FOREST INVENTORY MAPPING PROCEDURES ACROSS CANADA

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Abstract

Provincial management inventories across Canada use similar approaches and have many common elements, but each has unique features resulting from the nature of the forest, requirements, historical developments, the personnel involved, and budgetary considerations. This report details, for each province, the procedures used, organizational structure, and schedule followed in the production of inventory maps. In addition a summary of the volume sampling component is given. A description of stand attributes and examples of the forest inventory map and legend for each province are provided.

Résumé

Au Canada, les inventaires provinciaux d'aménagement utilisent des approches similaires et ont plusieurs éléments en commun, mais chaque province a ses particularités à cause de la nature de ses forêts, de ses spécifications, des développements historiques, du personnel affecté, et des contraintes budgétaires. Ce rapport décrit en détails, pour chaque province, les procédés utilisés, la structure organisationnelle, et les calendriers de production de ces cartes d'inventaire. De plus, une synthèse de l'aspect «échantillonnage du volume» y est donné. Une description des attributs des peuplements et des exemples de cartes d'inventaire forestier et de leurs légendes sont fournis pour chaque province.

Introduction

The management of Canada's 453 million hectares of forest land requires basic information on the location and extent of the resource. Forest inventories provide the data used to derive this information. A forest inventory may be defined as a survey of an area to provide information on the present extent, quality, and location of the forest resource and the manner in which it is changing. A forest inventory program based solely on ground survey measurements would be much too expensive for such a large area as Canada's forests. As a result, techniques employing aerial photography for mapping followed by a limited ground survey have been developed to acquire the basic information for the management of the resource.

Forest management and forest inventory in Canada are primarily provincial responsibilities. The federal government's involvement in forest inventory is in the areas of research and development, compilation and summation of provincial data into a national inventory, and in the inventory of federally administered forest lands. The provinces employ a number of inventory systems, from a reconnaissance inventory (e.g., an exploratory inventory for strategic level planning) to an operational inventory (e.g., a detailed inventory of a specific area for operational harvest planning) to satisfy the varied needs of forest management. The forest management inventory has been the most prevalent and important (Table 1). A typical forest management inventory is defined as a detailed, intensive forest inventory for management purposes of an area managed as one unit (Haddon 1989), and includes forest type maps and volume sample data. Aerial photography is the primary source of data for producing the forest type maps and the maps form the basis for stratification for volume sampling programs. Photography is acquired in the summer and received by the forest management agency in the fall. Forest stands are then delineated and classified by photointerpreters. Most classification attributes are ascribed from the interpretation of photographs, but some are derived from rules using interpreted and other appropriate data. The interpreters use field surveys to calibrate their interpretation or to verify certain conditions. The interpretation is transferred to a base map that either exists or is produced at the time. This map is then drafted or digitized to produce the forest type map. Volume estimation is linked to the production of forest type maps. Maps are used for stratification, to determine the area of each stratum, and for sample plot location. Sample plot data are used to derive volume estimates for the sample plot; these volume estimates are then used to derive the overall estimate of volume for the inventory. Gillis and Edwards (1988) described volume sample and compilation procedures used across Canada.

Forest management inventories in Canada are carried out in cycles typically ranging from 10 to 20 years. In some provinces the cycle is continuous (i.e., a percentage of the province is inventoried annually) while other provinces conduct their inventory over a short period of time and repeat the entire procedure periodically. Table 2 shows some general characteristics related to provincial inventory map production.

Although provincial inventories have a similar approach and many elements in common, each has

Table 1. Area of inventory (1 000 000 ha) by province and territory and inventory type.

Province	Inventory Type[1]			
	Reconnaissance	Regional	Management	Other
Newfoundland	17.51	10.53	7.96[2]	
Nova Scotia	0.16		5.31	0.01
Prince Edward Island			0.58	
New Brunswick			7.26[3]	
Quebec	49.03		73.08	
Ontario	0.08	0.56	59.26	
Manitoba			40.56	
Saskatchewan	8.23		15.88	11.36
Alberta	6.43		38.68[4]	6.90
British Columbia	0.46		93.43	
Territories	151.14		2.47	
Total	233.04	11.09	344.46	18.27

[1] 2.27 million ha of inventory are not classified by type.
[2] 7.96 million ha is for the Island. Management inventory mapping has recently been done for 2.2 million ha in Labrador.
[3] Includes 158 000 ha federal land.
[4] Includes areas covered by the Phase 3 Inventory and Alberta Vegetation Inventory.

Table 2. Provincial forest inventory map production characteristics.

Province	Inventory Area (000 000 ha)	Forest inventory procedure				Annual[2] area inventoried (000 000 ha)	Map characteristics			
		Type	Cycle number	Cycle period	Elapse time[1]		Scale	Size (km)	Area (ha)	Total number
Newfoundland	10.16[3]	continual	3	10	10	0.50	1:12 500	9.0x7.0	6 300	1600
Nova Scotia	5.31	continual	3	10	10	0.50	1:10 000	8.0x5.6	4480[4]	515
								6.4x4.6	2944	1792
Prince Edward Island	0.58	discontinuous	2	10	2		1:10 000	7.7x5.6	4300	196
New Brunswick	7.10[5]	discontinuous	4	10	5	1.40	1:12 500	7.7x5.6	4300	1889
Quebec	73.08[6]	continual	2	10	9	6.00	1:20 000	14x18	26 000	3300
Ontario	59.26	continual	3	20	20	4.00	1:20 000[7]	10x10	10 000	5185
							1:10 000	5.0x5.0	2500	5380
Manitoba	40.56	continual	3	10-25	10-25	1.50	1:15 840	9.7x9.7	9500	4300
Saskatchewan	15.88	continual	4	15[8]	15	0.75	1:12 500	10x10	10 000	1696
Alberta (Phase 3)	33.60	discontinuous	3	14	8	5.00[9]	1:15 000	9.7x9.7	9324	3600
Alberta (AVI)	5.08	pilot	1[10]	-	2	2.50	1:20 000	9.7x9.7	9324	545
British Columbia	93.43	continual	3	10-20	10-15	8.00	1:20 000	14x11	15 400	7000

[1] Time to complete inventory within a cycle.
[2] Typical annual area. Average annual area can be calculated from total annual area and elapse time or, alternately, cycle period.
[3] For Newfoundland and Labrador.
[4] There are two sizes of map sheet; currently 2/3 are the small sheets. All new maps are being generated at the larger size.
[5] Does not include federal land.
[6] Total inventoried area. The second inventory cycle is for the southern zone which is 36.5 million ha. The first inventory cycle included the whole inventory area of 73.08 million ha.
[7] Forest districts in the south are mapped at 1:10 000. Approximately 20% of the inventoried area is mapped at this scale.
[8] The third cycle, 1974 to 1983 was a 10-year cycle.
[9] There was less done in the start-up years. The amount given is that done over the five or six peak production years.
[10] The pilot area is in the agricultural fringe forest zone; this is the first management inventory forest type mapping of this area.

unique features resulting from the nature of the forest, requirements, budgets, history of inventory development, and the personnel of each province. It is, therefore, useful to summarize all the provincial management inventories in one document.

Inventory procedures are constantly evolving. The implementation of geographic information systems (GIS) has resulted in fundamental changes in the production of forest type maps. The implementation of GIS has provided a framework for other survey technologies to use. New remote sensing technologies are being examined as primary data sources for inventory mapping. More demands are being made on the forest management inventory to provide information to satisfy other needs than those of traditional timber management (e.g., environmental, conservation, recreation, wildlife, aesthetics). In addition, the inventory is increasingly being used, often out of necessity, for purposes for which it was not designed and is not appropriate. More people are using the inventory data without knowledge of how the inventory is derived and of its applications and limitations.

In order to understand the environment into which new technologies must fit and on which new procedures will evolve to meet new challenges and demands, and to understand the applications and limitations of management inventories, it is useful to detail the scenario followed to produce maps for provincial forest inventories. Leckie and Gillis (in prep.) outline the production considerations and costs of management inventories and discuss current trends and issues. This report examines the technical components of the mapping phase of a forest management inventory by detailing, for each province, the procedures used, the organization involved, and the schedule followed. It reflects provincial inventories of Canada in the early 1990s. In addition, a summary is given of the volume sampling component of each inventory. Interpreted and derived forest stand attributes are described and an example of the inventory map and legend from each province is presented.

Newfoundland

Overview

Forest inventory in the province of Newfoundland is carried out on a continuous cycle with the area of merchantable forest[1] being fully covered by management inventory every 10 years. The first management level inventory for the province began in 1975 and was completed in 1982. The second cycle of management inventory began in 1985 and is scheduled for completion in 1995. One significant difference between the two inventories is that the forest type map is now being computerized in a geographic information system. Previous to 1975, a reconnaissance level forest inventory was conducted of the entire province, including Labrador. This 'global' forest inventory, carried out over a 10-year period between 1966 and 1975, consisted of independent mapping and volume sampling projects and covered a total area of 37.1 million hectares, of which only 9.4 million were considered productive forest lands. Recently, the management inventory has been extended to include selected areas in Labrador.

The inventory procedure for a particular area takes between 2 and 3 years. Aerial photography is acquired in the summer and received by the Mapping Section of the Forest Management Branch, Department of Forest Resources and Lands within 2 months of acquisition. The Mapping Section catalogues the photographs and creates an index map before passing the photos to the Inventory Section for interpretation. Photointerpretation begins as early as October or November upon receipt of the photographs (previously the delivery time for photography was 4 months following acquisition and the interpretation began in February). Field checking is done at the same time as the interpretation to verify stand conditions. Interpretation is completed by the end of April. A preliminary map is produced and used for planning the volume sampling program. Volume sampling begins with a planning stage in May, followed by summer field work which is completed in October. Photo interpretation is then revised, based on volume sample plot information, and finalized before being passed back to the Mapping Section in the second winter. The Mapping Section prepares the base maps while the Inventory Section is involved in photointerpretation and volume sampling. There is a continuous delivery of interpreted photographs to the Mapping Section beginning in the winter of the second year. The Mapping Section transfers the forest type information to the base map and digitizes this map to create the forest type map.

[1] Merchantable forest is defined as forest containing trees with diameter at breast height of 9 cm or greater and providing $60m^3$ (solid) per hectare on slopes of 30 percent or less, or providing $90m^3$ (solid) per hectare on slopes greater than 30 percent.

Scenario

Photo interpretation is done in-house by a staff of 8 full time interpreters, including 2 supervisors. Their first task is to gather reference material, such as old inventory maps, records of silvicultural activities, cuts, and burns. Photographs are received approximately 2 months following acquisition (October/November) and the interpreter begins by delineating stands on the photographs and labeling stand attributes. During the interpretation, verification field checks are made in stand types that pose problems. These visual checks are made, usually from helicopter, on the attributes in question (i.e., the interpreter checks age, height, and species composition). Typically 20 stands per day are checked. field notes for these checks are only used as reference material for interpretation. The interpreter is then involved in the volume sampling phase of the inventory (i.e., plot allocation, field sampling, and post stratification). Plot allocation is based on preliminary map information from the typed aerial photographs, and is done in May following the interpretation. Volume and other field sampling takes place from June to October. An effort is made to ensure that the technician responsible for volume sampling is not the same one who interpreted the photography for the area. Following volume sampling, the interpreters review their interpretation based on the volume sample plot information and produce the final typed photographs. These photos are then checked by two senior interpreters before being delivered to the Mapping Section.

A typical year for an interpreter consists of approximately 60% interpretation and 40% field work. The interpretation time can be further divided into 85% interpretation and 15% final typing. The 40% field work time consists of approximately 75% field sampling and 25% interpretation verification. The field sampling consists of establishing temporary sample points for volume estimation, remeasuring permanent sample plots for growth and yield determination, and establishing damage plots to analyze change.

Recently, in order to ease the workload of in-house interpreters, the Forest Management Branch established a contract for the interpretation of aerial photography. This work was for a management unit in Labrador. In this case the contractor was responsible for verification field checking and the Inventory Section was responsible for quality checks. The contract interpreters were

required to become familiar with both the area and the classification system. The interpreters used both aerial reconnaissance and field plots to familiarize themselves with local forest conditions. At each field plot the interpreter completed a field tally sheet for sample tree measurements. Stands were examined for species composition, crown density, and site class. Age and height were determined for sample trees. Field plots were allocated according to the variability of forest conditions within the management unit. All sample plot information was submitted to the Inventory Section. The interpretation quality assessment, conducted by the Inventory Section, was carried out in two phases. First, all photographs were examined, without ground checking, to determine if they met predetermined conformity standards. The second phase involved ground truthing a sample of phase one photos. The sample intensity varied and was dependent upon the variation of forest types and the experience of the individual interpreter. The quality check was conducted by the Section Head in charge of forest inventory and a senior interpreter.

The Mapping Section is responsible for preparing the base map, transferring the interpretation to the base map, digitizing, and final map production. Maps from the National Topographic System of Canada (NTS) provide most of the base map information. Base maps are created by dividing the 1:50 000 NTS mapsheets along lines of latitude and longitude into 16 equal parts. Each part is then photographically enlarged to the desired scale of 1:12 500. Photointerpreted information, forest typing, and new base map information (e.g., new roads and powerlines) are transferred in pencil to a transparent copy of the base map using a reflecting projector (Kargl) to match positions on aerial photographs to corresponding positions on the map. Ownership and management unit boundaries are also transferred from 1:50 000 master ownership maps to the pencil manuscript. Four cartographic technicians in the Mapping Section were responsible for base mapping and transfer. Two supervisors inspected the work and assigned numbers to individual stands on the map. In 1992, the number of employees was reduced to two technicians and one supervisor. Approximately 20 hours are required to create a pencil manuscript for a 1:12 500 mapsheet.

Until 1985 all maps were drafted. There were seven full time people, including one supervisor responsible for the creation of the inked manuscript from the pencil version. Forest stand area was determined electronically by digitizing stand boundaries and was performed by a full time clerk within the Mapping Section.

