated by temporary ponds and other limitation factors such as climate, soil moisture, salinity, flooding, or poor interspersion of water areas. Classes 6 and 7 have severe limitations degrading downward to a capability that is negligible or nonexistant.

2. CAPABILITY SUBCLASS

In general the classes are divided into subclasses according to the nature of limitations that determine the class level. These denote significant limiting factors that may affect either waterfowl or the ability of the land to produce suitable habitat conditions. Examples are: *Aridity* (A)—land

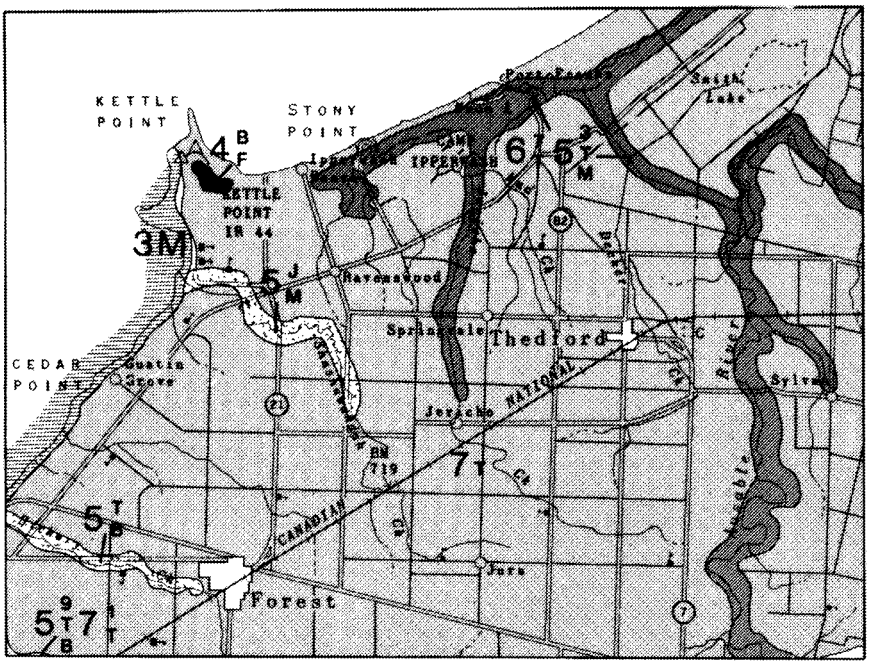

Fig. 4—Wildlife waterfowl. Symbol 3M indicates area of Class 3 with limitations due to poor water-holding capacity of soils (M).

Symbol $\frac{7}{6T}$ $\frac{3}{3T}$ M

This complex unit indicates 70% Class 6 adverse topography (T); 30% Class 5 adverse topography (T) and poor waterholding capacity of soils (M).

susceptible to periodic drought, *Climate* (C)—where adverse climatic factors inhibit development of favorable habitat and restrict waterfowl production, or *Soil Moisture* (M)—where soils have a poor water-holding capacity adversely affecting the formation of permanent water areas.

3. CAPABILITY CLASSES FOR UNGULATES (FIG. 5)

The basic unit of the classification system is the capability class, which denotes the ability of land to support or produce wild ungulates. The capability class level is determined by the degree of limitations which affect either the quality or quantity of habitat for the animals. Classes 1 to 3 lands generally have no significant limitations for the production of ungulates. The classes range from lands which provide a wide variety of food plants and other habitat elements, to lands which have slight limitations due to factors that affect the quality and quantity of habitat, such as the availability of food and cover. Classes 4 and 5 lands have moderate to moderately severe limitations usually arising from a combination of two or more factors such as shallow soils, topography, flooding, and climate. Classes 6 and

