GUIDELINES FOR BIO-PHYSICAL LAND CLASSIFICATION

For Classification of Forest Lands
and Associated Wildlands

A progress report based on results of Bio-physical Land Classification pilot projects and discussions of Subcommittee on Bio-physical Land Classification National Committee on Forest Land

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PREFACE

These Guidelines are a revision of the "Outline of Bio-physical Land Classification - Guidelines for Pilot Studies" dated June 1967.

This report is a summary of the basic agreements on classification techniques and procedures that have developed following meetings in 1968 with participants in the Bio-physical Land Classification Pilot Projects, and the meetings of the Sub-committee on Bio-physical Land Classification in Victoria and Winnipeg in 1967, and at Laval University Montmorency Center in 1969.

The pilot studies undertaken during the summers of 1967 and 1968 provided the opportunity to modify the 1967 guidelines on the basis of experience in a variety of landscapes throughout Canada. Classification standards for the description of several bio-physical features have been left open for the present. National guidelines, or standards that will meet regional requirements, will have to be developed as the field program progresses.

Many persons have assisted in the preparation of these "Guidelines", and grateful thanks are extended to all of them.

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* See Progress Report, Bio-physical Land Classification Pilot Projects, Canada Land Inventory, ARDA, April 1968.

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I. INTRODUCTION

The terms of reference of the Subcommittee on Bio-physical Land Classification are:

(1) To examine and review systems of land classification developed and used at national and regional levels.

(2) To present recommendations to the National Committee on Forest Land concerning a suitable physical land classification, of a reconnaissance nature, that will provide a base from which lands can be classified as to their use for Forestry, Agriculture, Recreation, Wildlife and Water Yields.

At recent workshop meetings it was concluded that the term "Wildlands" was subject to misinterpretation both from administrative and technical points of view. It was suggested that the term "Bio-physical Land Classification" be adopted in place of the term "Wildland Classification".

The proposed Bio-physical Land Classification, primarily of a reconnaissance nature, will initially be applied and tested in large, unsettled areas of forest and associated "wildlands". These are the areas in Canada in which very little basic ecological knowledge is available. Many single-resource studies or surveys may have been completed in these areas but overall land resource surveys have not been attempted.

Discussions at subcommittee meetings have led to the general agreement that a land classification that begins with a broad areal appraisal of land resources and provides a summary of data that sets the stage for more detailed work on those areas that warrant closer attention, is the most reasonable and practical one to pursue in a country as large as Canada.

Although emphasis throughout the Guidelines is placed on land patterns and groupings of characteristics for broad land planning, it is clear that more detailed mapping and descriptions can be undertaken, when and if necessary, using the information included in the basic reconnaissance classification framework and accompanying summaries of physical data. (See Part V of this report for examples.)

The following discussions and descriptions are presented as first approximations and they are not to be regarded as inflexible standards. Revisions and additions to regional descriptions of various features will be made as the testing and application of the "Guidelines" continues.

II. GENERAL AIMS AND PROCEDURES

The aim of the present Bio-physical Land Classification projects is to differentiate and classify ecologically-significant segments of the land surface, rapidly and at a small scale (reconnaissance survey); it is to satisfy the need for an initial overview and inventory of forest land and associated wildland resources. This inventory will serve as the ecological basis for land use planning involving future management of lands for forestry, agriculture, recreation, wildlife and water yields.

A Bio-physical Land Inventory that is expected to cover large areas quickly will have to rely on the use of airphotos and airphoto interpretation techniques combined with supporting field checks. This approach eliminates the possibilities of mapping in detail certain attributes of the soil and vegetation components of the landscape. Emphasis is placed on the classification and mapping of patterns of soil, landform, vegetation and water.

The combination of field observations with airphoto interpretation gives rise to specific problems and adjustments. The total number of field investigations is considerably less than in a conventional survey. The value of each individual field observation is much greater; therefore both its choice and location, and its description and classification are of more critical nature (Vink, 1964). Field investigations in land surveys using airphoto interpretation are never carried out in an absolutely regular pattern; also the size and number of the sample areas selected depends largely on the specific characteristics of the project and the morphology of the terrain.

It is assumed that, in initiating surveys in new areas all available land resource data (soils, climate, vegetation, geology and related subjects) will be studied. It is strongly recommended that pre-field airphoto interpretation be undertaken. Major breaks in the land surface can be delineated, the types and size of contrasting areas of land can be estimated, and points and transects in which field sampling should be initiated can be selected.

III. CLASSIFICATION AND MAPPING UNITS AND LEVELS OF GENERALIZATION

The discussions of the Pilot Projects leaders at Edmonton and Quebec workshops have led to the acceptance of the following terminology, definitions, levels of classification and basic frame of reference.

LEVEL	UNITS OF CLASSIFICATION	PRACTICABLE SCALE OF MAPPING
Level 1	Land Region	1:1,000,000 to 1:3,000,000 or smaller
Level 2	Land District	1:500,000 to 1:1,000,000
Level 3	Land System	1:125,000 (on occasion up to 1:250,000 if landscape pattern permits)
Level 4	Land Type	1:10,000 - 1:20,000

The Land Region (Level 1)

Land Region is presently defined as an area of land characterized by a distinctive regional climate as expressed by vegetation. The Land Region is usually of large areal extent and is inevitably more or less heterogeneous. It is often an aggregation of several distinctive contiguous landscapes.

The climatic information necessary to classify these regions does not exist at present throughout most of Canada. In addition we are not always certain of which ranges, extremes or averages in climatic data are of significance for the various management uses foreseen. In some areas, therefore, investigators may have to rely on gross form or major physiographic variations (and the implied variations in associated climate) to obtain a useful framework of "regional differences". The importance of basic ecological and climatic regions is recognized, but the absence of information needed to develop a regional framework using any one criterion or group of criteria precludes the formulation of a set of national guidelines at this time.

Land regions, as envisaged, are of such a size that they can be mapped conveniently at scales between 1:1,000,000 to 1:3,000,000, or smaller.

The Land District (Level 2)

The Land District is comparable to the "Site District" of Hills (1959), and is defined as an area of land characterized by a distinctive pattern of relief, geology, geomorphology and associated regional vegetation. The Land District is a subdivision of the Land Region based primarily on the separation of major physiographic and/or geologic patterns which characterize the region as a whole. Land Districts have a common pattern of relief, structure or comparable geomorphic evolution.

Land Districts can be conveniently portrayed on maps at scales from 1:500,000 to 1:1,000,000.

Units at levels 1 and 2 have not been described nor mapped in all the pilot projects undertaken. It is evident that in many areas meaningful boundaries will be developed only after the study of interrelationships and patterns at levels 3 and 4 are documented and understood.

The Land System (Level 3)

The Land System is presently defined as an area of land throughout which there is a recurring pattern of landforms, soils and vegetation. This is similar to the Australian definition of a Land System described by Christian (1958). An example of a Land System would be "a rolling, shallow, till plain overlying granite bedrock, characterized by Podzol soils and a yellow birch - balsam fir forest cover". (See also the examples included in Part V of this report).

The majority of the pilot studies have indicated that a mapping scale of 1:125,000 is the most useful one for reconnaissance mapping. There is a possibility that Land Systems could be mapped at a scale of 1:250,000 where the complexity of the glaciated landscape is not a limiting factor.

In keeping with the purpose and aims of the Bio-physical Land Classification of forest and related wildlands, it is clear that the Land System will be the working level in most instances, and it is at this level that we should concentrate our present efforts. Land divisions at higher levels will be developed regionally or nationally as the need arises.

The Land Type (Level 4)

The Land Type is presently defined as an area of land, on a particular parent material, having a fairly homogeneous combination of soil (at a level corresponding to the Soil Series) and chronosequence of vegetation. An example of a land type would be "a well drained portion of a gravelly outwash terrace with an Orthic Dystric Brunisol soil supporting lodgepole pine-*Vaccinium scoparium* vegetation". (See also illustrations in Section V of this report).

The Land Type is the basic unit for which specific use capability ratings will be made.

Land Types are areas of land that can be most readily delineated at scales ranging from 1:10,000 - 1:20,000. In arid areas some land types may be mapped at scales of 1:30,000 to 1:60,000.

IV. GUIDELINES FOR DESCRIPTION AND CLASSIFICATION OF FEATURES OF LAND SYSTEMS (LEVEL 3) AND LAND TYPES (LEVEL 4)

1. INTRODUCTION

The mapping program of the Bio-physical Land Classification will not be carried out at the detailed level of the land type units (Level 4). The present survey will focus on the Land

System Level -- the primary operating level which will provide a preliminary overview of the bio-physical resources of the region. The omission of land type boundaries does not eliminate the need to describe clearly the characteristics and distribution of land types within the geographic patterns of Land Systems. The variety and proportional distribution of land types within each Land System, therefore, should be estimated, described, and summarized in cross section or block diagrams and accompanying tables (See Section V). This information on land types can be used for more detailed surveys of some portions of the region for specific resource management problems whenever the need arises.

The Land System is a complex mapping unit - a broad subdivision of the landscape identifiable and mappable from airphotos primarily as pattern of landforms and vegetation. Within land systems the soil and vegetation are heterogeneous, but repeated distinctive patterns can be identified and related to patterns of landforms. Landforms are areas of land, or topographic features, that are defined in terms of their slopes and slope patterns, the materials that produce the relief, and wherever possible, in terms of their mode of origin. Landforms provide the framework to which patterns and changes in vegetation and soils can be geographically related.

2. DESCRIPTION AND CLASSIFICATION OF FEATURES OF LANDFORMS (LEVEL 3)

It is proposed that the landform and landform patterns be classified and separated on the basis of the following characteristics:

(a) Mode of origin and/or deposition of landforms

(b) Materials of landforms described in terms of:
- texture
- thickness of deposit
- general chemical and mineralogical composition
- compaction of materials

(c) Topography and relative relief of landforms.

A. Mode of Origin and/or Deposition of Landforms

Considerable discussion has centred on the pros and cons of including a reference to the genesis and glacial history of the landforms in their definition. Difficulties in sorting out the glacial history in some areas have led to a rejection of landform origin as being of any use; but on the other hand, in many areas of Canada the incorporation of an understanding of the development of the landscape and its deposits has been most valuable in mapping large, inaccessible areas. The point is that in using airphotos and airphoto interpretation a knowledge of landform origin permits a prediction of landforms and materials that may be in the vicinity (Lacate 1966, Kowall and Runka 1968). Underlying the definition of landforms which includes origin is the element of prediction; that by knowing about the origin of a unit, one may make predictions about the geographically associated parts within the pattern under study, and about adjacent patterns that fit into the genetic picture of the area (MEXE Report No. 940, 1966).

In areas where little information is available concerning geomorphology then the obvious approach is to describe such areas in general "topographic or terrain" terms; though this should be a temporary measure to be used until new knowledge or new surveys become available.

The following list and grouping of landforms* is one example of a classification of landforms that could be developed at a regional level, and subsequently incorporated into a national set of guidelines. The Geological Survey of Canada

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* Original draft prepared by R.J. Fulton and J.G. Fyles, Department of Energy, Mines and Resources.

has indicated that regional mapping of forest lands will be one of its major priorities, and a more comprehensive set of guidelines should be available in the near future following their review of national and regional requirements.

