ECOLOGICAL LAND SURVEY IN MANITOBA, A DISCUSSION AND EVALUATION

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Master of Science

by

Hugo Veldhuis

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ABSTRACT

The objectives of the study are to review the approach taken by Ecological Land Surveys (ELS) to the inventory of land resources in Manitoba and to evaluate the extent to which the survey data have ecological significance and value to users of the land resource. This evaluation suggests certain modifications to the ELS methodology to improve the usefulness of the survey data to potential users.

The analysis and evaluation of Ecological Land Survey in Manitoba is accomplished through detailed study of the maps and descriptive reports derived from the Northern Resource Information Program (NRIP). Certain weakensses are evident in the hierarchical system in terms of developing relationships between the taxonomy and the map units depicting landscape segments at the Ecosection level. Ecological integration on the NRIP ecosection map is only weekly expressed. Data collection and data presentation of the NRIP surveys are not as well developed as would be expected from a truly integrated ecological land survey.

Although the NRIP ecosection maps provide a large amount of land resource data for terrain where little previous information existed, the lack of a descriptive report and interpretation keys limit the usefulness of the data. The complexity of the ecosection map unit also limits its use as an ecological unit for planning and management purposes. Detailed descriptions explaining the ecology of the Ecosite components in each map unit are required to realize the full potential of the Ecosection map as a resource document.

The results of this evaluation suggest that the Ecological Land Survey as carried out in Manitoba could be improved through a better definition of objectives, a greater balance of expertise on the study team and a better structured and increased effort towards data collection. The uefulness of the data can be increased most readily by provision of map unit and map unit component descriptions and evaluation of these units for particular land resource uses. Increased communication with potential users during the planning stage and by means of an extension function following completion of the project should greatly facilitate use of the data.

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Chapter 1

INTRODUCTION

Sound land use and management require that baseline data on aspects of the environment be as complete as possible. Land resource data can be collected according to various themes, each designed to provide information on a particular component of land. Land use planning and management decisions may be based on a single attribute of land or, preferably, a combination of land attributes. Planning or management decisions for a single attribute of land generally are based on data provided by a survey of a single resource attribute of land, characterized by a specific kind of classification with its own unique terminology.

Resource surveys which collect data on a wide range of land attributes provide information which is thought to be more useful to the collective group of land resource planners and managers than the data concerning a single attribute of the land resource. Such classifications should be broadly based and sufficiently complete to serve, directly or by means of interpretation, a wide spectrum of user groups. Multi-disciplinary surveys of land resources have developed in recent years to provide a single data base which included a large body of information on the physical and biological attributes of land. Integration of these physical and biological components into a single data base is attempted by Ecological Land surveys.

A number of Ecological Land surveys have been carried out in Manitoba during the last decade, but a review of the surveys and their application to land management has not been attempted to date.

The objectives of this study are:

1. to provide an in-depth description and critical analysis of the approach taken by Ecological Land Surveys to the inventory of land resources in forested terrain in Manitoba;
2. to evaluate the extent to which ecological land survey data have ecological significance and their value to users of land resource data;
3. to suggest modifications to the Manitoba Ecological Land survey methodologies and the kind and level of integration of potential users in the planning process and data presentation phase, in order to enhance the capability of the maps and reports to satisfy needs of potential users.

The objective of the study are met by an evaluation of Ecological Land Survey, as carried out under the Northern Resource Information Program (NRIP) in Manitoba, through a review of ecological land survey in general and a comparison to the Ecological Land Surveys produced in the Cormorant Lake Pilot Project in Manitoba and the James Bay Project in Quebec.

Chapter 2

THE LAND RESOURCE

"Land, in its broadest sense, is a segment of space where plants grow, animals roam, people live, water flows in rivers and collects in pools" (Zoltai, 1969). Rowe (1980) described land as "a continuum over the planet's surface, comprising an air layer resting on an earth layer, with organisms and soils sandwiched at the energized interface." Land is a three-dimensional entity, having a horizontal plane, as well as a vertical dimension, extending for a certain distance above and below the earth's surface.

The components that make up land are of two kinds: 1. physical components such as surficial materials, the form of these materials, the soils developed on them and the associated drainage system, including both surface and ground water; and 2. biological components in the form of vegetation, wildlife and man. The interactions of these components are governed and driven by energy derived from climate. A look at land in this fashion comes conceptually very close to the concept of an eco-system as defined by Odum (1959) as "an area of nature, that includes living organisms and non-living substances interacting to produce an exchange of materials between the living and the non-living parts."

However land means different things to different people. Many people tend not to look at land according to such holistic descriptions.

When referring to land some people identify it by one of its components or the use that is being made or can be made of it. Different points of view and different interests often result in land use controversy between concerned groups.

The most complete knowledge possible of the landbase and related resources is essential for sound land use and management. Inventory of land or its components should aim to collect data in a way that will allow for a balanced evaluation of the potential uses of the land and the impact these uses may have in a short and long term time frame.

Land attributes that are important for land use in any area with respect to agriculture or forestry are climate, relief, water, vegetation and soil conditions (Vink, 1975). Other factors such as geology and artificial lanscape elements may also be of great importance depending on the type of land use.

In this chapter single attributes of land like surface deposits, topography, climate, soil and vegetation are discussed and some of their interactions and interrelationships mentioned. In the last sections of this chapter, the ecosystem as the holistic land element is discussed and its significance to land use and management noted.

SURFACE DEPOSITS AND TOPOGRAPHIC EXPRESSION

Geomorphology is concerned with form and structure of surface materials. It includes characteristics such as slope, arrangement of slopes to produce landforms, relief, and resulting drainage patterns. The organization and distribution of landforms in the landscape includes spatial relationships both of materials in the horizontal plane (surface distribution) and vertical plane (stratigraphy, thickness). Properties and conditions of surface materials include characteristics that are obtained and observed in the field as well as properties that are measured in the laboratory. The former include moisture regime, the latter chemical and physical properties. Other properties that are described and documented are texture, coarse fragments and organic material characteristics. The temperature regime is an important property of surface deposits particularly with respect to permafrost characteristics and distribution.

Geomorphic processes may be both originating and modifying processes. The former are responsible for producing the original landform and the latter are those processes that have acted or still are acting to change the surface (Fulton *et al.*, 1974). The form of the deposits and their structural and textural properties are to a large extent dependent on the mode of deposition.

Topography

Topography is often directly related to the mode of deposition and nature of the surficial deposits. Lacustrine deposits are usually level or very gently sloping except in areas where the topography of underlying materials (bedrock, till) affects the relief of the lacustrine sediments whereas till landforms range from level to undulating, hummocky to rolling, and ridged.

Relief and topography play an important role in controlling or conditioning the type and effect of soil-forming processes (Eilers et al, 1977). Soil formation and vegetation characteristics often directly relate to landscape position. In rolling or undulating terrain the tops of the knolls tend to be more arid than the adjacent depressional sites. Differences in parent material, geographic location, temperature and precipitation determine the extent to which the apex may be too dry or the low lying areas too wet for optimal plant growth.

Aspect may have a marked effect on soil development and vegetation type, especially in areas were moisture deficiency is common during the growing season. Undulating and rolling topography results in characteristic patterns of soils and vegetation. In rolling terrain in sub-humid climates south facing slopes may have grass vegetation while the north slopes support aspen. Under cool humid climates, depressional areas are invariably occupied by organic soils while lower slopes often have wet soils with thick organic surface horizons.

Materials

Textural properties of surficial materials are also related to mode of deposition. For example, tills usually consist of materials that are mixed and non-sorted with textures ranging from clay to fine loam and sand. Lacustrine sediments, on the other hand, are usually well sorted and stratified, ranging in texture from heavy clays to silts and fine sand.

The chemical characteristics (eg. calcareousness, acidity, salinity) of surficial materials are closely related to the original materials (bedrock, older surface deposits) that contributed to its composition.

The kind of material and its physical and chemical composition are of great importance to the formation of soils and growth of plants. Physical properties related to particle size distribution determine to a large extent characteristics of the soil such as water holding capacity, structure and water movement through the soil. Chemical properties influence nutrient levels and inherent fertility, which in turn affect and are affected by plant growth.

CLIMATE

Weather is the state of the atmosphere at a given moment or for a short period, whereas climate is commonly regarded as the generalized weather for a long period of time (Shaykewich and Weir, 1977). Climate of a region is usually identified by a broad descriptive terminology like Boreal Temperate, moist sub-humid, while its parameters are defined by means of data from meteorological stations. Usually monthly average and yearly total values for the thermal and moisture attributes of climate are provided. Detailed information on distribution of events like heavy rain, or extreme values for frost-free periods and temperatures also form part of a climatic description. Information on the probability that such extremes might occur is of great importance to many biological uses of land such as agriculture, forestry and wildlife.

Climatic Elements

Climatic elements such as temperature and precipitation are of major importance to soil formation and vegetation distribution, but elements like wind, humidity or cloudiness have significance as well. Temperature is largely a function of the amount of solar radiation reaching a given area. Although each area on earth receives potentially the same amount of sunlight (barring cloudiness) on an annual basis, intensity of radiation diminishes from the equator to the poles as result of angle between the sun rays and the surface of the earth. Consequently land areas farther north have colder climates than areas closer to the equator. Elevation and proximity to large water bodies influence atmospheric circulation and so modify local climate to a great degree, causing areas to be either colder or warmer than would be expected on the basis of insolation alone.

Precipitation in the form of rain and snow is the major source of moisture available for plant growth. Locally dew, fog and humidity play a role but are insignificant compared to the total precipitation. In cold climatic areas, rainfall during the spring and summer months is of prime importance to the process of soil and vegetation formation. Run off from snow is important in charging the upper layer of soil with moisture and in its erosive and depositional effects on the landscape and in the recharging of depressions and wetlands.

Climate, Soil and Vegetation

Effect of climate on soil and vegetation is both direct and indirect in regulating processes of soil formation and influencing vegetation distribution. The formation of major vegetation zones is dependent on climate. Temperature modification (micro-climate, soil-climate) is largely dependent on topography and structure of vegetation. Similarly the type and rate of organic material accumulation on or below the soil surface relates directly to the type of vegetation (grass vs forest) (Crompton, 1962). This in turn affects the soil flora and fauna and the cycling of nutrients through the system.

Direct effects of climate are related to physical and chemical weathering of rock material, minerals and the breakdown of organic matter. The rate of, and balance between processes in horizon differentiation ie. additions, removals, transfers and transformations (Simonson, 1959), are largely governed by temperature of the soil and its moisture status. Minimum temperature and moisture conditions are required for the processes to take place, whereas too much moisture may reduce the rate of these processes significantly.

Temperature and precipitation commonly vary according to altitude and latitude. Under moist, cool conditions, evaporation losses are low and more moisture can infiltrate and leach the soil. Soils developed under these conditions eg. soils under forest cover, are often deeply leached, whereas soils in northern regions, which contain permafrost or stay frozen for a long time have shallow sola resulting from an excess supply of moisture in combination with low soil temperatures. Many soils under such cold climatic conditions are churned by the action of freezing and thawing resulting in strongly disturbed profiles which are relatively shallow (Zoltai and Tarnocai, 1974).

Climate can not be observed directly. Meteorological data have to be collected over a period of time in order to make valid statements about climatic characteristics. Climatic characterization is an integral part of the data requirement for land and soil evaluation. However such data is seldom adequate for detailed land evaluation purposes and often not available for inaccessible regions of the north.

In general terms, climate can be inferred from a careful study of soil and vegetation properties. Such inferences are often used to help define climatic regions where other climatic data are not available (Mills, 1976).

SOIL

Soils comprise the uppermost part of the earth's surface. They have developed where the action of water (liquid and frozen), wind, temperature and organic decay have resulted in the aggregation of unconsolidated mineral and organic particles - the regolith. The combined effect of climate and organic life modified by topography acting on the regolith over time results in the formation of soils.

Soil Formation

Simonson (1959) proposed the view that soil genesis consists of two overlapping processes: 1. the accumulation of parent materials and, 2. the differentiation of horizons in the profile. The first process is largely of concern to the surficial geologist while the second process is mostly of concern to the soil scientist. However, an understanding of the first process greatly facilitates the work of the pedologist in producing a soil map. Soil formation involves the differentiation of horizons on a given parent material due to additions, removals, transfers and transformations within the soil system. These processes take place in most and probably in all soils, but the rate at which they take place varies widely. Shifts in balance among combinations of processes are responsible for soil differences and horizon differentiation rather than a single process by itself. This view explains the existence of soils as a continuum over the land surface and also explains the lack of sharp boundaries between soils (Simonson, 1959).

State Factors in Relation to Soil Formation

The processes involved in soil differentiation are governed by the combined effect of climate, organic life and topography on the regolith over time. Although often described as soil forming factors, none of these factors is a former, creator, or force. They are rather the independent variables (state factors) that define the state of the soil system (Jenny, 1961). None of these state factors are uniform from area to area with the result that the soil forming processes they govern also vary in their combined effect from location to location. This variation results in a population of soils in which each member has a unique combination of characteristics.

The idea that soil formation is dependent upon environmental factors is generally credited to the Russian soil scientist Dokuchaev. He established the concept that climate, subsoil (parent-material), vegetation, fauna, man, age of land surface and relief are the significant pedogenic factors (Crocker, 1952). More recently it has been determined that Dokuchaev related the factors in an equation as follows (Jenny, 1961):

$$s = f(cl,o,p)t^{o}$$

where s represents soil, cl climate of a given region, o the organisms (plant and animals), p the "geologic substratum" and t^{o} is relative age (youthfulness, maturity, senility).

The equation published by Jenny (1941) is quoted more commonly and is given below:

$$1)\quad s = f(cl,o,r,p,t\ \ldots)$$

which equation he later expanded (Jenny, 1961) to:

$$2)\ l,s,v,a = f(cl,o,r,i,t)$$

where l = any ecosystem property or ecosystem

s = any soil property or soil

v = any vegetation property or vegetation

a = any animal property or all properties

cl = climate

o = organisms

r = topography

i = initial state of system,at t=o, i=parent material

t = time

The dots stand for unspecified components. Climate (cl) is and organisms (o) may be functions of time (t); but topography (r) and parent material (p) are never time dependent (Jenny, 1961). Factors p and r pertain to initial states and as such remain invariant. During genesis p becomes soil and some of the r components (eg. slopes) become soil properties that may vary with erosion and its depositions (Jenny, 1980).

The number of factors in soil formation can be expanded by differentiation within the five state factors. The water table and often man are listed as separate factors in relation to soil formation (Ellis, 1938). Man is seen as a disturbing force in comparison to other factors and the results of his activity are often destructive to some degree and cause sudden change in a dynamic equilibrium.

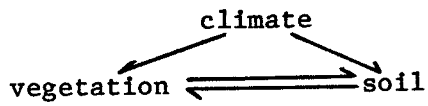
Time is not considered a factor in the same way as the other state factors; time is a dimension, like space is a dimension. For that reason the equation is sometimes written in the following manner:

$$s = f(cl,o,r,p...)t$$

The role of time is nevertheless important in the formation of soils and vegetation communities and exerts a strong influence on these attributes of land.

Time is required for a process to show effect through changing state of object observed. Studies have shown that it may take several hundred years for some soil horizons to form, while other soils may develop over 2000 to 10000 y. Parsons et al. (1970) found cambic horizons formed in a little more than 500 y whereas Bt horizons formed within 5250 y. On the other hand Crocker and Major (1955) showed that marked change in pH, calcium carbonate content, organic carbon and total nitrogen can be observed in periods of 35 to 50 y. A well developed Brunisol examined on a former marine beach in Northern Manitoba was found to be at least a few thousand years old (Mills and Veldhuis, 1978).

Except for an interdependence between climate, organisms and time, the state factors are considered to be independent variables. Climate changes over time. Although changes may be slow, some very different climates may have influenced soil development since its inception. (Mills and Veldhuis, 1978). Bryson and Wendland (1966) established some tentative climatic patterns for the last 10 000 y in North America; patterns which suggest dramatic changes in climate during that period. Past climates may still have an indirect effect on vegetation through species distribution (Löve, 1959) and through vegetation, an effect on soils. The state factor o includes both animals and plants. With respect to soil, this includes the soil flora and fauna as well as the flora and fauna on and above the soil surface. The vegetation cover is usually seen as the most important aspect of the factor o, as it provides the organic material needed to sustain animals as well as the soil flora and fauna. Vegetation provides the means of intercepting energy from the atmosphere and transferring it to other forms in the soil system. However, interrelationships must be acknowledged, as composition, structure and growth of vegetation are influenced by other elements in the factor o. Plant and animal populations may change fairly rapidly over time. The cyclic nature of some animal populations (Colinvaux, 1973) is a well established fact as is the pattern of succession in vegetation communities. (Kershaw, 1973; Dansereau, 1957). There are also important interrelationship between climate, soil and vegetation which can be represented by the triangle:



(Jenny, 1958)

It implies that climate affects soil and vegetation independently, that soil (edaphic factors) influences vegetation, and that vegetation reacts upon soil. It suggests that the soil-plant relationship is difficult to interpret. Major (1951) established the concept:

$$v = f(cl, o, r, p, t \ldots)$$

This equation indicates that vegetation is as much governed by environmental factors as is soil and that these factors are identical to the ones directing soil formation. This similarity in controlling factors fosters the idea of correlation between vegetation and soil type, as long as both are still in tune with climate. On the other hand, it also suggests that the vegetation factor cannot be considered to be independent.

Soil, Climate and Vegetation

The principle of varying one factor while others are kept constant has found wide spread application in soil survey and land classification. It permits one to make inferences about soil development on the basis of information on state factors. For example, within a region of uniform present (and historic) climate it is possible to predict soil development on a particular parent material in a particular topographic setting on the basis of information obtained on soils developed under similar conditions, but in a different area within the region. Conversely, regions with uniform climate can be established by comparing soils on similar parent materials and in similar physiographic settings. Similarity between soils usually means development under the same set of climatic conditions, whereas dissimilarity may point to variations between all or a number of climatic elements.

VEGETATION

Plant cover can be considered in two ways: 1. as an assemblage of plant species (flora) or 2. as a community of plant individuals and plant groups. Flora refers to kinds of plants (species) in a chosen landscape, regardless of number of individuals of each species present. Accordingly the flora of an area is described by a species list. Vegetation, on the other hand, refers to quantity and quality of growth. Vegetation has structure and shows changes over time in structure, species and number of individuals.

The vegetation component is strongly influenced by climate and similar factors in the environment which interact in soil formation. The plant factor in turn is one of the state factors affecting soil formation.

State Factors in Relation to Vegetation Formation

A plant community is an aggregation in definite proportions of more or less interdependent plants, utilizing the resources of a common habitat which they either maintain or modify (Dansereau, 1957). Particular vegetation characteristics result from interactions of organisms (plants and animals), parent soil material, relief or topography under the influence of climate over a period of time. The definition has been expressed in a function similar to Jenny's (1941) by Major (1951):

V (plant community) = f(o,c,p,r,t)

where o = organisms, c = climate, p = parent material, r = relief or topography and t = time.

Mueller-Dombois and Ellenberg (1974) proposed the following equation:

plant community = fl(f,a,e,h,t)

where fl = flora,

a = accessibility factor

e = ecological plant properties

h = habitat

t = time

In this equation, the factor flora is the entire range of plants (species) in a given area and thus comprises the species pool potentially avaiable for occupation of the site. This concept is similar to Jenny's (1961) plant biotic factor.

The ability of a given species to reach the habitat in question is largely dependent on distribution of a species in an area, its dispersal mechanism (seeds, rootsuckers, vegetative propogation etc), barriers between the source and the habitat. This is the accessibility factor a.

The ecological factor e refers to the properties of the species themselves, particularly their lifeforms, physiological requirements (tolerances), and other characteristics that influence their ability to compete with each other after they have become established.

The habitat h is the sum total of environmental factors operative at the particular locality in question and include those factors which are listed by Major as parent soil material, relief or topography, climate and to some extent other organisms.

Time plays the same role in this concept as in that of Major or Jenny. Time is required for a process to cause changes. Marked changes in vegetation over time have been studied by means of pollen analysis and buried organic fragments. Both Ritchie (1966) and Shay (1966) show evidence of major vegetation shifts across large areas of Manitoba and Minnesota - North Dakota respectively. The extent and magnitude of these shifts indicate that they are mainly due to climatic change, rather than to less drastic and much slower shifts in vegetation resulting from natural succession and colonization. Vegetational change as result of surface age has been shown by Gill (1968) for alluvial soil material in the MacKenzie Delta N.W.T.

Dansereau (1957) describes the various factors or subfactors as elements competing for control, control that shifts with the successional stages of vegetation in time. The process of succession of plant communities does not continue indefinitely, eventually a dynamic equilibrium is established, called climax or stable state. This community varies geographically with climate and is the best expression of the controlling effect of climate on a region, when the communities on well drained, medium textured uplands (normal site, mesic site, normal physiographic site) are considered. In some areas the expected stable state is never reached as a result of a high frequency of disturbance by forest fires.

Vegetation Structure

The organization in space of the individuals that form a stand

(and by extension over a larger area a vegetation type or plant association) is called structure (Dansereau, 1957). Different categories of structure, can be recognized. Mueller-Dombois and Ellenberg (1974) list the following types of structure: 1. Vegetation physiognomy, 2. biomass structure, 3. life form structure, 4. floristic structure, 5. stand structure. These groups of structure are hierarchically integrated, the first being the most generalized and the fifth level the most precise or exacting. Physiognomic structure refers to the external appearance of vegetation, while biomass structure relates to the spacing and height of plants. Life form structure relates to the composition of growth forms or life forms in a vegetation stand. Floristic structure refers to floristic composition usually at the species level. Structure as used in this and following sections is the stand structure. Kershaw (1973) distinguishes three components of vegetation or stand structure: 1. vertical structure, 2. horizontal structure (relating to pattern) and 3. quantitative structure (the abundance of each species in the community, often measured as percent coverage, or number of individuals). Dansereau (1957) describes the primary elements of structure as: 1. growth (not considered here), 2. stratification and 3. coverage.

Stratification refers to the layering of the vegetation. In a well established forest stand in the boreal forest it is usually possible to recognize an arrangement of individual plants at various heights above ground. Stands with this characteristic may consist of an upper layer of mature trees (canopy), or second layer of younger trees (understory) and one or more layers of shrubs or juvenile trees. The lower layers consist usually of a herb layer with ground cover of mosses and trailing plants.

Horizontal structure refers to the arrangement of individual plants with respect to individuals of the same and other species. Arrangements can vary from a single individual or a small group to many dispersed individuals or carpets. The arrangement of individuals in a stand may provide information about history or succession within plant communities (Kershaw, 1973).

Vegetation Succession

Each plant community found on a particular site has in some measure adapted as a whole to the available resources. This habitat, however, is being modified in quality, quantity, and proportion of its resources due to (Dansereau, 1957):

1. more or less rapid physical and chemical change of the substrate;
2. modification in amounts and proportions of its elements induced by plants and animals occupying the site;
3. forces active within and among the living occupants which themselves will induce change.

These habitat changes in turn induce gradual changes in the vegetation communities. After disturbance, the vegetation is altered considerably and the plant community moves through a number of successional stages until it again reaches some kind of dynamic equilibrium with its environment, the climax or stable state. This state of succession is a stage "where plants may enjoy full vitality under conditions of their own making". The climax stage is often not the most common type of successional stage in an area. The majority of forests in the boreal region do not represent this stage and it is therefore of great importance to know how vegetation structure, soil conditions and forest productivity change from the initial through to the final stages of succession (Kojima and Krumlik, 1979).

Successional stages as result of disturbance (eg. fire, windthrow, disease, insect infestation) are called secondary succession (Kershaw, 1973). The successional stages are elements in a cyclic pattern which regulates the continuing creation of slightly different habitats for various life forms. When studied in detail, at many sites, the cycle can be understood and the changes can be predicted. Knowledge of the various cycles which a vegetation stand passes through permits its classification according to its stage in the cycle, or the site according to its predicted climax.

Drastic changes in the environment can disrupt the cyclic nature of vegetation communities. Mechanized logging (Weetman, 1974) may alter inherent properties of a site; forest fire protection may arrest cycles at a certain stage for a longer period, while logging may prevent a community from reaching overmature stages. If disturbance is not too severe, then succession will follow a predictable course.

Successional stages express themselves most strongly in the properties of the vegetation community (structure, biomass distribution, and species composition). However, changes also take place at the surface of the soil and in the soil. Amount and composition of litter on the forest floor change and so do soil flora and fauna (Houtzagers, 1956). Litter tends to build up, and biomass to increase until an equilibrium is reached between gains and losses (Bellamy and Clarke, 1968). Changes in wetland vegetation are often drastic as not only the vegetation is disturbed but the soil material and, in the case of frozen peatlands, the landform itself may be destroyed (Thie, 1974). The development of organic landforms often has a cyclic nature (Kershaw, 1973). Stages in peatland formation correlate strongly with a number of well defined vegetation types (Moore and Belelamy, 1974; Tarnocai, 1970, 1974).

ECOSYSTEM

The concept of land as an ecosystem developed over many years. The beginnings of the concept trace back to Dokuchaev and later the views of Jenny (1941) and Major (1951) which express soils and vegetation as natural entities resulting from the interaction of state factors. In Canada, the ecological concept of land was introduced by Hills through "physiographic sites and site regions" which were based on work by Christian and Stewart in Australia (Rowe, 1962). Krajina (1977) developed forest classifications based on the biogeocoenosis concept, which emphasizes the land as a natural system. In this approach, land is viewed holistically, in other words, land is seen as a whole of component parts which are interdependent and interrelated. Of the many definitions or ecosystem that exist three are given below:

> "a complex unit in space and time so constituted that its component subunits by "systematic" cooperation, preserve its integral configuration of structure and behaviour and tend to restore it after non-destructive disturbances" (Weiss in Wiken, 1978).

"living organisms (biota) and their non-living (abiotic) environment are inseparably interrelated and interact on each other. Any area of nature that includes living organisms and non-living substances interacting to produce an exchange of materials between the living (biotic) and the non-living (abiotic) parts is an ecosystem (the driving force which causes this exchange is the energy incident on the given area)" (Bellamy and Clarke, 1968).

"a limited space where cycling of resources through one or more trophic levels is affected by more or less fixed and numerous agents utilizing mutually compatible processes, simultaneously and successively, which engender products that are usable on short and long term" (Dansereau and Paré, 1977).

These definitions emphasize different characteristics of the ecosystem. Weiss emphasizes the tendency of the ecosystem to preserve and restore its structure and behaviour; to make itself whole again after disturbance. Bellamy and Clarke emphasize the exchange of materials between living and non-living components, an exchange which is fueled by the incident energy of the area. Dansereau and Paré put limitations on the extent of an ecosystem and also emphasize the cycling of substances within an ecosystem.

In the following sections of this study an ecosystem will be viewed as a limited area in space where interactions between biotic and nonbiotic components create characteristics which are particular enough to allow classification at detailed levels of abstraction.

State Factors in Relation to the Ecosystem

The development and existence of an ecosystem is governed by the same state factors which affect soil and vegetation. Thus Jenny's (1941) and Major's (1951) equations are applicable to the ecosystem as well:

ecosystem or ecosystem property = f(o,cl,p,r,t...)

or f = (o,cl,p,r,...)t

The properties of the ecosystem refer back to its component parts, either physical or biological. In the ecosystem concept the interactions and interrelationships between the biotic and abiotic components are emphasized. These interactions define the ecosystem and direct its functioning as an entity. By studying a land entity (ecosystem) a more complete picture of these interactions and relationships and the factors regulating them should evolve than is possible through study of component parts.

Ecosystem Characteristics

Three characteristics are common to all land ecosystems (Wiken, 1978): 1. location, 2. organization, 3. stability.

1. Location refers to the position of the component parts of the ecosystem. The delineation of an ecosystem means that the interactions of relations between the component parts of that ecosystem are different from those bordering it. It does not mean that the one ecosystem and its neighbours will not or cannot have component parts, or interaction between parts, in common. A boundary only suggests that the one ecosystem differs in some aspects, either parts or interactions. These differences mean that the ecosystem will function differently and likely will behave differently when subjected to the same treatment. Ecosystems showing fairly distinct boundaries in nature will differ more from their neighbour than ecosystems with very diffuse boundaries.

2. One common property on the basis of which ecosystems can be ordered is their organization or pattern. Organization refers to the distribution of characteristics in time and space. Pattern refers to spatial arrangement of elements, but also refers to behaviour, response, chronological events or sequences.

The organization of an ecosystem most readily observed is that of structure, both the vertical and horizontal arrangement of species or species groups. Chronological events or sequences and patterns of behaviour are more difficult to ascertain and usually require monitoring over time. In Weiss' (in Wiken, 1978) definition for ecosystem both structure and behaviour are an integral part of an ecosystem and are therefore means of identification. Pattern characteristics are of course best expressed at the centre of a system, while they tend to intergrade with those of other systems along common borders.

3. Stability refers to the relative static state of an ecosystem. Ecosystems are by definition not static entities but change constantly because their controlling factors change. Such change is usually very slow when the ecosystem is viewed holistically. Component parts such as vegetation may show rapid change whereas changes in landform are usually very slow. Ecosystems are usually rather persistent in their organization and interactions of component parts. Changes in vegetation may be abrupt but the chronosequence of successional stages may be very much fixed in time and predictable as a result.

This implies that when the ecological classification of land is attempted, the more stable component parts like landform, soils and vegetation chronosequences should be used to identify the system within a climatic setting.

Chapter 3

CLASSIFICATION AND MAPPING

Classification groups objects on the basis of their similarities and dissimilarities. The classification of similarities is based on the smallest natural body that can be identified as a complete entity: the individual. All individuals of a natural phenomenon are collectively called a population. In the similarity classification, groups of individuals similar in selected properties, are distinguished from all other classes of the same population by differences in these properties (Cline, 1949). These classes can then be grouped on the basis of common properties into classes at a more generalized level, and so on until a level of generalization is reached where grouping of classes results in the arrangement of the total population into one group (eg. soil or animals). A series of classes, collectively formed by differentiation within a population on the basis of a single set or group of criteria is called a category. It is a level of generalization or abstraction. A category includes all individuals of the population. The categories of classification form the hierarchy of the classification system. This type of classification often is called "classifying from below" (Rowe, 1979) and is based on agglomeration.

The classification of dissimilarities can be carried out by dissecting wholes into parts on the basis of differences, so that categories and classes are arrived at by subdivision "from above" (Rowe, 1979). The approach is to divide a heterogeneous whole into parts that are increasingly homogeneous. If at each division a consistent use is made of differentiating criteria, the resulting system can be as consistent and logical as the classification by agglomeration. The categories of this system also form a hierarchy. Classification by division is commonly applied in the mapping of land, although usually, both approaches are applied, as initially neither whole nor individuals are completely known or understood.

Terrain, vegetation, soil and ecological land mapping all depict portions of the landscape. Mapping is defined as the process, which attempts to represent on a planar surface the extent of various physical and biological landscape features and their relationships to each other. The identification, description and delineation are based on direct field observations or indirect inferences from such sources as aerial photographs.

CRITERIA FOR CLASSIFICATION AND MAPPING

A number of attributes or properties of land are used in the classification and mapping process. Three kinds of land attributes or properties can be distinguished (Rowe, 1979):

1. Inherent properties. These are factual properties and usually pertain to morphological characteristics like form, structure, and anatomy.

Some are directly observable (such as soil horizons, texture, or landform) while others are inferred (such as drainage).

2. Developmental properties. These are genetic or chronologic properties and pertain to morphogenesis and express the time relationships as inherent properties develop and change. Soils are classified on, among other properties, the genesis of parent material (eg. lacustrine vs. glacio-fluvial). Vegetation may be classified on the basis of the successional stage or on its chronosequence. Genetic or chronologic similarity however, does not mean objects have to be similar in factual properties.

3. Spatial properties. These properties relate to association by contiguity, the sharing of the same geographic space. Soil associations, vegetation communities, groups of landforms are examples. Spatial contiguity does not imply a sharing of factual or inherent properties.

All three properties are used in the classification and mapping of land and its attributes. For example, in the taxonomic soil classification factual and inherent properties are used at the lowest level of the hierarchy to define the classes. Soils are grouped on the basis of similarities into increasingly generalized higher categories (and classes). The binding criteria between highest class and lowest is a developmental property. In the Field System of Soil Classification (Ellis, 1932) the classifying property is contiguity and area.

TAXONOMIC AND FIELD CLASSIFICATION SYSTEMS

The classification of land and its attributes has two fundamental aspects. The first aspect refers to classification as an ordering of landscape elements into classes based on concepts developed from the study of real elements in the landscape. The classification aims to answer the question "What is it?", to provide the scientific criteria on which basis the classification can proceed. Such systems are called Taxonomic Classification Systems.

A taxonomic or natural classification system shows relationships in the greatest number and most important properties of individuals or groups being ordered. The lowest category of a natural classification is a prerequisite of all other groupings. The classes of the lowest category are homogeneous with respect to a) accumulated b) differentiating and c) accessory characteristics of all categories of the system (Cline, 1949). The classes are homogeneous within the limits of existing knowledge about the properties of the population and about the significance of differences within the population. As knowledge expands the formation of new classes or lower categories may be necessary. For example, increased knowledge about permanently frozen soils required the formation of a new class at the Order level in the Canadian Soil Classification.

The second aspect of classification refers to the ordering of landscape elements in space through mapping. This classification not only tries to answer the question "What is it", but also aims to answer the question "Where is it?". An answer to the latter question regarding land attributes is as important as the first. Classifications systems which provide criteria for mapping are called Field Classification Systems.

MAPPING

The mapping of soil, vegetation, or land units on aerial photographs in reconnaissance type surveys relies on classification by subdivision. The whole is subdivided from above into units which then can be classified from below on the basis of their component parts. The delineation of units is subjective and, to some extent, arbitrary where choice of boundary placement exists. The reason for the boundary placement is explained by a symbol which is different from those of contiguous units. A legend or report informs the user what is contained within each unit, and in what properties they differ. These differing properties are the criteria for boundary placement.

Vegetation cover and soils distribution show both discontinuous (sharp boundaries) and continuous (gradually changing) pattern (Mueller-Dombois and Ellenberg, 1974). The distance over which a change in vegetation and soils depends on the effect of associated environmental factors such as climate, parent material, microclimate, fertility and soil moisture. In detailed studies, minor changes in soil moisture may be detected in the vegetation community, while at small scales of mapping, these changes are either not noted or not perceived as being of importance. At the regional scale climate is most significant, whereas at the local scale site qualilty with respect to aspect or drainage is of greater concern. The environmental factors perceived as being important in controlling vegetation pattern change with the scale of mapping (Damman, 1979). Thus criteria for boundary placement vary with scale of mapping and purpose of map.