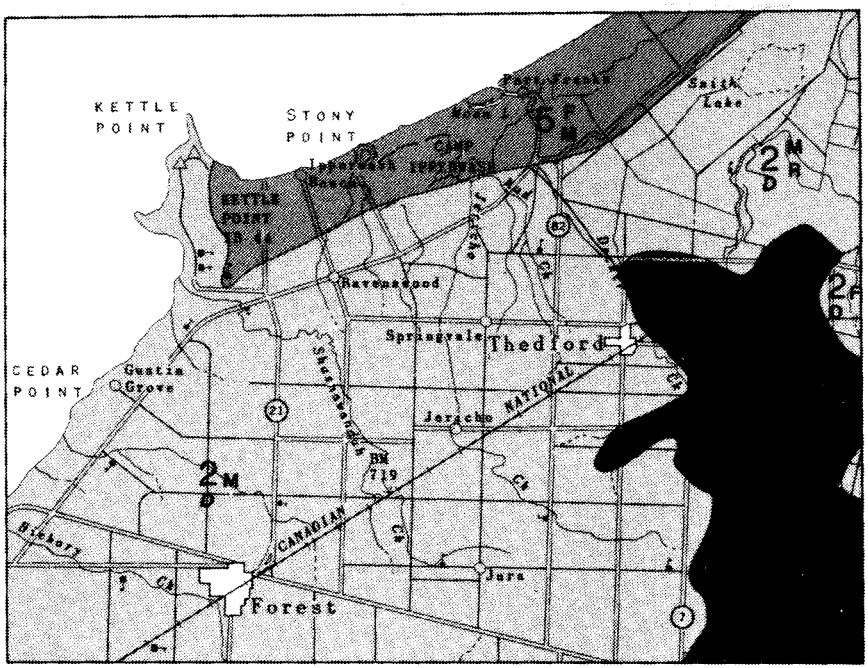

Fig. 5—Wildlife ungulates. Symbol 2M DR indicates Class 2 land having moderate limitations due to deficient soil moisture (M) and soil depth (R); ungulate specie is deer (D).

7 have severe limitations to limitations so severe that there is little or no ungulate production.

4. CAPABILITY SUBCLASSES

With the exception of Class 1, the classes are divided into subclasses according to the nature of limitations that determine the class level. Usually, the limitations do not have a direct effect on the animals but they do affect the ability of the land to produce suitable food and cover plants. For convenience the subclasses are placed in two main groups: those relating to climate and those relating to inherent characteristics of the land.

Significant climatic factors, for example, would be Aridity (A) restricting the development and growth of suitable food and cover plants or Snow Depth (Q) resulting in limitations caused by prolonged periods of snow conditions reducing the mobility of animals and the availability of food plants. For land, Fertility (F) indicates a limitation due to lack of available nutrients in the soil for optimum growth of food and cover plants, whereas Landform (G) indicates the limitation is a poor distribution or interspersion of landforms to provide optimum ungulate habitat.

An additional factor is provided in the ungulate subclass information to identify the species for which capability ratings are assigned, for example, Antelope (A), Caribou (C), and Elk (E).

D. Land Capability for Outdoor Recreation

The objectives of the recreation-land classification program (Environ. Canada, 1969a) are twofold: to provide a reliable estimate of the quality, quantity, type, and distribution of outdoor recreation resources within settled parts of Canada and to supply basic information for the formulation of policy and plans by the levels of government involved. Compatibility with other sectors of CLI is mandatory to facilitate intersector comparisons in integrated resource management planning.

The recreation sector's initial task was to develop a national classification system acceptable to all provinces and, in conjunction with the provinces, to apply the classification to all lands within the inventory area. A seven-class classification system was developed to rank land according to its capability for outdoor recreation and to recognize present popular preferences.

The recreation-land classification, though consisting of classes like the other systems, differs from them in that lands are classified according to their limitations for use. The basis of the classification is the quantity of recreation (measured in visitor days or hours) that may be sustained per unit area per year under perfect market conditions. Thus, lands with a capability to sustain intensive use, such as sandy beaches and slopes suitable for skiing, are rated higher than lands which support less intensive uses, such as pastoral landscapes offering interesting viewing experiences. For purposes of uniformity, class ranking does not take into consideration present use or accessibility.

1. CAPABILITY CLASSES FOR RECREATION (FIG. 6)

Classes 1 to 3 lands have a very high to moderately high capability for outdoor recreation; capability ranges from a natural capability to engender and sustain an extremely high total annual use based on intensive activities to a moderately high total annual use. Classes 4 and 5 lands have a moderate to moderately low capability based on dispersed activities. Class 6 lands have a low capability lacking natural attractiveness or presenting severe limitations to recreational use, whereas Class 7 lands have very low capability.