(i) Post Glacial

STREAM DEPOSITS -

- Alluvial Terrace and Floodplain Deposit: sand, gravel, silt, minor clay and organic material; includes various features of modern floodplains including deltas.
- Fan deposit: poorly sorted gravel, sand, silt and clay; (fine materials generally restricted to gently sloping toe of fan); in a fan shaped deposit.

LAKE DEPOSITS - deposits forming in present day lakes exclusive of fans and deltas (restricted to shore deposits).

- Beach Complex: mainly sand and gravel; includes various beach features such as spits, bars, wave cut benches, etc.

WIND DEPOSITS - material that has been transported and deposited by the wind.

- Silt: silt and fine-grained sand; forms a mantle of uniform thickness; generally termed loess; mapped where more than 5 feet thick (show as pattern where thinner).
- Sand: medium and fine-grained sand; may be duned or form a mantle of uniform thickness; mapped where more than 5 feet thick (show as pattern where thinner).

ORGANIC DEPOSITS - type(s) should be specified (See Section 5 on Wetland Classification for examples).

LANDSLIDE DEPOSITS - materials deposited by large scale mass movements; slide deposits generally lie at or near the foot of the scar from which the material moved.

- Bedrock: blocks and rubble in finer matrix of crushed rock; ridged and hummocky form-slide involving consolidated rock.
- Unconsolidated: gravel, sand, silt, clay or mixture depending on source; hummocky or ridged form-slide involving unconsolidated material.

SLOPE DEPOSITS - materials deposited by various processes of mass movement (on a small scale contrasted with landslides).

COLLUVIUM - loose material accumulated on the surface of other unconsolidated deposits by various processes of mass movement; same general texture as underlying deposits but primary structure obliterated and fines often removed.

TALUS - angular rubble accumulated as a mantle on bedrock or as a cone or fan at the foot of a steep bedrock slope.

(ii) Glacial

GLACIAL LAKE DEPOSITS - material deposited in lakes resulting directly or indirectly from the presence of a glacier (ice dam or tilting due to isostatic depression).

- Hummocky: silt, clay and fine-grained sand; hummocky, ridged and kettled; formed by melting of glacier buried by lacustrine deposit.
- Thick: silt, clay and fine-grained sand; (more than 10' thick), flat to gently rolling surface.
- Veneer: silt, clay and fine-grained sand; (less than 10' thick), too thin to mask underlying topography.
- Beach Complex: mainly gravel and sand; includes various beach and related features.
- Wash: gravel, sand, and boulders; veneer of debris developed by washing action of glacial lake (show as

pattern on underlying deposit).

GLACIAL FLUVIAL DEPOSITS - gravel and sand deposited by glacial meltwater or washed into juxtaposition with ice from an ice-free area.

- Hummocky: irregular hummocky, ridged and kettled topography; includes kames, kame and kettle, eskers, etc.; fluvial material deposited on, within, under or against ice (symbol may be used to show individual esker ridge or kames).
- Valley-wall Terrace: bench of glacio-fluvial material deposited in a position requiring ice on one or more sides for deposition (kame terrace).
- Kettled Terrace Deposit: gravel and sand; flat surfaced but containing closed depressions.
- Level Terrace Deposit: gravel and sand; flat surfaced benches above present river level but not inferred to have been deposited against ice (as contrasted with valley-wall terrace).
- Rill Complex: lag gravel, channel-bottom gravel, areas of unmodified till, small pockets of backwater silt (in general areas of glacial till washed and channelled by meltwater).

GLACIAL TILL DEPOSITS - materials deposited by the direct action of ice; largely till but minor areas of gravel and sand may also be present.

- Drumlinoid: characterized by streamlined and linear features.
- Hummocky and Ridged: characterized by sharp ridges, hummocks and kettles.
- Undifferentiated Drift: areas without the distinguishing features mentioned above.
- Thin Drift: thin till, topographic form controlled by underlying bedrock; may include up to 25% outcrop.

(iii) Marine Deposits

- Marine plains, terraces, veneer deposits, lag deposits, etc.
- Associated spits, bars, deltas, tidal flats.
- Glacio-marine deposits, lag deposits.

(iv) Bedrock

- specify type(s).

B. Description of Materials of Landforms

The materials or patterns of materials within each landform should be described in terms of the following characteristics and groupings:

(i) Texture (the following nomenclature has been accepted by the National Soil Survey Committee, and to minimize overlapping it should be followed whenever possible)

Textural Class Name	Term to describe general range of textures at level 3
Gravels and coarse sands	Very coarse textured
Sand Loamy sand	Coarse textured
Sandy loam Fine sandy loam	Moderately coarse textured
Very fine sandy loam Loam Silt loam Silt	Medium textured

Textural Class Name	Term to describe general range of textures at level 3
Sandy clay loam) Clay loam) Silty Clay loam)	Moderately fine textured
Sandy Clay) Silty Clay) Clay)	Fine textured
60% Clay)	Very fine textured

(ii) Thickness of Deposit

The term "thickness" will be used with reference to the landform and landform patterns (level 3) and the term "depth" will be reserved for use with reference to soil descriptions (level 4). Class limits for thickness and depth should be set up in each region on the basis of the variability within the landscapes present. It is suggested that when "thickness of a material over bedrock" is used, the type of bedrock and its condition (shattered, porous, impermeable, etc.) should be specified.

(iii) Petrography and Mineralogy

It was decided that national classification standards should not be set up at this time. Classes and/or general descriptions would be established on the basis of regional requirements during the pilot studies, e.g., general descriptive terms such as "derived from weathered granite or derived from limestone" could be used.

(iv) Compaction of Materials

Three general classes have been suggested (Kowall and Runka 1968).

- loose
- semi compact
- compact

C. Topography and Relative Relief of Landforms

It was decided that some combination of relative relief, slope frequency and slope gradients should be attempted. The classes suggested for relative relief are:

Relative Relief

Class	Change in elevation per mile
1	less than 25 feet
2	26 - 150 feet
3	151 - 500 feet
4	501 - 1,000 feet
5	1,001 - 2,000 feet
6	2,001 feet +

In British Columbia, relative relief is more meaningful if it is summarized in descriptive terms indicating range of relief and elevation above sea level within the Land System, although it is recognized that change in elevation per mile may be useful in other areas (Kowall and Runka 1968).

Combined with these classes should be a statement or notation concerning, (1) frequency of slopes per mile (the average condition to give some indication as to whether the land is irregular or composed of one simple slope), and (2) a general description of slope gradients (modal slope) using the following groupings (some subdivisions may be necessary to suit local needs).

Class	Slope gradient
1	0 - 15%
2	16 - 30%
3	31 - 60%
4	61 - 100%
5	101 +

3. SOIL DESCRIPTION AND CLASSIFICATION (LEVEL 4)

In this type of reconnaissance survey, we should try to describe the individual soils and soil patterns in detail at each field check point, even though we may not be able to extrapolate confidently much of this information over large areas.

Wherever possible soil descriptions should follow the classification system and guidelines provided in the reports of the National Soil Survey Committee of Canada (e.g. Report on the Sixth Meeting of N.S.S.C. at Laval University, Quebec 1965). Certain features of the soil should be highlighted when the characteristics of the Land Types are being summarized and described. The features that are of considerable value in characterizing the Land Types, and in making interpretations for various uses at a later stage are:

A. Soil Morphology

Use N.S.S.C. classification as follows: where possible classify at the Soil Subgroup level for all Orders. Where not possible use Soil Great Group for the Chernozemic, Solonetzic, Gleysolic and Organic Orders. Note:- use N.C.F.L. classification for humus-forms (National Committee on Forest Land, 1967).

B. Soil Drainage Classes (use the 6 classes described by N.S.S.C.)

(1) Rapidly drained, (2) Well drained, (3) Moderately well drained, (4) Imperfectly drained, (5) Poorly drained and, (6) Very poorly drained.

C. Moisture Status

Use descriptive terms to indicate telluric water, moisture balance, moisture holding capacity, etc.

D. Soil Texture

For a description of the classes to use, refer to the groupings outlined above in "Description of Materials of Landforms".

E. Gravel and Stone Content

Describe the gravel content as follows:

	Class	
1.	Textural class name only	0 - 20% by volume
2.	"Gravelly" + textural class	21 - 50% by volume
3.	"Very Gravelly" + textural class	51 - 90% by volume
4.	"Rubbly"	91%+ by volume

Generally acceptable definitions of stoniness classes have not been established as yet. Whether or not stones affect forest productivity adversely is still open to question; nevertheless, some generalized descriptions should be attempted to permit evaluation of the effect of stones on harvesting machinery and silvicultural management practices on recreational development possibilities, and so on.

F. Soil Structure and Soil Consistence

Use N.S.S.C. Classification

G. Soil Material Depth (to impermeable pans, etc., within the rooting zone that affect the depth or degree of development of rooting).

It is recognized that regional groupings of soil depth based on the local variations in landscapes may be necessary. An example of the type of classification, and the depth ranges that could be used within each class, is as follows:

	Depth to Restrictive Layer
very shallow rooting depth	15" or less
shallow rooting depth	16 - 30"
moderately shallow rooting depth	31 - 45"
moderately deep rooting depth	46 - 60"
deep rooting depth	60"+

4. VEGETATION DESCRIPTION AND CLASSIFICATION (LEVELS 3 AND 4)

Prepared by J.S. Rowe, Department of Plant Ecology,
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The purpose of a forest and "wildland" inventory is to identify and map the recurring patterns of units of the landscape using the ecologically-significant criteria of surface materials, topography, vegetation. The purpose of this outline is to provide guidelines for the description and classification of the vegetation.

The Land Type unit of landscape is defined as an area with uniform topography, underlain primarily by one kind of material (for example, a level, medium sand plain). At a scale of 1:15,000 such units or facets of the landscape are mappable. Different but geographically associated surface materials may, and usually do, occur as inclusions within such mapping units. Each unit of the landscape has its particular local climate and soil moisture characteristics related to topography and surface material. As a result, each is characterized by a particular plant cover and type of soil. Looked at from the other side, each kind of plant cover (and associated soil) indicates a particular kind of land and is useful in defining and bounding it.

At the smaller scale of reconnaissance survey (1:60,000 or smaller) it may not be possible to map Land Types but only <u>patterns</u> of them (i.e. Land Systems). However, the omission of boundaries between Land Types does not eliminate the need to clearly define and describe their distribution within the geographic patterns. The concept of the catena, the topographically-related "chain" of units making up the pattern, is probably most useful in describing the vegetation (and soils) within the larger mapping unit (Land System) of the reconnaissance survey.

The major problem in integrating vegetation in the Bio-physical land inventory revolve around:

(1) the absence of a generally accepted description method for vegetation
(2) the absence of a framework classification of Canadian vegetation
(3) the rapid reaction of vegetation to disturbance, and the resultant occurrence of variable vegetation cover on essentially similar kinds of land.

A. Description of the Vegetation

In describing vegetation it is important to pay attention to (a) vegetation structure, (b) species composition, and (c) abundance of individual species. Descriptions should be made in physiognomically uniform plots, large enough to contain the normal variety of species. All descriptions should be kept on file for future use during, as well as after completion of, the survey. For land use interpretations other than forestry there is a need for more emphasis on the description of the shrub layers, and on the description of non-forest vegetation above the tree-line and on bogs.