Jenny (1958) noted that if in a given area the five state factors vary continuously, soil and vegetation will very likely vary continuously also; and diffuse boundaries are to be expected. However, if in a given area, one or more state factors vary in a discontinuous fashion, soil and vegetation very likely will show discontinuity as well. Of the five state factors, parent material and topography are most commonly observed to change abruptly. But again the recognition of gradual or sudden change depends on scale of mapping. The postulation that change in surficial deposits and topography often result in more clearly defined changes in vegetation and soils is used extensively in the delineation of mapping units by aerial photographic interpretation. Nevertheless, the delineation of mapping units remains often an arbitrary decision especially in cases where differences can be observed between two points along a gradient, but where the change occurs very gradually between the points.

TAXONOMIC UNIT, SAMPLING UNIT AND MAPPING UNIT

Taxonomic units provide the means of differentiating and describing elements in the landscape and the mapping units the means of delineating them in space. There are, however, differences between taxonomic units, sampling units and mapping units, although each map unit is identified by a taxon or taxa.

The taxonomic unit embodies the concept of the segment of a population belonging to a class and is based on the study of individuals in that class, eg, the taxonomic unit in soil classification is the profile, the vertical exposure of the pedon. In vegetation classification the concept is based on the data from a vegetation plot.

In soil classification the sample unit is the test pit used to define the in situ characteristics of the soil profile and in vegetation classification the sample stand is the unit of sampling for vegetation community characterization.

The mapping unit is a two dimensional unit, which actually represents a three dimensional landscape segment and includes in the case of soil, properties from the surface down, for vegetation properties from the surface up and for land, usually a combination of both types of properties. Mapping requires the delineation of segments of the soil, vegetation or landscape, that are relevant to the objective of the survey, The type of unit delineated in land resource mapping varies with the objective and therefore scale of mapping. At very detailed levels the classification of units is based largely on field inspections of the units and verification of the boundaries. Most mapping units are taxonomically pure or almost so. At reconnaissance scales of survey, the mapping depends heavily on the aid of air photographs, and map units are delineated primarily on the basis of landform characteristics and inferences that can be made. Only a small percentage of the population of map units are investigated. Boundaries are largely determined on landscape features which are discernible on air photographs. Limitations of scale require that the map unit represents a relatively large segment of the earth's surface. Consequently, the map units are hardly ever taxonomically pure and usually contain a number of taxonomically different elements.

Three general kinds of mapping units have been used on soil and land maps: 1. "association" - compound mapping units; 2. "unspecified proportions" - compound mapping units; 3. "specified proportions" - compound mapping units (CSSC, 1980):

1. "Association" - compound mapping unit

This type of unit contains one specified entity (association) which contains in turn a number of specified elements, as defined for that entity, which are unspecified in proportions. Associations are groups of different elements related through some properties (eg. a soil association is a group of soils developed on one kind of parent material, but differing in their properties due to topographic position in the landscape).

2. "Unspecified Proportions" - compound mapping unit

This type of unit contains several specified elements (soils, vegetation), but unspecified in their proportions. (eg. a mapping unit identified by two landforms, like peat plateaus and collapse scars, in which the proportion of the unit area each occupies is not shown).

3. "Specified Proportions" - compound mapping unit

This type of unit contains several specified elements and the proportion of each element with respect to the whole unit is shown. Proportions can be in the form of percentile proportions or in the form of a convention of slashes or dots each indicating a certain portion (eg. geological surficial maps (Klassen and Netterville, 1973).

ECOLOGICAL LAND CLASSIFICATION

The objective of land classification is to subdivide the landscape into units that can be described and evaluated for particular uses and their responses to those uses. Ecological Land Classification strives through an integrated approach, to provide a system that expresses the interactive character of the land components. The landscape segment in which the interactions and the relationships between environmental factors and land components are strongly expressed is an ecosystem. By classifying and mapping of ecosystems or complexes of ecosystems the Ecologial Land Classification attempts to collect sufficient relevant data on the environment, that an evaluation for various uses can be accomplished and at the same time the impact on the environment of these uses can be understood.

Each ecosystem is thought to possess a population of elements with characteristics sufficiently different from adjacent ecosystems to enable the establishment of a natural boundary (Wiken, 1978). Populations can be homogeneous as well as heterogeneous. The degree of homogeneity and heterogeneity are dependent on a number of factors including extent of the system and the scale of classification. A small area has the natural tendency to be more homogeneous than a large area. Homogenous of vegetation and soil conditions are more likely to occur on the well drained portion of a drumlin than when the entire drumlin is considered. Heterogeneity of vegetation is quite common, especially when the vegetation has been disturbed or is in an unstable successional stage.

Hierarchical Structure and Categories

The hierarchial structure proposed for the study of the land in the "Guidelines for Biophysical Land Classification" (Lacate, 1969) is designed to describe, characterize and map the biological and physical features of the land and to organize knowledge at various levels of generalization. Thus the ecological land classification system is a hierarchy of classification in both a taxonomic sense and a mapping sense. The original system described by Lacate consisted of four categories, whereas currently five and six categories are mentioned in the literature.

In recent years, a number of additional categories as well as new names for the original categories have been proposed by the Canada Committee for Ecological Land Classification (CCELC, 1977, 1979). The new names are generally accepted and therefore used throughout this report, although reference is made to the old names where appropriate. The new names and their old synonyms are presented in Table 1.

A discussion of the four categories from the original hierarchy namely the Ecoregion, Ecodistrict, Ecosection and Ecosite are presented in the following section. In addition, the recently added Ecoelement category is discussed as well.

Ecoregion. The Ecoregion is the most generalized level of abstraction used to date in Manitoba. In the 1969 guidelines an Ecoregion (Land Region) is defined as:

> "an area of land characterized by a distinctive regional climate as expressed by vegetation".

The Ecoregion is usually of large areal extent and is inevitably more or less heterogeneous, and is often an aggregation of several distinctive contiguous landscapes.

It was realized at the time that because measured data on climate was lacking in most remote areas, that climate must be inferred from vegetation characteristics. Lacate's definition was adhered to for a number of years but eventually a number of different versions appeared. Mills (1976) proposed that in addition to vegetation, trends in soil development and permafrost could be used to characterize regional climate. Gimbarzevsky et al (1978) introduced size as criterion. "Soils and permafrost conditions" (Tarnocai and Boydell, 1975), "pedogenic processes" and "vegetation growth" (Woo and Zoltai, 1977) are mentioned as criteria to determine the expression of regional climate.

Table 1 - Comparison of Categories Used or Proposed in the Hierarchies of Ecological Land Classifications in Canada and Manitoba

Reference Names	Categories within the Hierarchical Structure		Common Mapping Scales
Ecoprovince	-	-	> 1:3 000 000
Ecoregion	Land Region	Land Region	1:3 000 000 to 1:1 000 000
Ecodistrict	Land District	Land District	1:500 000
Ecosection	Land System	Landscape Unit Land System	1:250 000 to 1:50 000
Ecosite	Land Type	Land Type	1:20 000 to 1:10 000
Ecoelement	-	-	1:10 000 to 1:25 000
National - 1980 (CCELC)	Canada-Manitoba Soil Survey 1974-1980	Canada-Manitoba Soil Survey 1968-1973	

It is questionable whether references to permafrost, growth, or processes should be part of the definition. A definition for a category should be applicable to all occurrences of entities within that category (Wiken, 1978). Permafrost and size or pattern of landscapes are not applicable in all cases and "pedogenic processes" refer to one aspect of soil. It seems advisable to keep the definition general as that recently is proposed for national use by CCELC (1979):

> "Ecoregion - an area of the earth's surface characterized by distinctive ecological responses to climate as expressed by vegetation, soils, water, fauna, etc."

This definition is general enough to satisfy most people concerned with ELC and still leaves to individual option the choice of those parameters that give the best expression of climate in the area of study.

The establishment of regions on the basis of vegetation and/or soils is based on the rationale that areas having a uniform climate will show throughout their extent the development of similar ecosystems given that materials have similar properties. Thus sites having similar (landform, slope, soil parent material, aspect, and drainage characteristic within a region, will show strong similarities in:

a. soil development (kind and sequence of horizons, depth) and soil properties such as moisture regime and soil temperature;
b. vegetation development in the form of communities with uniform characteristics like species composition, structure, productivity and successional trends.

<u>Ecodistrict</u>. The Ecodistrict (Land District) was defined by Lacate (1969) as:

- "an area of land characterized by a distinctive pattern of relief, geology, geomorphology and associated regional vegetation" -

Lacate stated further that "the Ecodistrict is a subdivision of the Ecoregion based primarily on the separation of major physiographic and/or geological patterns which characterize the region as a whole. Ecodistricts have a common pattern of relief, structure, or comparable geographic evolution."

In Manitoba the definition has been applied without change. The districts are defined on the basis of properties given in Lacate's definition. However, the descriptions have been expanded to include references to soil associations or soil complexes, drainage and hydrology.

Other investigators have changed the definition to fit the area or their field of interest. Tarnocai and Netterville (1976) defined the district as "a subdivision of the ecoregion" and added "ground-ice conditions" as a criterion for definition. The introduction of ground-ice as a criterion is project dependent and makes the definition only locally applicable. The use of Ecodistrict as a subdivision of a region is valid as it reinforces the hierarchial concept and emphasizes the climatic properties of a district. At the same time districts are agglomerations of ecosections which are defined at the next lower level of the hierarchy.

Soil, vegetation and hydrology are influenced to a large extent by surficial material properties like form and texture. The inclusion of these criteria for the ecodistrict definition allows for a somewhat more definitive expression of climate on materials and places the district in a stronger ecological context. However, these criteria should only be used if they result from the geomorphology and physiography of the area, and do not result from difference in climate. The CCELC (1979) proposed definition is:

> Ecodistrict - a part of an ecoregion characterized by a distinctive pattern of relief, geology, geomorphology, vegetation, soils, water and fauna.

It is understood, that elements defined at a particular level of the hierarchical classification, except at the ecoelement level, are parts of the elements defined in the level above, as well as agglomerations of elements from the level below. The section on classification notes that both approaches to classification are valid and usually applied simultaneously. This is especially true in land classification where most of the investigations are carried out at the lowest level of the hierarchy, but not all classes at this level are defined or known.

<u>Ecosection</u>. The Ecosection or Land System has been defined by Lacate (1969) as:

> "an area of land throughout which there is a recurring pattern of landforms, soils and vegetation"

From the outset of the Ecological Land Classification in Canada this category was defined by criteria which would encompass the elements of ecosystems. Consequently, there was less need to change the definition of this category and the original definition is still very acceptable. Recently however, water bodies and fauna have been added to the definition (CCELC, 1979). These ecological relations have recently been achieved for the ecoregion and ecodistrict categories by redefining their concepts.

At the scale of mapping (1:125 000) commonly used to delineate Ecosections the size of an individual ecosection may be too small to be shown as a pure map unit. Consequently, they are combined into larger units to form a composite mapping unit. This group of ecosections is also considered an ecosection for mapping purposes. As a result, bordering ecosections may have so many components in common, with closely similar proportions, that they are merged into an even larger ecosection. The increase in size of these units makes them less useful for planning or management decisions. Increase of mapping scale to the level where the primarily identified ecosection can be delineated would solve the problem.

Ecosite. The Ecosite (Landtype) is the smallest unit recognized in the 1969 Guidelines. It is similar to the "site type" (Hills, 1976), and contains a number of "physiographic site types" which are equivalent to Ecoelements.

The Ecosite was originally defined as:

> "an area of land on a particular parent material which possesses a fairly homogeneous combination of soil (eg. soil series) and chronosequence of vegetation".

Although a number of variations have been proposed, this definition is still used at present. The newest version proposed (CCELC, 1979) is:

Ecosite - a part of an ecosection having a relatively uniform parent material, soil and hydrology, and a chronosequence of vegetation."

Unlike the previous three categories discussed, the ecosite mapping units are intended to be uniform with respect to soil and vegetation. At large mapping scales, the units are relatively pure and soils may be described in terms of soil series, developed on one or part of one landform. Similarly vegetation is relatively homogeneous when undisturbed and follows the same chronosequence. When mapping scales are smaller the units will tend to contain some inclusions a number of soil series and vegetation types of which one may be dominant. Such map units are more like small ecosection map units.

Ecoelement. The Ecoelement is a recent addition to the hierarchy. It is defined as follows (CCELC, 1979):

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

This category is closely equivalent to Hills "physiographic site type" or portion thereof. The ecoelement will not frequently be mapped. It can be viewed as the unit of study of an ecosystem like the pedon is the unit of study of soil and the vegetation plot the unit of study for a vegetation stand or community. It is a unit where all characteristics are homogeneous throughout its extent. The basic difference between this category and that of the ecosite seems to be related to scale and degree of refinement rather than of concept.

Pattern

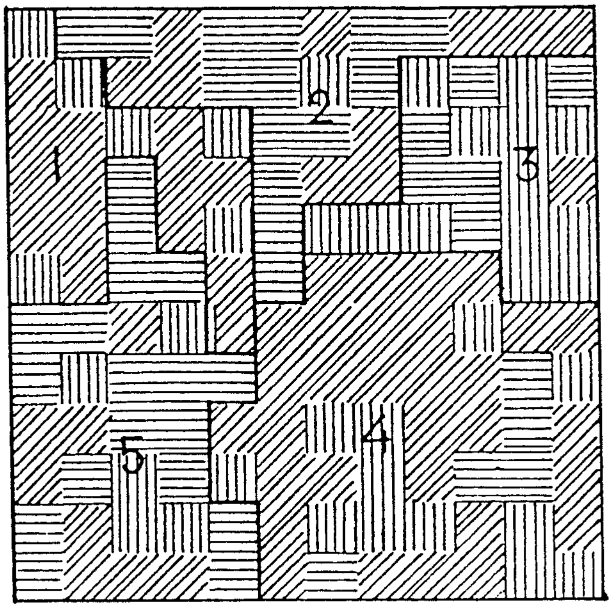
In the definitions for ecodistrict and ecosection the pattern of the land attributes is of importance. The key modifying word, in the district definition is "distinct" whereas in the ecosection definition it is "recurring". Pattern implies order and reoccurrence of attributes, organisms or events. Pattern is not limited to a spatial arrangement of parts but also can refer to behaviour or sequence in time (Wilken, 1978). Although "pattern" is only part of the definition for district and section, some kind of pattern is implied in the definition for the other levels as well In the ecoregion concept, pattern is implied in the concept of repetition of climatic effects on materials to produce certain types of soil or vegetation, at the ecosite level it is implied in the pattern of vegetation succession (chronosequence of vegetation).

The practical application of the term "pattern" in the definition is that land segments should be delineated on the basis of the repetitive occurrence of a land or resource attribute ie. bedrock outcrops can be used as a characterizing feature only when they occur throughout the district or section. A unique outcrop or several outcrops clustered in one portion of the area are not definitive. In the latter case that portion of the element is better delineated separately or if too small in extent, flagged by a cartographic on-site symbol.

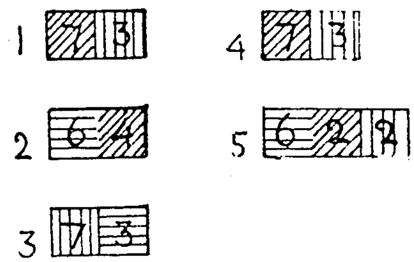
"Distinctive" with respect to Ecodistrict definition implies obvious, easily observed; "recurring" with respect to the Ecosection definition refers to "pattern of patterns" a pattern of component parts, which contain patterns at a larger scale.

The effect of pattern on of landscape components together with the scale of photographic image and scale of map on the delineation of map units is shown in Figure 1. The various maps show the way in which the distribution of three land components of one kind (eg. either landform or vegetation), and the scale of photography and mapping affects the delineation of ecosection mapping units. The hypothetical examples at the 1:125 000 scale show that a certain amount of subjectivity (artistry) is involved in subdividing the are shown. Basically two processes are involved; subdividing and mental classification and agglomeration of the types ("ecosites"). At the same time the map scale has to be kept in mind as the scale of the map requires the delineation of "minimum" areas.

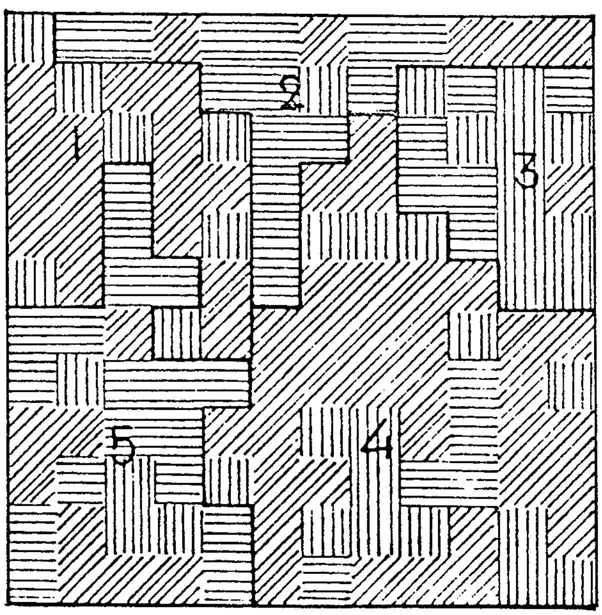
The examples in Figures 1a and 1b illustrate two different versions of a map of the same terrain (scale 1:125 000). The two examples show that the delineation of map units is arbitrary to a degree. Boundary placement is based on the same criterion of creating units of a certain size with as little heterogeneity (complexity of component parts) as possible. In Figure 1c the same area is shown but the map units are delineated for a map at a scale of 1:50 000. The larger scale allows the delineation of map units which seems to be less heterogeneous than the ones in Figures 1a and 1b. However if a "photograph" at larger scale is used it becomes obvious that these units are heterogeneous as well, but that the differentiating criteria become more exact. Thus ecosites judged similar at a small scale are found to be dissimilar at a larger scale, and found to contain a number of subtypes. In reference to Figure 1, it is seen that at the 1:125 000 scale, mapping is based on differences in



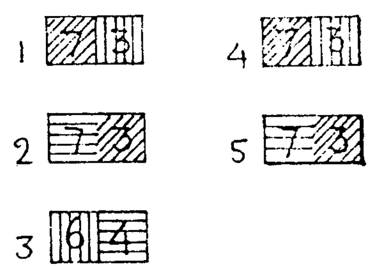
Scale of "photograph" 1:60 000
Scale of map 1:125 000
Unit area ≥ 20 squares



1a. Ecosection Map No. 1

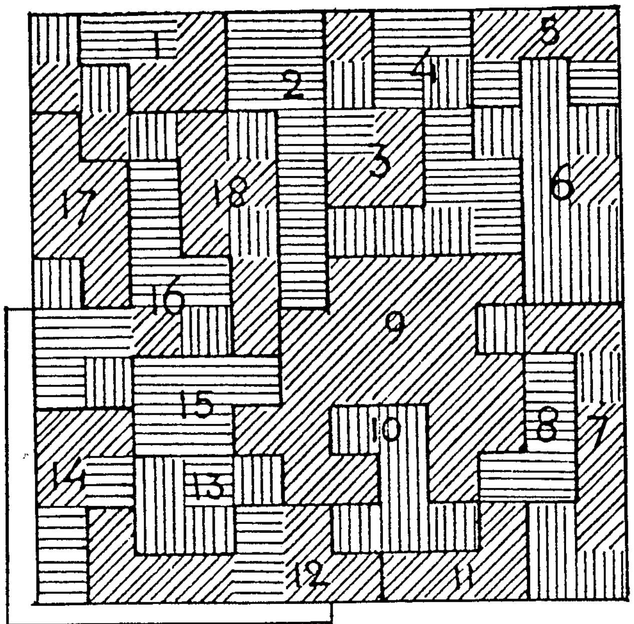


Scale of "photograph" 1:60 000
Scale of map 1:125 000
Unit area ≥ 20 squares

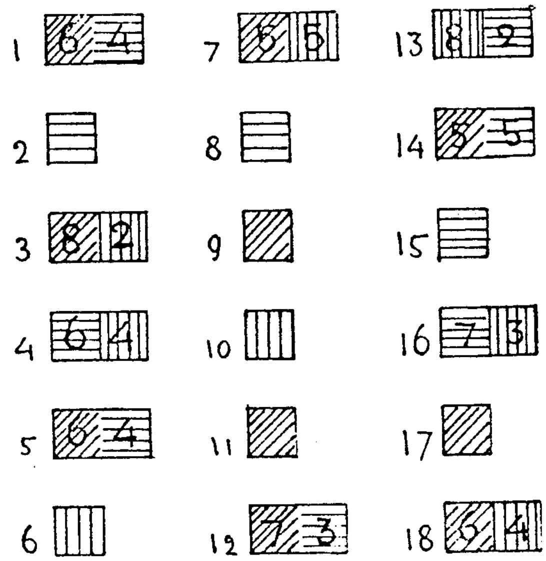


1b. Ecosection Map No. 2

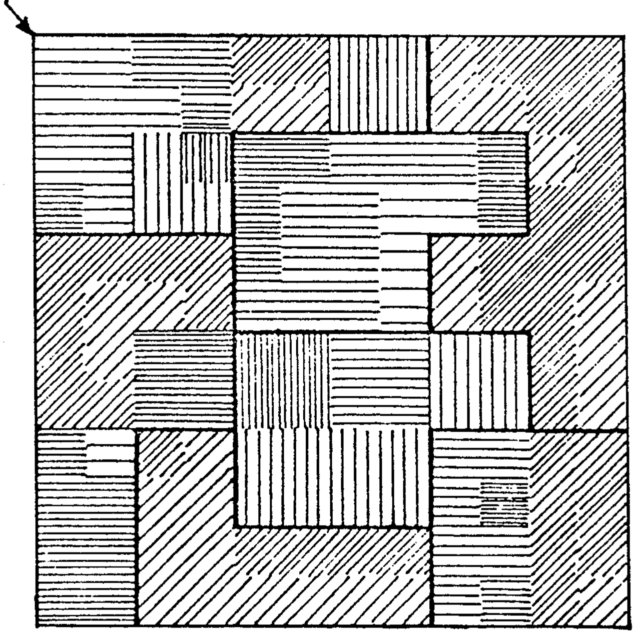
Figure 1. Effect of Scale of Air Photograph and Scale of Map on Map Unit Delineation.



Scale of "photograph" 1:60 000
Scale of map 1:50 000
Unit area ≥ 4 squares



1c. Ecosection Map No. 3



Scale of "photograph" 1:30 000
Scale of map 1:50 000
Unit area ≥ 15 squares

1d. Ecosection Map No. 4

Figure 1. Cont'd.

shading, and that at larger mapping scales, the variations within the shading (representing intergrades of particular conditions), should also be taken into account. One should recognize that subjectivity of grouping and, even more so, subjectivity of boundary placement between or around types is greater when interpreting aerial photographs. The number and kinds of ecosites is greater and boundaries are often much more diffuse.

Relationships between Categories and Classes in Ecological Land Classification

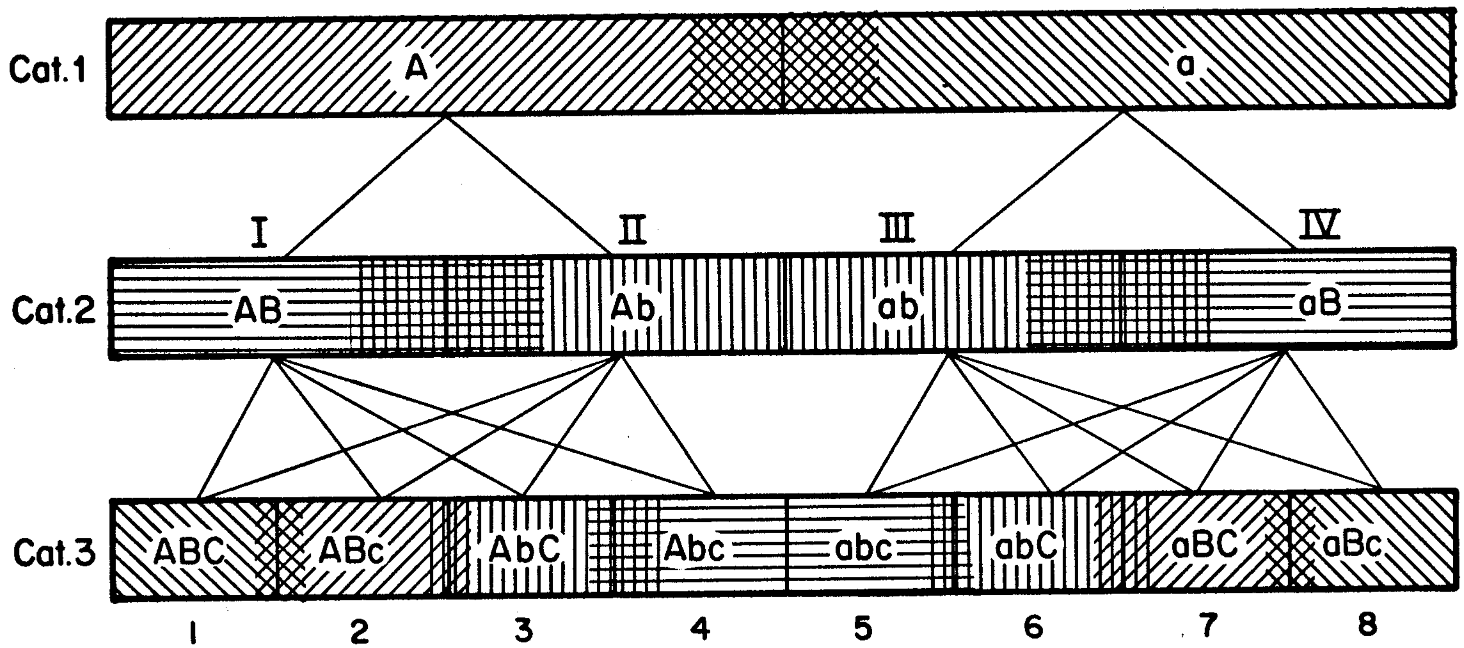
Ecosystems or any land segment delineated in space are not entities completely different from each other. Because (land) ecosystems are complex natural entities, the categories and classes in the hierarchical structure cannot be completely independent. The gradation into classes as well as into categories is determined by the kinds and the degrees of unity discernible with respect to biological and physical land characteristics. As these characteristics are partly overlapping both between categories and classes the hierarchical network can be said to be coalescent (Wiken, 1978). Figures 2, 3 and 4 illustrate some of the relationships between classes and categories.

Figure 2 shows that at the first category (Ecoregion) level, (the level of greatest generalization), the criterion for differentiation the classes is climate only. Although surficial materials and other factors may be dissimilar or similar, they are not differentiating. At the second categorical level (Ecodistrict), another differentiating criterion is introduced, that of surficial materials. As a result the number of classes doubles. If more criteria had been introduced the number (n) of classes would have multiplied greatly but not to 2^n classes. Some interactions between factors may result in not very dissimilar responses, and although in theory should be differentiated, in reality the products are indiscernible in nature. For example, certain carbonate levels in parent materials may not result in discernibly different ecosystems. Although the property is easily determined in the field, it may not affect the function of the system.

Choice of differentiating criteria for the categories in ELC has been based on those properties that are easily observed (landforms) or inferred from vegetation characteristics (pattern, forest) which can be observed on air photographs. Other inferred properties (soils, texture, drainage) are introduced at lower levels to refine the classification and to strengthen the response of the classification to the various ecological relations in the landscape.

At the third categorical level (Ecosite), shown in Figure 2, separation becomes more difficult as responses or properties are less easily observed. As noted earlier interactions between factors or the overriding influence of a single factor in the environment indicates that the theoretically differentiated classes are often not that clear in nature. For example, ecosite ABc will look much like ecosite aBc and abc as a result of the factor of excess moisture, overriding the effect of climate and parent material.

As can be seen from Figure 2, horizontal differentiation allows the separation of units of similar rank. In category 3, which refers to



Climate: A = temperate boreal   a = low boreal

Surficial Material: B = loamy till   b = lacustrine clay

Drainage: C = well drained   c = poorly drained

Figure 2. Relationships between Categories and Classes in Ecological Land Classification.

the ecosite category of the ecological land classification hierarchy, the unit ABC will have a soil series different from ABc and they will have different vegetation communities (associations), perhaps "black spruce-feathermoss" and "black spruce-Ledum groenlandicum-Sphagnum moss" respectively. However, the unit ABc may not differ very much in soil and vegetation characteristics from ecosite aBc because of the dominant effect of drainage.

The expression of climate at the various category levels changes to such a degree that at the region level, climate is of primary interest (Category 1), but at Category 2 the (Ecodistrict) local climate is the factor controlling processes and function of the system. The micro-climate, is of course, a function of regional climate in relation to other factors like vegetation, aspect and relief. This is true for a number of criteria used at the higher categories and which through the hierarchy express themselves at the lowest level as well.

In Figure 3 and 4, some of these relationships and data flows are shown. It should be understood that in the application of a hierarchical system, the movement of the data flow is in both directions, descending as well as ascending. Sometimes these two movements are interrupted or the movement in one direction takes place to a greater extent than movement in the other direction.

Mapping of Ecological Land Units

In the Section on mapping (page 31) it has been noted that the criteria for boundary placement in the delineation of soil, vegetation or

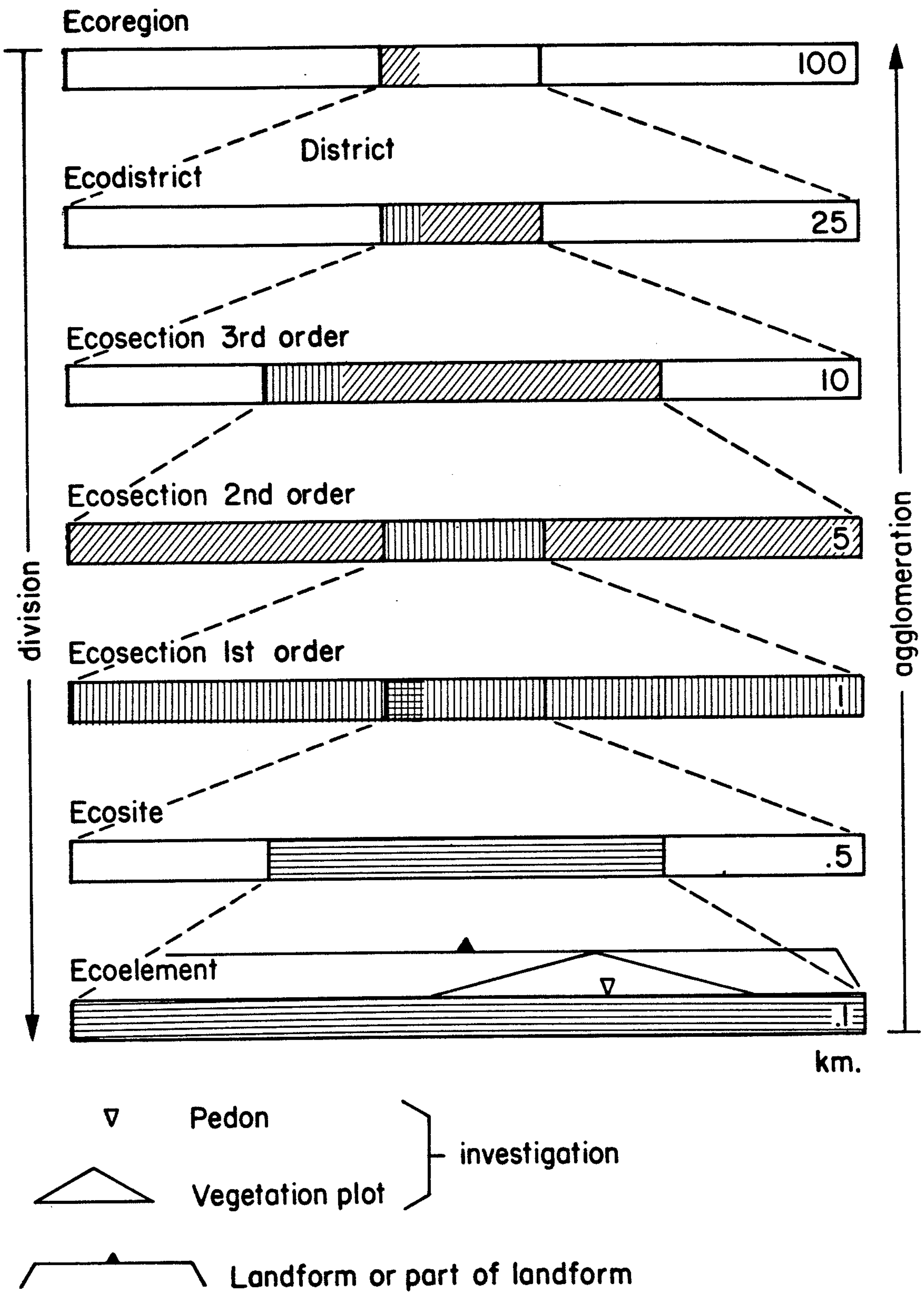


Figure 3. Area Relationships in Ecological Land Classification.

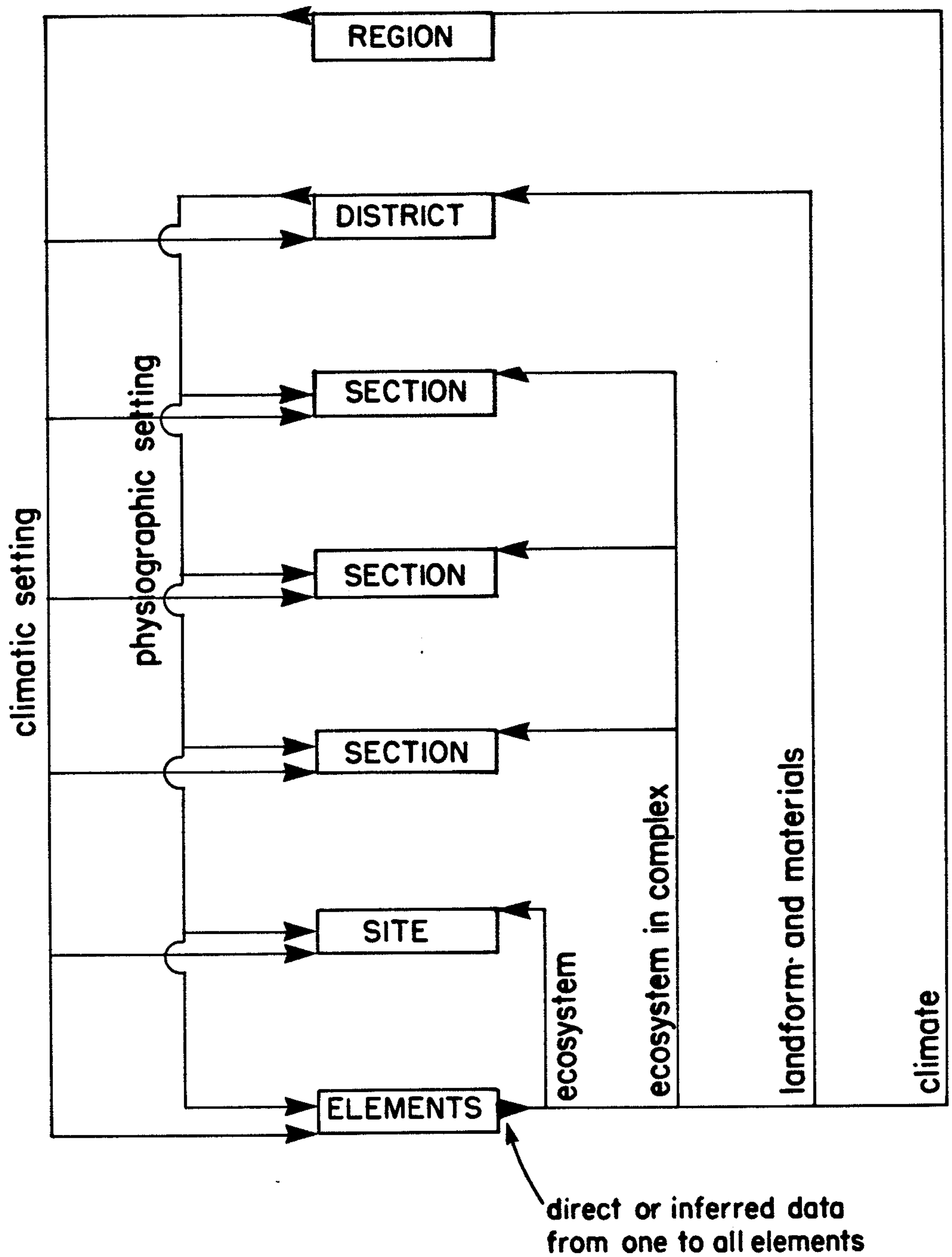


Figure 4. Data and Information Links between Categories in Ecological Land Classification.

land units depend on scale and purpose of the mapping.