2. CAPABILITY SUBCLASSES

There are 25 recreational features which represent the primary uses of land for recreation as indicated by present popular preferences. The opportunities for recreation provided by a feature or combination of features and assessed in terms of quantity of use determine the class of the land unit. Recreation features are considered as aspects of land units providing opportunities for recreation.

Examples of recreational features indicated by subclass are Angling (A), denoting land which provides access to water with natural capability

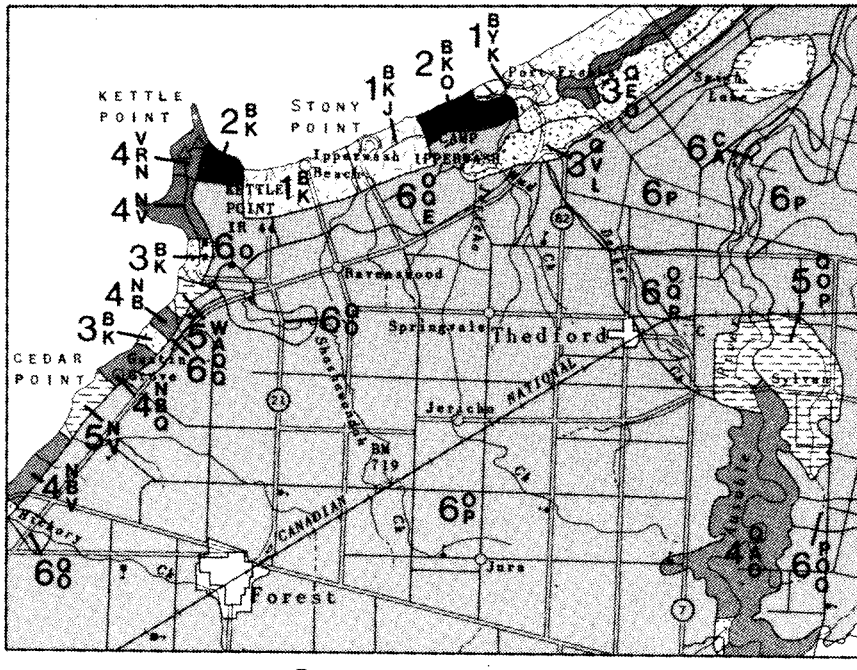

Fig. 6—Recreation. Symbol $^{B}_{J}$ 1 K indicates Class 1 land suitable for beach activities (B), comfortable water temperatures, wet beach gradient 2 to 5% with 3.3 m minimum length of fine-grained sand or pebbles. (K) indicates shoreland suited for organized tent or trailer camping and (J) indicates areas offering opportunities for gathering or collecting rocks, fossils, etc.

for production, harvesting, or viewing sportfish; Beach (B), shoreland capable of supporting beach activities; Deep Inshore Water (D), shoreland with deeper water inshore suitable for swimming, boating, mooring, or launching; Glacier (G), area offering a glacier view or experience; and Lodgings (N), land suited for family cottage or other recreation lodging use.

E. Classification of Land Use

In addition to the mapping of the land resource capability sectors within the CLI boundary, present land use was considered essential in the program for determining the extent and nature of existing uses, particularly agricultural lands. A classification for mapping land use (McClellan et al., 1968) was devised and a program initiated to cover the areas of Canada lying within the CLI boundary (Fig. 7).