It has been suggested that some of the plots in the ecological surveys should be permanent (providing time, funds, and crew organization permit such an arrangement). These plots would be of high value for future reference, especially to study succession after logging and/or fire. If the plots and soil pits are carefully located on the airphotos then in most instances it would be easy to relocate the sample point for many decades after initial examination.

The guidelines for the description of the vegetation are as follows:

(i) Vegetation structure:
The vegetation should be divided in the major strata or sub-strata if distinguishable: e.g., tree layer, shrub layer, dwarfshrub layer, herb layer and moss layer. For each of these strata the predominant height and its total percentage cover should be recorded.

(ii) Species composition:
Species occurring within the plot should be listed for each stratum separately. This listing should be as complete as possible, and herbarium material of provisionally identified specimens should be collected.

(iii) Species abundance:
The following scale is suggested for a rapid estimation of abundance as indicated by density and cover:

r = single specimen only
\+ = sporadically occurring
1 = few to common, but covering less than 5%
2 = covering 5 - 25% (if desired a further refinement of the scale can be made: 2- = 5-15% cover; 2 + = 15-25% cover)
3 = covering 25 - 50%
4 = covering 50 - 75%
5 = covering 75 - 100%

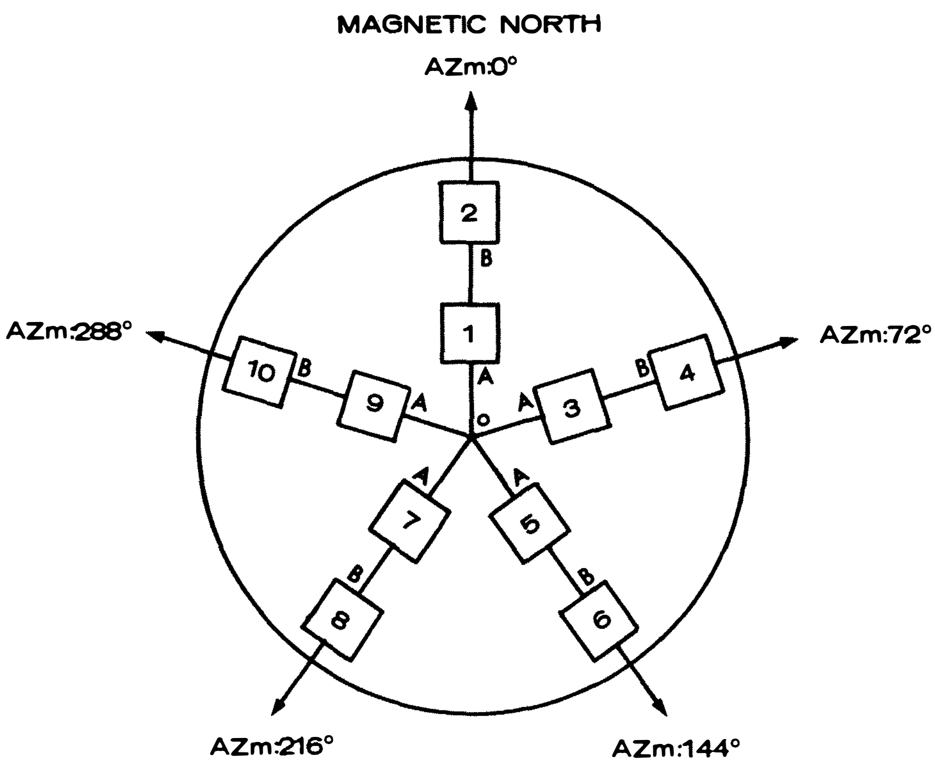
(iv) Species frequency:
As an alternative, it has been suggested that a measure of Species Frequency be used. In the Biophysical surveys in Quebec, Species Frequency has been handled as follows: Ten milacre quadrats are

distributed in the sample plot (see figure 1) and the presence of each species and tree seedlings is recorded. If the observations are recorded in succession in each quadrat (number 1 to 10), the data can be used for successional studies when the plot is permanent. The method can be used by technicians providing they collect all unknown species for further identification.

FIGURE 1

DISTRIBUTION OF MILACRE VEGETATION PLOTS (10 X 10 LINKS)

(Quebec Pilot Project - M. Jurdant)



1/10 ACRE PLOTS: OA = 15 links
OB = 40 links

1/5 ACRE PLOTS: OA = 20 links
OB = 50 links

B. Classification

It is difficult to give hard and fast rules as to how vegetation should be classified. Conditions will vary between geographic areas, and there will be different amounts of background information available for different parts of the country prior to the surveys.

In most cases, each classification should be developed during the survey, as an outgrowth of it. The rule ought to be:- describe first, classify later. The following are tentative guidelines only; the level of sophistication of the classification will necessarily depend on the experience of the investigators and on the time available for the survey.

(i) Make the first subdivision according to dominant cover if dealing with forest or shrub vegetation. Do not try to define types in such a way that they include either more than one cover type, or more than one kind of vegetation (e.g. forested and non-forested communities).

(ii) A further subdivision should be attempted on a structural (physiognomic) basis;

e.g. black spruce forests with almost pure moss carpet
black spruce forests with moss carpet and herbs
black spruce forests with well-developed fern layer
black spruce forests with dwarfshrub layer

(iii) At the Land Type level attempt a further breakdown on a compositional (floristic) basis:

e.g. the balsam fir/moss forests may be subdivided into:
Pleurozium - balsam fir forest
Hylocomium - balsam fir forest
Sphagnum - balsam fir forest

Use should be made of those species whose occurrence or abundance appear to be indicative of environmental differences.

(iv) Only one or two species names should be used in the type name. Nevertheless, all species found useful for separating the types from others in the same physiognomic unit should be listed.

(v) It should be emphasized again that a classification along the above lines ought not to be made during the early stages of the survey, but only after sufficient field data have been collected to provide a firm basis. The first classification should be provisional and should be checked continually in the field as the survey progresses, and refined or modified as required.

C. Succession

An understanding of trends in the development of vegetation ("succession") provides the basis for predicting future cover and for classing together those units of land with the same potential cover. This is a most important but difficult side of vegetation studies, requiring the services of a competent ecologist. Without dealing adequately with this time aspect, much of the value of the vegetation descriptions and classsifications will be lost.

The purpose is to discover what range of vegetation types, due to history and disturbance, can occupy essentially similar types of land. To be useful, the studies ought to take a short-term viewpoint, specifically excluding long-term primary succession and succession associated with or resulting from irreversible changes in soil condition. It should be noted that descriptions of very early successional stages are of considerable importance in wildlife interpretations.

Successional relationships should be studied in areas where burned, logged and virgin stands can be observed in close proximity on the same surface materials and topographic facets. It will not be possible in all areas to work out successional relationships, and where the evidence is poor it will be best simply to describe the present vegetation without conjecturing about possible changes in the future. Successional relationships should be described in more detail in a separate section of the report, along with detailed information on the structure and floristic composition of the vegetation types.

5. PROPOSED OPEN WATER AND WETLAND CLASSIFICATION *

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The objective of a water and wetland classification is to recognize and group ecologically significant open waters and wetlands into classes that are meaningful to a number of resource managers and users.

The classification system must be oriented to serve the needs of several disciplines, as wild ungulates, fish, waterfowl and furbearers, as well as hydrology, forestry, recreation and agriculture. It is expected that such multi-disciplinary classification can be successful only to a certain level of generalization. Beyond this level, the requirements of each

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discipline become varied and a single classification system may break down. The acceptance of a broad wetland classification by a number of disciplines would contribute greatly to the value of the Bio-physical survey program.

The following principles must be considered when a wetland classification is attempted:

1. The classification should involve water or wetland classes that are significant ecological units from the standpoint of fish, wildlife and vegetation productivity.

2. The classification should be a hierarchical system permitting the workers to go to various levels of detail as desired.

3. The classification should be relatively simple, involving easily recognizable wetland or water areas at the class level.

4. The classification of wetlands and open water should be possible from the interpretation of aerial photographs, at least at the class level. A further breakdown into subclasses and types is also feasible when supported by aerial reconnaissance and ground checking. Site descriptions are obtainable only from ground surveys.

5. The description and mapping of water and wetland classes should be integrated with the description and mapping of the related land components in the Bio-physical Program.

6. The responsibility for the final delineation and appraisal of the wetland components should rest with the resource personnel engaged in the Bio-physical Program.

Such a water and wetland classification is outlined in Table 1. The various classes were based on the examination of literature,* mainly North American and Swedish, on the authors' experience and on consultations with fish and wildlife biologists and forest ecologists. To a large extent it reflects continental temperate, boreal and subarctic conditions, but not necessarily maritime conditions. Hence this proposal is incomplete, and suggestions for improvement are welcomed.

The classes and subclasses are significant to most disciplines. In a broad reconnaissance survey the classes or patterns of classes may only be mapped, although the subclasses are also readily recognizable. The more detailed information on the particular wetlands may be given as descriptive material during such a broad survey.

In Table I the wetland types, water types and site descriptions are examples only, showing the possible subdivisions of the classes and subclasses. These and other similar types may form the basis of mapping units in more detailed surveys.

In the field pure wetland types are seldom found in large blocks, and the boundaries may be indistinct. Fens may gradually give way to bogs, or marshes to fens. This produces a great number of intergrades, or transitional types of wetlands.

When mapping at a small scale, it is inevitable that different types of terrain be included within a common boundary. These complexes will include wetland-wetland, wetland-dryland, wetland-open water, and dryland-open water areas. Most of these can be identified as recurring patterns in much the same manner as various landform patterns.

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* See Appendix I for references consulted in the preparation of this Classification.