The mapping of ecological land, soil or vegetation units requires the delineation of units that may be managed or planned for as a unit at the level of generalization chosen for the project. Management decisions with respect to a land resource should be made at a level of generalization compatible with that of the units delineated. Thus a mangement decision at the farm-field level can only be made for small units delineated on the basis of very precisely defined properties regarding soil, drainage, slope etc. At a much more generalized level, a management decision only may be possible with respect to general potential of a unit for crop production based on general information on soil materials and climate.

The purpose for which ecological mapping is carried out affects the delineation of map units because a choice has to be made which ecological or environmental factors to investigate. It is impossible to investigate all ecological factors such as climate, relief, water and soil, which are always important, in addition to attributes like geology, vegetation and artificial elements (Vink, 1975). All of these factors are not of equal importance to each mapping project. If the project is carried out to determine the agricultural potential and possibilities for development of infrastructure of an area, then the inventory of geology and vegetation will be less important than the collection of data pertaining to soils, climate, water and topography. The delineation of units will be based on soil and topographic properties and the ecological significance of soil and climate will be emphasized. However, if an area is surveyed for which no decision has been made with respect to the resource use then the inventory must collect data on climate, soils, water, topography and vegetation. In this situation the delineation of ecological significant units becomes somewhat more difficult as a decision has to be reached as to whether vegetation or soils provide the criteria for boundary placement. At detailed levels of survey the identification and definition of ecosystem characteristics and their boundary criteria must be carried out before satisfactory mapping can proceed.

At more generalized levels of mapping the units always will contain a number of ecologically significant, but different, elements. Some of these elements may be related through parent material or topography, while others may be coalescent but completely different. The delineation of this type of unit will be through the mapping of pattern of elements in the landscape (see Section on pattern, page 44). Such generalized mapping attempts to delineate units which contain the least number of different elements and for which the comprising elements occur in a predictable pattern or sequence. If this is achieved then some statements with respect to management of the unit and location of the elements within the unit can be made. At the highest levels of abstraction, the criteria for mapping become very much detached from those used at the most detailed level. Only very generalized information is required and therefore the criteria for mapping also are very broadly defined.

Mapping at the ecosite level of the ecological land classification hierarchy requires the identification of the ecosystems present in the land area being inventoried. The classification and identification of the ecosystems and their boundaries will be based on the soil and vegetation component characteristics. Both elements will be studied to determine which provides the best criteria for boundary placement for each ecosystem. When mapping at this level of abstraction, a minimum level of information on climate, soil parent materials and landforms must be available. The mapping of ecological units at the ecosite level is usually too expensive and time consuming to be applied in unknown terrain, which may have low or limited potential for development.

At the ecosection level of mapping the identification and classification of all the ecosystems types within the area is valuable but not essential. However the important or more frequently occurring systems must be known in order to understand the landscape pattern and to be able to delineate the units. At this level of abstraction the delineation of the mapping units is based largely on air photo interpretation supported by only a limited number of site inspections per unit area. Therefore the boundary placement is largely dependent on photographic pattern in the form of stereoscopic relief or vegetation pattern created by the variation in landforms, topography, materials and drainage.

At the ecodistrict level the delineation of units is either on the basis of the grouping of ecosection units or, if this information is not available, on the basis of broad patterns of landforms, geology or waterbodies, which only are verified to a very limited extent in the field.

The delineation of ecoregions, although very broadly defined units, requires some key site inspections in order to determine climate related soil and vegetation characteristics. Characteristics like soil profile development, soil temperature at certain times of the year, plant species', cover of key plant species' or growth of trees all can and may be used in the delineation of ecoregions and the boundary placement between adjacent ones. The boundary placement is often very arbitrary as changes between regions are usually gradual.

Chapter 4

ECOLOGICAL LAND SURVEYS

Ecological land surveys are inventories of the land base, which through an integrated approach to data collection, mapping and data presentation provide a holistic view of the landscape.

The commencement of the ecological approach to land classification and mapping in Canada is Hills' (1953) holistic approach to site classification, which was based on the concept of "physiographic site type" and "site region" (Hills, 1960; Burger, 1976), which in turn was modelled after that developed by Stewart and Christiansen in Australia (Rowe, 1962). In 1968 a national program was initiated to develop, through a series of pilot studies, a rapid and economical methodology for collecting and mapping ecological data concerning land resources in relative inaccessible terrain. The results from this series of pilot studies were published in 1969 as "Guidelines for Biophysical Land Classification" (Lacate, 1969). These guidelines outlined the objective of ecological land surveys and methodology and suggested criteria to be applied at various levels and scales in the hiearchy of the classification.

Although the various ecological land surveys and the single land resource surveys differ in approach and objectives to classification and mapping of land and its attributes, land resource surveys have a number of characteristics and objectives in common. All land resource surveys are of fundamental importance for land development planning as they provide the land use planner and manager with data on the present status of land attributes like soils, hydrology, vegetation and surficial materials. The content of a survey depends on the scale of the map, the special purpose of the survey and the nature of the region (Vink, 1975).

CHARACTERISTICS OF LAND RESOURCE SURVEYS

Although land resource surveys may focus their attention on different elements in the landscape they usually have a number of characteristics of approach to inventory in common. The following characteristics are considered as part of a complete land resource survey: a. planning, b. data collection, c. classification and mapping, d. data presentation and e. evaluation and review. Data collection, classification, mapping and data presentation collectively form the methodology of a survey.

During the planning stage of the survey potential users are consulted to determine the data requirements and define the objectives of the survey. The objectives of a survey govern both the scale of mapping and the criteira and level of taxonomic classification used to describe and identify the mapping units. Scale and mapping criteria determine the method of survey and ultimately the usefulness of the survey (Jurdant, 1974).

The collection of data in resource surveys is basically of two kinds: 1. background data available from maps, reports and other sources pertaining to the area of concern and, 2. data collected in the field through site investigation and the collection of data from air photographs. Amount and type of data to be collected, depend on purpose and objective of the survey determined in the planning stage.

Classification and mapping refer to the processes of identification and ordering of landcape elements taxonomically and the portrayal of their distribution in the form of mapping units.

The presentation of data is important to the success of a survey. It is the means by which the knowledge obtained during the survey will be passed on to the user. Data presentation is usually by means of maps and reports. These may contain all of the data collected or a synthesis of the data, in the form of interpretation for particular uses either in tables or in the form of thematic maps. Form of data presentation will commonly be decided in the planning stage.

During the evaluation of the survey the usefulness of the product is assessed. The usefulness of a survey is judged by the degree to which it meets the objectives set out in the planning stage. Usually, a review of the survey project is carried out to identify problems encountered during various stages of the survey and to determine possible ways of improving methodology with respect to future projects.

OBJECTIVES OF LAND RESOURCE SURVEYS

Although the objectives of resource surveys vary from project to project, they usually include one or more of the following:

1. to determine, classify and map the population of one or more land resource elements in the area of concern,

2. to correlate and to predict behaviour and suitability of these natural objects or units to management practices and other uses,

3. to provide a data base on which land resource elements or units can be selected for research and to provide a means by which research results or management practices can be extrapolated to other areas and

4. to provide the basis for monitoring changes of physical, chemical and biological processes in land resource elements.

Ecological land surveys attempt to satisfy most of the objectives stated for resource surveys and in addition "differentiate and classify ecologically significant segments of the land surface, rapidly and at a small scale" (Lacate, 1969). Such an inventory "would serve as the ecological basis for land use planning involving future management of lands for forestry, agriculture, recreation, wildlife and water yields."

SINGLE-DISCIPLINARY AND MULTI-DISCIPLINARY SURVEYS

The collection of land resource data has been accomplished by two types of survey defined according to team composition and team approach:

1. single-disciplinary surveys and
2. multi-disciplinary surveys.

Single-disciplinary surveys are inventories in which data collection and data presentation are carried out by one or more people with similar land resource expertise. The product of this type of survey usually emphasizes one or a few land attributes. These surveys may be truly single disciplinary with respect to data collection and presentation or they may be single disciplinary in terms of team composition, but provide a product with a wider scope than that derived from a truly single discipline presentation.

The first category of survey collects data on one particular land attribute and the data presented pertains only to that attribute. Forest inventories fall into this category. The second category of survey emphasizes the collection of data on a particular land attribute but also collects data on other components, either directly, or from other land resource reports. Data presentation by this type of survey provides a more balanced land resource map and report, which have a wider application in land management than truly single-disciplinary surveys. The soil survey belongs to this category, because in addition to the soils data information pertaining to landforms, hydrology, vegetation and climate are collected as well. However, the emphasis remains on the description, classification and mapping of soils. In the report data on climate, landform, topography, hydrology and artificial elements in the landscape are provided to enhance the value of the soil information to the user.

Multi-disciplinary surveys are carried out by a team composed of experts in various resource fields. This type of survey is subdivided into two categories based on the method of data collection and data presentation ie: non-integrated and integrated multi-disciplinary surveys.

In non-integrated surveys the resource data is collected by each discipline separately and only partially integrated before presentation. Data presentation may be in the form of separate overlay maps or in the form of a map and report where the map unit delineated by one discipline is used by the other disciplines to structure their data presentation.

In the latter case, the map unit acts as a base for the stacking of land resource data for various disciplines. Although level of detail for each resource component is approximately the same "the emphasis is still very much on the parts instead of on the unity of the land as an ecosystem, as a whole" (Wiken, 1978).

In the integrated survey approach, the team members attempt to combine their knowledge in the various fields of expertise. Vink (1975) noted that "the most comprehensive and therefore at least in theory the best way of surveying land resources is undoubtedly the 'integrated' survey, which comprises a multi-disciplinary inventory, producing in an integrated manner all possible relevant data on the natural and human resources and constraints." In this type of survey, all or a large number of single land attributes like soils, vegetation, landforms and climate are investigated to produce, hopefully, a common, integrated, ecological data base, founded on ecosystems or complexes of ecosystems. Although an integrated survey theoretically is very valuable because it provides all relevant information for land use planning, it is in reality quite difficult to carry out as there may be a wide number of variables for each project; especially when these projects are large (Vink, 1975). For this reason integrated surveys attempt to collect data on those variables in the environment that have been found to be of great importance in the making of land use decisions. The integrated product of these surveys, if necessary, can be separated into its contributing parts. Maps and reports on a single land resource or possibly a single resource attribute can be produced, but the linkage to other land components stays intact through the 'master' map and report.

ECOLOGICAL LAND SURVEY IN MANITOBA

Since 1968 three major ecological land survey projects have been undertaken in the province of Manitoba (see Figure 5):

1. Land classification for land evaluation: Cormorant Lake Pilot Project (S.C. Zoltai, et al, 1969)
2. Bio-physical Land Inventory, Churchill-Nelson River Study area, North-Central Manitoba (Beke et al, 1973)
3. Northern Resource Information Program (Mills et al, 1976b, 1976c, u977, 1978; Dutchak et al, 1978; Woo et al, 1977; Veldhuis et al, 1979).

A number of smaller ecological land survey projects have been carried out since 1977. These are:

1. Sand Bay - Cross Lake terrain analysis - land suitability study (Forrester, 1977)
2. Ecological Terrain Analysis, Whiteshell study, 1978 (Forrester, 1978)
3. Ecological (Biophysical) Land Classification (Terrain and Resource Analysis), L.G.D. Mystery Lake (Forrester, 1980)

The following review will deal mainly with the first three projects with an emphasis on the Northern Resource Information Program (NRIP) experience. Reference will be made to characteristics of projects in other areas of Canada.

Cormorant Lake Project

The objective of the project was the development of a national

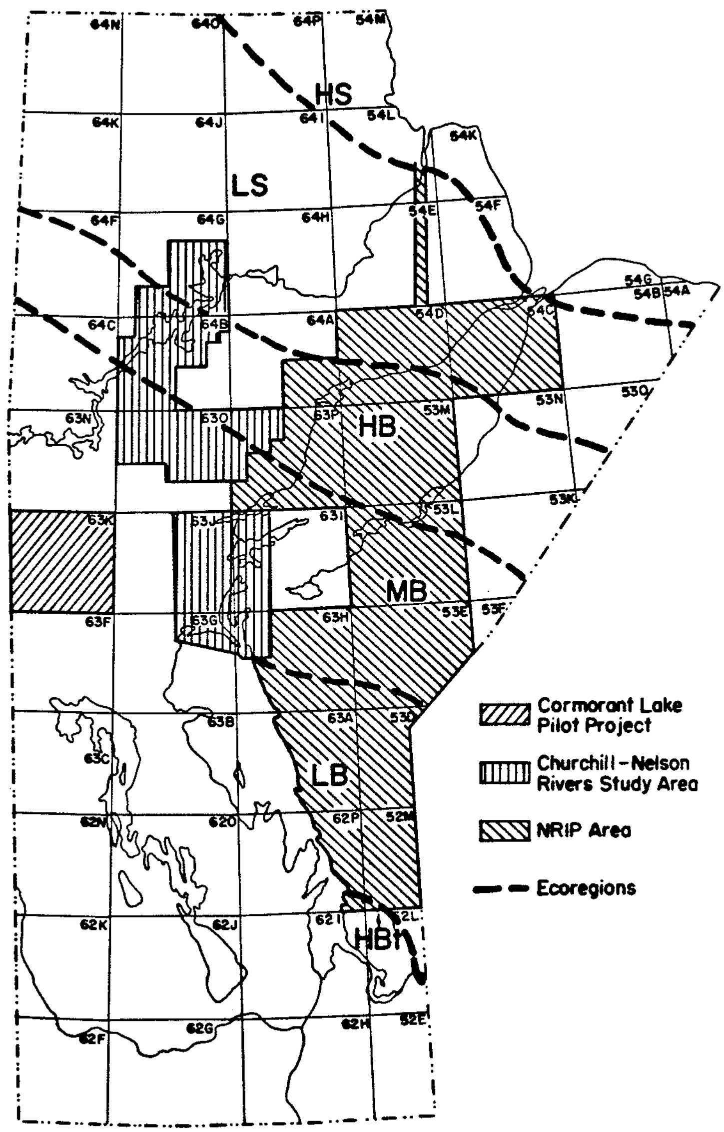


Figure 5. Map of Area Covered by Ecological Land Surveys in Manitoba.

system for ecological land classification. The approach used followed very closely the national guidelines formulated by Lacate in 1968, which were, as a result of the experience obtained through several pilot studies, accepted in 1969. In addition to the four levels of the hierarchy defined by Lacate (1969) another level of abstraction was applied in the Cormorant Lake project. This level was called the Landscape Unit category which attempted to integrate the land and water portions of the landscape. These units are "patterns of land types and water types grouped together to provide a convenient unit for resource management and multiple land use planning" (Zoltai _et al_, 1969).

A three member multi-disciplinary team consisting of an ecologist, phytosociologist and a pedologist conducted the survey during the summer of 1967. The data are presented at 5 levels of abstraction viz. ecoregion, ecodistrict, landscape unit, ecosection and ecosite. The basic mapping unit is the Ecosection unit mapped at a scale of 1:250 000. The ecosections are grouped into Landscape Units on the basis of land and water system characteristics. Ecodistricts and Ecoregions are delineated on a small scale map in the report. The Ecoregions and Ecodistricts are briefly described in the report, while the Ecosections are described with the aid of a cross-section through a representative part of the unit. The Ecosites are identified on the basis of geologic material and drainage characteristics. Associated soils, stable and common present vegetation, identified by dominant tree species, and forest capability ratings are also listed for each ecosite. In Appendix A (page 138) a map sample and legend are provided as an example of the data presentation for this project.

Churchill-Nelson Rivers Study

The "Biophysical Land Inventory of the Churchill-Nelson Rivers Study Area" (Beke et al, 1973a) was the second ecological land survey in Manitoba and was patterned closely after the Cormorant Lake project. An area of approximately 33 000 km^2 was surveyed in 1972 by a four member team consisting of two pedologists and two forest ecologists. Three Ecosection maps at 1:250 000 scale and seven "Ecosite" maps at a scale of 1:50 000 were compiled for selected portions of the survey area.

The objective of the survey was to provide baseline data on land attributes useful for other disciplines evaluating the impact of the Churchill-Nelson Rivers diversion on various land and water resources in north-central Manitoba (Beke et al, 1973 b).

The data are presented at 5 levels of abstraction viz. the Ecoregion, Ecodistrict, Landscape Unit, Ecosection and Ecosite. The Ecoregions and Districts are delineated on the ecosection maps and described in the report on the survey. The Ecosection mapping units are not described in th report so the mapping unit symbol must be decoded with the aid of the map legends to obtain information pertaining to topography, soil parent materials and permafrost. The mapping units delineated at the 1:50 000 scale maps consist of agglomerations or complexes of ecosites and therefore portray Ecosection maps as well. In addition to information in the legend, selected ecosites are described in greater detail in the report with respect to landforms, soils, vegetation and climate information. A section of an air photograph showing a delineation of the Ecosites is presented along with photographs and a cross-section illustrating landscape position, vegetation and soil characteristics. In the appendices of the report all pertinent field and laboratory data collected on soils and vegetation is provided.

Sections of the 1:250 000 and 1:50 000 scale maps and descriptions of selected map units on these map samples are presented in Appendix A (page 142).

Northern Resource Information Program

The Northern Resource Information Program is the most ambitious ecological (biophysical) land survey undertaken in the province of Manitoba to date.

The objectives of the land survey carried out under the NRIP were twofold (Mills *et al*, 1974; Mills, 1976):

1. to classify a large tract of land (approximately 390 000 km^2) into ecologically significant landunits through an integrated ecological survey. Terrain would be mapped in terms of landforms, surface deposits, vegetation, soils, drainage, permafrost, associated aquatic systems and climate.

2. to provide data useful for macroscale planning on an ecologically sound basis. The data would be useful for the development of renewable and non-renewable resources on a regional basis; for planning for industrial and community development, the protection of the environment, the development of infrastructure (Mills, *et al*, 1974; Mills, 1976).

Although the project was set up to cover this large tract of land

and water within 6 to 8 years, the program was terminated in the fall of 1976. During the course of the program, (1974-1976) approximately 93 400 km^2 were surveyed (see Figure 5). Maps and guides for all areas, with the exception of the Island Lake, (53E) and Norway House, (63H) map-sheets have been published to date.

Survey team. To carry out the survey a study team was assembled consisting of a. a senior pedologist (project leader) b. a pedologist (with forest management background) c. a forest ecologist (with a background mainly in technical forest management) and d. a wildlife ecologist.

The team included expertise from several resource fields and qualified in this regard as a multi-disciplinary team. However pedalogical expertise was represented more strongly than disciplines like forestry, vegetation ecology, geomorphology, or climatology, which were not or only weakly represented. Although the study team was expanded in subsequent years, no great improvement was achieved in balancing the expertise.

Pilot project. To develop the system of classification and the method of presenting the data to potential users a pilot project was initiated, which would also serve to evaluate manpower, transportation, time and monetary requirements to carry out this type of survey in future years. Because of the large area to be mapped, the amount of ground-truthing must be limited and mapping had to depend heavily on air photo interpretation. Consequently, only the mapping of complexes or patterns of landtypes would be feasible.

The study team proposed to use a hierarchical classification system defined by Lacate (1969). The landbase would be delineated at the Ecosection level of Lacate's system and the units would be presented at the 1:125 000 map scale.

The N.E. 1/4 of the Kettle Rapids map sheet was produced in this fashion and, a legend prepared (see for legend example of NRIP maps, Table 4, page 79). This product was circulated among a group of previously identified potential users. Comments were solicited and these were generally non committal. The users could foresee some use of the data and no major changes to the methodology were proposed (personal communication). However, users indicated, that data presentation, enhanced by a report and illustrated descriptions would result in a product easier to understand and use.

Although the general response of potential users was not very supportive, the methodology adopted for the remainder of the survey was similar to that developed during the pilot project. The number of stops (one or more sites) was increased to minimal 80 per map sheet area. Extensive use was to be made, where available, of open file maps on landforms and surficial deposits prepared by the Geological Survey.

Data collection. During the second year of the survey an area of approximately 63 000 km^2 in east-central Manitoba was covered. This area included the following mapsheet areas, Island Lake (53E), Oxford House (53L), Knee Lake (53M), Sipiwesk (63P), SE1/4 Split Lake (64A) and W1/3 Kettle Rapids (54D) (see Figure 5, page 65). Discussions on terrain, water and wildlife investigations are largely based on the area represented by the mapsheet areas listed in Table 2.

During the second year of the survey the following types of investigations were carried out: 1. terrain investigations, 2. water studies, 3. wildlife studies.

1. Terrain investigations were carried out on sites selected with the aid of air photographs and surficial geology maps. As the number of site investigations per mapsheet area is relatively small (see Table 2), selection becomes a very important aspect of the survey. Information obtained on a particular site must be useful for extrapolation throughout a large part of the area under investigation. A full site investigation included the collection of data on for example landforms, parent materials, drainage, soils, slope, aspect, erosion and present land use (see Soil Data Form in Appendix C, page 173).

Soil data were collected at three levels of detail during the survey. The first level includes the very detailed description of particular soil types thought to be very extensive in the study area. These soils are also sampled by horizons in order to obtain a complete physical and chemical characterization. The second level of soil description is less detailed and is recorded on a form as shown in Appendix C (page 173). Often a parent material sample is obtained at these sites. The third level refers to soil descriptions consisting of short notes, usually recorded during foot transects between sites, where occasionally checks are made to determine any change in soil properties.

The detailed soil descriptions were recorded on standard soil survey forms using methods and notations defined in the "Manual for Describing Soils in the Field" (CanSIS, 1975). Thus soil investigations

Table 2. Number and Kind of Soil and Vegetation Inspections Carried Out in the Selected Study Area of 63P, 64A, 53M and 54D. (Some sites from the Churchill-Nelson Rivers study included)

Mapsheet	Number of Stops	Number of Sites	Soil Data				Samples		Vegetation Data		Total	Area in km2
			Very Detailed	Detailed	Notes	Total	All Horizons	Parent Material	Floristic and Cover	Floristic		
Sipiwesh 63P	84	141	26	90	11	127	24	56	83	10	93	14058
SE1/4 Split Lake 64A	24	37	4	33	-	37	4	19	30	1	31	3418
SW1/4 Kettle Rapids 53D	11	16	8	6	-	14	8	4	9	3	12	3418
W1/2 Knee Lake 53M	48	81	12	61	3	76	10	28	52	1	53	7029
Total	167	275	50	190	14	254	46	107	174	15	189	27923
Number of x / number of sites x 100%	61	100	18	69	5	92	17	39	63	5	69	

are thus similar to those carried out during soil surveys of forested terrain. The level of detail recorded is independent of the scale of mapping. The scale of mapping is reflected primarily in the number of investigations and the type of transects, but does not affect the data collection method.

Vegetation data collected during the survey included tree measurements, stand measurements, data on regeneration, plant species' and cover and sociability for plant species (see Vegetation Data Form in Appendix C, page 175). The stand and tree measurements are much less detailed than those carried out during cruising operations in support of forest inventories (Forest Inventory, 1979), but still permit a productivity rating to be assigned. A species list was compiled and the cover and sociability were estimated for each species, and recorded separately according to class limits shown in Table 3. Plant species and cover were recorded while walking an area adjacent to or around the soil pit. No plot was staked out, or otherwise marked so that the area recorded probably varied in size among observers. Data were collected by almost all members of the team, regardless of expertise. The data consequently vary widely in quality and quantity among sites.

2. The study and classification of aquatic ecosystems as an integral part of land classification was defined as one of the objectives for the NRIP. During the first and second year of the program water bodies were selected with the aid of aerial photographs and subsequently investigated during the field study. Criteria for selection were distribution in the area, affiliation with surficial materials, shore line configuration, size and also tone of photographic image. The aim was to establish a

Table 3. Scales for Cover and Sociability of Plant Species

	Cover % and Description			Sociability Grouping Description		
Code	NRIP	Domin *)	Braun – Blanquet *)	Code	NRIP	Braun – Blanquet
x or +		isolated, cover small	Sparsely or very sparsely present; cover very small			
1	1%	scarce, cover small	Plentiful, but of small cover value	1	single plant	growing singly, isolated individuals
2	1	very scattered cover small	very numerous, or covering > 5% of area	2	few plants	grouped or tufted
3	5	scattered cover small	any number of individuals covering 25-50%	3	several plants	in small patches or cushions
4	0	abundant about 5%	any number of individuals covering 50-75%	4	many plants	in small colonies in extensive patches, or forming carpets
5	5	abundant about 20%	covering > 75% of area	5	almost continuous	in pure colonies
6	0	25 – 33		6	continuous	
7	5	33 – 50		7	single patch	
8	25-33	50 – 75		8	few patches	
9	33-50	> 75		9	several patches	
10	50-75	100 +		10	large patch	
11	> 75			11	almost continuous	
12	100+			12	continuous	

*) From Kershaw (1973)

number of classes for the lakes and river population within the study area.

A total of 295 waterbodies were investigated during 1975 by means of an eighteen second lake survey method (Nelson and Faulkner, 1971) which uses an instrument equipped helicopter. Data on specific conductance, temperature and depth were collected in this way. Through examination of aerial photographs and direct visual assessment from the helicopter also information on shore and back shore properties were obtained.

3. During the first two years of the NRIP the wildlife-ecologist attempted to characterize major landform-soil-vegetation associations in each map sheet area in terms of the fauna component on the basis of small mammal counts, songbird counts, winter aerial surveys for moose and caribou and wetland/waterfowl studies (Veldhuis and Schmidt, 1975; Mills, 1976; Schmidt, 1979).

The wildlife studies, to be successful, required the use of both helicopter and fixed wing aircraft. The time required and the methodology used for site studies did not permit a team approach to data collection. Data on wildlife were collected on sites, previously investigated in the course of the soil and vegetation studies. During the course of the field studies it became apparent, that terrain investigations and wildlife studies are logistically incompatible. Greater efficiency of field time could be achieved if the wildlife studies were initiated after the basic ecological terrain information was collected. The wildlife component of the study team thus was more appropriately placed in the user category. Consequently, the systematized collection of wildlife data was dropped from the survey after the second season.

Data presentation. Data for a particular map sheet is presented on a map with extended legend and in a Guide book containing information on methodology, rationale descriptions, and definitions for soil, landform and vegetation terminology in a glossary. However, the basic document of the NRIP surveys is the map and legend.

The map depicts ecosections at a scale of 1:125 000. Ecodistricts and Ecoregion boundaries are superimposed on the map. This approach permits the relationship between ecosection, ecodistrict and ecoregion to be shown, and places the terrain conditions shown on the ecosection map in a physiographic and climatic perspective. Generalized descriptions of the various characteristics of each Ecodistricts are provided in a tabular and narrative form in the guide for each map sheet area. The properties of the Ecoregions are presented in three tables. Data and information on "selected biophysical (ecological)", climatic and vegetative characteristics are provided. The tabular write-up for the Split Lake Ecodistrict from the Sipiwesk map sheet area (Veldhuis et al, 1979) and the tables for ecoregion characteristics of northern and eastern Manitoba are presented in Appendix A, (page 147 to 149) as an example of the kind of data and information contained in the NRIP-guides.

The ecosections boundaries were delineated on panchromatic, black and white, 1:64 000 scale aerial photographs. The delineations were made through stereoscopic interpretation of the photographic images. The boundaries were drawn on the basis of landforms, landform patterns and tone and texture on the photograph resulting from differences in vegeta tive cover. Surficial geology maps, and to some extent topographic maps, were used to provide guidance in the air photo interpretation. These maps also provided a framework for the extrapolation of ground truth data throughout the map sheet area during the interpretation phase.

Subsequent to delineation of the ecosection boundaries, the more broadly based ecodistrict boundaries (initially delineated on the basis of surficial geology maps) were adjusted to coincide with section boundaries.

Almost all ecosections are composed of more than one ecosite, as is evident from the symbols depicting the ecosection mapping units (see Figure 6 and Table 4). The component parts of the ecosection are described in terms like topographic variation and pattern of soils and drainage condition. Most of this information has to be obtained from the extended legend accompanying the map. Definitions of landforms, explanation of terms and classes are provided in the guides.

The map symbol for an ecosection is set up in the following manner:

$$\text{topographic expression}\ \frac{\text{Mineral landforms}}{\text{Soil Association(s)}}\ \Bigg|\ \frac{\text{Organic landforms}}{\text{Soil Association(s)}}$$

The various components of the landscape in a particular landsystem are described in terms like genetic landform, texture, form etc. (see Table 4, and map symbol below).

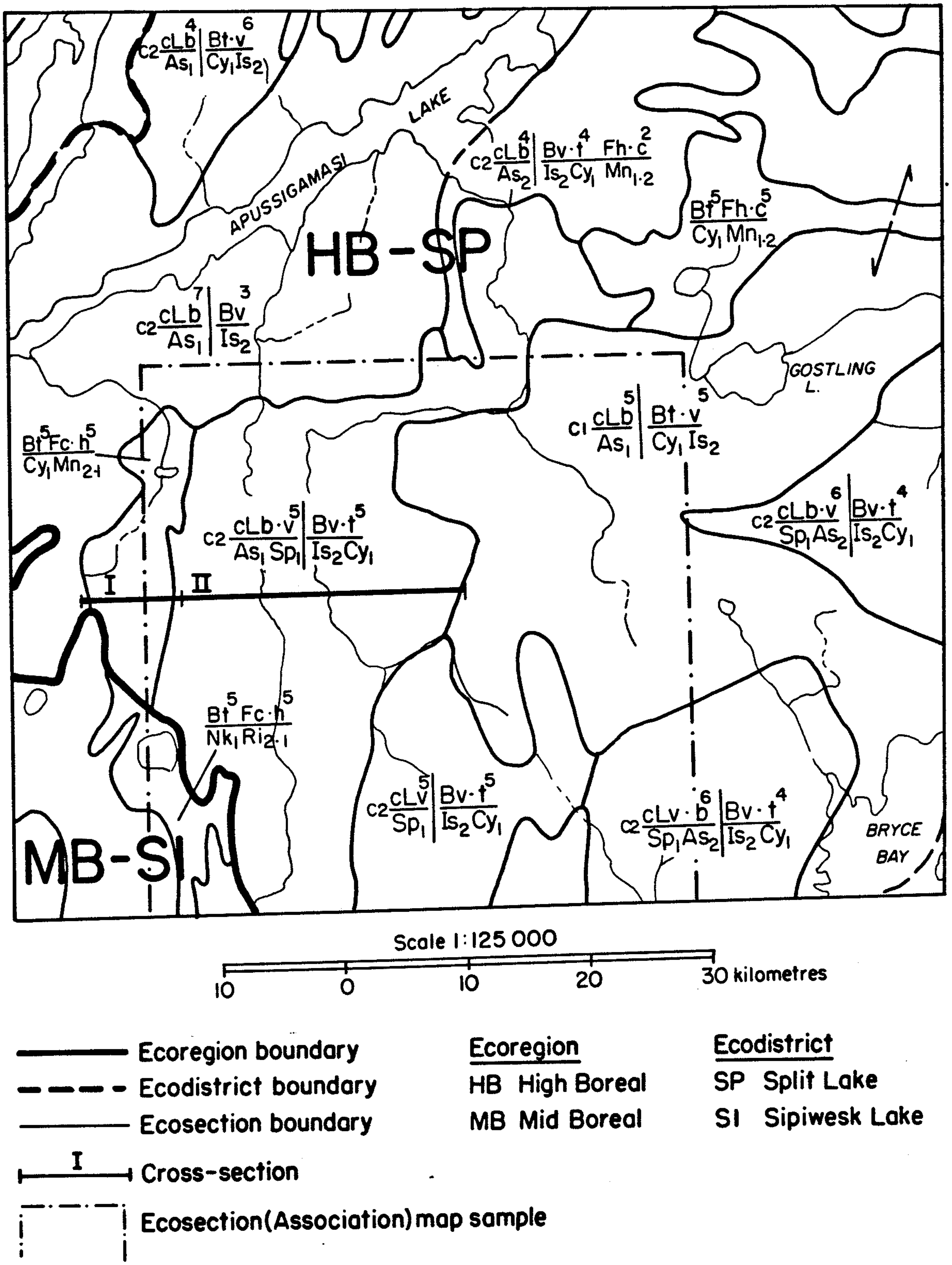


Figure 6. Map Sample of Sipiwesk Map Sheet Area, 63P; Northern Resource Information Program (scale 1:125 000).

Table 4. Legend for Sipiwesk Map Sample.

