SCALE

PROCEEDINGS OF CANADIAN FORESTRY SERVICE WORKING GROUP ON SITE CLASSIFICATION

FREDERICTON MEETING

OCTOBER 6, 1985

Compiled by W.D. Holland

Government of Canada
Canadian Forestry Service
Northern Forestry Centre
Edmonton, Alberta
T6H 3S5

December, 1985

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AGENDA

CANADIAN FORESTRY SERVICE

WORKSHOP MEETING OF CFS WORKING GROUP

"Site Classification, Interpretation, and Land Evaluation"

(SCALE)

10:00 a.m. to 5:00 p.m.

October 6, 1985

Keddy's Motor Inn

Fredericton, New Brunswick

Session 1: CFS Regional Review of SCALE
Comparison of methodology, future needs, and direction

10:00	Wil Holland Introduction
10:01 - 10:20	Ed Oswald, PFRC, Victoria Site classification in B.C. and Yukon
10:20 - 10:40	Ian Corns, NoFRC, Edmonton Site classification in Alberta, Saskatchewan, Manitoba, and N.W.T.
10:40 - 11:00	R.A. Sims, GLFRC, Sault Ste. Marie Site classification in Ontario
11:00 - 11:20	Dr. D. Quellet, LFRC, St. Foy Site classification in Quebec
11:20 - 11:40	Herman von Groenewoud, MFRC, Fredericton Site classification in New Brunswick, Nova Scotia, and Prince Edward Island
11:40 - 12:00	W.J. Meades, NeFRC, St. Johns Site classification in Newfoundland

Session 2: Information Exchange

1:00 - 1:30	Wil Holland, CFS, Edmonton Background and objectives of SCALE, current situation in Canada, future
1:30 - 2:00	Charles Tarnocai, LRRI, Ottawa The contribution of soil information and LRRI to development of SCALE
2:00 - 2:30	Jean Thie, LD, Ottawa What the Lands Directorate could contribute to the development of SCALE for forestry
2:30 - 3:00	Mike Brklacich, LEG, University of Guelph A land evaluation model and comprehensive land use information system that integrates the biophysical and social sciences
3:00 - 3:30	Keith Jones, LRRI, Guelph Extension work in site classification with OMNR foresters

3:30 - 5:00 Discussion by CFS Working Group

1. Objectives of SCALE.

2. Why does Canada need SCALE?

   a. Locally; how are site variables such as soil, precipitation, temperature, vegetation, and drainage, etc. used to determine silvicultural prescriptions, forest renewal options, forest management, and development and growth of industry?

   b. Internationally; what is the demand for forest products for which SCALE is needed; i.e. how much pulp and what kind, construction material, hardwoods, etc.?

3. Does Canada need a national system of SCALE or are regional systems adequate?

4. Should there be a comparative study of site classification methods on the same area?

5. What kind of soil (site) manuals does forestry need?

6. What kind of vegetation data, classification, and mapping does Canada need?

7. Can the Working Group develop a set of guidelines for SCALE? Examples:

   a. Use permanent physical features as a SC base rather than vegetation.

   b. Determination of scale of SCALE.

   c. Objectives of SCALE.

   d. The type of base data that can be used for various purposes.

   e. Acceptance of a set of data collection guidelines; standardization, specialization, synchronization, concentration, maximization, and centralization.

5:00 Wil Holland, CFS, Edmonton
Assignment to the Working Group

W.D. Holland
Chairman, SCALE
Canadian Forestry Service
Northern Forest Research Centre
5320 - 122 Street
Edmonton, Alberta
T6H 3S5

Circulated list of participants for CFS Working Groups

The agenda for the October 6, 1985 meeting of the CFS Working Group for SCALE is being circulated to all directors and people named in this list. The meeting is intended as one of information exchange, with an assignment after the discussion. It is hoped that participants will include those interested in site classification, land classification and evaluation, and interpretations for forest land use.

	Research Scientist	Silviculture	Forestry Agreements
PFRC - Victoria	Ed Oswald John Senyk	Jim Arnott	John Edwards or designate
NoFRC - Edmonton	Ian Corns Wil Holland	Ross Waldron Lorne Brace	Mike Heit c/o Steve Price
GLFRC- Sault Ste. Marie	J. Jeglum R.A. Sims Greg Wickware	designate	Robert Haig or designate
LFRC - St. Foy	D. Quellet C.H. Ung	designate	Normal LaFreniere or designate
MFRC - Fredericton	H. van Groenewoud	Gerrit van Raalte (seconded to Ottawa)	H. Oldham c/o Janice Campbell Implement. Officer
NeFRC - St. Johns	W.J. Meades B. Roberts	Jim Richardson (seconded to Ottawa)	John Munro or designate
PNFI - Petawawa	M.B. Weber	designate	
CFS HQs -	Dave Winston		

PARTICIPANTS

Jean-Louis Belair
Canadian Forestry Service
P.O. Box 3800
Ste. Foy, Quebec
G1V 4C7

Mike Brklacich
Land Evaluation Group
University School of Rural
Planning & Development
University of Guelph
Guelph, Ontario
N1G 2W1

Ian Corns
Canadian Forestry Service
Northern Forest Centre
5320 - 122 Street
Edmonton, Alberta
T6H 3S5

J.S. Clark
Director
Land Resource Research Institute
Research Branch, Agriculture Canada
K.W. Neatby Bldg.
Central Experimental Farm
Ottawa, Ontario
K1A 0C6

Herman Van Groenewoud
Canadian Forestry Service
Maritimes Forest Centre
P.O. Box 4000
Fredericton, N.B.
E3B 5P7

Wil Holland
Northern Forest Centre
Canadian Forestry Service
5320 - 122 Street
Edmonton, Alberta
T6H 3S5

John Jeglum
Canadian Forestry Service
Great Lakes Forest Centre
P.O. Box 490
Sault Ste. Marie, Ontario
P6A 5M7

Keith Jones
Land Resource Research Institute
Guelph Agricultural Centre
P.O. Box 1030
Guelph, Ont., N1H 6N1

Donald G. Leckie
Petawawa National Forestry Institute
Chalk River, Ontario
K0J 1J0

Joe Lowe
Canadian Forestry Service
Petawawa National Forestry Institute
Chalk River, Ontario
K0J 1J0

Bill Meades
Canadian Forestry Service
Newfoundland Forest Centre
P.O. Box 6028
St. John's, Newfoundland
A1C 5X8

Tom Moore
Canadian Forestry Service
Maritimes Forest Centre
P.O. Box 4000
Fredericton, N.B.
E3B 5P7

Ed Oswald
Canadian Forestry Service
Pacific Forestry Centre
506 Burnside Road
Victoria, B.C.
V8Z 1M5

Steve Price
Canadian Forestry Service
Northern Forest Centre
5320 - 122 Street
Edmonton, Alberta
T6H 3S5

Gerrit Van Raalte
Canadian Forestry Service
Maritimes Forest Centre
P.O. Box 4000
Fredericton, N.B.
E3B 5P7

PARTICIPANTS

Bruce Roberts
Canadian Forestry Service
Newfoundland Forest Centre
P.O. Box 6028
St. John's, Newfoundland
A1C 5X8

Clay Rubec
Lands Directorate
20th Floor, Place Vincent Massey
351 St. Joseph Blvd.
Hull, Quebec
K1A 1G5

John Senyk
Canadian Forestry Service
Pacific Forestry Centre
506 Burnside Road
Victoria, B.C.
V8Z 1M5

Richard Sims
Canadian Forestry Service
Great Lakes Forest Centre
P.O. Box 490
Sault Ste. Marie, Ontario
P6A 5M7

Charles Tarnocai
Land Resource Research Institute
Agriculture Canada
K.W. Neatby Building
Central Experimental Farm
Ottawa, Ontario, K1A 0C6

Chhun-Huor Ung
Canadian Forestry Service
Laurentian Forest Centre
P.O. Box 3800
Ste. Foy, Quebec
G1V 4C7

Ross Waldron
Canadian Forestry Service
Northern Forest Centre
5320 - 122 Street
Edmonton, Alberta
T6H 3S5

Dave Winston
Canadian Forestry Service
19th Floor, Place Vincent Massey
Ottawa, Ontario
K1A 1G5

Richard Zarnovican
Canadian Forestry Service
Laurentian Forest Centre
P.O. Box 3800
Ste. Foy, Quebec
G1V 4C7

Steve Zoltai
Canadian Forestry Service
5320 - 122 Street
Edmonton, Alberta
T6H 3S5

Minutes of CFS Site Classification Working Group Meeting

Date: October 6, 1985, 10:00 hrs.
Location: Keddy's Motor Inn, Fredericton, N.B.

Chairman: W. Holland, NoFC
Secretary: D. Winston, CFS-HQ

1. Introduction by Chairman
   Proceedings will be prepared for internal CFS, DOE, Agriculture Canada distribution.

2. Speakers on CFS Research
   (a) E. Oswald PFC

   Spoke on classification system for Yukon which attempts to stratify plant communities and examine vegetation changes due to regional climate and topography interactions. He suggested that there is a need for a Canadian wide network of plots. In discussion Sims supported a concept of Bench- mark sites, possibly in collaboration with the Remote Sensing Working Group and the Acid Rain permanent sample plots. Leckie suggested that these plots could be flown with Large Scale Photography (LSP) for permanent monitoring.

   (b) I. Corns, NoFC

   Described the Biogeoclimate zones developed in Alberta for use in the Integrated Resource Inventory Program. The work on developing an Ecological Land Classification for Banff-Jasper has been published. Latest work has involved the development of a Field Guide for Resource Evaluation in Alberta. This work has 900 permanent sample plots. Sites will be evaluated for factors such as optimum season of harvest, site preparation intensity, soil compaction hazard, erosion hazard, reforestation species and method, frost heave hazard, vegetation competition hazard etc. There is a need to stratify information within a regional context.

   (c) R. Sims, GLFC

   Briefly described the past history of site classification work in Ontario, including Polonski's yield tables and Hills Physiognomic Site Classification. Work is currently underway in Ontario by Prof. Carmean (Lakehead University), by Prof. Carleton (University of Toronto) and by CFS (GLFC) and LRRI. In cooperation with OMNR, the CFS and LRRI have developed the Forest Ecosystem Classification (FEC). This work was initiated in 1979 in Northern Region Clay Belt, in 1983 in North-central Region and in 1985 in North-western Region.

Jeglum reported that the Clay Belt FEC (during 1979-84) was completed at a cost of approximately $350K through the combined efforts of research and management foresters.

Jones reported that Algonquin Region is now initiating a Soil-Site Study similar to an FEC. In the Northern Region, the FEC work is being extended into a Prime Site Iventory of Inherently Productive Sites. This will involve an intensive examination of soil cirteria, an interpretation of existing soil surveys and a detailed survey of prime lands.

(d) R. Zarnovican, LFC

Reported that no soil-site classification research is being conducted in Quebec. Jean Louis Belair suggested that there is a need to develop research to relate productivity to site classification.

The Chairman requested Dr. Belair to prepare a list of proposals describing the types of research that should be done.

(e) H. van Groenwoud, MFC

Reported on his method of site classification proposed for widespread use in N.B. This method is now approved under the NRC PILP program for implementation by J.O. Irving Ltd.

There is currently no input into Nova Scotia or PEI by the MFC.

(f) W. Meades and B. Roberts, NeFC

Reported an extensive list of research work requiring action which relate site to land utilization. These include:

- finish assessment on quantity and quality of seepage by forest type and parent material.
- complete assessment of 70km area 15-years after a variety.

  of site interpretations were made on a range of land capabilities following detailed mapping.
- to initiate an operational trial of drainage on fragipans with several different slope positions.
- to write a handbook on logging effects under different conditions of soil/climate.

(g) D. Leckie and J. Lowe, PNFI

Indicated that PNFI's program require a strong link to site classification. These include fire ecology project, the forest management systems project and the remote sensing project. Leckie commented on the need for site classification sytems to be adaptable to the use of remote sensing.

3. Invited Participants.

(a) C. Tarnocai, LRRI

LRRI has been active in the past in the Canada Land Inventory (CLI) and is now conducting soil surveys in forested areas. Welcomes opportunity to cooperate with CFS (see Handout). LRRI is planning to develop a model to predict forest productivity changes resulting from such factors as improved forest management and silviculture. CFS input to this will be very useful.

Meades suggested that there is a need to predict the nutritional status of sites. This requires the use and understandig of indicator plants or other means.

(b) C. Rubec, Lands Directorate, DOE

Described the Working Groups of the Canadian Committee on Ecological Land Classification. These are: 1) Wetlands 2) Vegetation 3) Wildlife 4) Climate. There is an opportunity, if desired, to form a new W.G. on Site Classification.

The new draft map of 200 Ecoregions is now available and regional Ecodistricts are now being mapped.

Lands Directorate has considerable expertise and experience in GIS, and in macro-modelling using inter-disciplinary data systems. Possible future cooperation with CFS could include the Prime Lands Data Base use for National and Regional applications and evaluation of the C.L.I. data base for forestry.

Zoltai elaborated on the Climatic W.G. A preliminary draft map and report is now available showing ecoclimatic regions of Canada. There is a future need to break these regions down to productivity classes using other, additional criteria.

(c) M. Brklacich, Land Evaluator Group, University of Guelph

Described a Land Evaluation System for Ontario which attempts to evaluate land productivity using factors such as climate and land types. It provides a mechanism for determining best alternatives for land use given various social and economic factors (see Handout).

(d) K. Jones, LRRI

Described in detail the extension program on site clssification that LRRI does with OMNR forest managers in Ontario. A new Field Manual for describing soils has been developed.

Discussions and Recommendations

Motion by: E. Oswald - Working Group restricted to Internal CFS

1. Reporting and Monitoring Mechanism - what are we doing; meeting every 2 years?

2. Development of some Commonality for a National Program - do we wish to do this.

   Need for each scientist to better describe their terminology and details of work.

   Need to report on how forest Site Classification inter-relates with Forest Management.

   Site types and potential productivity - a goal of Site Classification systems - need for a model which reflects effects of changing conditions.

   What research is required in Site Classification - can we properly describe factors affecting Site?

Jeglum - What effect will drainage have on productivity?

Senyk - Can we identify representative Zonal forest types across Canada?

Corns - Can we look at 2-3 multivariable approaches in more detail?

Jeglum - Can we define and/or identify research approaches?

- provincial jurisdiction impacts on CFS ability to conduct research.
- GLFRC - is at an end of era of Site Classification - OMNR is now developing the techiques developed, i.e. good technology transfer.
- silvicultural interpretations of site types need to be done, also need to expand relationship between remote sensing and site classification.

Sims:

Future research - silviculture and clasification link.

Manitoba - can it adapt the systems developed by FEC-NW in Ontario or Alberta? Can Ontario Northern FEC be adapted to western Quebec?

Denham Grey, South Africa:

Working Groups - first 3 years served as a Communication link, next 3 years have allowed closer cooperation meetings 1 year apart, first two internally, 3rd is external.

Sims - yes have a W.G., next meeting 12-14 months.

Jeglum - yes have a W.G., next meeting 12-14 months
- emphasize communication links
- suggest 1-day field trip to see work.

Belair - need to document information available that is already published, need for research on basics of site.

Roberts - need for 1-year meeting

Meades - need for 1-year meeting, proposes each Establishment reply to Holland's questions.

Senyk - need to keep going..

Rubec - need for communicating internally.
- need budget and responsibility of a specific task for national benefit, e.g. terminology.

Oswald - yes meet in summer.
- evaluation major concern.
- bench mark plots essential.

Leckie - need to look at evaluation research needs. Forest management requirements are changing.

Waldron - Scientists should say if want W.G.

Price - try W.G.

Corns - need for meeting.
- research and communication.

Holland - please answer questions.

Meeting Adjourned 18:15 hrs. by Chairman.

Introduction

W.D. Holland

NoFC, Edmonton

Welcome to the first meeting of the CFS Working Group on Site Classification. You have been invited to this meeting because of your interest in site classification work, and because of your ability to provide input. It is your input that is being sought in order to present CFS Headquarters with a report that will guide them in future site classification work in Canada.

A quick definition of SCALE is in order. I believe that the earth science and ecological disciplines must include more than the taxonomic effort that goes into site classification. Interpretation of site classification, site productivity, and economic land evaluation rank as most important aspects of our work. Hopefully, this importance is reflected in today's agenda and the acronym SCALE. SCALE was chosen to represent site classification, interpretation, and land evaluation.

The objectives of the first meeting of the CFS Working Group on site classification follow:

1. A CFS regional review of SCALE, including a comparison of methodology, future needs, and direction (see Session 1 of today's agenda).

2. An information exchange (Session 2 of today's agenda).

   1) We want to know about the different SCALE systems in use or being developed in Canada.

   2) We want to know about SCALE work that is being done outside of the CFS; i.e. other federal and provincial agencies, etc.

3. We want to know what is needed in SCALE.

4. We want to make a Working Group recommendation for future action on SCALE work in the CFS.

5. The final report to CFS Headquarters is due by December 1986, but an earlier report is desirable in order to secure feedback.

6. A copy of today's presentations is requested by December 1, 1985 in order to provide a proceedings of today's meeting.

7. The Working Group is asked to prepare a set of recommendations TODAY for presentation to CFS Headquarters.

8. Today's recommendations will be organized and distributed to the Working Group by October 25 for comments from Working Group members. Comments on recommendations, discussion, and opinion to be returned to the chairman by December 1, 1985.

SESSION I

CFS Regional Review of SCALE

BIOGEOCLIMATIC SITE CLASSIFICATION

By E.T. Oswald

Introduction

In essence, biogeoclimatic site classification began in Yukon in 1975 when a survey was conducted to map and describe the ecoregions at a scale of 1:1,000,000. Before getting into the details of our procedure, it may be worthwhile to briefly discuss some of the concepts of site as they are conceived to pertain to northern and western Canada, in essence the cordilleran area. In this area, the regional climate and gross topography interplay to have the primary influence on site, both in terms of productivity and in development of its components such as vegetation, soil, moisture regime, etc. (Figure 1). Though the regional climate can be viewed as a large blanket descending on the topography, the topography has such a strong influence on governing storm tracts and intensities that it becomes meaningless to attempt separation of these factors. The climotopographic regions can be divided into landscape units based on whatever criteria is appropriate to derive more homogenous components. The landscape units consist of relatively large pieces of terrain comprising complete ecosystems, including both land and water components, and an associated subregional climate. For the purposes of site classification, we are primarily interested in the land component since that is where most of the vegetation is growing. This can be further subdivided into somewhat more homogeneous units based on surficial materials, and further divided into sites based on other physical factors such as elevation, aspect, or slope, each segment of which has its own climate. A site then is a relatively small piece of landscape composed of a segment of land homogeneous in physical characteristics possessing a uniform climate and capable of supporting vegetation.

The site is definable by the sum total of its component parts, some of which are indicated in Figure 1. These can be divided into independent (soil texture, slope, aspect, elevation, etc.) and dependent (vegetation, fauna, microclimate, nutrient flux, soil development, etc.) components. The independent components are relatively stable, and measurements of a definitive nature can be made. The dependent components can change over relatively short periods of time, often largely associated with changes in vegetation. The extent, rate, and time of change can potentially vary considerably from one site to another depending on the degree of dissimilarity among the sites. These parameters can usually

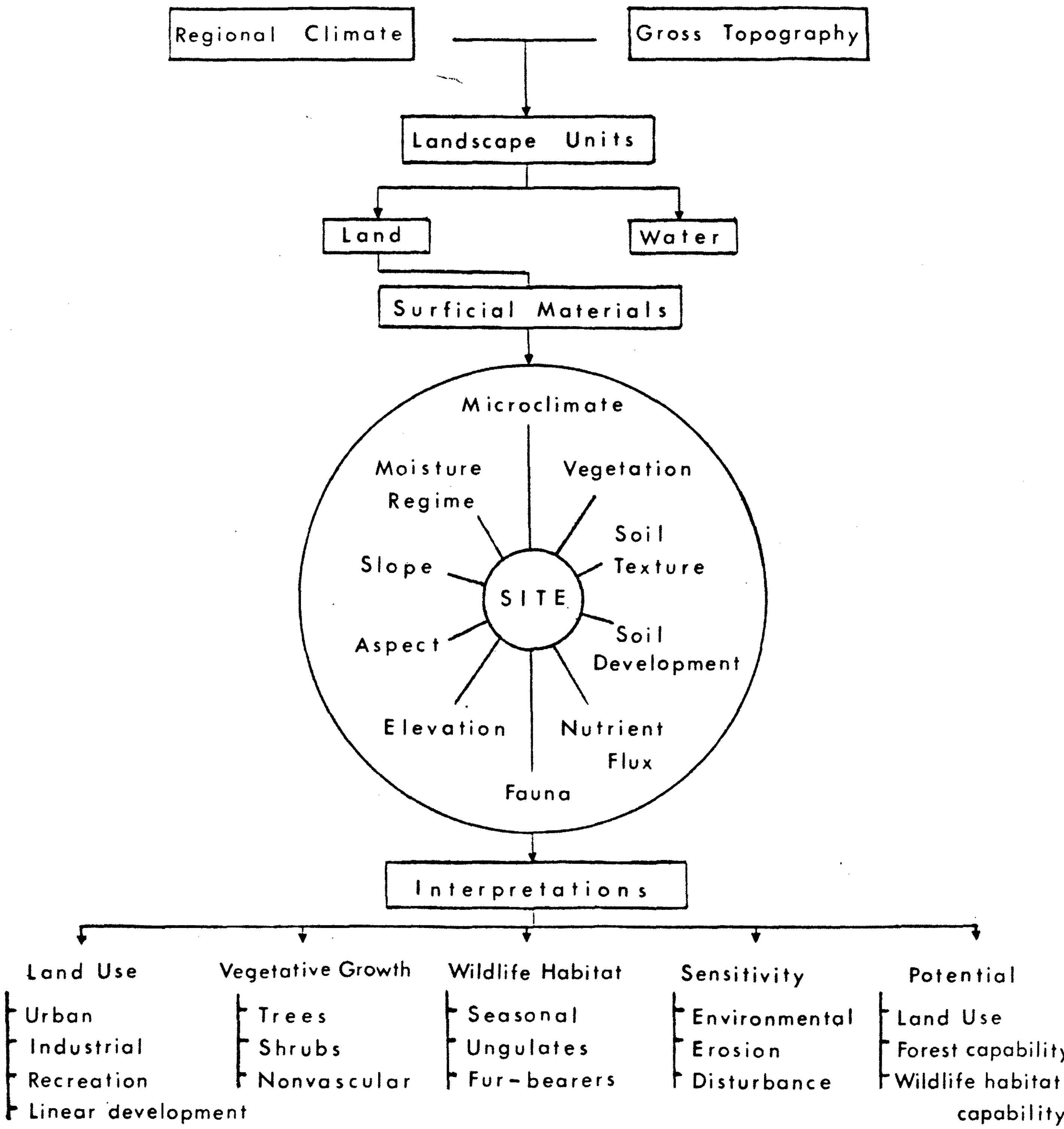

Figure 1. SITE IN RELATION TO ENVIRONMENT

be measured, but require periodic remeasurement to maintain current-status data. Some factors may change, sometimes drastically so, over relatively short periods of time (decades). A primary factor that can cause change is vegetation succession; as the vegetation proceeds from early to late seral stages, the fauna, microclimate, and nutrient flux change with it, especially in shrublands and forests. Some factors may change more or less synchronously with vegetation development, while other factors, such as soil development, may be much slower.

Consequently, a site is not a static entity in consideration of the sum total of physical and biological components, but most often only the more stable physical components are recognized in definitions for classification and mapping. These units serve as a firm basis onto which the dependent parameters can be superimposed, and modified as required to maintain current data status. The site also serves for extrapolating data from one area to another, and for making a wide variety of interpretations about the site and landscape on which it is located.

Methodology

Subsequent to defining ecoregions, procedures were developed for more refined classifications at scales of 1:250,000, 1:100,000 and 1:50,000. Any sample is site specific; the scale of mapping is relevant only to the interpretations made on the site specific data and usually to the density of sampling. The Ecological Land Survey hierarchy (ecoregion, ecodistrict, ecosection, ecosite, ecoelement) provides a convenient framework for focusing on progressively more homogeneous pieces of the landscape. Though the type of data collected remains much the same, the sampling density/intensity must necessarily increase progressing down the hierarchy so that samples occur on representative pieces of the landscape (sites). It would, however, be virtually impossible, and impractical for that matter, to sample every conceivable site within any given unit. Rather, attempts are made to sample modal or representative types based on geomorphology and vegetation (Figure 2).

Plot Number ________ MEASURED BY ________

LOCATION ________

DATE ________ U.T.M. GRID ________

PHOTO ________ N.T.S. NO. ________

LATITUDE ________ LONGITUDE ________

ELEVATION ________ m SLOPE ________ % ASPECT ________

STAND HISTORY ________ PRESENT LAND USE ________

BEDROCK ________ DEPTH TO ROOT RESTRICTING LAYER ________ cm

TERRAIN CLASSIF. ________

SLOPE LENGTH ________

SOIL CLASSIF. ________

SOIL PHASE ________

DEPTH OF ACTIVE LAYER ________ cm.

PERMAFROST (YES, NO) DEPTH: ________ cm.

SOIL DRAINAGE
1 VERY RAPID
2 RAPID
3 WELL
4 MOD. WELL
5 IMPERFECT
6 POOR
7 VERY POOR

MOISTURE REGIME
1 PERAQUIC
2 AQUIC
3 SUBAQUIC
4 PERHUMID
5 HUMID
6 SUB HUMID
7 SEMI ARID
8 SUB ARID
9 ARID
10 XERIC

PAR. MAT. CALCAREOUSNESS
1 CALCAREOUS
a WEAKLY
b MODERATELY
c STRONGLY
2 NOT CALCAREOUS

SLOPE POSITION
1 CREST
2 UPPER
3 MIDDLE
4 LOWER
5 TOE
6 DEPRESSION

PERVIOUSNESS
1 RAPID
2 MODERATE
3 SLOW

SEEPAGE
1 ABSENT
2 PRESENT

HORIZON	DEPTH	TEXTURE	STRUCTURE	COLOR	COMMENTS

VEGETATION TYPE ________

MAJOR SPECIES AND PERCENT COVER: ________

LC 101

TREE COVER BY SPECIES ________

________ TOTAL TREE COVER ________ %

AVERAGE TREE HEIGHT ________ m. DIAMETER ________ cm

WEDGE PRISM POINT SAMPLES B.A.F. ________

SPECIES			SPECIES			SPECIES		
BASAL AREA = m^2/ha			BASAL AREA = m^2/ha			BASAL AREA = m^2/ha		

FOREST CAPABILITY (EST.) ________

SAMPLE TREES

NUMBER	SPECIES	DIAMETER AT 1.3 m.	AGE AT 0.3 m.	HEIGHT	HEIGHT CLASS

FACTORS LIMITING TREE GROWTH
1 EXPOSURE
2 SOIL MOISTURE DEFICIENCY
3 SOIL MOISTURE EXCESS
4 IMPERMEABLE LAYER
5 SHALLOW TO BEDROCK
6 PERMAFROST
7 OTHER ________

COMMENTS ________

Figure 2. PLOT DATA CARD

Sampling primarily consists of assessing and comparing parts of the physical and biological components of sites. Landforms or surficial materials are identified, along with the measurement or estimation of such site features as slope, aspect, elevation, soil texture, soil development, and moisture regime. The vegetation is analyzed by measuring or estimating the cover of each species and strata, and the heights of woody plants. From these data, a community or association name is determined, the successional status estimated, and a possible potential (climax) association indicated. On forested sites, tree growth is assessed by determination of species, ages, heights, diameters, basal area, and mean annual increment. Particular attention is given to white spruce and lodgepole pine in the Yukon since they are the preferred harvestable species, but black spruce, alpine fir, and aspen are usually included. Balsam poplar, paper birch, and tamarack rarely occur in sufficient quantities on any one site type to allow meaningful measurement.

Climate presents one of the biggest problems in terms of assessment, yet has a dominating influence on the site. Data are obtained from surrounding meteorological stations, which are virtually all located in urban areas, most often in broad valleys and near lakes or rivers, and from interpretive reports. Since the Yukon and British Columbia are mountainous, the meteorological data have limited application to most of the upland terrain. Temperature inversions are common which further complicates extrapolation of data. Melting of seasonal frost can maintain a relatively moist soil throughout much or all of the growing season on some sites that would otherwise be dry. Because of these complicating factors and the absence of site specific climatic data, inferences about climate are made based on vegetation and soil data, though often we are trying to compare these parameters from one site to another; therefore, we are using vegetation to compare vegetation or soils to compare soils without a definable base.

The collected data are entered into a computer storage and retrieval system. This system has very limited manipulative capability, but does assist sorting types for analysis and certain groupings can be done. The primary analyses conducted to date have been concerned with tree growth and grouping sites by vegetation type and landform, though some analyses have been done in relation to wildlife habitat and recreation capability. Another system, called Yukon RRAMS, is designed for storage and presentation of areal data. A link between the two systems needs to be developed that will permit areal presentation of the site data in relation to the ELS hierarchy.

The data are used in forest survey mapping by the Yukon Lands and Forest Service, for the national forest inventory by the Canadian Forestry Service, in wildlife habitat assessments by the Yukon Territorial Government, Dept. of Renewable Resources, and by park planners for recreational development.

Future Needs and Direction

A more indepth look at sites is required to disclose the factors that influence productivity and how to quantify these factors under survey conditions. For example, it seems that once a forest stand is cut, the succeeding stand often has a much lower productivity than the previous stand. What factor(s) of the site cause this to happen, and how can it be reversed? Do we really have an adequate handle on site factors sufficient to allow prediction, controlled manipulation, and evaluation based on the parameters that are commonly measured? Seems that there is much work to be done on identifying, measuring, and evaluating site parameters to see what limits their range of activity, how they interplay to produce the effects we see, and how they can be modified to produce the effects we would like.

The development and adoption of national guidelines for recognizing and measuring controlling parameters, conducting analyses, and making interpretations have several merits. Perhaps the more prominent merits are improved comparisons of data across Canada and communication from a common platform. On the other hand, the guidelines must not be so stringent that variations in procedures can not be made for specific areas or situations. It may be necessary to modify or update the guidelines periodically as new information is obtained.

One event that may aid both situations indicated above is the establishment and maintenance of "benchmark" sites. This would entail construction of a network of sites across Canada with representation of as many site types as possible, with the collection of a minimum set of data in a prescribed manner and placing the data in an appropriate accessible registry. Such plots would serve as a comparison of site quality or productivity across Canada and for various purposes, form a reference base to which other plots could be related, form baseline data for monitoring change in any dynamic site component, e.g., vegetation succession, soil development, climatic change, and nutrient flux, and serve as educational material for scientific meetings, school systems, and the general public. The establishment of such plots would entail an initial expenditure of time and money to obtain a description of the site, after which monitoring would be conducted as deemed relevant to the site and parameters of concern.

EO:bb

Site Classification in British Columbia

J.P. Senyk

A system of ecosystem (site) classification based on the work of V.J. Krajina has become well entrenched in British Columbia.

The Biogeoclimatic Ecosystem Classification modified from Krajina by the B.C. Forest Service and in operational use in a number of Forest Regions throughout the province is based on the assumption that macroclimate strongly influences vegetation distribution and soil development. The classification is hierarchical with several interrelated levels of integration and deals primarily with three components - climate, vegetation and soil (including landform characteristics).

Levels of Classification (utzig et al, 1983)

Climatic Regions are based on very broad climatic patterns as expressed by differing vegetation sequences.

Biogeoclimatic Zones are defined as above, except climatic characteristics are more closely defined (relatively homogenous). These zones are named after the dominant climax tree species.

Biogeoclimatic Subzones are subdivisions of zones based on defined climatic (more homogenous) characteristics (variations in seasonal temperature and precipitation amount and distribution) and specific elevational sequences of ecosystems. Each biogeoclimatic subzone has a characteristic ecosystem made up of a plant association and soil which occurs on zonal sites (a site which best reflects the macroclimate in the subzone). The shade tolerant or climax tree species are used to name the subzone.

Biogeoclimatic Variants are further refinements of subzones based on minor climatic differences reflected in ground vegetation and/or tree species.

Edatopic Grid

The range of soil characteristics within a subzone are depicted schematically on a grid with soil moisture regime and soil nutrient regime forming the two axes. This (edatopic) grid potentially portrays all possible combinations of soil moisture and nutrient status.

The grid is broken into a series of "fields" called ecosystem or site associations which are vegetation types with similar moisture and nutrient status. These ecosystem or site associations, named after one or two diagnostic plant species, are further subdivided into site series and site types (named after diagnostic combinations of plant species and landform type). It is at this level that management interpretations are made.

Field guides for the identification and interpretation of ecosystems are being developed for the various Forest Regions in the province. Field examination in company with the field guide and biogeoclimatic subzone map provides a fairly precise means of locating oneself within a particular portion of the "Edatopic" or soil moisture - nutrient grid

Site Variables

Soil moisture regime (1) is assessed on the basis of slope position, soil texture, depth of surface organic layers, depth to impermeable layer, slope gradient and indicator plants.

Soil nutrient regime (2) is assessed on the basis of coarse fragment type (bedrock origin), slope position, soil texture, soil color (O.M. content) and depth of impermeable layer.

(1) Soil moisture regime refers to moisture available to vegetation during the growing season (May to September).

(2) Soil nutrient regime refers to the availability of nutrients (cations) for plant growth.

Interpretations

Based on these identified characteristics, a number of management interpretations have been developed to date:

1. recommended tree species
2. stocking levels
3. prescribed burning
4. grass seeding
5. drainage requirements
6. windthrow hazard
7. relative forest productivity
8. brush hazard sites

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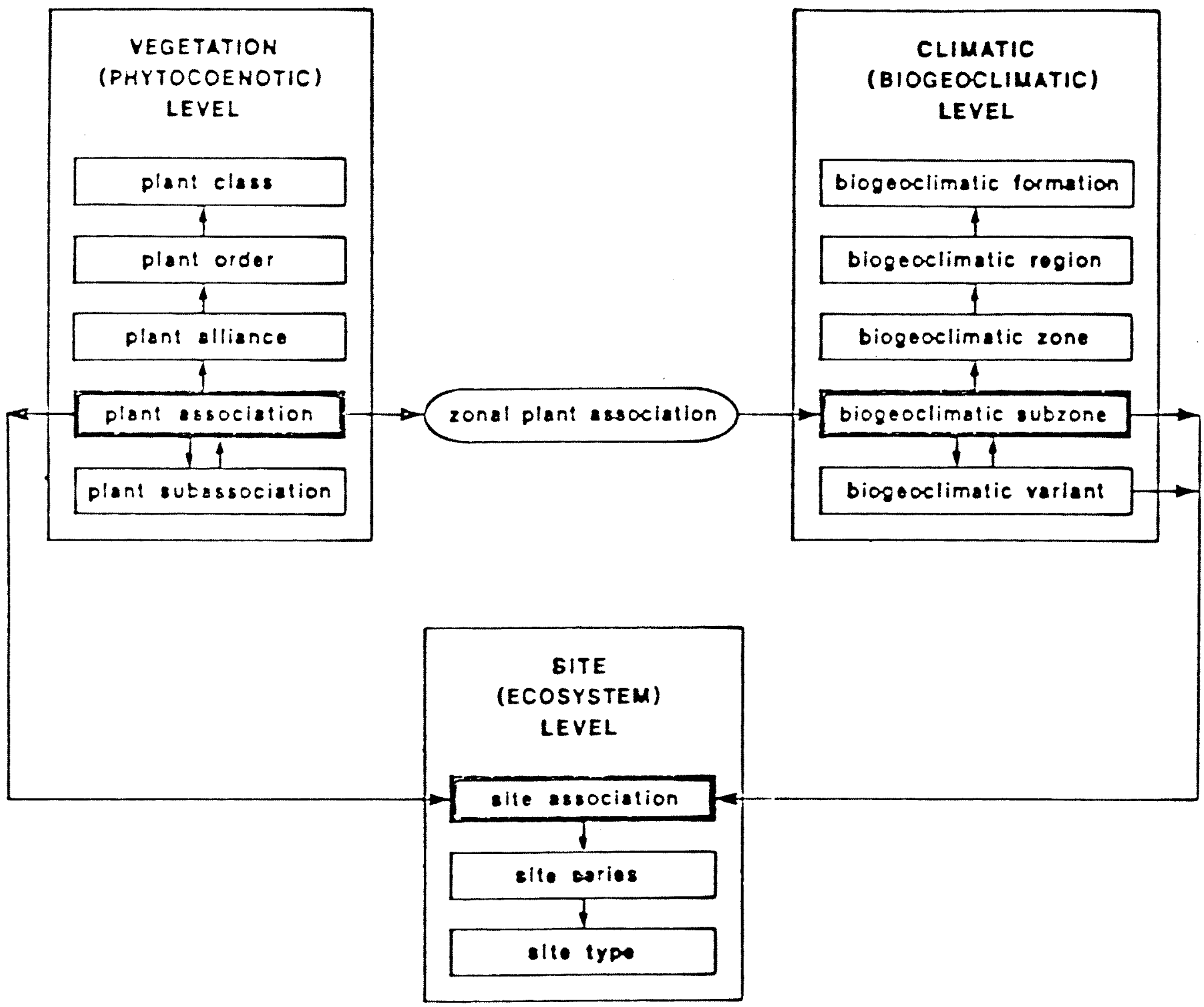

Levels of Integration (Pojar, et al, in press)

Forest Site Classification in the Western and Northern Region

by

I.G.W. Corns

Work on forest site relationships in the Western and Northern Region (Alberta, Saskatchewan, Manitoba and the Northwest Territories) is probably less plentiful in this region than in any other region of the country, due in part to the relatively recent (i.e. in the last 30 years) demand for large amounts of forest products. This review concentrates on studies relating forest productivity and composition to some aspects of the environment and does not dwell at length with studies that are mainly descriptive nor those focusing on broad scale inventories of forest resources, although it is recognized that such inventories and descriptive reports may often provide a focus for more detailed studies.