Since 1985, the pencil manuscript maps have been the basis for digitizing. Digitizing is done in-house, two shifts per day, with each shift consisting of five digitizers and one supervisor. Digitizing staff has also been reduced since 1992 to one shift per day. A stand list is prepared by a data preparation clerk. Approximately one week is required to output a computer map (1:12 500). This week consists of the following work schedule:

- 12 hours digitizing forest stand boundaries, which includes lake and swamp polygons,
- 4 hours digitizing base map features such as roads, rivers, and power lines,
- 3 hours digitizing administrative boundaries (e.g., forest management unit boundaries, ownership),
- 3 hours edge matching at the boundaries of map sheets,
- 5 hours editing and cleaning,
- 5 hours label placement,
- 2 hours quality control, and,
- 3 hours final map output.

The volume sampling portion of the inventory uses the interpreted photographs for initial stratification and sample plot allocation. Plots are sometimes allocated on old inventory maps to allow volume sampling to begin in the time period between photointerpretation and final map creation. Approximately 600 sample plots are measured each year, which corresponds to one plot for every 1330 hectares inventoried. Sample plots may have to be post-stratified when the final map is produced if stand boundaries or descriptions differ from the interpretation used for initial stratification. As a result, some strata may be oversampled, some undersampled, and some not sampled at all. Unsampled strata make up a small percent of the total area so these are often included with strata having similar stand conditions, whereas additional plots are usually added to undersampled strata. Stand and stock tables are developed by strata and are applied to strata area from the map to estimate wood volume by strata.

Productive Forest Land Classification

Productive forest land in Newfoundland is defined as land presently producing or capable of producing 30 m^3 of wood per hectare at rotation and is interpreted based on site conditions including soils, ground conditions, and terrain. Forest capability maps, produced by the Canada Land Inventory (CLI), from photography acquired between 1964 and 1970, are frequently used to determine site conditions. A productive forest stand is a homogeneous unit, sufficiently uniform in species

composition, crown density, height, age, and site to be separable from adjoining stands. A productive forest stand may also be classified by disturbance type and silvicultural treatment, when applicable. Figure 1 is an example of a typical forest type map and legend.

The species composition lists species, to a maximum of three, in decreasing order, based on crown closure. Any single species must comprise at least 25 percent of the total crown closure.

Crown density is the percentage of ground area covered by a vertical projection of tree crowns onto the ground. The interpreter uses a crown density scale as a comparator to estimate crown density from aerial photographs. There are three 25% crown density classes interpreted. Stands that have less than 25% crown density are labeled N.S.R. (not sufficiently restocked) or Di (disturbed), with the appropriate disturbance codes to identify the type of disturbance. Stand attributes are not interpreted for these stands.

Height class is based on the average height of dominant and codominant trees in the stand. Heights are estimated to the nearest 3 meter class. Sample plot measurements are used to calibrate height estimation.

Age class is interpreted based on the average age of dominant and codominant trees. The interpreter uses a combination of factors such as species, height, site, and history of disturbance to aid interpretation. Increment cores, obtained from sampled stands, are used to calibrate the interpretation. There are seven 20-year age classes and an upper class, which is open (i.e., 141 + years).

Site class is an expression of forest site quality and is based on the height, at a certain age, of the dominant and codominant trees of the predominant species in the stand. The interpreter assigns a site class while interpreting. The assignment is based on height and age for stocked stands and land capability, from CLI maps, for unstocked or disturbed stands. There are four defined classes; poor, medium, good, and high.

The interpreter uses historical records to assign disturbance codes and to describe silviculturally treated areas.

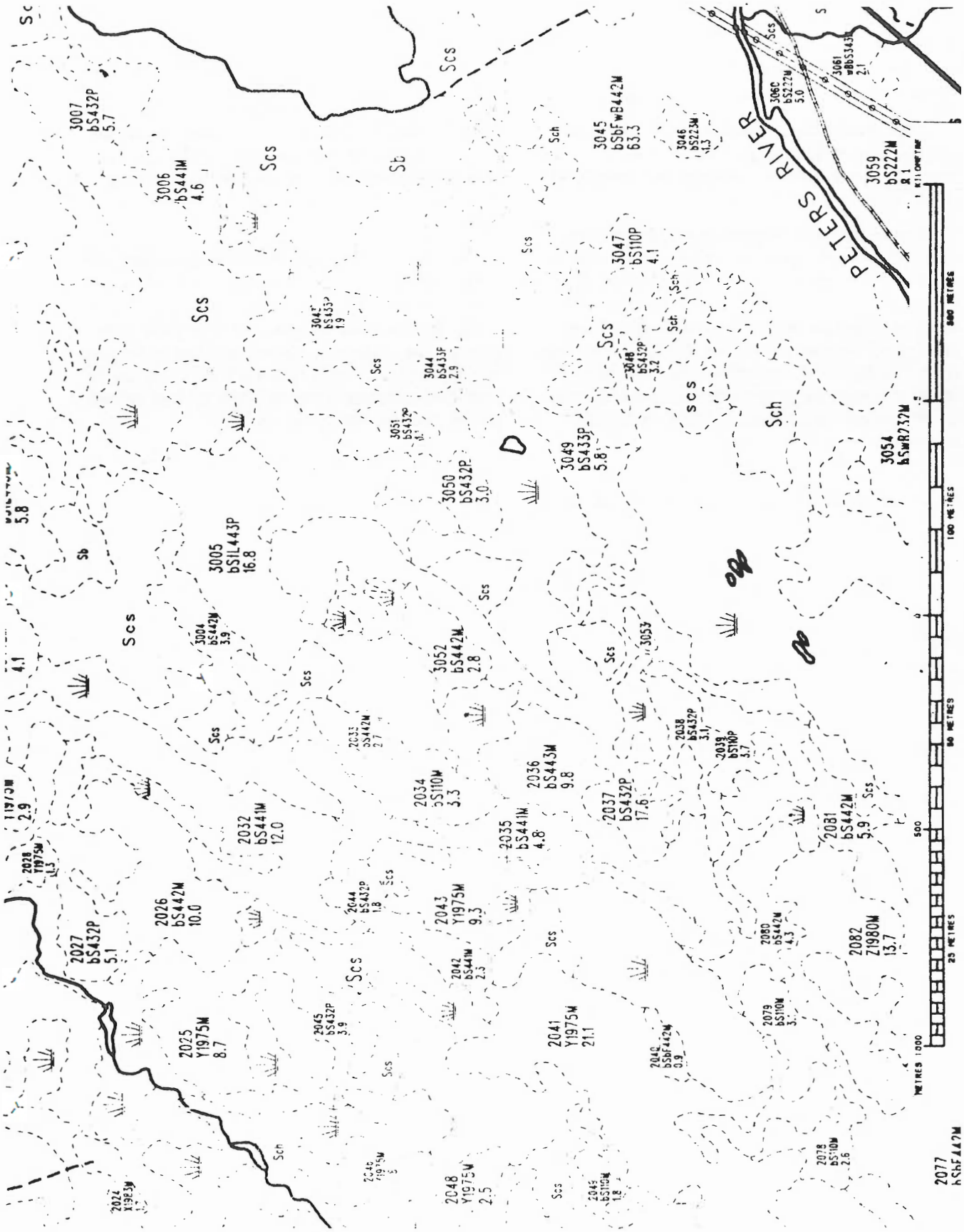


Figure 1. Example of forest type map and legend for Newfoundland.

FOREST TYPE MAP

SCALE 1:12 500

STAND IDENTIFICATION

Stand Number.....12
Stand Composition.....bF 3 6 2 H
Species.....
Age.....
Height.....
Crown Density.....
Site.....
Hectares.....34.1

REFERENCE

Species Composition

bF	=	Balsam Fir
bS	=	Black Spruce
wS	=	White Spruce
wB	=	White Birch
yB	=	Yellow Birch
tL	=	Tamarack/Larch
tA	=	Trembling Aspen
bP	=	Balsam Poplar
wP	=	White Pine
rP	=	Red Pine
jP	=	Jack Pine
sP	=	Scots Pine
NSR	=	Not Sufficently Restocked

Height Class **Height Code**

0	-	3.5 Metres	1
3.6	-	6.5 Metres	2
6.6	-	9.5 Metres	3
9.6	-	12.5 Metres	4
12.5	-	15.5 Metres	5
15.6	-	18.5 Metres	6
18.6	-	21.5 Metres	7
21.6	+	Metres	8

Site Index Class

P.....Poor
M.....Medium
G.....Good
H.....High

bF - indicates 75-100% of the basal area comprised of bF.
bF,wB - indicates 50-75% of the basal area is comprised of bF and the remainder is wB.
bF,bS,wB - indicates that 40% of the basal area is comprised of bF, 30% is bS and 30% is wB.

Disturbance **Code**

Logging.....X
Fire.....Y
Insect.....Z
Wind.....W
Vegetation.....V
Miscellaneous.....M

Crown Density Class	Crown Density Code
Unclassified	0
Over 75%	1
51-75%	2
26-50%	3

Age Class	Age Code
0-20 years (immature)	1
21-40 years (immature)	2
41-60 years (immature)	3
61-80 years (immature)	4
81 + years (overmature)	5
(41-80 years mature)	7
All ages	9

Non-Productive Forest

Scs.....Softwood Scrub
Sch.....Hardwood Scrub

Ownership - Nature of Tenure

P.....Private/Freehold
L.....Licenced
H.....Charter
E.....Special Agreement
R.....Reserved

Non-forest

Rb = Rock Barren
Sb = Soil Barren
C = Cleared Land
A = Agricultural Land
Rw = Right-of-Way
Res = Residential
= Bog
= Treed Bog

Ground Plots (Cut) .....
Permanent Sample Plots .....
Ground Plots .....
Photo Center .....
Cruise Line and Number ..... CL 12
Trans Canada Highway .....
Paved roads .....
Unpaved Roads .....
Primary Woods Roads .....
Secondary Woods Roads .....
Extraction Woods Roads .....
Trails .....
Railway .....
Transmission Line .....
Bridge .....
Marsh .....
River .....
Indefinite Stream .....

Nova Scotia

Overview

Forest inventory in Nova Scotia has consisted of independent mapping and volumetric sampling projects. The mapping project is now on its third cycle. The entire province has been fully covered by forest inventory mapping between 1953 and 1955 and again between 1965 and 1971. The current forest inventory mapping project began in 1987 and was planned to be complete between 2000 and 2002. Under an accelerated inventory program, started in 1992, it is scheduled for completion by the end of 1996. Some new procedures have also been added. Volumetric sampling is conducted on a continuous 10-year cycle, and its fourth cycle was completed in 1991. Volume statistics are reported at the county level and have not been related to the forest inventory maps. Starting in 1992, a fifth phase of volume sampling and reporting began and is directly related to, and conducted along with forest inventory mapping.

Approximately 1.5 years were required to map an entire inventory block or county. Under the accelerated program this is expected to decrease. Aerial photography is acquired in the summer but is not received by the Department of Natural Resources until the end of December. Photointerpretation begins in the winter and includes a field check to verify the interpretation. Stand boundaries are digitized directly from the aerial photographs and aligned to a digital base map by means of geometric correction software. Volume sampling is now linked to map production, with field work carried out in the April to December following final map production.

Scenario

Photointerpretation is done both in-house by the forest resources planning and Mensuration Division in Truro and by contract. In-house, five people, including one supervisor are fully committed to the task of interpretation. Approximately one day per week is spent in the field, checking stands that posed problems during interpretation. Field notes are made on species composition, height, crown closure, and site conditions. This information is used both to verify the interpretation and to help calibrate the interpreter. The quality of interpretation is systematically checked by an independent field sampling program. A two person crew conducts a high intensity cruises of sites selected by the photointerpretation supervisor in order to determine the accuracy of interpretation. This quality check survey takes place following photointerpretation from May to mid-December of the year following photo acquisition. Sites are selected in those stands considered most difficult to interpret. Approximately six stands per mapsheet (one stand per 500 ha) are checked. Point samples are established in each of the six stands and measurements of species composition, height, crown closure, and site, as well as volume and basal area, are recorded. The field data are compared to the photointerpreted attributes and the interpretation is revised to agree with the data collected on the ground. The source of attribute data (i.e., field check versus photointerpretation) is recorded in the database. Checking is done for each interpreter.

To supplement in-house work, the forest resources planning and Mensuration Division is letting a contract for interpreting approximately 750 000 to 1 000 000 hectares annually. The contractor is required to become familiar with local ground conditions by spending one day per week in the field. Field notes are used both for calibration and for verification of interpretation. Formal sample plots are not required for this purpose. The quality of interpretation is checked by an experienced photo interpreter who works closely with the contractor and by an independent field sampling program, both conducted by Forest Resources Planning and Mensuration Division personnel. The normal procedure, that is, revising the interpretation to agree with the field work, is followed.

Orthophoto maps, created between 1975 and 1980 by the Land Registration and Information Services (LRIS) of the Council of Maritime Premiers from 1:40 000 black and white aerial photography, provided the initial base map information. The digital base maps for the first two counties were created by the Forest Resources and Planning Division by digitizing base map information directly from the orthophoto map. Starting in 1991, digital base maps created by LRIS are being used as the base for the remaining counties. Because enhancements will be required to bring the base map information up-to-date (i.e., for new roads and hydro lines), it is not expected that receiving the base map in digital format will result in a noticeable time saving. The transfer of interpretation to a map base is unique in Nova Scotia. Control points are established on both the aerial photographs and the orthophoto maps (8 per photo, 160 per mapsheet). This takes about one day for each map. Forest type delineations are then digitized directly from the aerial photographs. Rubber sheeting software uses control points to align air photointerpretation to the orthophoto derived base map. The forest type delineations are then

merged with the digitized base map information from the orthophotos.