Table I. - Classification of Open Waters and Wetlands

A. Open Waters

Class	Subclass		Drainage System	Basin Topography Horizontal	Basin Topography Vertical	Water Type	Site Description
Standing	Permanent	Deep	Open	Regular	G. sloping	Soft	% Shoreline in:
Open		Shallow				Hard	(1) Rock
Water		Open Water Marsh	Restricted	Irregular	M. sloping	Brackish	(2) Mud
	Intermittent	Open Water				Saline	(3) Sand & gravel
			Closed	Very Irregular	S. sloping		(4) Peat
							Vegetation
							Backshore slope
							Erosion
Running	Permanent	Deep	-	Straight	G. sloping	Clear	Shoreline
Water				Curved			material
	Periodical	M. Deep	-	Sinuous	M. sloping	Stained	Vegetation
				Meandering			Gradient or
	Intermittent	Shallow	-	Meandering	S. sloping	Turbid	velocity
				with oxbows			Volume of flow
				Braided			Erosion
				Beaded			
				Dendritic			

Table I (Continued)

B. Wetlands

Class	Subclass		Wetland Type	Site Description
Marsh	Fresh	Lakeside	Deep Marsh	Shoreline configuration
		Streamside	Shallow Marsh	Zonation of vegetation
	Brackish	Deltaic	Wet Meadow	Bottom soils
		Seepage		Water depths
	Saline	Catchment		
		Tidal		
Swamp	Minerotrophic	Alluvial	Alder-Willow Swamp	Water regime
		Lakeside		Nutrients
		Seepage	Cedar Swamp	Vegetation
	Transitional	Catchment		Soils
		Water track	Hardwood Swamp	
		Peat Margins		
Fen	Flowage	Lakeside	Inundation fen	Water regime
		Streamside	Floating fen	Nutrients
		Water track	Spring fen	Peat morphology
				Vegetation
	Soligenous	Seepage	Retention fen	Permafrost
		Catchment	Flat fen	
		Lowland		
	Topogenous	Seepage	Sloping fen	
		Catchment	Patterned fen	
		Lowland	Pond fen	
		Water track		
Bog	Transitional	Bowl bog	Sinkhole bog	Water regime
		Hanging bog		Forested or non-forested
		Flat bog		Vegetation
				Peat morphology
	Ombrogenous	Raised bog	Wooded island	Nutrients
			Palsa bog	Permafrost
			Peat plateau	
			Peat polygon	
		Blanket bog		

A. Definitions of Terms

Definition - Standing Open Water

Continuous uninterrupted expanses of permanent or intermittent standing surface waters of variable depth (usually exceeding 30 cm) that lack any continuous directional flow and occupy more than 5 per cent of the area of a defined basin in rock, mineral soils or peatlands. The open water portion is generally free of rooted emergent plants which are usually restricted to a fringe around shorelines, islands or reefs. This class includes all lakes and ponds, including water bodies with inlets and outlets. For convenience, open water bodies or land-water complexes may be described according to these proposed size classes:

1. 0 - 5 hectares
2. 6 - 20 hectares
3. 21 - 250 hectares
4. 251 - 2000 hectares
5. >2000 hectares

Definition - Running Water

Surface water with a significant and discernible flow in a definite direction, following a gradient, and usually confined to a defined bed or course. Running water is usually impounded by water eroded banks or shorelines. This class includes all streams, brooks and rivers. Running waters may be grouped into useful size classes based upon stream widths.

Definition - Wetlands

Wetlands are areas of predominantly organic or water-worked soils that are permanently or periodically saturated. The water table persists for a time at or above the ground surface, but it may drop well below the surface for seasonal periods. Standing waters, usually not exceeding 2 m in depth, may be present seasonally or persist over long periods of time.

Wetlands are periodically saturated or inundated by local seepage or ground water flow, or they may receive water from remote sources by stream inflows, surface runoff, or flooding. Usually characteristic kinds of wetland vegetation develop.

I. Marsh

Grassy wet areas, periodically inundated up to a depth of 2 m or less with standing or slowly moving water. Surface waters occur seasonally or persist for long periods. Water levels may fluctuate, but the water table remains within the rooting zone of the plants during at least part of the growing season. The substratum usually consists of mineral or organic soils with a high mineral content, but there is little peat accumulation. Waters are usually circumneutral to alkaline, and there is a relatively high oxygen saturation. Grass and sedge sods may be anchored or floating, but usually are not consolidated, and are frequently interspersed with small areas of open water. The vegetation consists of a variety of emergent non-woody plants such as rushes, reeds, reed grasses and sedges often growing in the center of the basin. Where open water areas occur, a variety of submerged and floating aquatic plants flourish.

II. Swamp

Forested wetlands where standing to gently flowing waters occur seasonally or persist for long periods. The bottom soils are usually continually waterlogged. Waters are often stained, and are circumneutral to slightly acid in reaction, with little deficiency in oxygen or other nutrients. The substrate consists of mixtures of transported mineral and organic sediments with little peat accumulation. Usually the peat, when present, is well decomposed but there is no continuous moss carpet and *Sphagnum* is not abundant. The understory vegetation usually consists of mosses, ferns, grasses, rushes and sedges. Tree cover includes tall shrubs, hardwoods and conifers. Swamps often occur along the margins of bogs, open waters and streams.

III. Fen

Peatlands characterized usually by poorly and moderately decomposed peat of variable thickness and covered by a dominant component of sedges, although grasses and reeds may be associated. Often there is much shrub cover and sometimes a sparse layer of trees, usually larch. The water table is at the surface most of the time and some standing water may occur in the spring. Waters and peats are not very acid, often showing alkaline reactions. Fens usually develop in restricted drainage situations where oxygen saturation is low, and mineral supply is restricted. The sod covering is more consolidated than in marshes but pools of water and inclusions of marsh vegetation may be present. Intergrades with marshes and bogs.

IV. Bog

A peat covered area or peat filled depression with a high water table and a surface carpet of mosses, chiefly *Sphagnum*. The water table lies at the surface in the spring and slightly below the moss carpet during the rest of the year, but there is little standing water except for ponds. The mosses often form raised hummocks separated by low wet interstices. Upper peat and bog waters are strongly acid, although associated open water may be slightly alkaline. Peat is usually formed in situ under closed drainage, and oxygen saturation is very low. Bogs may be covered by shrubs or trees such as larch and black spruce.

B. Classifications

Classification - Standing Open Water

I. Subclasses

1. Deep Open Water - Permanent open water with depths in excess of 5 m and having a narrow offshore sublittoral zone. Water bodies in this class usually have sufficient winter oxygen saturation to sustain fish; and depths in excess of 5 m usually mark a decline in most species of rooted submerged plants.

In more temperate regions these water bodies may become thermally stratified.

2. Shallow Open Water - Permanent water bodies or portions of water bodies in which midsummer water levels range from 30 cm to 5 m deep. More than 95 per cent of the basin is occupied by open water with an emergent fringe, if present, less than 3 m wide. Rooted submerged plants may occupy the center of the basin.

3. Open Water Marsh - Shallow, but permanent open water with midsummer levels exceeding 30 cm in depth with deeper portions ranging up to 5 m deep. Differentiated from shallow open water by a wider sublittoral zone (less than 2 m deep). Open water occupies more than 5 per cent of the basin area, with a broad peripheral band of rooted emergents more than 3 m wide. Submerged and floating leaved plants usually occupy the deepest part of the basin.

4. Intermittent Open Water - Flooded areas, catchment basins or tidal flats, often adjoining streams or permanent open waters. These areas lacking well defined shorelines, are seasonally or periodically inundated by surface waters that persist for only short periods before being lost rapidly due to surface drainage, evaporation or seepage. Tall rooted emergent plants usually do not get established over any considerable area, but grasses and some herbaceous plants may be present. The bottom soils alternately undergo periods of water-logging and drying. When drawdowns occur, barren mudflats are usually exposed.

II. Drainage System

1. Open Drainage: Open water or wetlands with inlets and outlets assuring a circulation of water. The main source of water is stream inflow which is usually sustained in nature. The water bodies or wetlands are drained through sustained or intermittently flowing outlets.

2. Restricted Drainage: Open waters or wetlands whose main water source is ground water, seepage, overflow or runoff. Usually there are no inlets, but there may be intermittent inflows. Outlets are usually present, but flows are intermittent or low, and circulation is restricted.

3. Closed Drainage: Closed or landlocked basins whose chief water source is ground water, runoff precipitation or seepage. There are no inlets or outlets, unless of intermittent nature, with flows insufficient to maintain water circulation. Wetlands or small water bodies in closed drainage situations usually have low oxygen levels.

III. Basin Topography

The physical characteristics of the shoreline and offshore zones of large open water bodies are important considerations for recreation, fish and wildlife resource use.

1. Horizontal

The nature of the shoreline in the horizontal plane or the regularity of the permanent shoreline. This is interpreted as the actual shoreline length in miles per linear mile of shoreline, a measure of the departure of the shoreline length from a straight line one mile in length. Irregularities such as headlands, bays, points, spits, inlets, and dissected shores result in deviations from a 1:1 relationship.

a. Regular: Broadly curving or straight shorelines with few or no irregularities per mile of shoreline. The shoreline ratio is about 1.0-1.5 per linear mile.

b. Irregular: A moderate number of irregularities per mile, but with few prominent inlets or peninsulas. The shoreline ratio should vary from 1.5-3.0 per linear mile.

c. Very Irregular: Numerous inlets or bays with indentations or dissections of variable size and occurring frequently within the linear mile. A shoreline ratio of >3:1

2. Vertical

The average offshore relief, or slope from the high water line proceeding towards the deepest part of the basin.

a. Gently sloping: A gradient of 0-5%.

b. Moderately sloping: A gradient of 6-15%.

c. Steeply sloping: A gradient of 16% or more.

IV. Water Type

The following water type classes, as proposed, are intended to reflect relative differences in water quality and fertility as they affect associated plant and animal productivity, and desirable recreation use. The classification has been adapted from Moyle (1946) and Stewart and Kantrud (1969).

1. Fresh Water

Waters with specific conductivities ranging from <40-700 mmhos/cm.

a. Soft water group: Total alkalinity: 0.0-40.0 ppm.
Sulfate ion : 0.0-10.0 ppm.

b. Hard water group: Total alkalinity: 41.0-200 ppm.
Sulfate ion : 0.0-50.0 ppm.

2. Brackish Water

Waters with specific conductivities ranging from 300-18,000 mmhos/cm.

Total alkalinity: >200 ppm.
Sulfate ion : 50.0-300 ppm.

3. Saline Water

Waters with specific conductivities ranging from 3500-100,000+ mmhos/cm. Total alkalinity >200 ppm; sulfate ion >300 ppm. Saline waters are usually marked by salt encrusted shorelines or flats, and reduced emergent growths.

Classification - Running Waters

I. Sub classes

1. Permanent Running Water - Streams with a sustained, uninterrupted flow, maintaining a lentic continuum at all times of the year. Flows may be reduced, but the stream rarely dries

up except during prolonged severe drought.

2. Periodic Running Water - Streams that flow with a seasonal rhythm, flowing for short periods of time every spring or fall, and subsequently going dry. The volume of flow may be quite variable.

3. Intermittent Running Water - Streams that flow at irregular intervals, usually following spring runoff and high precipitation. The streams cease to flow continually, or cease as a lentic continuum at some time of the year. The waters may dry up, seep underground, or be reduced to a series of scattered pools or trickles.

4. Water Depths

a. Shallow streams - Streams with average midsummer depths less than 30 cm except for scattered pools which may be deeper. The stream bottom should be visible; and the streams are usually intermittent in nature. Usually not navigable by small boats.

b. Moderately Deep - Streams with midsummer depths ranging from 30 cm to 2 m.

c. Deep - Streams with average midsummer depths exceeding 2 m. This usually indicates a permanent stream.

II. Basin Topography

1. Horizontal

a. Straight - Straight, usually rapidly flowing streams. No appreciable change in direction over a mile of stream course.

b. Curved - Streams with one or two gentle or broad curves per mile of stream course.

c. Sinuous - A winding stream making several bends or changes in direction per mile.

d. Meandering - Frequent changes in direction, forming almost enclosed loops within a mile of the stream course. On the outer side of the loops, the banks are often undercut or eroded; and material is deposited on the inner side of the loops. The stream is usually a level to gently sloping flood plain.

e. Meandering with Oxbows - As above, except for numerous crescent or horseshoe shaped depressions and pools separated from the main stream.

f. Braided - Youthful streams with numerous divisions or branching, and reuniting of flows forming an intertwined or braided effect.

g. Beaded - Streams with numerous interconnected enlargements or pools interspersed along the course.

h. Dendritic - Segments of streams with dichotomous branching leading to progressively lesser flows, or fan-like branching as on deltas or alluvial fans.