Mapping was done on 1:50,000 National Topographical System map sheets or, if they were not available, at the most suitable alternative scale, and adjusted by photographic reproduction. The 1:50,000 map sheets were later generalized to 1:250,000 for input into the Canada Geographic Information

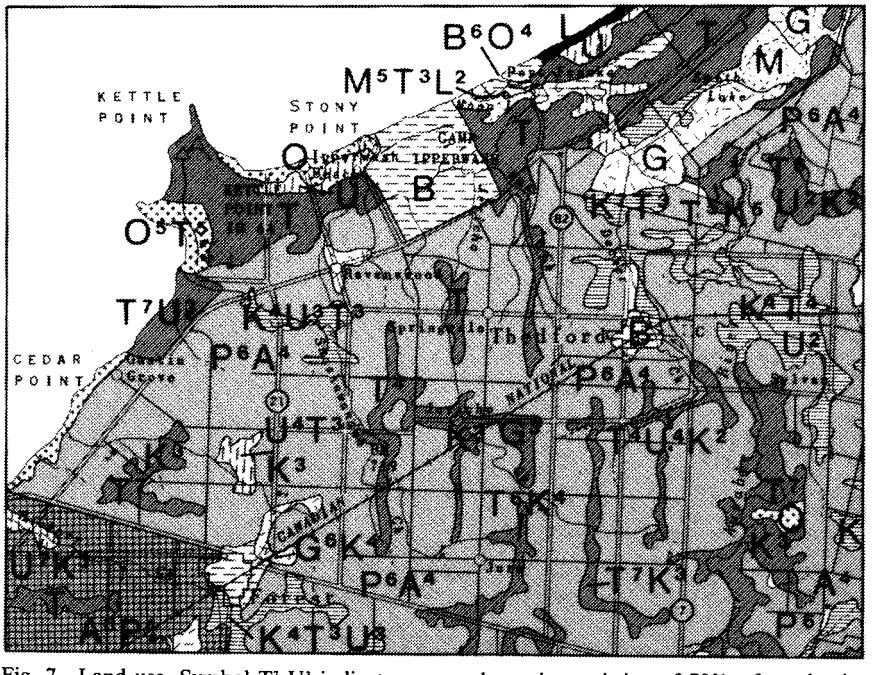

Fig. 7—Land use. Symbol T^7 U^3 indicates a complex unit consisting of 70% of productive woodland (T) and 30% of nonproductive woodland (U).

System for reference and overlay analysis with other CLI data and related information.

Land-use information was mapped with the aid of aerial photographs and frequent ground checks. Symbols based on the classification developed for this purpose were used to identify the nature of land use. The minimum land unit identified and classified represented an area on the 1:50,000 map by a square of 0.32 by 0.32 cm, which corresponds to an area of 2.6 ha on the ground.

IV. USE OF CLI INFORMATION

As already outlined, the CLI sector maps are based upon national interpretative classification systems which have been designed for specific objectives.

Because these interpretative classification systems identify only that biophysical information from the landscape that is required in accordance with predetermined objectives, the resulting data provide only one of several important inputs required in an environmental data bank.

When combined with other environmental, social, and economic factors, these interpretations provide the basis for the derivation of environmental management policies and land use planning programs which are consistent with desired social values and goals (Dean & Romaine, 1972).

A. Land Use Planning

In three studies conducted in each of the Maritime provinces of Nova Scotia, New Brunswick, and Prince Edward Island, the CLI data have been applied to regional planning concerned with the rationalization of the agricultural industry, associated land use adjustments, and the economic improvement of the rural resource base. In each of the three studies, the CLI data provide the basis for the initial physical analysis of available renewable resources. Detailed socioeconomic data, gathered concurrently, are utilized to influence decisions that were made during the capability analysis phase.

In 1966, the Government of Ontario launched a program called Design for Development aimed at regional development through comprehensive planning. Under this program, regional land use planning was undertaken so that the regions of the province could be developed according to an orderly plan based on environmental, social, and economic considerations. The CLI data formed an important input for the analysis of the physical capabilities of the land base. The analysis identified resource growth zones in addition to and complementary to urban growth areas. Predominant resource use was designated in areas where there was little or no overlap between land potentials. Multiple and competing resource use areas were designated along with zones of conflict between urban and resource use. Furthermore, zones of damage-prone environments or physical hazards were indicated.

The primary purpose of the pilot land use study undertaken in the Rocky Mountain Foothills of Alberta was to provide the province with a design for the most beneficial allocation of the conflicting resource demands in the area. Opposing interests in the study area included: coal, oil, and natural gas extraction, range and forest management, recreation and hydroelectric development, and wilderness and wildlife habitat preservation and protection. An overriding factor was that the area is the headwaters of the South Saskatchewan River, which flows across the semiarid region of the Prairie Provinces.