Up until 1992 digitizing was done within the Division by four full time digitizers, including one full time editor. One of the digitizers worked on the transfer of ownership boundaries while the other three worked on the base map information and the forest type delineations. Approximately 9 days were required to digitize and output one complete mapsheet (3000 ha). The typical breakdown of this time is as follows:

- 38 hours digitizing forest stand boundaries, water, and nonproductive polygons, as well as, all base map features; also includes: edge-matching at the boundaries of photographs and mapsheets; editing and cleaning; and label placement,
- 7 hours digitizing administrative boundaries (e.g. forest management unit boundaries, ownership),
- 9 hours quality control,
- 1 hour final map output.

A biophysical classification layer was also added to the database. Approximately 3.5 hours were required to add this layer for one mapsheet.

Digitizing of stand boundaries is now done under contract. In-house staff continue to edit base maps, edit and conduct quality checks on contract work, enter attributes, and carry out final data base map compilations. In addition, in-house staff are involved in the transfer and digitizing of administrative boundaries and in digitizing biophysical classification layers.

The fourth volume sampling phase of the inventory (1981 to 1991) was carried out independent of the mapping phase. A three-stage 3-P sample design was employed where the stand at the centre of each aerial photograph within the inventory area is delineated and classified by photo interpretation in the first stage; a random number of the stands are selected for point sampling in the second stage; and certain trees within the plots are selected for detailed measurements in the third stage. A typical sample size for a county would include 70 stands for each ownership category (i.e., crown large and small private ownership), with an average of five point samples per stand and one tree per point sample (i.e., an average of one stand every 1800 ha). Wildlife information was also collected at each sample location. The volume sampling phase provided an estimate of wood volume by ownership at the county level by the direct compilation of sample unit estimates.

The current volume sampling program (1992 to 2001) is integrated with the forest type mapping program. Stands in the digital map files are selected for volume sampling. The field data collected during volume sampling provides additional data that are added to the attributes of the forest stands sampled. The volume sample plots also provide field check data used to assess the quality of interpretation. A number of non-timber items are again also being collected by field crews as requested by the Forest Protection, Wildlife, and Parks and Recreation Divisions.

Productive Forest Land Classification

Productive forest land in Nova Scotia is defined as land presently producing or capable of producing 3 m^3 of wood per hectare per year. Forest area is delineated into homogeneous units (stands) based on crown closure, height, and obvious differences in site. Forest stands are then classified by species composition, crown closure, height, and site. Stands that have been disturbed or treated in some manner are classified separately. An example of a forest type map and legend for Nova Scotia is shown in Figure 2.

Species composition lists the most common tree species in the stand to the nearest 10 percent based on gross merchantable volume, in decreasing order, to a maximum of four species. A species must contribute a minimum of 10 percent to the canopy of the stand. There are 34 species and species groups recognized. Species groups are used when individual species are not distinguishable or cannot be recognized. An unclassified grouping (i.e., species not specified) is utilized when species identification is impossible (e.g., when natural regeneration is too short to allow accurate identification).

Crown closure is an estimate in percent of the ground area covered by a vertical projection of the tree crowns and is recorded as the actual percent estimated. Closure is estimated for each storey in a two-storeyed stand.

Stand height is an estimate to the nearest meter of the actual average height of codominant trees. Field notes are used to help calibrate the interpretation. In all aged stands, an estimate is made of the average height of merchantable stems.

Maturity class is a derived attribute. Rules based on interpreted attributes are used to distinguish seven classes: regeneration, young, immature, mature, overmature, pole, and uneven-aged. Height, age, species composition, and an interpretation of volume con-

tribute to the determination of maturity class. For example, a stand is considered mature if it is between 60 and 70 years old and composed of 60 percent or more jack pine, whereas a stand composed of the same amount of white pine is not considered mature until 120 years of age. Age is derived from a look-up table relating site (i.e., forest capability in cu. ft./acre/year) and stand height.

Site class is determined from the Canada Land Inventory (CLI) map. Interpreters use the 1:50 000 CLI map as a guide to classify the capability of a stand and this value is converted to metric capability classes (m^3/ha/year). Each stand is then assigned a class. Merchantable volume and total basal area are calculated for each stand by use of regressions provided by the Division's Research Section. Merchantable volume is included as a stand attribute on the inventory map.

Interpreters use historical records and local knowledge to determine disturbance or treatment classifications.

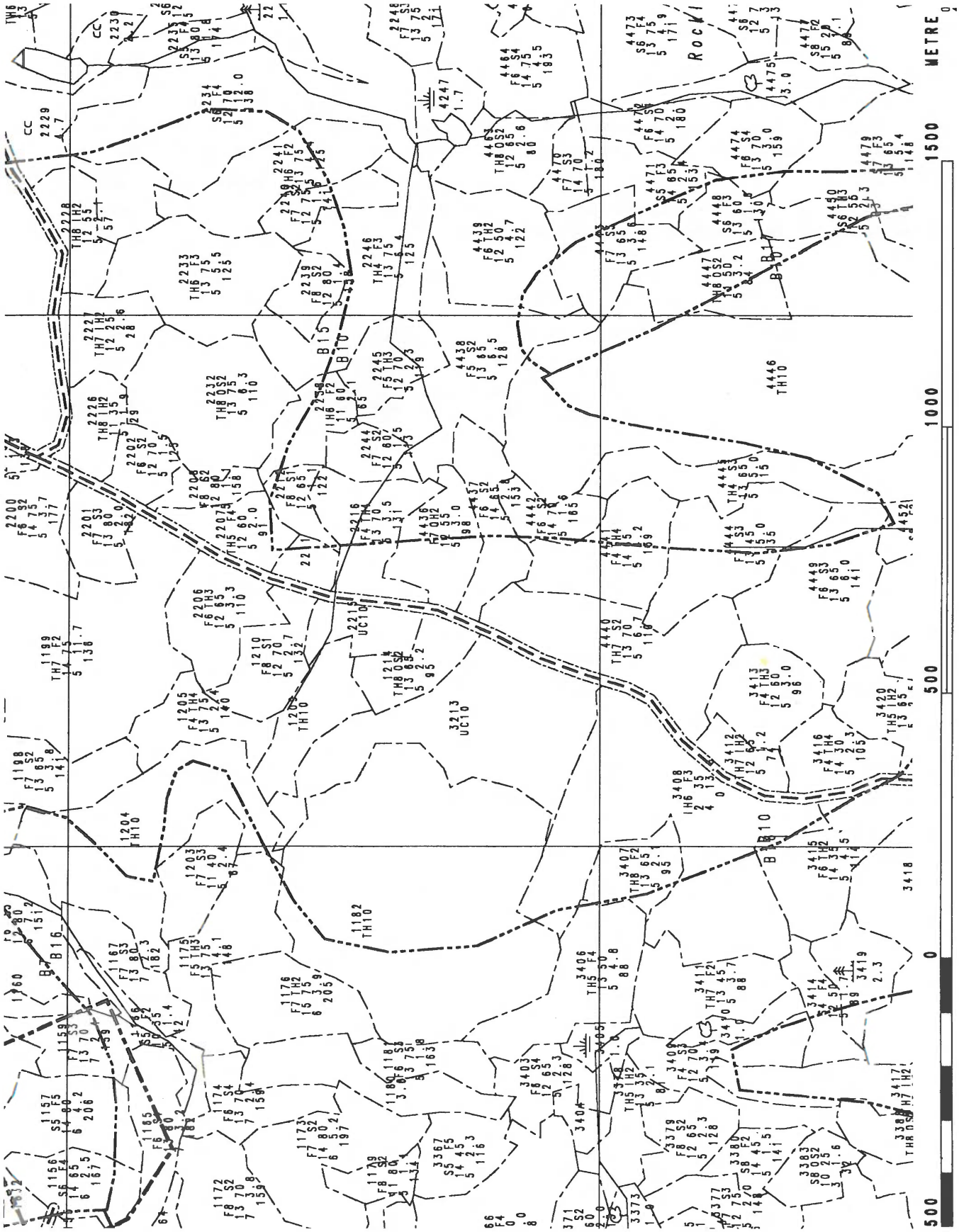
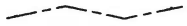


Figure 2. Example of forest type map and legend for Nova Scotia.

FOREST COVER TYPE MAP

SCALE 1:10 000

FOREST STAND BOUNDARY 

FOREST STAND NUMBER

2231 - 1ST DIGIT INDICATES MAP QUADRANT
- FOLLOWING DIGITS INDICATE STAND #
- MAP QUADRANT 2 STAND NUMBER 31

1	2
3	4

FOREST STAND DESCRIPTION

WS5 H4	MAJOR SPECIES % - WHITE SPRUCE 50%, HEMLOCK 40%	
10 30	HEIGHT (METRES)	CROWN CLOSURE (%)
4 67.2	SITE (CUBIC METRES/HA/YR)	AREA (HECTARES)
127	MERCHANTABLE VOLUME (CUBIC METRES/HA)	

SPECIES CODES CAN BE FOUND IN THE DOCUMENT ENTITLED " FOREST DATA BASE SPECIFICATIONS " PUBLISHED BY THE FORESTRY BRANCH.

DEAD STAND DM / area (hectares)

PLANTATION PLT / area (hectares)

CLEARCUT CC / area (hectares)

BURN / area (hectares)

PROPERTY BOUNDARY 

OO - OTHER OWNERS	SP - SMALL PRIVATE (MANAGEMENT PLAN PREPARED)
LP - LARGE PRIVATE	IM - INDUSTRIAL MANAGED
FL - FEDERAL LAND	LL - NATURAL RESOURCES CROWN LEASED LAND
FP - FEDERAL PARKS	CR - NATURAL RESOURCES CROWN LAND
DND - DEPT OF NATIONAL DEFENSE	NL - NATIVE LANDS

BIOPHYSICAL SYSTEM BOUNDARY 

CROWN ROADS

CLASS A

CLASS B

CLASS C

CLASS D

OTHER ROADS

100 SERIES HIGHWAYS

ALL OTHER HARD SURFACE

LOOSE SURFACE ALL WEATHER

TRAILS

COUNTY BOUNDARY

RAILROADS

RAILROADS ABANDONED

TRANSMISSION LINES

PIPELINES

OCEAN SHORELINE

RIVER/STREAM

LAKE

BEACH

AIRPORT/AIRSTRIP

AGRICULTURE AGR

ALDERS

BARREN

BLUEBERRIES BLU

BRUSH & ALDERS

FIRE TOWER

GRAVEL PITS

MARSH/SWAMP

N.S.C. MONUMENT

OPEN BOG

RADIO TOWERS

ROCK BARREN

SANITARY LANDFILL

TREED BOG

BEAVER FLOWAGE

URBAN AREA

Prince Edward Island

Overview

Forest inventory in Prince Edward Island is carried out on a 10-year cycle, with the whole province mapped in a survey conducted over a short period of time. The first survey of general forest types and volume classes was conducted in 1965. The next survey, conducted between 1980 and 1982, was the first thorough management inventory of Prince Edward Island. This survey was unique in that it was the first major inventory in Canada where a systematic effort was made to assess total forest biomass. Prince Edward Island has recently completed a third provincial inventory (1990 to 1992). The most significant difference is the use of geographic information system technology for computer mapping.

For the second survey, both black and white and colour infrared aerial photography at a scale of 1:10 000 were acquired simultaneously in the summer of 1980. Interpretation, map production, volume sampling, and compilation were undertaken under one contract for the Forestry Branch, Department of Energy and Forestry. Photointerpretation, which included field checking, began in the fall of 1980. The interpretation was transferred to an orthophoto map using vertical projection equipment and then drafted to a stable base mylar manually in 1981. Volume sampling took place during the summer of 1981 and compilation of the inventory was completed by 1982.

For the 1990 inventory, colour infrared photography (1:17 500) was acquired in August 1990. Interpretation and map production occurred from September 1990 to October 1991, volume sampling took place in the summer of 1991, and the results compiled and a final inventory report produced in January 1992.

Scenario

For the 1980 inventory photointerpretation was carried out under subcontract by one interpreter. The contract called for the interpreter to become familiar with ground conditions before interpretation. This was accomplished by scanning the photographs, noting conditions on the ground that were particularly important or difficult to interpret, and then field inspection of points within these conditions. Several hundred points were identified across the Island for field checking. Field work was completed in February, 1981, and used by the interpreter to calibrate the photointerpretation which began in the winter of 1981. Verification field work was carried out by the interpreter and an independent field crew of the Forestry Branch during the summer of 1981. Volume sampling data, collected that same summer, was also provided to the interpreter. Both the verification field work and volume sample data were used to modify the initial interpretation. Interpretation was conducted using the panchromatic photographs. Colour infrared photographs (transparencies) were used to confirm specific conditions related to diseased and dying trees, occasionally to double check species identification, and to fill gaps in panchromatic coverage. Photointerpretation was completed in December 1981.

A series of 1:10 000 scale orthophoto maps were produced to provide base map information. These were created by reducing 1:5 000 orthophoto base maps that had been previously created by the Land Registration and Information Services (LRIS) of the Council of Maritime Premiers from 1970 photography. They contain road, water, and land ownership information. A total of 196 map sheets (1:10 000) were photographically produced. Polygons delineated on the aerial photographs were transferred manually onto 1:10 000 scale paper copies of the orthophoto maps using zoom transfer scopes. The classification label was also added to the paper copy of the orthophoto map. Delineations, some base map information (e.g. road, rail, and water), and polygon labels were then transferred to a stable base (Translar). The area of all mapped polygons was estimated using a 10 dots per ha dot grid. The accuracy of the dot count was checked by a digitizer, with new dot counts made where discrepancies of greater than 0.5 percent existed. Approximately 7.5 days per map sheet were required by the contractor for transfer and drafting, including map reproduction. Another 1.5 days per map sheet were required for area determination and attribute data entry. The orthophoto base map and the forestry map can be used independently or combined by printing them together. They have, however, been used exclusively as separate maps.