GEOMORPHOLOGY

TOPOGRAPHIC EXPRESSION

RELIEF CLASS (meters)		SLOPE CLASS	degrees	%
a	0- 2	1	0- 2	0- 5
b	3- 5	2	3- 7.5	6-15
c	6- 20	3	8-15	16-30
d	21- 50	4	16-30	31-60
e	51-100	5	> 30	> 60
f	> 100	6	complex	

TEXTURAL CATEGORY
(placed before landform class)

- c clayey
- l loamy
- s sandy
- f fragmental (gravelly, cobbly or bouldery)
- -s skeletal (used in combination with clayey, loamy or sandy)

GENETIC MINERAL LANDFORM CLASS

- A alluvial
- C colluvial
- E eolian
- G glacio-fluvial
- L glacio-lacustrine
- M morainal
- W marine
- U undifferentiated

BEDROCK CLASS

- aR bedrock, acidic
- bR bedrock, basic
- cR bedrock, carbonatic
- uR bedrock, undifferentiated

MORPHOLOGY and SURFACE FORM CATEGORY
(placed after landform class)

- p plain
- h hummocky
- u undulating
- m rolling
- d drumlinized
- k kettled
- r ridged
- t terraced
- a apron
- Δ delta
- f fan
- b blanket
- v veneer

GENETIC ORGANIC LANDFORM CLASS AND CATEGORY

B	Bog	F	Fen
a	palsa	c	collapse scar
b	bowl bog	f	floating fen
f	flat bog	h	horizontal fen
l	blanket bog	l	sloping fen
m	peat mound	m	minerotrophic palsa
p	bog plateau	p	patterned fen
t	peat plateau		
v	bog veneer	S	Swamp
y	polygonal peat plateau		

MAPPING CONVENTIONS

1. Morphology and surface form categories are applied individually or in combination to the Genetic Mineral Landform or Bedrock Class.

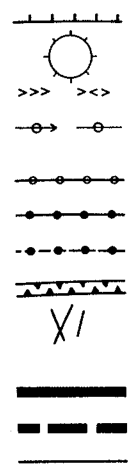
2. Topographic expression applies to both mineral and bedrock landforms and, as well, to shallow organic landforms (bog veneer and blanket bog) which reflect the configuration of the underlying material. The topographic characteristics of all other organic landforms are described in the definition of each landform.

3. Map units may be pure or complex:
   Pure units consist of one component covering 85 percent of the map unit.
   Complex units consist of two or more components, the relative proportion of each being designated in deciles by Arabic numerals placed as superscripts after each landform. The organic landform portion of the map unit is always designated last in the symbol and is separated from mineral and/or bedrock portions by |

4. Thin veneers or blankets of one geologic material may overlie another morphologically dominant unit. Where the overlay is a continuous blanket, the nature of the underlying material is described at the Land District level; if the overlay occurs as a continuous veneer, the underlying materials are described in the definition of the soil association.

5. Areas of dominantly deep organic deposits are designated according to the organic landform only. The underlying materials are described at the Land District level.

CARTOGRAPHIC SYMBOLS



- break of slope (scarp)
- isolated hillock or hummock
- esker (direction of flow assumed, uncertain)
- drumlin or drumlinoid (ice direction shown, not shown)
- moraine ridge
- abandoned strandline
- buried strandline
- meltwater channel
- minor intersecting lineaments or grooves

BIO-PHYSICAL BOUNDARIES

- Land Region (see Guide)
- Land District (see Guide)
- Land System

EROSIONAL MODIFIER
(placed after morphology & surface form category)

- c channeled
- e eroded
- i dissected
- l deflated
- w washed

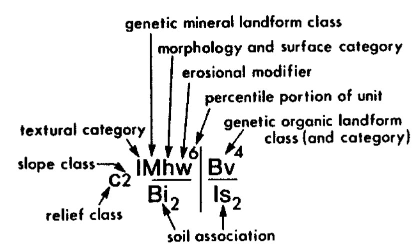


Table 4. Continued

Soil Association Symbol	Soil Association Name	Land Region	Parent Material	Map Unit Symbol	Soil[1] and Drainage[6]: Dominant Subgroup[2]	Soil[1] and Drainage[6]: Significant Subgroup Inclusions[2]	Topography and Landscape Position[3]	Permafrost, Ice Content and Depth of Thaw[4]	Dominant Vegetation[5]
As	Arnot Siding	HB	Deep, moderately to strongly calcareous, clay textured lacustrine sediments (varved silts and clays).	As_1	Solonetzic Gray Luvisol(w-m)	Orthic Gray Luvisol(m) Gleyed Gray Luvisol(i)	Gently undulating terrain; apex and upper slopes	non-frozen	bS-Fm (jP-bS-tA-Al-Fm)
				As_2	Gleyed Gray Luvisol(i)	Solonetzic Gray Luvisol(m) Gleyed Solonetzic Gray Luvisol(i) Orthic Gleysol, peaty phase(p)	Gently sloping terrain; mid and lower slopes	non-frozen	bS-Lg-Fm (bS-jP-tA-Al-Lg-Fm)
				As_3	Orthic Gleysol, peaty phase(p)	Gleyed Gray Luvisol(i) Rego Gleysol, peaty phase(p) Gleysolic Static Cryosol, peaty phase(p)	Lower slopes and level to depressional terrain	non-frozen (low to moderate, 50 to 100 cm)	bS-Lg-Mx
Cy	Crying Lake	HB	Deep, perennially frozen mesic forest peat, or thin Sphagnum peat overlying perennially frozen forest peat. Undifferentiated mineral materials occur deeper than 1 m from the surface.	Cy_1	Mesic Organic Cryosol(i-p)	Fibric Organic Cryosol (i-p)	Peat plateaus and palsas	moderate to high, 50 cm	bS-Lg-Rc-Li-Sp
Is	Isset Lake	HB	Shallow (40 to 100 cm) deposits of dominantly mesic forest peat or thin fibric Sphagnum peat, overlying mesic forest peat, underlain by moderately to strongly calcareous clay textured lacustrine sediments.	Is_2	Terric Mesic Organic Cryosol(i-p)	Terric Mesisol(p) Terric Fibric Mesisol(p)	Gently sloping bog veneer areas with shallow channels, runnels and depressions	low to moderate, 50 to 100 cm+	bS-Lg-Vc-Ox-Li-Mx
Mn	Machiewin	HB	Deeper than 160 cm deposits of moderately well decomposed mesic fen peat or very thin (15 to 60 cm) discontinuous fibric Sphagnum peat overlying fen peat, underlain by undifferentiated mineral deposits. Shallow hydric layers (water and semi-fluid peat) may occur within 100 cm of the surface.	Mn_1	Typic Mesisol(v)	Typic Mesisol, sphagnic phase(v)	Level to depressional fens, water track fens	non-frozen	Cx-Dp-(Er)-Bn-Eq-(tL)
				Mn_2	Typic Mesisol, sphagnic phase(v)	Typic Mesisol(v)	Level to depressional fens	non-frozen	Cx-Sp-(tL)-Er
Nk	Nekik Lake	HB	Deep, perennially frozen mesic forest peat, or thin Sphagnum peat overlying perennially frozen forest peat. Undifferentiated mineral materials occur deeper than 1 m from the surface.	Nk_1	Mesic Organic Cryosol(i)	Fibric Organic Cryosol(i)	Peat plateaus and palsas	moderate to high, 50 to 70 cm	bS-Lg-Mx-Li

Table 4. Continued

Soil Association Symbol	Soil Association Name	Land Region	Parent Material	Map Unit Symbol	Soil[1] and Drainage[6]: Dominant Subgroup[2]	Soil[1] and Drainage[6]: Significant Subgroup Inclusions[2]	Topography and Landscape Position[3]	Permafrost, Ice Content and Depth of Thaw[4]	Dominant Vegetation[5]
Ri	Rock Island	HB	Deeper than 160 cm deposits of moderately well decomposed mesic fen peat or very thin (15 to 60 cm) discontinuous fibric Sphagnum peat overlying fen peat, underlain by undifferentiated mineral deposits. Shallow hydric layers (water and semi-fluid peat) may occur within 100 cm of the surface.	Ri_1	Typic Mesisol(v)	Typic Mesisol, sphagnic phase(v)	Level to depressional fens, water track fens	non-frozen	Cx-Dp-(Er)-Bn-Eq-(tL)
				Ri_2	Typic Mesisol, sphagnic phase(v)	Typic Mesisol(v)	Level to depressional fens	non-frozen	Cx-Sp-(tL)-Er
Sp	Split Lake	HB	Thin (less than 1 m) moderately to strongly calcareous clay textured lacustrine sediments overlying bedrock.	Sp_1	Orthic Gray Luvisol, lithic phase(w-m)	Solonetzic Gray Luvisol, lithic phase(w) Gleyed Gray Luvisol, lithic phase(i)	Gently to moderately rolling terrain; apex and upper slopes	non-frozen	bS-Fm-(jP-Al-Fm)
				Sp_2	Gleyed Gray Luvisol, lithic phase(i)	Orthic Gray Luvisol, lithic phase(m) Orthic Gleysol, peaty phase(p)	Mid and lower slopes	non-frozen	bS-Lg-Fm-(bS-tA-Al-Wi-Lg-Fm)

Notes:

1. Canada Soil Survey Committee, Subcommittee on Soil Classification, 1978. The Canadian System of Soil Classification. Can. Dep. Agric. Publ. 1646, 164 pp.
2. Dominant subgroup comprises more than 40 percent of soil association. Significant subgroup inclusions are 20 to 40 percent of soil association. Minor subgroups are listed in order of dominance.
3. Topography and landscape position refers to dominant subgroups and significant subgroup inclusions.
4. Permafrost, ice content, depth of thaw refer to the dominant subgroup. Notations in brackets refer to significant subgroup inclusions.
5. Vegetation type is defined in terms of significant key species usually associated with the dominant soil subgroup. Species in brackets are found in early seral stages of succession.
6. Drainage classification
   - e - excessively drained
   - w - well drained
   - m - moderately well drained
   - i - imperfectly drained
   - p - poorly drained
   - v - very poorly drained

VEGETATION: SPECIES ABBREVIATION

TREES

- bPo - balsam poplar (Populus balsamifera)
- bS - black spruce (Picea mariana)
- jP - jack pine (Pinus banksiana)
- tA - trembling aspen (Populus tremuloides)
- tL - tamarack (Larix laricina)
- wS - white spruce (Picea glauca)

MOSSES

- Dp - Drepanocladus sp.
- Fm - Feathermosses
- Mx - Mixed mosses (Feathermosses and Sphagnum sp.)
- Sp - Sphagnum (Sphagnum sp.)

LICHENS

- Li - Lichen (Cladonia sp. and others)

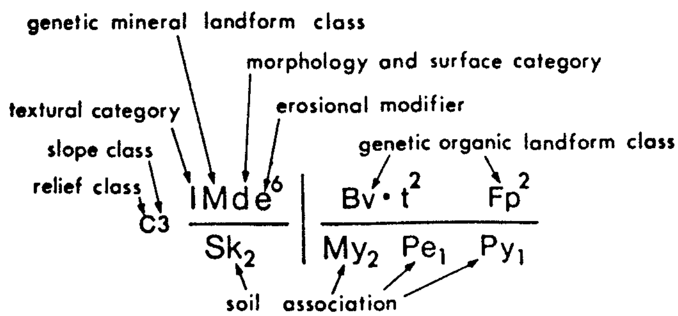
SHRUBS

- Al - alder (Alnus sp.)
- Bb - bearberry (Arctostaphylos uva-ursi)
- Er - Ericaceae (Chamaedaphne, Andromeda, Kalmia, etc.)
- Lb - twinflower (Linnaea borealis)
- Lg - Ledum (Ledum groenlandicum)
- Ox - bog cranberry (Oxycoccus microcarpus)
- Rc - appleberry (Rubus chamaemorus)
- Vc - rock cranberry (Vaccinium vitis-idaea)
- Wi - willow (Salix sp.)

HERBACEOUS

- Bn - bogbean (Menyanthes trifoliata)
- Cx - sedge (Carex sp.)
- Eq - horsetail (Equisetum sp.)
- Gr - grasses (sp.)

Map Symbol:



The soil association symbol directs the user to the extended legend. The legend provides information on parent material, soil subgroups belonging to the association and other associated properties and accessory information (see Table 4). In addition to the narrative descriptions and tabular information on districts and regions a number of cross-section through portions of districts or ecosections are presented in the guides. Two examples from the Sipiwesk mapsheet guide are presented in Appendix A, page 151 and 152.

Chapter 5

EVALUATION, CRITIQUE AND RECOMMENDATIONS

This evaluation is concerned mainly with the ecological land surveys carried out in Manitoba during the period 1974 to 1976, under the Northern Resource Information Program (NRIP).

Although some NRIP maps and guides have been available for a number of years very little feedback in the form of inquiries, suggestions or comments have been received to date. This is possibly due to lack of interest in the land resource data provided by the NRIP or a temporarily decreased need for such data. Equally as possible, the kind of data generated by the program either did not meet the requirements of users or else the form in which the data were presented was too difficult to understand.

In this chapter the NRIP is evaluated in terms of purpose, approach and utility of the final product. The definition provided earlier for ecological land surveys places emphasis on the integrated approach to land classification and the classification and mapping of ecologically significant land units. The term "integrated approach" refers to the methodology of data collection and data presentation, while purpose of the survey and usefulness of the final product relate to the extent to which the mapping units convey ecologic significance. The evaluation of the classification and mapping approach used in the NRIP is accomplished in general terms and by comparison to some of the characteristics of the Cormorant Lake project in Manitoba and the James Bay project in Quebec. The usefulness of the data derived from the Cormorant Lake project was evaluated in 1968 by a number of potential users involved with land capability studies for forestry, agriculture, wildlife, recreation and sportfish (Zoltai et al, 1969). The Cormorant lake map and reports offer a fair and rather detailed amount of information with respect to map units and their component parts, but interpretation keys and ratings for land resource uses are not provided. The James Bay project in Quebec is generally considered to be a hallmark for ecological land classification studies in Canada (Wiken, 1978). The systematic mapping of some 410 000 km^2 of the James Bay area of Quebec is the largest ecological land survey of this kind in Canada to date. It was carried out over a period of 5 years and involved an integrated multi-disciplinary team of up to 26 members supported by adequate resources (Jurdant et al, 1977a). The usefulness of the James Bay project has been evaluated by means of a users survey (Gantcheff et al, 1978).

EVALUATION BY POTENTIAL USERS

The success of any land survey program and ecological land surveys in particular, depends very much on decisions taken at the planning stages regarding the formulation of objectives by the potential users and identification of their data requirements. Based on these objectives and the defined taxonomic criteria, the type of map units, map scale and form of data presentation can be established. At this stage cost and time estimates for the methodology selected help to decide if this methodology can be carried out within time and budgetary constraints for the project or if modification is required.

Gantcheff et al (1978) note several criticisms of the ecological data presented in the James Bay Study. Potential users may find data presented at the ecosection level too detailed to serve broad regional planning activities. Users in general felt that the classification of aquatic habitats, streams and wetlands did not receive sufficient attention. Also lack of emphasis on riparian habitats and present vegetation cover were often mentioned as important deficiencies in a supposedly ecological land inventory. It is expected that similar comments also will be forthcoming with respect to the NRIP data, as users attempt to apply the information in land planning.

Shortcomings like these could be prevented by means of communication with users during the initial stages of the survey. Communication with users during and after the survey is actually a form of integration. This type of integration is especially important with respect to ecological land surveys where the number of users is potentially large. Although other types of land resource surveys will also benefit from user input, they do not require it to the same extent. For example, soil surveys and forest inventories have well established methodologies and user clientele for which data requirements are generally well known.

The NRIP lacked adequate user input at the planning stages and in addition, insufficient evaluation when the maps and guides became available. When the initial pilot project was completed an attempt was made to solicit comments on the product by means of a number of user workshops. However, insufficient time was allowed for the users to understand and evaluate the data presented and to formulate their own requirements for land base data in these map areas. Only minor suggestions were made and as a result the decisions on scale, mapping criteria and methodology for the survey were made taking into account mainly time, budget and available expertise rather than the objectives defined for the inventory. Although the NRIP product may prove to be useful in future years, more extensive user input would have insured this to be the case.

DATA COLLECTION

Land planning and management concerns deal primarily with the potential of the land and environment to support various activities and the performance of land under various treatments. To that end, ecological land classification criteria should reflect function (Walmsley, 1976). The properties selected as criteria are used as indicators of performance characteristics (function). It is difficult to decide which biological and physical properties to emphasize for classifying and mapping various land attributes without knowing or understanding all of the ecological relationships of land. Attributes not chosen for differentiation may be important but if not recognized as such during the survey will not be capable of contributing to the quality of the final product. Although this factor applies equally well to other types of survey, it is very important in ecological land classification and survey where numerous criteria must be considered because of the multitude of land resources involved. The attributes chosen for the differentiation of the land base are reflected in the composition of the ecological survey team and the nature of the data collected.

Survey Team and Its Approach to Data Collection

The NRIP survey team included expertise in the fields of pedology, forestry and wildlife ecology, with expertise in plant taxonomy added later in the program. Although the team was multi-disciplinary in composition, expertise in pedology was more strongly represented than expertise in the other fields of study. The plant taxonomist, who provided expertise in plant species identification, had very little experience in vegetation ecology. Much vegetation data was collected by the pedologists and forester, who were not specifically trained in this resource field. As a result, the emphasis in the mapping of land units is placed on landform and soil characteristics, biasing the map and report towards soils and geomorphology.

Both the NRIP in Manitoba and the James Bay project in Quebec relied on a team approach to carry out the ecological land survey. Although the scale of the James Bay Project is much larger in terms of manpower and funds than the NRIP, the composition of the respective teams and field parties can be compared. Regardless of size of the project team, each field party is restricted to a small number of people by the logistics of transportation in inaccessible terrain. Field parties in the James Bay project consisted of a pedologist and a phytosociologist. Each member of a field party had, in addition to the expertise in their respective field of specialization, a good working knowledge of the other member's field of expertise (Jurdant, 1977). This allowed for fruitful discussion and exchange of ideas on the ecology of the terrain unit being studied and the placement of mapping unit boundaries. The NRIP team, lacking equivalent input by phytosociologists was not able to carry on such an exchange.

The amount of budget assigned to a project determines the number of field parties which can be maintained and the kind of transportation which can be provided. During the NRIP surveys transportation support consisted mainly (exclusive of logistical support for camp moves, and supply runs) of one Jet Ranger helicopter. This type of aircraft allows safe transportation of field parties of up to three people, including equipment. Under optimum working conditions it allows for the deployment of three parties per day: one on a day-long detail transect with two parties being ferried alternately throughout a portion of the area. A larger field operation consisting of more than 3 field crews requires, in order to maximize efficiency additional helicopter support.

Based on the NRIP in Manitoba, and the Quebec experience, the following study team is suggested:

- one ecologist-team leader; with sufficient experience in all fields to understand the work of other team members; is strongly involved with the synthesis and correlation of data.
- two or three pedologists; all with good knowledge and skills in the use of aerial photographs for mapping; preferably one pedologist with a background in agriculture, and one with a background in forestry.

- two or three phytosociologists or vegetation ecologists; all with skills in photointerpretation, good knowledge of the flora of the area, data collection and manipulation methodologies.
- one geomorphologist; highly developed skills in photointerpretation.

Operating 2-member field parties with expertise in soils and vegetation is in most cases the most efficient way of data collection. Helicopter support capable of carrying larger fieldcrews also permits the expansion to three member parties when additional expertise is required in a particular area or site.

A team comprised of soil and vegetation expertise will be able to collect most of the baseline data required for an ecological survey. Experience indicates that climatic data is best collected separately and information on wildlife populations and habitat must be generated by other studies. The proposal permits the collection of data in a manner that emphasizes its ecological relevance through the integration of ideas on the ecosystems and the mapping units in the field and later in the office. Thus delineation and labeling of map units will be the result of the exchange of opinion and ideas between two or more fields of expertise.

Selection of Field Investigation Sites

Most of the sites to be investigated are selected before data collection starts. The process of site selection is very important in reconnaissance scale ELS because of the rather low number of investigations per map sheet area (see Table 2, page 72). Sites are selected with great care with the aid of aerial photographs and if available, surficial geology maps. Information obtained at a particular site must be useful for extrapolation throughout large parts of the area. Therefore rarely occurring landscape entities are usually avoided and each site investigated should represent a large population of similar sites.

Sites are usually selected to represent a number of observed and inferred characteristics such as landform and material of a certain kind, particular drainage condition and vegetation characteristics. Site selection on the basis of vegetation criteria becomes a very random process when dependent on aerial photography which is not current. Often the preselected site has been burned or otherwise disturbed when the surveyors arrive to start the investigation. Out of date photography also hampers the extrapolation of such data as the signature on the photo is out of tune with the present day vegetation. The old, 1955 air photography used in the NRIP program created continual problems throughout the survey and often necessitated the ad hoc selection of an alternate site.

The availability of recent air photography at an appropriate scale is very important in the conductance of reconnaissance type land resource-surveys. If an ecological land survey is planned well ahead new photography may be procured before the actual field survey begins.

Landform, Soil and Vegetation Investigations

Soils and landforms were investigated during the NRIP according to standard-soil survey procedures. Because of the strong representation of pedological expertise on the team the soil data is generally of good quality, complete and can usually be classified at the soil subgroup level and mapped at the soil association level. Landform descriptions are fairly complete and additional data collected on organic land forms served to enhance the information obtained from available surficial geology maps.

The collection of vegetation data on the other hand was little structured except for the use of vegetation data recording forms. The method suggested for collecting vegetation data in the Guidelines (Lacate, 1969) was not implemented during the NRIP because of inadequate representation of phytosociologists on the study team. Lack of structure in vegetation sampling led to incomplete and unreliable data. Inadequacies of the approach are quite evident in the raw vegetation data lists provided in the Ecosection descriptions presented in Appendix B (page 153). In many cases large gaps and inconsistencies exist in the number of species recorded. The introduction of the detailed scales for cover and plant sociability made the recording of these parameters unnecessarily complicated and also unreliable. The application of the Braun-Blanquet scale would have been more appropriate in view of the level of phytosociological expertise available.

The summary of data types in Table 2 (page 72) indicate that no vegetation data were recorded at many sites. Species lists, cover estimates and stand measurements are more complete for upland sites than for wetlands. The main site at each stop is usually treated in greater detail than are subsequent sites at the same stop. The numbers of soil investigations also show that soil data collection was incomplete on a number of sites, but not to the same extent as the vegetation data collection.

The amount of land attribute data collected during the field investigation phase must be sufficient to map and classify the majority of map units at the level of abstraction chosen.

During this review it was found that in the Sipiwesk map sheet only 39 of the 56 soil-association "drainage members" used in the mapping, had been investigated at least once within the map sheet boundaries. However, a number of these members were described in adjacent map sheets. These figures are an indication of the extent to which classification and delineation of mapping units depend on photo-interpretation.

The number of investigations per map sheet is low with respect to scale of map, intensity of map units and complexity of mapping unit symbol. The number of sites investigated per map sheet should be increased to ensure quality control on the photointerpretation. Adequate soil characterization and sampling may require a level of groundtruth 3 to 4 times (or more depending on terrain) the number of expected types. This number of investigations will offer sufficient replication to provide adequate data to describe the range of soils and landform segments.

However, vegetation classification and characterization carried out at a comparable level of detail would require many times that number of sites. A reliable vegetation classification depends on large amounts of data collected in homogeneous vegetation communities in a repetitive manner (Mueller-Dombois and Ellenberg, 1974). A reconnaissance type survey of low intensity, with respect to number of site inspections, is not capable of providing the required amount of data. Although it is possible to collect accurate data on each site investigated, the number of sites is insufficient, and only more detailed surveys or studies will generate the amount of data necessary to successfully attempt a classification. However, a reconnaissance type survey may provide sufficient vegetation data to attempt an ordination for gross climatic differentiation of ecoregions.

A better relationship between the number of investigations and the final published map may be achieved either by increasing the intensity of the survey or by mapping at a more generalized level. All pertinent data should be collected at each site, and the vegetation data collection should be structured using plots and subplots as recommended by Lacate (1968). The number of samples for soil typing should also be increased, to provide reliable descriptions for a greater range of types.

Waterbody and Wildlife Investigations

The waterbody investigation and the study of aquatic systems were a relatively minor part of the total NRIP, so it is not possible to make an in depth evaluation of the collection method of the resulting data. It appears that the collection of data on some water parameters, like temperature and turbidity, is not appropriate for reconnaissance surveys, because of the temporal aspects of such properties. However, permanent physical features such as shoreline characteristics can be easily handled by an ecological survey team during the normal course of the field survey (Jurdant *et al*, 1977a). Much related data such as shoreline length, total waterbody area and shoreline configuration can be obtained from air photographs. In addition some inferences concerning water chemistry and nutrient status are possible if the water data is considered together with knowledge gained from the study of associated mineral and organic terrain of an area.

Although wildlife investigations carried out concurrently with the basic ecological land survey have some benefit for all disciplines, the NRIP experience indicates there are also several disadvantages. Concurrent field studies are not able to accommodate certain temporal aspects of wildlife investigations like the study of habitat use during a particular season and it is difficult to match the rate of progress of the wildlife component studies to that of other land resource studies. Successful wildlife evaluations require the ecological overview and relationships between land, vegetation, soils and climate provided by a ELS. Limited integration of wildlife expertise into the study team at the data gathering stage serves to keep all personnel aware of the data requirements for wildlife evaluation. For instance, the lack of riparian vegetation data is noted as limiting the usefulness of ecological land based data by wildlife managers and recreational development planners (Zoltai et al, 1969). The inclusion of data on aquatic ecosystems and their relationship to terrestrial ones is of great importance to wildlife managers (Gantcheff et al, 1978). Aquatic ecosystems are an integral part of the landscape and directly influence the value of terrestrial ecosystems to both wildlife (Schmidt, 1979) and recreants. However, in most cases, the collection of basic wildlife data is better left to separate studies subsequent to the initial gathering of ELS data.

DATA PRESENTATION

The objective of all ecological land surveys at the reconnaissance level, is to cover large tracts of previously unmapped terrain rapidly and to delineate the land base into ecologically significant map units. The purpose of this type of survey is to provide basic information on the land base to a larger number of users than is usually reached by single land resource surveys. An advantage of broadly based resource information is that thematic maps and various interpretations that may be derived have a common base, through which the relationship between the second generation maps and reports remains intact.

The integration of the data on various land attributes into ecologically significant map units and their descriptions is difficult to accomplish. The ecological surveys carried out in Quebec in the Lac St. Jean and James Bay projects are generally considered to be most successful in achieving a degree of integration (Wiken, 1978). In these surveys a very definite attempt was made, by means of an integrated survey team, to create an integrated product which showed the relationships between various landscape components in the form of ecological land units and, which also included information, to some degree, on aquatic ecosystems as well (Jurdant et al, 1976, 1977 a and b). Other ecological land classifications such as the Carajou area study in Alberta attempt to present resource data in an integrated fashion but are not integrated at the data collection phase (Dutchak, 1979). The ELS maps resulting from this study were derived mainly from data collected in previously published soil survey and CLI inventory projects. Ecological integration in the NRIP surveys in Manitoba was achieved to some extent but with strong emphasis on two components of the land resources: soils and surficial materials.

Ecological land survey maps and reports are the means by which the information obtained during the survey are relayed to the users of land resource data and some measure of the success attained by such surveys is gauged by user response. As noted in the introduction to this chapter response of users to the NRIP product have been very minimal. However, the land resource data generated by the James Bay project has been used in the following planning and management areas (Gantcheff et al, 1978):

1. location of utility corridors, 2. impact studies, 3. land use planning, 4. resource management, 5. environmental descriptions, 6. background information for various resource studies and 7. miscellaneous applications such as archeologic studies.

The same survey of Quebec users also yielded five basic reasons explaining under-utilization of the data of ecological land surveys:

1. the information was not readily available at the time it was required, 2. the degree of reliability of the interpretation keys was unknown, 3. the data often were presented at a level of perception which is incompatible with the user's needs, 4. lack of information at the ecosection level on key components of the environment such as aquatic and riparian habitat and present vegetation cover, 5. the user did not have the necessary experience to handle the information.

Gantcheff et al (1978) conclude that the successful application of the land resource data in the future will "largely depend upon the familiarity of the potential users with the classification, its results and their possible interpretations." They further state that "the development of interpretation keys will also have to receive more attention in the future. These keys represent the point where resource specialists and users meet; the degree of confidence the latter has in the interpretation will determine the extent of the utilization of the ecological data."

Ecosystem and Ecological Land Classification Map Units

The hierarchical Ecological Land Classification system applied in Canada serves both as a taxonomic and as a mapping system. The dual purpose of the classification system creates some problems with respect to the delineation of ecologically significant land units at various levels of generalization in ecological land survey.

In Table 5 a taxonomic hierarchy for ecosystems is suggested in order to illustrate the differences that exist between the categories of an ecosystem classification and the categories of the Canadian ecological land classification system. At the most generalized level of abstraction the earth is viewed as the ultimate ecosystem. If one considers terrestrial ecosystems only, a terrain unit, very "pure" in regard to soil and vegetation type forms the smallest identifiable, complete ecological unit, the so called Element, which represents in most cases the most homogeneous part of an ecosystem.

Table 5 indicates that all levels below the Mega Order have broad

Table 5. Suggested Taxonomic Classification System for Ecosystems and Comparison with ELC System.

Taxonomy	Differentiating Criteria	Schematic Presentation	Ecosystem examples	Approximate Equivalent in ELC-system
Kingdom		Earth	Global	
Phylum	Landmasses vs. oceans	continents; oceans	North America	
Mega Order)	)	→ province; x	Boreal Region	Ecoprovince
Order)	Climate)	→ zone; x	High Boreal Region	Ecoregion
Suborder)	)	→ subzone; x		
Great Group	Land vs. Water	→ terrestrial; aquatic	All Land Systems) Blanket)	)
Subgroup	Mineral vs. Organic surficial Materials	c → mineral; organic	Glacolacustrine)	Ecodistrict and Ecosection
Family	Mode of deposition and form of surficial materials	l i m → landform; landform	Blanket)	)
Association	Soil association Vegetation association	a t e → parent mat.; parent mat.	Arnot Siding Ass.)	)
Series	Soil series, vegetation chronosequence	→ soil, veg; soil, veg	Arnot siding soil series and vegetation chronosequence	Ecosite
Element	Soil series type and vegetation type	→ soil, veg; soil, veg	Arnot Siding soil series type and vegetation type	Ecoelement

regional climate as a common environmental factor, but only at the Mega Order, Order and Suborder levels is climate a differentiating factor. At lower levels like Element, Series and Association climatic influence is at a local or micro scale and is really a function of regional climate modified by topography, aspect, texture and drainage which result in particular soil and vegetation characteristics. Land as opposed to water and mineral as opposed to organic surficial materials are the differentiating criteria for the Great Group and Subgroup categories of the suggested hierarchy. The Family category is based on geomorphologic criteria such as form and genesis of surficial materials.

The ecologically significant element in the landscape is an ecosystem described at the Ecosite level of abstraction. This is a landscape element which shows strong relationships between its various physical and biological attributes and is also fairly homogeneous, with respect to these attributes, throughout its areal extent. These units are therefore generally limited in size and are usually mapped at scales of 1:10 000 to 1:20 000 and occasionally 1:40 000. At this level of abstraction the delineation of map units does not conflict with the taxonomic classification of ecosystems as can be seen in Table 5.

As Table 5 also indicates the recognition of landscape units at the Ecosection and Ecodistrict levels of the Ecological Land Classification system results in some disagreement with corresponding levels of the taxonomic classification system. At these levels the map units contain ecosystems that belong taxonomically to different classes. The map units lose their ecological unity because they become agglomerations of ecosystems which are heterogeneous with respect to soils and vegetation and in the case of large units also with respect to landforms. At the Ecoregion level of the ELC system ecological unity is regained because of the single differentiating criterion of regional climate. Although the regions may be very diversified with respect to geomorphological, geological and hydrological attributes, they have unity because of climate. Thus at the Ecoelement, Ecosite and Ecoregion levels of the ELC system conflict between map unit and the ecological taxonomy of the landscape unit it represents is minimal. On the other hand, the Ecosection and Ecodistrict map units often represent a diverse group of ecological entities that are not ecosystems as such and need to be described on the basis of their component parts.

In Table 6 a comparison is made between a USDA Land Classification System devised by Wertz and Arnold (1972), and the equivalent Ecological Land Classification categories used in Canada. The Canadian Ecosection category straddles the subsection and landtype association categories proposed by the U.S. system. The landtypes of the U.S. system are their basic units and building blocks for overall land use study and planning. The land type association groups a number of land types into larger units. This resembles the approach in Canada, but the landtype associations appear to be less complex and are usually mapped at a scale of 1:20 000 to 60 000; a much larger scale than usually employed to map Ecosections in Canada. The USDA system is not considered an ecological land classification system, its objective is to subdivide the land into increasingly more refined units which happen to coincide at the Landtype level with ecosystems and at the Landtype Association level with ecosystem associations.

Table 6. Comparison of USDA and Canadian Land Classification Systems

System outline, land base portion of integrated environmental inventory (after Wertz and Arnold, 1972)					Canadian ELC System
Category	**Name**	**Basis for Delineation**	**Size Range**	**Principal Application**	**Approximate Equivalent**
VII	Physiographic Province	Basic Elements: Structure, lithology, climate. First order stratification.	1000s of km^2	Nationwide or broad regional data summary.	Ecoprovince
VI	Section	Basic Elements: Structure, lithology, climate. Second order stratification.	100s to 1000s of km2	Broad regional summary. Basic geologic, climatic, vegetative data for design of individual resource inventories.	Ecoregion Ecodistrict
V	Subsection	Basic Elements: Structure, lithology, climate. Third order stratification.	10s to 100s of km2	Strategic management direction, broad area planning.	
IV	Landtype Association	Manifest Elements: Soils, landform, biosphere. First order stratification.	2 to 10s of km2	Summary of resource information and resource allocation.	Ecosection
III	Landtype	Manifest Elements: Soils, landform, biosphere. Second order stratification.	1/5 to 2 km2	Comprehensive planning, resource plans, development standards, local zoning.	Ecosite
II	Landtype Phase	Manifest Elements: Soils, landform, biosphere. Third order stratification.	1/25 to 1/5 km2	Project development plans.	
I	Site	Represents integration of all environmental elements. Units are generally not delineated on map.	less than 1/25 km2	Provides precise understanding of ecosystems. Sampling will be for defining broader units, for research, and for detailed on-site project action programs.	Ecoelement

A more refined category like the USDA Landtype Association (but association defined as group of land units related through common properties with respect to parent material) would bridge the gap between the Ecosite and Ecosection categories of the Canadian ELC. The Ecosection would then be redefined as an area of land throughout which there is a recurring pattern of landforms. Soils, vegetation and water bodies can be described in general terms in the legend or report to provide more information on the land base. Scale of mapping would be 1:250 000 and the map unit would appear as a subdivision of the district. The "Ecosite Association" would then be mapped at scales from 1:40 000 to 1:100 000 depending on terrain conditions and the survey would be termed "medium intensity" survey.

Ecosection and "Ecosite Association" Map Units

The ecosection map units shown on the NRIP map represents generally a rather large and, in terms of constituent ecosites, a complex landscape unit. Examination of 8 ecosections, partially or entirely shown in the map sample of the Sipiwesk map sheet area (Figure 6, page 78), yielded figures areal measurements as follows: 8, 12, 19, 22, 45, 50, 83 and 116 km^2, with an average size of 45 km^2. The complexity of two ecosection map units is illustrated in Figures 7 and 8. These cross-sections show that each ecosection consists of a large number of small landscape entities, which can be grouped into a number of landform classes eg. cLb, Bt, Fc. The cross-sections also show that the component parts of each ecosection occur in a repetitive pattern throughout the unit.