The review deals with the region by province, and identifies the focus of the study and classifying criteria considered such as climate, floristic composition, soil and physiographic properties, foliar characteristics and whether or not mapping was attempted. These classification categories are analogous to those used in the review by Rennie (1963). A thorough review of forest site classification activities in Canada prior to 1972 has been compiled by Burger (1972).

Alberta

Some of the earliest work in the western boreal forest was done by Brinkman (1931, 1936) in Alberta using lichens and mosses as site indicators. Smithers (1956) assessed site productivity in dense lodgepole pine stands in the Kananaskis Forest Experiment Station, Alberta, on the basis of physiography, moisture regime and parent material.

Heringa and Cormack (1953) related lodgepole pine site index to soil parent material, texture and vegetation cover in central Alberta. Horton and Lees (1961) described black spruce silvics and site relationships in the Alberta foothills. Similar studies relating height growth of dominant trees to landform, vegetation, and soils were conducted in southwestern Alberta by Jeffrey et al. (1968). A physiographic classification based upon aerial photo interpretation was the basis for assessing total volume production on land units of the St. Regis (Alberta) lease (Gimbarzevsky 1964). Duffy (1964) used multiple regression techniques to find relationships between site factors and growth of lodgepole pine in the Alberta foothills and in 1965 he developed a forest land classification for the Mixedwood section of central Alberta on the basis of differences in soil parent material and soil moisture status as they influence white spruce site index.

Several authors have attempted to use soil survey reports to evaluate site productivity. Crossley (1951) had only very limited success in interpreting soil productivity relationships in a soil-surveyed subalpine area of southwestern Alberta. Duffy (1962) was able to show differences in merchantable volume between two soil series in western Alberta and was optimistic about the utility of soil surveys for delineating areas for intensive management. Dumanski et al. (1973) used soil survey information to stratify productivity (periodic annual increment) differences between parent materials, soil map units and various physiographic and soil properties. Lesko and Lindsay (1973) classified 15 forest community types and related lodgepole pine and white spruce site index to soil map units and soil properties in west-central Alberta.

Corns (1983) similarly related forest community types and their site index and mean annual increment to several environmental factors and Corns and

Pluth (1984) expressed lodgepole pine and white spruce site index and mean annual increment as a function of several soil, vegetation and climate variables using stepwise multiple regression. Forest productivity stratified against reconnaissance soil survey soil associations was also tested. In recent years the provincial government has been conducting integrated resource inventories within Alberta's forests (e.g. Bentz et al. 1984). These inventories have evolved from earlier biogeoclimatic classifications (Kojima and Krumlik 1979).

Most recently, Corns and Annas[1] have developed a field guide to forest ecosystem classification and interpretations for 12 forest management concerns for a west-central Alberta study area.

In addition, many descriptive studies of the vegetation of Alberta have been conducted with varying amounts of soils data included. Reconnaisance soil surveys are available for much of the southern and central Alberta boreal forest.

Saskatchewan

A study by Losee (1942) that ranked the forest productivity of six physiographic classes was among the earliest site classification work in Saskatchewan. Rowe (1956) used understory plant species to quantify site moisture regime and mentioned his methods' potential for rating a site's nutrient or climatic regime. Jack pine site index was related to three site quality classes that were defined primarily on understory vegetation (Kabzems and Kirby 1956). Jameson (1965) similarly related jack pine height growth to

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[1] Corns, I.G.W. and R.M. Annas manuscript in preparation, Northern Forestry Centre, Edmonton.

site defined by soil pore pattern moisture regime, and inferred nutrient regime. Van Groenwoud (1965) distinguished three white spruce community types that had characteristic species composition, soil properties, pH regimes and tree height growth.

Site classification methodology for the estimation of potential productivity of large tracts of land mapped at small scale was developed by Zoltai _et al_. (1967) under the Canada Land Inventory land capability classification for forestry as reported by McCormack (1967). The recent published work by Kabzems _et al_. (1976) characterizes the predominant forest ecosystems of the Boreal Mixedwood ecoregion with respect to vegetation, parent materials, soils, productivity and some management concerns. Most recently, Liu (1984) used regression analysis to express productivity, expressed as MAI, as a function of soil texture and drainage, within the provincial forest inventory framework.

Other descriptive accounts of vegetation plus reconnaisance soil survey information is available for much of Saskatchewan's forests. In addition, a number of ecological land classification studies have been conducted as background to assessing wildlife habitat and impact from resource development as reported by Appleby (1979).

Manitoba

Site classification began in Manitoba with the work of Halliday (1935) who elucidated relationships between understory vegetation, parent material and tree growth of _Populus_, _Picea glauca_, _P. mariana_ and _Pinus banksiana_ in Riding Mountain National Park. His widely accepted "Forest classification for Canada" (Halliday 1937) delineated forest regions, later subdivided into forest sections by Rowe (1959, 1972). Local volume tables for

Picea glauca and *Populus tremuloides* were constructed by Jameson (1963) for several combinations of physiographic site type (texture and moisture regime) and cover type. Jameson (1964) constructed empirical yield tables for *Picea mariana* on four groups of physiographic sites in four forest sections in Manitoba and Saskatchewan. Understory vegetation, moisture and nutrient regime were related by Mueller-Dombois (1964) to site index, considerations for potential productivity, choice of species and method for reforestation, and potential for habitat amelioration by drainage in forests of southeastern Manitoba. Subsequently, Mueller-Dombois (1965) provided keys to mapping forest sites based upon landform, parent material, drainage and vegetation. A soil survey covering a 7700 km^2 area of southeastern Manitoba (Smith *et al*. 1964) was used to rate the productivity and regeneration of 13 tree species on 36 soil series.

The potential productivity of large tracts of land was mapped at 1:250,000 during the Canada Land Inventory land capability classification for forestry (Zoltai *et al*. 1967, McCormack 1967). More recently ecological land classification studies were completed at 1:125 000 scale with several pilot areas mapped at 1:6000 (Borys and Mills 1979).

Northwest Territories

Very little work has been concentrated on the evaluation of land for timber production in the Northwest Territories as commercially valuable timber occurs only in the southern Yukon and Mackenzie River valleys (Zoltai 1979). Most ecological land classification studies have been conducted as baseline data for resource extraction (mainly pipelines) and for National Parks. Zoltai (1979) has cited a number of these. Rubec *et al*. (1984) have mapped ecodistricts of northern Canada at 1:1 000 000 scale.

A study of forest types defined on the basis of topography, soils, and vegetation and their relation to tree height growth was conducted by Jeffrey (1964) for the Liard River area.

Summary

I have mentioned over 30 accounts of work where attempts have been made to relate forest growth to site. Is there a thread in common with these studies or is there evidence of an evolution in thinking in studies of site classification? Early studies tended to focus upon attributes of soils, physiography, vegetation or climate and it was unusual to find studies that considered all of these important site characteristics.

During the past 15 years especially, we have seen the development of site classifications and land mapping systems that are more holistic and hierarchical. There is an awareness of the need to stratify the sample population, particularly in regional studies, according to macroclimate and physiography before attempting to ascribe site and productivity differences to soil and vegetation properties. Soil and vegetation scientists across Canada including the Canada Committee on Ecological Land Classification have played an important role here and Canadians are in the forefront in the development of regional site classifications. Such studies, whether they are called biogeoclimatic, integrated resource inventory, forest ecosystem classification, or ecological land classification have certain similarities. I am not suggesting that the value of much of the earlier work is somehow made less valuable. Rather, by now putting these studies within a bioclimatic and physiographic framework, we can supplement our knowledge of particular ecoregions, ecosections and land units at larger scale and we may with a greater degree of confidence, further extrapolate the results of many of these high quality earlier studies.

Successful, future site classification efforts (particularly those of a regional nature) will integrate climate, physiography, soils, vegetation, and perhaps other ecosystem components. Such integration will be necessary to make the classification work cost effective and to serve as a framework for an ever increasing variety of interpretations being demanded including forest productivity, several silvicultural and land management concerns, wildlife habitat, recreation, and even engineering and road construction.

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SOME CURRENT SITE CLASSIFICATION ACTIVITIES IN THE CANADIAN FORESTRY SERVICE

by R.A. Sims

INTRODUCTION

Site classification is recognized throughout Canada as an important area of scientific research and development for forestry. Numerous examples exist in the literature of past investigations in Canadian forest site classification, ranging from small-scale local studies to large, in some cases province-wide, integrative and long-term programs. The Canadian Forestry Service (CFS) has played a key role in some of these efforts. Currently, virtually every CFS regional establishment has scientific staff who are actively involved in the development of forest site classifications or in the utilization, interpretation or enhancement of classifications already in place (Fig 1). There are at least twelve professional staff in the CFS who are presently devoting all or much of their research time to problems of forest site classification. With associated support staff, this is a fair manpower commitment; moreover there are considerable research budgets associated with these current undertakings.

SUMMARIES OF INDIVIDUAL RESPONSES

Within the past three months, a number of CFS researchers with active studies in forest site classification were asked to provide brief notes on their current interests and work. Following is a summarization of the responses received; it is incomplete in some instances, and a few individuals may have been misrepresented or even overlooked. For this I apologize; perhaps we could plan on rectifying these shortcomings and redrafting this short working paper following the first meeting of the

Fig. 1. Range of current CFS site classification activities. Numbers correspond to those in the text in parenthesis after researchers' names.

CFS site classification working group in October, 1985. This is only as a first effort, prepared as background for the working group's first meeting.

W. Stanek, PFRC (1)

Efficient silviculture, including re-establishment of fire devastated stands and regeneration of logged areas, requires silvical and forest environmental information. A field guide for forest ecosystem classification is currently being prepared for stands along the Alaska Highway from Watson Lake to the Alaska border, Yukon Territory. The field guide is destined primarily for use in resource development, and will allow forest ecosystem types to be identified, and their potentials appraised. The guide will contain:

1. A key to ecosystem types using dominant or indicator plant species and soil characteristics.
2. Schematic stand diagrams and soil profiles representative of the types.
3. A scheme to allocate stands to operational groups which combine forest types of similar ecology into practical units.
4. Diagramatic presentation of operational groups as functions of vegetation and several environmental variables and for comparison in a framework of productivity and soil moisture regime.
5. Detailed description of operational groups with emphasis on forestry applications.

6. Keys to identification of soil properties.

7. An illustrated guide to the recognition of plant indicator species.

8. Growth curves for major tree species and their site index estimations.

Present work on the guide is based on vegetation and environmental assessment data collected for the impact assessment of the Foothills Pipelines Ltd. proposal to construct a gas pipeline from Alaska to Alberta, and additional soil and tree-growth data collected since 1978. It is expected the report will be completed during 1985, and available for testing and idea exchange during the 1986 field season.

E.T. Oswald, PFRC (1)

Oswald's work in site classification is centered in the Yukon and for the most part, south of the Ogilvie Mountains where the trees are, with some extension into northern B.C. From 1975 to about 1981, most site classification work was on a reconnaissance mapping level, (1:100,000 or smaller scales). Since then, classification has been done within a particular Ecoregion. In essence, the site classification amounts to measuring or determining site characteristics (elevation, slope, aspect, moisture regime, etc.), landform, tree productivity (mostly mean annual increment), vegetation (to the community or association level), and sometimes soil characteristics (mostly determination of Great Group and subgroup, with texture).

Currently, emphasis is placed in three directions. One involves determining forest productivity within an Ecoregion and relating this to site characteristics. A second thrust is establishing permanent plots on recently burned lands to follow vegetation succession and forest re-establishment. Site conditions are considered in selecting plot locations with the idea in mind of selecting plots on different site types within a given burn. The third thrust is to establish bench-mark forest sites throughout the Yukon. This is in its infancy and the details and procedure need to be worked out yet. The ideal would be to have replicated plots on each site type, but this would lead to an unmanageable number of plots. The criteria for plot establishment is currently under review. The intended purposes of these bench-mark sites are to serve as voucher samples for classification and mapping, to monitor vegetation succession both under current climates and under the expected "greenhouse" climates, to serve as demonstration sites for school systems, the public and scientific organizations, and to serve in other related functions. It is anticipated that detailed soil and vegetation data will be collected from each site, along with physical site parameters, and changes in soils and vegetation will be monitored over time. A computer storage and manipulation system will be designed for analyzing the data.

<u>J.P. Senyk, PFRC</u> (1)

Senyk has been interested and involved in forest site classification work for some time. This interest developed partly as a result of discussions with Yukon people and partly as a result of a few years with the Lands Directorate. The Ecological Land Classification system, at the most detailed levels, seemed to offer a sound basis for forest site identification and Senyk had initiated work in this area prior to having been redirected to the forest "weed" (vegetation) management program.

Although the forest "weed" management program at PFRC is still in its infancy, if it develops as expected, there will be considerable opportunity to study forest ecosystems in their natural and post-disturbance phases. These studies could be ideally suited to researching effects of a variety of management practices on forest site and productivity.

I.G.W. Corns, NoFRC (2)

The following description summarizes Corns' current research activities related to forest site classification and evaluation; he is involved with four projects:

The first deals with forest ecosystem classification and interpretation for forest management in a field guide format for a west-central Alberta study area comprising 3 NTS map sheets. The classification and interpretations were developed in conjunction with the Alberta Forest Service (AFS) Research Branch. The study synthesized data from five ecological and three soil survey studies done in the study area in the past 15 years. A draft has been completed and has been reviewed by several operational foresters in provincial government and industry. The field guide should be published in 1985 if publication funds are secured.

A second project is an illustrated (color plate and line drawing) guide to common Alberta forest plants for the western and northern Alberta area. It is meant to complement the field guide described above and was prepared in cooperation with the AFS Research Branch. The plant guide is currently awaiting publication.

A third project deals with the characterization of highly productive sites (6.0 $m^3 ha^{-1} yr^{-1}$) with the objective of identifying and ranking potentially manageable physical and chemical factors (including micro-nutrients) that may be managed to increase productivity on similar less productive sites. The project is CFS-sponsored and will focus on the central portions of Alberta, Saskatchewan, and Manitoba. To date, several sample plots and analyses have been obtained for Alberta. Plot sampling and analysis will continue in Saskatchewan and Manitoba during 1985-86. The final report should be published in 1989.

The fourth project deals with effects of logging and site preparation equipment on forest soils and subsequent tree growth. Four soil types with a long history of logging are being examined. The study is CFS-sponsored with assistance from St. Regis (Alberta) Ltd. on whose FMA the study is situated in west-central Alberta. Field work is to be completed in summer, 1985 and most analyses are complete. A final report should be published in 1987. Similar work has been done in B.C., the Pacific Northwest, U.S. and in eastern Canada but equipment effects on forest soils and tree growth in our region have not been quantified.

W. Holland, NoFRC (3)

Two major ELC-approach land classification studies have recently been completed: Banff-Jasper Park biophysical survey and Kootenay-Glacier-Revelstoke survey.

R.A. Sims and G.M. Wickware, GLFRC (4)

Current efforts are being devoted to a forest ecosystem classification (FEC) for Ontario's North Central Region. This program was jointly undertaken by the CFS and the Ontario Ministry of Natural Resources (OMNR) in spring, 1983; work should proceed to scheduled completion in 1990.

The FEC program should lead to the development of sets of field keys and guides for identifying and understanding the forest ecosystems of the North Central Region. Additional outputs will be demonstration maps, remote sensing guidelines and keys, and forest management guidelines associated with the FEC types.

To date, work has focussed on the development of the classification itself. During 1983-1985 field programs data was collected throughout the Region on a wide range of forest sites (1300 stands). Datasets from the first two summers have been subjected to statistical and classification-type computer analyses and results have permitted the development of preliminary keys and fact-sheets for both soil types and vegetation types. There are actually two soils keys, one for 100 cm deep soils, and one for shallower soils. The vegetation key is undergoing revision currently, but main assignments to vegetation types are made based on overstory composition with some modification based on shrub and moss cover. There are currently 45 soil types and 36 vegetation types delineated and described.

The keys and fact-sheets were tested in summer, 1985 and a number of revisions will be incorporated into them over coming months. Additional data collected in summer, 1985 are now being placed on computer files for analysis during winter, 1985/86. Plans are underway to initiate mapping and photo-interpretation work in 1986.

Wickware recently coauthored a report on ecosystem classification for the Turkey Lakes Watershed, near Sault Ste. Marie, Ontario [Lands Directorate ELC Series No 18 (1985)], and was previously involved with the Clay Belt FEC study during employment with the Lands Directorate.

J.K. Jeglum, GLFRC (5)

Jeglum participated as a major cooperator in the Clay Belt FEC program during 1979-1983. That multiagency research program culminated in the production of a field guide in 1983 that has since received wide attention and widespread use by Clay Belt foresters. He recently returned from a one year development leave to Finland to study the well established Finnish site classification system; he cultivated a particular interest in the forest management interpretations made by the Finns.

He is currently reworking some of his earlier collected data on Ontario wetlands for physiognomic wetland classification, and amalgamating it with Clay Belt FEC datasets for reanalysis. In particular he is carrying out a thorough objective analysis (classification and ordination) and making interpretations on habitat-vegetation-tree growth relationships. He is comparing the Ontario forested peatland types with Finnish ones in a partly quantitative-partly qualitative manner. Results will include comparisons of vegetational data, and peat chemistry data. As well, he intends to make comparisons of the trophic regimes used in Finland with vegetation types in Ontario.

R. Zarnovican & D. Ouellet, LFRC (6)

A la fin des années 60, il s'est formé au CRFL un groupe de travail multidisciplinaire à qui on a confié le mandat de la classification écologique du territoire. La formation du groupe était la suite de l'implication de plusieurs membres du personnel du CRFL dans les projets du Comité national des terres forestières (CNTF).

Si le groupe a vu le jour, c'est grâce au travail du regretté Michel Jurdant. Les réalisations du groupe, appelé alors "Service des études écologiques régionales", furent spectaculaires et à ce sujet, il suffit de rappeler les projets "Saguenay-Lac St-Jean", "Baie James", "Côte Nord", etc.

En 1975, le groupe du SEER a quitté le CRFL et le Service canadien des forêts pour former une nouvelle direciton au sein de l'Environnement Canada, à savoir la Directionn régionale des Terres. Le départ du groupe a créé au CRFL un vide en matière de la recherche en écologie végétale et particulièrement celle touchant la classificaiton des sites forestiers. Dix ans après, le CRFL n'a pas de projet ni d'étude en cette matière et les réalisations sont nulles.

Durant les dix dernières années, le CRFL s'est tenu à l'écart du développement de la classification de sites forestiers en général; de l'établissement des clés d'interprétation pour la sylviculture ou les pratiques d'aménagement; de la cartographie écologique ou du développement des nouvelles techniques ou des méthodes en écologie forestière.

Selon les orientations perceptibles quant à la recherche en cette matière au CRFL, il n'y a aucune indication qu'il y aura un changement dans un avenir prévisible.

H. van Groenewoud, MFRC (7)

In 1979, Dr. A.A. Ruitenberg (Geol. Surv. Branch, N.B. Dept. of Na. Res.) and H. van Groenewoud (MFRC) initiated the Forest Site Classification Council of N.B. with representation by industry, provincial and federal government, woodlot owners and one private person.

In 1980, Ruitenberg and van Groenewoud proposed a site classification scheme which was tested the year before at the regolith level. This scheme visualized four different levels of division - climatic region, geomorphologic district, regolith system and site type. The Council unanimously accepted the proposal. This proposal was then submitted to the N.B. Forest Research Advisory Council that made funds available for implementation of the scheme. This was to be managed by the Forest Management Branch (FMB) of the N.B. Dept. of Natural Resources. The FMB hired a number of foresters who, since 1981, have been working in four different regions of N.B. The absence of regolith maps (3rd level) caused a slightly different approach to be followed. In an attempt to develop keys for the determination of site class, more or less random samples were computer analyzed following the same methods as the Ontario Claybelt group. As a result of pressure by the Forest Site Classification Council, NBFRAC now is hiring a surficial geologist to do the regolith mapping in selected areas in New Brunswick. Cooperation with the Geological Survey of Canada is being furthered.

At the MFRC, van Groenewoud has been working on multivariate analytical methods and just published a paper on that topic in collaboration with Prof. Ihm of the University of Marburg, Germany. Van Groenewoud is further testing the Decorana and Twinspan programs on hypothetical data, and is also working on the site classification of the Long and Trouser Lake and the Lepreau areas in New Brunswick. One report is expected in spring, 1986.

W.J. Meades, NeFRC (8)

Between 1954-67, A.W.H. Damman developed a comprehensive forest classification system covering insular Newfoundland with the exception of the eastern region. In 1965, Wilton produced the only forest classification for Labrador, which includes correlations between forest types and productivity. In the late 1960s and 1970s several reports using the bio-physical (ELS) land classification approach were produced. These reports used Damman's classification almost exclusively and no new forest types were formally defined by vegetation analysis.

Since 1975, Meades has been working on a study to complete the forest classification of eastern Newfoundland, provide a heathland classification for this region and sort out chronological relationships between forest and heath vegetation. (This study was undertaken as a Ph.D thesis.)

In addition, between 1981 and the present, NeFRC staff have been developing a system of classifying forest land in relation to environmental sensitivity to logging disturbance. Vegetation is not a component of this study.

A proposal has been developed for the technology transfer of the forest classification system to the province and industry. This proposal is being considered for funding under the new forest subsidiary agreement.

In Newfoundland the emphasis in site classification is switching from concerns with correlations with growth and yield to concerns with the dynamics of cut and burnt sites. Although forest site classification formed the backbone of land capability mapping for forestry, there was never a serious effort to correlate the forest site classification and forest inventory.

Most requests now for site assessment involve disturbed sites in terms of "proper" silvicultural management. There is no system to differentiate cutovers other than to type them according to their original forest type. Such typing has limited application because individual types can follow completely different successional trends dependent on the history of disturbance. This past field season (1985) Meades initiated a new study on the vegetation and site classification of cutovers in western Newfoundland.

<u>B.A. Roberts, NeFRC</u> (8)

Since 1967, Roberts has been working on several projects which have utilized and modified existing forest site classification methods. They are as follows:

1. Biophysical/ecological and classification studies were conducted during 1967-1972 in western Newfoundland. Reconnaissance survey of a 1500 sq. mile area was carried out. Damman's (1967) forest site classification was used for vegetation typing and the corresponding soils associated with each vegetation group were modified from the sub-group to the series level.

2. During 1972-73, an operational bio-physical survey of the Badger - Diversion Lake area was conducted using Damman's forest types, and soils modified to the series level. Land types were mapped at a scale of 1:15, 840. Most of the major types in central Newfoundland were identified.

3. Effects of fluoride emissions from a phosphorous plant on the vegetation and soil types of the Long Harbour area, eastern Newfoundland were studied during 1974-1976; several reports were produced.

4. Site classification for budworm and spruce decline impact plots has been studied during 1977 - present. A final report is near completion.

5. Studies of the ecology of Newfoundland soils has led to several main outputs including:

   - a number of detailed soil site papers of which most are cited in the "Biogeography and Ecology of the Island of Newfoundland". Soils, Chapter 4, p. 107-161. This was the first island wide compilation of soils.
   - review of a forest site classification for the boreal forest of central Newfoundland using a bio-physical-soils approach (given in 1984 at IUFRO Symposium in Switzerland).

6. Site classification work relating to eastern larch and red pine has been carried out during 1977 - present and is near completion. Several abstracts and papers have been produced. Robert's Ph.D. thesis was on the "Ecology of Red Pine in Newfoundland".

GENERAL

This summary is effective in making two main points. First, it demonstrates the wide range of current site classification interests and activities within the CFS (not to mention, the existence of considerable cooperative work with other agencies, in particular provincial governments). Second, it indicates there is a great deal of "parallel thinking" by scientists (working in relative isolation from one another) at CFS establishments across the country. Both of these points infer a need for an active working group within CFS on forest site classification. There are areas where commonalities can be recognized and perhaps even national perspective adopted regarding site classification for forestry. Since many CFS site classification scientists are working on different approaches in different areas of the country, and since undertakings are all in different stages of development/finalization, we should all be able to benefit from one another's experiences.

FOREST ECOSYSTEM CLASSIFICATION

JOHN K. JEGLUM

The most important recent classification work in Ontario for forestry is the Forest Ecosystem Classification (FEC) for the Clay Belt in the mid-boreal of eastern Ontario (Pierpoint 1981, Jeglum et al. 1983a, Jones et al. 1983a, 1983b, Jones 1984, Pierpoint et al. 1984). The purpose of this work was to provide a practical forest site classification for forest management in the Clay Belt. The classification encompassed both uplands and forested peatlands, represented in Figures 1 and 2.

The program was aimed specifically at the forest manager, and was carried out at the request of and in cooperation with the Northern Region of the Ministry of Natural Resources. The main requirements defined by this agency were that the classification serve current purposes and needs of practical field forestry, emphasizing regeneration silviculture; that it be simple and rapid to apply in the field; and that it consist of a limited number, e.g. 10 to 15, practical management-orientated groups. Early in the program, a thorough survey was conducted among all practicing foresters in the Clay Belt to determine their perceived needs and requirements, and what they felt to be important site factors and types. It was determined that managers were most interested in information pertaining to regeneration silviculture. They wanted the classification to help them to make decisions such as the appropriate cutting system, the most desirable season of harvest, the most suitable site preparation method following harvesting, the most suitable species and type of stock per type, the potential for using natural regeneration systems, anticipated tending requirements, and so on.

The classification was based on 250 forested stand samples, located on both mineral and organic soils, sampled intensively for vegetation, soils and site, less intensively for forest composition and growth. A TWINSPAN analysis (Hill 1979b) of the vegetation, using presence and absence only, was used to derive 23 vegetation types (VTs). Soils and site data were analyzed in various ways. Discriminant analyses were done for subsets of stands on mineral soil and organic soil. TWINSPAN was also used to derive a classification of 14 soil types (STs), but this was not an essential part of the classification.

It was decided at this point to merge the vegetational and site type data. Twenty-three VTs were too many for the practical operational groups. Hence, some of the VTs were combined if they had similar soils and vegetation. In other cases VTs were divided into two or sometimes three units, based on the selection of important boundaries of soil or site features found to be important in the discriminant analysis, important to some aspect of forest management, and easy to recognize in the field. In this way, 14 operational groups (OGs), two of which are rather poor and often unmerchantable, were recognized.

The classification features a key which can be used to key out a site in the field rapidly to one of the 23 VTs, and then to one of the 14 OGs. It is cautioned that the key should be applied only in forested sites in the Clay Belt; it may not be valid outside this biogeoclimatic area. It is also cautioned that the key does not always work optimally in its dichotomous splits, and there are misclassifications at certain levels of the divisions, particularly the higher level ones. Three reasons account for this: (1) To make it easy for the field man to use the key, only a maximum of seven species were allowed at any one division. (2) Only presence/absence data was used. (3) The data contained much heterogeneity, because it was for the whole range of upland and lowland forests. It is advised that after a VT has been keyed out, the actual stand be compared with the description for the type in the guide (Jones et al. 1983b) to check whether it fits. Nonetheless, the key does give a tool for identifying VTs and OGs, rapidly and relatively accurately, in the field. The main strength is that it gives the same identification no matter who uses it, so long as the user can identify all the diagnostic plant species and the diagnostic site features.

The OGs, VTs and STs have been described for some key vegetation and soil properties (Jones et al. 1983b). One of the methods for portraying variation of many of these properties was the DECORANA ordination (Hill 1979a). In this work it was the vegetational types which were ordinated. Schematic lines were drawn on the resulting two-dimensional ordination to show the grouping of types into OGs. Lines often passed through VTs, and this was because the soil boundaries that were used to separate OGs often subdivided the VTs.

Current Site Classification Activities in Quebec

by R. Zarnovican and D. Ouellet

(Translation from report by R.A. Sims)

In the late sixties, a multidisciplinary task force was formed within the LFRC as a result of LFRC staff involvement in National Forest Lands Committee (NFLC) activities. The task force's mandate was one of ecological classification.

Brainchild of the late Michel Jurdant, the group was first called the Service des études écologiques régionales (SEER) [regional ecological studies service] and its achievements were spectacular: Saguenay-Lac St-Jean, James Bay, North Shore, etc.

In 1975, the SEER left the LFRC and the Canadian Forestry Service to create a new branch within Environment Canada, the Lands Directorate. The move left the LRFC lacking in the area of research on plant ecology, particularly with regard to forest land classification. Ten years later, the LFRC still has not undertaken any projects or studies in that area.

Over the past ten years, the LFRC has stayed away from forest land classification in general, the development of forestry and forest management interpretation keys, ecological mapping and the development of new forest ecology techniques.

And the direction taken by LFRC research does not indicate any changes in that regard in the foreseeable future.

The climatic regions of New Brunswick: a multivariate analysis of meteorological data

H. VAN GROENEWOUD

Maritimes Forest Research Centre, Canadian Forestry Service, P.O. Box 4000, Fredericton, N.B., Canada E3B 5P7

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New Brunswick was divided into 11 climatic regions by means of three multivariate statistical analyses (principal component analysis, *R* and *Q* type, and cluster analysis) of data on precipitation, various temperature parameters, elevation, latitude, and longitude for 76 climatological stations. These regions form the first-level division for a forest site classification scheme being implemented in New Brunswick. Comparison of the climatic and geological maps of New Brunswick with the plant community distribution shows that either climatic or geologic parameters may control the distribution of the vegetation.

VAN GROENEWOUD, H. 1984. The climatic regions of New Brunswick: a multivariate analysis of meteorological data. Can. J. For. Res. **14**: 389–394.

Le Nouveau-Brunswick a été divisé en 11 régions climatiques d'après trois analyses statistiques à plusieurs variables (analyse en composantes principales, type *R* et *Q* et analyse par grappes) des données de 76 stations météorologiques, soit les précipitations, divers paramètres de la température, l'altitude, la latitude et la longitude. Ces régions constituent le premier niveau de division d'une classification des stations forestières entreprises au Nouveau-Brunswick. Une comparaison des cartes climatiques et géologiques du Nouveau-Brunswick avec la distribution géographique des groupements végétaux révèle que des paramètres climatiques ou géologiques peuvent déterminer la distribution de la végétation.

Introduction

Putnam (1940) described the climate of the Maritime Provinces of Canada and divided New Brunswick into three regions: northern, southern, and the Bay of Fundy. This does not appear to be a sufficient number of divisions to express the differences between climatic conditions in the various regions of New Brunswick.

Other researchers have divided New Brunswick into regions that sometimes have been related to climate, but they based these divisions on something other than meteorological data. Rowe (1972) divided New Brunswick into forest regions and sections on the basis of broad differences in forest physiognomy and composition. He clearly disavowed the idea of a cause–effect relationship between present climate and forest regions. Loucks (1960) based his ecoregions on differences in composition of the forest. He noted that changes were mostly gradual, and broke up the gradation into several arbitrary steps, each constituting an ecoregion. He described the climate in each in very general terms. Fowler and MacGillivray (1967) delineated five seed zones in New Brunswick, based on Loucks' (1960) ecoregions and Putman's (1940) climatic regions, and they described the climate in these zones in general terms.

Forty years have passed since Putnam's work and a great deal of meteorological data has accumulated. This prompted me to have a new look at the possibility of dividing New Brunswick into climatologically distinctive regions. A climatic region is here defined as a region having a distinctive and relative homogeneous climate.

The aim of this study is to develop a climatic zonation that will be compatible with the forest site classification system now being developed and tested in New Brunswick (van Groenewoud and Ruitenberg 1982).

The meteorological data are available on magnetic tape from the Canadian Climate Centre, Downsview, Ont., and from the New Brunswick Department of Environment, Fredericton, N.B.

Methods

Various multivariate methods, including factor analysis, principal component analysis, *R* (correlation matrices) and *Q* type (distance matrices), and different cluster analysis methods have been used to delineate climatic regions.

Steiner (1965) was the first to use factor analysis (FA) for this purpose. Since then, especially in Canada, many have used principal component analysis (PCA) or factor analysis for delineating climatic regions, (e.g., PCA: Newnham 1968; Nicholson and Bryant 1972; Williams and Masterton 1983; FA: McBoyle 1972; Miller and Auclair 1974; Powell and MacIver 1977). In most studies, one of the greatest shortcomings was the lack of a sufficient number of meteorological stations for a satisfactory delineation of the various climatic regions.

van Groenewoud (1965, 1976) drew attention to some of the limitations of PCA that should be considered when applying this method. Johnston (1981) also criticized the use of PCA and pointed out some of the weaknesses. Requirements of linearity, spatial autocorrelations, and possible absence of simple structure were his main concerns.

To avoid or circumvent some of the problems mentioned above, three multivariate analytical methods were used and, to approximate linearity, the data were partitioned into four 3-month periods; winter (December, January, February), spring (March, April, May), summer (June, July, August) and fall (September, October, November). The following analytical methods were included. (*i*) Principal component analysis of the (*R*) matrix of correlations among meteorological factors was performed to investigate whether a simple structure was feasible. Here, simple structure refers to whether there are sufficiently high correlations among some variables to warrant replacing them with new synthetic ones each representing a composite of original variables. In other words, to determine whether the original number of variables could be replaced by fewer independent synthetic components and still account for a sizable portion of the total variability. The analysis was performed on two sets of data: (1) all available meteorological data and (2) all available meteorological data, plus degree days, and data on elevation, longitude, and latitude of the stations. (*ii*) The equivalent to a principal component analysis of the distances or dissimilarities among stations ((*Q*) matrix) was performed to ordinate the stations so that the climatological relationships among them could be easily visualized and used to make deductions.

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[1]Revised manuscript received January 19, 1984.

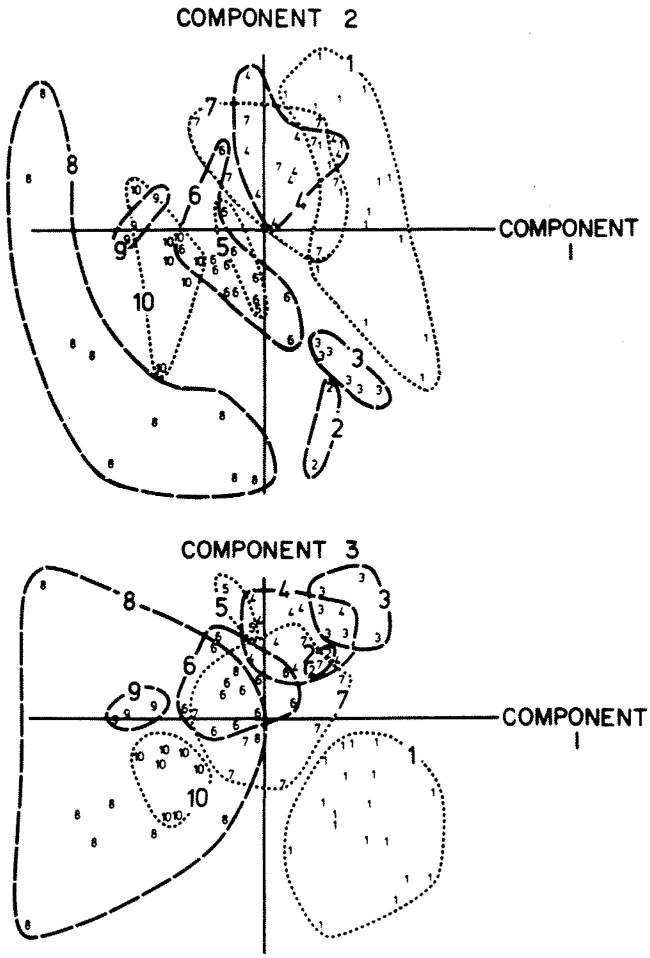

FIG. 1. Projection of the meteorological stations on the planes through the first and second, and first and third axes. Groups of similar stations are indicated by numbers and encircled by lines. Group numbers are identical to region numbers.

The ordinates for each station were computed by multiplying the coefficients of each eigenvector by the mean of the relevant variable for each particular station and summing the results for each component (axis). (*iii*) A cluster analysis on the distance matrix was also performed.