The volume sampling phase of the 1980 inventory was conducted independent of the mapping phase during the summer of 1981. A random sample design of 900 plots (one for every 644 hectares total land, or one for every 325 ha of forest land) was employed to obtain volume. Each plot consisted of a cluster of five variable radius plots (prism points). At each prism point, in addition to volume data, biomass data were collected on stems greater than 8 cm in diameter at breast height. For stems 8 cm and less in diameter, fixed area plots were established at each prism point while subplots were established to measure woody

ground vegetation. Approximately 20 percent of the time spent at each plot was devoted to collecting biomass data. The Forestry Branch conducted a check of a sample of these plots. One prism point from the cluster of five points was remeasured. Plots were post-stratified according to mapping criteria and volumes determined for each strata. This stratification of plots was also used to assign each forest stand to a volume class.

The 1990 provincial inventory used 1:17 500 colour infrared prints with negative reversal processing. The procedure followed for interpretation was unique. Interpreters began by delineating only the stand boundaries. The boundaries were then transferred to a 1:17 500 scale print of the existing digital base maps from LRIS by simply laying the maps over the delineated air photo on a light table and tracing the boundaries. There is enough control from the base map information to permit a good overlay of the map and photo. The stand delineations were then digitized and the resulting preliminary map given to the interpreter along with a reference map containing the location and data of temporary sample plots (including those from the previous inventory), permanent sample plots, silviculture treatments, and other records. These data and their assigned UTM coordinates had previously been transferred to computer files. This information plus field notes were used for calibrating the actual interpretation of stand attributes. Field checks were conducted by the interpreters or a field technician as required throughout the interpretation. Random plots were also established as an independent quality check (approximately 30 per map). Also unique is the use of historical information. For example, a land use map showing cleared and forest areas was produced from aerial photography acquired in 1935. These were provided to the interpreters and used to help assign a stand origin and history (e.g., age of specific white spruce stands derived from old agricultural fields). The final digital attribute files and maps were then produced. The interpretation and map production occurred in a continuous sequence. As stand delineations on the air photos for one map sheet were completed, they were transferred and digitized and then the map and photos were given for interpretation of stand attributes. Interpretation was done by three interpreters on contract, with one interpreter conducting the delineation and the other two the interpretation of stand attributes. Digitizing was done in-house by three digitizers on three digitizing stations, plus one edit station.

Digitizing times were as follows:

- 10 hours digitizing forest stand boundaries and polygons of non-forest land types,
- 3 hours edgematching at the boundaries of map sheets,
- 7 hours editing and cleaning,
- 1.5 hours label placement, and
- 7 hours quality control,

Editing, cleaning, and quality control were onerous due to the large number of small polygons. Digitizing of base map features such as roads , power lines, rivers, lakes, and coastlines, as well as administrative boundaries, were already digitized on the LRIS digital base map. Final map production was done commercially.

The 1990 inventory used a similar volume sampling procedure as the 1980 inventory with a random sample design and subsequent post-stratification. It included 1200 plots, 600 of which were in the same stands as the 1980 inventory plots. The 1990 field work also included a soil profile description, a soil sample, a subplot to measure tree species regeneration and vascular plants, and an assessment of tree cavities.

Productive Forest Land Classification

Forest stands and non-forest types were delineated to a minimum of 1 hectare, except for hedgerows which were mapped below 1 hectare. This detail of mapping is unique. A forest stand was defined as an homogeneous unit based on species composition, crown closure, height, and ground condition extremes (e.g. swampy, sandy). Stand history was also added to the stand label. An example of both the 1980 and 1990 forest type maps produced for Prince Edward Island are illustrated in Figure 3.

Species composition was based on the percent crown closure of the dominant and codominant trees in the stand. Up to three species could be designated, in decreasing order of content. The first species or species group designated indicates the major component of the stand, the second species indicates an important minor component, while the third species indicates any other component in the stand. The first and second species had to represent a minimum of 75 percent of the composition of the stand. A stand composed of primarily one species with scattered individuals of another species would contain a first species and a third species designation separated by a slash, indicating the absence of the minor component. Nine softwood and 10 hardwood species were recognized. There were also three species groups (SF—spruce-fir, IH—intolerant hardwood, and TH—tolerant hardwood) which were used when species were difficult to identify. Their use was, however, discouraged in favour of designating a predominant species. For the new inventory, species are

identified in 10 percent classes to a maximum of five species and no species groups were recognized.

Canopy density (crown closure) is the actual estimate of the ground area covered by a vertical projection of the tree crowns. There are four classes 0-30%, 31-60%, 61-80%, and 81-100%. Interpreters used dot grids, stereograms, or charts as comparators to estimate stand density from aerial photographs. The 1990 inventory recognized 10 percent crown closure classes.

Height class was based on the average height of dominant and codominant trees in the stand. Stands were placed into five-meter classes; 0-5.0, 5.1-10.0, 10.1-15.0, 15.1-20.0, and 20.1+. Field measurements were used to guide the interpretation while photogrammetric measurements were used to verify the interpretation. Height is interpreted to the nearest meter for the 1990 inventory.

Age was not interpreted for either the 1980 or 1990 inventories.

Three classes of forest ground condition were also interpreted; wet or swampy, steep, and sandy. A class representing origin and stand history was also added to the stand description. This was assigned based on cause of disturbance as determined from photointerpretation and silvicultural records.

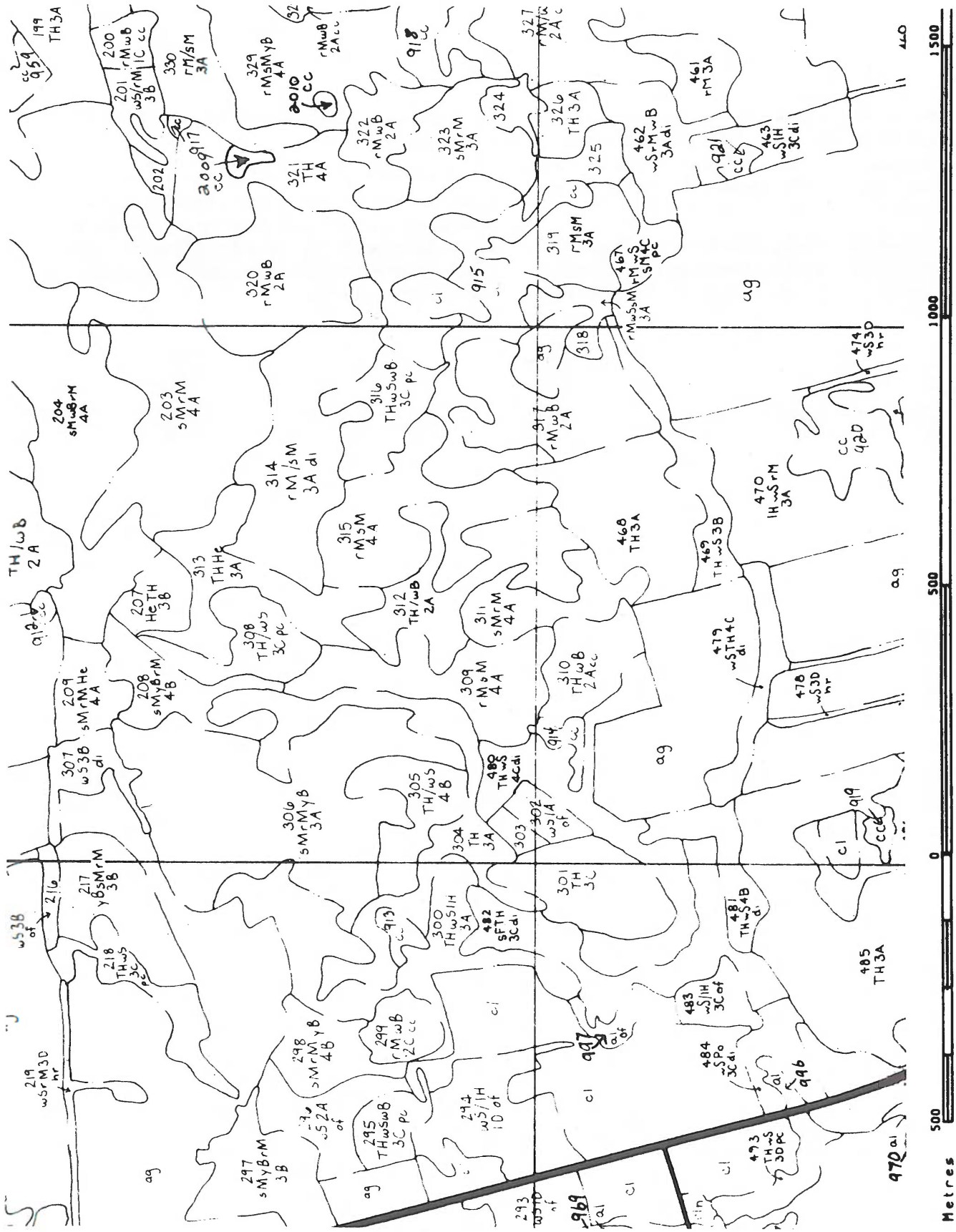


Figure 3a. Example of forest type map and legend for the 1980 Prince Edward Island inventory.

FOREST COVER MAP

SCALE 1: 10 000

SAMPLE CONDITION

749	Stand Number
rMsMyB	Species
4A	Height, Density

REFERENCE

SPECIES

Softwood Codes:

sF	-	Spruce and Fir in varied mixture
wS	-	White Spruce
bF	-	Balsam Fir
He	-	Hemlock
wP	-	White Pine
rP	-	Red Pine
jP	-	Jack Pine
Ce	-	Cedar
La	-	Larch
bS	-	Black Spruce and/or Red

Hardwood Codes:

TH	-	Tolerant hardwoods--generally a combination of the following northern hardwoods: Hard Maple, Red Maple, Yellow Birch, Beech, Red Oak, etc.
yb	-	Yellow Birch
sM	-	Sugar Maple
Be	-	Beech
IH	-	Intolerant hardwoods--generally: White Birch and/or Poplar, but also including other pioneer species
wB	-	White Birch
Po	-	Poplar
rM	-	Red Maple
rO	-	Red Oak
wA	-	White Ash
Em	-	Elm
gB	-	Gray Birch

HEIGHT (meters)

0.0	-	5.0	1
5.1	-	10.0	2
10.1	-	15.0	3
15.1	-	20.0	4
20.1 or more			5

DENSITY

81	-	100%	A
61	-	80%	B
31	-	60%	C
0	-	30%	D

FOREST GROUND CONDITIONS

Wet, Swampy	sw
Steep	st
Sandy	sy

NON-FOREST LAND TYPES

Bog	bo
Alders	al
Cleared Land	cl
Cleared Land Non Productive	cln
Flowage	fl
Swamps - open	so
Agricultural Land	ag
Gravel Pit	gp
Recreational Land	rc
Sand Dune	SD

ORIGIN AND HISTORY

Burn	br
Wind Fall	wf
Partial Cut	pc
Pc for Logs	pl
Pc for Pulp	pp
Clearcut	cc
Disease-Insect	di
Agricultural	of
Plantation	pn
Hedge Row	hr

Lake or Pond	
Stream	
Property Boundary	
Suvey Monument	2833
Pre-redefined grid	
Redefined stereographic projection	N31 60 00 m
U.T.M. 5 km grid	N 515 00 00 m

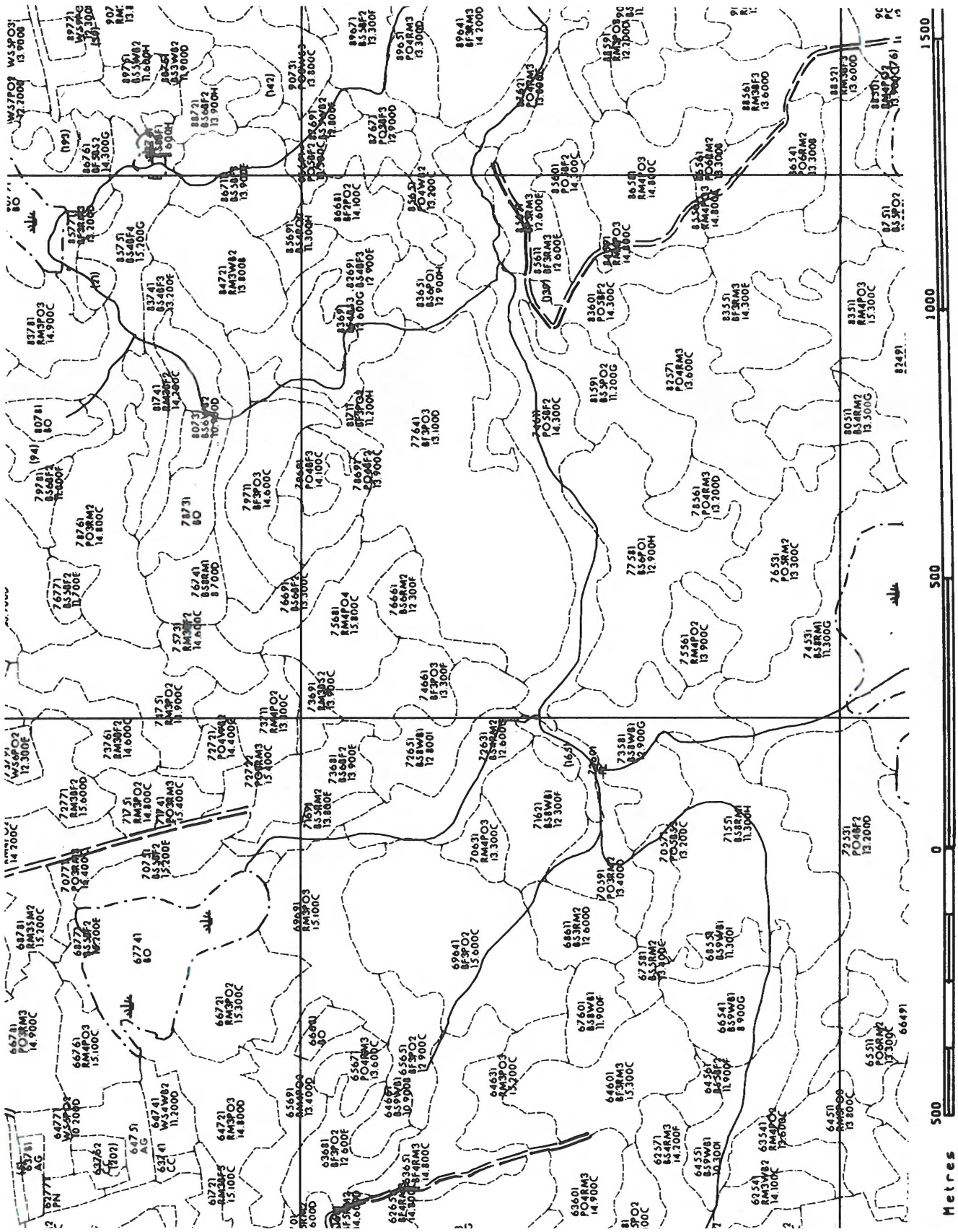
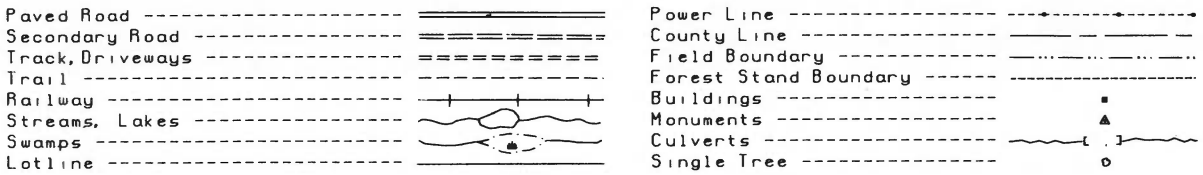


Figure 3b. Example of forest type map and legend for the 1990 Prince Edward Island inventory.