2. Vertical - The range in the degree of slope of the stream valley from the banks to the rim. A description of the relative relief from the stream to the valley rim may also be desirable.

a. Gently sloping - 0-5% gradient.

b. Moderately sloping - 6-15% gradient.

c. Steeply sloping - 16% or more.

III. Water Type

The relative water quality as determined by inorganic and organic particles in solution or suspension.

1. Clear: Light transmittancy more than 90%. In shallow waters, the stream bottom should be visible.

2. Stained: Brown or dark colored waters containing organic or mineral compounds in suspension. Light transmittancy is reduced and the bottom is seldom visible. Common to fen and bog waters.

3. Turbid: Water with a milky grayish or brown cast imparted by suspended silt or mud particles. Light penetration is considerably reduced, and the bottom is not visible. Usually common in streams flowing through alluvium, fine textured or eroded soils.

Marsh Classification

I. Subclass

1. Saline: See above.

a. Lakeside: Marshes adjoining lake shores, forming an integral part of the lake or occurring as a unit behind the lakeshore (lagoon) but periodically receiving waters from the lake.

b. Streamside: Marshes associated with stream shorelines or occasionally receiving floodwaters from the stream.

c. Deltaic: Marshes developed on recent deltas, and periodically inundated by flood waters.

d. Seepage Basins: Marshes developed in basins whose chief sources of water are springs, or underground water flows.

e. Catchment Basins: Marshes whose source of water is dependent upon surface runoff. There is usually a tight basin seal.

f. Tidal: Marshes adjoining marine areas where the water source is tidal salt water, or where there are periodic inundations of fresh, brackish or marine salt waters.

II. Wetland Type

1. Deep Marsh - A permanent or semi-permanent marsh which seldom goes dry except during extreme droughts. The water levels varying from 30 cm to 2 m deep are usually maintained until at least early fall. The substrate usually consists of several cm. of organic or mixed sediments. Stands of emergent vegetation are usually interspersed with areas of open water throughout the basin. The characteristic emergents are bullrushes, cattails and reed grasses.

2. Shallow Marsh - A seasonal marsh which usually holds water until July, or after heavy precipitation. The marsh subsequently dries up, but the bottom soils usually remain waterlogged through the growing season. The marsh may hold up to 1 m. of standing water during flood stages, but there is little open water. Emergents usually grow in closed, dense stands, occupying most of the basin area. The common

emergents include bullrushes, cattails, reed grasses and rushes.

3. Wet Meadow - This is a seasonally flooded or shallow marsh, usually holding less water than the above types. This meadow may be a grassy marsh which loses water rapidly due to bottom seepage or evaporation. There is little persistent open water, and the soil is waterlogged at least during part of the growing season. Usually there is little accumulation of organic or muck soils. The vegetation is characterized by a closed stand of tall and medium height grasses, rushes and sedges. The wet meadow usually forms an outer or shoreward band adjacent to the shallow marsh.

Swamp Classification

I. Subclass

1. Minerotrophic

This includes rich swamps influenced by mineral charged waters or underlying mineral soils, often associated with continuously flowing waters, and pools. The substrate is usually well decomposed and aerated peat or muck. Waters are usually not acid. These swamps support good tree growth.

2. Transitional

This includes less productive swamps, receiving water either through seepage, ground water or runoff, but there is no continuous flow of surface waters. They are common along the margins of fens or bogs and usually contain some hummocks of mosses. Waters may be acid. This subclass may intergrade with bogs.

a. Alluvial - This includes swamps associated with alluvium, stream edges or levees or recent deltas.

b. Lakeside - This type is associated with lake edges.

c. Seepage - This includes swamps where the chief water source is due to seepage, springs or underground water flow.

d. Catchment - This includes swamps in defined depressions receiving water from surface runoff or intermittent streams. They are usually difficult to separate from the above types.

e. Water Track - This type includes swamps occupying concave natural drainage ways across peatlands - terminating at outlets. There is usually underground water flow and the substrate is usually well decomposed peat.

f. Peat Margins - Similar to above, but forming a narrow belt of swamp forest at the outer margins of fens and bogs where the peat contacts mineral soils. This type usually receives water from seepage outflow from the peatland.

II. Wetland Types

Characterized by the dominant vegetation.

1. Alder Willow

Found along lake or stream margins or at the edge of peatlands. The soils are usually mucky. The type is characterized by species of tall alders and willows, bog birch, dogwood, balsam poplar, and larch, usually with an understory of grasses and sedges.

2. Cedar Swamp

A swamp characterized by a hummocky substrate with moss mounds and wet hollows, with an undergrowth of ferns, grasses, rushes and shrubs. The tree cover is usually white cedar, balsam fir, larch and ash.

3. Hardwood Swamp

A swamp which is flooded seasonally but seldom holds water all year and which is characterized by rich muck or mineral soils, and hardwoods such as elms, ash, balsam poplar, maples and birches.

Fen Classification

I. Subclass

1. Flowage Fen - A fen which is being flushed by oxygenated water from creeks, rivers or lakes.

2. Soligenous Fen - A fen which is receiving some influx of water that has earlier been in contact with mineral soil.

3. Topogenous Fen - A fen developed on slightly sloping depressions in which there is a restricted internal drainage.

The lateral movement of water is not completely obstructed. The surplus water is drained off by open or restricted outlets.

II. Wetland Type

1. Spring Fen - A fen receiving distinctly localized outflow of water from the mineral soil.

2. Sloping Fen - A fen developed on appreciably sloping land, often in regions of high rainfall. It is fed by seepage water originating at higher ground.

3. Patterned Fen - A fen developed in a gently sloping topographic depression in which there are narrow, raised ridges of peat, oriented at right angles to the drainage. The spacing of the ridges is variable, giving rise to several subtypes. The fen between the ridges may be covered by shallow water.

4. Pond Fen - A fen resembling patterned fens, but with open water ponds of variable depth occurring between most ridges.

5. Retention Fen - A fen flooded for a short period, as at spring thaw, but retaining water for a long period or over the entire year. The fen may cover flat surfaces, valley floors and basins.

6. Inundation Fen - A fen flooded for a long period by river or lake water and found on flood plains and lake edges.

7. Floating Fen - A floating or quaking peat mat with fen vegetation, encroaching over a water surface. This represents a stage in the filling-in of a lake basin. This fen rises and falls with fluctuating water levels.

8. Flat Fen - A fen occupying extensive areas of flat, low lying land, with usually featureless microtopography except for creeks or open water areas.

Bog Classification

I. Subclass

1. Transitional Bog - Lands of congested drainage where the initial layers of peat developed under the influence of aerated or mineralized water. Consequent accumulation of peat reduces the movement of water and bog conditions become prevalent.

The peat is usually well decomposed below, and poorly decomposed near the surface. Intergrades with fens.

a. Bowl Bog - A bog developed in a topographic depression which is receiving mineralized water. This water is not reached by plant roots, due to peat accumulation, except near the margins of the bog.

b. Hanging Bog - A bog developed on a slope and which is receiving mineralized water. The internal lateral movement of water is restricted by the accumulation of peat and a bog vegetation dominates the surface.

c. Flat Bog - A lowland bog which was initially influenced by mineralized water, but where peat accumulation produced bog conditions. There is no appreciable central doming of the peat.

2. Ombrogenous Bog - A bog where the living plant communities receive water and nutrients chiefly from the rain. These bogs generally have strongly acid reaction and the peat is poorly to moderately decomposed.

a. Raised Bog - A bog having a raised, domed profile, gently sloping from the center toward the margins.

b. Blanket Bog - A bog covering evening up irregularities in the landscape, generally having a domed profile.

II. Wetland Types

1. Sinkhole Bog - A bog influenced by mineralized groundwater, with hummocks of ombrotrophic moss vegetation. This bog is characterized by a hummock and depression microtopography. The peat is usually poorly decomposed on the hummocks, but well decomposed in the sinkhole depressions.

2. Wooded Island - Heavily wooded peat dome which may or may not have an ice core. Generally it occurs as an 'island' in large fens.

3. Palsa Bog - Ice-cored peat dome, generally surrounded by fen and a strip of open water.

4. Peat Plateau - Ice-cored peat flat, elevated up to 1 meter above the regional water table.

5. Peat Polygon - Ice-cored peat flat, with shallow polygonal cracks at the surface.

6. OUTSTANDING NATURAL PHENOMENA

Outstanding features such as (1) Falls or rapids, (2) Hotsprings, (3) Rock formations, and (4) Unusual landforms, etc., should be highlighted (as points) on the map of an area. These characteristics of the landscape are of significance in outdoor recreation, and they can be readily interpreted from airphoto study. In fact, the "uniqueness" of some features may be evident only during airphoto interpretation when several landscapes can be examined from the "bird's eye view", and the relative uniqueness of a feature stands out in relation to the "background" landscapes imaged on the airphotos. The notation of these features would complement the data being observed by other resource sections more directly concerned with the ecology of the area. It is suggested that the list of features and types of symbols outlined in the "Land Capability for Outdoor Recreation" prepared by ARDA (1967) be used in the Bio-physical Survey when outstanding features are being noted and inventoried.

V. GUIDELINES FOR PRESENTATION OF DATA IN RECONNAISSANCE SURVEY (LEVEL 3)

All mapping units at the Land System level will be complexes consisting of areas of land having relative uniformity of soil materials (or predictable patterns of materials) within which repeated patterns or catenas of soils, slopes and vegetation will be evident.

Specific criteria concerning the amount of variation that will be permitted within Land System units are not possible nor desirable due to the complex nature of glaciated landscapes in Canada. It may be useful to consider the applicability of all or part of the concept of simple, complex and compound Land

Systems (Christian 1958), and MEXE Report No. 940 (1966) to assist us in understanding the variations in Land System descriptions that are documented in various parts of the country. Depending on the variety and complexity of a given area, for example:

(1) a Land System may have only one landform and material as its reference base, e.g., an extensive area of lacustrine silts (SIMPLE LAND SYSTEM).

(2) a Land System may be composed of two or more contiguous land systems that, for reasons of scale, cannot be portrayed separately (COMPOUND LAND SYSTEM) - a grouping made merely because of limitations of scale. An example could be a narrow mountain valley that features a pattern of soils and vegetation on outwash deposits, local lacustrine pondings, colluvium, and a distinct zone of alluvial fans, each of which may be mappable in an adjacent broad valley, but in this instance cannot be portrayed separately. Land System mapping units should be symbolized in such a way that the reader can refer readily from the map to the map legend, and then to a more detailed description of characteristics of the components in an attached series of tables and/or charts. The organization and presentation of data will depend in some instances on local or regional conditions.

There are several approaches to data presentation that could be followed: (1) the use of complex symbols on the map to describe many of the features of an area could be employed; or (2) the use of relatively simple map symbols or codes combined with a set of tables and diagrams illustrating the complex of features within each map unit. This latter approach is recommended for the present. If the procedure does not work out too well, then an alternative approach will have to be developed at a later date. The classification and sorting-out of all the physical information that will be generated in the Bio-physical survey is a major task in itself. Problems of keying-in the data and map areas to map reference sheets or map co-ordinates, or physiographic regions, etc., is a task that should be put off until such time as computer storage or related data storage procedures are initiated.