Clustering methods are many and varied. The method chosen for this analysis was the "sum of squares" method described by Orloci (1975). This type of clustering results in compact, more or less spherical clusters, as opposed to single-linkage clustering methods that may result in elongated and complex-shaped clusters (van Groenewoud and Ihm 1974; Ihm 1978; van Groenewoud 1983*a*). It was reasoned that well-defined compact clusters would delineate less variable climatic regions. Long elongated clusters could result in variable climatic conditions along the longest axes of the clusters, with much overlap among clusters, in contradiction to the definition of climatic regions as given before. Whereas in the ordination of the stations there may be a great deal of overlap in the projections of the clusters on the planes through the various axes, and a loss of the variability accounted for by the projections, this is not so in the cluster analysis where all variability is used and accounted for.

The clusters (groups of climatologically similar stations) were outlined in the projections of the station locations on the planes through the first three axes (Fig. 1).

Meteorological data were available for a total of 155 stations. Of these 155 stations, 38 were immediately discarded for reasons of discontinuity of data, insufficient factors measured, few years of measurement, etc. The data from 117 stations were analysed. After the cluster analysis, another 41 stations were discarded as not being related to any other station. Upon examination of the data for these stations it became clear they had the same deficiencies as the 38 stations discarded earlier.

In most studies of this nature, the period of measurement used for the analysis is the same for all stations. In this study, the number of measurement years used in the analysis varied, but for most stations measurements ran from between 1954 and 1969 until 1979. The loss of accuracy resulting from this was considered to be preferable over the loss of information by using the lowest common number of measurement years. Table 1 shows the variables used in the analyses.

The 76 stations did not form a sufficiently dense pattern to be able to delineate the regions on the basis of the distribution of the stations alone. The following rules were thus observed. (*i*) In fairly level terrain the lines were drawn midway between the stations belonging to different regions (clusters). (*ii*) In terrain with a steeper elevational gradient the contour lines on the topographic map of New Brunswick were used to judge where the boundary lines should run.

TABLE 1. List of variables and their abbreviations used in the analysis of climatic data

Abbreviation	Variable
FROW	Frost free days, winter
FROSP	Frost free days, spring
FROSU	Frost free days, summer
FROF	Frost free days, fall
PREW	Days with precipitation, winter
PRESP	Days with precipitation, spring
PRESU	Days with precipitation, summer
PREF	Days with precipitation, fall
MMAXW	Mean maximum temperature, winter
MMAXSP	Mean maximum temperature, spring
MMAXSU	Mean maximum temperature, summer
MMAXF	Mean maximum temperature, fall
MMINW	Mean minimum temperature, winter
MMINSP	Mean minimum temperature, spring
MMINSU	Mean minimum temperature, summer
MMINF	Mean minimum temperature, fall
MMTW	Mean mean temperature, winter
MMTSP	Mean mean temperature, spring
MMTSU	Mean mean temperature, summer
MMTF	Mean mean temperature, fall
EMXW	Extreme maximum temperature, winter
EMXSP	Extreme maximum temperature, spring
EMXSU	Extreme maximum temperature, summer
EMXF	Extreme maximum temperature, fall
EMINW	Extreme minimum temperature, winter
EMINSP	Extreme minimum temperature, spring
EMINSU	Extreme minimum temperature, summer
EMINF	Extreme minimum temperature, fall
RNW	Rain, winter
RNSP	Rain, spring
RNSU	Rain, summer
RNF	Rain, fall
SNW	Snow, winter
SNSP	Snow, spring
SNSU	Snow, summer
SNF	Snow, fall
Included in the second analysis:	
DDAYW	Degree days, winter
DDAYSP	Degree days, spring
DDAYSU	Degree days, summer
DDAYF	Degree days, fall
LAT	Latitude, stations
LONG	Longitude, stations
ELEV	Elevation, stations

TABLE 2. Principal component analysis of the correlation matrix

Variable	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6	Component 7
	Coefficients of the eigenvectors						
FROW	−0.679	0.124	0.022	−0.098	0.275	−0.188	0.319
FROSP	−0.759	−0.088	−0.244	0.095	0.506	0.044	0.042
FROSU	−0.561	0.008	−0.454	0.474	−0.161	−0.093	−0.084
FROF	−0.871	0.173	−0.040	0.037	−0.058	0.163	−0.216
PREW	0.333	−0.135	0.460	0.571	0.227	0.043	0.111
PRESP	0.126	−0.124	0.619	0.629	−0.077	−0.034	−0.101
PRESU	−0.380	−0.241	0.628	0.315	−0.113	−0.365	−0.054
PREF	0.065	−0.098	0.717	0.493	0.052	−0.299	−0.100
MMAXW	0.829	0.263	−0.228	0.296	0.082	−0.056	−0.142
MMAXSP	−0.096	0.889	−0.017	0.223	−0.255	0.067	0.160
MMAXSU	−0.253	0.895	0.082	−0.007	0.184	−0.013	−0.062
MMAXF	0.791	0.249	−0.299	0.178	0.235	−0.164	0.230
MMINW	0.930	−0.136	0.073	0.020	0.079	0.007	−0.153
MMINSP	0.712	0.284	0.397	−0.099	−0.356	0.184	0.043
MMINSU	0.532	0.216	0.567	−0.446	0.100	0.103	−0.047
MMINF	0.929	−0.118	0.034	−0.023	0.141	−0.113	0.204
MMTW	0.941	0.025	0.056	0.145	0.083	−0.027	−0.159
MMTSP	0.287	0.804	0.174	0.122	−0.384	0.150	0.154
MMTSU	0.120	0.785	0.392	−0.273	0.184	0.043	−0.072
MMTF	0.908	0.064	−0.136	0.078	0.185	−0.145	0.234
EMXW	0.605	0.441	−0.190	0.372	0.159	0.147	−0.136
EMXSP	−0.299	0.803	0.132	0.130	−0.043	0.114	0.108
EMXSU	−0.459	0.771	0.176	−0.032	0.226	−0.046	−0.033
EMXF	0.539	0.550	−0.259	0.231	0.351	−0.009	0.149
EMINW	0.819	−0.254	0.160	−0.143	0.171	−0.013	−0.127
EMINSP	0.796	0.058	0.329	−0.257	−0.306	0.008	0.020
EMINSU	0.716	−0.170	0.430	−0.440	0.051	0.053	−0.016
EMINF	0.826	−0.279	0.119	−0.178	0.300	−0.008	0.132
RNW	0.826	−0.135	−0.300	0.208	−0.122	0.130	−0.075
RNSP	0.413	−0.182	−0.097	0.471	−0.238	0.463	0.028
RNSU	−0.235	−0.412	0.061	0.296	−0.279	−0.128	0.454
RNF	0.815	−0.154	−0.195	0.276	0.084	0.151	−0.030
SNW	−0.482	−0.169	0.388	0.141	0.385	0.310	0.312
SNSP	−0.394	−0.284	0.212	0.204	0.367	0.492	−0.196
SNSU	−0.180	−0.386	0.068	−0.153	−0.066	0.476	0.312
SNF	−0.743	−0.073	0.456	0.116	0.090	0.069	−0.022
Eigenvalues	14.093	5.725	3.646	2.852	1.848	1.316	1.008
Percentage variation accounted for	39.147	15.903	10.127	7.923	5.133	3.657	2.799
Cumulative percentages	39.147	55.049	65.176	73.099	78.232	81.889	84.688

Results and discussion

Table 2 shows the eigenvalues (and the percentage variation accounted for) of the various components, and the coefficients of the eigenvectors of the PCA of the correlation (among the variables) matrix.

Though two analyses were performed, only the results of the analysis of the first set of data are shown here, because the coefficients for degree days and elevation, latitude, and longitude of the stations were very low for all eigenvectors. Also, the percentage variation accounted for by the first three components was lower (27.1, 10.9, and 8.3%, respectively) than for the first analysis. Inclusion of these variables thus contributed nothing to the analysis. A scrutiny of the original correlation matrix showed that, indeed, these variables had very low correlations with the measured meteorological variables. This precludes the creation of more map points according to the method followed by Hopkins (1968) and others, wherever a paucity of meteorological stations exists. The first three components accounted for 65.2%, the first five for 78.2%, and the first seven for 84.7% of the variation (Table 2).

The first component (axis) is characterized by high negative coefficients for the number of frost-free days in the winter, spring, and fall periods, and high positive coefficients for the extreme minimum temperatures in all yearly quarters, mean minimum temperature during the winter, spring, and fall periods, and mean maximum temperature, mean temperature, and mean rainfall during the winter and fall periods.

The second component is characterized by high coefficients for mean maximum temperature, mean temperature, and extreme maximum temperature during the spring and summer periods.

The third component is characterized by high coefficients for the number of days with precipitation during the spring, summer, and fall periods.

The coefficients of the fourth and higher numbered eigenvectors are too low to be meaningful, only two precipitation

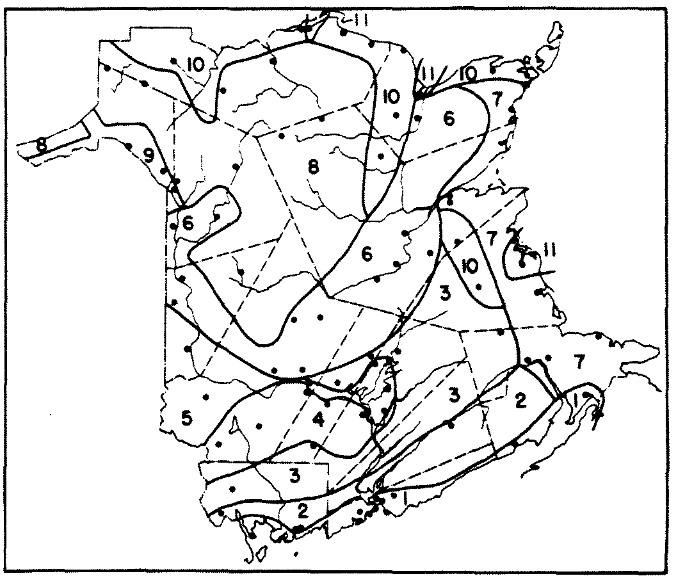

FIG. 2. Map of the climatic regions of New Brunswick. Meteorological stations used in the analysis are indicated by dots. Where stations were too close together some were omitted.

variables having a coefficient higher than 0.5 (Table 2). Also, practically all variables are represented in the first three components.

It appears then that the variability contained in the correlation matrix can be satisfactorily expressed by a lesser number of components and still account for a reasonable fraction of the total variability. The first component represents a relationship with frost-free days, mostly fall and winter temperatures, and rain in fall and winter. The second component represents spring and summer temperatures and the third component represents the number of days with precipitation in the spring, summer, and fall.

The ordination of the meteorological stations by the equivalence of a PCA of the distance (dissimilarities) matrix is presented in Fig. 1. It shows the projections of the points representing the stations in the multidimensional test space on the planes through the first and second axes and through the first and third axes. The eigenvalues are the same as in Table 2.

The distribution of points in Fig. 1 does not show many distinctive clusters. This, of course, does not preclude the possibility that clusters do exist in the multidimensional space. That possibility was investigated by the cluster analysis of the distance matrix.

The computer output of the cluster analysis is in the form of a dendrogram that is too large to be presented here (117 stations). This dendrogram shows the presence of 11 distinctive clusters. The points in these clusters all joined at distances less than 13% of the greatest distance in the matrix and formed very pronounced clusters. Since the 11th cluster contained only three very small separated areas along the coast, insignificant to forestry, this cluster was further disregarded. The remaining 10 clusters are delineated in the projections of the points on the planes through the three axes (Fig. 1).

Using the information from the cluster analysis, and following the forementioned rules, the climatic regions were delineated on the map of New Brunswick (Fig. 2).

Most clusters on the planes through the first, second, and third axes in Fig. 1 are compact, indicating great similarity among the stations in a region. Exceptions are the Central Highlands (No. 8) and the Fundy (No. 1) regions. The Central Highlands region varies more than the others along all three axes of the ordination, indicating a greater variability among the stations in the climatic factors considered. This is also reflected in greater standard deviations of the monthly means. Nevertheless, the cluster was well defined in the cluster analysis. If more stations were available, subdivision of this area might be possible. The Fundy Region, along the coast, is fairly compact along the first and third axes of the ordination, indicating little variation in the fall and winter temperature and the number of days with precipitation, among the stations. This region shows greater variation along the second axis, in spring and summer temperatures. The cluster for this region, however, was also very distinct in the cluster analysis.

Both regions appear to occupy extreme positions in the ordination. The Central Highlands region is typified by relatively low fall and winter temperatures while the Fundy region has relatively warm fall and winter temperatures, and a high number of days with precipitation in all seasons. Spring and summer temperatures vary more among the stations of these regions than in the other regions.

The other regions appear to occupy different, mostly overlapping, segments of a continuous gradient and are distinct only if more than one or two factors are considered.

The monthly maxima, minima, means, and standard deviations of all factors were calculated and tabulated for the 10 regions. To show some of the differences and similarities among the regions, the mean temperatures and rainfall for each month and each region are given in Tables 3 and 4. The complete set of tables with means, maxima, minima, and standard deviations are available from the Maritime Forest Research Centre (van Groenewoud 1983*b*).

The climatic regions delineated here form the first-level division of New Brunswick for the forest site classification system being implemented in the Province (van Groenewoud and Ruitenberg 1982). The other levels are geomorphologic districts based on major bedrock formations, the regolith systems based on land form and the lithologic–mineralogic compositions of the parent material, and the site type, based on soil profile, slope, aspect, position on slope, etc.

Usually, differences in climatic conditions between adjacent regions are not great. As a result, these dissimilarities will be reflected more in deviations in seasonal growth, date of commencing of new growth, date of onset of dormancy, and other phenological differences, rather than in the simultaneous appearance and disappearance of various trees and other species at the boundaries between regions. Abrupt changes in vegetation owing to differences in regional climates are thus not probable. Loucks (1960, p. 92) recognized the absence of sharp breaks in the vegetation patterns and broke up the gradual variation into arbitrary segments.

Depending on the relative influence of different soil associations, either climate or parent material can be the overriding factor determining the vegetation type. A comparison of three maps, Loucks' ecoregions (Loucks 1960), the New Brunswick geological map (Potter *et al.* 1979), and the climatic region map, shows that the distribution of the vegetation as determined by Loucks in the western half and the southern part of New Brunswick is more or less determined by climate. The lowland ecoregion, however, is determined by the occurrence of parent material and soils derived from Pennsylvanian rock formations.

TABLE 3. Mean monthly temperature (degrees Celsius) for 10 climatic regions of New Brunswick

	Region									
Month	1	2	3	4	5	6	7	8	9	10
January	−6.8	−8.4	−9.8	−9.5	−11.1	−11.1	−9.7	−13.6	−12.8	−12.4
February	−6.6	−8.2	−9.3	−8.8	−10.2	−10.5	−9.0	−12.7	−11.7	−11.1
March	−1.8	−2.2	−3.2	−2.8	−3.5	−4.2	−3.4	−6.3	−5.4	−4.8
April	3.7	4.1	3.5	3.8	3.7	2.6	2.9	0.9	2.5	1.3
May	9.2	10.3	10.0	10.5	10.9	9.4	9.6	8.0	9.9	8.3
June	13.8	15.2	15.4	15.9	16.2	15.4	15.2	14.0	15.3	15.1
July	16.8	18.7	18.8	19.1	19.4	18.5	18.9	16.8	18.3	18.2
August	16.7	17.7	17.7	18.2	18.0	17.2	17.8	15.4	17.0	16.7
September	13.4	13.4	12.9	13.6	13.3	12.5	13.3	10.5	12.3	11.7
October	8.4	8.1	7.2	7.8	7.3	6.7	7.5	4.7	6.4	5.7
November	2.8	1.9	1.0	1.4	0.9	0.1	1.2	−2.2	−0.6	−0.6
December	−4.0	−5.6	−7.1	−6.5	−8.0	−8.0	−6.5	−10.1	−9.1	−8.8

TABLE 4. Mean total rainfall (millimetres) for 10 climatic regions of New Brunswick

	Region									
Month	1	2	3	4	5	6	7	8	9	10
January	61.8	46.9	34.9	34.5	20.5	20.8	26.6	6.4	12.7	12.9
February	48.6	33.6	23.8	27.5	13.5	18.6	19.3	9.7	8.9	11.1
March	63.2	54.1	38.5	39.8	25.0	28.2	33.0	14.2	17.0	20.0
April	73.9	60.4	59.4	60.8	48.5	49.5	47.5	39.3	47.3	40.6
May	95.3	68.7	23.9	78.7	65.9	76.6	78.3	78.0	74.8	83.6
June	89.8	72.2	93.4	88.6	93.5	86.3	88.1	97.4	98.8	93.2
July	86.1	74.1	91.9	83.9	76.5	90.4	90.1	103.9	102.2	99.2
August	90.7	75.1	82.9	85.6	74.6	85.5	85.3	102.0	90.1	96.4
September	97.8	55.8	93.1	92.2	77.9	90.5	82.6	93.3	88.3	101.3
October	106.1	91.1	88.5	94.0	83.2	88.9	91.2	83.9	82.7	92.7
November	121.3	82.9	97.9	90.1	63.5	74.3	76.2	48.8	57.5	54.9
December	86.8	57.5	50.8	49.6	27.4	37.7	37.6	23.4	19.4	28.7

In the ecological land classification system, ecoregions are defined as areas of land characterized by a distinctive regional climate as expressed by vegetation (Lacate 1969). It is clear that gross vegetational changes are not always caused by climatic differences but may be the result of differences in parent materials and other factors of overriding importance. As a first-level division of the landscape it is thus better to replace ecoregions by climatic regions that are based entirely on meteorological data. This will place studies of causal relationships between vegetation pattern, tree growth, and environmental factors, essential for an efficient forest site classification, on a more solid basis.

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ESTABLISHMENT REPORT ON SITE CLASSIFICATION ACTIVITIES

AT THE NEWFOUNDLAND FOREST RESEARCH CENTRE

Prepared by: W.J. Meades

INTRODUCTION

The Canadian Forestry Service has played a leading role in the development of forest site classification systems for Newfoundland and Labrador. This exclusive position has developed primarily because the provincial government and industry have traditionally considered most forest research activities the responsibility of the Canadian Forestry Service. Thus, there has not been a parallel development of classification systems by federal and provincial agencies prevalent in some other regions of the country. The Damman forest type classification is generally considered the only system orientated to forest land management.

The forest classification developed by the NeFRC has put strong emphasis on the importance of identifying natural relationships between vegetation type, soil type and landform in defining the forest type. This approach is essential in the recognition of successional trends and, also, in stratifying the productivity of the land base. It is unlikely that future research will deviate significantly from this basic approach.

Through three decades of research all major regions of Newfoundland and Labrador have been classified and considerable progress has been made in correlating forest types with growth and yield and related forest capability classifications. In recent years, under the ENFOR program, studies have been initiated to calibrate the FORCYTE model using the forest site classification to define good, medium, and poor sites.

Although, a large body of information valuable to intensive forest management has been assembled the latest project view (Feb. 1983) has identified technology transfer to be wanting. Technology transfer has suffered in part because of staff turnover and related changes to research priority. However, an overriding problem until very recently has been the lack of a grass roots demand from the province and industry for site related information. In the last decade there has been a dramatic shift in forest management in this region from harvesting to more intensive silviculture and a genuine increase in demand for site information. This interest increased to the extent that in 1985 staff of the NeFRC had to conduct a one week in-field workshop for the provincial government and two paper companies in central and western Newfoundland.

However, the basic problem still remains that much of the site information is published in journal papers and thesis are not readily available or understandable by the forest technicians on the operations level. Although, this information in time, can be disseminated by the normal route of in-house funding and publications, it is unlikely that it can be achieved in the time framework and format most suitable to our clients. With this in mind a proposal for funding technology transfer of the site classification system has been made for consideration in the next forest subsidiary agreement.

EXISTING PROJECT STRUCTURE AT NeFRC

All site classification research at the NeFRC is conducted as part of the Forest and Plant Ecology project. The basic structure of the project is as follows:

Title: Forest and Plant Ecology

Project No.: 2314

Project Leader: W.J. Meades

Long Term Goals

(1) To complete forest, heath and wetland classifications for Newfoundland and Labrador and apply these classifications to operational problems in forestry, agriculture and wildlife. (2) To establish an ecological data bank of principal vegetation types for purposes of conservation and multiple use with local, national and international applications. (3) To provide basic ecological information on the major tree and shrub species of Newfoundland for use in forest management. (4) To gain a better understanding of the pedologic factors that control forest productivity and to apply this information to ensure more effective site management.

List of Studies

4301 - Ecological investigation of wetlands for forestry: Leader - E.D. Wells;

4302 - Ecological investigations of heathlands: Leader - W.J. Meades (A. Mallik - visiting fellow);

4303 - Forest classification, ecology and mapping: Leader - W.J. Meades, R. van Kesteren;

4304 - Autecological studies of major trees, shrubs and related vegetation: Leader - B.A. Roberts;

4305 - Ecology of Newfoundland soils: Leader - B.A. Roberts.

Although not all studies are directly concerned with site classification, most provide information essential to understanding and interpreting the classification in terms of intensive forest management. For example, studies on wetland forestry are pre-requisite to determining what if any wetland types are suitable for afforestation. Studies on autecology of forest trees provide the basis of inferring species - site preferences and species specific capability.

HISTORICAL BACKGROUND

1. Habitat Classification Using the Zurich-Montpellier (Z-M) Approach

Between 1955-67 A.W.H. Damman used the ZM methodology to develop a comprehensive forest classification system covering insular Newfoundland with the exception of the eastern region (Damman 1963, 1964 and 1967). Damman used relevé analysis of tabular vegetation data to define forest vegetation types. He used a combination of soil and other site characteristics to define forest types. This approach was necessary because certain vegetation types (i.e. black spruce-feather moss forests) occurred over a wide range of site conditions with consequent wide range of productivity. Equally important, similar vegetation on different substrates can respond quite differently to disturbance. Thus, to develop a system that could reliably predict vegetation response to fire and logging it was necessary to take into account the soil condition particularly with respect to texture, moisture regime and fertility. A final phase of this approach was to recognize the catenary relationships that existed for each of the predominant landforms forming the regional landscape. In its final form, Damman's classification provided the essential elements of an eco-site classification and later formed the backbone of Ecological (Biophysical) Land Classification in the province. In recent years Damman has published papers on the role of vegetation analysis in land classification (Damman 1979) and the Ecoregions of Newfoundland (Damman 1983).

Several mensurational studies were undertaken using the Damman site classification as a basis of stratification (Bajzak 1962; Bajzak et al. 1968; Page et al. 1970; Page and van Nostrand 1970). In eastern Newfoundland

Page (1970) concluded, "the classification system cannot, alone, achieve desirable levels of accuracy for site index and basal area". However, Roberts and Bajzak (1984) clearly demonstrated a distinct separation of site index curves related to Damman's forest types. The discrepency in results may be related to the fact that the eastern Newfoundland forest classification was only partially developed at the time mensurational studies were undertaken. Also, moisture and fertility are the most important factors controlling the vegetation composition of the forest types in eastern Newfoundland, whereas, wind to a large extent controls stand productivity.

The forest site classification provided the essential basis for the Newfoundland Forest Capability Classification (Delaney 1974). The capability classification was calibrated for the forest types in northern, central and western Newfoundland by using fully stocked stands near rotation age. The CFS mensurational data previously quoted were also utilized in this calibration.

Following Damman's departure in 1967 emphasis in site classification shifted to wetlands classification using the Z-M methodology. The results of this classification effort are summarized in Wells and Pollett (1983). Meades (1982) completed the forest classification for eastern Newfoundland with emphasis on the historical degradation of the forest to anthropogenic heath. A synopsis of heathland vegetation in Newfoundland is provided by Meades (1973, 1983).

The forests of Labrador were classified by Wilton (1965). Although the Z-M approach was not utilized the basic composition of the forest and related productivity were well documented.

Roberts and Bajzak (1984) have produced an updated classification of central Newfoundland forest types using a bio-physical soils approach. The classification for the most part uses Damman's (1964) forest types with some additional white spruce, larch, aspen and red pine cover types. Soil, landform, forest capability and site index correlations are presented. The report clearly demonstrates the wide variation of individual site types relative to the averaged curve frequently used in capability analysis.

A method of mapping land sensitivity to logging has been developed by van Kesteren and Meades (1984). The approach considers soil texture, slope and ground water conditions to be the most important variables controlling site disturbance by logging and uses eco-site grouping to delineate five levels of land sensitivity. Two plot areas in central and western Newfoundland have been mapped.

In September 1985 a forest site workshop was given in central and western Newfoundland by W.J. Meades, B.A. Roberts and R. van Kesteren. The workshop consisted of one-half day lectures and one and a half day field demonstration in both areas. A manual providing a key to the forest types of central and western Newfoundland was prepared for the workshop (Meades 1985).

2. Land Classification Using the Ecological (Biophysical) Classification Approach

The Canadian Forestry Service played the leading role in three pilot studies designed to evaluate the feasibility of Biophysical Land Classification in the Newfoundland and Labrador Region.

The first study was undertaken in the Lake Melville area of central Labrador (Bajzak 1959, 1973). Mapping was at the level of Land System and Land District at a scale of 1:125,000. Land system profiles were used to show the schematic distribution of land types. Land types were interpreted in terms of capability for forestry, wildlife and recreation.

A similar approach was used to map approximately 1000 square miles in western Newfoundland (Wells et al. 1972). Damman's forest type classification was used for the vegetation component. In addition to Land Capability, interpretations were made for Forest Land Management, i.e. erosion hazard, equipment restrictions and vegetation competition.

The bio-physical survey in central Newfoundland consisted of a 26 square mile area with detailed mapping at the level of land type (Wells and Roberts 1973). This study used Damman's forest types with more intensive soil delineation at the series level. Land use interpretations were made for: Forest Vegetation Type, Forest Capability, Erosion Hazard, Equipment Restrictions, Species Suitability, Logging Operation, Regeneration, Road Construction and Nursery Suitability.

Since that time several other land classification projects have been undertaken for specific parts of Newfoundland and Labrador as follows:

Gros Morne National Park	Airphoto Analysis (1974)
Terra Nova National Park	Gauthier, Polunin Therbiault - Canadian Forestry Service (1976)
L'Anse aux Meadows Park	Gimbarzevsky (1977)
Labrador Ecoregions	Lopukhine et al. (1978)
Central Labrador	Beak-Hunter (1980)

For the most part these studies extrapolated existing information and did not significantly contribute to an increased understanding of forest site relationships.

FUTURE INITIATIVES IN FOREST SITE CLASSIFICATION RESEARCH AT NeFRC

New initiatives in site classification under the forest and plant ecology project over the next five years will include the following:

1. Forest Site Classification

a) Technology transfer of the Damman forest site classification by means of a manual and related video and training courses. The success of this initiative will be strongly dependent on funding for a forest subsidiary proposal developed by Meades and Damman (1984).

b) New research will be undertaken to classify seral vegetation and soil conditions prevalent on cutover and burnt forest land in Newfoundland. The approach will be similar to Arno et al. (1985) in that successional stages of forest vegetation will be defined and related to the mature forest site type. However, the Z-M approach with relevé analysis will be used to define the vegetation types.

2. Autecology and Soils Research

a) To investigate the influence and quality and quantity of seepage water on stand productivity.

b) To do a 15 year follow up study of an area that was classified in central Newfoundland (Wells and Roberts 1973) to check forest management interpretations following logging of the area.

c) To produce a manual on guidelines for logging stressing techniques to be used on seepage sites.

d) To initiate an operational trial on drainage of sites having fragipans in several slope positions.

3. Wetlands Classification

a) To publish a wetland classification for Labrador.

b) To continue drainage experiments on Newfoundland peatlands for the purpose of determining the feasibility of afforestation.

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A FOREST SITE CLASSIFICATION FOR THE BOREAL FOREST OF CENTRAL NEWFOUNDLAND, CANADA (B.28A) USING A BIO-PHYSICAL-SOILS APPROACH

BY

B.A. ROBERTS AND D. BAJZAK

PAPER PRESENTED AT THE JOINT MEETING OF THE WORKING PARTIES No. 1.02-06 AND No. 1.02-10 OF IUFRO ON QUALITATIVE AND QUANTITATIVE ASSESSMENT OF FOREST SITES WITH SPECIAL REFERENCE TO SOIL.

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A FOREST SITE CLASSIFICATION FOR THE BOREAL FOREST OF CENTRAL NEWFOUNDLAND, CANADA (B.28a) USING A BIO-PHYSICAL-SOILS APPROACH

by

B.A. Roberts[1] and D. Bajzak[2]

INTRODUCTION

Site classification in the boreal forest of central Newfoundland, Canada (B.28a)(Rowe 1972) has been actively investigated since the mid-1940's. This paper summarizes the history of site classification for the region and compiles data on 38 site types for seven different tree species using a combined vegetation, soils, landform, drainage and productivity approach. This paper also discusses the problems in recognizing site types once the mature trees have been removed and some of the problems in mapping site types from aerial photographs.

METHODS

Since the 1960's data on soils and forest productivity has been assembled by the authors with more than 500, 1/25 ha sample plots established during various surveys. A minimum of 15 plots for the less common species were established. Sample plots were located in divisions 7, 8, 9 (Roberts 1983)(Fig. 1). The criteria for the classification of types were: 1) change in landform, soils and drainage, 2) ground indicator species and productivitv data. Forest productivity evaluation includes height/age, height/diameter, volume and MAI correlated with forest capability class.

[1]Research Scientist, Soils-Autecology, Canadian Forestry Service, Newfoundland and Labrador Region, P.O. Box 6028, St. John's, Newfoundland, CANADA A1C 5X8

[2]Associate Professor, Faculty of Engineering and Applied Science, Memorial University of Newfoundland, St. John's, Newfoundland, CANADA A1B 3X5

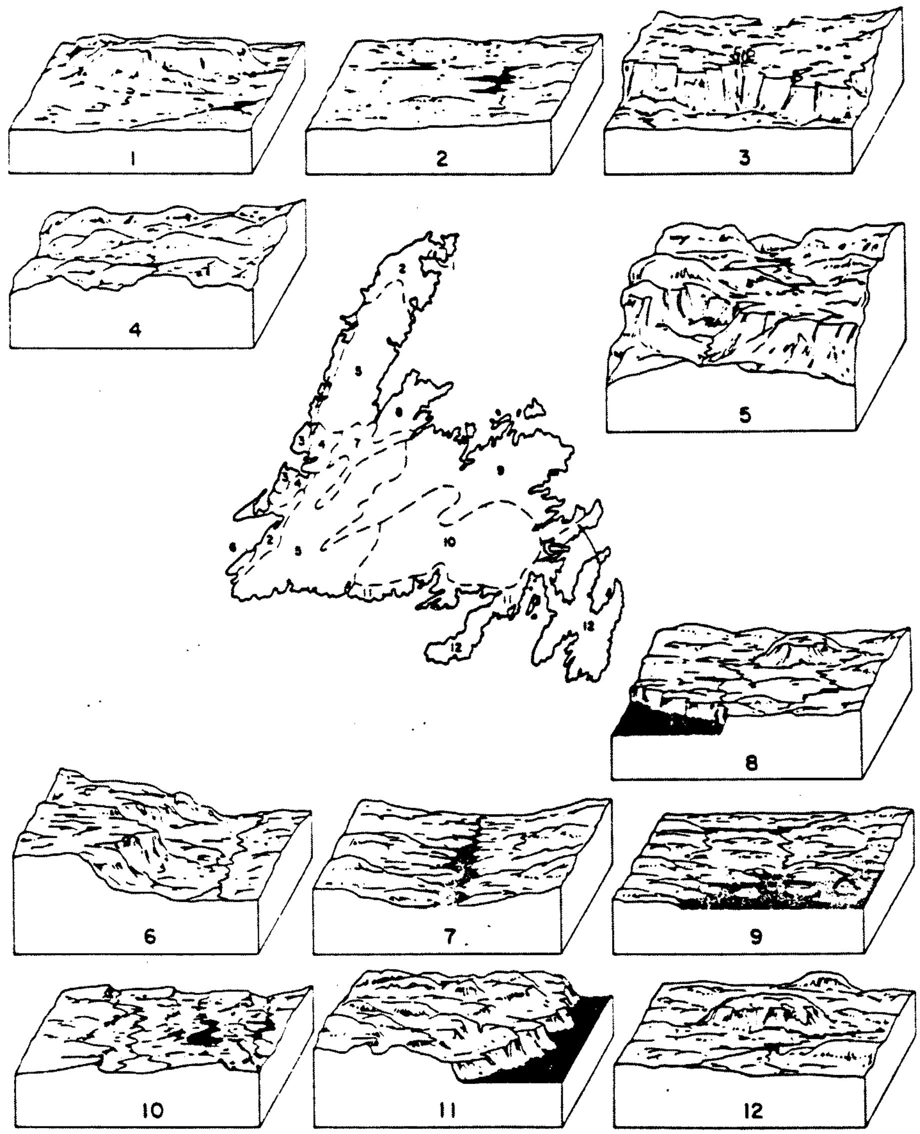


Fig. 1 . Physiographic divisions of Newfoundland. 1. Serpentinized Hills of Hare Bay; 2. West Coast Lowland; 3. Bay of Islands Serpentinized Range; 4. West Coast Calcareous Uplands; 5. Long Range Mountains; 6. Anguille Mountains; 7. Grand Lake – White Bay Basin; 8. Burlington Peninsula; 9. North East Trough; 10. Central Plateau; 11. South Coast Highlands; 12. Eastern Upland. (Roberts 1983).

HISTORY OF FOREST SITE CLASSIFICATION FOR CENTRAL NEWFOUNDLAND

The study of the kinds of forest in Newfoundland has attracted comment from the time of the discovery in 1497 to the present. By the time formal possession of Newfoundland had occurred in 1583, parts of the coastal forest, particularly in the eastern portion of Newfoundland had been removed by burning.

When John Guy established the first colony at Cupids, Kennedy et al. (1955) reported that the first Chief Forestry Officer, Captain Jack Turner had written:

> "The order issued to Guy for the governing of his Colony (1610) contains what is probably the first regulation which aimed at the protection of our forests. It is short and simple - and if it had been carried out all through the years would have made Newfoundland one of the richest countries in the world. Here it is 'No person shall set fire in the woods'. It would seem, however, that even in the good old days it was easier to make laws than to enforce them. In 1619 we learn of 'Five thousand acres of wood maliciously burned by fishers in the Bay of Conception'."

It was, however, some 150 years later before Pallistere ordered against firing the woods on the coast of Labrador in 1767 (Kennedy et al. 1955). This order may have been prompted by the early report by Sir Joseph Banks (Lysaght 1971) botanizing in Newfoundland in 1766 which produced a list of many of the trees, shrubs and related forest plant species as he travelled by boat to many parts of the Island.

William Epps Cormack in 1856 described the forests and their productivity from the eastern shore to central and western parts of Newfoundland as he journeyed by foot from Smith Sound to St. George's Bay with his Micmac guide, Joseph Sylvester.

The building of the railway in Newfoundland from 1889 to around the turn of the century led to the logging and lumbering of the white pine forests (Roberts 1983) of the region described by Cormack earlier and provided the access and the pattern of settlement inland. Prominent botanists such as Fernald (1911, 1933) in general noted the forest species but it was really several decades after the construction of the paper mills in 1909 in Grand Falls and 1925 of Corner Brook there became a need to classify the forests of Newfoundland and to relate the growth and productivity to various site conditions.

In 1937, before Newfoundland became a province, W.E.D. Halliday produced "A forest classification for Canada" where he gave the first descriptions of Canadian forest on a national scale. It would be some two decades before the regions would be described for Newfoundland and it was this next twenty years that much interest would occur in site ecology.

In 1945, W.M. Robertson (1945) from the Dominion Forest Service in Ottawa published a paper which covered a brief reconnaissance of the forest conditions in Newfoundland. In the timberland which he estimated covered some 10,000 sq.mi. (25 900.8 km^2) he reported that the 40 year old pulpwood industry had only cut over some 40% of the available stands. Robertson (1945) listed six site types of which four would bear timber of commercial importance. The top two types contained soils that were suitable for agriculture. Robertson also noted that "The Anglo-Newfoundland Development Company had been cutting pulpwood from the central, north and eastern sections since 1907 and certain restricted areas were logged for white pine between 1890 and 1914".

Robertson's (1945) classification is as follows:

Table 1.

	Sub-Type		Cover Type	Percent
I	Tr T	- Trillium	M.B.S	5*
II	Co T	- Cornus	BwA, B.S or B.S.	50
III	Sp T	- Sphagnum	Sb.	30
IV	K.VT	- Kalmia-Vaccinium	Sb.	5
V	K.LT	- Kalmia-Ledum	Sb. or B.S.**	10
VI		Cladonia		Unmerchantable not calculated

*This site type confined to the rich, well-drained areas of the St. George's district south of the Humber River.

**M - Red maple
B - Balsam fir
W - White spruce
Sb. - black spruce
Bw.BS - Balsam fir-black spruce

Some of Robertson's vegetation indicator species, however, are somewhat doubtful, e.g., his Trillium type was not correct as it is not common throughout the better forest types in Newfoundland. The only species of Trillium, Trillium cernuum is fairly rare and found usually in the alder swamps primarily in western Newfoundland. The Trillium type was probably the Rubus-balsam fir, one of the richest types with Rubus pubescens one of the plant indicator species.