FORESTRY SHEET

SCALE 1:10000

LEGEND



EXPLANATION OF FOREST CODES

SPECIES

WS	WHITE SPRUCE
BF	BALSAM FIR
HE	HEMLOCK
WP	WHITE PINE
RP	RED PINE
JP	JACK PINE
CE	CEDAR
LA	LARCH
BS	BLACK SPRUCE
RS	RED SPRUCE
JL	JAPANESE LARCH
EL	EUROPEAN LARCH
NS	NORWAY SPRUCE

SPECIES

SP	SCOTS PINE
AP	AUSTRIAN PINE
YB	YELLOW BIRCH
SM	SUGAR MAPLE
BE	BEECH
WB	WHITE BIRCH
PO	POPLAR
RM	RED MAPLE
RO	RED OAK
WA	WHITE ASH
EM	ELM
GB	GRAY BIRCH
AL	ALDERS

PERCENT

1	1-10%
2	11-20%
3	21-30%
4	31-40%
5	41-50%
6	51-60%
7	61-70%
8	71-80%
9	81-90%
10	91-100%

HEIGHT CLASS (M)

1	0-3.0
2	3.1-6.0
3	6.1-9.0
4	9.1-12.0
5	12.1-15.0
6	15.1-18.0
7	18.1-21.0
8	21.1-24.0
9	24.1 OR MORE

CROWN CLOSURE

A	91%-100%
B	81%-90%
C	71%-80%
D	61%-70%
E	51%-60%
F	41%-50%
G	31%-40%
H	21%-30%
I	11%-20%
J	0%-10%

NON-FOREST LAND TYPES

BO	BOG
AL	ALDERS
CL	CLEARED LAND
FL	FLOWAGE
CO	SWAMPS-OPEN
AG	AGRICULTURAL LAND
EP	EXCAVATION PIT
SD	SAND DUNE
PL	POWER LINE
UR	URBAN
C	CEMETARY
WW	WATER

FOREST GROUND CONDITIONS

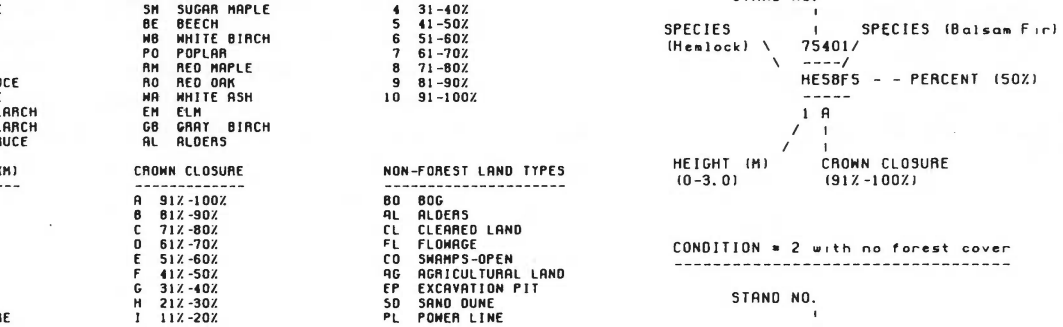
SW	WET-SWAMPY
ST	STEEP
SY	SANDY

ORIGIN AND HISTORY

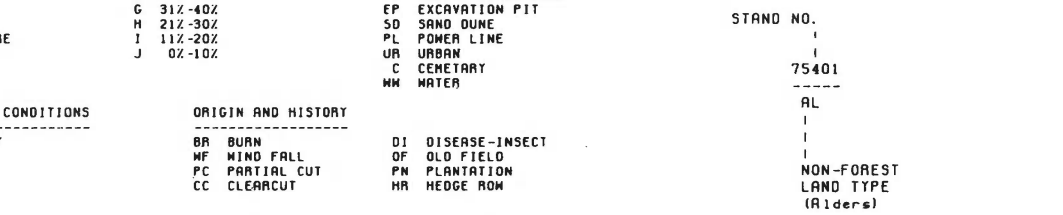
BR	BURN
WF	WIND FALL
PC	PARTIAL CUT
CC	CLEARCUT
DI	DISEASE-INSECT
OF	OLD FIELD
PN	PLANTATION
HR	HEDGE ROW

SAMPLE CONDITIONS:

CONDITION = 1 with forest cover



CONDITION = 2 with no forest cover



New Brunswick

Overview

New Brunswick forest land has been inventoried four times since the early 1950s. The first complete inventory was initiated in 1951 and reported in 1958. Since then, the inventory has followed a 10-year cycle where the whole province is completely reinventoried within successive 10-year periods. The actual inventory work may only take 5 years. The most recent version, the Forest Development Survey, was completed in 1986 from photography acquired between 1981 and 1985. A significant advance in the most recent version was the use of a geographic information system.

Approximately one and a half years were required to produce forest type maps for a particular area. Aerial photography was acquired in the late spring or early summer and prints were delivered to the Timber Management Branch (TMB) of the Department of Natural Resources within a month of acquisition. Poor quality photography and gaps in coverage were identified and such areas were re-photographed in early September. A contract for photointerpretation, field verification, and transfer to orthophoto mylar maps was put into place to coincide with the receipt and acceptance of photography. Upon receipt of the interpreted photographs from the contractor, TMB conducted an extensive quality control ground survey to check the interpretation. The contract was completed the following March. The mylar maps were digitized by TMB as they became available, in order to complete the map production process.

Scenario

Photography was supplied in the summer of the year it was acquired, and all work was completed under contract by March 31 of the following year. The majority of contractors were based in New Brunswick, so most of the interpretation was carried out within the province. Each contract was subdivided into four or five areas (blocks) depending upon the number of interpreters, and each interpreter was assigned a block. The interpreters were required to spend 40 hours in the field to calibrate themselves with the various forest conditions and to become familiar with the application of the classification system. The 40 hours consisted of three days of field work, one day of flying over the block using fixed wing aircraft and helicopters provided by the Department of Natural Resources, and one day back in the field evaluating problems with other interpreters and TMB staff who often accompanied the interpreters. The interpreters checked predominant as well as unfamiliar stand types. These stands types were identified and located before field checking. Photointerpretation followed the initial ground inspection, using notes from the field work and existing information (e.g., old inventory maps, records of silviculture activities, cuts, and burns) for calibration. When the interpretation was half completed the interpreter made another field check, similar to the initial check, for verification purposes. Additional ground checks of stands selected by the interpreter (approximately one for every 1000 ha) were conducted by contractor ground crews to assist the interpreters to calibrate or verify their interpretation. These ground checks consisted of establishing a minimum of two prism points per stand. The results of all the ground checking were delivered to the TMB.

The TMB established an extensive, independent quality check program, consisting of measurement plots and visual checks, to assess the quality of interpretation. For each interpretation block (typically 8600 ha) approximately 25 stands were selected for checking, eight stands for measurement plots, and 17 for visual checks. Stand selection was weighted by type (i.e., TMB was more interested in softwoods, so disproportionately more checking was done in softwood types). Measurement plots (approximately one for every 1100 ha) consisted of a cruise line containing five prism points and were only established in stands greater than 20 years of age. At each point, species, dbh, tree quality, age, height, site indicators, and crown closure were determined. Visual checks (approximately one every 400 ha) involved checking species and crown closure plus confirming age (development class) with increment cores. All plots were evenly distributed over the block by choosing the stand closest to the centre of every third or fourth photograph. There were, in total, approximately 5700 measurement plots and 17 000 visual checks. This information was acquired solely for the purpose of determining the accuracy of the interpretation and were not used to revise the interpretation. The measurement plots, although collected for determining accuracy, were also used as volume sample plots as part of the volume sampling program.

The photointerpretation contractor was also responsible for the transfer of stand typing and new base map information, the coding of stand attribute data, stand numbering, and edgematching between map sheets. Orthophoto maps (1:10 000), created between 1975 and 1980 by the Land Registration Information Service from 1:35 000 black and white aerial photographs, provided the base map information. These maps were reduced for TMB to a scale of 1:12 500.

Using the inventory photographs, contract interpreters transferred new road and transmission line features to the orthophoto maps. Staff at TMB then classified the road types before digitization. New base map information was transferred by the contractor directly from the updated orthophoto map to a mylar base. Linear features were marked on the mylar base. Forest type boundaries were then transferred from photographs to the mylar using vertical projection equipment such as a Kargl reflecting projector, zoom transfer scope, or vertical sketchmaster. Stands were numbered and attribute information was recorded on a separate computer coding form. Finally, the contractor checked map sheet borders to ensure continuity between adjoining sheets before passing them back to TMB.

Polygons and line feature information were digitized directly by TMB staff from the mylar overlay. During the peak periods, 1983 to 1985, up to 10 people were involved full time in digitizing. There were two 4-person shifts during the week and one 2-person shift on the weekend. The number of people on the shift included a supervisor. Approximately 2 days were required to digitize and output a map of average complexity. The typical breakdown of this time was as follows:

- 6 hours digitizing forest stand boundaries which generally includes lake and swamp polygons as well,
- 1 hours digitizing base map features such as roads, rivers and power lines,
- 1 hours digitizing administrative boundaries (e.g. forest management unit boundaries, ownership),
- 2 hours edgematching at the boundaries of map sheets,
- 1 hours editing and cleaning,
- 1 hours label placement,
- 2 hours quality control, and
- 0.5 hours final map output.

The Data Centre, Province of New Brunswick Department of Supply and Services, was responsible for keypunching attribute data.

Large forest companies were responsible for inventory on freehold lands. As well, one company agreed to inventory crown land, which they had under licence, in order to receive the information earlier than scheduled. In all cases the companies followed procedures similar to those set out by TMB and met similar specifications, or added enhancements (e.g., one company interpreted stems per hectare as well as crown closure). The companies employed their own staff or hired contractors for the inventory. The TMB quality check was not conducted on industrial freehold land.

Volume sampling was done in one of two ways. When maps were completed the area was stratified, and maps were used to locate sample plots randomly within each stratum. If maps were not ready, a systematic sampling scheme was established whereby sample plots were established at photo centres. Approximately 75 percent of the area was surveyed using the first method and 25 percent with the second. Following completion of the map production stage, sample plots were added to strata that were undersampled, using the map to locate plots within the appropriate strata. There are 13 625 sample plots located in all development classes on both private woodlots and crown land across the province. Along with the interpretation quality check measurement plots used as volume samples, this gives an average of one plot for every 300 hectares. A sample plot consisted of a cruise line containing five to seven prism points. Representative stand and stock tables were developed by stratum and applied to its area, from the map, to determine an estimate of volume.

Productive Forest Land Classification

Productive forest land in New Brunswick is defined as areas with tree cover producing or capable of producing 35 m^3/ha of merchantable forest and is interpreted using development class and crown closure. A forest stand is defined as a homogeneous unit based on species composition, crown closure, and development class. Productive forest stands may also be described by a stand indicator, an attribute to indicate stand types altered by management intervention or influenced by site condition. An example of a New Brunswick forest type map and legend is given in Figure 4.

Species composition is given to the nearest 10 percent by gross merchantable volume, in decreasing order, to a maximum of three species. The interpreter uses crown closure and ground truth data as a guide to interpret percent species composition. A species must contribute a minimum of 20 percent to the gross merchantable volume of the stand in order to be included. The total need not add up to 100% but should not be less than 80% (e.g., Sp5 TH2 bF2 would represent 50% spruce, 20% tolerant hardwoods, and 20% balsam fir). There are 18 species and species groups recognized. Hardwoods are not specified by species but into three species groups: tolerant, intolerant, or just hardwoods (if there is difficulty distinguishing between tolerant and intolerant species). Spruce/fir and fir/spruce are often used softwood species groups. Species groups

can sometimes be used to give a more complete stand description. For example, a stand containing 40% tolerant hardwoods (TH4), 20% spruce (Sp2), 20% balsam fir (bF2), and 20% intolerant hardwood (IH2), because of the limitation to three species labels, could only include three species in the description (TH4 Sp2 bF2). However, the spruce and balsam fir could be grouped as SF4 to give TH4 SF4 IH2, which is a more complete stand description. Dead fir and spruce are also recognized.

Crown closure is the actual estimate in percent of the ground area covered by a vertical projection of the tree crowns. There are five classes: 10-30%, 30-50%, 50-70%, 70-90%, and 90%+. Patchy or variable closure within the stand is distinguished from uniform closure by a special stand attribute code followed by the average percent closure.