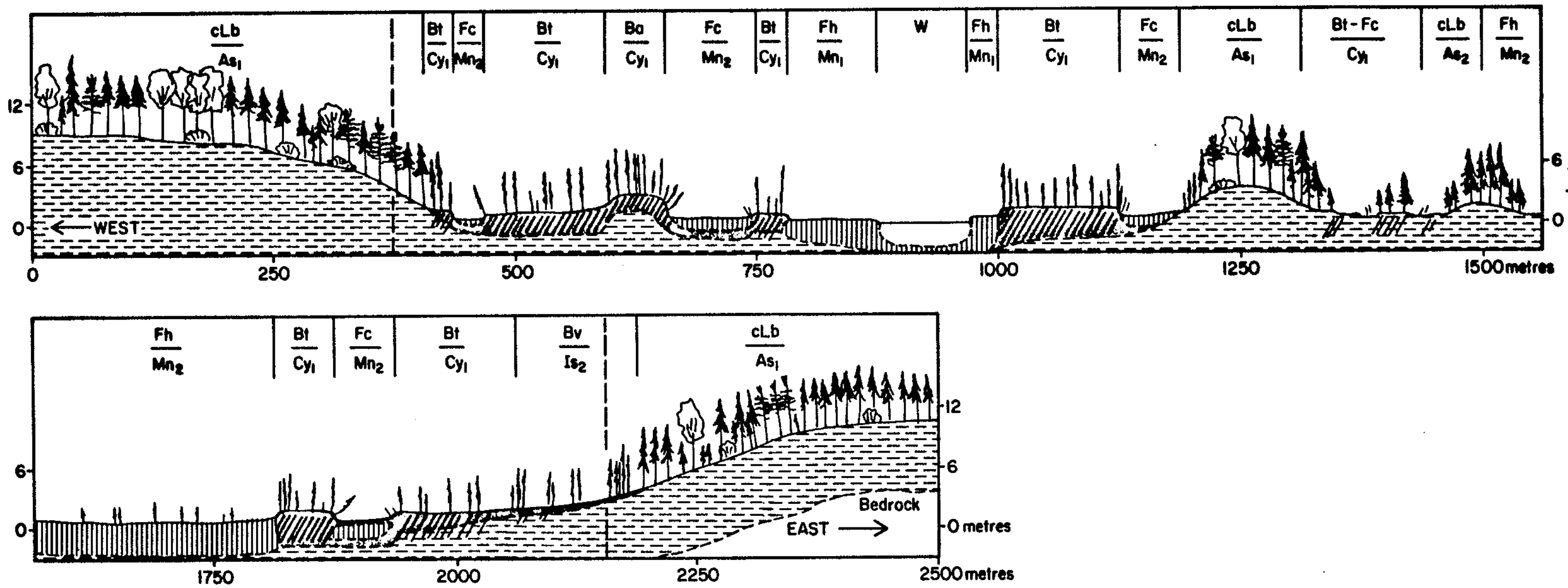


Figure 7. Cross-sectional Diagram of an Ecosection (I)

Ecosection $\frac{Bt^5 \ Fc.h^5}{Cy_1 \ Mn_{2.1}}$

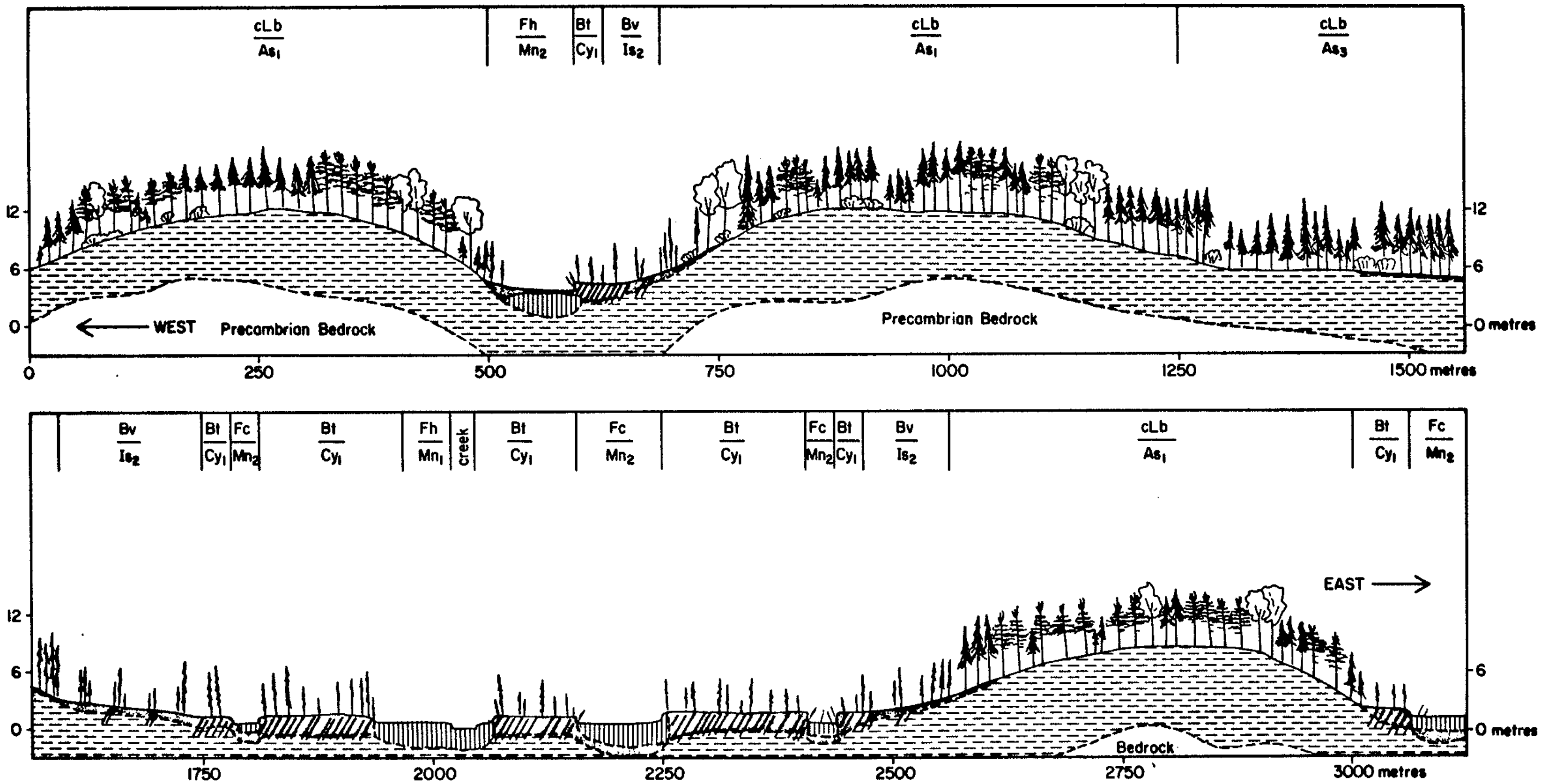


Figure 8. Cross-sectional Diagram of an Ecosection (II)

Ecosection $c2 \; \frac{cLb \;\; . \;\; v^5}{As_1 \;\; Sp_1} \Big| \frac{Bv \;\; . \;\; t^5}{Is_2 \;\; Cy_1}$

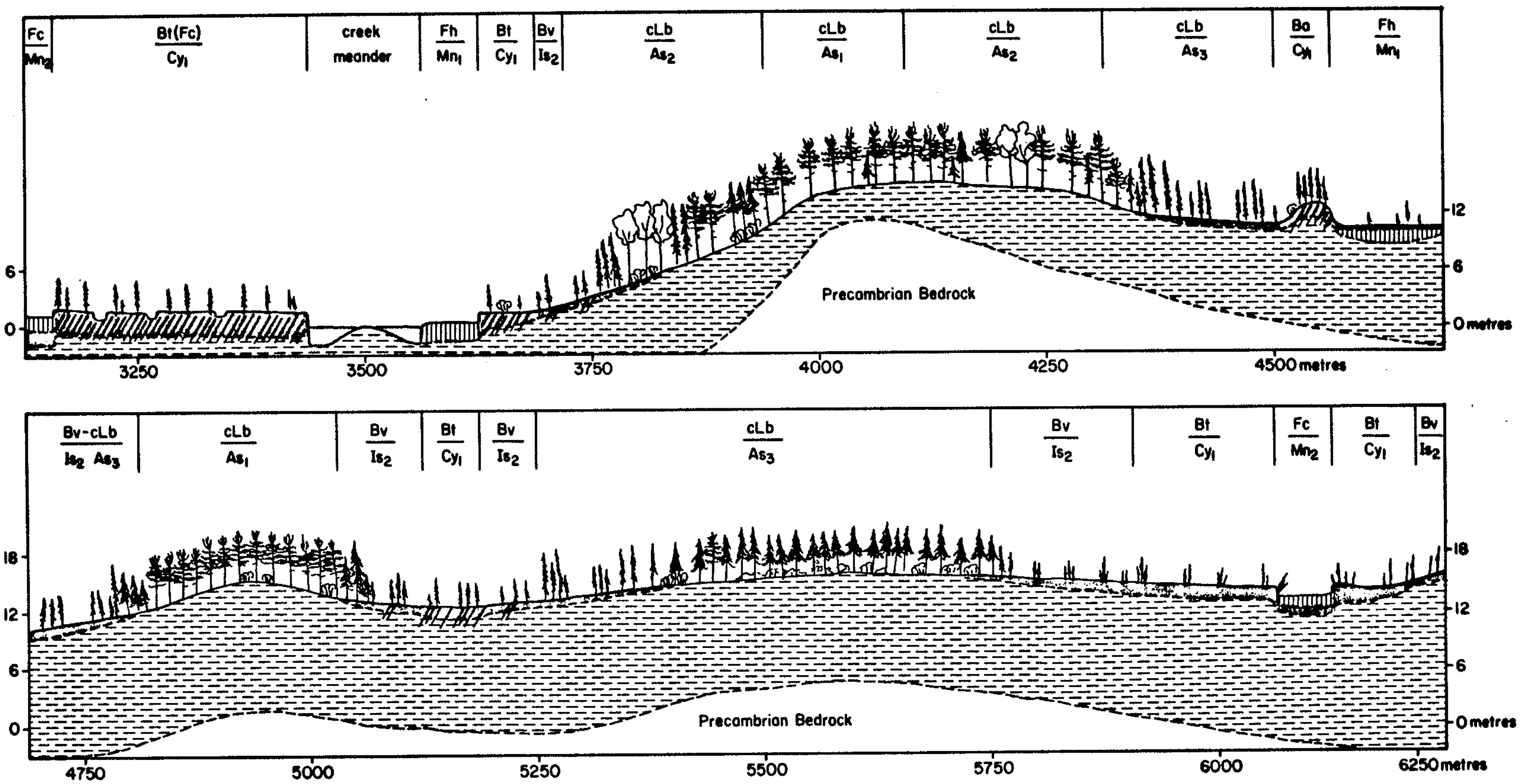
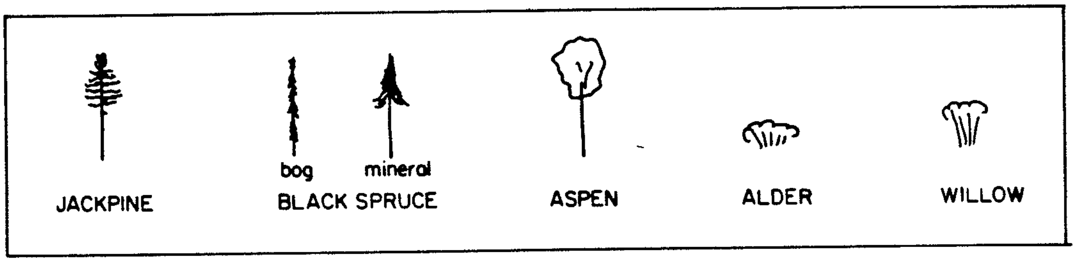
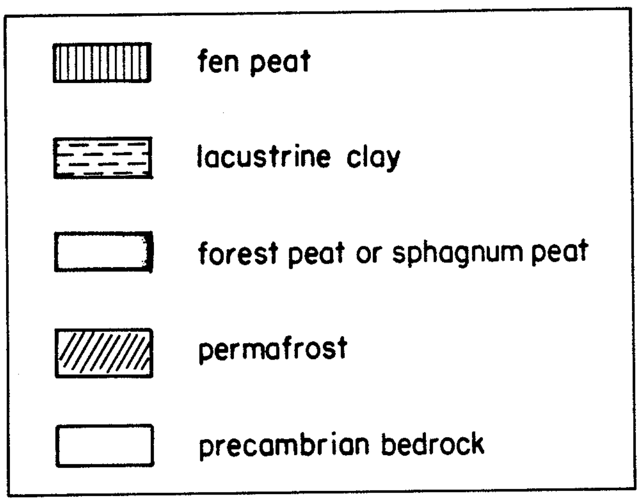
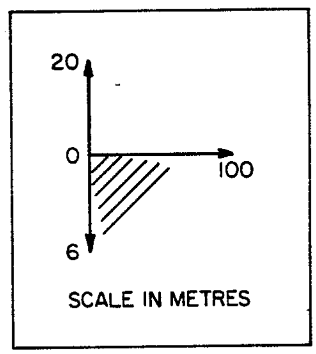


Figure 8. Continued

Table 7. Partial Legend for Cross-sectional Diagrams I and II. (Legend for Unit Symbols in Table 6. page 90)







The large areal extent and complexity of the ecosections used to map terrain in northern and central Manitoba is attributed in part to landscape conditions in which a generally poorly developed drainage system results in many areas of organic accumulation. This characteristic combined with the occurrence of permafrost gives the terrain a mosaic-like appearance and its ecological heterogeneity. The mapping of such complex terrain from limited ground-truth results in the delineation of ecosection map units that are, in reality, complexes or combinations of smaller ecosections. These large complex ecosections usually have many component parts in common, varying only in distribution, size and proportion between the ecosections.

The use of air photographs to facilitate terrain mapping permits the identification of landscape elements at a larger scale than actually can be portrayed on a 1:125 000 scale map. Because of this, map units are labeled by means of complex symbols which identify 3 to 5 classes of component parts in decile portions within the map unit. This complex map unit symbol implies a degree of accuracy to the user that is not always warranted. Accuracy of the map unit symbol in reconnaissance survey mapping is very dependent on the photointerpretation skills and experience of the surveyor-mapper and the quality and quantity of groundtruth. However, groundtruth for a particular landscape component is only an aid in the classification of similar components, if a particular ecosite has not been investigated it will not be properly mapped and identified regardless of the number of investigations that have been carried out per map sheet, per map unit or per km^2.

The choice of map scale relates to objective and purpose of the survey and the scale of the map determines the detail of landscape attributes that can be portrayed. A map unit with a dimension of 1 cm^2 usually is considered the smallest entity that can be shown on a map. At the 1: 125 000 scale this unit represents an area of about 1.5 km^2. The extent of landscape units delineated on a map should relate to the scale of the map and therefore map units of a size easily portrayed at a smaller scale should not occur frequently. The size of the average landscape unit, represented on the ecosection maps produced by the NRIP, indicate that the majority of the units could have been portrayed at a scale of 1:250 000.

As part of the evaluation of Ecosection map units a small area in the Sipiwesk map sheet was re-interpreted to produce a more detailed map with smaller map units (Figure 9). The reinterpretation was carried out on the same air photos and using the same groundtruth data as in compiling the NRIP map. It is hoped that the creation of the smaller map units also resulted in the delineation of landscape units with stronger ecological unity than was portrayed on the original ecosection map. Each map units consist of a small ecosection which is described as an "associations of ecosites" and is identified by a dominant "Ecosite Association." The members of this "Association" have strong ecological affinity. The map unit also includes a number of spatially associated but ecologically different ecosites or ecosite complexes, which are flagged by means of a symbol modifier (Figure 9 and Table 8). These units still are basically ecosections but they have greater homogeneity and are therefore probably easier to interpret for various uses than the more complex NRIP map units.

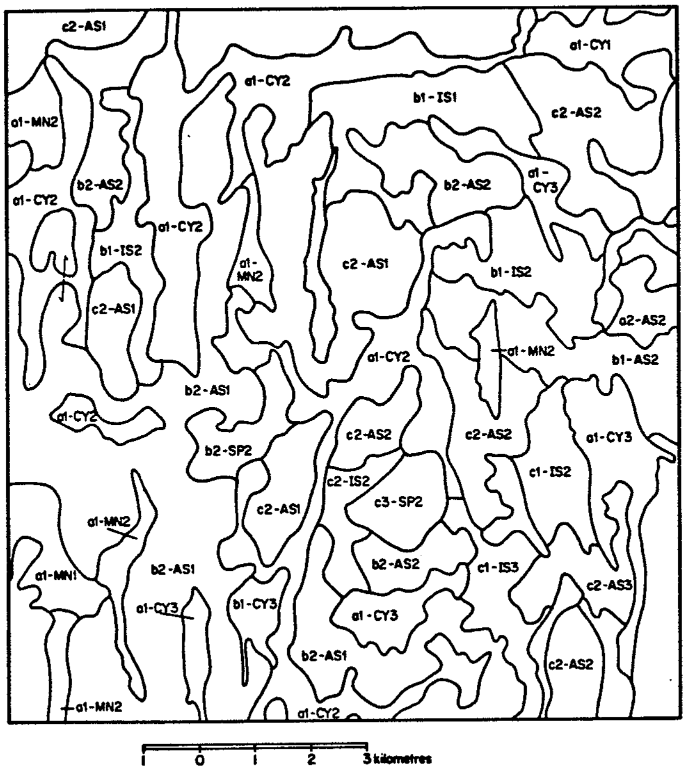


Figure 9. "Detailed" Map Sample for Sipiwesk Map Sheet Area (scale approximately 1:120 000).

Table 8. Legend for "Detailed Map" Sample for Sipiwesk Map Sheet Area

Eco-section Symbol	Eco-section Name	Eco-region	Landform and surficial material	Map Unit Symbol	Dominant Ecosite Association	Significant Ecosite Associations Inclusions: Names	Significant Ecosite Associations Inclusions: %	Soil Association *	Vegetation Association
AS	Arnot Siding	HB	Lacustrine blankets, clay textured, calcareous	AS1	Arnot Siding	Isset Lake	< 20	Arnot Siding (As)	Arnot Siding (Asv)
				AS2	id.	Isset Lake	20 - 40		
				AS3	id.	Isset L. & Crying L.	20 - 40		
CY	Crying Lake	HB	Peat plateaus, deep mesic forest peat and/or fibric forest peat	CY1	Crying Lake	Machiewin	< 20	Crying Lake (Cy)	Crying Lake (Cyv)
				CY2	id.	Machiewin	20 - 40		
				CY3	id.	Machiewin & Isset L.	20 - 40		
IS	Isset Lake	HB	Bog veneer, shallow mesic forest peat over lacustrine clay	IS1	Isset Lake	Arnot Siding	< 20	Isset Lake (Is)	Isset Lake (Isv)
				IS2	id.	Arnot Siding	20 - 40		
				IS3	id.	Arnot Siding & Crying L.	20 - 40		
MN	Machie-win	HB	Collapse scars and horizontal fens, deep mesic fen peat	MN1	Machiewin	Crying Lake	< 20	Machiewin (Mn)	Machiewin (Mnv)
				MN2	id.	Crying Lake	20 - 40		
				MN3	id.	Crying L. & Isset L.	20 - 40		
SP	Split Lake	HB	Lacustrine veneer over Precambrian bedrock; clay textured, calcareous	SP1	Split Lake	Arnot Siding	< 20	Split Lake (Sp)	Split Lake (Spv)
				SP2	id.	Arnot Siding	20 - 40		
				SP3	id.	Acidic bedrock	< 20		
				SP4	id.	Acidic R. & Arnot S.	20 - 40		

Topographic Expression

Relief Class	meters	Slope Class	degrees	%
a	0-2	1	0-2	0-5
b	3-5	2	3-7.5	6-15
c	6-20	3	8-15	16-30

* Additional information on soils can be provided in the same manner as in Table 4, page 79, or in the form of the descriptions given in Appendix B, page 153 to 172.

Three "new" ecosections are described in Appendix B (page 153 to 172) in order to portray some of their characteristics in more detail. The format for the soil descriptions is similar to that used in many soil survey reports. The vegetation component found on various ecosites must also be described in the form of general vegetation types. The vegetation data collected during the NRIP survey has been used in establishing and describing vegetation types in relation to the soil and landform on which they were found. The selection of some of the vegetation types presented was accomplished through manipulation of the data for species and cover, and the application of Sorensen's Similarity Index (Mueller-Dombois and Ellenberg, 1974) after the initial grouping had been accomplished.

The foregoing discussion indicates the necessity for the descriptions of "Ecosite Associations" in terms of soils, vegetation and possible other land attributes as well, to be part of the report on the ecological land survey.

Utility of the Ecosection Map Unit

The basic document of the NRIP consist of an Ecosection map at a scale of 1:125 000, on which map units at the Ecodistrict and Ecoregion level are superimposed (see Figure 6, page 78). An extended legend attached to the map (see Table 4 for example of Sipiwesk map legend) and a Guidebook containing information on ecoregion and district properties (see Appendix A, page 146) and a glossary of terms used on the map and in the legend are part of the information package. A small (4 to 6) number of cross-sections through ecosections or parts of ecodistricts are also presented in the Guidebook, in order to show some spatial relationships between and location of various ecosites in the landscape. No descriptions of ecosites or ecosections are provided and no ratings are given for ecosections or their component parts.

The value of the ecosections as a base for making land use decisions depends not only on basic information about the component parts but also on how well the essential properties of the landscape segment shown on the map are conveyed to the user. Ecosection map units, which are very complex, must be evaluated on the interpretation of the component parts of the entire unit. Although the interpretations of each component part may be more precise and accurate than those for the overall map unit, their value is limited because often the potential use of particular components depends on their size, distribution and spatial distribution with other components within the unit. The way in which a user of the NRIP ecosection map obtains an understanding of the landscape adn its component parts is by decoding the connotative map unit symbols. Although some landscape cross-ections are provided as an aid in understanding the complexity of the landscape, they cover only a small range of conditions. Therefore the accuracy of the mental picture formed by the user depends on the success with which the legend information and the descriptions of terms in the glossary are applied in the decoding of the symbols. Thus, although large amounts of data collection during the survey are used to delineate map units and to describe landscape conditions by means of complex map unit symbols, much information is not readily available to the user. Through the addition of a report containing informative descriptions of the kind as presented in Appendix B (page 153 to 172), understanding of the data by the user may be facilitated. However for many users who lack the expertise to understand complex ecosystems the generation of thematic maps and interpretations for various uses seems of even greater importance. The need for interpreted data for the ecosection map unit and for its comprising ecosite components, as well as the more generalized ecodistricts, in the form of thematic maps and ratings has been documented in the Quebec experience (Gantcheff et al, 1978). Therefore the development of reliable interpretation keys in cooperation with potential users is highly important to the successful utilization of ecological survey data.

Ecological land surveys in Manitoba have utilized various approaches to enhance their usefulness. In the Cormorant Lake project the areal relationships between different ecosites of ecosections were conveyed by means of cross-sectional diagrams depicting the various landforms or components (see Table 9 in Appendix A, page 140). The Cormorant Lake project was evaluated in 1968 by resource specialists involved with the Canada Land Inventory program. The data were found to be quite useful in accelerating individual resource inventories. However it should be kept in mind that the evaluations were carried out by various resource specialists well acquainted with mapping procedure and mapping units. This data base provided guidance for further survey work in their particular fields and aided in the preselection of areas requiring additional survey effort.

Similarly, in the Churchill-Nelson Rivers Study report an attempt was made, through the description of landtypes and the inclusion of small segments of air photographs, to portray and convey some of the complexity and relationships of units mapped at a scale of 1:50 000.

It is difficult for two reasons to evaluate the usefulness of the ecosection maps of the NRIP survey in Manitoba for land planning and management. Firstly the term "useful for broad regional planning and management" was never defined adequately for the study team. Secondly, only limited use has been attempted of the data and it is such experiences in using the data that will provide the only true answer to the question about utility of this product.

A survey of foresters in Manitoba regarding their use of soil survey and NRIP information for forest management (Veldhuis, 1977) indicates a lack of awareness of the NRIP product as one of the reasons for not using the information. However, those familiar with the product thought the map scale and the kind of information provided would not help in management and planning and definitely would not reduce their reliance on forest inventory information (scale of maps is 1:16 000) as the base for their management decisions. Response from the foresters indicated that ecological land data would be of great value for forest management if available at the Ecosite level (map scale 1:20 000) and particularly if the map units were rated for properties such as potential and actual forest productivity, natural and artificial regeneration potential and problems, species selection, trafficability and effect of cutting practices.

It is concluded from the foregoing that forestry is one of the potential users of ecological survey data in Manitoba. However they require data at a level of abstraction not being collected in Manitoba as yet on a routine basis.

Recently some use of the data was made by delineating areas with certain agricultural potential based on climatic zone, drainage and texture related to landform (F. Piturá, personal communication). The information derived will be portrayed at a scale of 1:1000 000, which may indicate the kind of broad planning the information on the NRIP map may be used for. Although some assistance from survey personnel was required the agricultural background of the user allowed a rapid familiarization with the material at this scale.

Utility of the Ecodistrict Mapping Unit

The terrain described as an Ecodistrict is viewed either as a subdivision of an Ecoregion or an agglomeration of Ecosections. In Manitoba, ecodistricts were delineated with the aid of geological surficial deposit maps, topographic maps and the interpretation of small scale satellite images within areas thought to be climatically uniform. The ecodistrict boundaries were adjusted during the course of field studies and again after the compilation of the ecosection map.

In Manitoba, the ecodistricts are largely delineated on the basis of patterns in geology and geomorphology. The more recent proposed national definition (CCELC, 1979) lists vegetation, soils, water and fauna as differentiating criteria as well. Vegetation, soil and fauna characteristics result from climatic influence on the land surface. To delineate a district on the basis of vegetation is only correct if the vegetation characteristics are a result of particular physiographic conditions. If the vegetation differences between two districts are due to climatic parameters rather than physiographic ones, then the ecoregion delineation should be adjusted. Affinity between vegetation and physiographic characteristics were noted by Ritchie (1960b) in the Hayes River (54C) map sheet where vegetation pattern relates closely to the organic landforms covering most of the area.

Introduction of water characteristics (lakes, streams, drainage systems) appears to be a valid addition to the definition. Drainage systems, size, shape and frequence of lakes usually relate to physiography and so provides a valuable additional descriptor for the Ecodistrict. A few Ecodistricts shown on the NRIP maps may encompass a fairly narrow range of conditions which are not much different from ecosections (ie. organic dominated terrain in the Hudson Bay Lowland). More often, the ecodistrict delineations include a complex of landscapes such as morainal veneers and blankets, lacustrine veneers and blankets, all intimately distributed with organic deposits and rock outcrops. A general description of the range of conditions in a district is provided in the NRIP Guidebook for a particular map sheet area. The use of the district delineations is most appropriate at a very general level of planning. Detailed knowledge concerning an Ecodistrict is only gained by examining the constituent ecosections within the overriding climatic framework provided by the ecoregions. Analysis of this data permits the selection of districts with higher potential for particular uses over those which have little or none.

Utility of the Ecoregion Map Unit

As climate is the most important influence on biological processes and is to a large extent the critical, often limiting factor, in forest and agriculture production, the Ecoregion concept and its application is very important in ecological land classification.

The Ecoregion category as used in ecological land surveys in Manitoba describes map units which have the highest degree of ecologic unity in both taxonomic and cartographic terms. At this level of mapping aspects of the environment like soils and vegetation are placed in an overall climatic framework which permits the extrapolation of generalized growth data and capability ratings over large areas.

Because measured climatic data are often incomplete, and the influence of specific climatic properties on the environment is often not well known, it has become the practice to use other parameters such as soils and vegetation characteristics to help define the climatic regime over large land areas. Soils and vegetation are a direct function of climate but they do not necessarily reflect the influence of present day climatic parameters. Contemporary soil conditions in particular may be a reflection of climate of the past. Although vegetation and fauna may be more sensitive indicators of climatic differences than soil, this sensitivity is also a limitation in their use for describing ecoregions. As climate changes, threshold levels for physiological requirements may not be met for some plant species. Seeds may not ripen and growth may be stunted, resulting in floristic and structural changes in the vegetation. Gross vegetation characteristics (forest, grassland) are known to change slowly with climatic change. Nichols (1976) refers to the historical or relict nature of the present treeline in some areas. However the treeline is widely used to separate the forest tundra from the true tundra and climatic regions are based on this vegetation difference. Tikhomirov (1970) holds the view that forest limits are the most important biogeographical boundaries in the north, but what constitutes a forest or a tree needs clarification (Hustich, 1970). The term subarctic is often used to delineate the zone south of the treeline in ecological land classification. The subarctic is defined as the narrow or indeed very broad "ecotone" between the polar tree line and the boreal forest region proper, but according to Hustich (1979), Soviet scientists speak both of arctic and subarctic tundra. Their subarctic region includes treeless tundra as well.

It is clear that even in areas where there is apparent dramatic change in the vegetation the delineation of the Ecoregion is not easy. The problem is even more confounded by the use of terms that are similar but have different meanings (Löve, 1970; Hustich, 1979). It is obvious that South of the treeline the problem becomes even more complex because of the greater diversity of vegetation. Differentiation between open forest and closed forest (Ritchie, 1960a and b) is sometimes used as a criterion for delineating subarctic regions from boreal regions (Mills et al, (1977), although these terms are very subjective and their definitions vary among investigators.

Soils are known to respond relatively slowly to climatic change as is evident from degradation or Chernozemic soils under forest vegetation (Pettapiece, 1969). Permafrost occurs in areas where it is not in equilibrium with present climate conditions. Soils on the other hand are little affected by environmental disturbances as fire and therefore are in many areas a more permanent, but still environmentally sensitive, record of climatic parameters than vegetation. For those reasons soil and vegetation characteristics are used to help define regional climate.

In the Guidebooks produced by the NRIP it is stated that vegetation characteristics, trends in soil development and permafrost conditions are utilized "to provide more reliable criteria for the establishment of Land Regions than those based on meteorological data alone" (Mills, 1977, Veldhuis, 1979). This statement is very valid although Dansereau and Paré (1977) state: "It cannot be emphasized too strongly that meteorological data are the only proper direct expression of climate." Inferences from vegetation and soils with respect to the climatic factor often can, when used with careful judgement, provide a more reliable picture of climate and how it affects plant growth than can be obtained from a dense network of climatic stations. Only through the study of vegetation growth and ecosystem behaviour can the significance or relevance of climatic data to biological uses of the land be determined. However, to achieve full benefit of ecoregion delineations a correlation of inferred and measured climatic data must be attempted to improve the statements that can be made so far with respect to biological productivity and critical limits of climatic parameters. Hare (1950) delineated broad climatic zones on the basis of aerial photographs, observation flights across suspected zonal boundaries and some limited ground traverses. Correlation with climatic data suggested that northern forests are governed in their growth by temperature, and that precipitation was adequate throughout the area of study. His investigations also pointed to a correlation between zonal forest divisions and thermal efficiency (potential evapotranspiration).

Although the selection of criteria for delineation of climatically uniform regions is difficult, the rationale for the selected criteria and the inclusion of the ecoregion in the hierarchy is quite appropriate. The region is a very useful mapping unit in the ELS, because through its single overriding criterion, strong ecological implications are provided for data collected at lower levels in the hierarchy.

Data Flow in Land Resource Surveys

In this section three types of land resource surveys are compared in terms of data flow from the initial definition of a concrete land base to the creation of planning and management land units.

The Forest Inventory is an example of a single disciplinary type survey designed to provide data for one purpose and one user group. The data is collected to help foresters to make decisions with respect to area to be cut, allowable cut per management unit and areas to be protected from fire. The maps are simple and the user group has no problem understanding and using the information. The data is of little value in this form to other land resource data users. To enhance the information and to make it useful for other user groups requires resurvey of the areas utilizing on a new set of criteria. In Saskatchewan, forest inventory personnel initiated the classification of ecosystems for forest management in the Mixedwood Section (Kabzems et al, 1976). Data of this nature have a wider appeal than that of traditional forest inventories. However forest inventory data generated in Manitoba can be used to augment data collected in soil and land surveys through correlation of growth data with mapping units. A diagram of the data flow in a forest inventory is presented in Figure 10. The emphasis in the data collection is narrowly placed and the resulting planning unit has a strong single land resource bias.

Although the Soil Survey is usually classed with single disciplinary surveys, the data generated have been used by a number of different land resource data users like agriculturists, foresters, engineers and wildlife planners. Soils have strong ecological affinity to other components in the environment and the study of soil and its mapping is indirectly the study of other environmental parameters as well. As soils are the product of the interactions of a number of environmental attributes they form an important, if not essential criterion in the Ecological Land Classification at the lower levels of the hierarchy.

Therefore in ecological land resource surveys conducted at mapping scales of 1:125 000 and larger, the map units delineated often have strong resemblance to those that would be delineated on soil survey maps. The main difference between the two types of survey lies in the emphasis that is placed in the data presentation to include other landscape attributes. The map product is actually not much different from that of soil survey maps and reports (Jurdant et al, 1977a and b; Lavkulich, 1973). Vink (1975) states that the delineation of mapping units is based largely on the same criteria for both surveys when mapping similar terrain.