Almost immediately the Anglo-Newfoundland Development Company Ltd. (A.N.D.) paper company in central Newfoundland summarized Robertson's six types into three site types (Table 2).

Table 2. Robertson's site classification compared to the A.N.D. site classification method.

Robertson's sites	A.N.D. Company sites	Extent in Company's merchantable stands
I - Trillium)) II - Cornus)	I - Cornus	80%
III - Sphagnum	II - Sphagnum	15%
IV - Kalmia-Vaccinium)) V - Kalmia-Ledum)) VI - Cladonia)	III - Kalmia	5%
	Total	100%

At the same time in 1947-49 more than 1750 permanent sample plots were established in central Newfoundland by the A.N.D. Company and they were distributed mechanically by the line plot system. Measurements including site classification conducted in the early 1970's by the author as well as 10 year measurements have been made on a portion of these plots in 1957-58, 1967-68 and 1977-78. These data are indeed valuable in looking at site index, long-term yield and stand dynamics and many of the comments in this paper are attributed to this work.

In the early 1950's the Federal Forestry Branch had George Brown make a reconnaissance trip to Newfoundland. He produced an unpublished report in 1953 (Brown 1953) followed by the later publishing of his general site classification map in the 1955 Royal Commission Report (Kennedy 1955). Gill (1955) continued on this work and a formal study on Newfoundland Forest Site Classification was initiated

In 1956, Teuvo Ahti (1959) reported on the lichen forests and barrens as the food source for a declining caribou population. He reviewed the vegetation and some of the site work to date reporting that although the flora was fairly well known the vegetation had not been so thoroughly studied. Ahti's review of the bogs, heathlands and lichen forests with a comparison to vegetation types of various regions in Europe provided the framework for future studies on these types later in the 1960's and 1970's. His work also reflected observations on the changing vegetation as a result of disturbance, especially fire, as he studied the various types from lowland to alpine areas.

In the later 1950's significant progress was made in site classification in Newfoundland. George Brown's earlier work was reflected in a revision of Haliday's "Forest Classification of Canada" which was published (Rowe 1959) and included Newfoundland for the first time.

In 1957 A.W.H. Damman continued the site classification program at the Federal Forestry Branch and produced many reports on the site conditions in various sectors of the Island. His monograph on "Some of the Forest Types of Central Newfoundland and Their Relation to Environmental Factors" (Damman 1964) gave both an edaphic and vegetative classification of the forests. He also included the successional status after fire and logging and the ecological position of each type with respect to moisture and fertility. Concurrently, extensive measurement projects of growth and yield, site index and general mensurational characteristics were conducted (Bajzak 1962, van Nostrand 1964).

The Newfoundland Forest Research Centre continued the site-soils program through the next decade and again significant contributions were made. Page (1968) produced site index curves for spruce and fir for the forest regions of Newfoundland and Page (1972) reported on the growth of trembling aspen. A revision of Rowe's "Forest Regions of Canada" (1972) left the regions in Newfoundland unchanged.

In this period under provision of the Federal Canada Land Inventory (CLI) Program, the mapping of the island of Newfoundland for forest and soil capability was completed (Delaney 1974). Much of the work was based directly on the earlier site work of Damman (1964) but included a first approximation of mapping site productivity on aerial photographs for all of Newfoundland. Bajzak (1964) had showed the technique was feasible in a test area in western Newfoundland.

As part of the Biophysical Mapping Program, Wells and Roberts (1973) mapped in detail a 70 km^2 area which contained most all the forest and soil types in the central part of the Island. Soils to the series level combined with landforms, and vegetation enabled the land types to be rated for forest growth. Many environmental parameters were related to site and logging systems. Work is currently continuing on succession and disturbance 11 years after the various predictions were made and early indications show that many of the interpretations had good merit.

Since the second and third Royal Commissions on Forestry (Rousseau et al. 1970, Sheppard and Carrol 1973) there has been a greater awareness to forestry problems including site classification. In the mid-1970's, 19 provincial forestry management units were established, forest management plans drawn up and a new system of taxes and forest inventory established. In addition, mechanical logging and the onslought of the hemlock looper and spruce budworm have created a new management awareness. Federal funding agreements for forest renewal studies and such programs as ENFOR have contributed to the current management strategies.

The Newfoundland Forest Research Centre is conducting autecological studies on the lesser known species such as larch, white spruce, red pine and poplars (Roberts & Khalil 1980, Roberts 1981, Roberts and van Nostrand 1983). In addition other site work as related to logging systems has been summarized (Case and Donnelly 1979) and the Province-wide foresty inventory continues to be updated.

Recently Damman (1983) produced an ecoregion map, revising some of the boundaries of Rowe (1972). Roberts (1983) has reviewed the soils of Newfoundland including the central portion of the Island. Robertson (1980) has produced a phytogeographic map for insular Newfoundland in connection with work on urban vegetation management. This map has now been revised in color as related to his studies on wind (Robertson 1984).

RESULTS

Tables 3 to 9 correlate the forest types with succession, forest capability, soil parent materials and landforms, soil drainage and soil subgroup (C.S.S.C. 1978). The wood production of merchantable volume and mean annual increment in the main capability classes are given in Table 10.

Some of the differences in productivity by site and species are shown by various height/age curves. The average site index curve for the central region (Page 1968) is shown in Figure 2. The average height/age curves for the major spruce and fir types and the influence of soil seepage is given in Figure 3. Figure 4 shows the growth of larch (Lh), balsam fir and black spruce on the same type which effectively raises the capability class by one unit for larch over the other hardwoods. Figure 5 shows the growth of trembling aspen (Page 1972) compared with white birch and softwoods.

Table 3

Site Classification: Black Spruce Forests
Region: Central Newfoundland

Forest Type	Succession	Forest Capability	Soil Parent Materials and Landforms	Soil Drainage	Soil Subgroup
I a Kalmia-Conifer black spruce forests					
1. Kalmia-bS (KbS)	KbS —F,L→ K.barren (unstable)	5MF-6FM	Sandy loam to loamy sand Mv (± lithic)	2 - 3	Orthic Humo-Ferric Podzol (± local ortstein, ± lithic) discontinuous or weak
2. Sphagnum-Kalmia-bS (KbSs)	KbSs —F,L→ Dwarf Shrub Bog (KbSs —allogenic→ D.S. Bog) normally stable	6MF	Mv (± lithic)	4	Gleyed Humic Podzol, thick ericaceous mor ± lithic Orthic Gleysol
3. Cladonia-Kalmia-bS (KbSc)	KbSc —F→ K-barren or —F→ bS-moss (stable)	7M	Loamy sand +/or gravel Mh, Gr, Gp, Ge	1	Orthic Humo-Ferric Podzol, with continuous or discontinuous ortstein
I b Black spruce Moss forests					
4. bS-moss on sandy loam (Pm1)	bS-moss —F→ KPc (unstable) poor germ. bS-moss —L→ Larix alder	5MF 4-5FM	Mp, Ap, At, Mv Sandy loam to loamy sand	2	Orthic Humo-Ferric Podzol (± ortstein, ± lithic)
bS-moss on loamy sand	bS-moss ——→ Fp				
5. bS-moss on sand and gravel (Pm2)	bS-moss —F,L→ KPt bS-moss —F→ KPc	6M	Mh, Gr, Gp, Ge Loamy sand/gravel	1 - 2	Orthic Humo-Ferric Podzol (ortstein)
6. bS-moss on seepage soils (Pm3)	bS-moss —L→ wB bS-moss —L→ Fh	5F-4F	Mp, MvCx, long slopes	3 - 4	Orthic Humo-Ferric Podzol seepage in lower B. Orthic Gleysol ± Ae (seepage over fragipan)
7. bS-moss on Hydromorphic Humus Podzols without peat cover (Pm4)	bS-moss —L,F→ K.barren (stable)	5FM	Mv (± lithic) Mp	4	Gleyed Humic Podzol
8. bS-moss on Lithosols (Pm5)	bS-moss —F→ R.barren bS-moss —L→ K.barren (stable)	6r-7r	R, Bc	1 - 2	Folisols/boulder paynerd/rock
9. bs-moss on Gleyed Podzols/Brunisols±mor. (Pm6)	bS-moss ——→ Ericaceous Larix bS-moss ——→ Herb and moss Larix (stable)	5FM 4F-5FM	Mv (lithic) Mp	4 4	Gleyed Ferro-Humic Podzol, Humic Podzol rare Gleyed Brunisol

Table 4

Site Classification: Balsam Fir - White Birch Forests
Region: Central Newfoundland

Forest Type	Succession	Forest Capability	Soil Parent Materials and Landforms	Soil Drainage	Soil Subgroup
II Balsam Fir-White Birch forests					
1. Pleurozium-bF (bFp)	bFp —F→ bS-moss (stable)	5MF	Sandy loam to loamy sand Mp, Ap, At, Mv (± lithic)	2 - 3	Orthic Humic Ferric Podzol (± local ortstein, ± lithic) also on lithosolic Podzols, with medium texture
2. Hylocomuim-bF (bFh)	bFh —F→ bS-moss	5FM-4FM	Variable texture Mp, Mv, Cx (long slopes)	3	Orthic Ferric-Humic or Humo-Ferric Podzol with seepage
	bFh —F→ wB (stable)	4F	Variable texture Mp, Mv, Cx (long slopes)	4	Orthic Gleysol ± Ae with seepage over a fragipan
3. Rubus-bF (bFr)	bFr —F→ wB (stable) or bFr —severe fire→ ALL	4W - 3W	Variable texture Mp, Mv, Cx (long slopes)	4 - 5	Orthic Gleysol, thin mucky phase (i.e. < 25 cm) with seepage over fragipan
4. Carex-bF (bFc)	bFc —F→ Ac-p (stable)	5W - 6W	Variable texture Mp, Mv, Cx (long slopes)	5	Orthic or Rego Gleysol, mucky phase (i.e 15-40cm muck)
5. Dryopteris-Lycopodium-bF (bFdl)	bFdl —F→ wB (stable)	3F - 4F	loam texture Mp, Mv, Cx (long slopes)	2 - 3	Degraded Dystric Brunisol, loam + seepage. Orthic Humo-Ferric Podzol, loam texture + seepage over a fragipan
6. Dryopteris-Lycopodium-bF wet varrient (bFdlw)	bFdlw —F,L→ All (stable)	3W - 4W	variable texture Mp, Mv, Cx (long slopes)	5	Mucky Orthic or Rego Gleysols
	bFdlw —F,L→ Larix alder	4W			
7. Sphagnum-bF (bFs)	bFs —F,L→ bFs (stable?)	6W	Mv, Mp	5 stagnant	Peaty Fera or Fera Eluvated Gleysol

Table 5

Site Classification: Larch Forests
Region: Central Newfoundland

Forest Type	Succession	Forest Capability	Soil Parent Materials and Landforms	Soil Drainage	Soil Subgroup
III Larch Forest					
1. Mesotrophic Larix Fen (Lfm)	?	6W	Organic	5 - 6	Typic Mesisol
2. Eutrophic Larix Fen (Lfe)	?	6W	Organic/base rich till	5 - 6	Typic Humisol, Fera Gleysol, Mucky Orthic Gleysol
3. Carex Larix alder (Lc)	?	6W	Alluvium	5 - 6	Mucky Orthic Gleysol, Typic Humisol, Typic Mesisol
4. Lycopodium Larix alder (Ll)	?	5W	Alluvium	4 - 5	Orthic Gleysol, Gleyed Humo-Ferric Podzol
5. Typic Larix alder (Lt)	?	5 - 6W	Alluvium	5 - 6	Mucky Orthic Gleysol, Typic Humisol
6. Ericaceous Larix (Le)	Stable ?	6 F/M	Mv, Mh	2 - 3	Orthic Humo-Ferric and Ferro-Humic Podzols, coarse
7. Herb and Moss rich Larix (Lh)	?	4F	Mp, Cx	2 - 4	Orthic and Gleyed Humo-Ferric and Ferro-Humic Podzols

Table 6

Site Classification: White Spruce Forests
Region: Central Newfoundland

Forest Type	Succession	Forest Capability	Soil Parent Materials and Landforms	Soil Drainage	Soil Subgroup
IV White Spruce Forests					
1. Coastal and alpine White Spruce (Ws1)	Ws1 —C→ Ws1	6-7 F W	Mv, Mv/R	1 - 2	Typic Folisol/Rock, Orthic Humo-Ferric Podzol ± lithic
2. Oldfield White Spruce (Ws2)	Ws2 —C→ Ws2	5 - 6	Mp, Mh	2 - 3	Orthic Humo-Ferric Podzol on loam with seepage
3. White Spruce on a. rich soils natural - (Wsa)	Wsa —C→ bFh?	3 - 4F	Mp, Alluvium	2 - 3	Orthic Humo-Ferric Podzol on loam with seepage
b. ungulate induced - (Wsb)	Wsb —C→ Wsb? Wsb —C→ bFh?	3 - 4F	Mp	2 - 3	Orthic Humo-Ferric on loam with seepage, Orthic Dystric Brunisol

Table 7

Site Classification: Red Pine Forests
Region: Central Newfoundland

Forest Type	Succession	Forest Capability	Soil Parent Materials and Landforms	Soil Drainage	Soil Subgroup
V Red Pine Forest					
1. Red Pine on medium textured sands. (Rp1)	Rp1 ——> KbS	5MF	Sandy loam Gt, Gp	2	Orthic Humo-Ferric Podzol
2. Red Pine on coarse textured glacial fluvial deposits (Rp2)	Rp2 ——> KbSc	6MF	loamy sand Gt, Ge	1	Ortstein Humo-Ferric Podzol/or Fragic Humo-Ferric Podzol
3. Red Pine on Folisols over bedrock (Rp3)	Rp3 ——> KbSc	6MF	Dry Organic FH/Rock	1	Lithic Folisol/ bedrock

Table 8

Site Classification: White Birch Forests
Region: Central Newfoundland

Forest Type	Succession	Forest Capability	Soil Parent Materials and Landforms	Soil Drainage	Soil Subgroup
VI					
1. White Birch Forest on unstable soils (Bu)		6 - 7E	talus and scree slopes, boulder colluvium	2	Orthic Regosol on unstable boulder colluvium
2. Rubus - birch (Br)		4W	Colluvium and till, Mp.	4	Gleyed Dystric Brunisol, Orthic Gleysol with seepage
3. Dryopteris - Clintonia - Birch (Bdc)		3W - 4W	Mp, At, Cx	2 - 3	Orthic Humo-Ferric Podzol, Gleyed Humo-Ferric Podzol with seepage
4. Dryopteris - Birch (Bd)		3W - 2C	Mp, At	3 - 2	Orthic Humo-Ferric Podzol, Gleyed Dystric Brunisol
5. Kalmia - Birch (Bk)		5 - 6MF	At, Gt	2	Orthic Ferro-Humic Podzol, with Mor ± weak ortstein

Table 9

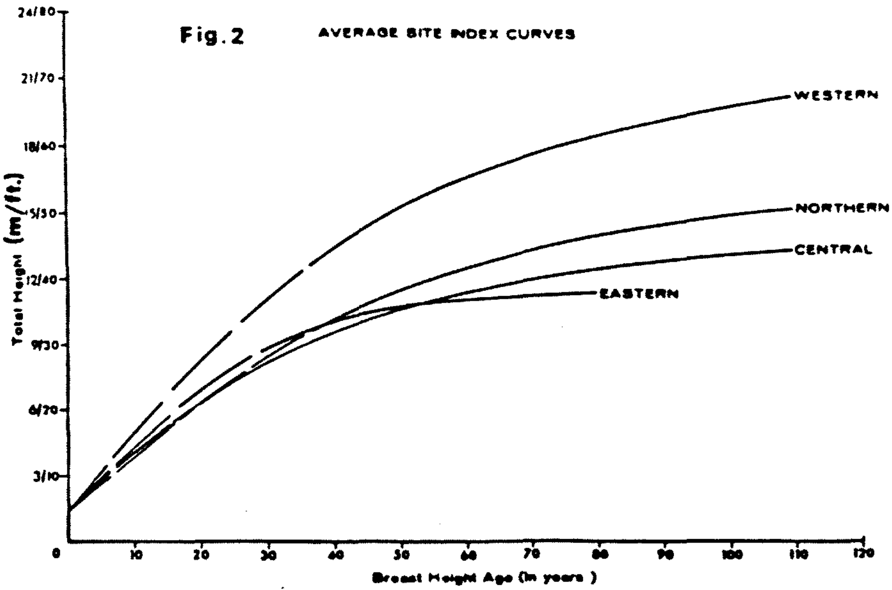
Site Classification: Trembling Aspen Forests
Region: Central Newfoundland

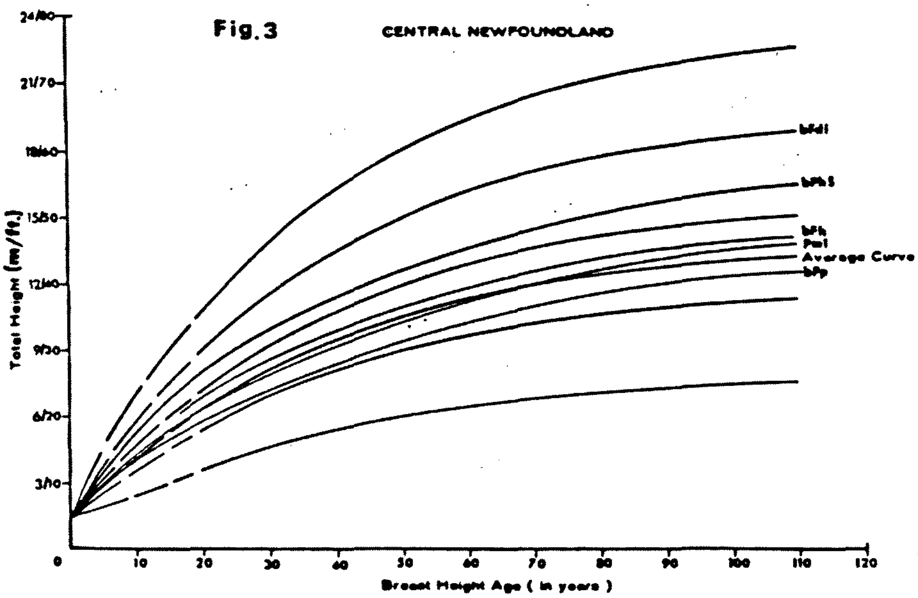
Forest Type	Succession	Forest Capability	Soil Parent Materials and Landforms	Soil Drainage	Soil Subgroup
VII					
1. T. Aspen on moist alluvial soils (TAa)		2*- 4F	At, Ap Silt loam / sand and gravel	2 - 3	Eluviated Dystric Brunisol, or Orthic Regosol with seepage
2. T. Aspen on well drained till soils (TAt)		4F	Mp, Mh loam to sandy loam	2 - 3	Orthic Humo-Ferric podzol with thin LFH
3. T. Aspen on imperfectly drained soils (TAg)		4F - 5FW	Mp silt loam to sandy loam	3 - 4	Orthic Gleysol with seepage, Gleyed Humo - Ferric podzol with seepage
4. T. Aspen on Lithic soils (TAs)		5 - 6MF	Mv/r, sandy loam FH, Organic	2	Lithic Humo-Ferric podzols, Lithic Folisol / bedrock
		* very rare in occurrance			

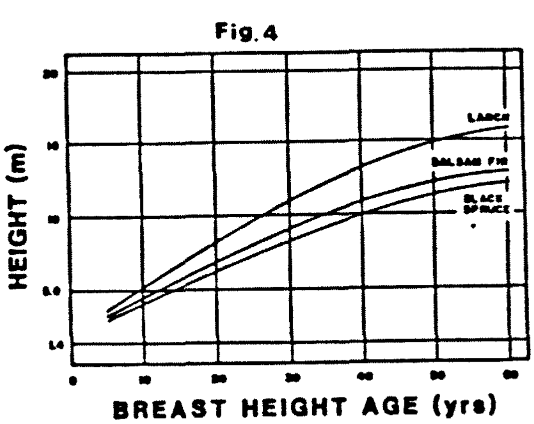
Table 10. Wood production in several capability classes.

Capability class	Merchantable ft^3A^{-1}	Merchantable m^3ha^{-1}	Merchantable cords A^{-1}	MAI[a] @ 60 years $ft^3(A^{-1})yr^{-1}$	MAI[a] @ 60 years $m^3(ha^{-1})yr^{-1}$
7	200	14.0	2.4	3	0.21
	400	28.0	4.7	7	0.49
	600	42.0	7.1	10	0.70
6	800	56.0	9.4	13	0.91
	1000	70.0	11.8	17	1.19
	1200	84.0	14.1	20	1.40
	1400	98.0	16.5	23	1.61
	1600	112.0	18.8	27	1.89
	1800	126.0	21.2	30	2.10
5	2000	140.0	23.5	33	2.31
	2200	154.0	25.9	37	2.59
	2400	168.0	28.2	40	2.80
	2600	182.0	30.6	43	3.01
	2800	196.0	32.9	47	3.29
	3000	210.0	35.3	50	3.50
4	3200	224.0	37.6	53	3.71
	3400	238.0	40.0	57	3.99
	3600	252.0	42.4	60	4.20
	3800	266.0	44.7	63	4.41
	4000	280.0	47.1	67	4.69
	4220	294.0	49.4	70	4.90
3	4400	308.0	51.8	73	5.11
	4600	322.0	54.1	77	5.39
	4800	336.0	56.5	80	5.60
	5000	350.0	58.8	83	5.81
	5400	378.0	63.5	90	6.30

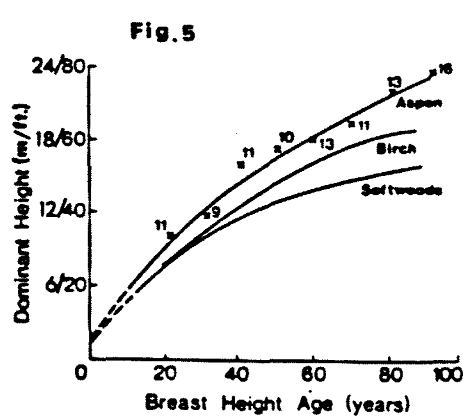
[a]MAI = Mean annual increment.







* Herb & Moss Type Only



DISCUSSION

The black spruce and balsam fir types shown in Tables 3 and 4 are based on those of Damman (1963, 1964) with the exception of minor additions and an update of the soils, landforms, drainage and capability class (Wells and Roberts 1973). The importance in recognizing soil seepage and its contribution to growth is a main feature in regards to soils of the area. Balsam fir is becoming much more common in this region due to logging and the lower frequency of forest fires and as a result many of the former black spruce areas in moist areas are succeeding to balsam fir.

The larch types have developed since the major logging disturbances in the last three decades and although now sporadic in occurrence, the larch types are becoming more common each year. Exceptionally good growth occurs on the medium quality sites.

White spruce forms a minor component in most of the better quality softwood stands but there are few pure stands with the exception of those where the more palatable balsam fir and white birch has been dwarfed by continuous feeding by moose. Exceptionally good growth occurs on the better quality sites.

Red pine is the rarest coniferous tree species in Newfoundland and is restricted to some 20 locations. The species however produces merchantable timber on the otherwise nonproductive dry Cladonia-Kalmia outwash sites and raises the capability class by two units over black spruce to medium quality capability class 5.

The hardwood types are becoming much more common as merchantable forests in central Newfoundland, succeeding balsam fir from cutting and fire. They are only partly utilized as fuelwood and a percentage of the aspen as pulp. These hardwoods tend to dominate the richer sites and hence the more valuable softwoods are out-competed. On the poorest of the capability class 5 and upper 6 class, trembling aspen is often the species which appears to dominate over black spruce after fire. This is exemplified in the central areas after the disasterous forest fires in 1961. After some 20 years however the black spruce tend to catch up with the aspen which after a much better start has ceased to grow at the rate (from layers) immediately after the fire. The black spruce in these stands will slowly catch up giving a black spruce forest with some 10% aspen. It should be noted that black spruce is more tolerant than we sometimes realize and in these stands we find this is so. In addition the growth of black spruce particularly on lithic soils is better with the nurse crop of aspen. Besides better growth and more resistance to fire and insects, the mixed bS aspen are about the right density as they reach semi-maturity, and thinning is not recommended as this enhances damage from spruce budworm (Roberts and Chow 1977).

Problems in assessing forest sites are not new or restricted to this area, and at this point in time different methods are being employed in the Boreal Forest of Canada. Recent classification includes Jones et al. (1983) for the Clay Belt of Ontario, Canada and Van Groenewoud and Rultenberg (1982) for New Brunswick, Canada. One of the main problems in assessing site types is in the recently disturbed forest types, e.g. one to five years after logging where the herb and moss indicator species are replaced by a variety of herbs and shrubs which bear no resemblence to the mature ground flora. Hence the ability to look at the site from a soils-drainage, landform point of view is most important.

The forest management systems now in place in Newfoundland depends on the fact that the best sites and problem sites be treated in an effective manner. It is recognized that now there is a higher percentage of treatment dollars available and the number one priority is the rehabilitation of recently disturbed sites. At the same time all the forest land in each management unit should be site typed. With the semi-mature to mature types in place, suitable predictions can be made to evaluate and identify what will happen to the various sites as a result of logging, fire, windthrow, insect damage, etc. Since the 1970's spruce budworm infestations, succession after insect kill is being researched based on the Damman site framework (Meades 1983).

In addition to classifying forest types, the problem of mapping site types from aerial photographs are well known (Bajzak 1964, Damman 1979). Interpretation of black and white or natural colour aerial photographs at a scale of approximately 1:20,000 to 1:12,000 can now be mapped with 80-90% accuracy by experienced interpreters. There is, however, often a need to map out the landforms as a complex of two or three site types. By accessing the slope, parent material, aspect and drainage, one is able to map the site types with a fair degree of accuracy.

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CFS Workshop - SCALE, 6 October 1985

Site Classification, Interpretation and Land Evaluation

Canadian Forest Inventory Committee (CFIC) Expression of Need

(J.J. Lowe, Manager, Forest Inventory, FORSTATS, PNFI)

The CFIC consists of the chiefs of forest inventory of all provinces and territories, with CFS involvement and 1 consultant. I am now the CFS Member of CFIC, Rob Keen is Chairman and Brian Haddon is Secretary. In 1985 CFIC added 2 new CFS ex officio non-voting members:

- Director CFS Research Branch (Les Carlson);
- Chairman CFS Regional Committee on FORSTATS (Jack Smyth).

The committee is now 10 years old, it is an excellent forum for exchanging inventory ideas, and probably represents the major clientele of SCALE. CFIC would welcome the initiative of SCALE, and if there are no objections I plan to keep them advised.

At the June 1985 meeting CFIC had a frank, closed session on Forest Inventory Compilation.

The following quotations from the minutes are pertinent to SCALE. The underlines are mine.

"One of the trends most evident during the discussions was the distinct shift in emphasis towards site-specific data and the much greater detail called for both in the classifiers and the quantitative estimates. The shift included particularly a change in focus away from overviews of the larger, administrative units and towards the individual stand or local aggregations. The trend reflects the change from a liquidation approach to the forest to the management of the resource. Accompanying this shift is the increasing pressure to divert forest land to other uses and to apply limits or restrictions which recognize environmental concerns and other societal issues. The increasing pressure is constantly calling for more detailed, up-to-date information. The impact of this trend was clearly reflected in the presentations. The rapid development of geographic information systems (GIS) for providing a means of analyzing and manipulating the data and updating and monitoring change is an example of the response. These systems use the forest stand, that is the polygon, as the basic building block. Other aspects of forest inventory, such as compilation, are compelled to follow suit. Accompanying this trend is the greater call for quantitative stand data such as stems per hectare, basal area, expressions of productivity by species and the size class structure as expressed by stand and stock tables.

During the discussions of the presentations, the need for stand age, site index and growth productivity information arose frequently. Often these quantities had not been sampled in the past and efforts were made to approximate them. In some cases the variables could not be measured. For example, the height/age relationship of trees could not be used to evaluate site index in forest land devoid of trees or with young stands. The use of lesser vegetation indicators and other ecological indicators may disagree. In other cases both the ecological site classification and site based on height/age are used together and were found to conflict. The reconciliation of differences was expressed as a problem by several delegates.

Parallel to the trend for more detailed inventory data related to the needs of intensified management, has been the need for more growth productivity data. These data are required primarily to improve annual allowable cut figures, to aid in decisions on silvicultural practices, to evaluate the effectiveness of stand treatments and to improve growth projections. The development of yield tables and the establishment of permanent sample plots (PSP) were cited as examples having problem areas."

It should be pointed out that the discussion ignored a characteristic of Canadian forest management inventories that is too obvious to CFIC to have been mentioned. This is that the majority of the millions of mapped stands are not visited by the inventory team, but are delineated and described through photo interpretation or other remote sensing. This means that stand and site descriptors must be capable of relating to interpretation on an image as well as on the ground if they are to be used in forest management inventories, and hence to contribute to the subsequent activities of projection, modelling, analysis, planning and operations based on these inventories.

The session ended with the recognition of 6 major problems and recommendations, of which one is a clear statement to SCALE.

"Site index classification

Problem: The sometimes conflicting results of site classification based on vegetation indicators and other ecological factors and quantification based on the height/age relationships has led to some confusion and inconsistency. The topic requires further investigation to better understand the inconsistencies, to anticipate under what circumstances they are likely to occur and to provide some guidelines for reconciling the differences.

Recommendation: That differences between site classifications based on ecological factors and those based on height/age be investigated with the purpose of reconciling the differences or establishing guidelines for applying the results for cases where inconsistent differences occur."

ECOCLIMATIC REGIONS OF CANADA

Prepared by: Ecoregions Working Group
(Canadian Committee on Ecological Land Classification)
Contributors: Regional Working Groups (one per province)

Purpose: To delineate regions of eco-(bio-)climate; units within which the ecological effects of climate upon vegetation (including chronosequence) is relatively uniform. To produce a map (1:7,500,000) and brief descriptions of the regions.

Application: Within ecoclimatically uniform regions relationships (forest productivity, plant succession, competition potential, etc.) can be determined for each soil-site and these relationships can be applied to similar sites within the same region.

Status: Preliminary map and descriptions of 65 regions have been completed. These are now in the final review process by the contributors. This CCELC project has been given a substatntial boost by a contract from Lands Directorate. Final manuscript is expected by March, 1986, ready for publication.

September, 1985

S.C. Zoltai

Chairman,
Ecoregions Working Group

A NATIONAL SYSTEM FOR FORESTED ECOLOGICAL AREAS*

Since 1970, Canada has made much progress in establishing ecological areas, but a national and comprehensive system of representative sites is far from complete. This is particularly true of forests, where representative areas are lacking for major ecosystems. The need for action is urgent because opportunities for selection of areas are diminishing rapidly.

In 1985, the Canadian Institute of Forestry (CIF), supported by the Canadian Forestry Service, renewed plans to establish a National System of Forested Ecological Areas. The goals of the program are to:

- prepare standards to guide selection, protection and management of forested areas representative of Ecoregions in Canada;

- maintain a National Register of Forested Ecological Areas;

- foster completion of the National System through designation of candidate areas.

Through its national network of 22 sections, the CIF initially will identify good examples of Ecoregions on lands already under secure ownership and suitable management. Liaison with government, non-government, or other agencies responsible for these lands will be facilitated through the Canadian Council on Ecological Areas (CCEA). Where landowners agree, sites meeting selection criteria will be documented and entered in the National Register. Ecoregions not represented in such de facto reserves will be identified with a view to active search for and establishment of candidate areas.

The scheme will be initiated in 1985-86 with a pilot study in three CIF Sections, chosen to sample the diversity of ecological and administrative conditions to be encountered in Canada. The goal of the study is to develop a provisional Register of forested ecological areas on de facto reserves within each Section.

Since its purpose is to provide ecological and genetic baselines for current status and future change in naturally-evolved ecosystems, the System would appear to be particularly suited to long term needs for reference points for land classification; agreement in principle by land classification specialists on the proposed System would be beneficial to its developments.

D.F.W. Pollard
Canadian Forestry Service
Ottawa

19 September 1985

*This presentation was not made at the meeting, but is provided here as additional information to the Working Group.

SESSION 2

Information Exchange

CONTRIBUTION OF SOIL INFORMATION BY LRRI TO DEVELOPMENT OF SCALE

C. Tarnocai

INTRODUCTION

Soil Survey was involved in the preparation of the Canada Land Inventory (CLI) forest capability maps and provided soil data for this work. The Land Resource Research Institute (LRRI), through Soil Survey, has in recent years become increasingly involved in surveys of forested areas of Canada. These surveys are at various intensity levels. They are, however, generally reconnaissance or exploratory types. During the interpretation of this soil survey data forest capability ratings of soils mapped are often provided.

During the past few years we have been working on the application of a computerized forest productivity model which will generate forest productivity values based on soil and climatic information. LRRI is also in the process of setting up an updated national soil landscape data base which will provide the necessary data for various interpretations, including forestry.

LRRI has worked closely with foresters in the past and has found this interaction to be very productive. We welcome the invitation from the Canadian Forestry Service's Site Classification, Interpretation and Land Evaluation (SCALE) Working Group to work on the development of a forest land resource and land evaluation program. LRRI has placed a high priority on this activity and is looking forward to being involved with this Working Group. This paper describes the LRRI forestry-related activities and outlines those in which input could be provided to the SCALE program.

THE ROLE OF SOIL IN FOREST PRODUCTIVITY

The soil provides anchorage for trees and other plants as well as much of the materials, such as water, nutrients and oxygen, necessary for plant growth. The soil can thus be viewed as part of the energy cycle, supporting the plants and providing raw materials to be utilized through photosynthesis to produce organic matter. In annual or short-lived perennial agricultural crops it has been possible to establish well-defined relationships between soil properties and crop growth and development. In the case of trees, a long rotational crop, however, this relationship is not clear. Foresters on this continent have so far been mainly concerned with mature stands. This is probably because so much virgin timber has been available in Canada. This view has already begun to shift as these virgin stands are rapidly diminishing. In order to manage forests, increase their productivity, and reduce their rotation time, more attention must be given to the soil and its management for forestry purposes.

There has been some similarity in the development of agriculture and forestry in Canada with regard to soils and productivity. Agriculture started with a "pioneer" outlook - cut the trees or break the sod and the area of agricultural land will increase. Canada has been viewed, and still is viewed by some people, as a land of limitless and vast agricultural potential. It is now slowly being realized that Canada's agricultural lands are in fact extremely limited and are composed of only 6% of Canada's total land area. In addition, the climate and soil properties impose serious limitations on the productivity of arable agricultural land. This "pioneer" outlook and poor management practices have led to serious soil degradation with resulting erosion problems. Only recently has the importance of soil conservation been recognized.

In order to increase productivity in agriculture, great emphasis has been placed on plant breeding, plant physiology, and pathology, the biological components. It has been recognized, however, that the main source of productivity gain in agriculture comes from the soil. Increased soil fertility, irrigation, drainage and soil protection have accounted for 75% of the crop production increase per unit of land area in the developed world. A similar situation probably exists in forestry. Highly productive stands occur on fertile soils with adequate nutrients, rooting depth and moisture. Fertilizer and silviculture studies have indicated that the growth response is greater on forest stands occurring on high quality soils than on poor quality soils.

FORESTRY-RELATED ACTIVITIES IN LRRI

Forest capability rating using CLI methodology

Capability ratings for forest growth have been provided for some areas covered by soil surveys, especially if the area is forested. These capability ratings are tied to the soils, both mineral and organic, occurring in the map area. Most of these capability ratings have been derived from measurements obtained on the best mature stands. The capability classification used for these ratings follows the method of McCormack (1967) and is similar to the method used for the CLI forestry capability maps. An example is the soil-related capability from the Red Rose - Washow Bay soil survey area in Manitoba (Smith et al. 1975) given in Table 1.

ECSS* Forestry Working Group's activities

A report being prepared by the Forestry Interpretation Working Group includes the soil interpretation methodologies for forestry. This report, as described by Moon (1985), will include the

* Expert Committee on Soil Survey

methods for preparing forestry interpretations. The report also includes various case studies in which interpretations were carried out for forest road construction, off-road operations, sedimentation following forest operations, mass movement following road construction, and forest productivity, regeneration and species suitability.

Folio type of surveys in B.C.

The Mill and Woodfibre Creeks folio provides a resource inventory and guide for operational planning for roads, cut-blocks and other forestry-related developments. The main objectives of this work were as follows:

1. To demonstrate the feasibility of producing an adequate inventory base to guide operations in the development for forestry of watersheds characterized by rugged terrain and dense forest cover.
2. To design an inventory specific to the planning needs of forestry, but which also retains much of the information necessary for the broader-based planning needs of a general purpose soil survey.
3. To evaluate the utility of a number of interpretive and derivative maps (based on the basic inventory) as an aid to developing management guidelines and presenting them in map form.
4. To compare various scales and types of inventories as a base for forestry planning needs.