The following points are presented to serve as general guidelines for map and data presentation.

(A) The distribution of land systems on the map should be identified by relatively simple symbols.

(B) At the very least a sketch (or preferably a block diagram or oblique airphoto) should be prepared for each Land System that can be mapped. This sketch should indicate the distribution of the types of soil, vegetation and water bodies with respect to the topographic units of the Land System. (For examples see C.S.I.R.O. Land Research Reports Nos. 1-24 and the illustrations in Sections A-D that follow).

(C) Data on the soil and vegetation characteristics of the land types within each Land System should be summarized and included in a table or series of tables, attached to each sketch or diagram (see C.S.I.R.O. Land Research Reports Nos. 1-24 for illustrations; also Sections A-D that follow).

(D) A general introductory statement should be prepared for each Land System. This brief statement should describe in general terms the composition and structure of the Land System in terms of materials, their origin, textures, depths, topography, range in elevations, etc. (see examples that follow in Sections A-D). General vegetation descriptions and capability ratings for the Land System should also be included.

(E) In this reconnaissance survey we should attempt to estimate in terms of percentages (to the nearest 10%) our decisions as to which land types are dominant within each Land System. This information should be included in the tabular description with the parallel data on soil, materials, vegetation, etc.

(F) It is suggested that not more than 5 or 6 land types (preferably 3-4) be described for a Land System. Minor inclusions should be described only if they are of major importance or are strongly contrasting in characteristics compared to the dominant features of the Land System (e.g. gravel deposits occupying less than 10% of a broad area of lacustrine clays should be highlighted and described as inclusions in the tabular summary). In this type of reconnaissance survey we will have to ignore some of the minor physical variability that we know is present in a given area, and attempt to organize our data in terms of the major land units that will form the basis for management and/or planning decisions.

(G) If the information is available, the capability ratings for various uses (forestry, agriculture, wildlife, etc.) should be included in the summary table for each Land System.

(H) It is recommended that airphoto mosaic maps (rather than topographic maps) be used for land system mapping wherever they can be obtained.

(I) Finally, wherever existing airphoto coverage of an area is of variable scale and of limited use for a rapid reconnaissance survey, it is recommended that every attempt be made to re-photograph the area at a scale of 1:50,000 or smaller (1:60,000 - 1:90,000) before the survey program is initiated.

The figures and tables from the pilot projects (Sections A-D prepared for inclusion in these guidelines by Messrs. Bajzak, Jurdant, Zoltai and Kowall) are good illustrations of the ranges in landscape complexity that can be encountered in various parts of the country. The summaries of the data and the cross-section diagrams give some indications of the difficulties that can arise in trying to set national standards of class limits for some features. For example, the range in elevation for the rather complex Land System in the Manitoba-Saskatchewan presentation is 0-50 feet, whereas the range in elevation within some mountainous land systems in British Columbia can be 1,000-2,000 feet. Clearly in other associated features such as the establishment of class limits for soil depth, the complexity of the landscape from region to region will dictate the degree to which specific class limits for depth set up in one region can be applied with any confidence in another region.

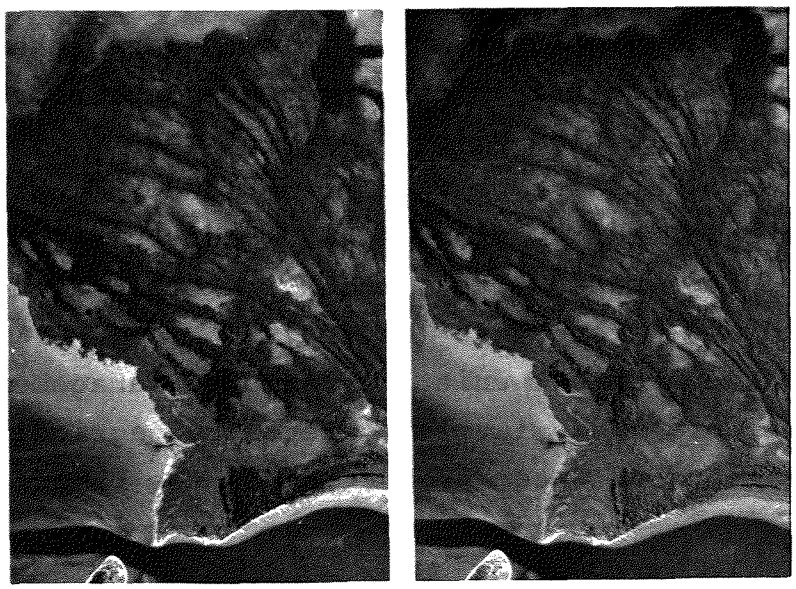
Although the integration of land and water patterns is not discussed in the guidelines, the Manitoba-Saskatchewan report prepared by S. Zoltai in the "Progress Report on Biophysical Land Classification Pilot Projects" (ARDA 1968) is a good illustration of an attempt to combine land and water types in a region where lakes of various sizes occupy a major part of the landscape. "Landscape Units", which are broad groupings of patterns of land and water types (Hills 1966, Anon. 1968), are used to provide a convenient unit for resource management and multiple land use planning, involving forestry, agriculture, wildlife, recreation and water production at the broader planning level.

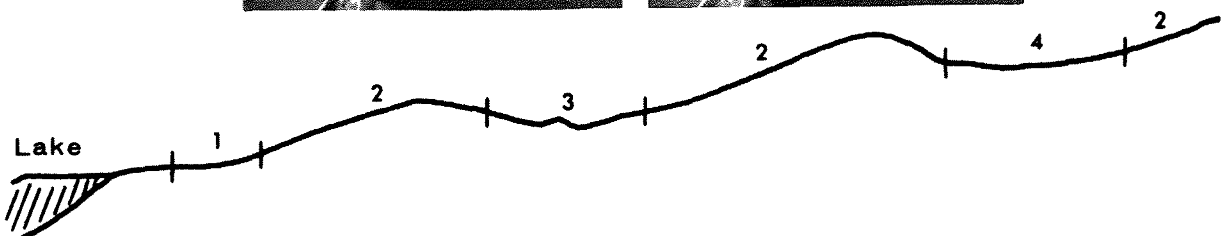
Data and map presentation possibilities, from the simplest to the highly sophisticated, will need further study and evaluation. The continuation of existing projects and the initiation of new pilot projects should lead to the development of procedures and presentations that will be of major use to those concerned with multi-purpose resource management and area design programs.

SECTION A - NEWFOUNDLAND PILOT PROJECT: ILLUSTRATION AND DESCRIPTION PREPARED BY D BAJZAK*

EPINETTE LAND SYSTEM (EP)

Widely spaced raised beach ridges of fine sand with boggy swales, supporting open bogs and mixed forests of black spruce and balsam fir.





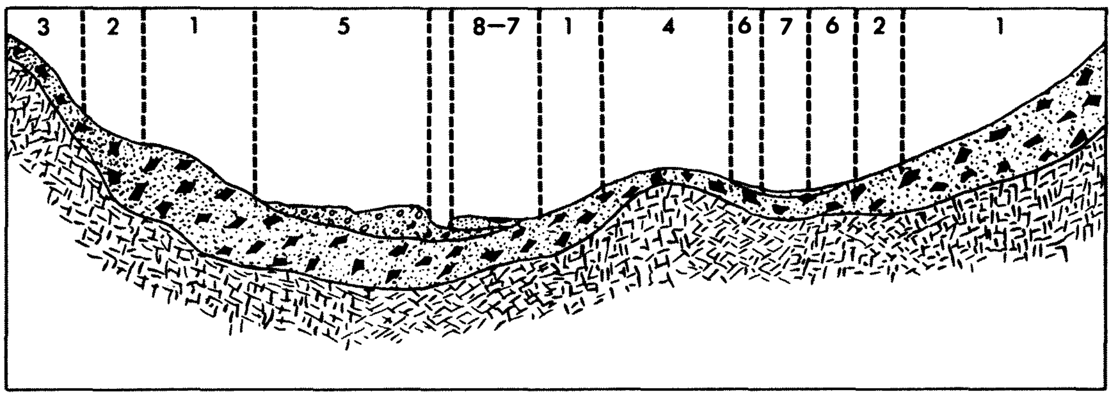
Land Type & Distribution	Soil	Vegetation	Capability Class (forestry)
1) Small wet depressions alongside the lake, 10%	Waterlogged Rego Gleysol	Murica-Alder thicket	71
2) Gentle sloping beach ridges of fine sand, 30%	Well-drained Rego Gleysol	Mixed black spruce balsam fir forest	6F w bS
3) Imperfectly drained depressions between ridges, 20%	Imperfectly drained Rego Gleysol	Open black spruce forest	7F w bS
4) Wet flats between ridges, 40%	Very poorly drained Fenno-Fibrisol	Open bog	7F w

*See BAJZAK, DENES, 1969. Bio-physical Land Classification, Labrador. Internal Report N-13, Dept. of Fisheries and Forestry, St. John's, Newfoundland

SECTION B - QUEBEC PILOT PROJECT: ILLUSTRATIONS AND DESCRIPTIONS SUBMITTED BY M. JURDANT

LAND SYSTEM: L'ABBE : LB

LAND REGION: C
LAND DISTRICT: C-II
GEOLOGY: Granite of Precambrian age
GEOMORPHOLOGY: Valleys 200-500 feet deep in rolling or hilly areas. Slopes covered with till; bottom filled with fluvio-glacial and glacio-lacustrine sediments
ALTITUDE: 500-1600 ft.
VEGETATION: Balsam fir and aspen forests on valley slopes, black spruce-balsam fir forests in wet and/or sandy areas.

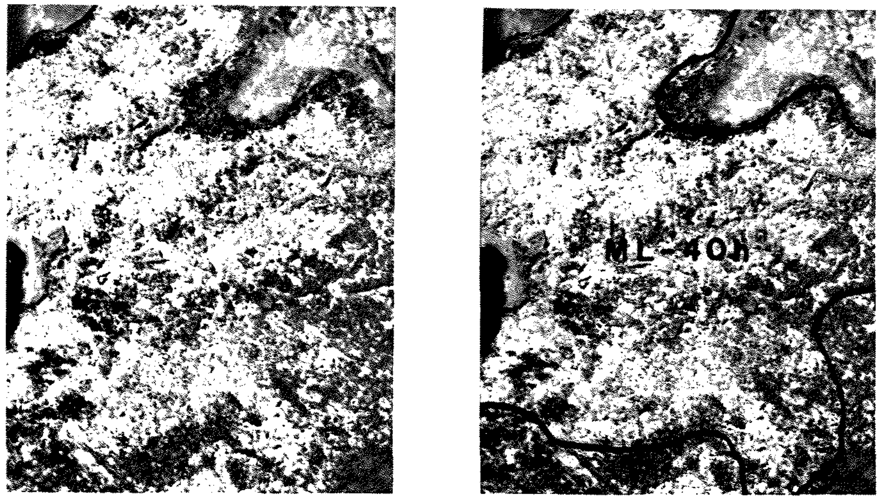


LAND TYPES	%	LANDFORM*	SOIL*	VEGETATION*	LAND CAPABILITY				
					FOREST	AGRI-CULTURE	WATER	RECRE-ATION	WILDLIFE
1	30	1a	br	Pt→BA.d	3				
2	10	1a	lb	Pt→BA.d	3				
3	10	1a-(R)	co	Pt→BlA.t	3				
4	10	1a-(R)	ly	Pt→BA.d	4R				
5	20	2a-2b	ml	KP.t→HP.t→BA.h	4M				
6	10	2a-1F-4a-4c	ec	HP.s→BA.hs	4W				
7	10	4a-4c	ls	SP	5W				
8	inclusions	7a	ba	SP.l - SC	7WF				
9	inclusions	4c-4b	cp	AAl	7W				
10	inclusions	R	mo	BA.hs	6R				

* See P 138-140 in "Progress Report on Bio-physical Land Classification, Pilot Projects April 1968", for Explanation of Symbols Used.