The study had two additional purposes, namely to develop a coordinated planning process that could be extended to other regions of the province and, to develop an analytical computer-based procedure for efficiently processing the large volume of data necessary for the physical, economic, and social analysis. The CLI capability data which formed a major input into the initial phase of the study included an assessment of the renewable and nonrenewable resource potential, a compilation of current land use, and a review of basic legislation.

As an alternative to the above studies, the Province of British Columbia elected to carry out Land Capability Analysis studies in conjunction with their ongoing Canada Land Inventory Program. A similar approach was taken by Newfoundland. The Land Capability Analysis map was compiled by a group of specialists representing the following professions: biolo-

gy, agrology, ecology, pedology, forest economics, sociology, geography, education, forestry, climatology, and landscape architecture. Usually, the specialists who had prepared the CLI sector maps were present; moreover, each had thorough knowledge of the area under discussion. The analysis is restricted to the physical capabilities identified in the CLI data because no social or economic inputs are considered at this time since data in these files are incomplete.

Land capability analysis maps were compiled using an overlay technique involving 'prime use areas' (generally the first three classes of each sector) for the five capability sectors (Rees, 1977). Prime use areas were identified on the map except where two or more were coincident. In areas where no single high 'prime use' capability was evident from the first overlay, conflict was resolved in committee by reverting to class ratings and making trade-off comparisons between sectors. While only a single use is shown on the finished map, it is recognized that other uses are possible.

The resulting British Columbia land capability analysis maps are thus basically an evaluation of physical land capabilities and show the 'best' prime use of land from an ecological viewpoint within the narrow range of choice provided by the original CLI resource sector information. Social and economic factors are explicitly excluded from the analysis; thus, there is no pretence that this system comprises an overall land use planning process. It serves rather as a reference point for land managers and planners when considering the allocation or alienation of 'best' prime use land in land use or development programs.

Perhaps the single most dramatic and significant example of the application of CLI data in Canada, arising out of the British Columbia land capability analysis map studies, is that province's designation of Agricultural Land Reserves. These were established by the British Columbia Land Commission in the 1970's with the principle objective of preserving agricultural land for farm use.

Rapid growth and urbanization in British Columbia had consumed nearly 4,050 ha (10,000 acres) of prime agriculture lands per annum. CLI agricultural data for British Columbia indicated that less than 5% of the province's lands were suitable for agriculture. Based on the availability of CLI data, which recorded the location and paucity of the supply of good agricultural land, the British Columbia Land Commission was able to react to the need to help future agricultural land use options open. Most significantly the identification of all land with agricultural potential within the short time constraints of the Land Commission Act, necessitated as it was by the quickening pace of alienation of farm land for urban purposes, would have proved an unsurmountable problem had it not been for the existence of the Canada/BC Land Inventory (CLI) (McCormack, 1970; British Columbia Land Comm., 1974).

While the identification of potential Agricultural Land Reserves was perhaps the most important use of CLI data, several other aspects of the British Columbia Land Commissions operations are worth mentioning in the context of CLI. Small farm, orchard, and ranch holdings were acquired

to facilitate consolidation of farm lands and to encourage younger farm families through career farm leases. Other special projects of the Commission, such as assistance in routing rail and road right-of-way, land assembly for experimental spray irrigation, and identification and acquisition of greenbelt, land bank, and park lands, were also facilitated by the availability of CLI data (Rees, 1977).

Similarly, the other provinces in Canada have used the CLI data in selecting areas for zoning on the basis of land capability and for the formulation of guidelines to assist in resolving land allocation problems and as a follow-up to regional planning and development programs.

At the national scale, CLI data provide the basis for an assessment of the nature of land use and land use changes in Canada particularly in terms of the encroachment of urban sprawl into agricultural and other 'prime' resource lands (Environ. Canada, 1976b). Although Canada has the second largest land area of any nation, through CLI it has been established that only 10% of that area is, in practical terms, suitable for agriculture. From this 10% the nation obtains a variety of produce including large quantities of food for the world market. Owing to the dependence of Canada on the produce of land, it is essential to understand the limits of the land resource, the location of prime lands, and the forces that may effect the capability of the land resource to continue to serve Canada's needs (Environ. Canada, 1976b; Gierman, 1977; Manning & McCuaig, 1977).