The ELS product of the NRIP bears a strong resemblance to a soil survey map based on the same data partly due to the strong representation of pedological expertise on the ecological land survey team. The data

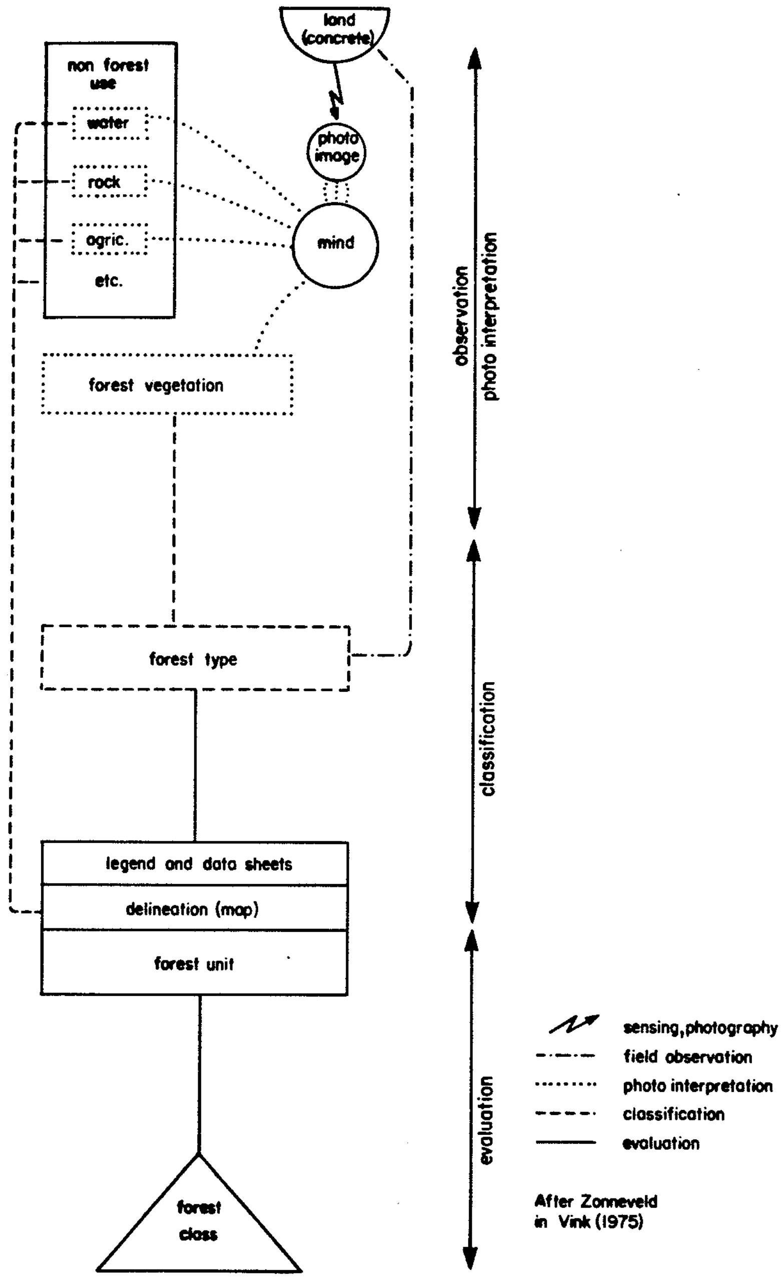


Figure 10. Diagram of Data Flow in Forest Inventory.

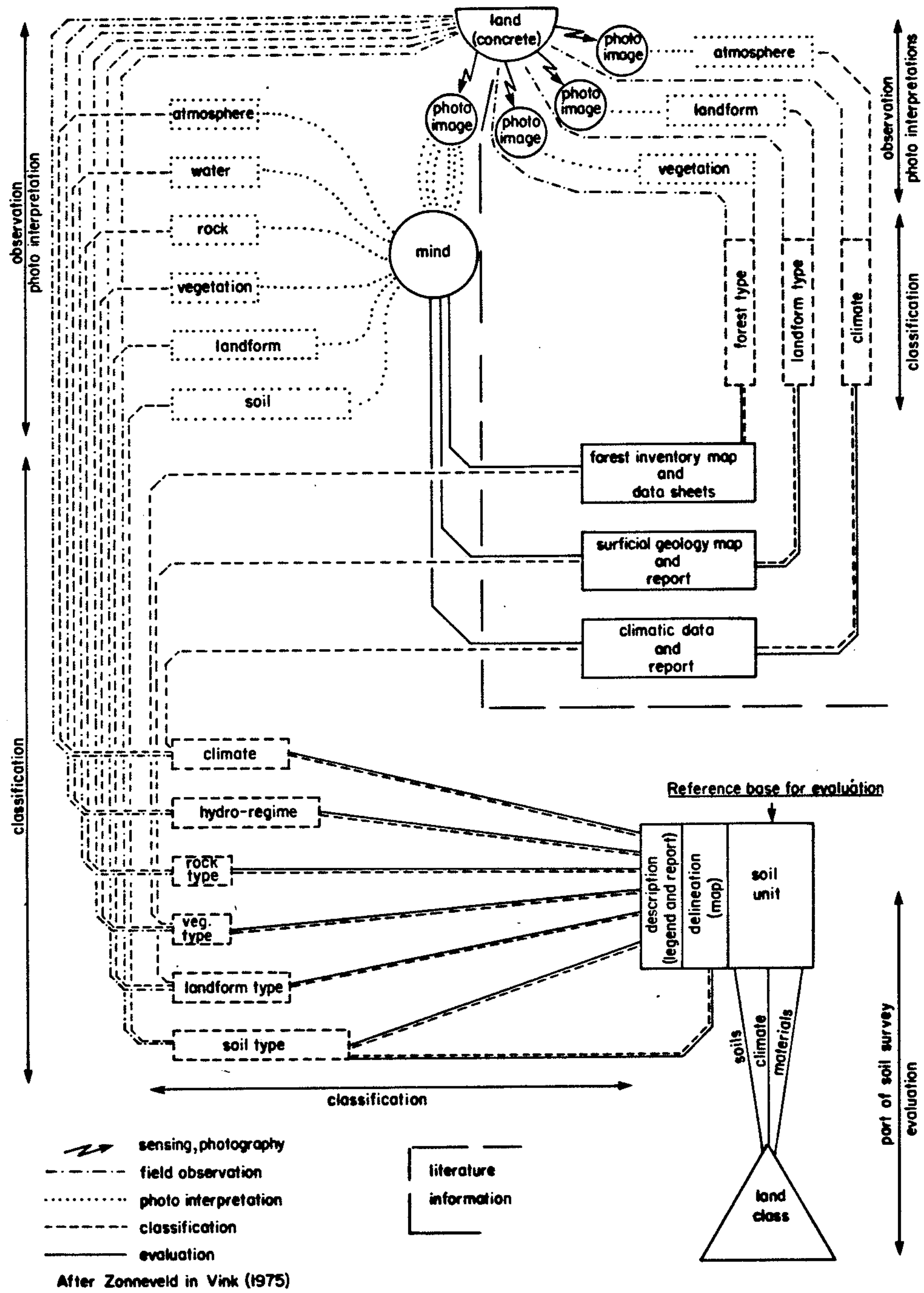


Figure 11. Diagram of Data Flow in Soil Survey.

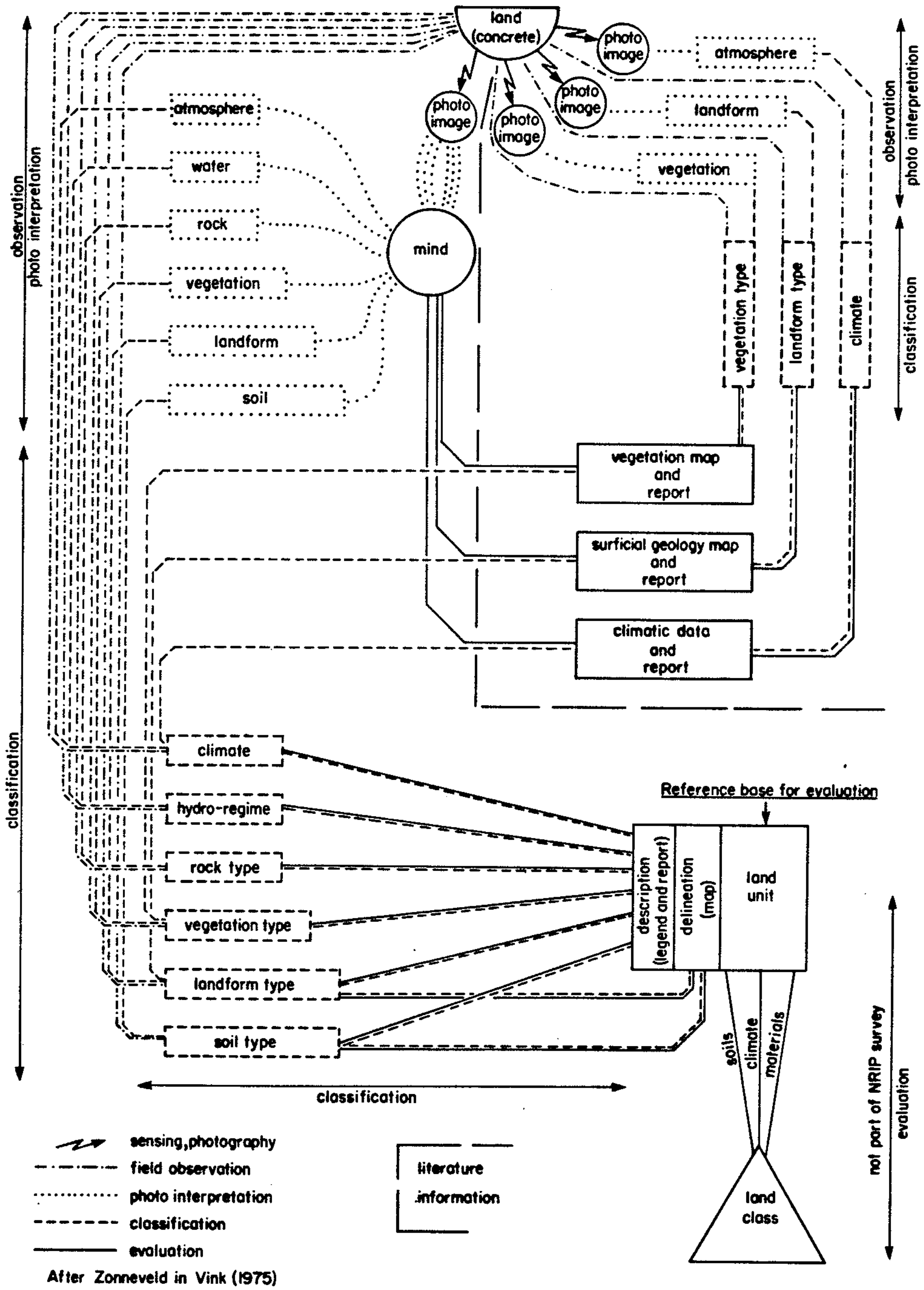


Figure 12. Diagram of Data Flow in Ecological Land Survey (NRIP)

flow for a soil survey and a NRIP survey are presented in Figures 11 and 12 respectively. In these diagrams, the difference in data flow appears to be more of degree rather than kind. In the NRIP the emphasis on various land resource components is slightly more balanced than in the soil survey, but in both surveys the main emphasis is placed on soils.

The diagrams also show that evaluation of the data for various uses is an integral part of soil survey but was not in the NRIP surveys.

Chapter 6

CONCLUSIONS

The application of the Ecological Land Survey approach in Manitoba is patterned after national guidelines developed for Canada, differing mainly in the greater emphasis given to the landform and soil portion of the environment as compared to that allocated to vegetation. The basic unit of classification is the ecosite having a very narrowly defined range of attributes important to land use. Ecosites are not shown as map units but serve mainly as building blocks for the ecosection map unit. Although ecosites approximate simple ecosystems their ecological integration as map units is not adequately shown at the Ecosection level of mapping. Available examples of ELS in Manitoba do provide in general terms a preliminary assessment of the land base for a number of specific purposes. The ELS in Manitoba was carried out at a reconnaissance scale primarily because of time and budgetary constraints.

The maps and descriptions generated by the Northern Resource Information Program did not achieve the degree of ecological integration that was expected. The reasons were the inability of the Ecological Land Classification System to portray ecological significant land units at all levels of abstraction and because of problems particular to the NRIP effort. The latter problems are related to the imbalance of expertise in the resource fields represented on the study team, especially with respect to phytosociology. This resulted in a data base showing strong bias towards information on landforms and soil. Also the scale of mapping (1:125 000) and the selection of the ecosection map unit as the basis for the portrayal of landscape data, precluded the delineation of units with a fair degree of ecological unity. Although data for individual components of the ecosection map unit are provided in the legend, the interrelationships are not conveyed to potential users of the data. However at the generalized Ecoregion level of mapping ecological relationships are more strongly portrayed. Broad ecoregion boundaries are superimposed on the ecosection map and provide a framework which has strong biological and climatic connotations. The addition of the ecoregion map units enhances the ecological significance of the survey maps. Ecodistricts map units are superimposed on the ecosection maps by agglomeration of the ecosections based mainly on physiographic and surficial material properties, providing a very broad level for land use planning.

Although the NRIP did not generate land resource data of the kind anticipated, it did produce large volumes of landform, soil, permafrost and, to a limited extent, vegetation data for extensive areas of northern and central Manitoba. The level of detail provided by this data base was not previously available and much experience was gained in conducting and planning this type of survey.

The usefulness of the NRIP data could not be ascertained in any detail, because of insufficient user response to the program. Nevertheless, an integrated data base, even if only based to a limited degree on ecological criteria, is potentially a very valuable tool to the collective user group of land managers and planners. Evaluations of other ELS's, eg. the Cormorant Lake Project in northern Manitoba and the James Bay Project in Quebec, indicate that the usefulness of the data base will only be fully realized if the data is interpreted by means of reliable interpretation keys developed in cooperation with various land resource specialists.

The evaluation of the ELS as applied in the NRIP in Manitoba indicate that a greater effort is required, particularly in the related vegetation and ecosystem classifications, to produce a more integrated ecological land survey. It also shows that more effort is needed in the formulation of objectives for the surveys, and in the development of descriptions and interpretations of data for various uses. The expansion of the information package should greatly increase the usefulness of the data base for land resource use and management even if greater degree of ecological integration is not achieved.

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Appendix A

MAP AND LEGEND EXAMPLES OF ECOLOGICAL LAND SURVEYS IN MANITOBA

CORMORANT LAKE PROJECT DATA PRESENTATION (After Zoltai et al, 1969)

Land Region (Ecoregion)

Boreal, moist subhumid Land region

Regional vegetation on gently sloping loam is trembling aspen, white spruce and black spruce. Black spruce occupies wet depressions and moist lower slopes. Jack pine is common on sand and on bare bedrock. A few palsas, peat plateaus with permafrost and collapsed palsas occur on fibric organic materials.

Land District (Ecodistrict)

Namew Lake Land District: characterized by low relief till plain, with flat, low dolomite plateaus, small lacustrine clay plains and peat plains occur in flats.

Landscape Unit

Chocolate Landscape Unit: weakly to very weakly broken area of loamy till and clay till, with shallow loamy till over bedrock on some low plateaus and deep lacustrine clay in some flats. Peat plains occur in some depressions.

Landsystems composing the land portion of this landscape unit are: ML-P; ML-P45; ML-65; ML-76.

Lakes cover four per cent of the area. Lakes of various size classes

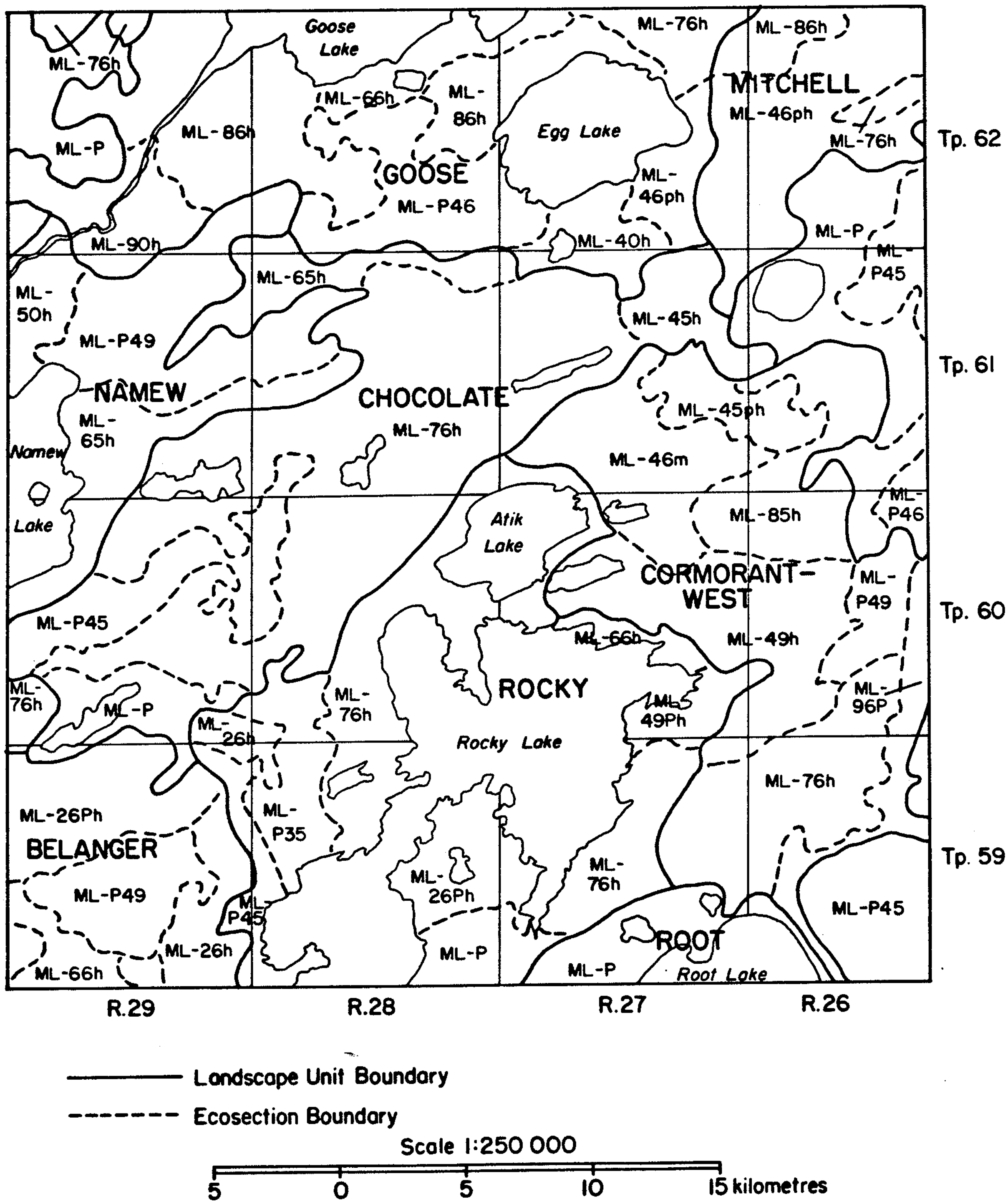
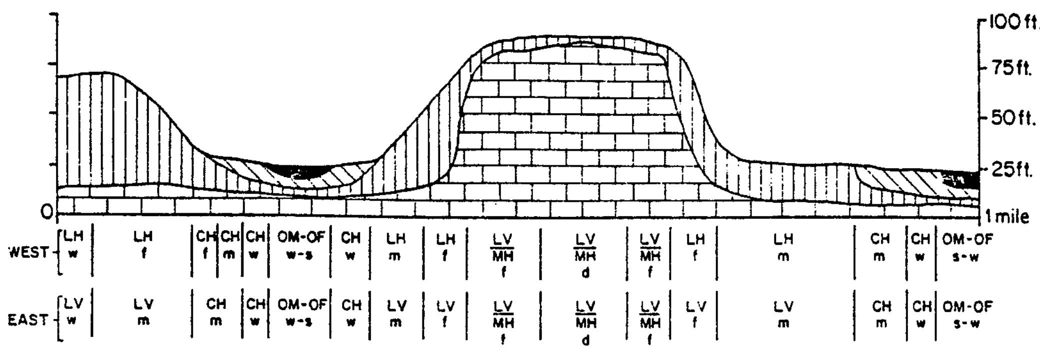


Figure 13. Map Sample of Cormorant Lake Project (scale 1:250 000)

Table 9. Data Presentation for Land Systems (Ecosections) (From Zoltai et al, 1969)
Landsystem ML-76
Weakly broken areas of deep highly calcareous loamy till (ML-76h) or very highly calcareous loamy till (ML-76v), with plateaus of shallow, very highly calcareous loamy till over dolomitic bedrock. Deep highly calcareous clay occurs in flats. Minor areas of shallow to deep mesic to fibric peat in some depressions.

Example:



Land Type					Soil	Stable vegetation	Common Present Vegetation	Forest Capability
Material			% Area					
Symbol	Geologic Material	Moisture	W	E				
LV/MH d	Very highly calcareous loamy till over dolomitic bedrock	dry	10	10	Atikameg rock substrate phase	bS	jP	6RM
LV/MH f	As above	fresh	15	15	Atikameg rock substrate phase	tA,bS,wS	tA,bS;jP	5R
LV f	Very highly calcareous loamy till	fresh	-	10	Atikameg	tA,bS,wS	tA,bS;jP	5ML
LV m	As above	moist	-	25	Chitek	tA,wS,bPo	tA,bS;bS	5L
LV w	As above	wet	-	5	Dering	bPo,bS,wS	bS	6W
LH f	Highly calcareous loamy till	fresh	25	-	Atikameg Westray	tA,bS,wS	tA,bS;jP	4
LH m	As above	moist	10	-	Chitek	tA,wS,bPo	tA,bS;jP	4
LH w	As above	wet	5	-	Dering	bPo,bS,wS	bS	5W
CH f	Highly calcareous lacustrine clay or clay till	fresh	5	-	Wabowden Sipiwesk, Cedar Lake, Wanless	tA,wS	tA,bS, jP	4
CH m	As above	moist	10	15	Roe Lake Dyce	tA,wS,bPo	tA,bS;bs	4
Ch w	Highly calcareous lacustrine clay	wet	10	10	La Perouse Medard	bPo,bS,wS	bS	5W (W) 6W (E)
OM-OF w-s	Mesic to fibric organic matter	wet to satur.	10	10	Chocolate Hargrave, Moose Lake	Carex, bS	Carex, bS	7W

occupy the following proportions of the landscape unit:

Relatively small lakes: 2%

Small lakes: 2%

The lakes have regular to somewhat irregular shorelines. All lakes are shallow. The shore material is mainly organic matter, or, less frequently, bouldery till the lakes are without open outlets, draining through bogs.

Note: Landscape units are identified by a name. The land systems are identified by a code, the first part identifying the broad physiographic province (ML-Manitoba Lowlands; CS-Canadian Shield). The numerals in the second part refer to particular combinations of geologic materials and relief classes (Zoltai, 1968; also in Beke et al, 1973, map legend). The letter 'P' indicates the presence of organic material modifying the mineral soil land. Placed before the numeral, it shows dominance of the peat, but following the numeral, it indicates that although the peat occupies large areas, it is not dominant. A lower case letter following the numeral indicates the petrography of the dominant mineral soil.

CHURCHILL-NELSON RIVERS STUDY
DATA PRESENTATION

Boreal Land Region(3): Regional vegetation on gently sloping, medium and fine textured materials in closed black spruce forest with a continuous ground cover of mosses. White spruce and trembling aspen are restricted to lake shores and river courses. Jack pine occupies sand plains and bedrock outcrops. Localized permafrost in mineral materials; but discontinuous occurrence of wooded palsas and peat plateaux with permafrost in organic materials.

Mystery Lake Land District(MY): An area of moderate relief, characterized by gently undulating to gently rolling lacustrine deposits and undulating to rolling glacio-fluvial materials. Precambrian bedrock outcrops occur infrequently. Organic accumulations of varying thickness overlay the lacustrine deposits. Permafrost occurs discontinuously in the peat accumulations and less extensively in the mineral deposits.

Landsystems: 40 xh - FB9 and 40 xh - 80 kh

Legend

Topographic class and surficial materials
40: weakly broken terrain with deep and shallow (with some bare) clay, with silt, loam and/or sand
80: moderately broken terrain with deep and shallow (with some bare) clay, with silt, loam and/or sand
Landform:
B: bog
F: fen
Modifiers
h: highly calcareous, free carbonates within 15 to 70 cm of the soil surface
k. localized permafrost, less than 15% permafrost in landform component
x: discontinuous permafrost, between 15 and 50% permafrost in landform component

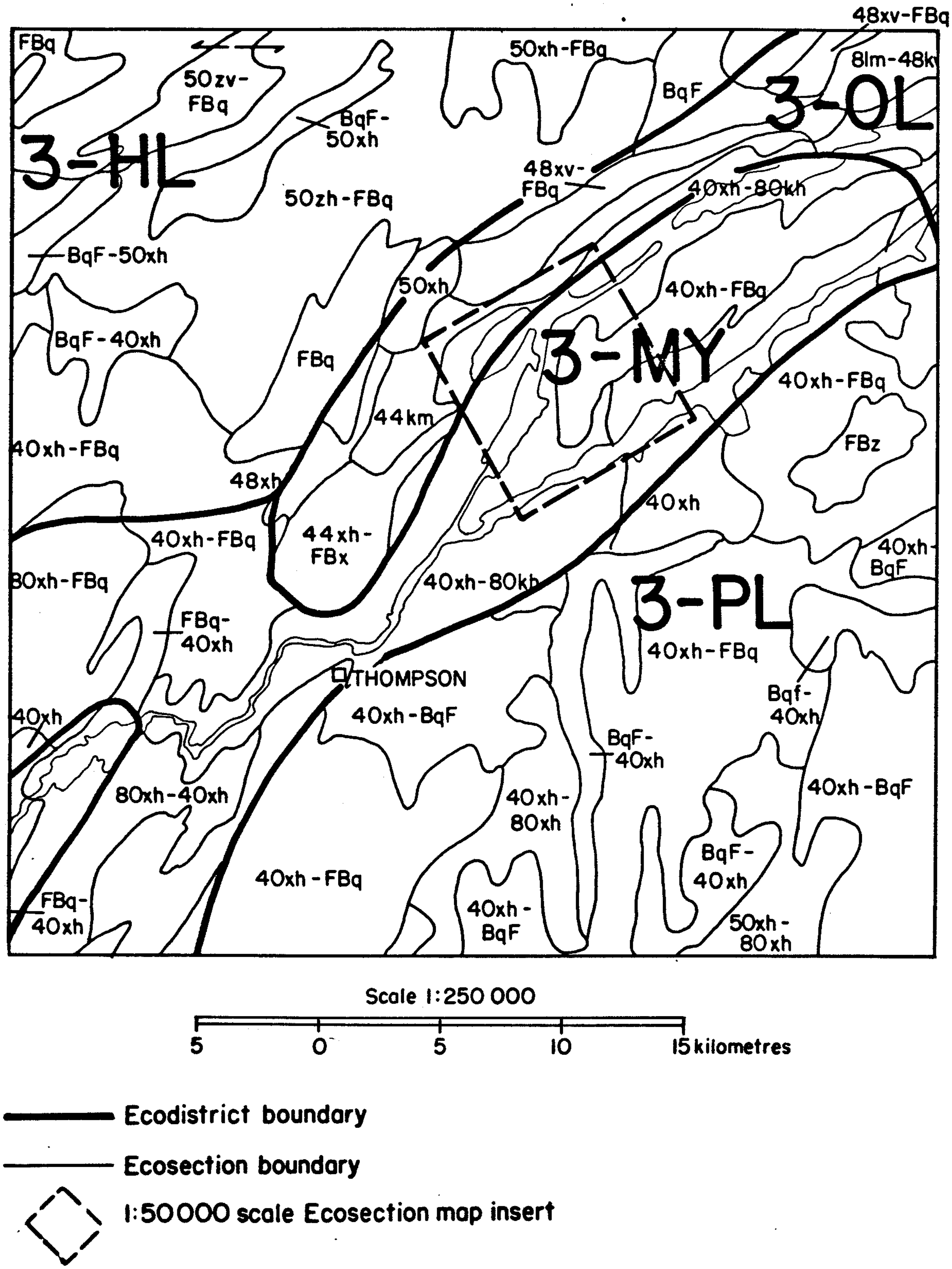


Figure 14. Map Sample of Churchill-Nelson Rivers Study (scale 1:250 000)

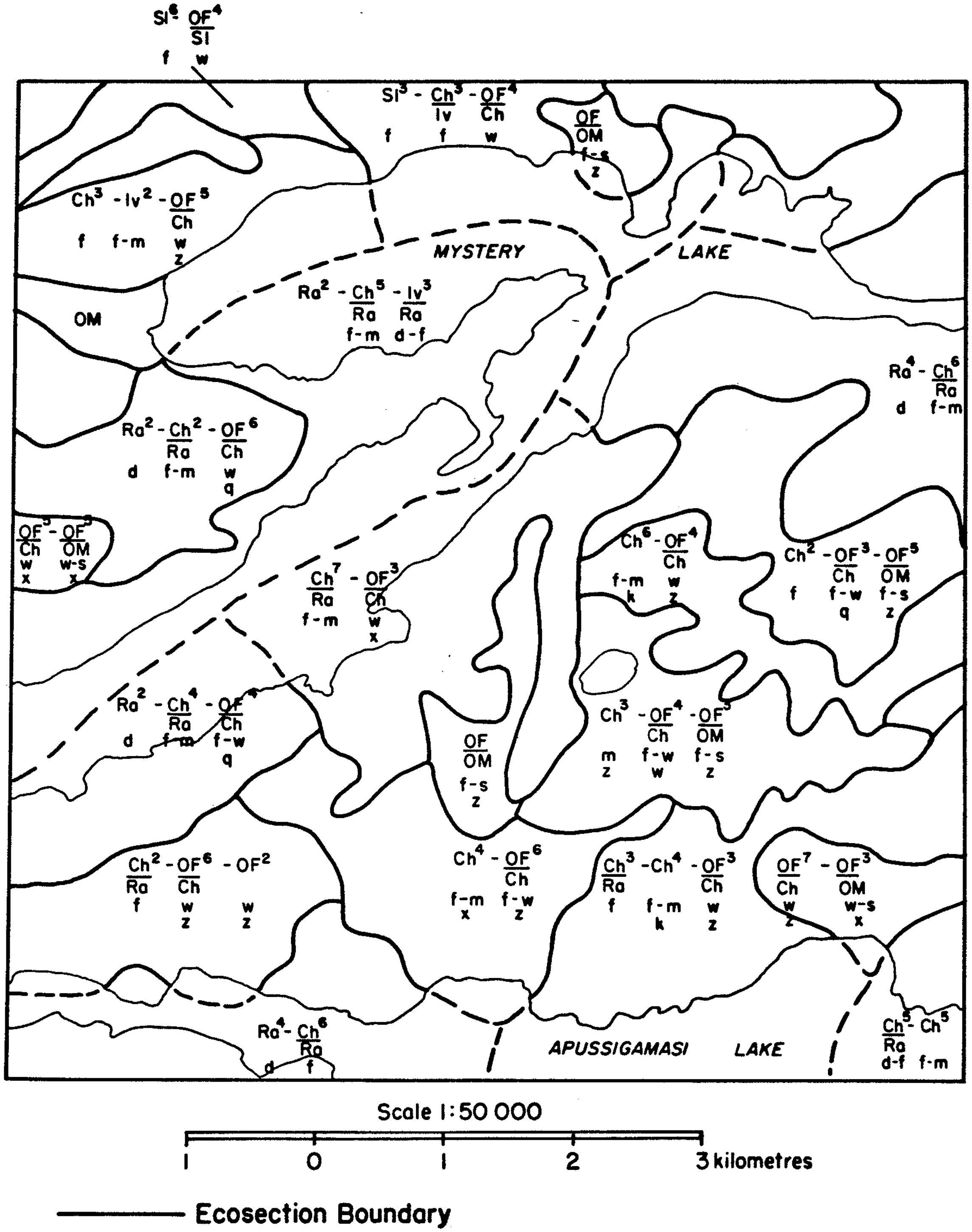


Figure 15. Map Sample of Churchill-Nelson Rivers Study (scale 1:50 000)

Table 10. Legend for 1:50 000 scale Map, Churchill-Nelson Rivers Study (After Beke *et al*, 1973)

Landtypes: $\frac{Ra^{4}}{d} - \frac{Ch^{6}/Ra}{f\text{-}m}$ and $\frac{Ch^{6}}{f\text{-}m\ k} - \frac{OF^{4}/Ch}{w\ z}$

Land Type			Soil	Stable vegetation
Material		Moisture		
Symbol	Geologic Material			
Ch f	Highly calcareous lacustrine clay or clay till	fresh	Solodic Gray Luvisol (Wabowden)*	tA,wS,bS
Ch/Ra f	Highly calcareous lacustrine clay or clay till over granitic bedrock	fresh	Solodic Gray Luvisol	tA,wS
Ch m	Highly calcareous lacustrine clay or clay till	moist	Gleyed Solodic Gray, Luvisol	tA,bS,wS
OF/Ch w	Fibric organic matter over highly calcareous lacustrine clay or clay till	wet	[Peaty] Rego Gleysol (Medard)	bS,bPo
Ra	Granitic bedrock	dry	nil	jP

Symbol	Description
k	Less than 15 per cent permafrost
x	Greater than 15 per cent but less than 50 per cent permafrost
z	Greater than 50 per cent permafrost.