This folio includes a terrain and general soil association map, a forest inventory map, and a soils and vegetation map. From this baseline information a number of interpretative maps were generated relating to mass movement, sedimentation as a result of road construction, and other problems relating to road construction and maintenance.

Forest ecosystem classification in the Ontario Clay Belt

A generalized forest ecosystem classification (Jones et al. 1983) was developed for the Clay Belt of Ontario. This classification, based on vegetation, soil and moisture conditions, allocates any stands in the Clay Belt to one of fourteen operational groups. Identification of these ecological classes helps the forester to make management decisions concerning the forest.

Computer-derived forest productivity

In order to demonstrate the interrelationships between forest productivity, climate and soils, the production of plant material (total biomass production) was modeled as a function of climate and soil properties (Clark 1984). This was carried out by taking the general biomass production model developed for FAO (the United Nations Food and Agriculture Organization) by de Wit (1965) and adapting it to tree growth patterns. This model was also modified to take into account soil characteristics affecting tree growth. The forest productivity was derived by applying the above model to a national 1:5,000,000 scale soil data base. It was also applied to four 1:60,000 and 1:125,000 scale soil data bases representing small areas from various parts of Canada (Figures 1 to 5).

The resulting computer-derived forest productivity rating showed close correspondence to the measured maximum forest productivity (CLI) as indicated in Table 2. Good correlation was found between the potential productivity estimated from the model and the measured forest productivity on the better drained sites. The model, however, was insensitive for excess moisture. On poorly drained soils the model overestimated the forest productivity. There were also some discrepancies in the mountainous regions of British Columbia. In these regions, since the weather stations were situated mainly in the valleys, the areas at higher elevations were overestimated. Some extremely high productivity values (based on actual measurements), which were not predicted by the forest productivity model, were also found on river benches and islands in the Kootenay River. Obviously these highly productive sites, because of their very favourable water regime and high fertility, were not taken into account in the model. There were some problems in Newfoundland areas with high wind exposure. Wind exposure has a negative effect on tree growth and this was not built into the model. These areas were thus predicted to have a higher forest productivity than the measured values. Since the model calculates only biomass with no indication of plant species, a further problem arose when wood productivity was erroneously predicted north of the arctic tree line. These were some of the conclusions drawn from evaluation of the results generated by this model (Clark 1984). Since then, work has begun on solving these problems, thus making the model more reliable for forest productivity estimates.

POSSIBLE CONTRIBUTIONS OF LRRI TO SCALE

Activities by LRRI described in this section are those which could be considered as contributions to SCALE's activities. Most of these projects are in the developmental stage and are described briefly below.

Soil-based forest productivity on various scales

The FAO biomass model has demonstrated potential for predicting forest productivity as has been indicated above. Work has already begun in LRRI on solving the problems involved. In mountainous areas the solution was to generate productivity estimates at 500 metre intervals (vertically), rather than at the elevations where the climatic stations were located. This solution was tested and produced very promising results. Work is continuing on solving the remaining problems. This model will eventually provide a soil-climate based forest productivity estimate for various scales of maps. Our first goal is to apply the model to the 1:5,000,000 scale soil data base and generate an updated national forest productivity map. After this, the model will be applied to the 1:1,000,000 scale soil landscape data base being prepared by LRRI. This soil landscape data base will provide a flexible system for evaluating forest productivity by selecting productive sites on a national basis. The model could also be applied to larger scale soil maps at the reconnaissance and detailed survey levels.

National soil landscape data base

The Soil Survey is currently preparing a 1:1,000,000 scale computerized soil landscape data base for Canada (Figure 6). This new national soil data base, which will provide information for various interpretive and derivative maps, is based on the permanent landscape features and is being mapped on a systematic basis throughout the country. These computer stored maps are associated with an extended, computerized legend. The first phase of mapping (Figure 6) has now been completed. It is planned that the mapping of the remainder of Canada will be completed during the next five years. One of the interpretations for which this data base will be used is forestry. Before the forestry interpretation begins, however, the following must be done:

1. Identify those soil properties which are essential in determining forest productivity.
2. Include the identified forestry-related soil properties in the data base (extended legend).
3. Include a vegetation module in the data base.

Preparation of forestry manuals

LRRI could help in developing forestry manuals similar to that developed for the Ontario Clay Belt. This manual (Jones et al. 1983) was found to be useful by foresters.

Developing approaches for forest land evaluation

It is the plan of LRRI to develop a model which will be able to make predictions relating to forest productivity changes resulting from such factors as improved management practices, a change in soil fertility, and silviculture. The FAO, model which was found to be very successful in generating forest productivity values, is one possible model. We will be working on this problem in the coming years and will welcome expertise from this committee and from the Canadian Forestry Service.

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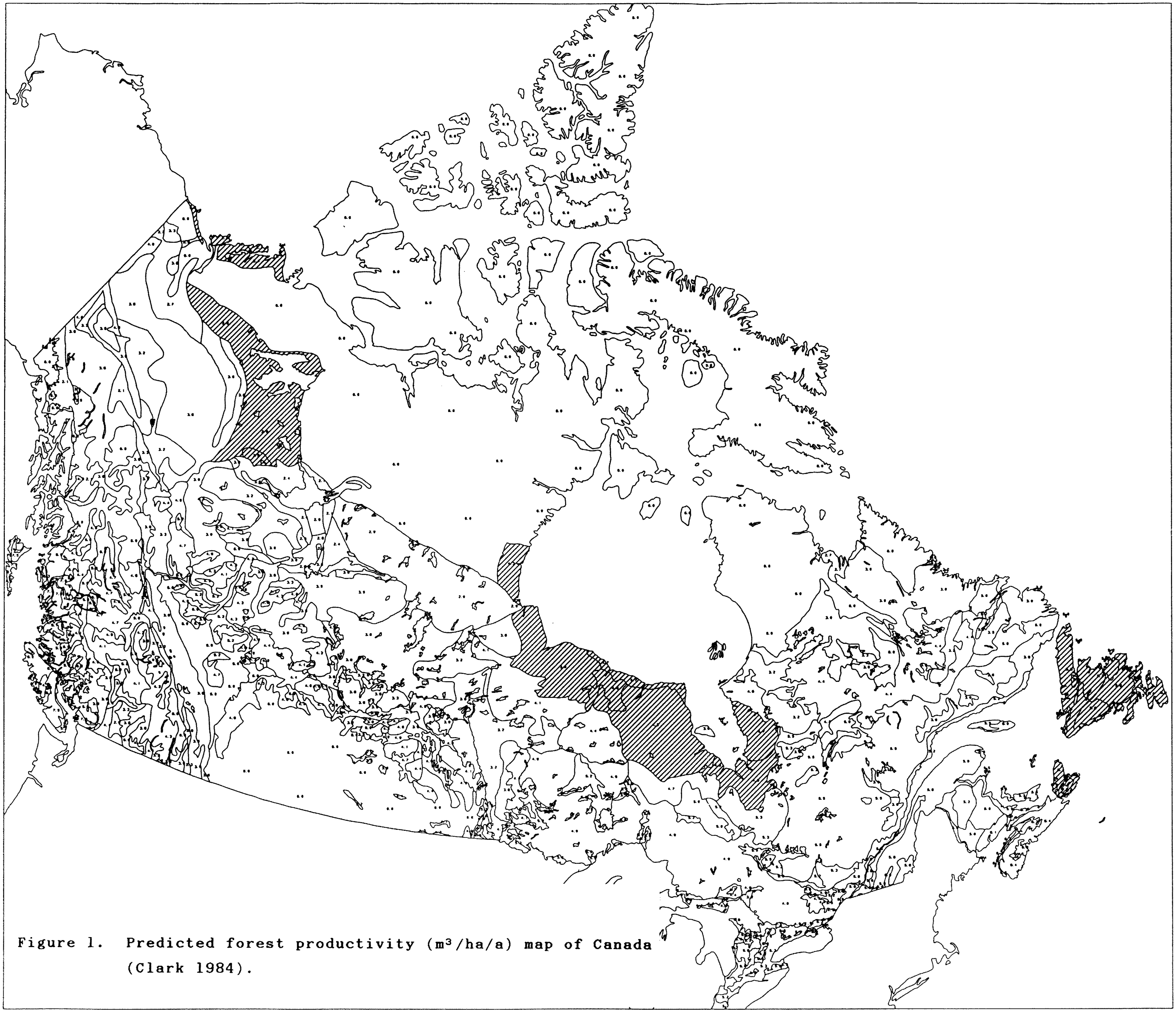

Figure 1. Predicted forest productivity ($m^3/ha/a$) map of Canada (Clark 1984).

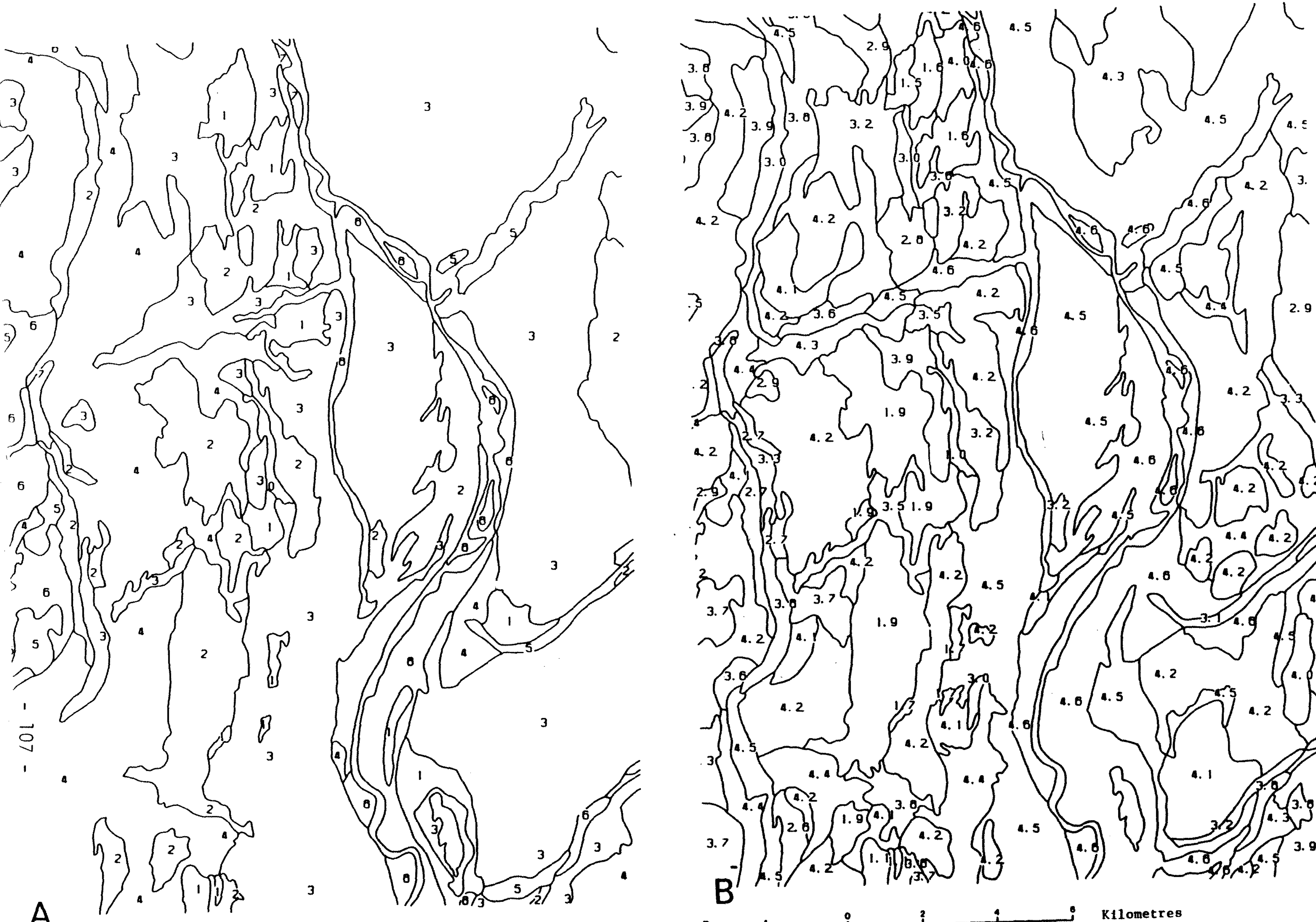

Figure 2. Estimated (A) and predicted (B) coniferous forest productivity (m³/ha/a), East Kootenay area, British Columbia (Clark 1984)

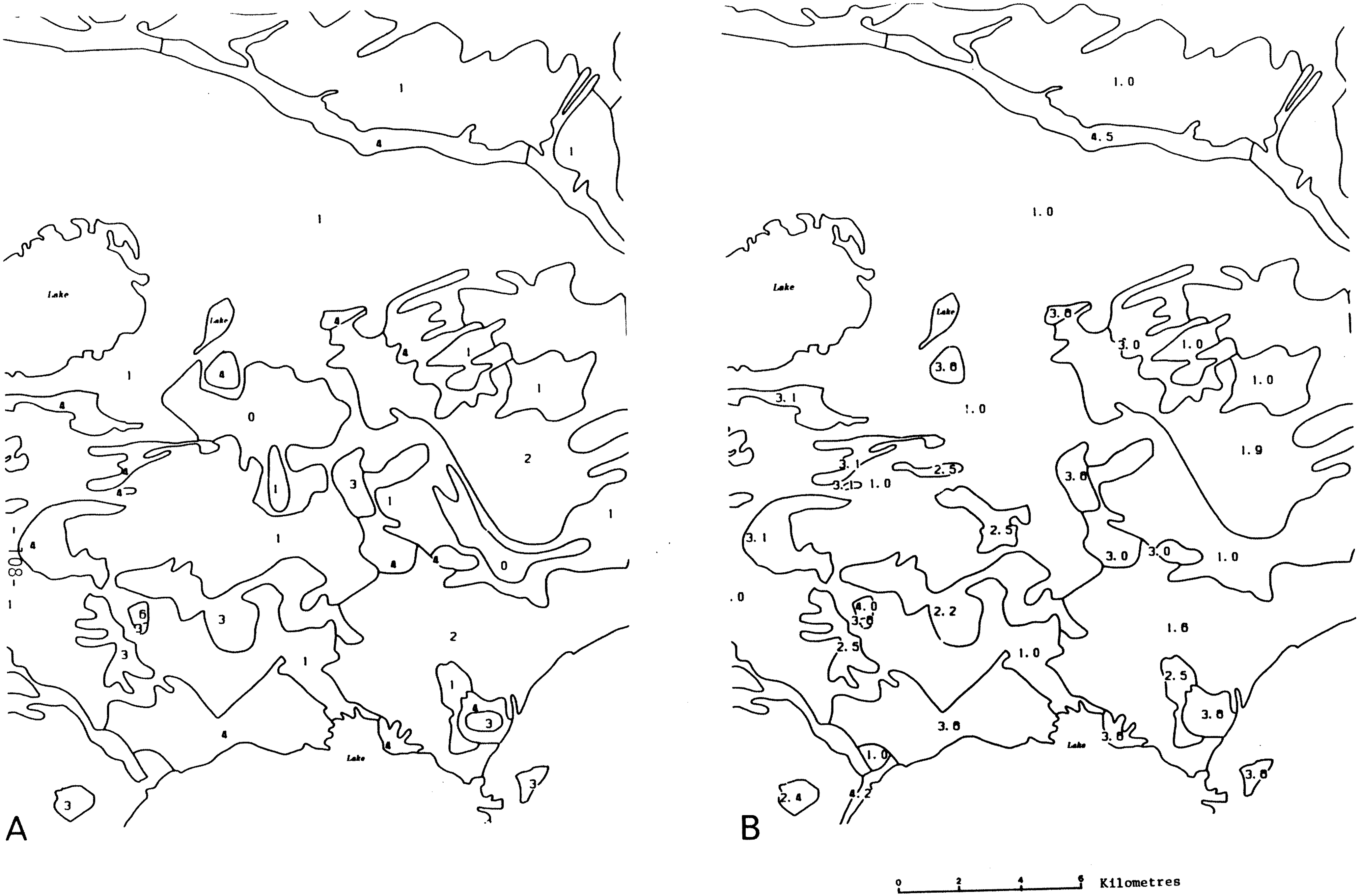

Figure 3. Estimated (A) and predicted (B) coniferous forest productivity (m^3/ha/a), The Pas area, Manitoba (Clark 1984).

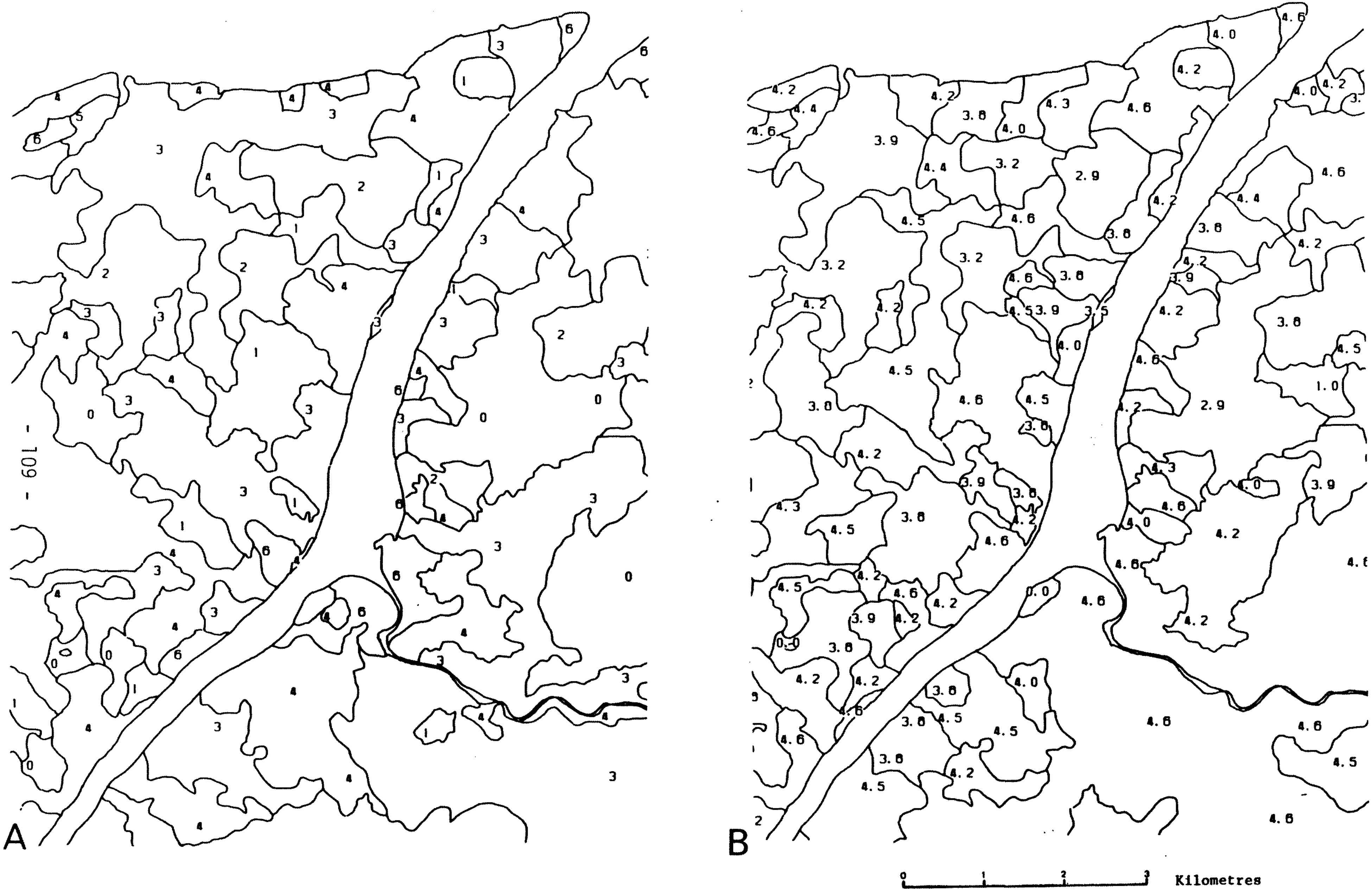

Figure 4. Estimated (A) and predicted (B) coniferous forest productivity ($m^3/ha/a$), Richibucto area, New Brunswick (Cl[illegible] 1984)

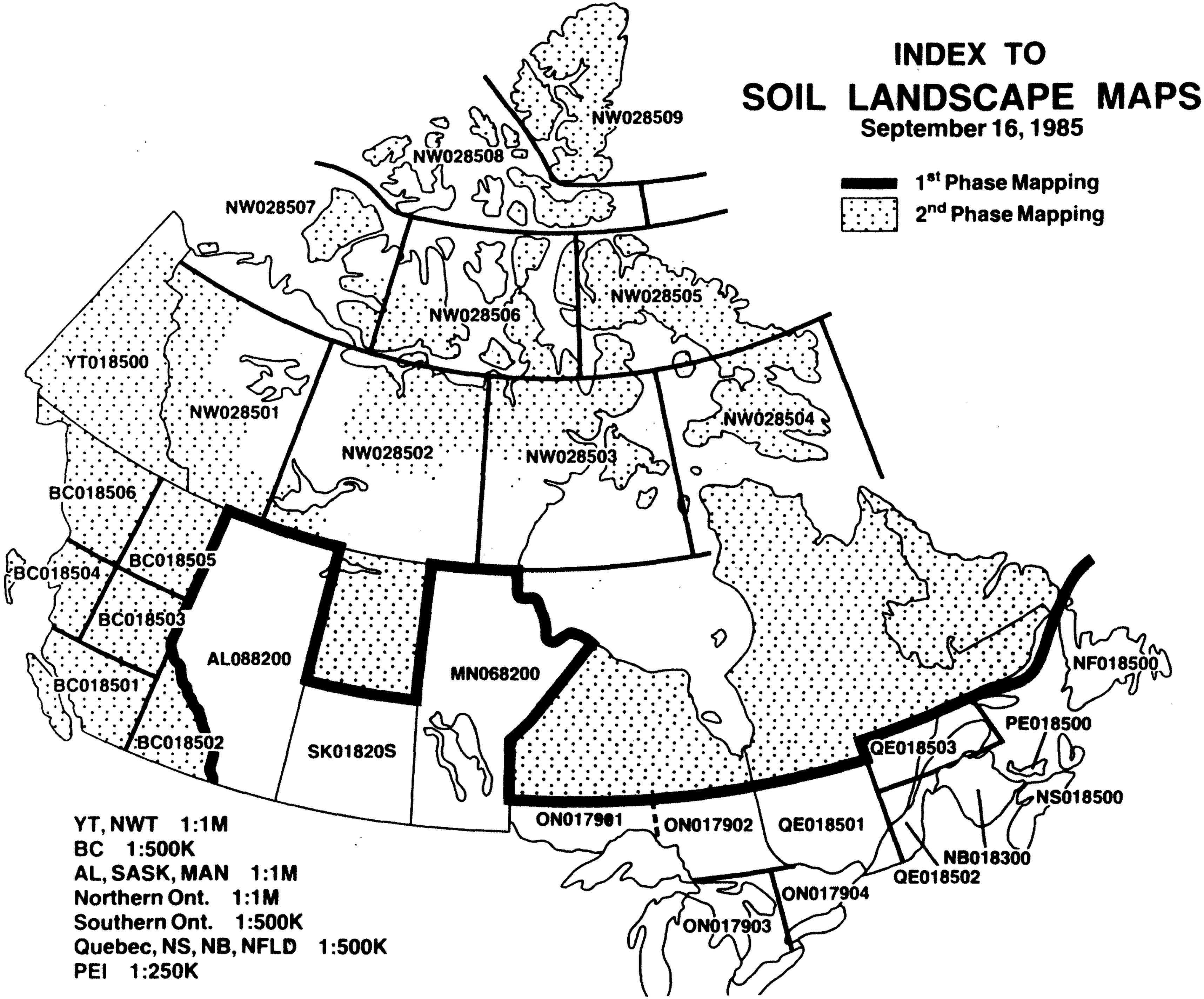

Figure 5. LRRI's national soil landscape maps (two phases).

Forest Productivity* of Soils

Parent Material	Moisture Class	Soil Name	Softwood					Hardwood							
			jP+	wS	bS	bF	tL	tA	bP	wB	As	bO	W	mM	wE
Moderately coarse to medium textured, moderately calcareous, stony till	fresh	McArthur	4	3	—	4	—	3	—	3	—	—	—	—	—
	moist	Pinawa	4	3	—	—	—	5	—	5	—	—	—	—	—
Recent alluvium	fresh	Hodgson	—	5	—	—	—	5	6	—	6	—	—	5	—
	moist	Fisher	—	5	—	—	—	3	3	—	5	—	—	5	—
Thin mucky loam deposits	saturated	Marsh	—	—	—	—	—	—	—	—	—	—	7	—	—
Limestone and dolostone rock outcrop	dry	Rock Outcrop	—	—	—	—	—	7	—	7	—	7	—	—	—
Recent beach deposit	dry to moist	Sand Beaches	—	—	—	—	—	—	—	—	—	—	—	—	—
Dominantly moderately decomposed forest peat, less than 52 inches thick	wet	Okno	—	—	5	—	5	—	—	—	—	—	—	—	—
	wet	Rat River	—	—	5	—	5	—	—	—	—	—	—	—	—
	wet	Grindstone	—	—	5	—	5	—	—	—	—	—	—	—	—
	wet	Janora	—	—	5	—	5	—	—	—	—	—	—	—	—
Dominantly fibric Sphagnum peat less than 64 inches thick	wet to saturated	Molson	—	—	7	—	7	—	—	—	—	—	—	—	—
	wet to saturated	Sand River	—	—	7	—	7	—	—	—	—	—	—	—	—
	wet to saturated	Kilkenny	—	—	7	—	7	—	—	—	—	—	—	—	—
Dominantly mesic sedge peat, less than 52 inches thick	saturated	Cayer	—	—	—	—	—	—	—	—	—	—	7	—	—
	saturated	Kircro	—	—	—	—	—	—	—	—	—	—	7	—	—
	saturated	Crane	—	—	—	—	—	—	—	—	—	—	7	—	—
	saturated	Holditch	—	—	—	—	—	—	—	—	—	—		—	—
Dominantly moderately decomposed forest peat, greater than 52 inches thick	wet	Baynham	—	—	6	—	6	—	—	—	—	—	—	—	—
	wet	Bradbury	—	—	6	—	6	—	—	—	—	—	—	—	—
Dominantly fibric Sphagnum peat, greater than 64 inches thick	wet to saturated	Julius	—	—	7	—	7	—	—	—	—	—	—	—	—
	wet to saturated	Sproule	—	—	7	—	7	—	—	—	—	—	—	—	—
	wet to saturated	Denbeigh	—	—	7	—	7	—	—	—	—	—	—	—	—
Dominantly mesic sedge peat, greater than 52 inches thick	saturated	Stead	—	—	—	—	—	—	—	—	—	—	—	—	—
	saturated	Macawber	—	—	—	—	—	—	—	—	—	—	—	—	—

* Productivity is gross mean annual increment of merchantable volume

1 over 100 cu ft acre
2 91-110 cu ft / acre
3 71-90 cu ft / acre
4 51-70 cu ft / acre
5 31-50 cu. ft./acre
6 11-30 cu ft./acre
7 less than 10 cu. ft./acre

Common and Scientific Names of Tree Species Used in the Text

Common name	**Abvr.**	**Scientific Name**
Aspen, trembline	tA	Populus tremuloides Michx.
Ash, green	As	Fraxinus pennsylvanica Marsh.
Birch, white	wB	Betula papyrifera Marsh.
Elm, white	wE	Ulmus americana L.
Fir, balsam	bF	Abies balsamea (L.) Mill
Larch, tamarack	tL	Larix laricina (Du Roi) K. Koch
Maple, Manitoba	mM	Acer Negundo L.
Oak, bur	bO	Quercus macrocarpa Michx.
Pine, jack	jP	Pinus banksiana Lamb
Poplar, balsam	bPo	Populus balsamifera L.
Spruce, black	bS	Picea mariana (Mill.) BSP
Spruce, white	wS	Picea glauca (Moench) Voss
Willow	W	Salix sp.

Table 1. Forest productivity classes of some soils in the Red Rose - Washow Bay area, Manitoba (Smith et al. 1975).

Table 2. Predicted* climate and water limited forest productivity ($m^3/ha/a$) (Clark 1984).

AREA	AVAILABLE SOIL WATER STORAGE CAPACITY IN mm						MAXIMUM MEASURED PRODUCTIVITY
	UNLIMITED	200	150	100	50	25	
HINTON-EDSON	5.3	5.3	5.2	5.0	4.6	4.3	5.0
THE PAS	5.3	4.5	4.5	4.2	3.8	3.6	6.0
RICHIBUCTO	6.1	6.0	6.0	5.9	5.5	5.3	6.0
E. KOOTENAY	5.6	4.6	4.5	4.2	3.8	3.5	6.0
COASTAL B.C. (LOW)	8.2	8.2	8.2	7.8	7.5	6.8	8.5
COASTAL B.C. (HIGH)	5.7	5.7	5.7	5.7	5.6	5.1	6.0

*the model does not account for nutrient deficiency, excess water, or exposure limitations.

SITE CLASSIFICATION INTERESTS AND ACTIVITIES
LANDS DIRECTORATE, ENVIRONMENT CANADA

Presentation to Site Classification Workshop
Canadian Forestry Service
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C.D.A. Rubec
Lands Directorate
Environment Canada
Ottawa, Ontario
K1A 0E7

1.0 INTRODUCTION

The Lands Directorate of Environment Canada has been an advocate of ecological land survey and site classification since the early 1970's. This paper reviews some of the Directorate's past and on-going activities, the role of the Canada Committee on Ecological Land Classification, and our current interests which support the creation of a national forum for ecological site classification in Canada.

2.0 BACKGROUND ACTIVITIES (1970-84)

During the period from 1974-84, Lands staff in units in the Ontario, Quebec, Atlantic, and Pacific and Yukon regions were participants in numerous site classification projects in association with the Canadian Forestry Service, Agriculture Canada, Parks Canada and various provincial agencies. Highlights and references to these are identified below.

2.1 ONTARIO REGION

In this region, site classification projects were numerous until late 1984 when Lands staff were reassigned to other Environment Canada programs.

(a) The Forest Ecosystem Classification (FEC) program in Ontario has developed cooperatively between CFS, the Ontario Institute of Pedology, Lands Directorate, and the Ontario Ministry of Natural Resources. It has been an excellent example of federal-provincial cooperation and is now leading to operational application in several provincial management districts beyond its initial research phase.

(b) Forest Ecosystem Classification during 1981-82 in the Turkey Lakes Watershed near Sault Ste. Marie has resulted in creation of a site level research management framework, a baseline data base and map at 1:12 000 for this area. This research was conducted under the federal acid precipitation (LRTAP) program in association with the Inland Waters Directorate of Environment Canada, CFS Great Lakes Region, and Fisheries and Oceans Canada (Wickware and Cowell, 1985).

(c) Site classification in the Experimental Lakes Area (ELA) near Kenora, Ontario in 1976-77 has resulted in a baseline data set and 1:20 000 mapping of this federal LRTAP research area (Wickware and Rubec, 1977).

(d) An ecological land survey program in the Hudson Bay Lowland was conducted from 1976-78 by Lands in cooperation with CFS and the Canadian Wildlife Service resulting in a wildlife habitat and research data base for major portions of the coastal zone (Cowell et al, 1979; Cowell, 1982).

2.2 QUEBEC REGION

Up to 1979, Lands Directorate staff included the scientific expertise of the Service des Études Écologiques Régionales (SÉÉR), the ecological land survey group headed by the late Michel Jurdant. Subsequently this group, to a major degree, was transferred to the Quebec Ministry of Environment to form the Service des Relevés Écologiques du Québec (SRÉQ). This group from 1970-79 headed numerous site classification studies including the following:

(a) The James Bay Territory - a major ecological land survey program at 1:250 000 was completed covering a major portion of the province (Jurdant et al, 1977; Gantcheff et al, 1979).

(b) Numerous small area site classification projects involving Lands staff have been summarized in Ducruc, 1979 and include:
- Nicouba Experimental Forest (1:8 000)
- Montmorency Experimental Forest (1:4 000)

- Belle River Forest Interpretation Centre (1:5 000)
- Mont-Valin (1:15 000)

(c) The Saguenay - Lac St-Jean region (1:125 000) (Jurdant et al, 1972).

2.3 ATLANTIC REGION

The Lands Directorate staff of this region were active in site classification programs throughout the four eastern provinces; projects conducted up to 1984 include:

(a) The ecological land survey (ELS) of Labrador (Lopoukhine et al, 1977).

(b) ELS of the St. John N.B. airport (EMS, 1979).

(c) ELS of several national Parks Canada properties in PEI and Nova Scotia.

2.4 PACIFIC AND YUKON REGION

Lands staff in this region have worked directly with CFS staff for some time in numerous site specific land classification studies and several regional programs including:

(1) Yukon Territory 1:2 500 000 (Oswald and Sengh, 1977).

(2) Bowen Island 1:15 840 (Hirvonen, 1976).

(3) Victoria Metropolitan Area (McMinn et al, 1976).

2.5 LANDS NATIONAL WORKING GROUP ACTIVITIES

Staff in each region of Lands Directorate participated in the completion of the Ecological Land Survey of Canada at the Landscape

Ecodistrict and Ecoregion levels. This program, initiated in 1980, was completed in 1985 resulting in 74 1:1 000 000 file maps providing the base map series for 5 450 Landscape Ecodistricts and 190 Ecoregions across the nation. Components of this program have included:

(a) LRTAP impact assessment data base for eastern Canada - ELS coverage for all 6 eastern provinces was applied to acid precipitation sensitivity assessment (MOI, 1983).

(b) ELS of all of District of Keewatin, most of District of Mackenzie and 60% of the Arctic Islands have been published at 1:250 000 through over 300 map sheets of the Northern Land Use Information Series from 1978-85 (Wiken et al, 1986).

(c) Specific ecological land surveys at 1:500 000 to 1:100 000 in the Mackenzie Mountains (Yukon, NWT), northern Yukon (Wiken et al, 1981), Northwest Passage, Mackenzie Delta, and Ellesmere National Park.

(d) National perspectives on ecological land data requirements have been completed (ECS, 1979; Wiken, 1986).

The national ELS of Canada has been completed in western Canada in cooperation and with the assistance of the Land Resource Research Institute of Agriculture Canada. The ELS of Canada has recently been fully digitized at 1:2 000 000 scale and more specific, regional computerized data bases for the Northern Yukon, Northwest Passage (NWT), Mackenzie Mountains, Quebec, Ontario and National Parks are on-line through the Canada Land Data System at Environment Canada.

3.0 THE CANADA COMMITTEE ON ECOLOGICAL LAND CLASSIFICATION (CCELC) 1976-85

The CCELC was formed in 1976 as a result of recommendations at several national workshops in the 1973-75 period and the dissolution of the

National Committee on Forest Lands in 1972. The general objectives of the CCELC are:

(a) to encourage development and wide distribution of ELS methodological information and procedures;

(b) to develop national standards, terminology, philosophy and definitions for ELS application across Canada;

(c) to act as a national forum for scientific exchange and cooperation;

(d) to support working group activities and publications;

(e) to act as a link to international landscape ecology agencies;

(f) to act as a focal point for national networking and general monitoring and reporting of Canadian ELS experience and applications.

The CCELC National Committee has met three times (1976, 1978 and 1983) with a meeting currently being organized for May 1986. It sponsors through publications, Secretariat support, and funding the meetings and activities of several active working groups including (a) Wetlands; (b) Climatic Ecoregions; (c) Wildlife Integration; and (d) Vegetation. Several other working groups are no longer active-having met specific needs as required: (e) Methodology/Philosophy Development and (f) Land/Water Integration.

The CCELC operates in a fairly informal fashion with the cooperation of numerous federal, provincial and territorial agencies. It also involves specialists from university and corporate groups. The CCELC Secretariat, provided by the Lands Directorate, does not direct the activities of its working groups, providing only loose coordination and general support.

New working groups are possible at all times. Should a national forum identify needs for a working group on site classification, for example, the CCELC Secretariat could be of considerable assistance in setting this up and acting in such ways to foster its growth as needed.

The Secretariat publishes outputs of the working groups through the Ecological Land Classification Report Series (of Environment Canada) and several CCELC Newsleters each year. Lands Directorate also is currently acting as an interim supporting secretariat for the Canadian Society for Landscape Ecology and Management (CSLEM) which is proposed to be incorporated in 1986.

3.1 ACTIVITIES OF CCELC WORKING GROUPS

Examples of the accomplishments of various CCELC Working Groups include:

Wetlands - first draft national classification system (1978)
- national wetland regions map (1979, 1986)
- national wetland distribution map (1979, 1986)
- revised national classification system
- Wetlands of Canada book (1986)

Wildlife - three national symposia (1979, 1983, 1985)
- national handbook (in preparation)
- international cooperation (USA, Mexico, Canada)
- national terminology standardization

Climatic Ecoregions - national map (in preparation)

Vegetation - national classification system (in preparation)

As a matter of note, CFS staff participate in the Wetlands (3 contributors), Climatic Ecoregion (3 contributors), and Vegetation (4 contributors) working groups.