Height is not interpreted, but is incorporated in age and site class data.

Age or maturity is incorporated into the stand description by a concept of development stage, relating a stand to a given growth rate (e.g., immature-increasing, mature-nil, and overmature-volume loss). Nine classes (i.e., field, burn, cut, blowdown, regeneration, young, immature, mature, and overmature) are specified. The interpreter assigns the development stage by looking at species composition, size of crowns, holes in the canopy, down stems (i.e., stems that have recently fallen), average height, and vertical development. For example, a stand would be interpreted as immature if it had small crowns, an uniform canopy with few holes, and low height, whereas a stand would be interpreted as overmature if it had tall trees, large crowns, and holes in the canopy with down stems visible on the floor. Problems have been encountered on poorer sites where mature stands have short heights, small crowns, and an uniform canopy.

Stand indicators are used to delineate stands altered by management or influenced by site. These include poor site, cuts with residuals, partial cuts, and silviculture treatments. They are determined using historical records and local knowledge.

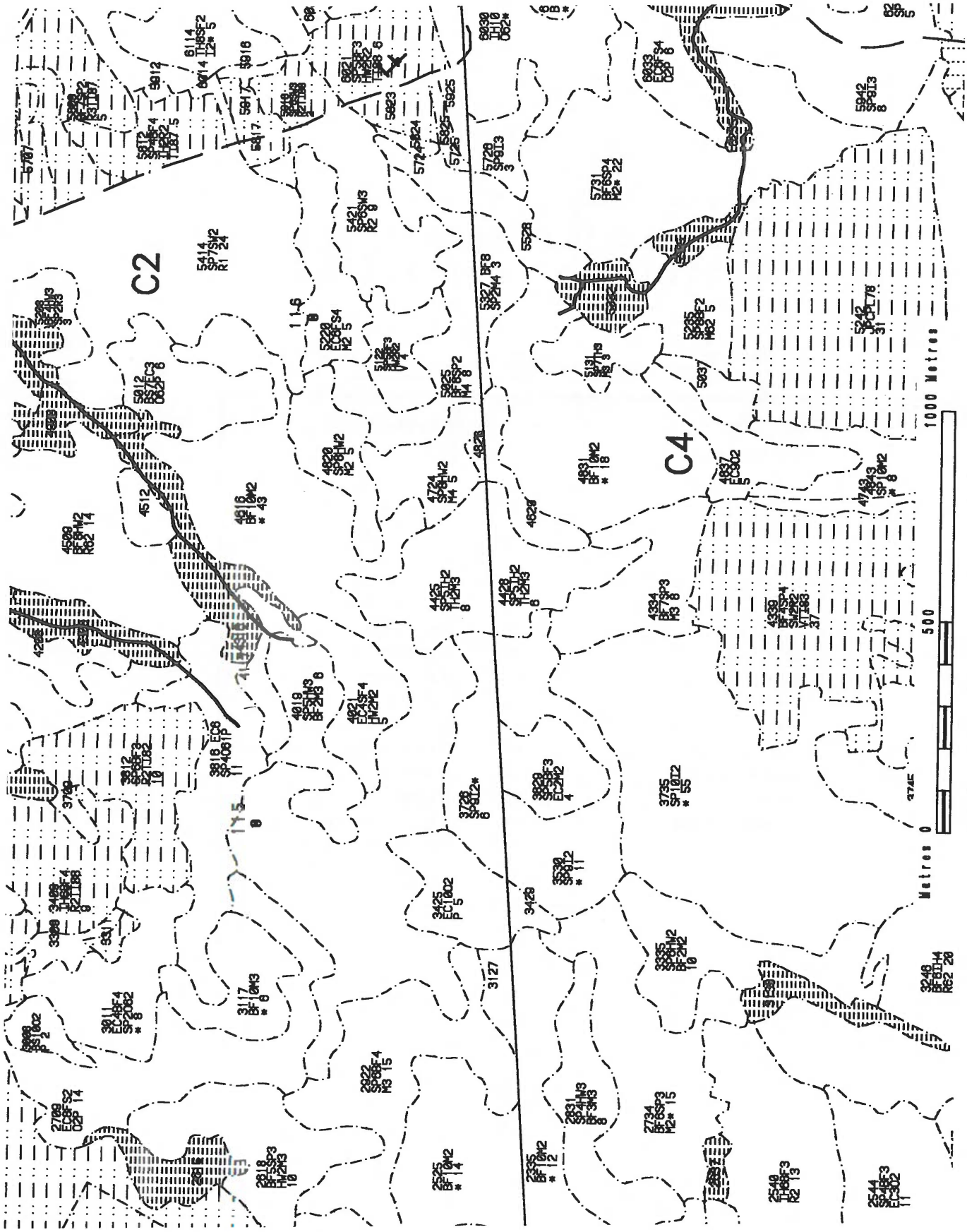


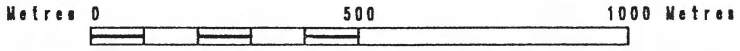
Figure 4. Example of forest type map and legend for New Brunswick.

FOREST DEVELOPMENT SURVEY

NATURAL RESOURCES and ENERGY
NEW BRUNSWICK
RESSOURCES NATURELLES et ÉNERGIE
NOUVEAU-BRUNSWICK

INVENTAIRE DE L'ÉTAT DU DÉVELOPPEMENT DES RESSOURCES FORESTIÈRES

Scale 1:12 500 Échelle



SPECIES		ESSENCES
RED and WHITE SPRUCE	SP	ÉPINETTES BLANCHES ou ROUGES
BLACK SPRUCE	BS	ÉPINETTES NOIRES
SPRUCE/FIR	SF	ÉPINETTES/SAPINS
BALSAM FIR	BF	SAPINS BAUMIERS
FIR/SPRUCE	FS	SAPINS/ÉPINETTES
DEAD FIR	DF	SAPINS MORTS
DEAD SPRUCE	DS	ÉPINETTES MORTES
RED PINE	RP	PINS ROUGES
JACK PINE	JP	PINS GRIS
WHITE PINE	WP	PINS BLANCS
PINE	PI	PINS
LARCH (TAMARACK)	TL	MÉLÈZES (TAMARACS)
EASTERN CEDAR	EC	CÈDRES BLANCS
EASTERN HEMLOCK	EH	PRUCHES
SOFTWOOD	SW	RÉSINEUX
TOLERANT HARDWOOD	TH	FEUILLUS D'OMBRE
INTOLERANT HARDWOOD	IH	FEUILLUS DE LUMIÈRE
HARDWOOD	HW	FEUILLUS

DEVELOPMENT STAGE		STADE DU DÉVELOPPEMENT
OLD FIELD	F	ANCIEN CHAMPS
BURN	B	BRÛLIS
CUT	C	COUPE
WINDTHROW	W	ZONE DE CHABLIS
REGENERATING	R	PEUPLEMENT en RÉGÉNERATION
IMMATURE -YOUNG	Y	PEUPLEMENT IMMATURE - JEUNE
IMMATURE - OLD	I	PEUPLEMENT IMMATURE - PLUS ÂGÉ
MATURE	M	PEUPLEMENT ARRIVÉ À MATURITÉ
OVERMATURE	O	PEUPLEMENT SURÂGÉ

CROWN CLOSURE		COUVERT VERTICAL AU SOL
10-30%; PATCHY, VARIABLE	61	10-30%; INÉGAL, VARIABLE
10-30%	1	10-30%
30-50%; PATCHY, VARIABLE	62	30-50%; INÉGAL, VARIABLE
30-50%	2	30-50%
50-70%; PATCHY, VARIABLE	63	50-70%; INÉGAL, VARIABLE
50-70%	3	50-70%
70-90%; PATCHY, VARIABLE	64	70-90%; INÉGAL, VARIABLE
70-90%	4	70-90%
90% and more	5	90% et plus

STAND INDICATORS		INDICATEURS DE L'ÉTAT DES PEUPLEMENTS
POOR SITE	P	STATION PAUVRE
PARTIAL CUTS	H	COUPE PARTIELLE
RESIDUAL VOLUME (< 35 m^3 / ha)	V	COUPE AVEC VOLUME RESIDUEL (< 35 m^3 / ha)
PLANTED (followed by YEAR)	PL	PLANTATION (en l'AN)
THINNED (followed by YEAR)	TI	ECLAIRCIE (en l'AN)

NON-FOREST CONDITIONS		TERRES NON FORESTIÈRES
AGRICULTURE LAND	AG	TERRE AGRICOLE
OCCUPIED	OC	TERRE OCCUPÉE
ROCK OUTCROP	RO	AFFLEUREMENT ROCHEUX
ALDER on FIELD	AF	AULNAIE sur ANCIEN CHAMPS
ALDER on CUT	AC	AULNAIE sur TERRAIN DÉBOISÉ
GRAVEL PIT	GP	CARRIÈRE de GRAVIER
MINING	MI	MINE ou GISEMENT MINIER
FEDERAL LAND	FL	PROPRIÉTÉ FÉDÉRALE

OWNERSHIP		PROPRIÉTÉ
UPSALQUITCH LICENSE	C1	PERMIS UPSALQUITCH
NEPISIQUIT LICENSE	C2	PERMIS NEPISIQUIT
LOWER MIRIMICHI LICENSE	C3	PERMIS BASSE - MIRIMICHI
UPPER MIRAMICHI LICENSE	C4	PERMIS HAUTE - MIRAMICHI
KENT LICENSE	C5	PERMIS KENT
QUEENS-CHARLOTTE LICENSE	C6	PERMIS QUEENS-CHARLOTTE
FUNDY LICENSE	C7	PERMIS FUNDY
YORK LICENSE	C8	PERMIS YORK
CARLETON LICENSE	C9	PERMIS CARLETON
RESTIGOUCHE-TOBIQUE LICENSE	C10	PERMIS RESTIGOUCHE-TOBIQUE
INDUSTRIAL FREEHOLD	IF	TERRES INDUSTRIELLES sous TENURE LIBRE
PRIVATE WOODLOT	PW	BOISES PRIVE

SHADE SYMBOLS		OMBRES
WATER		EAU
WASTELAND, ALDER SWAMP NON-PRODUCTIVE FOREST		FORÊT NON PRODUCTIVE, TERRAIN VAGUE, AULNAIE
PLANTED or THINNED STANDS (CROWN LAND)		PEUPLEMENT PLANTÉ ou ÉCLAIRCI (COURONNE)
CUTOVERS		COUPES À BLANC

LINE SYMBOLS		SIGNES LINÉAIRES
PRIMARY D.O.T. HIGHWAY		ROUTE PRINCIPALE ENTRETENUE PAR LE MIN. DES TRANSPORTS
SECONDARY D.O.T. HIGHWAY		ROUTE SECONDAIRE ENTRETENUE PAR LE MIN. DES TRANSPORTS
PRIMARY FOREST ROAD		CHEMIN FORESTIER PRIMAIRE
SECONDARY FOREST ROAD		CHEMIN FORESTIER SECONDAIRE
TERTIARY FOREST ROAD		CHEMIN FORESTIER TERTIAIRE
POOR ROAD		CHEMIN FORESTIER EN PIÈTRE ÉTAT
RAILROAD		CHEMIN DE FER
TRANSMISSION LINE		LIGNE ÉLECTRIQUE
STREAM		COURS D'EAU
OWNERSHIP BOUNDARY		LIMITE DE PROPRIÉTÉS
FOREST STAND BOUNDARY		LIMITE D'UN PEUPLEMENT FORESTIER

POINT SYMBOLS		SIGNES PONCTUELS
AIRFIELD or AIRPORT		TERRAIN D'AVIATION ou AÉROPORT
PERMANENT SAMPLEPLOT		PARCELLE-ÉCHANTILLON PERMANENTE
PHOTO CENTRE		CENTRE DE PHOTO

SAMPLE CLASSIFICATION

6020 SP4SW3IH2I62P• 12

STAND 6020 CONTAINS 40% SPRUCE, 30% SOFTWOOD AND 20% INTOLERANT HARDWOOD; THE DEVELOPMENT STAGE IS IMMATURE-OLD; THE CROWN CLOSURE IS PATCHY, VARIABLE AT 30-50%; THE SITE IS POOR. THE STAND SIZE IS 12 HECTARES.

•INDICATES TWO AGE CLASSES (THE SECOND AGE CLASS IS NOT PRINTED IN THE LABEL)

EXEMPLE D'UNE CLASSIFICATION

6020 SP4SW3IH2I62P• 12

LE PEUPLEMENT 6020 CONTIENT 40% D'ÉPINETTES, 30% DE RÉSINEUX ET 20% DE FEUILLUS DE LUMIÈRE; STADE DE DÉVELOPPEMENT EST IMMATURE-PLUS ÂGÉ; LE COUVERT VERTICAL AU SOL EST INÉGAL ET VARIABLE DE 30 À 50%; LA STATION EST PAUVRE; LA SUPERFICIE COUVRE 12 HECTARES.

•INDIQUE DEUX CLASSES D'ÂGES (LA SECONDE N'EST PAS INDIQUÉE DANS LA DESCRIPTION)

Quebec

Overview

Forest inventory in Quebec is carried out in 10-year cycles. The first cycle conducted from 1970 to 1978 included the inventory of 70 million hectares in the central portion of the province. Previous to 1970 there was no formal inventory program and inventory mapping and volume estimation was done selectively over different areas. Before the start of the second cycle of inventory, crown land was divided into three distinct zones. The southern zone of 36.5 million hectares was the focus of the second cycle, with a reconnaissance inventory done in the northern zone and the intermediate zone being updated for major depletions (i.e., cuts and burns) using small scale aerial photography and satellite imagery. The second inventory cycle was started in 1980 and completed in 1989. A third cycle began in 1990 using procedures similar to the second cycle.