SECTION C - MANITOBA-SASKATCHEWAN PILOT PROJECT: ILLUSTRATIONS AND DESCRIPTIONS SUBMITTED BY S.C. ZOLTAI

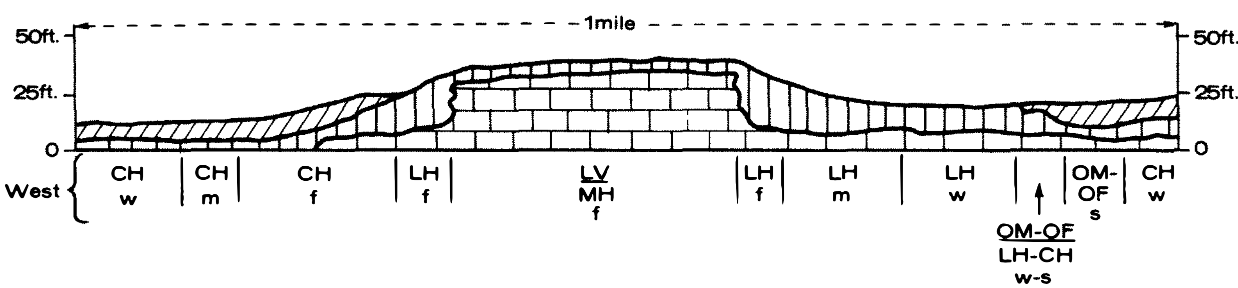
Land System ML-40



Scale 1" = 1 mile (approx.)

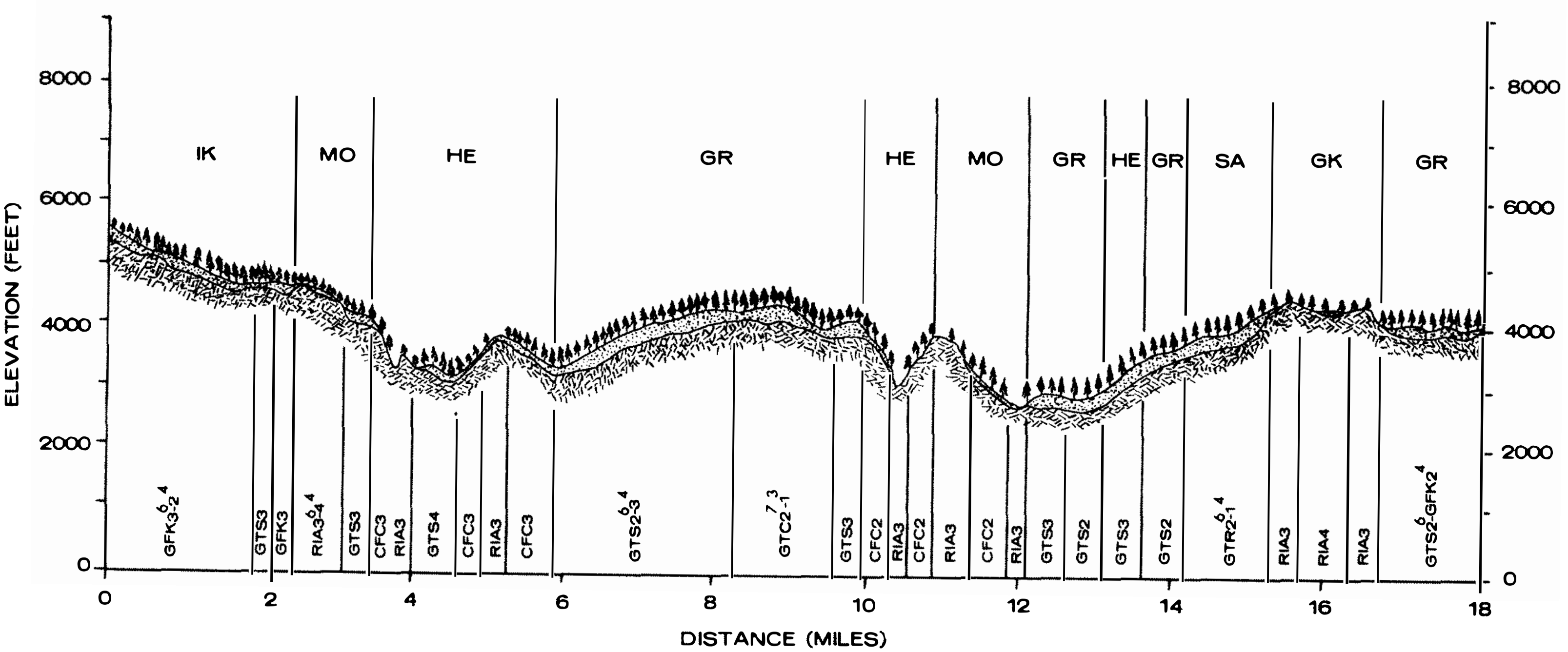
Very weakly broken area of highly calcareous lacustrine clay or clay till (ML-40h), with slopes and low plateaus of deep highly calcareous loamy till and shallow very highly calcareous loamy till over dolomitic bedrock. Minor areas of deep to shallow mesic to fibric peat in some depressions.

EXAMPLE:



Land Type					Soil	Stable veg'n	Common present veg'n	Forest cap'y
Symbol	Material Geologic Material	Moisture	% area West	% area East				
LV/MH f	Very highly calcareous loamy till over dolomitic bedrock	Fresh	25	-	Atikameg rock s.ph.	tA, bS wS	tA, wS or jP	5R
LH f	Highly calcareous loamy till	Fresh	10	-	Atikameg	tA, bS wS	tA, bS or jP	4
LH m	As above	Moist	10	-	Chitek	tA, wS bPo	tA, bS or bS	4
LH w	As above	Wet	10	-	Dering	bPo, bS, wS	bS	5W
CH f	Highly calcareous lacustrine clay or clay till	Fresh	15	-	Wabowden Sipiwesk Kinwow Wanless	tS, wS	tA, bS jP	4
CH m	As above	Moist	5	-	Roe Lake Montego	tA, wS pPo	tA, bS or bS	4
CH w	As above	Wet	15	-	La Perouse Medard	bPo, bS, wS	bS	6W
OM-OF/CH-LH w-s	Shallow mesic to fibric organic matter over clay or loam	Wet to satur.	5	-	Atik Iskwasum Chocolate Farewell	Carex, bS	Carex bS	7W
OM-OF s	Deep mesic to fibric organic matter	Satur.	5	-	Moose Lake Minago Rock Island Hargrave	Carex, bS	Carex, bS	7W

SECTION D - BRITISH COLUMBIA PILOT PROJECT



SECTION D BRITISH COLUMBIA PILOT PROJECT: ILLUSTRATIONS AND DESCRIPTIONS SUBMITTED BY R. KOWALL

LAND SYSTEM: GREGOIRE: GR

Predominantly basal till covered mountain slopes at elevations usually less than 5,000 feet and slopes less than 60%, with the occasional rock outcrop (intrusive, acidic, igneous bedrock). Tree cover consists of lodgepole pine, Douglas-fir, western larch and Engelmann spruce. Pinegrass is found wherever the tree canopy is open. Ratings for soil capability for agriculture include 6T, 7^T_C and 6^T_R with Class 6 varying between 60 to 100% and Class 7 between 0 to 40%. Gregoire land system covers approximately 10% of the area or 37,200 acres.

Symbol	%	Soil Profile Development	Slope	Soil Moisture Status	Material Description	Soil Capability for Agriculture
GTS2	50	Degraded Dystric Brunisol or Gleyed member	10-30%	Moderately well to imperfectly drained	Loose, loam to silt loam slopewash and/or gravelly sandy loam weathered glacial till, 10 to 30 inches in depth, over compact, vesicular, gravelly loamy sand basal till, 10 to 30 inches in depth, overlying compact gravelly sand loam basal till.	7^T_C and/or 6T
GTS3	40	Degraded Dystric	30-60%	Well drained	Loose, gravelly loamy sand colluvium and/or gravelly sandy loam weathered glacial till, 10 to 30 inches in depth, overlying compact gravelly sandy loam basal till; beneath the surface layer may be a compact, vesicular, gravelly loamy sand layer, 10 to 30 inches in depth; bedrock may be found as close as 20 inches to the surface.	7^T_C and 6^T_R and/or 6T
RIA4	10	Lithic Degraded Dystric Brunisol	15-40%	Well drained	Loose, loamy sand or sand loam soils, 4 to 20 inches in depth over bedrock, derived from weathered bedrock and/or weathered glacial till.	7^R_T and/or 6^T_R

LAND SYSTEM: HELLROARER: HE

Usually steep mountainous hillsides less than 4,500 feet elevation with slopes over 20% covered by mainly colluvium and some basal till with rock outcrops (intrusive, acidic, igneous bedrock). Slopes are predominantly southern exposures and have a tree cover of ponderosa pine and/or Douglas-fir. An understory of pinegrass and other grasses and herbs are found where the tree canopy is relatively open. Ratings for soil capability for agriculture include 6T, 6^{T}_{R} and 7^{T}_{R} with Class 6 varying between 60 to 100% and Class 7 between 0 to 40%. The Hellroarer land system covers approximately 3% of the area or 12,200 acres.