4.0 LANDS DIRECTORATE CURRENT SITE CLASSIFICATION INTERESTS

ELS and site classification at the Lands Directorate, since dissolution of its regional staff, to a major extent is now limited to an active headquarters group housed in the Ecological Research and Integrated Programs Division. Our major activities in the field of site classification can be summarized as follows:

(a) Correlation and Completion of a national environmental data base. This encompasses all previous regional, northern, territorial and national ecological land survey projects into an effective, standardized computer data base with full geographic capabilities. It is being applied to national macro-modelling and land degradation exercises.

(b) Acting in a Catalytic Fashion to encourage the formation of a national, (i.e. not exclusively federal) coordinated working group on site classification. Recognizing CFS as a lead agency in this field, ideally CFS could chair such a working group. It should include all federal, provincial and territorial interested agencies. The CCELC is offered as an option in supporting and coordinating such a group through the provision of a centralized, successful secretariat and at a time suited to the needs and interests of the various parties involved. This could build upon the internal CFS working group now established.

(c) Support for integration and multidisciplinary approaches to environmentally sound land management through continued CCELC support and existing federal-provincial and federal-territorial relationships. Also general support for the activities of the Canada Council on Ecological Areas (CCEA) and proposed Canadian Society for Landscape Ecology and Management (CSLEM).

4.1 POTENTIAL AREAS OF COOPERATION BETWEEN LANDS AND CFS

(a) Application of our national computer data bases to joint macro-modelling, prime lands studies, and general land degradation interests.

(b) Integration of forestry socio-economic impact assessments under the LRTAP and Toxic Chemicals programs with Lands data bases interrelating ecological land data, LRTAP loading rates, Census Canada data, and Canada Land Inventory sectoral data sets e.g. the Rural Land Analysis Project (RLAP), underway at Lands Directorate.

(c) Development of microcomputer-based land analysis software programs and systems for regional assessment studies.

(d) Exchange of further expertise in the field of geographic information systems.

5.0 FINAL REMARKS

This paper has only briefly touched on some of our current and previous expertise and activities in the field of site classification. Much of this was developed through local and regional interests and studies, often in cooperation with Canadian Forestry Service Institutes. The opportunity to meet jointly with CFS scientists working in this field and to summarize the Lands Directorate's role and activities has been a most welcome and refreshing opportunity.

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FEASIBILITY OF CONSTRUCTING A MULTISECTOR LAND EVALUATION SYSTEM: THE NEW BRUNSWICK PILOT STUDY[1]

by

Michael Brklacich[2] and Barry Smit[3]
University of Guelph
Guelph, Ontario
N1G 2W1

1 INTRODUCTION

1.1 Background

The development of effective policies for land resource use depends to a large extent upon evaluations of the biophysical characteristics of the land base relative to socio-economic conditions pertaining to its use. Biophysical characteristics that are often considered in evaluations include the availability and quality of land resources, the suitability and productivity of different types of land for selected uses, the vulnerability of lands to degradation processes, the constraints imposed by the land base, and the extent to which constraints can be ameliorated. From the socio-economic perspective, evaluations must recognize the long-term needs for the production of a wide array of commodities, the socio-economic conditions under which these commodities can and cannot be produced, and national and regional goals for development.

Any policy-oriented assessment of resource-use options requires the synthesis of vast amounts of diverse types of information. This process has been hampered by inconsistencies in the required data bases and by inadequate procedures for integrating information on biophysical characteristics with socio-economic conditions. Recently, however some practical methods have been developed for compiling and integrating the required data, thereby extending the applicability of land-related information in the policy arena.

These methods have been applied in Ontario by the University of Guelph's Land Evaluation Group (LEG) in collaboration with scientists from Agriculture Canada, Environment Canada, and the Ontario Ministry of Agriculture and Food. This land evaluation system for Ontario (LEM 2) comprises a comprehensive data base and associated analytical procedures designed to assess opportunities for land use and production given specified physical and socio-economic conditions. This system has been employed by federal and provincial agencies in the formulation of agri-food policies for Ontario.

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[2] Land Evaluation Group (LEG), University School of Rural Planning and Development

[3] Department of Geography and LEG

Many of the land-related issues that decision-makers must resolve are concerned with the concurrent opportunities for production in two or more sectors. The LEM 2 system however has been designed primarily to assess prospects for food production. In its application to a wide range of issues, other activities such as forestry, recreation and housing have been addressed indirectly. While it should be feasible to incorporate other sectors within this analytical framework and to develop operating systems in other jurisdictions and at other geographic scales, these extensions have not been investigated thoroughly. Some preliminary research indicates that it will be feasible to construct a national system which would assess production prospects from an agricultural perspective. Clearly, there is still a need to develop techniques which can gauge the concurrent opportunities for production in multiple sectors.

1.2 Purpose and Overview of the Project

The purpose of this project is to assess the feasibility of developing a multisector land evaluation system (MLES) which, if implemented, could assess constraints and opportunities for production in both the agricultural and forestry sectors.

Multisector resource assessment has application in decision making at the federal and provincial levels, and thus, this project is intended to provide guidelines for the development of MLES's at both levels. The strategy adopted to prepare these guidelines was to conduct a pilot study for the province of New Brunswick. New Brunswick was selected for the pilot for the following reasons:

1. Forestry and agriculture are currently the two most important sectors in the New Brunswick economy.
2. Many of the long-term development strategies for New Brunswick hinge upon further development of the forestry and agricultural sectors.
3. The relationship between the forestry and agri-food sectors is sufficiently complex that if it is feasible to construct a MLES for New Brunswick it should be feasible to do so elsewhere.
4. Scientists and government representatives in New Brunswick were eager to co-operate on a feasibility study.

The feasibility study for New Brunswick is divided into six stages:

1. Issue identification.
2. Development of an analytical framework.
3. Identification of data requirements.
4. Assessment of suitability of available data.
5. Recommendations for construction of a system for New Brunswick.
6. Pilot assessment (data permitting).

Each stage involved collaboration with scientists from Lands Directorate (Ottawa), Environment Canada; from the New Brunswick Departments of Natural Resources, Agricultural and Rural Development, and Environment; and Agriculture Canada (Fredericton).

An initial meeting was held in Fredericton on June 20 and 21, 1984, at which time the issues confronting agriculture and forestry were identified, and the status of land-related information systems were described. Progress reports which outlined the envisaged applications of a MLES for New Brunswick, sketched an analytical framework for multisector resource assessment, and proposed a structure for a MLES for New Brunswick were prepared in July and November 1984, and forwarded to Ottawa and Fredericton. Proposals introduced in the progress reports were endorsed by representatives from New Brunswick during a second meeting in Fredericton on January 21, 1985.

1.3 Organization of the Report

Section 2 outlines the potential applications of a MLES for New Brunswick. Major land-related issues in each of the agricultural and forestry sectors are reviewed, and the relationship between the sectors is examined. The section concludes with an outline of an analytical framework for a MLES for New Brunswick.

Section 3 introduces a general conceptual model for resource assessment and evaluation. It is based upon three distinct approaches to resource assessment, all of which should be part of a multisector land evaluation system. Section 3.1 outlines procedures for examining the resource base and its potential use. Section 3.2 describes a framework for measuring production potential, and Section 3.3 sketches a technique for judging the prospects for attaining specified levels of production. Section 3.4 summarizes the relationships among the three types of resource assessment.

Section 4 proposes a structure for a multisector land evaluation system for New Brunswick. It embraces the three approaches to resource assessment outlined in the previous section, and examines the options for implementing the proposed structure. Its major features are introduced in Section 4.1. Sections 4.2 through 4.4 respectively sketch procedures for addressing issues relating to:

- the resource base and its potential use,
- production potential, and
- prospects for attaining production targets.

The section concludes with an assessment of the feasibility of constructing the proposed structure using available data, and recommendations for the development of a multisector land evaluation system in New Brunswick.

Section 5 explores the opportunities for multisector resource assessment at the national level.

2 POTENTIAL APPLICATIONS OF A MULTISECTOR LAND EVALUATION SYSTEM FOR NEW BRUNSWICK

The improvement and maintenance of New Brunswick's land resources are often included as an integral part of provincial strategies for economic development. Recently completed studies have concluded that the overall productive potential of New Brunswick's land resources for forestry and agricultural commodities is far greater than current levels of production in these sectors. The sound development of this unused potential could strengthen the provincial and regional economies by providing employment opportunities throughout the entire economy. However the degree to which production could be expanded over the long-term, and the extent to which development in one sector would infringe upon opportunities elsewhere remain unclear.

A system for evaluating the extent to which land resources in New Brunswick constrain concurrent opportunities for production in the province's agricultural and forestry sectors would assist resource analysts during the policy formulation process. It would facilitate assessments of the limitations imposed by current and possible changes in biophysical conditions on the productive capacity of the land base. These broadscale assessments would provide a basis for more detailed appraisals of particular resource development options.

The necessary first step in the development of effective procedures for resource assessment is the identification of the major issues confronting decision makers and the information needed to address those issues. For New Brunswick, this involves a review of major land-related concerns in both of the agricultural and forestry sectors, as well as an appraisal of the extent to which these issues are interrelated.

2.1 Agricultural Issues

Within the agricultural sector, the majority of the land-related issues pertain to increasing production levels of feed crops and maintaining production levels for potatoes over the long-term. Specific issues needing investigation include:

1) To what extent would it be physically possible to expand the area of land used for the production of forages and feed grains, and potatoes?

2) Where are these areas relative to current livestock and potato producing areas?

3) What is the productivity of lands that are either currently being used or could be used for the production of livestock feeds or potatoes?

4) Which lands might benefit from improvements such as drainage or subsoiling? What is the extent and location of these lands?

5) To what extent would land improvements increase yields and upgrade crop quality?

6) What is the susceptibility of different types of land to erosion, and in which areas is erosion currently a problem?

7) What effect does erosion have on yields for particular crops?

8) Which land use practices would maintain land quality over the long-term?

9) To what extent do non-land factors such as farm management, tenure and the location of processing plants constrain agricultural production in New Brunswick?

10) What are the prospects for increasing the production of livestock feeds in New Brunswick under present conditions, and to what extent would changes in conditions (e.g. land improvements and better management) expand these opportunities?

11) To what extent could present feed shipments from Central and Western Canada be replaced by feeds produced in New Brunswick?

12) In order to maintain production levels for potatoes, how much land would be required for rotation crops? Could these rotation crops be used to increase livestock feeds?

13) To what extent would soil erosion reduce the production potential for potatoes?

2.2 Forestry Issues

The major land-resource issues confronting the forestry sector relate to the p tential shortfall in the supply of softwoods. Specific issues include:

14) How much softwood can New Brunswick's forests produce annually without impairing the productive capacity of the forest over the long-term?

15) What portion of this total supply originates
- from Crown lands?
- from large freehold lands?
- from small freehold parcels?

16) What is the milling capacity of New Brunswick's pulp mills, and other mills requiring softwood? In order to maintain a viable operation, what proportion of the productive capacity of the forest must be used?

17) At the provincial scale, what is the gap between annual supply of softwoods and annual milling capacity?

18) In which regions can periodic shortfalls in supply be expected given current management practices?

19) In which regions would the shortfalls be so serious (i.e. either in total magnitude or in duration) that it would not be economically viable to operate mills?

20) How would alternative management practices such as increases in rates of replanting, better weeding, timely harvesting and more intensive management of small freehold parcels affect the long-term supply of softwoods?

21) Would increases in supply via better management be sufficient to meet the milling demands for softwoods?

22) To what extent might insect infestations, disease and fire reduce the supply of softwoods?

2.3 Agricultural and Forestry Issues

The small freehold lands are the dynamic edge between the agricultural and forestry sectors. Future increases in agricultural production will to a large extent rely upon a more intensive use of existing farms and land clearing. The small privately owned woodlots are regarded as a valuable but presently underutilized forest resource. Issues relating to the concurrent opportunities for increasing production in the agricultural and forestry sectors include:

23) To what extent would an expansion of agricultural land in the small freehold areas impinge upon prospects for forest development? and vice versa?

24) What are the concurrent opportunities for expanding production in each sector?

2.4 Implications for the Analytical Framework

The units of analysis and structure of any resource evaluation system are determined by the intended applications of the system. The issues identified in Sections 2.1 through 2.3 indicate that the units of analysis would need to be structured around the following three dimensions: land uses, biophysical characteristics of the resource base, and infrastructure.

Land Uses:

The following land uses and their associated products would need to be considered explicitly:

forestry: softwoods (for pulp and paper)
hardwoods (for timber)

agriculture: potatoes (for processing, seed, table)
cereal grains (for feed and processing)
hay forage (for feed)
improved pasture (for feed)

Other land uses which currently utilize a small proportion of the province's land resource but are economically important would be exogenous to the MLES.

Biophysical Characteristics:

Climate and land quality are aspects of the biophysical resource base limiting the feasible location and yields for agriculture (crops) and forestry.

Infrastructure:

Tenure and proximity effectively limit either the areas useable by each sector or yields. There is need to delineate crown lands, large freehold lands, and small freehold lands. Proximity to processing plants effectively limits the areas useable for the production of potatoes and of forest products; and livestock production must occur in close proximity to the areas used for forages.

3 CONCEPTUAL MODEL FOR RESOURCE ASSESSMENT AND EVALUATION

It is convenient to classify the issues identified in the previous section according to three broad categories. First, there are those issues relating to the extent and quality of the resource base and its possible uses. Second, some of the issues pertain to possible levels of production that could be expected given a particular pattern of land use and other restrictions on resource use. And third, the remaining issues relate to the prospects for attaining production targets given specified limitations on the availability, quality and potential use of the resource base.

A land evaluation system for agricultural and forestry development in New Brunswick should encompass all the data and resource assessment procedures required to address issues in each of these categories. That is, it should have the capacity:

- to provide access to information on the resource base and its potential use,
- to assess production potential,
- to ascertain the feasibility of attaining production targets.

The general characteristics of these three approaches to resource assessment and the connections amongst them are represented schematically in Figure 1. Each approach has its own requirements for data and is based upon a different set of analytical procedures. These are expanded upon in Sections 3.1 through 3.3.

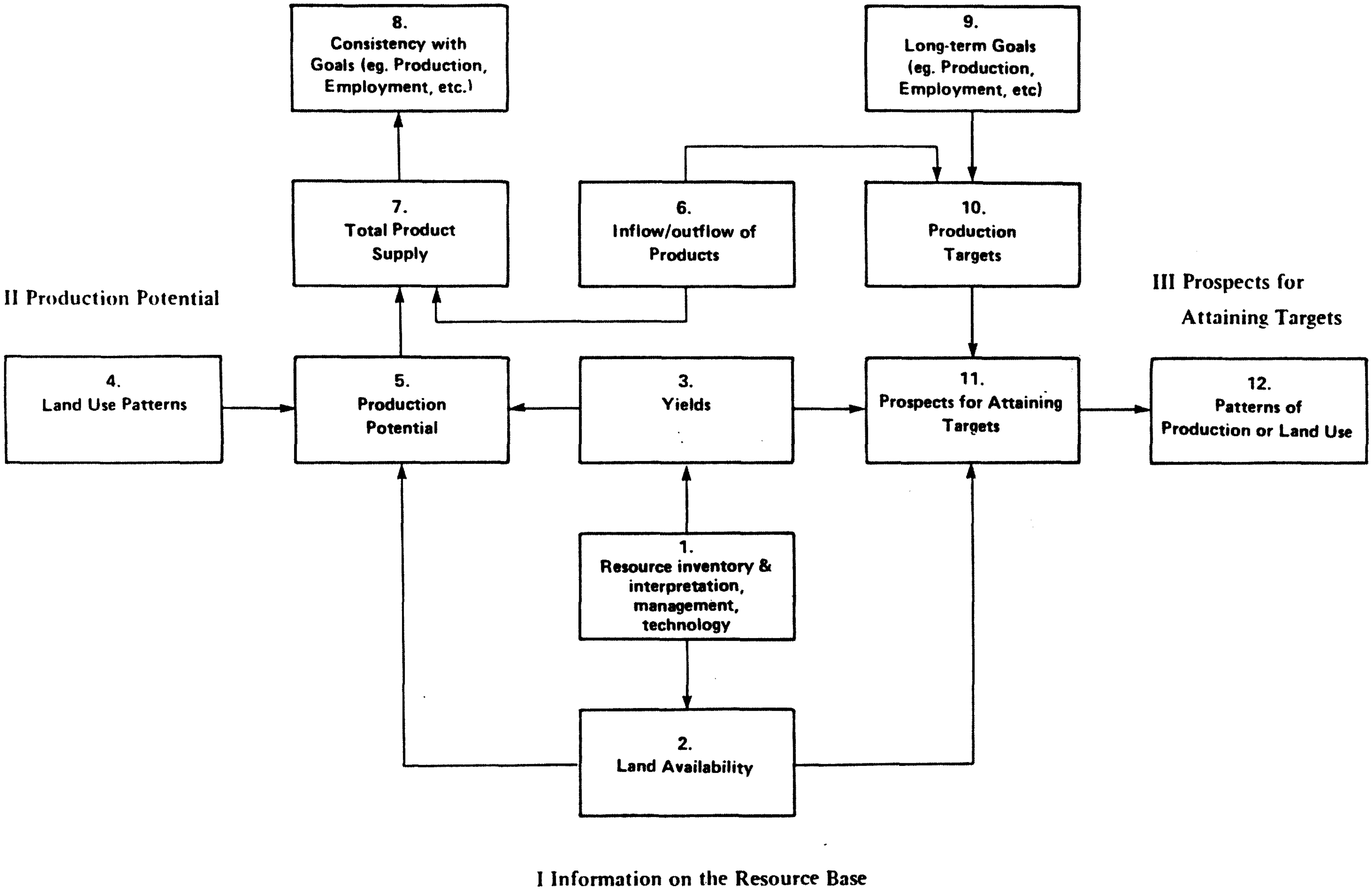
3.1 Information on the Resource Base

This approach to resource assessment is appropriate for addressing issues relating to the area of land available for crop production and forestry, the productivity of these lands for particular crops and tree species, and the extent to which management, technology and other non-land inputs might enhance or restrict land availability and/or quality. It involves collecting, managing and accessing information on resource availability, quality and potential use.

Compilation of this information base usually begins with an inventory and interpretation of land resources that might be used for the production of particular commodities, and assumptions regarding inputs to the production process such as management and technology (Figure 1, Box 1). The major products from this approach are estimates of the availability of different types of land (Box 2), and yield or productivity levels for specified uses on each of the land types (Box 3).

Within the policy formulation process, this approach to resource assessment has been used to provide qualitative assessments of the long-term adequacy of the resource base by evaluating the suitability of different types of land for the production of a wide range of possible uses, and by isolating areas or regions where there is untapped potential for production. The sensitivity of these assessments to changes in conditions such as climate change, degradation, and land improvements can be incorporated into this approach at the inventory stage or through the assumptions relating to production.

FIGURE 1: THREE APPROACHES FOR ASSESSING THE LONG-TERM ADEQUACY OF LAND RESOURCES FOR PRODUCTION



3.2 Production Potential

The "Production Potential" approach is designed to quantify possible levels of production given a predetermined pattern of land use and a set of restrictions on resource use (e.g. availability, quality, etc.). That is, it measures the extent to which these conditions constrain levels of production.

The approach utilizes the major outputs of land availability and yields from the previous approach (Figure 1, Boxes 2 and 3 respectively), and integrates these data with data on patterns of land use (Box 4). The major product is an estimate of the maximum levels of production for specific commodities that could be expected (Box 5) given the stated conditions. It would be possible to extend the analysis to include other factors such as interprovincial commodity movements (Boxes 6 and 7), and eventually infer whether the full set of assumed conditions or scenario is consistent with broader societal goals such as desirable levels of production, employment and so on (Box 8).

Production potential as an approach to resource assessment and a tool for policy formulation has been explored by the Food and Agriculture Organization of the United Nations (FAO). One of the strengths of the approach is that once the required data on land availability, productivity and land use patterns are compiled, it is a relatively straightforward task to implement procedures which would measure production potential. Of course, it would be possible to judge the sensitivity of these estimates of production potential to changes in future conditions by adjusting any of the input parameters.

3.3 Prospects for Attaining Production Targets

The "Prospects for Attaining Production Targets" approach to resource assessment is designed to measure the feasibility of attaining and exceeding predetermined levels for production given restrictions on resource availability and productivity. It is based upon procedures which systematically integrate targets for production with data on biophysical conditions affecting the production of specific commodities.

This approach commences with a clear statement of the long-term goals for production, employment, trade and so on (Figure 1, Boxes 6 and 9), and utilizes this to estimate targets or requirements for the production of specific commodities (Box 10). Then these data are integrated with data on resource availability and productivity (Boxes 2 and 3 respectively), thereby ascertaining the prospects for meeting and exceeding the production targets given the stated supply-side conditions (Box 11). The procedure can also be extended to indicate patterns of production and/or land use which would be conducive to meeting the targeted levels for production (Box 12).

The "Prospects for Attaining Production Targets" approach has been developed by the Land Evaluation Group (LEG). The Ontario Directorate of Agriculture Canada's Regional Development Branch has utilized it in its development of an agri-food strategy for the province (LEG 1984c and 1983). The approach relies heavily upon the availability of specific types of data, and sophisticated data management systems and analytical procedures. Once implemented, this approach to resource assessment is especially useful for quantifying the feasibility of attaining alternative projections for production given a specified set of supply-side conditions, and for measuring the sensitivity of feasibility assessments to likely changes in one or more supply-side condition.

3.4 Implementing the Conceptual Model

It should be possible to design and implement a land evaluation system which would store and manage the required data, and house the appropriate procedures necessary to implement each approach to resource assessment. Such a system could be constructed in an incremental fashion, adding data and analytical procedures as they become available.

Clearly there is considerable overlap in the information requirements associated with the three approaches to resource assessment. In order to ensure that the information can be used for all three types of assessment there must be a commitment to the development of a highly structured data base, with consistent units of analysis, and an efficient data management system.

4 PROPOSAL FOR A MULTISECTOR LAND EVALUATION SYSTEM FOR NEW BRUNSWICK

4.1 Overview

This proposal for a MLES for New Brunswick reflects the identified land-related issues, the information requirements of decision-makers, and the resource assessment procedures outlined in the previous section. Its major features are:

1. It considers the agri-food and forestry sectors.

2. It accommodates all three approaches for resource assessment outlined in Section 3.

3. The two sectors are linked via the land available for primary production.

4. It provides a framework for articulating the data requirements for each approach to resource assessment in both the agricultural and forestry sectors. A comparison of these requirements to available information can be used to indicate where there is sufficient data to develop particular aspects of the system, and to isolate areas where data deficiencies will need to be overcome.

5. Portions of the system can be implemented as data and analytical procedures become available. Hence, it would be feasible to construct the system in an incremental fashion, and address some questions before the system is fully developed.

6. Many elements of the system could be developed simultaneously, thereby minimizing the length of the development period.

7. The system is designed so that assessments of the agricultural and forestry sector can be conducted either independently or concurrently, depending upon the user's needs.

8. It should be possible to link the New Brunswick system to systems operating at a broader (e.g. national) scale.

The remainder of Section 4 examines the prospects for implementing each approach to resource assessment for both the agricultural and forestry sectors. Sections 4.2 through 4.4 each address one of the approaches to resource assessment and outline the elements within it and its analytical capabilities. Section 4 concludes with an assessment of the availability of the required data and recommendations for constructing a MLES.

4.2 Information on the Resource Base

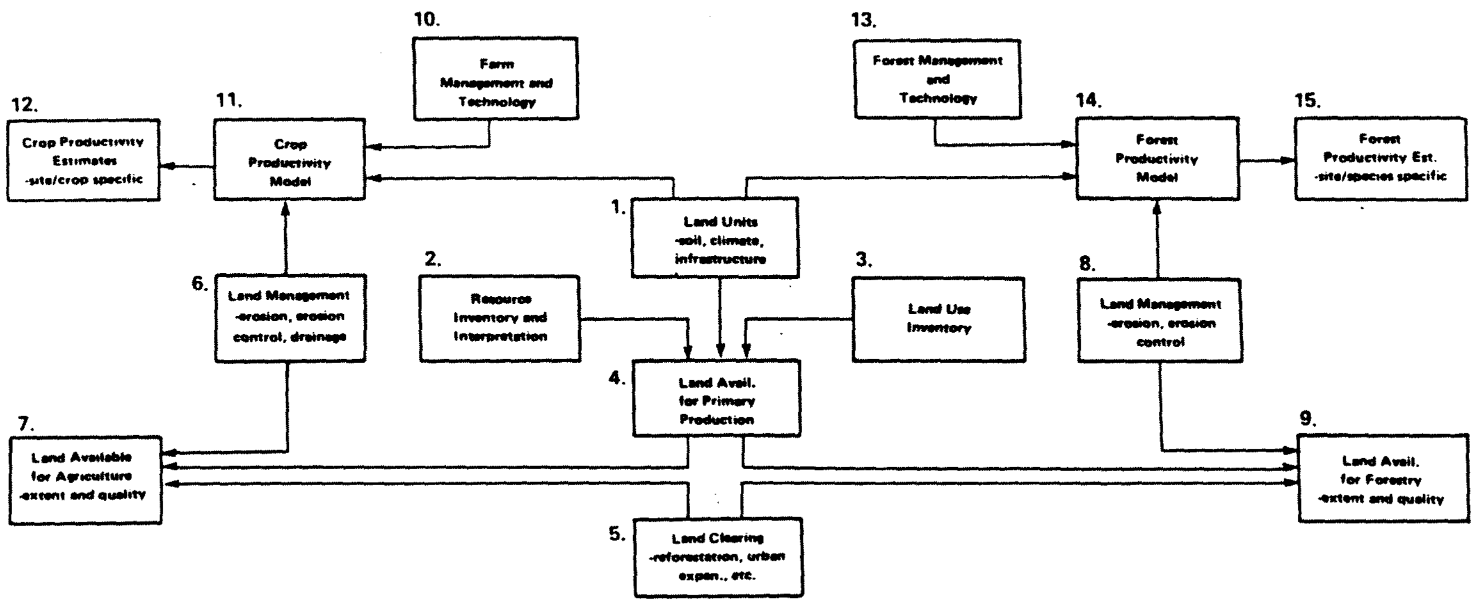
The "Information on the Resource Base" approach is comprised of two types of information (Figure 2): land availability and productivity. The issues to be addressed indicate that the land units will need to be defined according to the soil and climatic conditions which influence crop and forest productivities, and aspects of infrastructure (i.e. tenure and location) which effectively limit either the area available for production to each sector or productivity (Figure 2 - Box 1). Estimates of the area of each land unit available for primary production (Box 4) could be derived from existing inventories of biophysical resources and land use (Boxes 2 and 3 respectively). By considering these data relative to other factors such as land clearing, reforestation, land requirements for uses other than agriculture and forestry (Box 5) and land management practices (Boxes 6 and 8), it would then be feasible to estimate the extent and quality of lands available for agricultural and forestry production (Boxes 7 and 9 respectively).

Infrastructure and current land use would be used to designate those lands that are already committed to one of the two sectors, and those lands where land use change might occur. Crown lands are already committed to forestry production and it is unlikely that this will change substantially. Existing patterns of land use in the large freehold areas effectively designate the long-term use of these lands by each sector. The use of the small freehold lands by each sector may change considerably over the long-term. Thus the land availability portion of the information base would store several estimates of the availability of land for each sector, with each estimate reflecting an alternative set of assumptions regarding the disposition of the small freehold lands. If required, adjustments in the availability of crown lands and large freehold lands could be incorporated. Of course, the data management system would ensure that all estimates of land availability did not exceed the potential supply of land to primary production.

In the agricultural component of the system, a crop productivity model (Box 11) would integrate data on land quality, land management and technology (Boxes 1, 6, and 10 respectively), and estimate the productivity of different land units for the specific crops identified in Section 2 (Box 12). Similar procedures would be required in the forestry component (Boxes 1, 8, 13 and 14) in order to estimate the productivity of particular land units for alternative tree species. Several sets of productivity estimates would be required, with each set reflecting alternative conditions relating to management and technology.

Information on the availability and productivity of lands in New Brunswick for agriculture and forestry would assist resource analysts in identifying the extent to which the resource base is being utilized. By including infrastructure in the classification of land units, it would be possible to delimit the location of underutilized land resources relative to existing areas of production and processing facilities. Also, the development of productivity models for crops and forestry would facilitate gauging the effects of changes in biophysical (e.g. climate, drainage, degradation, and so on) and socio-economic conditions (e.g. production, management, technology, and so on) on long-term yield levels. All of these data would assist resource analysts in making qualitative assessments of the long-term adequacy of New Brunswick's land resources for the production of food and forestry products.

FIGURE 2: A MULTISECTOR LAND EVALUATION SYSTEM FOR NEW BRUNSWICK: THE INFORMATION COMPONENT



4.3 Production Potential

The "Production Potential" approach to resource assessment estimates possible levels of production by integrating land availability and productivity estimates with data or assumptions on the distribution of land uses (Figure 3).

The forestry and agricultural components are linked explicitly via the estimates of land available for production in each sector. That is, the multisector land evaluation system would include an accounting facility to ensure that available land resources are assigned to one but not both sectors. Thus, once it is determined for a particular scenario that certain lands are available to one sector they would be excluded from the other. Of course it would be feasible to consider alternative assignments of land availability by specifying another scenario, and conducting assessments of production potential under that scenario for comparison.

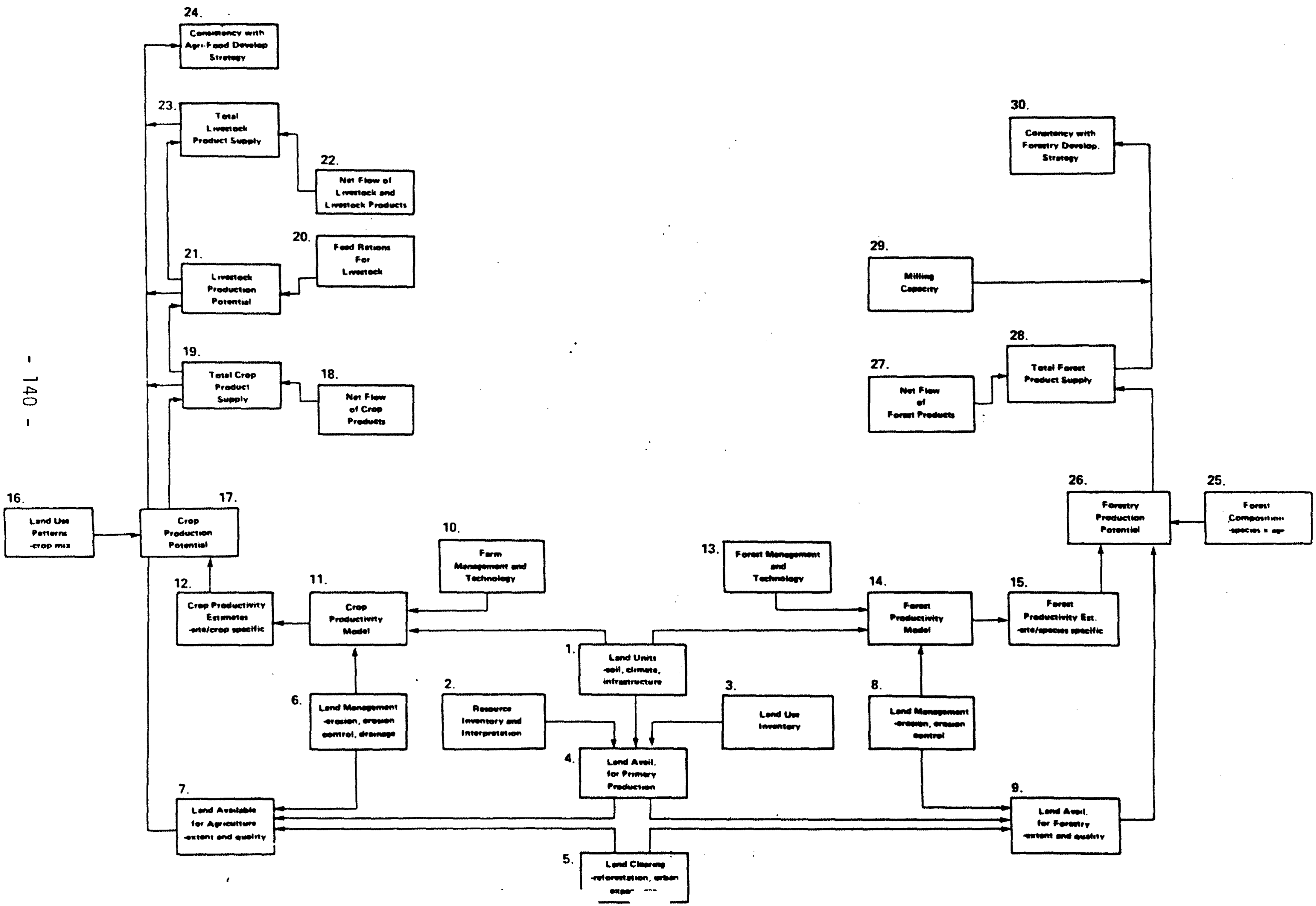
In the agricultural component of the system, estimates of the availability of land for crop production (Figure 3 - Box 7), crop productivity estimates (Box 12), and a predetermined assignment of crops to land units (Box 16) are utilized to estimate the production potential for crops (Box 17) in each region of the province. The land use patterns (i.e. crop mix) could be based upon an inventory of present land use (Box 3) and possible shifts from these, or it could reflect an independent analysis of trends in long term land use.

In order to determine the total supply of crop products (Box 19), it would be necessary to make assumptions about the movement of crop products in and out of New Brunswick (Box 18). These data could be used in conjunction with data on the rate at which feed stuffs are (or might be) converted into livestock products (Box 20), and thereby gauge the production potential for livestock products (Box 21). Of course, these estimates would be calculated on a regional basis since forages are not typically shipped long distances. By extending the analysis to consider the possible movement of livestock and livestock products at both the interprovincial and international scale (Box 22), it would be feasible to estimate maximum supply levels for livestock products (Box 23).

The final product from the agricultural component is a measure of the extent to which the assumed land use patterns and associated potential for agricultural production are consistent with long-term development strategies for the agri-food sector (Box 24). A wide range of scenarios can be considered by adjusting any of the input parameters (i.e. land availability, productivity, land use patterns, commodity flows and feed-to-livestock product conversion rates). A comparative assessment of production potential under each scenario would permit resource analysts to ascertain those scenarios which would and would not be compatible with development strategies, and to judge the trade-offs associated with pursuing one scenario over another.

The forestry component functions in a similar fashion to the agricultural component and has, to a large extent, already been implemented by the New Brunswick Ministry of Natural Resources. Central to the procedure for

FIGURE 3: A MULTISECTOR LAND EVALUATION SYSTEM FOR NEW BRUNSWICK: ASSESSING PRODUCTION POTENTIAL



estimating production potential for forestry products on a regional basis (Box 26) are data on land availability (Box 9), productivity (Box 15) and assumptions about the use of land for forestry (Box 25). The appropriate indicator of land use for the forestry component is forest composition based upon the current distribution of tree species and age. The effects of alternative management practices on production potential could be assessed by making appropriate adjustments to the forest composition, forest productivity and/or land availability data.

Maximum supply of forest products (Box 28) can be estimated as a function of production potential and the movement of forest products in and out of New Brunswick (Box 27). Total supply of forest products in each region could be compared to the milling capacity (Box 29) to determine those regions in which there would (or would not) be sufficient supply to sustain viable milling operations. This would assist resource analysts in judging the degree to which particular scenarios would be consistent with development strategies for the forestry sector (Box 30). It would also be feasible to extend the analyses to consider the effects of alternative scenarios on employment opportunities in each region.

While the assessments of the long-term adequacy of the resource base for agricultural and forestry production are conducted independently, they are linked via the land available for production to each sector. Thus, the concurrent opportunities for development in the agri-food and forestry sectors (Box 31) can be ascertained by considering the outputs from the agricultural and forestry components of the system.