CLI provides base data for an ongoing program of monitoring land use change in Canada, enabling an examination and measurement of the manner in which 'prime' lands are converted to uses other than what their natural capabilities may indicate are the best. Studies examining the rate of rural or urban land conversion in major metropolitan areas in Canada with over 25,000 population have been undertaken and will be continued at regular intervals (Gierman, 1976; 1977).

B. Management and Development Programs

In areas committed to land use planning studies, or where the studies were not completed in time, single sector resource capability information serves as a basis for the specific follow-up surveys and research, for the identification of areas for certain kinds of preferred activities or use, and for guidelines as follow-up management plans and programs (McCormack, 1970). More specifically, the CLI data are used in:

1) Land use zoning programs either to preserve prime significant or sensitive areas from being converted to nonreversible or incompatible land uses or, conversely, to restrict the types of land use commitments on those areas which inherently pose a hazard to development.
2) The acquisition of lands for subsequent consolidation into agricultural management units, for the development of new parks or for the acquisition of wetlands for waterfowl. As such, the CLI data are

used not only as the basis for land banking programs, but as a means for determining the subsequent use and disposition of these lands.

3) Compensation programs designed for the relocation of resource use activities, and individuals that are affected by encroaching resource developments such as hydro-electric reservoirs.
4) Environmental studies designed for selecting transportation and transmission corridors, and for assessing environmental impacts associated with site-specific development projects such as airports, pulpmills, and deep seaport facilities.

The use of CLI data was the subject of a questionnaire circulated at random in 1976 to some 500 individuals involved in a variety of occupations having relativity to the practices of land use management or planning, or the provision of information relating to the same. There were 365 replies, most indicating a familiarity with and use of CLI data in a wide variety of ways.

A selection of specific uses of CLI data noted in the questionnaires is as follows:

1) Land use studies in an area proposed for grassland National Park, Saskatchewan.
2) Preparation of a report for a local government district on drainage priorities for the area.
3) Advice to local farmers from their agricultural representative on farm land utilization.
4) Studies on the promotion of forage and grassland management on Class 4 and 5 agricultural soils.
5) Use in university studies for examination of relationship between soils, land-use, and land capability.
6) Identification of areas with intensive forest management potential.
7) Reassessment of farm lands for tax purposes based on CLI Agriculture soils capability.
8) The identification and introduction of zoning controls on hazard lands.
9) CLI data used as a teaching tool in climatological studies related to agricultural land use.
10) The determination of best use of noncommitted lands in regional land use planning studies.
11) The development of land capability classification for fruit trees.
12) Location of power line rights-of-way in relation to preservation of high value agricultural lands and associated environmental impact studies.
13) Reference data for considering farm loans related to productivity and soil ratings.
14) Study of recreational capabilities of cottage sites in regional outdoor recreation planning.
15) Examination of municipal boundary proposals in terms of conversion of rural to urban lands.

16) Waterfowl breeding surveys.
17) Used in the supervision of field service activities in the identification and management of grazing lands.
18) Economic studies in the establishing of rural estate values.
19) Teaching a course in integrated land use in forestry.
20) Site selection for industrial parks in regional land use planning studies.
21) Environmental impact studies: oil and gas pipeline locations; trans Canada pipelines.
22) The monitoring of land use change over a period of time and related loss of agricultural lands.
23) Cost/benefit studies for the implementation of drainage and land development schemes.
24) The inventory of land-based resources in urban commutershed for land use planning.
25) Evaluation of forest sites for intensive management—stand improvement, thinning, and fertilization.
26) Research studies into provincial land use policy.
27) Examination of land capability of hobby farms to study relation of land use to capability.
28) The assessment of areas identified for potential hydro development.
29) Evaluation of areas for future additional provincial park sites and determining the suitability of adjoining lands for extension of provincial parks.
30) Assessing areas for future highway locations across the province to minimize impact in 'prime-use' agriculture and other resource lands.
31) Examination of recreation potential of proposed reservoir and dam sites in a major river basin water supply study.