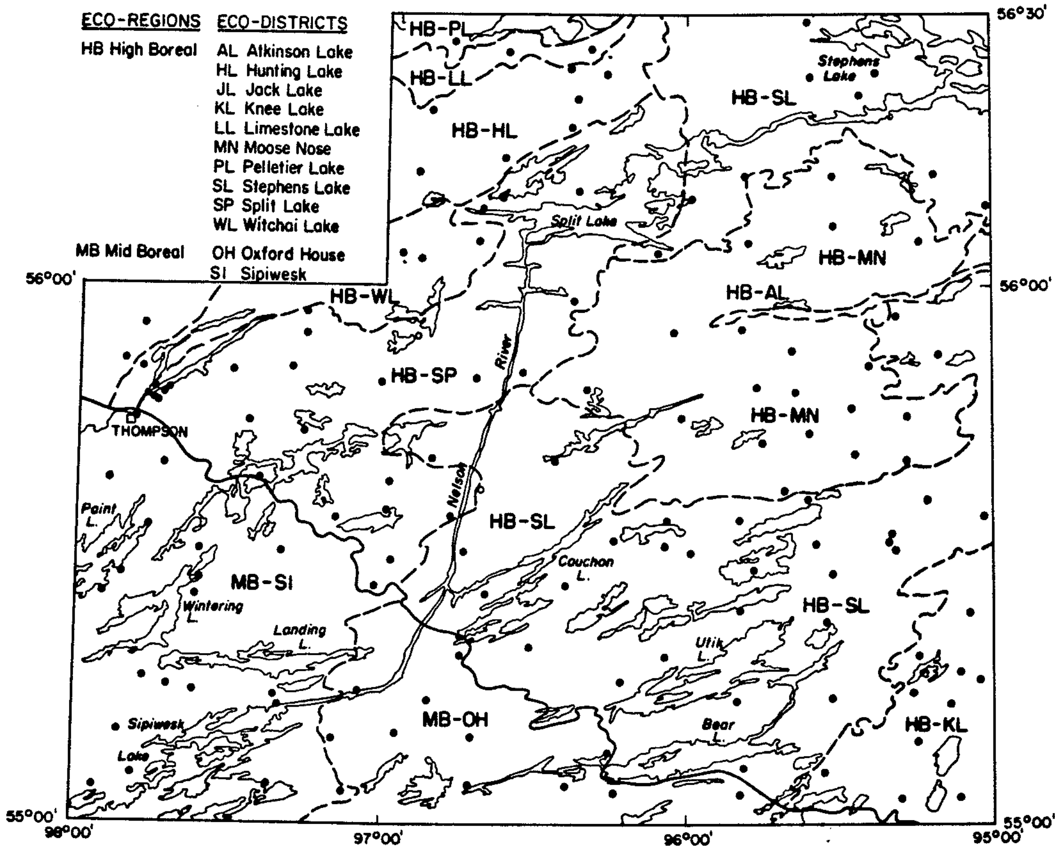


Figure 16. Map of Selected Study Area with Site Inspection Locations

Table 11. Selected Biophysical (Ecological) Characteristics of Land Regions (Ecoregions) in Northern, Central and Eastern Manitoba

Land Region		Physiographic Area	Dominant Vegetation Types					
			Normal Facies		Wet Facies			
Symbol	Name		Warmer-drier (south slopes, sand)	Normal-mesic (level-moderate slopes)	Cooler-wetter (north slopes, bottom lands)	Impeded drainage (sloughs, kettles, marshes, organic plains)	Lakeshore	Alluvial (streamside)
HS	High Sub-arctic	Hudson Bay Lowland	Lichen tundra	Lichen tundra-heath	Lichen-moss tundra	Lichen heath palsas and polygonal peat plateaus/sedge cottongrass fens	Sedge-grass meadow/larch-birch^{d} fens/willow	Willow-birch^{d}-alder scrub
		Canadian Shield	Heath tundra-lichens-spruce^{b}	Heath tundra-lichens-birch^{d}	Willow-heath tundra	Lichen heath palsas and polygonal peat plateaus/sedge cottongrass fens	Rush-sedge meadows	Spruce^{w}/willow birch^{d}-alder scrub
LS	Low Sub-arctic	Hudson Bay Lowland	Spruce^{w} (jackpine)	Open spruce^{b}-lichen-mosses	Spruce^{b}-lichen-larch-mosses	Open spruce^{b}-lichen-moss on palsas and peat plateau/sedge-larch fens	Rush-grass meadow/willow-alder	Spruce^{w}-poplar^{b}/willow-birch^{d}-alder scrub
		Canadian Shield	Spruce^{w} (jackpine)	Open spruce^{b}-lichens	Open spruce^{b}-lichen moss	Spruce^{b}-larch bogs/spruce^{b}-lichen-moss peat plateau and palsa/sedge-larch cottongrass fens	Sedge meadow	Spruce^{w}/willow-birch^{d}-alder
HB	High Boreal	Hudson Bay Lowland	Spruce^{b} (jackpine, poplar^{w})	Spruce^{b}-mosses (jackpine)	Spruce^{b}-mosses	Spruce^{b}-larch sphagnum bogs/spruce^{b}-lichen-moss peat plateau/sedge-larch-birch^{d} fens	Sedge meadow	Spruce^{w}/willow birch^{d}/alder
		Canadian Shield	Spruce^{b} (jackpine, poplar^{w}, birch^{w})	Spruce^{b} (jackpine, poplar^{w}, birch^{w})	Spruce^{b}-mosses	Spruce^{b}-larch-sphagnum bogs/spruce^{b}-lichen-moss peat plateau/sedge-larch-birch^{d} fens	Sedge meadow	Spruce^{w}/willow birch^{d}-alder
MB	Mid Boreal	Canadian Shield	Open spruce^{w}-fir^{b}-poplar^{w} (jackpine)	Spruce^{b}-fir^{b}-mosses	Spruce^{b}-mosses	Spruce^{b}-larch-moss bogs (bog veneer, plateau bogs, sloping bog, patterned fen) Spruce^{b}-birch^{w} palsas and peat plateau	Rush-sedge meadow	Sedge-grass meadow
LB	Low Boreal	Canadian Shield	Jackpine (poplar^{w}) (birch^{w})	Spruce^{w}-poplar^{w} (fir^{b}) (birch^{w})	Spruce^{b}-poplar^{w}	Spruce^{b}-larch bogs/sedge-larch fens	Sedge-rush meadow	Spruce^{w}-poplar^{b}
HBt	High Boreal-temperate	Canadian Shield	Jackpine (poplar^{w}) (birch^{w})	Spruce^{w}-poplar^{w} (fir^{b}) (birch^{w})	Spruce^{b}-poplar^{w}	Spruce^{b}-larch bogs/spruce-cedar bogs	Sedge-rush meadow	Spruce^{w}-poplar^{b}-ash^{g}

- = associated species or groups of plants / = different communities in same region (= successional communities

DOMINANT PLANT SPECIES

Common Name	Symbol	Scientific Name
Alder		Alnus crispa
Ash, green	ash^{g}	Fraxinus pennsylvanica
Birch, Dwarf	birch^{d}	Betula glandulosa
Birch, White or Paper	birch^{w}	Betula papyrifera
Cedar, white	cedar	Thuja occidentalis
Cottongrass		Eriophorum spp.
Heath	He	Various ericaceous shrubs, including species of Vaccinium, Arctostaphylos, & Kalmia
Fir	fir^{b}	Abies balsamifera
Larch		Larix laricina

DOMINANT PLANT SPECIES

Common Name	Symbol	Scientific Name
Lichens		Many species
Mosses		Many species
Pine, Jack	pine^{j}	Pinus banksiana
Poplar, Balsam	poplar^{b}	Populus balsamifera
Poplar, white (aspen)	poplar^{w}	Populus tremuloides
Sphagnum		Sphagnum spp.
Spruce, Black	spruce^{b}	Picea mariana
Spruce, White	spruce^{w}	Picea glauca
Willow		Salix spp.

* after S.C. Zoltai, unpublished manuscript.

Table 12. Climatic Characteristics of Land Regions (Ecoregions) in Northern, Central and Eastern Manitoba.

Land Region		Mean Temperature, °C			Degree Days 5.5°C May 1- Sept. 30	Frost Free Days	Precipitation, mm		Soil Moisture Deficit, mm
Sym-bol	Name	Ann.	Jan.	July			Ann.	May 1- Sept. 30	
HS	High Sub-arctic	<-6.6	<-26.1	<16.0	500	60 to 75	340 to 450	210 to 270	10 to 20
LS	Low Sub-arctic	-6.6 to -4.9	-29.1 to -27.5	14.1 to 14.6	500 to 700	70 to 80	415 to 560	265 to 360	20 to 40
HB	High Boreal	-4.9 to -3.9	-27.5 to -26.3	14.6 to 15.8	700 to 900	80 to 90	415 to 560	265 to 360	20 to 60
MB	Mid Boreal	-3.9 to -1.1	-26.4 to -21.8	15.1 to 18.3	900 to 1250	90 to 100	420 to 555	260 to 350	50 to 75
LB	Low Boreal	-1.0 to 1.7	-22.8 to -19.8	18.0 to 19.5	1300 to 1445	100 to 116	410 to 535	250 to 355	25 to 75
HBt	High Boreal-temper-ate	<2.0	<17.1	<19.7	1330 to 1600	100 to 120	410 to 575	250 to 385	75 to 185

References:

1. Temperature and Precipitation normals, 1941-1970, Vol. 1 & 2. Atmospheric Environment Service, Environment Canada.

2. Frost Data, 1941-1970 by G.M. Hemmerick and G.R. Kendall. Atmospheric Environment Service, Environment Canada.

3. Economic Atlas of Manitoba (1960). T.R. Weir (Ed.), Manitoba Dept. of Industry and Commerce.

Table 13. Vegetation Characteristics of Land Regions (Ecoregions) in Northern, Central and Eastern Manitoba

Land Region		Vegetation Zone[1]	Dominant Soils[2]	Organic Landforms	Permafrost Characteristics		
Symbol	Name				Regime[3]	Occurrence and Active Layer, cm	Pattern Ground and Degree of Disturbance
HS	High Subarctic	Forest-tundra transition	Turbic Cryosol Brunisols Organic Cryosol	Peat plateaus, palsas, minerotrophic palsas, peat polygons, fens	Continuous	Mineral soils: sand, non-frozen; loam, 40-100+ Organic soils: forest peat 40-60, fen peat, non-frozen	Hummocks, sorted polygons, circles, stripes, nets; very active on all materials in all landscape positions except well drained sands
LS	Low Subarctic	Open coniferous forest	Brunisols, Luvisols Turbic Cryosol Organic Cryosol Organic	Peat plateaus, palsas, bog veneer, fens	Discontinuous, widespread	Mineral soils: sand, non-frozen; loam, 40-100+; clay 30-100+ Organic soils: forest peat, 40-60, fen peat, non-frozen	Hummocks & mounds, very active in poorly drained depressions & lower slopes; scattered mounding and broad depressions on upper & mid slopes; all materials except sands
HB	High Boreal	Closed coniferous forest	Brunisols, Luvisols Turbic and Static Cryosol Organic Cryosol Organic	Peat plateaus, palsas, bog veneers, fens	Discontinuous, southern fringe, (north)	Mineral soils: sand, loam & clay, non-frozen except for poorly drained loam & clay, 40-100+ Organic soils: forest peat, 40-60, fen peat, non-frozen	Some hummocks and mounds in poorly drained depressions & lower slopes; apex & upper slope generally free of cryoturbation
MB	Mid Boreal	Closed coniferous forest	Luvisols, Brunisols Organic Cryosol Organic Static Cryosol	Peat plateaus, palsas, bog veneers, bog plateaus, blanket bog, fen	Discontinuous, southern fringe (south)	Mineral soils: non-frozen except for poorly drained clay, 60-100+ Organic soils: forest peat, 60-200, fen peat, non-frozen	Minor occurrence of mounds in depressions and on lower slopes
LB	Low Boreal	Mixed deciduous-coniferous forest	Brunisols, Luvisols, Gleysols, Organic	Bog plateau, flat bog, blanket bog, fens	Localized	Mineral soils: non-frozen Organic soils: non-frozen except for local occurrence of relict frost at 100-200 cm in forest peat	Absent
HBt	High Boreal-temperate	Mixed deciduous-coniferous forest	Luvisols, Brunisols, Gleysols, Organic	Bog plateau, flat bog, blanket bog, fens, swamps	Absent	Absent	Absent

[1] Rowe, J.S. 1972. Forest Regions of Canada, Department of the Environment, Canadian Forestry Service, Publ. No. 1300.
Ritchie, J.C. 1962. A Geobotanical Survey of Northern Manitoba, Arctic Institute of Northern Manitoba, Technical Paper No. 9.

[2] The System of Soil Classification for Canada. 1978. In press. Canada Department of Agriculture.

[3] Brown, R.J.E. 1967b. "Permafrost in Canada" map Publ. by Div. of Bldg. Res., Nat. Res. Council (NRC 9769) and Geol. Surv. of Can. (Map 1246A).

Table 14. Split Lake Land District (Ecodistrict) Physiographic, Soil and Hydrologic Characteristics (After Veldhuis, et al, 1979).

Land District		Physiographic Characteristics			Soil Characteristics			Drainage & Hydrologic Characteristics	
Symbol	Name	Elevation m a.s.l	Surficial Deposits	Topography and Landforms	Soil Association or Complex	Dominant Sub-Group	Subdominant sub-Group	Soil Drainage	Hydrology*
SP	Split Lake	170-215	Deep (> 1m) to shallow (< 1m) calcareous, clay textured lacustrine sediments overlying Precambrain bedrock.	Gently to moderately undulating lacustrine blankets and	Arnot Siding	Solonetzic Gray Luvisol	Gleyed Solonetzic Gray Luvisol	Well to imperfect	Many small to medium sized oval and rounded lakes with smooth shorelines. Several large lakes with irregular, bedrock controlled shorelines.
				Lacustrine veneers	Split Lake	Solonetzic Gray Luvisol, lithic phase	Gleyed Solonetzic Gray Luvisol, lithic phase	Well to imperfect	Except for areas adjacent to large lakes and rivers, the district is poorly drained. Drainage from the district is via the Nelson River.
			Widespread shallow to deep organic deposits.	Gently sloping thin (< 1m) bog veneer on lower slopes underlain by clayey lacustrine sediments.	Isset Lake Complex	Terric Mesic Organic Cryosol	Terric Fibric Mesisol	Poor	Major Drainage Divisions:
				Level to depressional peatlands characterized by peat plateaus and	Crying Lake Complex	Terric Mesic Organic Cryosol	Terric Fibric Organic Cryosol	Imperfect to poor	Gull Lake (5UF) Arnot (5UE) Grass River, lower (5TD) Burntwood River, lower (5TG)
				Horizontal and patterned fen complexes.	achiewin Complex	Typic Mesisol	Typic Mesisol, sphagnic phase	Very poor	Drainage Direction: Northeasterly within the Nelson River Watershed
			Minor Precambrian bedrock outcrops.	Local occurrences of hummocky and ridged rock outcrops associated with thin, discontinuous veneers of clayey lacustrine sediments.	Carriere Complex	Orthic Gray Luvisol, lithic phase	Gleyed Gray Luvisol, lithic phase	Very well to poor	

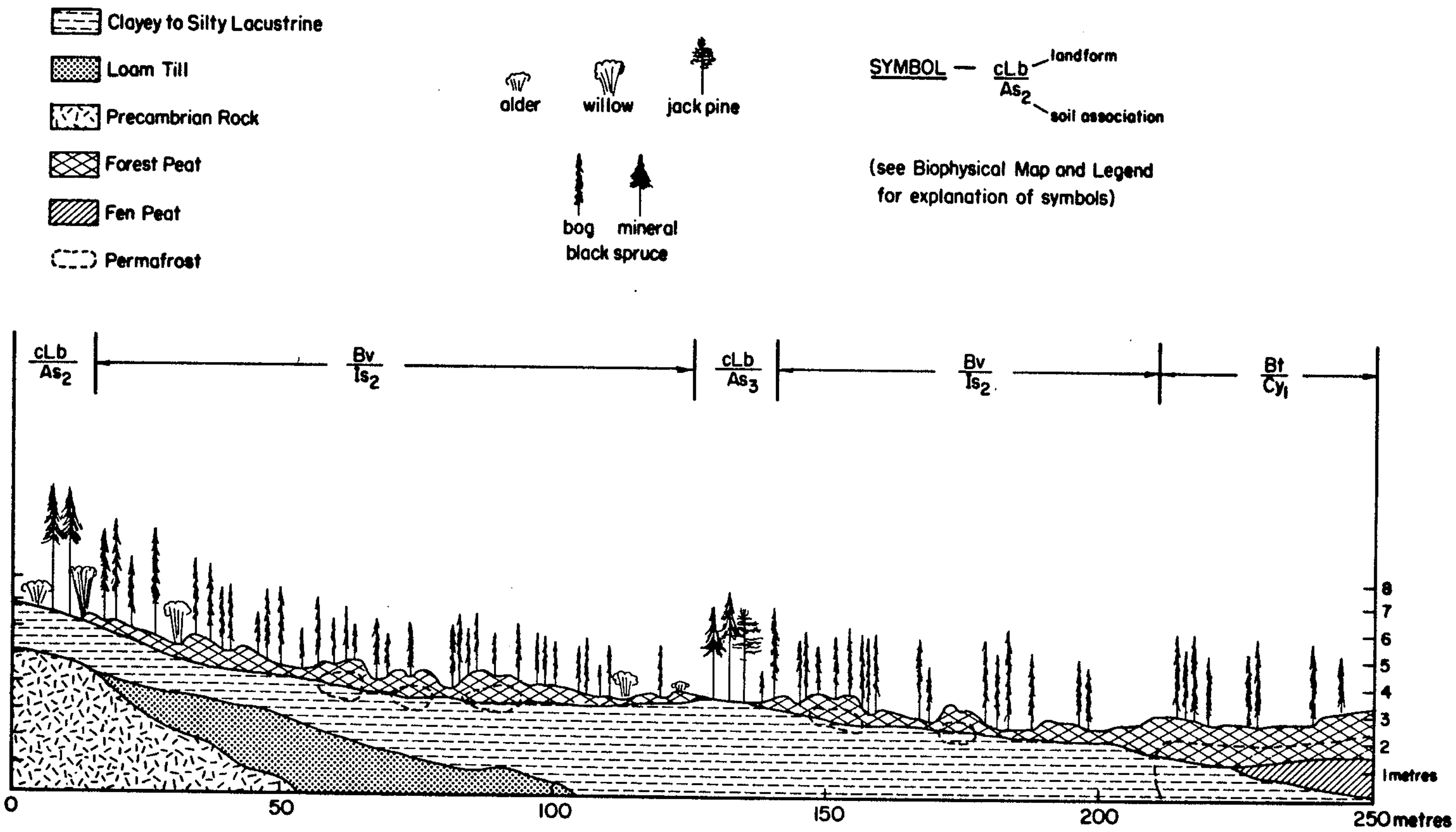


Figure 17. Cross-sectional Diagram of a Bog Veneer Area in the High Boreal Ecoregion (After Veldhuis et al, 1979).

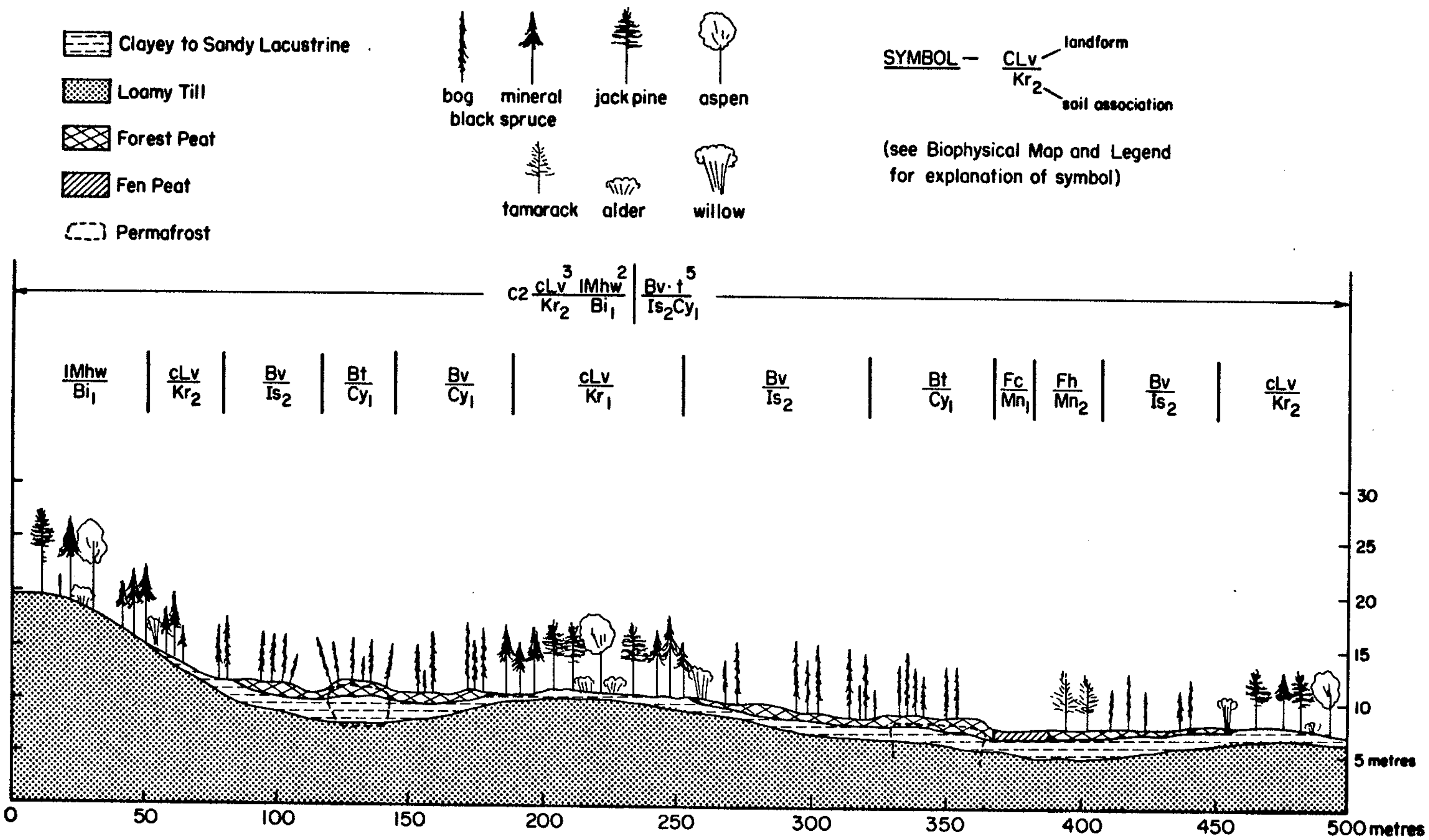


Figure 18. Cross-sectional Diagram of Portion of Hummocky Moraine with Clayey Lacustrine Veneers, Bog Veneers, Peat Plateaus and Fens in the Stephens Lake Ecodistrict (After Veldhuis et al, 1979).

Appendix B

ECOSECTION DESCRIPTIONS

1. Arnot Siding (AS) Ecosection

Ecoregion: High Boreal (HB) see Tables 11, 12 and 13 (page 147 to 149).

Ecodistrict: Split Lake (SP) see Table 14 (page 150).

The Arnot Siding Ecosection is composed dominantly of gently sloping to undulating, deep, glacio-lacustrine blankets. These sediments consist of varved clays and silts which are moderately to strongly calcareous. Associated with the uplands are varying proportions of bogveneers on very gentle to gentle lower slopes and some peat plateaus and collapsescars in deeper, peat filled depressions. Proportions of well, imperfectly and poorly drained sites depends largely on the slope of the terrain. The soils and vegetation belong respectively to the Arnot Siding soil association (As) and Arnot Siding vegetation association (Asv) respectively.

Well Drained Ecosites

Soils: The soils are dominantly Solonetzic Gray Luvisols and Orthic Gray Luvisol soils.

Vegetation: The vegetation consists dominantly of four general types:

- Populus tremuloides - Alnus crispa type
- Pinus banksiana - Alnus crispa - Cornus canadensis type
- Picea mariana - Pinus banksiana - Hypnum type
- Picea mariana - Hypnum type.

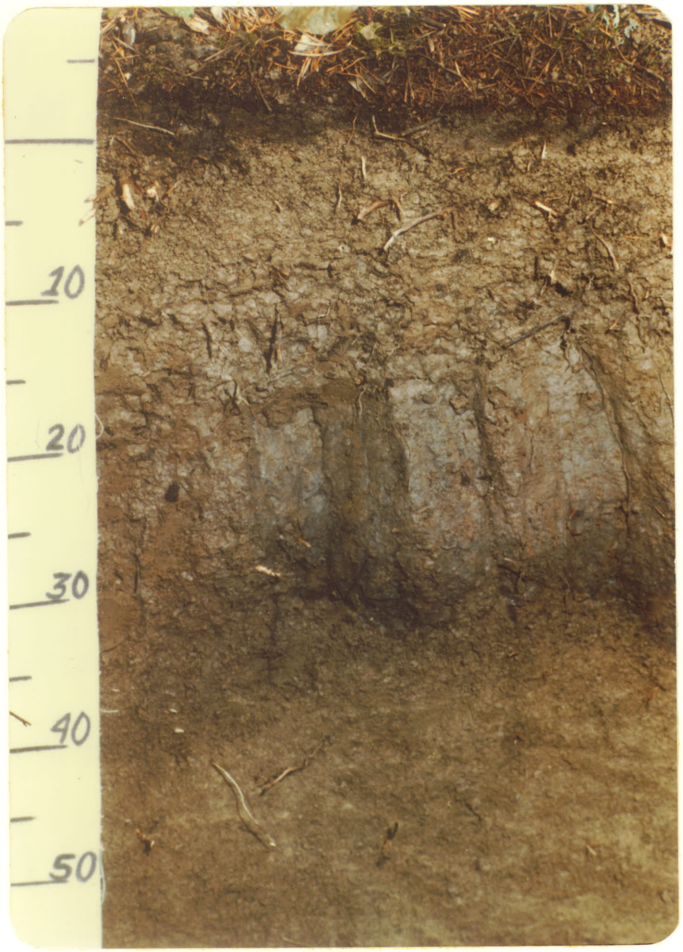


Plate I. ARNOT SIDING SOIL ASSOCIATION, SOLONETZIC GRAY LUVISOL SOIL.

Plate II. ARNOT SIDING VEGETATION ASSOCIATION, PICEA MARIANA - HYPNUM TYPE.

Imperfectly Drained Ecosites

Soils: The soils are dominantly Gleyed Solonetzic Gray Luvisol and Gleyed Gray Luvisol soils.

Vegetation: The vegetation is dominated by two general types

Populus tremuloides - Alnus rugosa type

Pices mariana - Ledum groenlandicum - Hypnum type.

Poorly drained Ecosites

Soils: dominantly Orthic Gleysol, peaty phase, soils and Rego Gleysol, peaty phase, soils and locally Gleysolic Static Cryosol, peaty phase, soils.

Vegetation: dominantly of one type, resembling very much the vegetation on bog veneers

Picea mariana - Ledum groenlandicum - Sphagnum type

Arnot Siding Soil Association (As), Well Drained Associate

The well drained member of the Arnot Siding soil association consists most often of moderately well to well drained Solonetzic Gray Luvisol soils developed on deep (>100 cm), moderately to strongly calcareous, fine textured lacustrine sediments. The surface texture is clay and the subsoil may contain varying proportions of very thin to thin silt varves in the clayey matrix. These soils occur on the apex and upper to mid slope position in gently to moderately sloping to rolling terrain. Surface runoff is moderate, but internal soil permeability is low, particularly in the more massive subsoil.

The solum of the Arnot Siding soils is shallow to moderately deep, leached of carbonates to about 60 cm at the maximum, but usually to between 30 and 40 cm.

An Arnot Siding Solonetzic Gray Luvisol soil is described below:

L-F-H- 3 to 0 cm; non-decomposed to well decomposed feathermoss with jack pine and spruce needles and remains of alder leaves and other herbaceous shrubs; fibrous and loose; few, fine, horizontal roots; strongly acid; abrupt, smooth boundary.

Ae- 0 to 8 cm; brown (10YR 5/3 m) heavy clay; moderate, fine to medium granular; slightly sticky and slightly plastic when wet, very friable when moist, loose when dry; abundant, medium and fine horizontal roots; strongly acid; clear, smooth boundary.

AB- 8 to 15 cm; brown (10YR 5/3 m) very heavy clay; moderate, medium to coarse subangular blocky; slightly sticky and plastic when wet, firm when moist, hard when dry; abundant, medium and fine horizontal roots; strongly acid; clear, wavy boundary.

Btnj- 15 to 26 cm; dark brown (10YR 4/3 m) very heavy clay; strong, very coarse columnar breaking to strong, coarse subangular blocky; slightly sticky and very plastic when wet, very firm when moist, very hard when dry; few, fine vertical exped roots; slightly acid; clear, wavy boundary.

Bt- 26 to 34 cm; dark brown (7.5YR 4/3 m) very heavy clay; strong, coarse subangular blocky breaking to moderate, fine subangular blocky; slightly sticky and very plastic when wet, firm when moist, slightly hard when dry; few, fine oblique roots; neutral; abrupt, wavy boundary.

BCk- 34 to 41 cm; brown (10YR 4.5/3 m) heavy clay; structureless, massive breaking to weak, fine pseudo angular blocky; slightly sticky and plastic when wet, friable when moist, slightly hard when dry; few, fine oblique roots; mildly alkaline, strongly calcareous; gradual, wavy boundary.

Ck- 41 to 100 cm; brown (10YR 4/3 m) heavy clay; structureless, massive breaking to weak, fine pseudo angular blocky; slightly sticky and plastic when wet, very friable when moist, slightly hard when dry; very few, fine oblique roots; mildly alkaline, strongly calcareous.

Arnot Siding Vegetation Association (Asv) on Well Drained Sites:

Climax vegetation on the well drained Arnot Siding association soils is a black spruce-feathermoss type, but because of fire disturbance, many sites now support mixed forest stands of spruce, jack pine, aspen and birch. Both jack pine and aspen can occur in relatively pure stands. A dense tall shrub layer of alder is very commonly associated with mixed forest stands.

Data for four Arnot Siding vegetation association types are presented in Table 16.

Table 15. Chemical and Physical Analyses of an Arnot Siding Solonetzic Gray Luvisol Soil.

Horizon	Depth	Text. Class	Sand %	Silt %	Clay %	pH $CaCl_2$	Cond. mmhos/cm	$CaCO_3$ Equiv. %	Cal-cite %	Dolo-mite %
LFH	3-0	-	-	-	-	-	5.2	-	-	-
Ae	0-8	HC	3	28	69	5.1	0.1	-	-	-
AB	8-15	VHC	1	13	86	5.3	0.1	-	-	-
Btnj	15-26	VHC	1	11	88	6.3	0.1	-	-	-
Bt	26-34	VHC	1	6	93	6.7	0.1	1.0	0.6	0.3
Bck	34-41	HC	4	21	75	7.4	0.2	16.6	10.4	5.7
Ck	41-100	HC	9	28	63	7.6	0.2	22.6	17.4	4.8

Horizon	Depth	Org. C	Total N %	C/N Ratio	Exch. Cap.. m.e./100 gm soil	Exchangeable Cations m.e./100 gm: Ca	Mg	Na	K	H	Ash %
LFH	6-0	43.5	1.3	33.5	75.5	37.5	7.5	0.1	2.4	31.6	28.9
Ae	0-8	3.0	0.2	15.0	37.7	14.3	3.3	0.1	0.9	13.5	-
AB	8-15	1.3	0.1	13.0	38.5	17.5	4.5	0.1	0.9	11.0	-
Btnj	15-26	9.9	0.1	9.0	39.2	24.7	6.5	0.2	0.8	7.5	-
Bt	26-34	0.9	0.1	9.0	41.3	27.5	7.8	0.2	0.7	5.9	-
Bck		0.5	-	-	30.0	-	-	-	-	-	-
Ck		-	-	-	25.6	-	-	-	-	-	-

Table 16. Floristic and Cover Data for Arnot Siding Vegetation Associations on well drained Sites.

Relevé number	1	2	3	4
Total no. of spp.	10	30	12	16
Species	Cover in %			
Trees				
Populus tremuloides	90			5
Pinus banksiana		60	40	
Betula papyrifera		10	10	
Picea mariana		20	50	90
Tall shrubs and trees regeneration				
Picea mariana	15		20	25
Alnus crispa	60	60		
Salix spp.		5		
Medium shrubs and herbs				
Viburnum edule			1	1
Rosa acicularis	1	5	1	1
Ribes triste		1		
R. oxyacanthoides		1		1
Ledum groenlandicum		15		
Rubus strigosus		1		
Epilobium angustifolium	1	20	1	1
Low shrubs and herbs				
Vaccinium vitis-idaea		15		
Arctostaphylos alpina				1
A. uva-ursi				1
Linnaea borealis	+	+		+
Rubus pubescens		1	+	
Aster spp.		+		+
Cornus canadensis	1	25	15	+
Achillaea millefolium		+		
Viola spp.		+		
Pyrola virens	+	+		
Fragaria vesca		1		
Mertensia paniculata		5	+	
Lathyrus ochroleucus		1		
Petasites palmatus		5		
Mitella nuda		5		
Geocaulon lividum			+	
Mosses and lichens				
Pleurozium schreberi		40	40	
Hylocomium splendens	+	15	40	80
Hypnum crista-castrensic		5		
Dicranum spp.	+	5		+
Aulacomnium palustre		+		
Cladina mitis		5		10
Litter	90			

2. Crying Lake (CY) Ecosection

Ecoregion: High Boreal (HB) see Table 11, 12 and 13 (page 147 to 149).

Ecodistrict: Split Lake (SP) see Table 14, page 150.

The Crying Lake Ecosection is largely composed of raised peat plateaus (and some palsas) and various proportions of collapse scars and small horizontal fens. The peat plateau landforms consist of deep (> 100 cm) of moderately to strongly decomposed forest peat and/or weakly decomposed Sphegnum peat overlying forest peat. The landforms are raised above the surrounding peat lands as result of ice built-up in the organic and the underlying mineral materials. The active layer is usually between 40 to 60 cm thick. Drainage is from poor to imperfect. The soils and vegetation belong respectively to the Crying Lake soil association (Cy) and Crying Lake vegetation association (Cyv).

Ecosites

Soils: The soils are dominantly Mesic Organic Cryosol and Fibric Organic Cryosol soils

Vegetation: The vegetation consists dominantly of three general types on the peat plateaus;

- Picea mariana - Ledum groenlandicum - Sphagnum type
- Picea mariana - Ledum groenlandicum - Cladina type
- Picea mariana - Ledum groenlandicum - Hypnum type

The vegetation on the palsas usually consist of two general types:

- Picea mariana - Hypnum type

Plate III. CRYING LAKE VEGETATION ASSOCIATION, PICEA MARIANA - LEDUM GROENLANDICUM - CLADINA TYPE.

Plate IV. COLLAPSING EDGE OF PEAT PLATEAU; MELTING OF PERMAFROST CAUSES SLOW DECREASE IN SIZE OF PLATEAU (LEFT) AND INCREASE IN SIZE OF COLLAPSE SCAR (RIGHT).

- Betula papyrifera - Ledum groenlandicum - Hypnum type

Crying Lake soil association (Cy), Mesic Organic Cryosol soil.

These soils consist of imperfectly drained, Mesic Organic Cryosol soils developed on deeper than 100 cm of moderately to strongly decomposed forest peat. These soils are permanently frozen within 60 cm from the surface. Ice content of the frozen materials is moderate to high, with ice usually in the form of segregated ice and small veins.

These soils usually have a weakly decomposed fibric surface layer consisting of medium to coarse fibric Sphagnum or feathermoss peat.

The subsurface peat is usually derived from mosses, forest litter (needles, leaves, branches, etc.) and remains of herbaceous plants and is referred to as forest peat. Various amounts of soft to slightly hard woody fragments occur throughout the peat deposit. Decomposition of the peat material is moderate to high and increases with depth. These soils are frozen within 1 m from the surface with the active layer usually being from 40 to 60 cm deep. At greater depth, these organic deposits are underlain by frozen, fine textured lacustrine sediments.

A Crying Lake Mesic Organic Cryosol soil is described below:

Of- 0 to 25 cm; dark brown (7.5YR 4/4 p, m) fibric, slightly decomposed Sphagnum and feathermoss peat; strong, medium fibered; hard, woody fragments; non-sticky when wet; few, medium random roots; extremely acid; clear, smooth boundary.

Om1- 25 to 35 cm; dark reddish brown (5YR 3/2 p, m) mesic, moderately decomposed forest peat; moderate, fine fibered; soft, woody fragments; non-sticky when wet; plentiful, fine random roots; strongly acid; clear, smooth boundary.

Om2- 35 to 42 cm; dark reddish brown (5YR 2.5/2 p, m) mesic, moderately decomposed forest peat; moderate, fine fibered; soft, woody fragments; non-sticky when wet; plentiful, fine random roots; very strongly acid; clear, smooth boundary.

Omz1- 42 to 75 cm; very dark brown (10YR 2/2 p, w) mesic, moderately decomposed forest peat; moderate, fine fibered; slightly hard, woody fragments; random ice, moderate ice content; strongly acid; clear, smooth boundary.