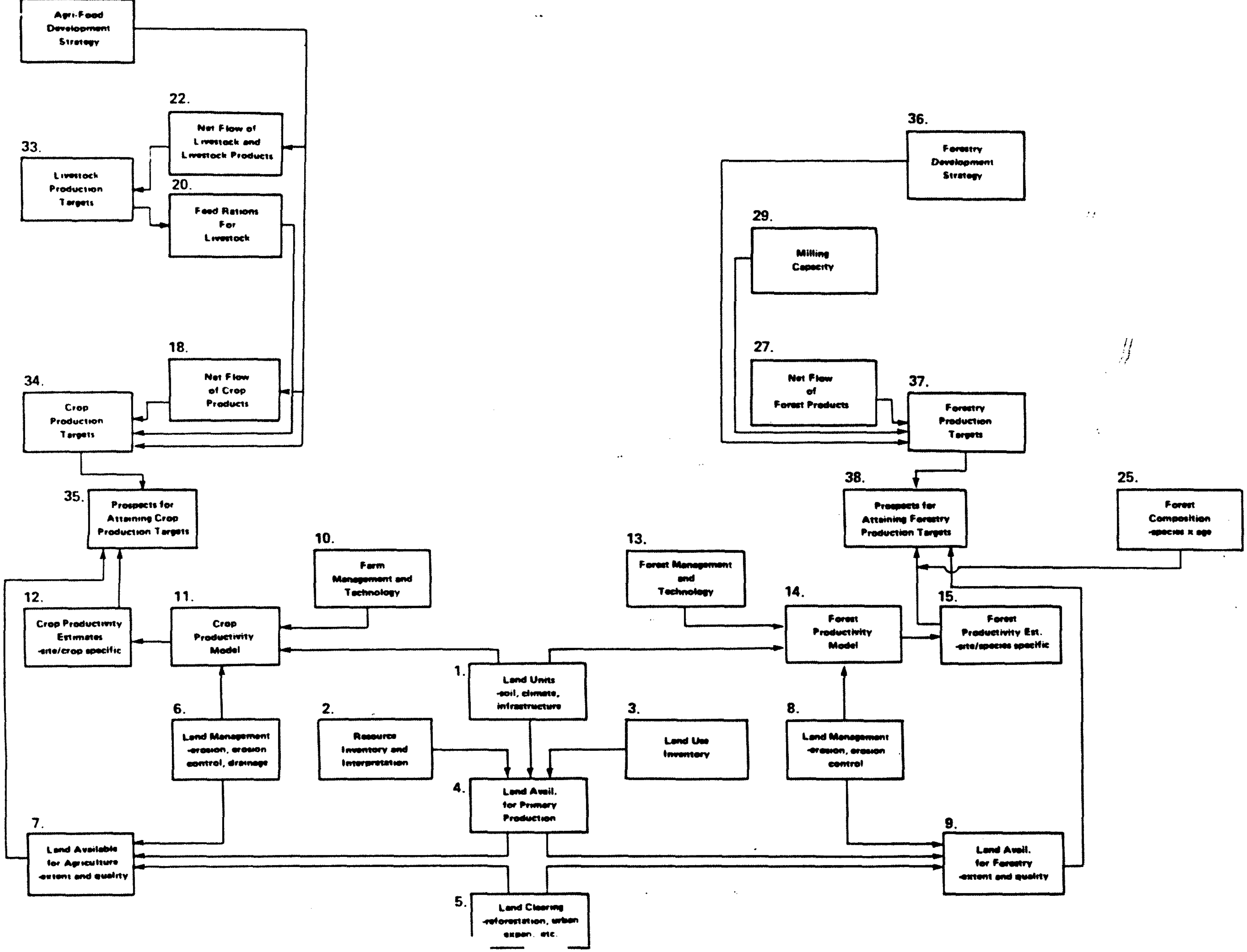
Analyses of the production potential in the agricultural and forestry sectors would assist resource analysts in addressing issues relating to the possible supply of commodities from each sector on a regional basis. It would provide quantitative assessments of production prospects under specified sets of conditions or scenarios. A comparison of assessments under different scenarios would facilitate a systematic evaluation of the trade-offs involved with particular strategies for land use planning and resource development. Linking the agricultural and forestry components via the availability of land resources to each sector facilitates the tailoring of the analyses to the needs of particular users. Analyses can be conducted for one sector independent of the other or the concurrent opportunities for production can be gauged.

4.4 Prospects for Attaining Production Targets

The "Prospects for Attaining Production Targets" approach to resource assessment utilizes much of the data required to conduct assessments of production potential, but the flow of information and analytical procedures are different (Figure 4). This approach is based upon prodedures which directly and systematically integrate data on resource availability and productivity with data on production levels.

The agricultural and forestry components of the system are constructed independently of one another, but their development and operation are co-ordinated through the availability of land for production purposes. The area of land available to each sector (Figure 4 - Boxes 7 and 9) would be related to current land use (Box 3) and separate analyses of possible trends in land

FIGURE 4: A MULTISECTOR LAND EVALUATION SYSTEM FOR NEW BRUNSWICK: PROSPECTS FOR ATTAINING PRODUCTION TARGETS



clearing, reforestation and future requirements for land by other uses (Box 5).

In the agricultural component, these estimates of land availability are combined with data on crop productivity (Box 12) and levels or targets for crop production (Box 34). Initially current levels of production could be used. Future targets for crop production however could be estimated given changes in provincial demand and development strategies for the agri-food sector (Box 32), and adjustments in the international and interprovincial movement of livestock, livestock products and crop products (Boxes 18, 20, 22, and 33).

Ascertaining the prospects for attaining crop production targets (Box 35) would require mathematical programming procedures to integrate data on resource availability, productivity, and regional and provincial targets for production. Resource analysts would then be able to judge for particular scenarios whether it would or would not be feasible to meet all the targets for production given the available resources. Scenarios reflecting alternative development strategies or changes in supply side conditions could be considered by adjusting the appropriate input parameters. This would facilitate assessments of the sensitivity of attaining production targets to specified changes in conditions.

In the forestry component, estimates of forest productivity (Box 15) would need to be considered relative to forest composition (Box 25) in order to develop annual yield levels. Forestry production targets (Box 37) could be estimated as a function of development strategies for the forestry sector (Box 36), milling capacity (Box 29) and the movement of forest products in and out of New Brunswick (Box 27). Of course, each of these parameters could be adjusted to reflect events such as rationalization in the forestry sector, regional development initiatives, and so on. Mathematical programming procedures could be used to integrate data on resource availability, forest productivity and production targets, and thereby quantify the prospects for attaining production targets in the forestry sector (Box 38).

Since assessments of the prospects for attaining production targets in each of the agricultural and forestry components of the system (Boxes 35 and 38) are linked via the land available for production in each sector, the concurrent opportunities for development in the 2 sectors can be measured by aggregating the independent assessments of production prospects. This would allow resource analysts to assess directly the implications of particular development policies within and among sectors.

4.5 Data Requirements and Availability

4.5.1 Land Units and Productivities

The envisaged applications of the MLES for New Brunswick indicate that the land units will need to include biophysical and socio-economic dimensions. The crucial biophysical characteristics include those aspects of soils and climate which influence the productivity of the resource base for agriculture and for forestry, whereas tenure and geographic location are the important socio-economic criteria which effectively limit either the area of land available for production or productivity.

Ideally crop and forest productivity models would be used to estimate yields for each land unit. This approach is favoured for land evaluation purposes because it facilitates the estimation of yields given long-term assumptions with respect to agricultural technology and management. Hence, further refinement of the particular aspects of climate, soil, tenure and geographic location for which data would be required depends upon the form and structure of productivity models for each sector. Unfortunately these productivity models have not been implemented for either sector in New Brunswick, and therefore assessments of data requirements and the suitability of available data sources are necessarily tentative. In the remainder of this section an approach to productivity modelling and its data requirements are outlined, and the available data are assessed relative to this approach.

The crop-weather analysis approach to productivity modelling developed by de Wit (1965) for the FAO has many characteristics which are suitable for broadscale evaluations, including its applicability to a wide range of crops and environmental conditions. Agriculture Canada (Stewart, 1981) has adapted these procedures to Canadian environmental and farm management conditions, and the resulting model (the FAO/LRRI model) is comprised of two components. The photosynthetic component of the model estimates the capacity of particular crops to capture and transform incoming solar radiation into biomass, and the useable portion of the plant is reported as constraint-free dry matter yield. The agroclimatic-edaphic component estimates the extent to which climatic and soil conditions combine to reduce constraint-free yields. This component has been refined by the LEG (1984b), and the output from this component, anticipated dry matter yields, represents yield levels that could be expected over the long-term given optimal farm management. Furthermore, it should be possible to add a third component which would relate socio-economic conditions to yield levels, and thereby estimate the influence of factors such as tenure, management skills and technology on long-term yields.

More recently, de Wit's approach to productivity modelling has been adapted to tree growth (Clark, 1984). Once again, the model has two components: a photosynthetic component and an agroclimatic-edaphic component. Preliminary findings from this research are encouraging, and indicate that prevailing climatic conditions are the chief determinants of tree growth, whereas agroclimatic and edaphic conditions can be viewed as localized factors affecting productivity within a given climatic region.

The geographic scale at which de Wit's approach to productivity modelling is implemented depends upon the intended use of the yield estimates. Stewart, the LEG, and Clark were all interested in broadscale assessments and therefore data inputs were compiled at the scale of 1:5M. This scale is not consistent with the intended use of the MLES for New Brunswick and therefore it will not be feasible to compile the required yield estimates from these analyses. Nevertheless, the approaches implemented by Stewart, the LEG, and Clark indicate the climatic and edaphic data required to model yields.

Implementation of the photosynthetic component for both the crop and forest productivity models requires data on maximum and minimum air temperature, and incoming global solar radiation. Climatic data reported by van Groenewoud (1983) and Dzikowski et al. (1984) should be sufficient. Monthly means for maximum and minimum temperatures can be used to estimate daily values, and information on incoming solar radiation can be derived from sunshine hours.

The agroclimatic-edaphic component requires data on precipitation during the growing season, the extent to which soil moisture is recharged during the winter and spring, moisture losses through potential evapotranspiration, and the extent to which soils impede root development (i.e. density, toxicity, depth to compact layer and drainage). The agroclimatic data are either available or can be inferred from available sources. It is doubtful however that all of the soil data could be compiled for all of New Brunswick at this time. Estimating the capacity of the soil to retain moisture and release it for plant growth requires data on soil texture, volume of coarse fragments, dry bulk density and depth to ground water. Data on volume of coarse fragments and dry bulk density are not readily available for all of the province.

The socio-economic dimension of the land units would reflect the extent to which geographic location limits the area available for primary production, and the degree to which tenure influences resource availability and expected levels of productivity. In forestry, the location of mills constrains the area that is economically viable for the production of forest products, and productivity levels are substantially higher on the highly managed crown and large freehold lands than on the nonindustrial woodlots that are typical of small freehold lands. Potato production is also constrained by the location of processing plants, and livestock feeds must be produced in close proximity to the livestock.

For the purposes of the MLES for New Brunswick, geographic location can be incorporated within the land units in two ways. The grid system employed by the Department of Natural Resources for estimating production potential for forestry is of sufficient detail to address all of the issues outlined in Section 2. Mills, potato processing plants and livestock producing regions could be located using this grid system, and appropriate distance decay functions could be developed for each activity. Alternatively, parish boundaries could be used to demarcate geographic regions which are in close proximity to mills, potato processing plants and livestock producing areas. In order to maximize the usefulness of existing information sources, it would probably be worthwhile to establish a link between the grid system and parish system.

Tenure can effectively be included within the land units via the existing three-tiered classification system. Crown lands and large freehold lands isolate the well-managed industrial forested lands, whereas the small freehold lands identify the area available for private woodlots and for crop production.

In addition to defining the land units according to specific aspects of climate, soil, geographic location and tenure, it will also be necessary to estimate the availability of each land unit for agriculture and for forestry. Environment Canada's Rural Land Analysis Program (RLAP) could be used as a basis for estimating availability of land to each resource sector, and ths information source could be supplemented with information available from the New Brunswick Forest Inventory.

4.5.2 Production Levels

Agricultural Products:

The base data for production of agricultural products can be compiled from existing data sources, and would include provincial consumption, movement of agricultural products between New Brunswick and other provinces, international exports and imports, and the conversion of livestock feeds to livestock products. For potatoes and livestock feeds, regional production levels reflecting existing processing facilities and livestock producing regions respectively would also be required.

Future levels of production would take into account possible changes in population, in consumption patterns, in the interprovincial and international movement of agricultural products and in the rate at which feed crops are converted into livestock products. Provincial projections for agricultural production can be derived from the Agri-Food Development Subsiduary Agreement (Agriculture Canada, 1984) and the Agri-Food Strategy for Canada (Agriculture Canada, 1981). Of course regional levels of production could be adjusted to depict new processing facilities or shifts in livestock production.

Forestry Products:

The base data for forestry production can be compiled from the milling capacity of existing mills. These data would be prepared for the province as a whole, and for supply regions for particular mills.

One of the long-term objectives for New Brunswick's forestry sector is to maintain existing mills. Hence, the current milling capacity on a provincial and regional basis represents a reasonable estimate of future targets for forestry production. Of course, it would be possible to adjust these levels to reflect rationalization or expansion in either the pulp and paper or saw log sectors.

4.6 Recommendations for the Development of a Multisector Land Evaluation System in New Brunswick

1. It is apparent that economic development in New Brunswick will continue to rely heavily on the forestry and agri-food sectors. A fully operational multisector land evaluation system (MLES) for New Brunswick would assist resource and policy analysts by providing assessments of the concurrent opportunities for forestry and agricultural production, and of the extent to which changes in the biophysical and socio-economic conditions would affect production prospects. Thus, it is recommended that a MLES for New Brunswick be constructed.

2. The structure proposed in this report for a MLES for New Brunswick has been shown to be practicable and has been endorsed by representatives from provincial Departments of Natural Resources, and Agricultural and Rural Development. Therefore, it is recommended that a MLES be developed around this framework.

3. Decisions affecting the long-term use of New Brunswick's land resources are being made in the absence of an analytical system that can measure the aggregated impact of several independent courses of action. It is recommended that the construction of a MLES for New Brunswick commence as soon as possible.

4. Many of the existing data sources are not consistent with the proposed structure for a New Brunswick MLES. Nevertheless, a first approximation of the data base could be compiled either by modifying the available data or by supplementing these with data from independent sources. Therefore it is recommended that a prototype MLES be constructed. This would permit an assessment of some of the issues at the earliest possible date, and facilitate construction of the system. The forestry component of the prototype could employ the data base and analytical procedures implemented by the New Brunswick Department of Natural Resources. The agricultural component would utilize reported data on land use and crop yields, and where necessary these data would be supplemented by expert opinion.

5. Implementation of all facets of the proposed structure for a MLES for New Brunswick and its efficient application should be guided by an interdisciplinary team of scientists. Without such a co-ordinating unit it is extremely unlikely that the necessary data would be generated or compiled in an appropriate form, and it is even more unlikely that the pertinent tools for data management and multisector analysis would be constructed. The expertise is available, but for constructing and implementing a MLES, this expertise needs to be co-ordinated. It is recommended that this team be established as soon as possible and include scientists with expertise in the following areas: co-ordination of interdisciplinary projects, land resource science, crop productivity modelling, forest productivity modelling, commodity demand forecasting, policy formulation, and systems design and programming.

5 IMPLICATIONS OF LAND EVALUATION SYSTEMS AT THE NATIONAL LEVEL

5.1 Overview

The New Brunswick pilot has shown that a multisector approach to resource assessment is needed and that it would be feasible to construct a land evaluation system with a capacity to incorporate several sectors simultaneously. One of the major uses of such a system would be to gauge the overall impacts of alternative development thrusts in two or more primary sectors on options for land use and on aggregate socio-economic benefits to society.

Preliminary evidence (Environment Canada, 1981; Simpson-Lewis et al., 1983) suggests that there is an urgent need at the national level for analytical systems which could assess concurrent prospects for production in two or more primary resource sectors. The approaches introduced in this report are sufficiently general that they could be applied at any geographic scale, and therefore they represent guidelines for a Canada-wide multisector land evaluation system. It would be premature however to begin construction of a national system without a thorough examination of how such a system would be employed by resource and policy analysts.

The LEG and Agriculture Canada are in the early stages of developing the agricultural component on a Canadian Land Evaluation System (CLES) (LEG, 1983a). The major use of this system will be to measure the extent to which the resource base constrains agri-food development options. Once the agricultural component is operational, it will have the capacity to assess production prospects given changes in climatic conditions, land degradation and land improvements, and adjustments to broadscale socio-economic conditions such as development of international markets and shifts in interprovincial trade.

Since the LEG is in the early stages of developing a CLES, it should be feasible to expand this effort to include other sectors in a cost-effective manner. Clark's (1984) adaptation of de Wit's crop productivity model to tree growth is encouraging in two respects. First, it indicates tentatively that the agricultural and forestry components of a national MLES would be able to share a common land resource information base. This consistency would reduce data collection costs and simplify data managemet and analytical procedures. Second, there is a great deal of similarity in approaches employed by Clark and the LEG (1984b) in measuring the extent to which edaphic conditions limit tree and crop yields respectively. Hence it should be feasible to add a forestry component to the system under construction.

It would appear that there are at least two options for developing MLES's with Canada-wide capabilities. One approach would involve constructing independent provincial systems which would be co-ordinated at the national level. The other approach would be to construct a highly aggregated national system which would be subdivided into provincial or regional components. These two options are expanded upon in the remainder of this section.

5.2 Co-ordinated Provincial Systems

This option would involve the construction of a series of provincial systems which would be linked nationally. Each provincial system would be an independent unit, and in many respects be similar to the system proposed for New Brunswick. The units of analysis would in all likelihood be relatively disaggregated and therefore permit detailed assessments of production prospects and economic opportunities in each sector, and for the province as a whole. At a minimum, the national co-ordinating mechanism would aggregate the findings from each provincial system. It would be feasible however to construct a more sophisticated co-ordinating mechanism using an inter-regional approach to resource analysis.

Implementing this option would require an interdisciplinary team in each province as well as a national co-ordinating unit. This approach would be very effective in the sense that it would maximize the use of specialists in each province. Furthermore, these systems could be used to provide the detailed types of analyses that are required to resolve land use planning conflicts at the provincial level, and, by aggregating the findings, these systems could service the needs of decision-makers responsible for formulating policies at the national level.

The principal limitation of constructing independent provincial systems which would eventually be housed under a national umbrella would be the costs associated with all aspects of the project. It would be very costly to establish and maintain the interdisciplinary teams and a national co-ordinating unit through the design, construction and application phases. The co-ordinating unit would need to ensure that the provincial systems were developed in a compatible fashion. Whether or not these costs would be prohibitive would depend to a large extent upon the intended use. That is, if this system is to be used for resource assessment at the national and provincial levels, then the benefits of a series of provincial systems linked nationally might outweigh the costs.

5.3 One National System

An alternative is to construct a national system which would have embedded in it provincial boundaries. The units of analysis would be highly aggregated, and therefore this system would be well-suited for gauging the extent to which the resource base limits opportunities for futher development and for broadscale socio-economic assessments at the national level. This option would assist resource analysts at the federal level by indicating those regions of Canada in which there exist the greatest opportunities for expanding production in the agricultural and forestry sectors, and those regions where developments in one sector would seriously impinge upon prospects for the other. At the provincial level, these findings would provide guidelines within which provincial policies might be formed, rather than a detailed assessment of policy alternatives.

The construction of an operational system with multisector capacity would require an interdisciplinary team with expertise in the following areas: project co-ordination, productivity modelling in the agricultural and forestry sectors, commodity demand forecasting, and systems design. In addition, this core of expertise could draw upon resources in each region as required.

It would be considerably less expensive to construct, maintain and apply a highly aggregated national system than a series of provincial systems that could be linked. Fewer personnel would be required. The aggregated structure should keep the costs of the data collection and compilation tasks down to a minimum, and it should be less expensive to maintain and operate a system with a smaller number of units.

The decision regarding which of these two options would be better rests largely upon the envisaged use of the system. If this system is to assist resource analysts in assessing the extent to which the resource base constrains concurrent opportunities for production in the agricultural and forestry sectors in different regions throughout Canada, then a national system which distinguishes provinces would be the appropriate option. On the other hand, analysis which would provide details on the prospects for increasing production in each sector and on the socio-economic benefits that would be expected with alternative policy thrusts would require a series of provincial systems that would be linked nationally. Clearly a thorough examination of the need and intended use of a multisector land evaluation system at the national level is a prerequisite to decisions regarding the suitability of alternative approaches.

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EXTENSION WORK IN SITE CLASSIFICATION WITH ONTARIO MINISTRY OF NATURAL RESOURCES FOREST MANAGERS[1]

by
R. Keith Jones[2]

INTRODUCTION

The extension or technical transfer of soil and site classification work requires the development of a relationship between us, the site classifier or surveyor, and the user. The success of the extension work is controlled strongly by the nature of the persons involved and their willingness to learn, think and talk in each other's "language". Technology transfer is important to the overall success of a site classification program and should be recognized as an integral component of the project at the outset and throughout its entirety. By implementing a well planned and integrated technical transfer component, both parties are equally responsible for the program's success. As a bonus to these activities, both the user and, in particular, the site classifier gain a better "sense of job worth". Throughout this presentation the terms extension and technology tranfer will be used interchangeably.

Today I will be telling you about the extension programs in Ontario as a part of our soil and site classification work for forest management. I will discuss the sequence of activities that we have found to be effective in technology transfer including a user needs assessment, problem analysis, program planning, training courses, field guides and the final implementation of the site classification into regular forest management activities. I will spend considerable time in describing our experience with the training courses. This is not because other technology transfer activities are any less important, but it is an area where our experience is greatest and, thus far, where we have had greatest impact.

Richard Sims, John Jeglum and I have already given an overview of some of our current site classification activities in Ontario and as you have heard there is lots of interest and activity. Coupled with this new interest in site classification shown by forest management staff, there has been a sincere effort on our part to produce classification and mapping systems that are sensitive to the needs of forest managers and that can be used readily on a day to day basis. While we still have things to learn in reaching these objectives, I believe we have made substantial progress. Effective technology transfer in our site programs clearly is helping us better meet the needs of forest managers.

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1. Presented at the Canadian Forestry Service Site Classification, Interpretation and Land Evaluation (SCALE) Working Group Workshop Meeting, October 6, 1985, Frederiction, New Brunswick.

2. Land Resource Research Institute, Agriculture Canada, Ontario Institute of Pedology, Guelph, Ontario.

Technology transfer is often viewed as work that is done more or less after the project is completed - "now that we have developed the classification or completed the survey, let's show the user or potential user how it can be used". We, however, view technology transfer work more fully and believe it is an important and integral component of the entire program from beginning to end. Initially, it is in the form of assessing user needs, a problem analysis and program planning. During the program, it involves the conducting of introductory level training courses, progress reports and the oral presentation of progress at technical tranfer meetings. Towards the end of the program it involves the conducting of higher level, usually interpretive-oriented, training courses and workshops and the development and monitoring of implementation procedures into forest management programs.

NEEDS ASSESSMENT

At the outset of our more recent site classification work in Ontario, we decided we could not provide all things to all possible users. Our major user group in our work is the forest manager. These managers are with either the government or industry and have either a technical or professional level of education. If the results of our programs end up serving other users, for example land planners or wildlife biologists, then we view it as a bonus. Because we clearly identify the prime user in our programs, you will seldom hear of us referring to the ubiquitous and vague "potential user".

The next step is to identify the needs and problems that have arisen in the forest management of a particular area and to design a site classification and mapping scheme that will serve these needs and problems as precisely as possible. To do this we must query the managers repeatably on what specific interpretations are required of the survey and what level of interpretive confidence is most desirable. Usually this task is iterative in that the site classifier must develop an appreciation of the nature of forestry practices in an area, while the forest manager must become familiar with the nature of site classification and mapping.

To accomplish this task in our Clay Belt program, an experienced management forester from the Clay Belt, Kent Virgo was added to the study team. Virgo conducted an extensive site-silviculture survey by using a questionnaire and interviews, and collated over 160 man-years of management experience. This survey guided the design of the program by providing an understanding of how the individual field staff had been perceiving and classifying forest sites; by identifying and ranking specific interpretive needs; by suggesting what possible site properties were most important for these interpretive needs; and by influencing the way in which sites were discussed with field staff during the work and in the final presentation of the classification.

PROBLEM ANALYSIS

The problem analysis for a site classification program is closely aligned with the needs assessment. While the needs assessment that I described for the Clay Belt was well done and is probably a first for such work in Ontario, the problem analysis could have been more complete. Improvements could have been made by spelling out more clearly the specific interpretive requirements beyond just noting such things as: preferred season and method of harvest, potential for competing vegetation following disturbance or suitability for seed dependent regeneration versus sites requiring planting. If preferred season and method of harvest was an important interpretation, it would have been useful to have considered specifically how we were going to interpret the data; namely, what interpretive procedure or algorithm will be used and hence what soil and site parameters are required in the data collection. Problem analysis procedures for soil survey have been outlined recently in a paper by Moon and Selby (1984). Often this level of consideration requires a thorough review of existing interpretive literature coupled with a careful, logical application of our knowledge about soil and site properties and their influence on, in this example, trafficability. Often we tended to fall back on the traditional belief that so called "holistic" ecosystem units, once defined, will generally serve the interpretive needs. We seem to assume that during or at the end of the work, a meaningful interpretive method will somehow emerge out of the data analysis.

PROGRAM PLANNING

Technology transfer plays an important role in overall program planning. Ideally, it involves the formation of a "site classification committee", formal or otherwise, whose responsibility it is to plan and guide the study through to its completion. As an example, in our current Algonquin Region project, we will be setting up a committee of key individuals representing regional, district and research staff in the Ministry of Natural Resources. This committee will help in finalizing the objectives of the program, in organizing field logistics, in planning technology transfer sessions, in guiding the interpretation of the data and in implementing the results of the program into day-to-day forest management activities. By setting up technical-administrative committees such as this, both parties become equally responsible for the program success.

TRAINING COURSES

Many of our extension approaches stemmed from earlier practical forest soil courses offered by the Ontario Ministry of Natural Resources to foresters and technicians. The teaching methods of the Ministry instructors Geoffrey Pierpoint and David Bates employed the now familiar "learn by doing" or "hands-on" adult education approaches. I witnessed a course in 1978 and was amazed at how easy it appeared to teach practical aspects of soil recognition and description and at the ease with which technical and professional forestry staff learned the material. Since that time, there are more of us involved in soil and site technology tranfer work, the training programs have been enhanced and we have published a number of field guides.

Based on the approaches initiated by the Ministry of Natural Resources in the mid-1970's, we have now expanded our training programs to include nearly all regions of the province. The types of courses include the recognition and description of basic soil properties, more advanced courses on soils and their silvicultural interpretation and the application of forest ecosystem classification systems developed for specific areas. For all programs, we begin by giving the forestry staff a basic soil course as an initial foundation for future field training and seminars. The participants in these courses include both Ministry and industry staff with varying levels of background in terms of their soil and ecological education. In addition to these courses, we also train company and Ministry summer cruising crews and various permanent and temporary research staff.

During the past 6 years some 30 courses have been given, training approximately 350 people. A typical course has no more than 30 participants and the participant to instructor ratio is about 5:1. The field to classroom time ratio is usually about 4:1. For most courses, field stops are preselected or at least candidate areas for stops are identified in advance. This is important for an efficient ordering of field stops and, for soil courses, it ensures that a complete range of conditions is covered. In our forest ecosystem classification courses, the stops towards the end of the course are usually not chosen specifically so that we can demonstrate that the system is applicable in all areas and not just those chosen by the instructors. To demonstrate our current training methods, I will now provide an example of our 3-4 day basic soil course.

The basic soil course is given to most staff involved in regular forest management. Course enrollment is usually limited to 25. Day 1 consists of 2-3 hours of classroom lectures: an overview of the course objectives relative to the site classification program in their area; surficial geology, soil texture, soil structure, soil drainage and soil moisture regime. The lectures on soil properties include a discussion of the importance of the properties to forest management, the nature of the properties and the field recognition of properties using various field guide materials. At the end of the lecture period the participants are divided into 4-5 groups of 4-5 individuals with an attempt to mix district staff and backgrounds (e.g. foresters, technicians, researchers and students). At this time, the participants are given the necessary field materials such as field guides, measuring tapes, shovels, acid bottles and augers, and the class goes into the field.

The field guide materials used on the courses are either the complete Ontario Institute of Pedology "Field Manual for Describing Soils" (Ontario Institute of Pedology, 1985) or abstracts from same. Naturally for the Clay Belt program, we use the "Field Guide to Ecosystem Classification for the Clay Belt of Site Region 3E" (Jones et al., 1983). As most of you are aware, these field guides are waterproof and fit into most field cruising vests. In designing the guide materials we have attempted to keep things simple, brief and relevant. The frequent use of dichotomous decision making keys helps to standardize and simplify procedures for the identification and description of site properties and classes. Now, the students take the guides back to their districts for continuing use in their everyday work.

Upon arriving at the first stop, each group is led by an instructor to a site and digs a complete soil pit. Stop 1 is usually a simple soil like deep, rapidly drained, outwash sand. After pit excavation, the group must work their way through the field guide material determining the texture of the parent material, drainage, moisture regime, mode of deposition and depth to free lime (if it occurs). The role of the instructor at each pit is simply to guide the participants deliberations, often answering questions with questions in order to encourage individuals to figure things out themselves. Naturally, when some of the morning lecture material needs clarification, this is given. At the end of the description of each pit, one member of the group is responsible for telling the class as a whole what the group has found. At this point there is a scramble for paper and pencils! With all pits described to the instructors' satisfaction, the entire class collects around a few of the different soil pits, and in turn each group representative describes the conditions found. At this time, the instructors again guide the discussion within the class. Once everyone is satisfied with the soil description and the use of the field guide material, a summary statement is made by an instructor about the range of conditions noted on the site and any other points that may have arisen during discussions. This first stop is often 2 hours long.

The remaining stops for day 1 also are selected to be relatively simple and ideally "textbook". Typically, 2-3 more stops are visited, each one having a significantly different texture and often drainage class. At each stop, the instructors alternate amongst groups and the group members take turns reporting the findings.

Day 2 begins with about 2 hours of classroom lectures. The topics may include forest humus horizon description and general classification, organic soil horizon description, guides for determining soil drainage and moisture regime on shallow and stratified soils and mineral soil horizon description. Note that there is very little if any discussion on the Canadian System of Soil Classification per se. The field stops following the lectures are selected to show slightly more complex conditions with respect to texture, stratification, soil depth over bedrock and more poorly drained soils. The same teaching approach of "learning by doing" is continued throughout the course.

At this point in the training, we often note several things. Firstly, most of the participants have gained a sincere interest in soils and are delighted to find that soil properties indeed can be recognized and described with a reasonable degree of consistency and with reasonable ease. Alas, some of the mystique associated with soils has been eroded! This of course is very rewarding and is usually well reflected in the course evaluations. Secondly, the subject of soil horizonation and its relevance usually arises during discussions about the soil pit. Generally, we try to discuss the dominant soil processes that are active in the horizon sequences encountered without discussing the soil taxonomy, and we discuss what the relevance of some horizons may or may not be to forestry. Thirdly, we have noted that an overconfidence and sloppiness can develop in some participants with soil description. To solve this problem, we frequently direct the individuals back to basics - "tell us why you think it is an imperfectly drained site by guiding us through the drainage chart key, step by step".

Days 3 and 4 are spent mainly in the field completing the range of soil conditions and reinforcing their descriptive skills with similar site conditions already covered. Depending on the course location, morning lectures may be given on "soil surveys and their use in forest management" or on the progress of the site classification program for the area. In our southern Ontario site program the last day is spent on a practical case study exercise which mimics the type of work required for site description and species prescription in the private land forestry program. The exercise demonstrates how existing soil survey information can be used and how to go about collecting additional soil information using the skills just acquired.

On the last day of the training session, a course evaluation is conducted to provide us with an immediate response to the training program and its relevance to forestry work. We also ask what topics should be covered in future training sessions. Some of the information contained in the evaluations is useful in guiding some aspects of the site classification program.

IMPLEMENTATION OF SITE CLASSIFICATION INTO FOREST MANAGEMENT

The implementation of the site classification program is logically a part of the technology transfer component of a project. It is the final step to ensure that the results of the program will be applied as part of the staff's routine management work. Effective implementation requires an understanding of current management procedures and how they may be adjusted to include the collection and interpretation of the new site classification information. This may include the modification of existing data cards and sampling procedures for timber cruising, regeneration surveys or growth and yield studies. The monitoring and guidance of user-conducted pilot survey projects is also useful to demonstrate the operational application of the site classification system and to show how to apply the classification in a mapping context. Finally, it is worthwhile to coordinate a series of follow-up interpretive workshops which facilitates an exchange of information among the various Ministry, research and industry staff on the application of the classification system.

ACKNOWLEDGEMENTS

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ECOLOGICAL LAND CLASSIFICATION

in

BANFF AND JASPER NATIONAL PARKS

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W.D. Holland
Research Scientist
Northern Forest Research Centre
Canadian Forestry Service
5320 - 122 Street
Edmonton, Alberta
T6H 3S5

Abstract

The Ecological Land Classification (ELC) methodology is described as it was developed and used in Banff and Jasper national parks. Principles of standardization, maximization, specialization, synchronization, concentration, and centralization are applied to data collection for ELC. Guidelines are suggested to make an ELC function more effectively. Advantages and disadvantages of an ELC are given. Suggestions are provided for development of new ELC projects. The conclusion is a discussion of applications of ELC.

Ecological Land Classification in Banff and Jasper National Parks

Introduction

The Ecological Land Classification (ELC) methodology used in Banff-Jasper and the other national parks in the mountains is outlined in detail in the various published reports emanating from the CFS in Edmonton (Holland and Coen, 1982, 1983; Holroyd and Van Tighem, 1983).

Banff and Jasper National Parks occupy about 17,520 km^2 (6765 mi^2) in Canada's southern Rocky Mountains. The ELC of Banff and Jasper presents landform and soil, vegetation and wildlife information in a map and descriptive format at a scale of 1:50,000 using a legend that integrates the resource components in a holistic fashion. A three-level, hierarchical land classification system was developed using established landform and soil taxonomies (C.S.S.C., 1978) plus a classification of 85 vegetation types developed by the authors of the Banff-Jasper report. The three levels are based on existing guidelines for Ecological (Biophysical) Land Classification in Canada (Lacate, 1969: Wiken, 1980) and include, from highest to lowest level of generalization, Ecoregion, Ecosection, and Ecosite.

Ecoregion separations are based primarily on vegetation physiognomy and species composition which reflect macroclimate. Montane, Subalpine, and Alpine Ecoregions are recognized. The Subalpine Ecoregion is subdivided into Lower Subalpine and Upper Subalpine portions based on vegetational characteristics reflecting macroclimatic differences.

The Ecoregions are divided into 55 Ecosections. Ecosection separations are based on broad landform, drainage class, and soil differences. Landforms are comprised of ten genetic materials that have been divided into twenty genetic material units based on broad textural and chemical (calcareousness/reaction) differences.

The Ecosections are further separated into 124 Ecosites based on specific soil and vegetational differences that are considered insufficient, in magnitude or kind, to warrant separation at the Ecosection level. The Ecosites, plus eight Miscellaneous Landscapes, are the mapping units delineated on 1:50,000 maps. Wildlife information is presented at the Ecosite level. The importance of each Ecosite for most of the large and medium size mammals is described. Eighteen breeding bird associations and seven small mammal associations are defined using multivariate statistics. The association and its relative abundance are listed for each Ecosite.

The ideal ELC system does not exist. In Banff-Jasper our use of ELC differed somewhat from that in other parts of Canada. The differences are mainly in scale and some of the concepts used to develop mapping units. However, the basic ideas of what constitutes an ELC are the same. The physical resources of climate, geology, landforms, and soils are united into one taxonomic classification system, including the biological resources of vegetation and animal life.

The obvious reason for an ELC is to obtain a quantification of the existing resources and their distribution. However, an integrated ecological approach does more. It provides a better understanding of resource relationships and the processes that explain why certain ecological relationships occur. Such knowledge helps the resource managers to interpret the data easier.

ELC Principles and Guidelines

Canada is a forestry nation, mainly because of the size of its forest resource, and because, up to now, it has been able to provide wood at low cost (Williams, 1985)[1].

Toffler (1980) describes the six interrelated principles of standardization, specialization, synchronization, concentration, maximization, and centralization that are required for industrialization. A brief look at these principles shows how they might relate to ELC:

1. Standardization of data collection

   Imprecisely defined terms abound in the literature describing the biosphere. Simple, easily definable and quantifiable terms need to be used in order to improve understanding. Some standard of language is mandatory before technical communications can proceed.

   Biological systems are products of ecological processes. If uniform resource evaluations are required in order to make management decisions, then valid methods of measurement need some kind of standardization. Some data gathering systems (e.g., botanical classification) are accepted throughout the world, but other systems are not. Environmental interrelationships of local, national, international and global scale require standardized description, quantification, and evaluation.

   At present there are at least eighteen different methods of ecological land classification and about ten resource data banks in Canada. In other words, standardization leaves much to be desired. Standardization may be relatively simple to implement for single resource components, but although very desirable, may be difficult to implement with integrated

[1]Williams, D.H. Unpublished. Economic Wood Supply Modelling. Presentation to the Tenth Meeting of the Canadian Forest Inventory Committee. June, 1985 P.N.F.I., Petawawa, Ont.

data bases, simple because of their complexity. Nevertheless, some degree of standardization is necessary before the scientist, the land manager, and public can communicate at local and more global levels.