V. IMPACT OF CLI ON RESOURCE MANAGEMENT IN CANADA

The CLI program produced about 20,000 1:50,000 scale maps, 1,200 1:250,000 and 1:1,000,000 scale maps, and reports covering about 2.5 million km^2 of Canada's land at a cost of about $37 million. Use and misuse has been extensive. Though no comprehensive cost/benefit studies have been carried out yet, results of user surveys indicate that much of the total cost has already been recovered through the reduction of incremental cost related to new activities and environmental impact assessment, prior knowledge and quantification of problem areas, and more effective planning, implementation, management, and use of land.

The success achieved in gaining general acceptance and application of the CLI program was due largely to the manner in which the cooperative program was implemented. The classification work for a resource sector

was undertaken by or through the government agency responsible for the planning and management of that sector. Thus the chief potential user of the data frequently is the same agency that was responsible for preparing the capability maps for a particular sector. By placing the land capability classification function close to the resource planning and management function, knowledge of the Inventory's potential use for planning was readily available to the personnel who could make most use of it.

Also, well over 1,500 professional, research, technical, and student staff were involved on a full- or part-time basis. Many of these have moved on to resource management and planning positions. Their multidisciplinary experience filled a vacuum that was created by the shift from single to comprehensive resource management.

In most provinces, the organization set up to carry out the CLI program was absorbed in the government structure. In British Columbia, the CLI team evolved into the Resource Analysis Branch with multidisciplinary staff of about 120, representing a unique integrated and concentrated effort towards environmentally sound use of the land resource, unequalled elsewhere in Canada. At the federal level, the CLI program became the nucleus of the Lands Directorate in the Department of Environment. This directorate, with headquarters in Ottawa and regional offices in Vancouver, Edmonton, Burlington, Quebec City, and Halifax, is responsible for continued federal-provincial cooperation in land inventories, land use monitoring, land use policies, and the promotion of environmentally sound land use planning.

Under auspices of the now virtually completed CLI program, other initiatives were taken that are continuing. The Subcommittee on Bio-Physical Land Classification started in 1966 the development of an ecologically based land inventory system for the more than 5 million km^2 that lie outside the CLI area. This system, presently developed further through the Canada Committee on Ecological (Biophysical) Land Classification (Canada Comm. Ecolog. Land Class, 1977a), is designed for rapid reconnaissance as well as detailed surveys (Canada Comm. Ecolog. Land Class., 1977b) and avoids limitations of the CLI systems. Rather than creating several interpretative maps, it provides one ecological base map from which a multitude of interpretations are possible (Jurdant et al., 1977). The CLI computer data bank has evolved into the Canada Land Data System. National significant and consistent data are continuously added to the CLI base to provide support for national land use policies and national perspective studies. A Canada Land Use Monitoring Program is being developed, building on the CLI land use base to provide material for and measure impact of policies, regulations, and plans. In his look at CLI in retrospect, W. E. Rees (1977) observes:

> In spite of many valid reservations concerning the structure and quality of CLI data, the program has contributed immensely to a revolution in land and resource planning in Canada.
>
> Apart from a basic planning framework and large quantities of data, the CLI has provided a number of indirect benefits to environmental management;

a medium for improved communication (and perhaps reorganization) of administrative and management agencies in the resource field; a stimulus for the development of improved approaches both to resource inventory itself and to land-use through integrated management; and an impetus for revision of land-use legislation, regulation and procedures. Clearly the CLI has served well to underscore the inadequacy of former approaches.

In a time when public participation is considered an integral part of planning and management, the Canada Land Inventory has allowed a rational public and political involvement in land use planning, policy design, and regulation. In recent national, provincial, and regional elections, environmental impact hearings, and regional planning exercises, Canada Land Inventory classes and statistics consistently provided the framework for debate and opinion-forming, especially related to the urban-agriculture land use conflict.

The CLI classification has become very much a part of public vocabulary.

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