Omz2- 75 to 125 cm; dark reddish brown (5YR 2.5/2 p, w) mesic to humic, highly decomposed forest peat; moderate, very fine fibered; random ice, moderate ice content; clear, smooth boundary.

IIAhkgz- 125 to 130 cm; very dark gray (10YR 3/1 w) silty clay; structureless, massive; random ice, high ice content; sticky and slightly plastic when wet; neutral, weakly calcareous; clear, smooth boundary.

IICkgz- 130 to 200 cm; dark gray (5Y 4/1 w) heavy clay; structureless, massive; oriented ice, ice high content; sticky and plastic when wet; midly alkaline, strongly calcareous.

Crying Lake vegetation association (Cyv)

The vegetation on peat plateaus consists of open black spruce, with large amounts of labrador tea and other ericaceous shrubs. The microhummocky appearance of the terrain is caused by Sphagnum moss hummocks. Older plateaus have usually increasing amounts of lichens and/or feather mosses in the vegetation component.

The vegetation on palsas consists usually of dense black spruce with large amounts of feathermosses. Labrador tea, and currants can be a significant component in the vegetation. Some palsas have an almost pure white birch tree cover, with shrub layers consisting of willow, labrador tea or rose. Ground cover can be either mosses or litter. This type is usually due to fire on old palsas. Vegetation data on 3 peat plateau plots, and 2 palsas are shown in Table 18.

Table 17. Chemical and Physical Analyses of a Crying Lake Mesic Organic Cryosol Soil.

Horizon	Depth cm	Text. Class	Fiber Content Unrubbed %	Fiber Content Rubbed %	Sand %	Silt %	Clay %	pH $CaCl_2$	Cond. mmhos/cm	$CaCO_3$ Equiv. %	Calcite %	Dolomite %
Of	0-25	-	84	56				3.9	-	-	-	-
Om1	25-35	-	50	28				5.1	-	-	-	-
Om2	35-42	-	56	32				4.9	-	-	-	-
Omz1	42-75	-	44	24				5.4	-	-	-	-
Omz2	75-125	-	26	10				-	-	-	-	-
IIAHkgz	125-130	SiC			5	51	44	7.2	-	4.2	-	3.9
IICkgz	130-200	HC			2	23	75	7.7	0.3	17.4	14.2	3.0

Horizon	Depth cm	Org. C	Total N %	C/N Ratio	Exch. Cap.. m.e./100 gm soil	Exchangeable Cations m.e./100 gm Ca	Mg	Na	K	H	Phos-Phate Solu-bility	Ash %
Of	0-25	54.4	2.1	25.9	129.5	32.8	9.5	0.3	0.7	86.4	20.8	5.8
Om1	25-35	53.2	2.3	23.1	182.5	92.8	15.8	0.1	0.1	74.0	87.0	12.6
Om2	35-42	55.6	1.6	34.8	193.0	92.8	13.2	0.1	0.1	77.1	66.0	7.4
Omz1	42-75	57.6	2.1	27.4	202.9	123.4	14.9	0.2	0.1	68.7	112.0	9.7
Omz2	75-125	49.4	2.4	20.6	217.5	141.2	18.0	0.4	0.3	53.1	128.0	16.3
IIAhkgz	125-130	15.1	0.8	18.9	-	-	-	-	-	-	-	-
IICkgz	130-200	1.0	-	-	-	-	-	-	-	-	-	-

Table 18. Floristic and Cover Data for Crying Lake Vegetation Associations

Relevé number	1	* 2	3	4	5
Total no. of spp.	14	17	10	10	11
Species	Cover in %				
Trees					
Picea mariana	15	30	30	20	75
Betula papyrifera			+	60	
Tall shrubs					
Alnus crispa			+	10	
Medium shrubs and herbs					
Ledum groenlandicum	60	60	40	40	5
Andromeda polifolia	1				
Chamaedaphne calyculata	20				
Ribes spp.				+	+
Viburnum edule					10
Epilobium augustifolium					
Low shrubs and herbs					
Rubus chamaemorus	5	20			
Oxycoccus microcarpus	1	1			
Vaccinium vitis-idaea	1	10	15		1
Equisetum sylvaticum	10			10	
Smilacina trifoliata			1		
Lycopodium annotinum			5		

Relevé number	1	2	3	4	5
Total no. of spp.	10	17	10	10	11
Species	Cover in %				
Mosses and lichens					
Pleurozium schreberi	15	10	60		15
Hylocomium splendens			5		+
Hypnum crista - castrensis					10
Polytrichum commune			1		
Dicranum scoparium			+		
D. fuscencens		5		10	1
Pohlia nutans					+
Mnium spp.	1				
Sphagnum rubrum	20				
S. fuscum	20	10			
Cladina alpestris	25				
C. mitis	30	40	40		
C. rangeferina	1	30	1	+	+
Lichen spp.		5			
Peltigera aphtosa			1		
Liverworts					
Marchantia polymorpha				15	

*) Releves no. 1-3 are from peat plateaus, releves no. 4 and 5 from palsas.

3. Isset Lake (IS) Ecosection

Ecoregion: High Boreal (HB) see Table 11, 12 and 13, page 147 to 149.

Ecodistrict: Split Lake (SP) see Table 14, page 150.

The Isset Lake Ecosection is largely composed of gently to very gently sloping bog veneer areas, with shallow channels, runnels and depressions. The surficial material is composed of very shallow (15-40 cm) and shallow (40-100 cm) mesic forest peat and fibric Spaghnum peat over mesic forest peat. The peat accumulation have an irregular micro hummocky topography and are underlain by moderately to strongly calcareous clay textured lacustrine sediments. The deeper peat materials contain locally permafrost especially in well developed Sphagnum moss hummocks and in areas shaded by trees. Associated with the bog veneer areas are lacustrine upland sites, peat plateaus and collapse scars in deeper peat areas. The terrain is generally poorly drained, although in some area drainage is provided by shallow channels and runnels.

The soils and vegetation belong respectively to the Isset Lake soil association (Is) and Isset Lake vegetation association (Isv).

Ecosites

Soils: The soils are mainly of three types viz. Terric Mesic Organic Cryosol, Terric Mesisol and Terric Fibric Mesisol soils, associated are some peaty Gleysol and Terric Fibrisol soils.

Vegetation: The vegetation consists largely of one general type.

Picea mariana - Ledum groenlandicum - Sphagnum type

Plate V. ISSET LAKE SOIL ASSOCIATION, TERRIC FIBRIC MESISOL SOIL.

Plate VI. ISSET LAKE VEGETATION ASSOCIATION, PICEA MARIANA - LEDUM GROENLANDICUM - SPHAGNUM TYPE; PERMAFROST IN SPHAGNUM MOSS HUMMOCK.

Isset Lake soil association (Is), Terric Fibric Mesisol soil

These soils consist of poorly drained Terric Fibric Mesisol soils developed on shallow (40 to 100 cm) dominantly mesic forest peat overlying fine textured lacustrine sediments. These soils are characterized by a discontinuous layer of Sphagnum peat and dark brown, medium to strongly acid forest peat. These soils occur in near level to gently sloping terrain, usually in the lower slope position.

Runoff is slow and internal soil permeability is low because of the fine textured materials and the high groundwater level that persists for a greater part of the year. Lateral drainage tends to take place along the contact of the peaty surface layers and the less permeable massive clay substrate.

An Isset Lake, Terric Fibric Mesisol soil is described below:

Of1- 0 to 16 cm, yellowish brown (10 YR 5/6 m, 10YR 5/6 p) fibric sphagnum moss, strong, fine fibered, nonwoody, extremely acid; about 95 percent fiber; abrupt, wavy boundary.

Of2- 16 to 23 cm, dark brown (7.5YR 3/2 m, 7.5YR 7/4 p) fibric mixed mosses, moderate fine to medium fibered, nonwoody; strongly acid; about 90 percent fiber; abrupt, smooth boundary.

Om1- 23 to 48 cm; black to dark reddish brown (5YR 2/1 m, 5YR 2/2 p) mesic forest peat; structureless; amorphous and weak, very fine fibered, moderate wood content; slightly acid; about 65 percent fiber; clear, smooth boundary.

Om2- 48 to 68 cm; black to dark reddish brown (5YR 2/1 m, 5YR 2/2 p) mesic forest peat; structureless, armophous, nonwoody; slightly acid, about 25 percent fiber; abrupt, smooth boundary.

IICg- 68 to 88 cm; dark yellowish brown (10YR 4/4 w) clay, structureless, massive; very sticky when wet, very plastic; mildly alkaline; abrupt, smooth boundary.

IICkg- 88 to 100 cm; yellowish brown (10YR 5/4 w) clay; structureless, massive; very sticky and very plastic when wet; mildly alkaline; weakly calcareous.

Isset Lake vegetation association (Isv)

The vegetation is very much the same throughout the ecosite association and has a distinctive pattern of clumped black spruce, scattered tamarack, willows, Sphagnum moss hummocks with lichens on older and drier parts, and patches of other mosses, Labrador tea, other ericaceous shrubs and sedges are found throughout.

Data from four Isset Lake vegetation association plots are given in Table 20.

Table 19. Chemical and Physical Analyses of a Isset Lake, Terric Fibric Mesisoil Soil.

Horizon	Depth cm	Text. Class	Fiber Content Unrubbed %	Fiber Content Rubbed %		pH $CaCl_2$	Cond. mmhos/cm	$CaCO_3$ Equiv. %	Calcite %	Dolomite %
Of1	0-16	-	91	76		3.3	-	-	-	-
Om2	16-23	-	92	76		5.4	-	-	-	-
Om1	23-48	-	68	32		6.1	-	-	-	-
Om2	48-68	-	26	10		6.1	-	-	-	-
			Sand %	Silt %	Clay %					
IICg	68-88	C	2	14	84	7.5	0.2	-	-	-
IICkg	88-100	C	1	16	83	7.7	0.3	5.0	5.0	-

Horizon	Depth cm	Org. C %	Total N %	C/N Ratio	Exch. Cap.. m.e./100 gm soil	Exchangeable Cations m.e./100 gm Ca	Mg	Na	K	H	Pyrophos. Solubility %	Ash %
Of1	0-16	55.6	0.5	111.2	116.1	12.7	7.3	0.3	1.0	90.1	5.7	3.2
Om2	16-23	56.8	0.5	113.6	123.3	80.7	23.2	0.4	1.1	23.5	8.6	5.3
Om1	23-48	52.4	0.7	74.9	188.4	138.8	31.8	0.5	0.5	16.2	28.3	9.5
Om2	48-68	54.3	1.1	49.4	256.5	181.4	20.1	0.5	0.1	29.4	93.0	11.6
IICg	68-88	-	-	-	41.8	25.6	7.9	0.2	0.7	-	-	-
IICkg	88-100	-	-	-	30.5	-	-	-	-	-	-	-

Table 20. Floristic and Cover Data for Isset Lake Vegetation Association.

Relevé number	1	2	3	4
Total no. of spp.	15	17	12	16
Species	Cover in %			
Trees				
Picea mariana	20	25	10	40
Larix laricina				+
Pinus banksiana				+
Tall shrubs				
Salix spp.	10	+		1
Betula glandulosa			5	
Alnus rugosa				10
Medium shrubs and herbs				
Ledum groenlandicum	30	20	40	30
Vaccinium uligonosum		5	10	
Chamaedaphne calyculata	25			
Kalmia polifolia		1		+
Rosa acicularis			+	
Eriophorum spissum		1		
Carex spp.		10		5
Low shrubs and herbs				
Vaccinium vitis-idaea	10	5	5	1
Oxycoccus microcarpus	1	1	1	+

Relevé number	1	2	3	4
Total no. of spp.	15	17	12	16
Species	Cover in %			
Equisetum sylvaticum	1	1	+	5
E. scirpoides		1		
Arctostaphylos alpina		1		
Salix spp.		5	+	
Rubus chamaemorus			+	
R. acaulus				+
Geocaulon lividum	1			
Drosera rotundifolia	1			
Mosses and lichens				
Pleurozium schreberi	25			5
Hylocomium splendens	10			
Sphagnum fuscum	30	25		
S. rubrum		40	5	60
Cladina mitis	30	15	25	30
C. rangeferina	5		30	
C. alpestris	5		15	
Peltigera aphtosa		1		

Soil Data Record Form.

SOIL RESEARCH INSTITUTE
DAILY FIELD SHEET RECORD
(FIELD DESCRIPTION INPUT DOCUMENT)

SITE NO. 54 | DATE 15 09 75 | SURVEYOR GM | FIELD SHEET NO. A21877-97

CARD NO. 0001 | ZONE 14 | ALPHA LET U | 100,000 METER NS | EASTING 7590 | NORTHING 9120 | MAP SHEET 63P | DIRECTION | SECTION | TP | RG | M | SERIES CODE | VARIANT

CARD No. 0002

LANDFORM CLASSIFICATION

MINERAL TERRAIN SURFACE FORMS

A001** Apron
A002** Blanket
A003** Delta
A004** Fan
A005** Hummocky
A006** Level
A007** Pitted
A008** Ridged
A009** Rolling
A010** Terrace
A011** Undulating
A012** Veneer
A013** Inclined

ORGANIC TERRAIN LANDFORMS

A021** Bog
A022** Domed bog
A023** Palsa
A024** Peat mound
A025** Plateau bog
A026** Bog plateau
A027** Peat plateau
A028** Flat bog
A029** Bowl bog
A030** Blanket bog
A031** Fen
A032** Horizontal fen
A033** Mesic fen
A034** Hydric fen
A035** Patterned fen
A036** String fen
A037** Net-like patterned fen
A038** Water track fen
A039** Sloping fen
A040** Floating fen
A041** Collapse scar
A042** Spring fen
A043** Domed fen
A044** Minerotropic palsa
A045** Swamp
A046** Lowland swamp
A047** Hydric
A048** Mesic

PARENT MATERIAL

PHYSICAL COMPONENT

A051** Undifferentiated
A052** Fragmental
A053** Skeletal in AB only
A054** Coarse loamy & coarse silty
A055** Fine loamy & fine silty
A056** Clayey
A057** Stratified (mineral)
A058** Statified (min. & organic)

CHEMICAL COMPONENT

A061** Undifferentiated
A062** Extremely/strongly acidic
A063** Medium acid/neutral
A064** Weakly calcareous
A065** Moderately/very strongly calc.
A066** Extremely calcareous
A067** Calcareous saline

MODE OF DEPOSITION OR ACCUMULATION

A071** Fluvial
A072** Colluvial
A073** Eolian
A074** Fluvioeolian
A075** Fluviolacustrine
A076** Fluviomarine
A077** Glaciofluvial
A078** Glaciolacustrine (+ Icecontact)
A079** Glaciomarine
A080** Lacustrine
A081** Lacustro-till
A082** Marine
A083** Morainal (till)
A084** Organic
A085** Residual

LITHOLOGICAL MODIFIER

A101** Undifferentiated or undet.
A102** Mixed
A103** Igneous
A104** Coarse Acid
A105** Coarse basic
A106** Fine acid
A107** Fine basic
A108** Sedimentary
A109** Shale
A110** Siltstone & mudstone
A111** Sandstone
A112** Conglomerate
A113** Marl & chalk
A114** Limestone
A115** Dolomite
A116** Cherty calcareous rock
A117** Breccia
A118** Metamorphic
A119** Gneiss
A120** Schist & phyllite
A121** Slate
A122** Quartzite
A123** Pyroclastic
A124** Tuff
A125** Ash
A126** Organic material (undiff.)
A127** Litter (leaves, needles)
A128** Sphagnum peat
A129** Forest peat
A130** Fen peat
A131** Aquatic peat

SLOPE

SLOPE TYPE

A141** Simple
A142** Complex

SLOPE CLASS

	% Slope	Class
A151**	0-0.5	1
A152**	0.5 to 2	2
A153**	2 to 5	3
A154**	5 to 9	4
A155**	9 to 15	5
A156**	15 to 30	6
A157**	30 to 60	7
A158**	60	8

01 | 70 | Percent Slope

SAMPLE SITE POSITION ON SLOPE

A161** Crest
A162** Upper slope
A163** Middle
A164** Lower slope
A165** Toe
A166** Depression

EROSION

GENERAL WATER EROSION

A181** Slight erosion
A182** Moderate erosion
A183** Severe erosion
A184** Gullied land

GULLY EROSION

A191** Shallow occasional gullies
A192** Shallow frequent gullies
A193** Deep occasional gullies
A194** Deep frequent gullies

WIND EROSION

A201** Eroded
A202** Severely eroded
A203** Blown-out land

DRAINAGE

A171** Very rapidly drained
A172** Rapidly drained
A173** Well drained
A174** Moderately well drained
A175** Imperfectly drained
A176** Poorly drained
A177** Very poorly drained

STONINESS

A211** Nonstony
A212** Slightly stony
A213** Moderately stony
A214** Very stony
A215** Exceedingly stony
A216** Excessively stony

ROCKINESS

A221** Nonrocky
A222** Slightly rocky
A223** Moderately rocky
A224** Very rocky
A225** Exceedingly rocky
A226** Excessively rocky

SALINITY

LOCATION

A231** No salts visible
A232** Salts in deep subsoil
A233** Salts in upper C
A234** Salts in B
A235** Salts in A

SALINITY CLASS

A241** Weakly saline
A242** Moderately saline
A243** Strongly saline

No.	Entry	Field
02	**	Depth to Bedrock (m)
03	*	Depth to Watertable (m)
04	*	Depth to Impermeable Layer (m)
05		Layer Type
06	18 **	A Horizon Thickness (cm)
07	620	Solum Thickness (cm)
08		Soil Map Unit Notation
09	**	Map Unit Numeric Modifier
10	*	Associated Soils
11	*	Associated Soils
12	CL	Texture A Horizon
13	C	Texture B Horizon
14	C	Texture C Horizon

Soil Data Record Form (cont'd)

SOIL CLASSIFICATION

CHERNOZEMIC

A301** Orthic Brown
A302** Rego Brown
A303** Calcareous Brown
A304** Eluviated Brown
A305** Solonetzic Brown
A306** Solodic Brown

A311** Orthic Dark Brown
A312** Rego Dark Brown
A313** Calcareous Dark Brown
A314** Eluviated Dark Brown
A315** Solonetzic Dark Brown
A316** Solodic Dark Brown

A321** Orthic Black
A322** Rego Black
A323** Calcareous Black
A324** Eluviated Black
A325** Solonetzic Black
A326** Solodic Black

A331** Orthic Dark Gray
A332** Rego Dark Gray
A333** Calcareous Dark Gray
A334** Solonetzic Dark Gray
A335** Solodic Dark Gray

SOLONETZIC

A341** Brown Solonetz
A342** Dark Brown Solonetz
A343** Black Solonetz
A344** Gray Solonetz
A345** Alkaline Solonetz

A351** Brown Solodized Solonetz
A352** Dark Brown Solodized Solonetz
A353** Black Solodized Solonetz
A354** Gray Solodized Solonetz

A361** Brown Solod
A362** Dark Brown Solod
A363** Black Solod
A364** Gray Solod

LUVISOLIC

A371** Orthic Gray Brown Luvisol
A372** Brunisolic Gray Brown Luvisol
A373** Podzolic Gray Brown Luvisol

A381** Orthic Gray Luvisol (circled)
A382** Dark Gray Luvisol
A383** Brunisolic Gray Luvisol
A384** Podzolic Gray Luvisol
A385** Solodic Gray Luvisol
A386** Solodic Dark Gray Luvisol

PODZOLIC

A391** Orthic Humic Podzol
A392** Ortstein Humic Podzol
A393** Placic Humic Podzol
A394** Duric Humic Podzol
A395** Fragic Humic Podzol

A401** Orthic Ferro-Humic Podzol
A402** Ortstein Ferro-Humic Podzol
A403** Placic Ferro-Humic Podzol
A404** Duric Ferro-Humic Podzol
A405** Fragic Ferro-Humic Podzol
A406** Luvisolic Ferro-Humic Podzol
A407** Sombric Ferro-Humic Podzol

A411** Orthic Humo-Ferric Podzol
A412** Ortstein Humo-Ferric Podzol
A413** Placic Humo-Ferric Podzol
A414** Duric Humo-Ferric Podzol
A415** Fragic Humo-Ferric Podzol
A416** Luvisolic Humo-Ferric Podzol
A417** Sombric Humo-Ferric Podzol

BRUNISOLIC

A421** Orthic Melanic Brunisol
A422** Degraded Melanic Brunisol

A425** Orthic Eutric Brunisol
A426** Degraded Eutric Brunisol

A431** Orthic Sombric Brunisol
A432** Degraded Sombric Brunisol

A435** Orthic Dystric Brunisol
A436** Degraded Dystric Brunisol

REGOSOLIC

A441** Orthic Regosol
A442** Cumulic Regosol

GLEYSOLIC

A451** Orthic Humic Gleysol
A452** Rego Humic Gleysol
A453** Fera Humic Gleysol

A455** Orthic Gleysol
A456** Rego Gleysol
A457** Fera Gleysol

A461** Orthic Luvic Gleysol
A462** Humic Luvic Gleysol
A463** Fera Luvic Gleysol

SUBGROUP MODIFIERS

A471** Andic
A472** Grumic
A473** Turbic
A474** Placic
A475** Saline
A476** Carbonated
A477** Cryic
A478** Gleyed
A479** Lithic

ORGANIC

A481** Fenno-Fibrisol
A482** Silvo-Fibrisol
A483** Sphagno-Fibrisol
A484** Mesic Fibrisol
A485** Humic Fibrisol
A486** Limno Fibrisol
A487** Cumulo Fibrisol
A488** Terric Fibrisol
A489** Terric Mesic Fibrisol
A490** Terric Humic Fibrisol
A491** Cryic Fibrisol
A492** Hydric Fibrisol
A493** Lithic Fibrisol
A494** Typic Mesisol
A495** Fibric Mesisol
A496** Humic Mesisol
A497** Limno Mesisol
A498** Cumulo Mesisol
A499** Terric Mesisol
A500** Terric Fibric Mesisol
A501** Terric Humic Mesisol
A502** Cryic Mesisol
A503** Hydric Mesisol
A504** Lithic Mesisol

A511** Typic Humisol
A512** Fibric Humisol

A521** Mesic Humisol
A522** Limno Humisol
A523** Cumulo Humisol
A524** Terric Humisol
A525** Terric Fibric Humisol
A526** Terric Mesic Humisol
A527** Cryic Humisol
A528** Lithic Humisol

A531** Typic Folisol
A532** Lithic Folisol

PRESENT LAND USE

URBAN

A541** Built-up areas
A542** Mines, quarries, etc.
A543** Outdoor recreation

AGRICULTURE

A551** Horticulture
A552** Orchards and vineyards
A553** Crop land
A554** Improved pasture/forage

ROUGH GRAZING AND RANGELAND

A561** Natural grazing
A562** Woodland grazing
A563** Abandoned farmland

WOODLAND

A571** Productive woodland (circled)
A572** Unproductive woodland

WETLAND

A581** Swamp
A582** Marsh
A583** Bog
A584** Fen

OTHER

A591** Sand
A592** Rockland
A593** Rough broken eroded
A594** Rubble land
A595** Alpine
A596** Arctic tundra
A597** Cryoturbated land

A599** Water

LAYER/HORIZON DESIGNATIONS

CARD NO. (20)	LITH. DIS. (24)	MASTER LAYER/HORIZON (25)	SUFFIXES (28)	MODIFIER (33)	DEPTHS (CM) MODAL UPPER LIMIT (34)	DEPTHS (CM) MODAL LOWER LIMIT (37)
0104		LF			10	0
0204		A	E		0	8
0304		AB			8	37
0404		B	T		37	62
0504		C	K	1	62	100
0604						
0704						
0804						
0904						
1004						
1104						
1204						

HORIZON CHRACTERISTICS

	Code	1	2	3	4	5	6
Mottles	A601**						
Clay films	A602**				—		
Conc., nodules, casts	A603**						
Salts	A604**						
Carbonates	A605**					—	
Coarse fragments	A606**			—			

SPECIAL NOTES

CARD NO. (20)	(22)	(24)	SPECIAL NOTES (FREE FORMAT) (25)
00	03	1	PM SAMPLED AT 90-110CM/VARVES DISTØRTED AND TWISTED/AB
00	03	2	HØR STØNY WELL RØUNDED, LIGHT CØLØURS ØN ØUTSIDE ØF PED
00	03	3	CØCL STRUCT./BT LFSBKY/ØRIGIN ØF PM LIKELY ASSØCIATED

WITH ICE CONTACT DEPØSITS IN AREA

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Vegetation Data Record Form.

PROV	YR	SITE ID. NO	UNIT	LAB	SOIL SERIES	PROJECT	PICTURES ROLL	PICTURES NO
04	75	54				NRIP	26	32

SURVEYORS	DATE DAY	DATE MONTH	NTS-MAP	PHOTO NO FLIGHT LINE	PHOTO NO NO	PHOTO NO MAP-LINE	POINT LOCATION LATITUDE	POINT LOCATION LONGITUDE	Tp	R	SEC
HV GFM	15	09	63P	A21877	97		MG 7590	9120			

VEG GENERAL	DOMINANT SPECIES TREE	SHRUB	HERB	MOSS	SITE LANDFORM	TEXTURE	DRAINAGE	ASPECT	SLOPE
0913	PIC MA	ALN CR	CØR CA	HYL SP	CLr	CLaY	MØD		7

TREE MEASUREMENTS GEN	SP	DBH	HEIGHT	AGE	DOM	STAND MEASUREMENTS OR ESTIMATES B.A	AN.INC	CLI-CLASS	DENS	CC	REGENERATION GEN	SP	COV
PIC	MA	152	137	62	CØD	170		5		90	PIC	MA	5
						180							
PIN	BA					10							
						180							

HISTORY: FIRE

SUCCESSION: ADVANCED

SPECIAL NOTES

SØIL PIT IN SMALL ØPEN
ING, REMAINDER ØF STAND
PRETTY WELL CLOSED/
CLUMPS ØF BIRCH NICELY
INTERSPERSED/
CAN BE CØNSIDERED AS
ALMØST STABLE/

SKETCH

Vegetation Data Record Form (cont'd)

PLOT OR QUADRAT NO																	
MICRO TOPO LOCATION																	
GEN	SP	Q	COV	SOC	DENS	GEN	SP	Q	COV	SOC	DENS	GEN	SP	Q	COV	SOC	DENS
PIC	MA	6	1.1	06													
PIN	BA		0.3	02													
BET	PA		0.4	03													
ALN	CR		05	0.2													
SLX	SP		03	0.2													
PIC	MA		05	03													
CØR	CA		03	03													
LIN	BØ		02	04													
RØS	AC		01	02													
VIØ	PA		01	02													
PYR	SE		08	1.0													
HYL	SP		08	10	11												
DIC	SC		04	09													
HYP	CC		08	09													
PØL	CØ		02	08													
DIC	RU		02	08													
CLA	RA		02	07													
PEL	AP		03	09													
CLA	MI		02	07													
LIT	TER		03	07													

Appendix D

GLOSSARIES

Glossary of Scientific and Common Plant Names

Scientific name	Common name
Vascular plants *	
Achillea millefolium	Yarrow
Alnus crispa	Green alder
Andromeda polifolia	Bog-Rosemary
Arctostaphylos alpina	Bearberry
A. uva-ursi	id.
Aster spp.	Aster
Betula glandulosa	Scrub birch
B. papyrifera	White birch
Carex	Sedge
Chamaedaphne calyculata	Leatherleaf
Cornus canadensis	Bunchberry
Drosera rotundifolia	Round leaved sundew
Epilobium angustifolium	Fireweed
Equisetum scirpoides	Dwarf scouring-rush
E. sylvaticum	Woodland horsetail
Eriophorum spissum	Cottongrass
Fragaria vesca	Wild strawberry
Geocaulon lividum	Northern comandra
Kalmia polifolia	Pale laurel
Larix laricina	Tamarack
Lathyrus ochroleucus	Cream-colored vetchling
Ledum groenlandicum	Labrador-tea
Linnea borealis	Twinflower
Lycopodium annotinum	Stiff clubmoss
Mertensia paniculata	Tall lungwort
Mitella nuda	Bishop's cap
Oxycoccos microcarpus	Small cranberry
Petasites palmatus	Palmate-leaved colt's-foot
Picea mariana	Black spruce

Scientific name	Common name
Pinus banksiana	Jack pine
Populus tremuloides	Trembling aspen
Pyrola virens	Wintergreen
Ribes spp.	Currant
R. oxyacanthoides	Northern gooseberry
R. triste	Swamp red currant
Rosa acicularis	Prickly rose
Rubus acaulis	Stemless raspberry
R. chamaemorus	Cloudberry
R. pubescens	Dewberry
R. strigosus	Wild red raspberry
Salix spp.	Willow
Smilacina trifolia	Three-leaved Solomon's seal
Vaccinium uligonosum	Alpine bilberry
V. vitus-idaea	Dry-ground cranberry
Viburnum edule	Low-bush cranberry
Viola spp.	Violet
Mosses, lichens and liverworts**	
Aulacomnium palustre	Ribbed bog moss
Cladina alpestris	Reindeer moss
C. rangeferina	id.
C. mitis	id.
Dicranum fuscescens	-
D. scoparium	Broom moss
Hylocomium splendens	-
Hypnum crista-castrensis	Plume moss
Marchantia polymorpha	Marchantia
Mnium spp.	Mnium
Peltigera aphtosa	Spotted peltigera
Pleurozium schreberi	Schreber's moss
Pohlia nutans	Nodding pohlia
Polytrichum commune	Hair-cap moss

Scientific name	Common name
Sphagnum rubrum	Sphagnum moss
S. fuscum	id.

*) Scientific names after Scoggan (1957), common names after Scoggan (1957) and Budd and Best (1969).

**) Scientific and common names after Cunningham (1977).

GLOSSARY OF TERMS*

Association, soil - a natural grouping of soil associates based on similarities in climatic or physiographic factors and soil parent materials.

________, vegetation - a community individualized in terms of its structure and quantitative floristic composition

Bog - a peat-covered or peat-filled area, generally with a high water table.

Boreal - of high latitudes, more or less coincident with the needle-leaf forest formations.

Blanket - an extensive area of relatively thick (>1m) surface deposits which subdue but do not completely mask the configuration of the underlying bedrock or deposit.

Category - a grouping of related natural entities defined at the same level of abstraction.

Chronosequence, vegetation - a sequence of related vegetation types that differ from one another in species composition and structure primarily as a result of time as a vegetation formation factor.

Class - a group of natural entities having a definite range in particular properties.

Classification - the systematic arrangment of natural entities into categories and classes on the basis of their characteristics.

Climax - a plant community of the most advanced type, capable of development under, and in dynamic equilibrium with, the prevailing environment.

Community, plant - an aggregation in definite proportion of more or less interdependent plants, utilizing the resources of a common habitat which they either maintain or modify.

Consolidation stage - plant associations of a more or less closed structure, but still floristically unstable; follows the first invasion or pioneer stage.

Coverage - the amount of space occupied by all plant individuals present in an area, estimated as vertical projection.

Ecology - the study of the relationship between organisms and their environment.

Edaphic - 1. of or pertaining to the soil 2. resulting from, or influenced by, factors inherent in the soil or other substrate rather than by climatic factors.

Ecosystem - the dynamic whole formed by the habitat and the association of living beings that occupy it.

Factor - a force or influence which determines a condition in the environment or a direct response from the organism.

Fen - a peat-covered or peat-filled area with a high water table, which is usually at the surface.

Glaciolacustrine - the materials deposited in glacial lakes.

Habitat - that part of the environment at which exchanges actually occur between the organisms and the resources which they utiize.

Horizon, soil - layer of soil or soil material approximately parallel to the land surface, differentiated from adjacent related as result of soil formation.

Land - the solid part of the earth's furface or any part thereof.

Land classification - the arrangement of land units into various categories based on properties of the land or its suitability for some particular purpose.

Landscape - all the natural features such as fields, hills, forests and water that distinguish one part of the earth's surface from another part.

Material, parent - the unconsolidated and more or less chemically weathered mineral or organic matter from which the solum has developed by pedogenic processes.

Moraine - an accumulation of earth, generally with stones, carried and finally deposited by a glacier.

Ordination - arrangement of vegetation samples in order of similarity.

Palsa - a mound of peat with a perennially frozen peat and/or mineral core.

Pedology - the aspects of soil science dealing with the origin, morphology, genesis, distribution, mapping and taxonomy of soils, and classification in terms of their use.

Pedon - the smallest, three dimensional unit at the surface of the earth that is considered as a soil.

Permafrost - perrennially frozen material.

Phytosociology - the branch of ecology that deals with the characteristics, relationships, and distribution of associated plants.

Pioneer - the plants or communities that occupy newly available or little differentiated sites.

Plain - an area of comparatively flat, smooth, and level land.

Plateau, peat - an area of perennially frozen peat, raised above surrounding terrain by accumulation of ice in peat or mineral materials, and extending for several hectares.

Proclimax - a stable plant community whose original establishment presumably took place under climatic conditions differing from those of the present.

Profile, soil - a vertical section of the soil through all its horizons and extending into the parent material.

Relevé - a quadrat survey where all species present are listed and given some quantitative coefficient.

Riparian - pertaining to shores and banks of lakes and streams.

Scar, collapse - fen areas that developed as a result of melting of permafrost in organic landforms.

Sere - a group of plant communities that successively occupy the same site, from the pioneer through the consolidation to the subclimax stages.

Site-type - an ecosystematic unit defined by its indicator species'.

Sociability - the spacing or aggregation of individuals of a species.

Soil - the natural occurring unconsolidated material on the surface of the earth that has been influenced by parent material, climate, organisms and relief, all acting over a period of time.

Stand - an area occupied by floristically and structurally homogeneous vegetation; it is the association-individual, a local example of an association.

Stratification, vegetation - the arrangement of plants in layers within a stand.

Structure, vegetation - the distribution in space of the living parts of the plants in a stand and, by extension, in an association.

Subclimax - a phase of succession occupied by associations with structure fairly close to that of the climax but biologically unable to perpetuate themselves on the same site.

Succession - the process through which a plant community invades and eventually replaces another.

Taiga - a needle-leaved (usually evergreen) parkland.

Taxon - a systematic natural unit of unspecified rank.

Texture, soil - the relative proportions of the various soil separates in a soil according to size.

Tundra - an area of generally open vegetation maintained by a short and cold growing season.

Vegetation - the total plant cover of an area, consisting of one or more communities.

Veneer - an extensive area of thin (< 1m) unconsolidated surficial deposits which mask little of the configuration of the underlying bedrock or deposits.

________, bog - an area of shallow peat (40 - 100 cm thick) that covers slopes and to some degree, depressions and uplands. Permafrost is discontinuous and most often found in better developed *Sphagnum* peat mounds.

Zone - natural geographical unit, whether latitudinal or altitudinal, generally climatic.

*) Terms regarding vegetation and plants from Dansereau's (1957) "Biogeography, an ecological perspective."

Terms regarding soil, landfrom and materials from glossaries prepared by the NRIP and the Canada Committee on Soil Classification.