Symbol	%	Soil Profile Development	Slope	Soil Moisture Status	Material Description	Soil Capability for Agriculture
CFC2	40	Orthic Regosol-Orthic Dystric Brunisol association	60%	Rapidly drained	Loose, stony or gravelly loamy sand or sandy loam soils of varying depths (usually 20 to 40 or more inches) derived from weathered glacial till and/or weathered bed-rock overlying bedrock or compact, gravelly sandy loam basal till.	7^{T}_{R} and 6T and/or 6^{T}_{R}
CFC3	30	Orthic Regosol-Orthic Eutric Brunisol association	60%	Rapidly drained	Loose, gravelly sandy loam soils of varying depths (usually 20 to 40 or more inches) derived predominantly from weathered glacial till and over-lying compact, gravelly sandy loam basal till or bedrock; lime may be found at a depth of 20 to 40 inches.	6T
GTS3	10	Degraded Dystric Brunisol	30-60%	Well drained	Loose, gravelly loamy sand collu-vium and/or gravelly sandy loam weathered glacial till, 10 to 30 inches in depth overlying compact gravelly sandy loam basal till; beneath the surface layer may be a compact, vesicular, gravelly loamy sand layer, 10 to 30 inches in depth; bedrock may be found as close as 20 inches to the surface.	6^{T}_{R} and/or 6T

LAND SYSTEM: HELLROARER: HE (Continued)

Symbol	%	Soil Profile Development	Slope	Soil Moisture Status	Material Description	Soil Capability for Agriculture
GTS4	10	Orthic Grey Luvisol to Orthic Dark Grey Luvisol	20-50%	Well drained	Loose, gravelly sandy loam colluvium and/or gravelly sandy loam weathered glacial till, 20 to 40 inches in depth, overlying compact gravelly sandy loam glacial till; lime may be found at a depth of 30 to 40 inches.	6T
RIA3	10		Variable	Rapidly drained	Predominantly exposed bedrock with a 0 to 4-inch overlay of loose, loamy sand or sandy loam soil.	7^{R}_{T} and/or 6^{R}_{T}

REFERENCES

Anon. 1967. Field Manual, Land capability classification for outdoor recreation. Canada Land Inventory, ARDA, Can. Dep. Forest. Rural Develop., Ottawa.

Anon. 1968. Progress report on bio-physical land classification pilot projects. Canada Land Inventory, ARDA, Can. Dep. Forest. Rural Develop., Ottawa.

Christian, C.S. 1958. The concept of land units and land systems. Proceedings of Ninth Pacific Science Congress 1957, Vol. 20, pp. 74-81.

Commonwealth Scientific and Industrial Research Organization. Land Research Series Report Nos. 1-22, Various authors, over the period from 1952-1968, Melbourne, Australia.

Hills, G.A. 1959. A ready reference to the description of the land of Ontario and its productivity. Ont. Dep. Lands and Forests, Preliminary Report.

Hills, G.A. 1961. The ecological basis for land use planning. Research Report No. 46. Ont. Dep. Lands and Forests, Research Branch.

Hills, G.A. 1966. The classification of land for multiple use. In Proceedings of National Committee on Forest Land, Can. Dep. Forest., Ottawa.

Holland, S.S. 1964. Landforms of British Columbia, a physiographic outline. Bulletin No. 48. B.C. Dep. Mines and Petroleum Resources, Victoria, B.C.

Kowall, R.C. and G.G. Runka. 1968. Revision of guidelines for bio-physical land classification. Canada Land Inventory, Can. Dep. Forest. Rural Develop., Ottawa.

Lacate, D.S. 1966. Wildland inventory and mapping. Forest. Chron. 42:2.

Military Engineering Experimental Establishment. 1966. Report on the working group on land classification and data storage. MEXE Report No. 940. Christchurch, Hampshire, England.

National Committee on Forest Land. 1966. Proceedings of Meeting, January 26-27, 1966. Can. Dep. Forest., Ottawa.

National Committee on Forest Land. 1967. Proceedings of Meeting, February 7 and 8, 1967, Victoria, B.C. Can. Dep. Forest., Ottawa.

National Committee on Forest Land. 1967. Outline of Biophysical Land Classification - Guidelines for Pilot Studies. Compiled by Subcommittee on Biophysical Land Classification, D.S. Lacate, Chairman. Can. Dep. Forest. Rural Develop., Ottawa. Mimeo report.

National Committee on Forest Land. 1969. Proceedings of Meeting, May 28-29, 1969, Laval University, Quebec. Can. Dep. Fish. Forest., Ottawa.

National Soil Survey Committee of Canada. 1966. Proceedings of Meeting held at Quebec, October 18-22, 1965. Can. Dep. Agr., Ottawa.

Rowe, J.S. 1959. Forest Regions of Canada. Can. Dep. North. Affairs Nat. Resources, Forestry Branch, Bulletin 123, Ottawa.

U.S.D.A. 1951. Soil Survey Manual. Soil survey staff, U.S.D.A. Handbook No. 18.

Vink, A.P.A. 1964. Field investigations and airphoto interpretation for the assessment of soil resources. Int. Training Centre, Delft, Netherlands.

APPENDIX I

REFERENCES FOR OPEN WATER AND WETLAND CLASSIFICATION

Curtis, J.T. 1959. The Vegetation of Wisconsin - An ordination of plant communities. Univ. Wisc. Press, Madison, Wisc.

Dansereau, P. and F. Segadas-Vianna. 1952. Ecological study of peat bogs of eastern North America. Can. J. Bot. 30:490-520.

Dirschl, H.J., A.S. Goodman and M.C. Dennington. 1967. Land capability for wildlife production and utilization in the western Saskatchewan River delta. Report to the Saskatchewan River Delta Development Committee. 233 pp.

Fedoruk, A. 1968. Water body (wetland) types. Canada Land Inventory, Unpublished ARDA Report, Can. Dep. Forest. Rural Develop., Ottawa.

Heinselman, M.L. 1963. Forest sites, bog processes and peat land types in the glacial Lake Agassiz region, Minnesota. Ecol. Monogr. 33:327-374.

International Biological Programme. Project Telma - Classification of peatlands. National Research Council, Ottawa.

Lacate, D.S. 1969. Guidelines for bio-physical land classification. Progress Report. Can. Dep. Forest. Rural Develop., Ottawa.

MacConnell, W.P. and P. Stoll. 1969. Evaluating recreational resources of the Connecticut River. Photogram. Eng. 35:686-692.

Martin, A.C., N. Hotchkiss, F. Uhler, and W.S. Bourn. 1953. Classification of wetlands of the United States. Spec. Sci. Rep. Wildlife. No. 20. U.S.D.I. U.S. Fish and Wildlife Service. 14 p.

Moss, E.H. 1953. Marsh and bog vegetation in northwestern Alberta. Can. J. Bot. 31:448-470.

Moyle, J.B. 1946. Some indices of lake productivity. Trans. Amer. Fish. Soc. 76:322-334.

Mueller-Dombois, D. 1964. The forest habitat types in southeastern Manitoba and their application to forest management. Can. J. Bot. 42:1417-1444.

Ritchie, J.C. 1960. The vegetation of northern Manitoba. V. Establishing the major zonation. Arctic 13:210-229.

Sjors, H. 1959. Bogs and fens in the Hudson Bay lowlands. Arctic 12:2-19.

Stewart, R.E. and H.A. Kantrud. 1969. Proposed classification of potholes in the glaciated prairie region. Saskatoon Wetlands Seminar. Can. Wildl. Serv. Rep. Series 6: 57-69.

APPENDIX II

UTILITY OF BIO-PHYSICAL LAND CLASSIFICATION TO HYDROLOGY

Prepared by W. W. Jeffrey

The Canada-wide Bio-physical Land Classification is oriented towards management of land for a variety of uses. One potential application of the classification is in hydrology. Increasing attention is being paid in Canada to water resources. Land managers have the power of asserting a significant influence upon water yield, regime and quality.

The hydrology of any basin is a function, firstly of climate, and secondly of the landscape within that basin. If precipitation is regarded as input and water yield as output, then the landscape is seen as having the function of a conversion plant. The Bio-physical Land Classification represents an attempt to inventory this conversion plant. To make an inventory of the landscape for hydrologic purposes, a number of alternative approaches are available, of which the present Bio-physical Land Classification is one.

Most of the parameters necessary for the qualitative evaluation of landscape components for hydrology are included in the Bio-physical classification. It is the task of hydrologists to interpret the information collected, both during the classification job itself and after the data become generally available. While at this time no more than a few examples will be given, no hesitation is felt in stating that the classification will be applicable and useful to hydrology and watershed management.

The Bio-physical Land Classification is a reconnaissance survey, based primarily upon aerial photographs, supplemented by ground checks, and adapted to a spectrum of uses. The reconnaissance nature of the inventory inevitably places limitations upon the level of detail of the information collected, which in turn restricts the uses to which the classification may be put. In spite of these restrictions, however, the Bio-physical Land Classification will be of considerable utility to hydrologists and will represent material from which hydrologists will profit. In fact, the availability of this information may give an impetus to some aspects of hydrologic study which otherwise might suffer from comparative neglect.

The classification is based in part upon variation in the geomorpholgy of the landscape, which is broken down into various geomorphological segments at the Land System level. It should be possible for relative (qualitative) ratings to be made of many of these segments with reference to their hydrologic functioning. For instance, an outwash terrace will be seen to have a higher percolation rate and a lower water-holding capacity than, for example, a fine textured lacustrine plain of equivalent depth. This in turn allows some interpretation to be made concerning water yield, surface runoff, flood susceptibility and other factors. Similarly, the disposition and representation of different Land Systems within drainage basins allows some qualitative prediction of their hydrologic behaviour.

The aim of hydrologists co-operating in land classification might be to divide the landscape, in a very general way -- at least initially, into classes having different features in terms of: (a) water yield (b) flow regime (c) water quality - sediment production potential, and (d) water quality - dissolved solids.

The parameters obtained in the inventory which would assist in differentiating landscape components of distinctive water yield potentiality include:

- depth of surficial mantle
- texture of material
- soil morphology
- topography
- soil moisture regime.

Obviously, only an extremely general evaluation of each Land System is possible. Nevertheless, such evaluation is useful.

The parameters listed above also help to characterize units in terms of flow regime. Rating for water yield and for flow regime logically should be done as one step. No implications are made that the parameters listed are all-inclusive. A great many others come into play, as is evident from even the most cursory reflection. It has also to be remembered that the initial, broad rating can be made only of potentiality and not of current yield and regime, since surface condition, history of use, and the nature of the vegetative cover have a profound influence upon the characteristics of water yield and regime.

Exact rating of Land Systems for water quality is also difficult. The various units of the landscape may, however, on the basis of their mineral composition be rated in terms of their potentiality to contribute dissolved solids. Qualitative schemes of rating erodibility (or stability) may also be possible.

In addition to general quantitative rating schemes, there is also a considerable body of information which hydrologists can obtain as part of their co-operation in land inventory teams. Obviously, not only the nature of Land Systems, but their positions within the basin are also important, from the standpoint of runoff contributing areas. Areas where groundwater tables appear close to the surface to provide a larger water source for evapo-transpiration can be recognized, as can major areas of groundwater recharge and discharge.

The Land Types, which are the components of the Land Systems, offer an opportunity to integrate vegetation into the evaluation of the landscape for hydrologic purposes. This is even more troublesome than the evaluation of geomorphology alone but, for instance, it may be possible to recognize units in which paludification may take place following forest removal or units where forest cutting would have a particularly pronounced effect in reducing transpiration.

Hydrologic interpretation of the Bio-physical classification will probably most usefully be oriented towards the descriptions which accompany mapping rather than towards mapping itself. Hydrology is only one of a number of uses of the classification. The fragmentation of units which would result from separate subdivisions being segregated out according to the needs of individual resource uses militates against all but a minimal application of such a procedure.

The extraction of mapping-classification data by computer should be kept in mind. Ready access to data tabulations and summaries should, once the potentialities are realized, give a considerable incentive to hydrologic studies, especially modelling studies, in which geomorphology is a dominant component. A large body of physiographic data is commonly used in hydrology. Availability of geomorphological, and geomorphological - ecological, data should allow companion progress to be made in geomorphological - hydrological inter-relationships.