2. Specializaiton of data input:

There is usually plenty of information available about why we cannot produce certain things on certain lands (limitations) but not much about what can be produced (suitability). To obtain better land management, land suitability for various land uses needs to be determined and described. Such an exercise aids in deciding what data to collect. Development of an integrated data base encourages the incorporation of specialization into biosphere studies and can include teams of scientific specialists; e.g., soil and vegetation scientists, wildlife biologists, social scientists, etc.

3. Synchronization of research:

Research carried out in the field at the same spot and at the same time by specialists (soil, wildlife, vegetation, and other fields) is much stronger and provides a better integration of the various biosphere components than one where the work is done in separate segments. An ELC team of specialists can encourage an interchange of ideas between geologists, soil scientists, vegetation scientists, and wildlife biologists. Also, there is a saving because all resource components are examined at the same time. Synchronization of research can result in a more thorough effort as well as better comprehension of the biosphere and consequent planning and management.

4. Concentration of data acquisition:

An integrated data base requires uniformity of data collection, both in intensity of sampling and quality of data. Greater success can be expected if the biosphere studies are carried out under one authority, thus coordinating the research and planning of provincial and federal agencies.

5. <u>Maximization of data use:</u>

Maximization of information and its use requires increased efficiency in terms of productivity and quality of data. Determination of how much data to collect, and what kind, is essential because of high costs of data acquisition. Reduced costs can be expected because data can be selected that is pertinent to the problem to be solved. Research is required to develop improved interpretation of resource data for land use purposes, including impact predictions of land management actions. Such research will increase the efficiency of resource data use and lead to maximization of return for the initial research input.

6. <u>Centralization of data base:</u>

A centralized data bank can provide an ELC technical centre. In addition, it can assist data users and provide encouragement of data use through data sharing.

It is not known whether use of the above principles is good or bad. Does Canada want to be an intensely industrialized forestry nation? What is the impact on the environment created by standardization, specialization, synchronization, concentration, maximization, and centralization?

An integrated data base could be used to develop a set of stop/go guidelines for land use management. A simple set of do's and don'ts. However, land use management goals must be clearly defined; e.g., the concept of sustained forest yield may have to give way to one of doubling or tripling of future yield. To answer such a question requires development of a predictive capability in the data base.

An integrated data base could be used for periodic land use review and monitoring of ecological change, especially in some of the monoculture types of land use. It could tell us about what is happening to nitrogen and phosphorus levels, the organic matter, soil pH, and all the other variables that we know are slowly changing but are rarely monitored over a long period of time. Comparison of land use within the ELC area with that outside can assist in the monitoring of ecological change and development of a predictive capability for impact of certain land uses.

A properly designed integrated data base would provide a great saving in time. A tremendous improvement over presently used methods would be development of a field to computer linkage where the data could be entered into the computer right in the field, doing away with field forms. An integrated data base developed over a number of years should be able to answer certain questions without the collection of additional data.

In addition to providing baseline resource studies, monitoring of the impact of various land uses on the environment, and prediction of response to management decisions, the ELC can provide some additional freedom for research. Some suggested topics are:

1. The relationship of forest to grassland and agriculture and to animal grazing, both wild and domestic.
2. The effect of ecological processes on environmental stability and fragility under different land uses. Included subjects are the intensity and time of land use (human and wildlife), development of interpretation for hazard ratings (e.g., windthrow, flooding and frost), determination of pathways and rates of vegetational succession, impact of insects and disease, and resource degradation.
3. The size, pattern, and distribution of land resources as it affects land use by wildlife and humans.
4. The impact of engineering (i.e., roads, trails, bridges, etc) on resource use.

5. Actual and predicted environmental response to various kinds of land management under specified land use: e.g., if an area is cut, how difficult is its regeneration on different kinds of land with different kinds of forests, and comparisons of different intensities of land use.

An immense amount of work is required between agencies and the public in order to gain acceptance of ELC concepts. Proposals are needed, responsible agencies need to be identified and involved, and the public informed through public meetings, mailings, etc.

The time for ELC is immediate. Environmental degradation can be so insidious that it is not noticeable until the cummulative impact is felt.

The experience gained in one ELC area can certainly be extended to other areas; if not directly transferable, then at least the methodology is transferable.

Suggested guidelines to make an ELC function better are as follows:

1. An ELC should be based on ecological principles, including suitabilities and limitations of resources for certain uses. Ecological principles are not adequately described in ecology texts; thus it seems appropriate to base them on biophysical relationships of heat, light, moisture, oxygenation, mechanical impedance to rooting, plant competition (e.g., light, moisture, nutrients), and damage and disturbance (e.g., undercutting and root pruning, or soil movement such as frost heaving and dessication cracking). However, it must be remembered that an ELC must include living things and their relationship to the above growth factors.
2. The map, legend, and report should be easily interpretable in order to assist with management decisions. There should not be too many map units and the system should be kept as simple as possible.

3. The map unit concept should be repetitive and holistic so that information obtained about land use response in a familiar area can be transferred to a similar but unfamiliar area. This is particularly useful when one wishes to develop response units for certain kinds of management.
4. The mapping must be based, as much as possible, on relatively permanent feature of the landscape; e.g., landforms, soil, climax vegetation, or seral stages with long term stability.
5. Mapped information should be of uniform intensity and reliability throughout the mapped area.
6. Classification units should not be confused with mapping units. Map polygons must be rigorously defined and maintained.

<u>Advantages of Using ELC</u>

See the principles and guidelines listed above, and the following:

1. First and foremost is the possibility of basing land classification on ecological principles.
2. A multi-disciplinary team of scientists can be assembled. This provides professional people with field experience and expertise.
3. An ELC can be designed with sufficient flexibility to suit your purpose.
4. ELC develops a holistic ecological viewpoint.
5. ELC replaces a variety of single discipline methods: e.g., landform, soils, vegetation.
6. It costs less than a number of separate inventories.

<u>Disadvantages of Using ELC</u>

1. Must have a multi-disciplinary team of scientists; decisions may take longer to develop.
2. ELC is difficult to apply where natural vegetation is severely disturbed or has been replaced; e.g., from Lethbridge to Calgary.

3. Because of the variety of disciplines involved, it is difficult to coordinate ELC work; i.e., to maintain concepts and guidelines: the team requires training and field trips that refresh concepts and use of ELC guidelines.

4. It may be a problem to satisfy all users; e.g. wildlife biologists, wardens, planners, botanists, etc. This is really a problem that needs to be handled by means of technology transfer through an extension service.

5. Occasionally there is not enough research available in order to establish ecological relationships; e.g. how to establish ecological response units where environmental conditions are assumed to be similar.

Suggestions for Development of New ELC Projects

1. Determine the objectives of an ELC through consultation with potential users. It is desirable to develop a set of specific criteria to guide formation of an ELC framework (Driscoll et al, 1983).

   The national parks, for example, imposed limitations on their ELC because they were not interested in vegetational growth data. Later, requests for reclamation work indicated that collection of growth data would have been useful. Similarly, some foresters impose limitations by confining their interests to stems of trees, or a single tree species such a' white spruce or pine and excluding hardwoods, understory vegetation, water, and wildlife concerns.

2. Decide on the kind and amount of data that are required, recognizing any research needs.

3. Mappers should be selected early, remembering that soil survey has a mapping tradition whereas many wildlife biologists, and others, do not; i.e., fit people to the job.

4. Mapping parameters must be rigorously defined and maintained; e.g., mapping scale, polygon base, mapping unit, and type of legend (open or closed).

5. Use, or develop a hierarchical classification. It is particularly useful for describing ecosystems and their components, and provides a means of understanding the landscape at different scales. Mapping, however, is usually done in one hierarchical level; e.g., mappers do not mix ecoregions and ecosites.
6. An adequate correlation level must be maintained.
7. Become involved with the data users, but do not stop at the taxonomic level of an ELC. Classification should be followed by applications; e.g., interpretive classifications and development of land evaluation techniques for various land uses.
8. Be aware of regional variations of resource components: e.g., climate, landforms and genetic materials, and water. e.g., the Shield at Flin Flon and the Shield at Thunder Bay.
9. Be aware of ELC applications.

Applications of ELC

Applications of ELC are limited by the kind and amount of data collected. Interpretations and decisions should not exceed such limitations. The following list suggests uses for ELC:

1. Quantification of resources; i.e., their distribution in map form. The mapping process quickly reveals details of the amount of certain resources and their location; see Tables 1, 2, 3, and 4 (Holland, 1984) and Table 5 (Tarnocai, 1975).

Table 1. Ecoregions and subdivisions

Montane	99 185	ha	5.5%
Subalpine	906 020	ha	50.3%
- Lower Subalpine	(512 831)	ha	(28.5%)
- Upper Subalpine	(393 188)	ha	(21.8%)
Alpine	101 665	ha	5.6%
Miscellaneous Landscape	691 650	ha	38.6%

The majority of the Montane Ecoregion occurs in Jasper. Approximately 2% of Banff national park is in the Montane. The climate of the Montane is warmer and drier than the harsher climate of the other ecoregions. This more-pleasing climate, along with the attraction of Banff townsite, causes humans and wildlife to use the Montane resources more intensively than those in other areas of the park. The result is overuse of resources in a small portion of the park and underuse elsewhere. The impact can be critical to some wildlife populations and to the appearance of the park, especially along the main entryway from the east. The ELC maps quickly indicate the location of the resources that are most in need of conservation.

Table 2. Dominant chemical characteristics of genetic materials by area

Miscellaneous landscapes (undivided)	38.6%
Calcareous	37.3%
Noncalcareous	15.5%
Variable (calcareous-noncalcareous mixtures or Undivided)	8.6%

This summary table indicates that less than half of Banff and Jasper are calcareous, upsetting previous concepts that the materials in the parks were nearly all calcareous.

Table 3. Banff-Jasper soil texture by area.

Miscellaneous landscapes	38.6%
Coarse	6.8%
Medium	42.0%
Fine (includes fine over medium or variable)	0.3%
Stratified (coarse stratified + fine stratified)	5.7%
Variable (coarse-medium-fine and medium-coarse mixtures)	6.6%

The percentage of fine clayey soil is extremely low.

Table 4. Banff-Jasper soil drainage by area.

Miscellaneous Landscape (undivided)	38.6%
Wetland soils (drainage classes 5-7)	8.0%
Well-drained or upland soils (drainage classes 2-4)	53.4%

The amount of poorly drained soil is low, only 8%. The impact on the wildlife resource can be predicted.

Table 5. Resource distribution in the Pas map area, Manitoba

Water	34%
Organic	32%
Poorly drained soil	14%
Well drained soil	20%

Twenty percent of the map area is suitable for most forestry operations. However, the pattern of distribution of well drained soils may well determine their usefulness. An examination of the resource map will indicate whether the useful soils are distributed in small scattered areas or whether they occur in larger, more contiguous blocks. The difference is one of economics.

2. Qualification of resource characteristics through determination of their suitabilities and limitations. In making an interpretive classification, several principles should be observed:

   a) Define clearly the purpose of each classification.

   b) Classifications are generally based on the kinds and degree of limitation for a specific land use. The ranges of the resource qualities that define the various classes should be defined as precisely as possible. Resource groupings are usually according to one resource quality.

   c) Classifications generally contain few classes. An odd number of classes permits two extremes as well as a mean average class, three to five being most common. More classes may be needed for intensive management, but a large number of classes becomes unwieldy and does little to help simplify the information.

   d) The intensity of management for a particular classification must be stated, because many limitations can be reduced by management. Thus, a factor such as high tree density, which may be severely limiting in a backcountry campsite with a low intensity of management, may present less severe limitations in a highly developed area where more intensive management permits clearing of access roads, paths, and tent pads.

   e) Interpretive classes are relative - good, fair, poor. Such groupings are dynamic and can be changed as situations change, for example, an altered management practice.

Examples of these principles applied to interpretive classifications based on soil limitations are in Soils of Waterton Lakes National Park (Coen and Holland 1976).

3. Gradient analyses can be developed from ELC data; e.g., moisture gradients from wet to dry according to vegetation types and soils.
4. ELC data can be used to make predictions, especially productivity. Predictions can also be developed for stability of resource use, impact of resource use on the environment, direction of vegetational succession, and management requirements (drainage, fertilizer needs, etc.).
5. ELC data can be used for modelling, especially for land use purpose. Serious efforts at land evaluation modelling have been done by the Land Evaluation Group, University School of Rural Planning and Development, University of Guelph, Guelph, Ontario.
6. ELC data can be used to develop management guidelines for such things as species suitability, fertilization needs, and silvicultural requirements for increased productivity.

Who are the successful people; regardless of activity? History shows it to be those that are best organized, in thought, research, planning, and action. ELC is one step along the road to progress.

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APPENDIX A

Chairman's Remarks

General impressions
Questionnaire
Recommendations

General impressions:

1. There is much interest in SCALE from all quarters. More site classification activity is occurring in Canada than was expected.
2. Some people are looking for a national plan for SCALE.
3. There appears to be agreement on some issues; for example, the need for SCALE. Harmony on other issues is not so clear; for example, some workers are enthusiastic supporters of an integrated ecological approach to SCALE, while others follow more traditional lines of forestry. Most members of the Working Group have a feeling for ecology. No one appears to be so extreme as to be concerned only with fibre production.
4. A higher level of scientific rigor must be developed in all aspects of SCALE work. Confusion was noted in the use of terms such as ecoclimate and ecoregion; site description, site classification, and interpretive classification; and in such things as objectives, goals, and methodologies. Even more serious is the lack of self-critiquing our own work; e.g., the users of methodologies such as Twinspan and Decorana are the people best able to point out advantages and disadvantages of using these systems; people involved with ecological land classification know the advantages and disadvantages of using such systems.
5. The need for more extension of SC knowledge to other forestry workers was recognized and well demonstrated.
6. The discussion following the meeting indicated hesitation in the formulation of future direction for SCALE activities and recommendations for action. Such hesitancy can probably be overcome by suggestions for agenda items coming from the Working Group members, particularly if more time is made available for discussion and field trips are included with future meetings.

Government of Canada / Gouvernement du Canada

MEMORANDUM **NOTE DE SERVICE**

TO / À: The CFS SCALE Working Group

FROM / DE: Wil Holland, Chairman

SECURITY - CLASSIFICATION - DE SÉCURITÉ:

OUR FILE/NOTRE RÉFÉRENCE: XXXX

YOUR FILE/VOTRE RÉFÉRENCE:

DATE: 25 October, 1985

SUBJECT / OBJET: Questionnaire and Recommendations

1. My thanks to attendants at the October 6, 1985 meeting of the SCALE Working Group in Fredericton. Thanks go to the speakers for their skilled and knowledgeable input. A special thanks to Herman van Groenewoud for his invaluable background work to the meeting.

   It was impossible to do 2 days' work in one day. Thus, I am using this questionnaire to determine the opinions of Working Group members and to determine our future direction. Please provide your response by December 1 in order that your input may be included in a preliminary report to headquarters by the end of the year. Suggestions are always welcome.

2. Discussion by CFS Working Group

   1. Objectives of SCALE. SCALE = Site classification, interpretation, and land evaluation for forestry.

   2. Why does Canada need SCALE?

      a. Locally: how are site variables such as soil, precipitation, temperature, vegetation, and drainage, etc. used to determine silvicultural prescriptions, forest renewal options, forest management, and development and growth of industry?

      b. Internationally: what is the demand for forest products for which SCALE is needed: i.e. how much pulp and what kind, construction material, hardwoods, etc.? That is, what is the purpose of SCALE?

   3. Does Canada need a national system of SCALE or are regional systems adequate?

   4. Should there be a comparative study of site classification methods on the same area?

   5. What kind of soil (site) manuals does forestry need?

6. What kind of vegetation data, classification, and mapping does Canada need?

7. Can the Working Group develop a set of guidelines for SCALE? Examples:

   a. Use permanent physical features as a SC base rather than vegetation.
   b. Determination of scale of SCALE: i.e. what is the best scale of SCALE maps for forestry?
   c. Objectives of SCALE.
   d. The type of base data that can be used for various purposes.
   e. Acceptance of a set of data collection guidelines: standardization, specialization, synchronization, concentration, maximization, and centralization.

8. What is the best way to relate SCALE to forestry needs: i.e. how should the extension work be done?

3. Structure of the Working Group.

Who should be included as members of the CFS Working Group for SCALE.

CFS only:-

CFS:- earth scientists only.

CFS:- earth scientists & vegetation scientists.

CFS:- earth scientists & vegetation scientists & silviculturists.

Other:-

Outside speakers:-

4. Recommendations to CFS Headquarters:-

1) That the SCALE Working Group be composed of CFS personnel only.

Yes____

No____

2) That the SCALE Working Group be drawn from as wide a range of scientific disciplines as possible.

Yes____

No____

3) That the SCALE Working Group recognize the need for interdisciplinary communication, establishment of commonality of terminology, and understanding of methodologies, and that these goals be achieved via regular meetings and field trips.

Yes____

No____

4) That the SCALE Working Group report periodically to CFS Headquarters and regional establishments on what is happening in Canada in site classification, interpretation, and land evaluation for forestry.

Yes_____
No_____

5) That Richard Sims expand his review of current site classification activities in the Canadian Forestry Service.

Yes_____
No_____

6) That the SCALE Working Group determine what research is required to assist site classification, interpretation, and land evaluation for forestry.

Yes_____
No_____

7) That the SCALE Working Group prepare a report that outlines basic SCALE philosophy and guidelines.

Yes_____
No_____

8) That the SCALE Working Group examine the need to establish benchmark sites in the forests of Canada to assist in achieving recommendation #3 above.

Yes_____
No_____

Wil Holland

Response to Questionnaire: (11 returns out of 40)

2.1 Objectives of SCALE:

The following concerns were expressed by respondents:

1. To determine the current status of SCALE in Canada.

2. To provide a forum for SCALE related personnel.

3. To identify SC factors (climate, soil moisture, nutrients, etc.) that require quantification, particularly those important to plantation management.

4. To determine suitable forest land use and management (biological and economic; e.g., maximum benefits at minimal cost) for specified areas (block) and to determine those areas (within specific blocks) that are best suited to given management techniques (e.g., species suitability, stand tending, fertilizing, preservation, etc.).

5. To develop a quantitative system of forest land use interpretations that will replace the largely qualitative site assessment methods used at present.

6. To develop a system of forest land evaluation that assists in determining the social and economic implications and relevance of forest management decisions over the long term and the impact of these decisions on alternate land uses.

7. To establish a geographic scale for each of the objectives. This would prevent development of an unwieldy methodology (i.e., site classification = micro scale, interpretation = intermediate level of generalization, and land evaluation = macro scale including portions of provinces, entire provinces, or the nation).

8. To produce a national publication on "SCALE in Canada". It would provide description, site classification, interpretation, and land evaluation as perceived by SCALE. Also included would be some detail on relationships between different kinds and types of forests, topography, and vegetational succession. Emphasis would be given to benchmark sites and unique forest stands. The book would provide standardization of terminology, procedures, and guidelines for development and use of SCALE in Canada.

2.2 Why does Canada need SCALE?

A. Local uses:

1. To guide investment dollars onto the more productive forest sites, especially in terms of forest land rehabilitation and management, and forest land use realignment.

2. Policy decisions at the national level must be based on a standardized country-wide data base.

3. Ecoregion classification in Canada provides a broad level of SCALE information, but there is still much potential for development and use of site specific interpretive information throughout the country.

4. Site classification is well advanced, but the application to silvicultural prescriptions has been limited.

5. Silvicultural practices and forest management decisions affecting forest growth are based mainly on climate, soil properties, and to some extent, vegetation. Soil properties are the growth factor that can be most readily manipulated for increased forest productivity. Hence their importance in future SCALE work.

B. International demand for forest products:

This concern was not adequately expressed in the Oct. 6 agenda or the questionnaire. Consequently the opinions expressed gave little or no opinion of what SCALE needs to do in this area.

The concern is how future demand for our forest products outside of Canada will impact the kind and quantity of forest goods Canada will produce, and how this will affect workers in SCALE. There has been, and still may be, a price differential for long fibre products over short. However, technology abroad (Williamson, personal communication) may eliminate such an advantage to the point that it does not matter whether Canada produces long or short pulp and paper products. Perhaps SCALE workers should be more concerned with poplar species. Which tree species should SCALE workers be concerned with? What is the future for lumber? Can foreign demand be developed for hardwoods?. What is required of SCALE in order to develop hardwood plantations for white birch, yellow birch, oak, maple, elm, walnut, butternut, etc.?

Respondent's opinions continue:

1. On the international scene, successfully forecasting future market trends is critical. The need to identify site suitability for growing a variety of wood products, achieved through plantation forestry is of utmost importance. We need to identify those sites and specific site factors and management options that will allow for the establishment and maximum growth of a variety of species. We must also examine the potential of site degradation under these intensive management systems.

2. Increasing demand (and prices) for forest products should be translated into increased concern for and management of the site, i.e., a larger proportion of the profit from the current crop should be invested in ensuring optimal productivity and site management for the subsequent crop(s). Planning must be more far-sighted than at present.

3. Internationally, I think that in the future there will be increasing competition in lumber production. This will require not only modernization of the outdated forest industry (sawmills, pulpmills, plywood and other forest product factories) but also maintenance and increase of the productivity of our forest land. The virgin forests of Canada are slowly diminishing; the productivity of the second growth stands is low. Forest site interpretation and evaluation will be necessary for silviculture and forest management in order to improve forest productivity.

4. Pulp and paper is the only international wood product produced in the Newfoundland region. SCALE would be primarily used for stratifying productivity, prescription of problem sites and rating environmental land sensitivity in the context of the pulp and paper industry.

2.3 Does Canada need a national system of SCALE or are regional systems adequate?

1. Canada does not need a national system of SCALE as regional (and local) needs differ and the systems used should reflect these. What would be desirable, I believe, is a national terminology or glossary so that we are all talking about the same thing when specific terms are used.

2. Regional systems are best for in-the-field forest management; however, a national system would be beneficial to managers dealing with national concerns; regional systems are mostly developed independently, and are incompatible with each other; a national system would provide a national perspective to the forest land base.

3. Sometime in the future it will be desirable to produce a national publication covering site classification. In this context some national system will be a necessity. At present I think the priority should go to developing classification systems where they are lacking and application of existing regional site work to forest management.

4. Most, if not all, provincial forest ministries in Canada have a site classification system of one form or another. The degree to which these systems have been incorporated into the various levels of forest management within each province varies a great deal, I suspect.

   Because of the jurisdictional arrangement between the provinces and feds it is difficult to envisage a direct role for CFS, within provincial boundaries, except by invitation. Regional classification systems evolved from identified local requirements and will likely always play a role in regional management. However, there is considerable divergence between provinces not only in approaches to classification, but also in degree of sophistication. A national system would overcome these problems and provide decision-makers with the necessary tools for a country wide perspective.

With respect to the land evaluation component of SCALE, I would suspect that several regional systems nested within a national system would be practicable. This would facilitate (i) the use of available expertise in each region (and hence reduce development and operating costs) and (ii) the development of a system with the capacity to assess the long-term adequacy of the land base for forestry relative to concerns at the subprovincial, provincial and national levels.

5. Yes, Canada does need a national system of SCALE. Without a national system it will be virtually impossible to carry out forestry interpretations and forest land evaluations on a national level.

2.4 Should there be a comparative study of site classification methods on the same area?

1. This would be interesting but I doubt if it would prove very much. One site classification method may be best suited for one region, and another method for a different region. Adherents of one method are not likely to change their minds because of the results of a comparative study on one area.

2. Different classification methods are suited to different objectives or uses/interpretations. The "optimal" system suited to a multitude of uses and interpretations will be holistic (ecological), hierarchical, and mappable at various scales depending on intended use. It should also be as simple and as easy to use as possible.

3. Comparative studies of site classification methods on the same area would have primary benefits for areas where a local system does not currently exist or where the existing system is deemed inadequate; CFS is not in a position to exercise control over what system the primary provincial governments and forest industries use.

4. Rather than comparative studies, there is perhaps a greater need to establish a system that has national relevance. This would not be reinventing the wheel but rather would draw heavily on systems already in place and provide a system that incorporates all the "good" from what is already available.

   This would satisfy a number of needs (i.e.) the need for a national, standardized format but perhaps more importantly, the system developed, could provide those provinces and industry that do not have an entrenched system in place with something they might want to adopt.

5. I think it would be desirable to produce a comparative study of Braun-Blanquet traditional classification and ordination methodology. However, there already are some comparisons available in the literature so this would not be an immediate priority.

6. A comparative study of site classification methods should be carried out on designated test or pilot project areas throughout the country.

2.5 What kind of soil (site) manuals does forestry need?

1. Forest managers need practical soil or site manuals which will help them to decide what to do where. The manuals need not be unduly simplified, but should have adequate back-up in the form of SCALE specialists who are willing to work with forest managers in workshops and on a one-to-one basis to help them use the manuals properly.

2. Soil (site) manuals similar to those developed for the Clay Belt or for British Columbia should be expanded to include other areas of Canada.

3. Site manuals should readily distinguish sites according to easily recognizable criteria and should as much as possible, provide a number of management interpretations based upon the best data available, but recognizing that interpretations and classifications will be revised in the light of new data. Field manuals should be well illustrated and should be at a technical level easily achieved by field foresters and technicians. The most useful manuals will require some upgrading in soils and vegetation expertise on the part of the average user. The agencies producing such manuals should be prepared to do a certain amount of this training and extension.

4. The type of manuals required for forestry relates silvicultural prescriptions to growth and yield on a site specific basis; these can take the form of regional written texts and maps or as computer displays, but in any case should be supported by case evaluation data and/or justification.

5. Soil (site) manuals must be relatively simple identifying those factors important to (1) harvesting, i.e., site sensitivity, (2) site preparation, (3) plantation establishment, and (4) plantation treatments to free trees to grow. They must be field oriented.

   The need really is to place both soil and vegetation within an ecological framework where climatic parameters are reasonably well defined.

   Old growth stands are slowly becoming a thing of the past. Vegetation establishment and growth following disturbance often follows unpredictable successional paths. The physical environment (soil ecosystem) provides a stable base upon which comparisons can be made. Though internal soil climate and chemistry may change considerably with disturbance, the physical characteristics most often remain recognizable.

6. Forestry site manuals should have the following content:

   a. A definition of types using vegetation and soil criteria that are comprehensible by a person with vocational training in forestry or BscF level.

b. Good illustration of key criteria used in definition of types of differentiation of different types. This should include illustration of differential plant species and a good key to forest types.

c. A thorough treatment of the ecological relationships of type particularly in the format of an edaphic grid and concise diagrams showing successional relationships. A forester using the manual should not only be able to recognize mature forest types but also all important successional phases making up the chromosequence of the site.

d. Good illustration of the topographic relationships existing in the landscape at level of landform.

e. Management interpretation of forest types or related working groups in two stages: (1) preventative measures to be undertaken in mature forest types to mitigate as far as possible the development of problem sites; (2) identification of problem sites and the identification of silvicultural treatments needed to bring these sites to a reasonable level of productivity. Reasonable level s uld be defined within the content of expectations within regions for a desired product.

2.6 What kind of vegetation data, classification, and mapping does Canada need?

1. A land classification scheme which systematically groups those biophysical attributes which influence forestry productivities would represent a major contribution.

2. A national vegetation classification system is being developed by a CCELC working group that should provide the necessary vegetation data. Primary problems occur with recently logged or burned land and early seral vegetation stages. The same vegetation association, or productivity, does not always return to a site after these disturbances--research into these problems would be beneficial to all concerned parties.

3. Needs will vary from region to region, but the practical concerns of the forest manager should be paramount.

4. Data needs will depend upon objectives. Site specific classifications using detailed soil and vegetation information will be required in some instances (e.g., silviculture). In others, more broad scale, generalized soil, landform, and vegetation information will be required where the classification is to be mapped or tied into provincial timber inventory and used for growth potential forecasting over larger areas.

5. There is a definite need to establish vegetation succession criteria, (i.e., seral classification). Early succession and growth following the variety of disturbances that take place on forest land are of utmost importance in plantation or second growth forestry.

6. In long-term forest management site classification offers two contributions that probably cannot be duplicated by any other means: (1) the definition of site capability regardless of existing vegetation cover; (2) the ability to predict the outcome of various management scenarios on the future productivity of a site. Site-specific modelling can also reinforce the latter contribution but there are several attributes of any site classification scheme that are prerequisite to these two functions. The forest type should be a synthesis of vegetation type, soil type and landscape not just a description of these three components. The chronological relationship particularly with respect to fire and cutting should be clearly understood and documented. It is this latter stage which maintains site classification as part of the broader discipline of ecological research.

7. I do not think that we need a vegetation mapping program. We should, however, develop a vegetation classification scheme which will not only provide information on vegetation but also indicate the soil or site and vegetation relationships.

2.7 <u>Guidelines for SCALE:</u>

1. Most of the items dealt with in (a-e of the questionnaire) are readily available in the literature to regional researchers. I would think that the cohesiveness created by the working group would inspire individual members to contact each other for assistance where required. Most of the country appears to be well advanced in site classification so that any standardization at this point in time is unrealistic and potentially a destructive goal. The essential goal should be to keep lines of communication between site researchers open throughout the CFS.

2. a. Although it is of utmost importance to work within an ecosystem concept, I feel the physical (soil) base provides the only stable (permanent) component upon which extrapolations and comparisons can be made.

   b. SCALE maps for forestry will vary as to scale depending on use or management level. Detailed mapping (i.e. 1:5000 - 1:15 000) will be required for operational use. This will broaden considerably for other concerns (i.e. regional, national).

   c. To provide a site classification and land evaluation system with national application.

   d. Both physical and biological data and the necessary research to quantify critical parameters for the complete range of forest management levels (i.e., silviculture, logging, etc.) are needed.

e. If we are looking at a national system, then standardization is of utmost importance not only in data collection but in research data analysis and display.

3. If SCALE as proposed becomes a national mandate, then guidelines would be an anticipated output.

   a. Physical features and vegetation should both be included in the guidelines, and must be viewed in a climatic setting; in other words adopt and maintain an ecological framework.

   b. The scale of SCALE will of necessity be multi-scaled; the manager in the field must have detailed maps, in the order of 1:20 000 to 1:5000 while office managers and most national interests would find scales of 1:50 000 to 1:1 000 000 or even smaller more suitable.

   c. See objectives above.

   d. The amount and type of base data required would likely change from one area to another, but a minimum set could be developed that would adequately describe the site to allow most interpretations to be made; such things as soil texture, moisture regime, aspect, elevation, etc. have been successful in relating productivity to site, but even with these R2 values above 0.8 are exceptional.

   e. Standardized collection guidelines are applicable only if a national classification and evaluation scheme is developed, and are part-in-parcel of each other; you can't have one without the other.

4. a. Whether permanent physical features or present vegetation are used as important determinants of the classification will depend on the use intended.

   b. Again depends upon objectives.

   c. See objectives.

   d. The greater the number of anticipated uses, the more different kinds of data that will be required. If the classification is to address wildlife habitat requirements in addition to forest management for example, much detailed climate, landform, vegetation, and soil information will be required.

   e. A set of data collection guidelines is desirable. See for example, Walmsley _et al_. (1980).

5. I would say it is imperative that the Working Group develop a set of guidelines for SCALE. Once your item 7(c) - the objectives of SCALE - is clarified, then it will be feasible to address the other items relating to guidelines.

6. Guidelines for SCALE:

   a. Site classification should use the more permanent features such as soils or soil parent materials rather than the unstable vegetation component.

   b. The scale of maps providing information pertaining to the objectives outlined for SCALE should be at several levels. Small scale maps will be needed for national evaluations (scales 1:5 000 000 to 1:1 000 000); small and medium scale maps will be needed for regional evaluations (1:1 000 000 to 1:100 000); and large scale maps will be needed for local evaluations (1:25 000 and larger).

   c. I agree with the objectives stated in 2.1.

   d. Data on climate, soil properties and vegetation is needed.

   e. Data collection guidelines should follow the nationally accepted data collection procedures of those disciplines mentioned in d. Only by doing this can equality, reliability and high quality be expected.

2.8 <u>What is the best way to relate SCALE to forestry needs: i.e., how should the extension work be done?</u>

1. Extension work and training will probably be done mainly by provincial staff under a certain amount of guidance from the CFS researchers involved in the development of the classification and interpretations. The present CFS mandate does not permit (or reward) a large amount of extension work on the part of its research scientists. Until such work is regarded as a significant component in appraisals for promotion, it will not likely be carried out to the extent necessary.

2. This will vary from region to region depending on how active provincial governments are in site classification. The provincial government in Newfoundland and Labrador is very interested in site classification but would prefer to see the CFS take the leading role in developing classification systems and related manuals. Because we are dealing with a relatively small group of people concentrated in 2-3 population centres direct communication is possible. Development funding is being made available for output of appropriate manuals and other support material. Field workshops were completed in the summer of 1985.

3. Admittedly, some scientists are better at this type of technology transfer than others, but I think personal contact and field workshops are very important if SCALE is to be accepted by forest managers.

4. Relative to land evaluation, I would expect extension work refers to convincing policy analysts that it is feasible, practicable and rational to systematically assess the extent to which land resources constrain or permit growth in the forest sector relative to domestic and foreign market opportunities.

5. The extension work should be carried out through education (similar to the program carried out in the Clay Belt), publications and meetings attended by forest managers and field foresters.

3. <u>Structure of the Working Group:</u>

1. A CFS Working Group should consist of CFS personnel only and include specialists in soil, vegetation, and climate. The Working Group should be limited to less than 20 people. Contact should be maintained between this WG and any silviculture WG that may form, plus any provincial groups that may exist. Once the CFS act is together, consideration could be given to symposia, etc. that would attract a much larger audience--these could be conducted on an annual basis and be held in different provinces each year as warranted. Large working groups are virtually ineffectual in achieving any worthwhile goals, particularly in relation to the costs associated with large groups.

2. CFS working group should be kept within CFS and should include soil and vegetation scientists and silviculturists that have a good appreciation of site classification methodology. Such individuals would provide useful input in making interpretations for management.

3. CFS only with membership designated by the appropriate program directors.

4. From my perspective, the crucial point is that the members of the Working Group process or have access to the myriad of scientific skills required to fulfill the stated objectives.

5. Since it is a CFS Working Group, I believe the members should be CFS scientists. Outside people could be invited to address meetings and workshops of the group from time to time, however. Within CFS, membership in the Working Group should be open to any scientists or manager interested in the subject area. This could include earth scientists, vegetation scientists and silviculturists. When it comes to meetings and workshops of the Group, the practical realities of restricted travel budgets will almost certainly limit participation to one or two SCALE specialists from each establishment. The net effect will probably be a broad mailing list (as you have) but a relatively small group of active members.

6. Structure of the Working Group. Work relating to the SCALE objectives is to be carried out by a number of disciplines and organizations. Thus, the members of this Working Group should not be restricted to CFS people only. Earth, soil and vegetation scientists from other organizations working on some of the aspects of SCALE should also be included as members of this Working Group. I am positive that this new blood will be beneficial to the Working Group.

4. Recommendations to CFS Headquarters (11 respondents out of 40):

1. That the SCALE Working Group be composed of CFS personnel only. Yes 9
   No ___

2. That the SCALE Working Group be drawn from as wide a range of scientific disciplines as possible. Yes 6
   No 4

3. That the SCALE Working Group recognize the need for interdisciplinary communication, establishment of commonality of terminology, and understanding of methodologies, and that these goals be achieved via regular meetings and field trips. Yes 10
   No ___

4. That the SCALE Working Group report periodically to CFS Headquarters and regional establishments on what is happening in Canada in site classification, interpretation, and land evaluation for forestry.
   Yes 10
   No ___

5. That Richard Sims expand his review of current site classification activities in the Canadian Forestry Service. Yes 5
   No 2

6. That the SCALE Working Group determine what research is required to assist site classification, interpretation, and land evaluation for forestry. Yes 10
   No ___

7. That the SCALE Working Group prepare a report that outlines basic SCALE philosophy and guidelines. Yes 7
   No 1
   Uncertain 2

8. That the SCALE Working Group examine the need to establish benchmark sites in the forests of Canada to assist in achieving recommendation #3 above. Yes 9
   No ___

Suggested SCALE Recommendations to CFS Headquarters:

The following suggestions are for approval of the W.G. at its next meeting:

A. That a small core of about 24 CFS staff form the SCALE Working Group which meets approximately once a year in order to formulate the following items:

1. Objectives and goals of the CFS Working Group for SCALE.

2. Guidelines to assist the Working Group achieve the objectives and goals of SCALE.

3. Plan and establish a system of benchmark sites across Canada to provide a comparison of site quality and productivity, to form a reference base to which other plots could be related, form baseline data for monitoring change in any dynamic site component, e.g., vegetational succession, soil development, climatic change, nutrient flux, and to serve as educational material for scientific meetings. They could also serve to standardize site description and site classification.

4. Plan and produce a national publication on "SCALE in Canada". It would provide description, site classification, interpretation, and land evaluation as perceived by SCALE. Also included would be some detail on relationships between different kinds and types of forests, topography, and vegetational succession. Emphasis would be given to benchmark sites and unique forest stands. The book would provide standardization of terminology, procedures, and guidelines for development and use of SCALE in Canada.

5. Plan a national symposium of SCALE activities in Canada, including people outside the CFS.