For the second inventory cycle approximately two years were required to produce maps for a particular area. Aerial photography was acquired in early summer and delivered to the Forest Inventory Section of the Ministère de l'Energie et des Ressources (MER)[1] in late summer. Poor quality photographs and gaps in coverage were replaced by aerial photography acquired the next summer. A contract for photointerpretation, ground checking, and transfer to a base map was let when the photographs were as accepted (August or September of the year of major photo acquisition). This contract was completed the following March. Another contract, for final drafting and area determination, began as soon as products from the photointerpretation and transfer contract were quality checked and accepted. Products began arriving in January, four months after the start of interpretation, and the contract was usually completed by the following December. Verification of the drafting and area determination took place throughout the process. A given area would be completely mapped by the end of March of the second year.

Scenario

All photo interpretation for the second inventory cycle was done on contract. Potential contractors were required to have forestry experience and be based within the province of Quebec. A contractor was responsible for interpretation, ground checking including field work for calibration, updating base maps, transferring the interpretation to a copy of the base map, and assigning slope class to individual stands. Contractors are assigned a particular area of the area being inventoried (typically 400 000 ha). Photographs were delivered to the contractor in the fall and all work was completed by the following March 31. Existing information about the forest resource in the area (e.g., old inventory maps and silvicultural records) were provided to assist the contractor with interpretation. Stands that were difficult to describe were delineated but not classified. The contractor conducted a ground check following interpretation both for verification of the initial classification and for calibration of interpretation for stands delineated but not classified. The ground check was conducted by the interpreters and consisted of a network of plots (approximately 1 plot for every 2000 ha) located in forest conditions that posed problems during the interpretation. Plots were generally located in readily accessible areas. Cover type information such as species composition, height, age and stem count, as well as a site description, were collected. Plots were well marked in the field so that they could be revisited by MER personnel as part of a quality assessment program. Approximately 15 days of field work was required to complete the ground checking for each particular area being interpreted by a contractor. Photointerpretation was completed using the field work as a guide to describe difficult stands. Following completion of the interpretation portion, the contractor had the option to submit the work to the Inventory Section of MER for a quality assessment by MER interpreters. This optional quality check was to ensure that the interpreter had sufficient experience and was familiar with interpretation standards.

The Cartographic Services Division of MER publish a series of topographic maps at a scale of 1:20 000. These are the standard base maps used for all subsequent mapping in the province. However, in some areas, approximately one third of the inventory area, MER base maps were not yet available. In these areas 1:50 000 National Topographic System (NTS) map sheets were enlarged to the 1:20 000 provincial scale and used as base maps for the forest inventory maps. The Forest Inventory Section adds ownership, administrative boundaries, and a legend to the base map before handing it to the contractor. The contractor updated the base map for changes in base map information (e.g., new roads and hydro lines) from the inventory photography. Air photo delineations were then transferred by pencil, using sketchmasters, to a mylar copy of the base map, to create a handwritten pencil manuscript forest-type map. The manuscript map was then superimposed over a slope class map, produced by MER from

[1]The Forest Inventory Secton is now part of Fôret Québec.

topographic maps, to derive slope class for individual stands.

The forest-type manuscript map, the ground check information, and interpreted aerial photographs were delivered to MER for quality checks as they were completed. A complete quality assessment was carried out by five experienced photointerpreters within the Inventory Section. The assessment consisted of checking 5 to 10 percent (typically 5 percent) of ground plots and 10 to 20 percent (typically 10 percent) of the interpretation. The ground plot assessment involved locating the contractor's plots and remeasuring all ground parameters. The interpretation check involved looking at all the interpretation along one in 10 flight lines. Discrepancies were resolved by an independent field check of the area to clarify points of concern. This check procedure was used as a basis to accept or reject the contractors' interpretation and mapping. The map was revised if the contractor's interpretation was rejected.

The final drafting of the forest type map, area determination, and keypunching stand attribute information from the handwritten manuscript forest type map was also contracted. Often one contractor handled both the interpretation and final map drafting contracts. The drafting of the final forest type map began as soon as the quality assessment of interpretation and transfer was completed for an individual map. Area was calculated using a 1-ha dot grid. Drafting, area estimations, and attribute information were all checked for quality and accuracy by MER. Final forest type maps and computer tapes containing stand attribute information were completed for a particular area by March 31 of the second year following photo acquisition.

A geographic information system (GIS) was not in place in Quebec during the second cycle of inventory and, as a result, the drafted map was not digitized. The MER plans are to acquire a GIS in 1992 and to digitize all new maps produced as part of the third cycle of inventory. Maps produced as part of the second cycle will only be digitized by request.

The province is divided into sampling zones for volume estimation; these zones are subdivisions of a management unit based upon forest ecological features. There are approximately 160 such zones, with an average of 500 plots established in each according to a stratified random sampling design. Approximately 8000 plots per year are measured for the zones just mapped. This gives a plot density of approximately one plot every 450 hectares. The handwritten manuscript map is used as soon as it is ready, normally in January, to locate plots within the strata. Local volume tables are constructed for each species within a sampling zone and applied to sample plot data to determine plot volume. Plot volumes are aggregated by stratum and applied to the aggregated area of the stratum, from the final map, to derive an estimate of volume for the stratum. When an estimate is required for a stratum outside the original sampling design, the original sample plots are sorted according to the desired stratification, plot volumes are determined and aggregated according to the new stratification, and stand and stock tables developed for the strata. Some of the desired strata may have an insufficient number of sample plots. In this case, plots from similar strata may be combined to create enough plots for an adequate estimation of volume. All aggregation follows strict rules.

Productive Forest Land Classification

Productive forest land in Quebec is defined as land presently or capable of producing greater than 30 m^3 of wood per hectare within a rotation of 120 years and is interpreted using the density, age, and height of the stand. A productive forest stand is defined as an homogeneous unit based on species composition, density, height, and age. Stands are assigned a slope class and may be classified by type of disturbance and percent defoliation where appropriate. Figure 5 shows an example of a forest type map and legend for Quebec.

Species composition is designated in terms of cover type, species groups and subgroups. There are three cover types: softwood, mixedwood, and hardwood. A species group is the major species in the stand and is based on the percent crown closure of live dominant and codominant trees. Old trees remaining from a former stand are not considered. A subgroup is a secondary species that comprises at least 25 percent of the cover type. The interpreter uses a systematic procedure (i.e., a key) based upon cover type and species to describe the composition of an individual stand. There are nine individual species groups recognized in the softwood cover type, 21 species groups in the mixedwood cover type, and 13 species groups in the hardwood cover type. For example, a softwood species group will be recognized and described if it comprises at least 50 percent of the softwood component of the cover type, and a subgroup, or species, of the species group will be added to the description if the species comprises at least 25 percent of the softwood component of the cover type.

Density (crown closure) is the percent of ground area covered by a vertical projection of tree crowns on the ground. Density is only assigned to stands greater

than 7 meters in height. The lowest class is 25-40%. It is followed by three, 20% classes including the highest class, 81-100%.

Height is interpreted from the average height of dominant and codominant trees in the stand. Stands are assigned to one of six approximately 5-meter height classes, ranging from a high of class 1 (greater than 22 m) to a low of class 6 (less than 4 m). In the event of two-storeyed stands, average height is based upon the predominant and most important species in the stand in terms of future utilization.

Age is estimated based upon the average age of dominant and codominant trees in the stand and age class is assigned using rules based on the vertical structure of the stand. In an even-aged situation, stands are assigned to simple 20-year age classes, of which there are six, starting with age class 0-20 and continuing up to age class 101 plus. Multistoreyed stands are identified by two non-consecutive age classes within the stand. The most important component, in terms of future utilization, is listed first on the label. An uneven-aged stand is one with many age classes within the stand. Uneven-aged stands are classified as young or old depending upon the species and age range of the majority of stems.

Site class is not included as part of the interpretation and inventory.

The slope of each stand is derived from 1:20 000 topographic maps using elevation and distance between contour intervals. There are five classes recognized: light (0-30%), medium (31-40%), strongly sloped (41-50%), steep or abrupt (51% plus), and land surrounded by abrupt slopes (e.g., an inaccessible plateau). Stands may be split to recognize slope class.

The interpreter uses historical records to assign disturbance class (e.g., partial cut or burn) to a stand. Stands are considered disturbed if 25 to 75 percent of stand volume has been removed or destroyed. As well, two 50% classes of defoliation are recognized: 0-50, 51-100%.

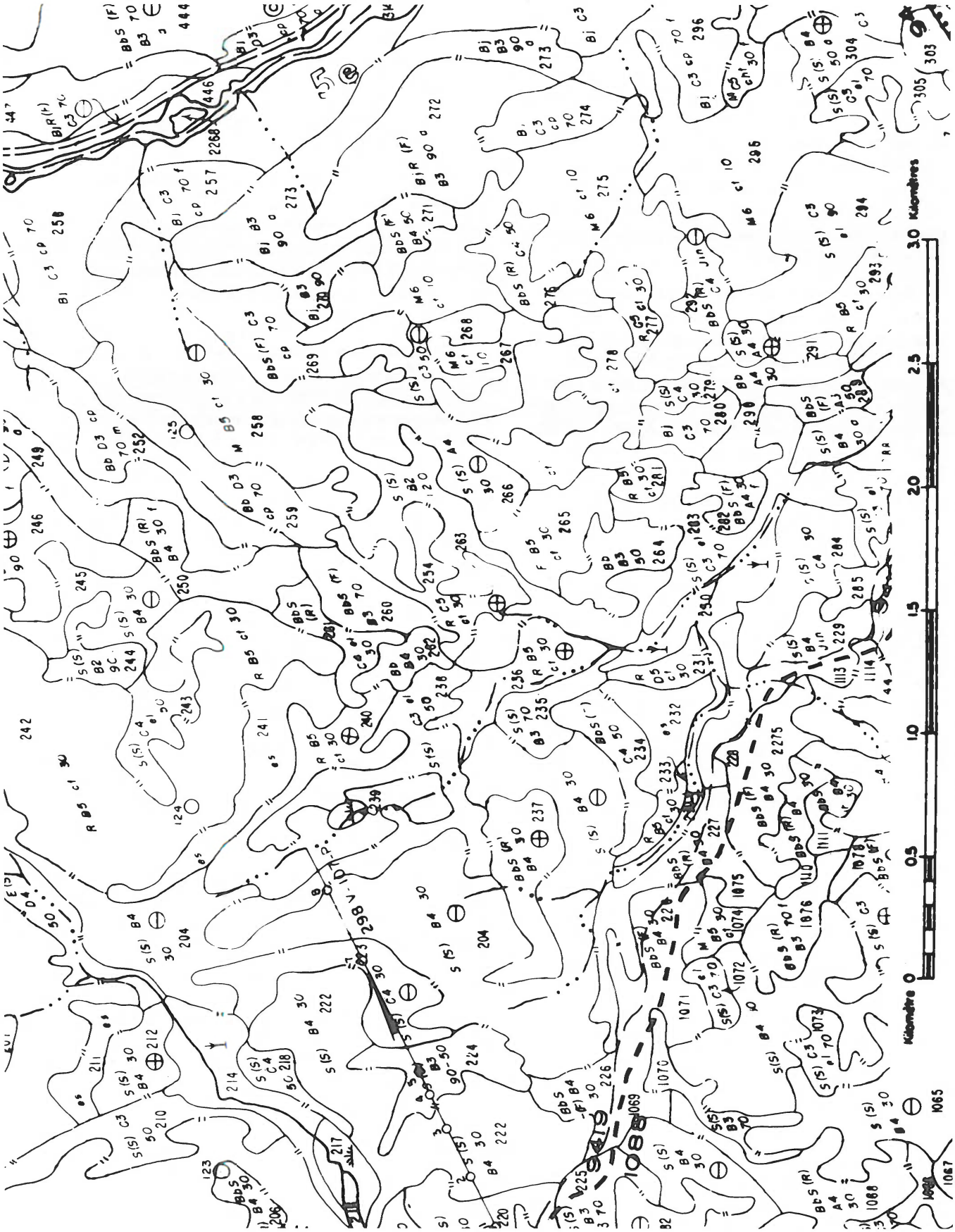
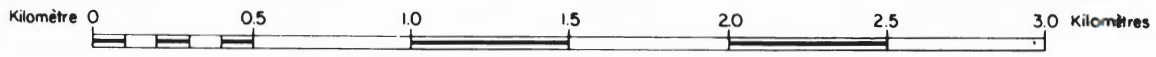


Figure 5. Example of forest type map and legend for Quebec.

CARTE FORESTIÈRE

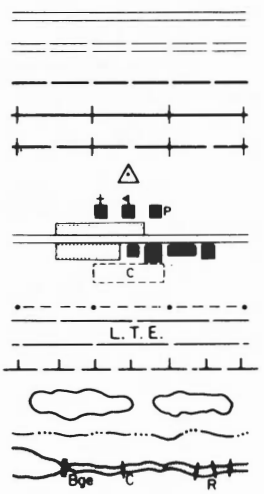
ÉCHELLE 1:20 000



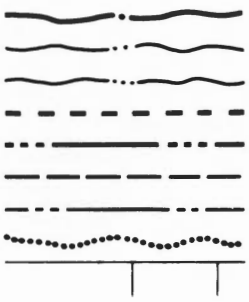
Cette carte provient d'un agrandissement du 1:50 000 du Ministère de l'Énergie, des Mines et des Ressources, Ottawa

Cette carte résulte de la compilation sur une base cartographique de l'information cadastrale disponible et n'a pas de caractère légal

Réseau routier primaire
_ _ secondaire
_ _ tertiaire
Voie ferrée
Voie ferrée abandonnée
Repère horizontal
Église École Poste
Zone urbaine, batiments
Cimetière
Ligne de transport d'énergie
_ _ _ (emprise)
Ligne téléphonique
Lac, étang
Ruisseau intermitent
Barrage, chute, rapides



Ligne de faîte, bassin primaire
_ _ ,bassin secondaire
_ _ bassin tertiaire
Limite de tenure
_ de division de recensement
_ de municipalité
_ de canton, de seigneurie
_ de parcelle
Ligne de rang, de lots



LÉGENDE FORESTIÈRE

TYPE DE COUVERT

RÉSINEUX (groupements et sous-groupements)

Résineux	R
_ _ (aucune essence compagne prédomine)	R (R)
_ _ à sapin et/ou épinette blanche	R (S)
_ _ à épinette noire et/ou épinette rouge	R (E)
_ _ à pin blanc et/ou pin rouge	R (Pb)
_ _ à pin rouge	R (Pr)
_ _ à pin gris	R (Pg)
_ _ à thuya (cèdre)	R (C)
_ _ à pruche	R (Pu)
_ _ à mélèze	R (Me)
_ _ (plantation)	R p
Pessière	E
_ _ (l'épinette noire et/ou l'épin. rouge occupent plus de 75% de la partie résin.)	E (E)
_ _ (aucune essence compagne prédomine)	E (R)
_ _ à thuya (cèdre)	E (C)
_ _ à mélèze	E (Me)
_ _ à pruche	E (Pu)
_ _ à pin blanc et/ou pin rouge	E (Pb)
_ _ à pin rouge	E (Pr)
_ _ à pin gris	E (Pg)
_ _ à sapin et/ou épinette	E (S)
_ _ (plantation d'épinette blanche)	EpB p
_ _ (plantation d'épinette de Norvège)	EpO p
_ _ (plantation d'épinette noire)	EpN p
_ _ (plantation d'épinette rouge)	EpR p
Sapinière	S
_ _ (le sapin et/ou l'épin. blanche occupent plus de 75% de la partie résineuse)	S (S)
_ _ (aucune essence compagne prédomine)	S (R)
_ _ à thuya (cèdre)	S (C)
_ _ à épinette noire et/ou épinette rouge	S (E)
_ _ à pin blanc et/ou pin rouge	S (Pb)
_ _ à pin rouge	S (Pr)
_ _ à pin gris	S (Pg)
_ _ à pruche	S (Pu)
_ _ à mélèze	S (Me)
_ _ (plantation de sapin baumier)	SaB p
Pinède à pin blanc	Pb
_ _ _ _ avec pin rouge	Pb(Pr)
_ _ _ _ et/ou rouge (s'ils occupent plus de 75% de la partie resineuse)	Pb(Pb)
_ _ _ _ _ _ (aucune essence compagne prédomine)	Pb (R)
_ _ _ _ _ _ avec thuya (cèdre)	Pb (C)
_ _ _ _ _ _ avec épinette noire et/ou épinette rouge	Pb (E)
_ _ _ _ _ _ avec mélèze	Pb(Me)
_ _ _ _ _ _ avec pin gris	Pb(Pg)
_ _ _ _ _ _ avec pruche	Pb (Pu)
_ _ _ _ _ _ avec sapin et/ou épinette blanche	Pb (S)
_ _ _ _ (plantation)	PiB p
Pinède à pin rouge	Pr
_ _ _ _ (le pin rouge occupe plus de 75% de la partie résineuse)	Pr (Pr)
_ _ _ _ (aucune essence compagne prédomine)	Pr (R)
_ _ _ _ avec thuya (cèdre)	Pr (C)
_ _ _ _ avec épinette noire et/ou épinette rouge	Pr (E)
_ _ _ _ avec mélèze	Pr(Me)
_ _ _ _ avec pin blanc	Pr (Pb)
_ _ _ _ avec pruche	Pr (Pu)
_ _ _ _ (plantation)	PiR p
Pinède à pin gris	Pg
_ _ _ _ (le pin gris occupe plus de 75% de la partie résineuse)	Pg(Pg)
_ _ _ _ (aucune essence compagne prédomine)	Pg (R)
_ _ _ _ avec thuya (cèdre)	Pg (C)
_ _ _ _ avec épinette noire et/ou épinette rouge	Pg (E)
_ _ _ _ avec mélèze	Pg(Me)
_ _ _ _ avec pin rouge	Pg(Pr)
_ _ _ _ avec pin blanc et/ou pin rouge	Pg(Pb)
_ _ _ _ avec pruche	Pg (Pu)
_ _ _ _ avec sapin et/ou épinette blanche	Pg (S)
_ _ _ _ (plantation)	PiG p
Plantation de pin sylvestre	PiS p

TYPE DE COUVERT

MÉLANGÉS (groupements et sous-groupements)

		Tendance feuillue	Tendance résineuse
Feuillu d'essences intolérantes avec pin gris	Fi Pg	Fi Pg (F)	Fi Pg(R)
_ _ _ _ _ _ avec pin blanc	Fi Pb	Fi Pb (F)	Fi Pb(R)
_ _ _ _ _ _ avec pin rouge	Fi Pr	Fi Pr (F)	Fi Pr (R)
_ _ _ _ _ _ avec résineux	Fi R	Fi R (F)	Fi R (R)
_ _ _ _ _ _ avec sapin	Fi S	Fi S (F)	Fi S (R)
_ _ _ _ _ _ avec épinette noire ou rouge	Fi E	Fi E (F)	Fi E (R)
Bétulaie à bouleaux blancs avec sapin	Bb S	Bb S (F)	Bb S (R)
_ _ _ _ _ avec épinette noire ou rouge	Bb E	Bb E (F)	Bb E (R)
_ _ _ _ _ avec pin gris	Bb Pg	Bb Pg(F)	Bb Pg(R)
_ _ _ _ _ avec pin blanc	Bb Pb	Bb Pb (F)	Bb Pb(R)
_ _ _ _ _ avec pin rouge	Bb Pr	Bb Pr (F)	Bb Pr (R)
_ _ _ _ _ avec résineux	Bb R	Bb R (F)	Bb R (R)
Bétulaie à bouleaux jaunes avec pin blanc	Bj Pb	Bj Pb (F)	Bj Pb (R)
_ _ _ _ _ avec pin rouge	Bj Pr	Bj Pr (F)	Bj Pr (R)
_ _ _ _ _ avec résineux	Bj R	Bj R (F)	Bj R (R)
Peuplerale avec sapin	Pe S	Pe S (F)	Pe S (R)
_ _ avec pin gris	Pe Pg	Pe Pg(F)	Pe Pg (R)
_ _ avec pin blanc	Pe Pb	Pe Pb(F)	Pe Pb (R)
_ _ avec pin rouge	Pe Pr	Pe Pr (F)	Pe Pr (R)
_ _ avec épinette noire ou rouge	Pe E	Pe E (F)	Pe E (R)
_ _ avec résineux	Pe R	Pe R (F)	Pe R (R)
Érablière rouge résineuse	Ero R	Ero R (F)	Ero R (R)
Érablière résineuse	Er R	Er R (F)	Er R (R)
_ _ à pin blanc	Er Pb	Er Pb(F)	Er Pb(R)
_ _ à pin rouge	Er Pr	Er Pr (F)	Er Pr (R)
Mélangés à feuillus tolérants	M Ft	M Ft (F)	M Ft (R)
_ _ sur station humide	M Fh	M Fh (F)	M Fh (R)

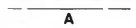
FEUILLUS (groupements)

Feuillus	F
_ _ d'essences intolérantes	Fi
_ _ d'essences tolérantes	Ft
_ _ sur station humide	Fh
_ _ (plantation)	Fp
Bétulaie à bouleaux blancs	Bb
_ _ à bouleaux jaunes	Bj
Peuplerale	Pe
Érablière rouge	Ero
Érablière	Er
_ _ à bouleaux blancs	Er Bb
_ _ à bouleaux jaunes	Er Bj
_ _ à peupliers	Er Pe
_ _ à feuillus d'essences intolérantes	Er Fi
_ _ à feuillus d'essences tolérantes	Er Ft
Plantation d'érable à sucre	ErS p
_ _ de bouleau jaune	BoJ p
_ _ de peuplier	PeU p
_ _ de peuplier hybride	PeH p

TERRAIN FORESTIER IMPRODUCTIF

Dénudé et semi-dénudé sec	
Dénudé et semi-dénudé humide	
Aulnaie	

TERRAIN NON FORESTIER

Eau (rivières et lacs)	
Ligne de transport d'énergie (emprise)	
Terrain agricole	A
Emplacement urbain, camping, villégiature, centre de ski, terrain de golf, etc	

PERTURBATION

Coupe partielle	cp
Coupe partielle en damier	cd
Coupe partielle par bande	cb
Coupe partielle plus épidémie légère	ce
Chablis partiel	chp
Épidémie légère	el
Brulis partiel	brp

Cédrière	C
_ _ (le thuya occupe plus de 75% de la partie résineuse)	C (C)
_ _ (aucune essence compagne prédomine)	C (R)
_ _ à épinette noire et/ou épinette rouge	C (E)
_ _ à mélèze	C (Me)
_ _ à pin blanc et/ou pin rouge	C (Pb)
_ _ à pin rouge	C (Pr)
_ _ à pin gris	C (Pg)
_ _ à pruche	C (Pu)
_ _ à sapin et/ou épinette blanche	C (S)
_ _ (plantation de thuya)	ThO p
Prucheraie	Pu
_ _ (la pruche occupe plus de 75% de la partie résineuse)	Pu (Pu)
_ _ (aucune essence compagne prédomine)	Pu (R)
_ _ à thuya (cèdre)	Pu (C)
_ _ à épinette noire et/ou epinette rouge	Pu (E)
_ _ à mélèze	Pu (Me)
_ _ à pin blanc et/ou pin rouge	Pu (Pb)
_ _ à pin rouge	Pu (Pr)
_ _ à pin gris	Pu (Pg)
_ _ à sapin et/ou épinette blanche	Pu (S)
_ _ (plantation)	PrU p
Mélèzin	Me
_ (le mélèze occupe plus de 75% de la partie résineuse)	Me (Me)
_ (aucune essence compagne prédomine)	Me (R)
_ à thuya (cèdre)	Me (C)
_ à épinette noire et/ou épinette rouge	Me (E)
_ à pin blanc et/ou rouge	Me (Pb)
_ à pin rouge	Me (Pr)
_ à pin gris	Me (Pg)
_ à pruche	Me (Pu)
_ à sapin et/ou épinette blanche	Me (S)
_ (plantation de mélèze européen)	MeU p
_ (plantation de mélèze japonais)	MeJ p
_ (plantation de mélèze laricin)	MeL p

GRILLE DENSITÉ - HAUTEUR

DENSITÉ \ HAUTEUR	22m 1	2	17m 3	12m 4	7m 5	4m 6	
A — 80%	A1	A2	A3	A4	A5		6
B — 60%	B1	B2	B3	B4	B5		6
C — 40%	C1	C2	C3	C4	C5		6
D — 25%	D1	D2	D3	D4	D5		6

DÉFOLIATION

⊖ 0 - 50% ⊕ 50 - 100%

ORIGINE

Coupe totale	ct
Brulis	br
Chablis total	cht
Épidémie sévère	es
Friche	fr
Plantation	p

CLASSES D'ÂGE

FORÊT RÉGULIÈRE

CLASSES	TIGES DE :
10 (ans)	0-20 ans
30 "	21-40 "
50 "	41-60 "
70 "	61-80 "
90 "	81-100 "
120 "	101 et plus

FORÊT ÉTAGÉE

CLASSES	
70-30 (ans)	30-70 (ans)
90-30 "	30-90 "
120-30 "	30-120 "
90-50 "	50-90 "
120-50 "	50-120 "
120-70 "	70-120 "

FORÊT IRRÉGULIÈRE

Jin (jeune inéquienne) { Peupl. à dominance de feuil. tolérants ; majorité des tiges entre 0 et 90 ans / Autres peuplements ; majorité des tiges entre 0 et 60 ans

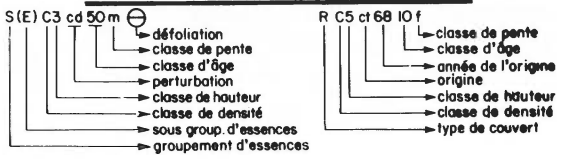
Vin (vieux inéquienne) { Peupl. à dominance de feuil. tolérants ; majorité des tiges ont plus de 90 ans. / Autres peuplements ; majorité des tiges ont plus de 60 ans

CLASSES DE PENTE

CLASSES	% DE PENTE	SYMBOLES CARTO.
Légère	0 à 30 %	aucun
Moyenne	31 à 40 %	m
Forte	41 à 50 %	f
Abrupte	51 % et plus	a
Superficie entourée de pentes > 51 %		s

N.B. : Les classes de pente sont indiquées dans les forêts publiques seulement.

EXEMPLES D'IDENTIFICATIONS FORESTIÈRES



Ontario

Overview

Forest inventory in the province of Ontario is conducted on a continuous cycle of approximately 20 years . The first cycle of Forest Resources Inventory (FRI) was initiated in 1946 and completed in 1958. The second cycle occurred between 1959 and 1976. The third FRI cycle began in 1977 and is scheduled for completion in 1997. The most significant difference between the second and third cycles is that, starting in 1987, forest type maps began to be computerized in a geographic information system rather than drafted. In 1992, The Ontario Ministry of Natural Resources had an organizational change which resulted in the evolution of the Forest Management Information Section, the group previously responsible for producing the FRI, into the Natural Resource Inventories Section (NRIS). This Section now also incorporates the Ontario Fisheries Information System and the Natural Heritage Information Centre.

The entire inventory procedure for a specific portion of the province takes three years. Aerial photography is flown in the summer and delivered to NRIS in the fall. In the first winter, historical records are gathered and the photos reviewed to identify complex forest conditions and problem conditions for interpretation, as well as to establish cruise plot locations. There is no interpretation for mapping in the first winter. Field plots for calibration of interpretation are established the following summer. Photointerpretation is conducted and completed following compilation of field work in the fall or winter of the second year. Map compilation and digitizing take place in the third year. Inventory mapping is done in blocks, generally Management Units, with up to seven such Units surveyed each year. Therefore, in any one year, up to seven Management Units are involved in each stage of the inventory.

Scenario

Photointerpretation is carried out by an interpretation group (Inventories Data Acquisition Unit) within the Natural Resource Inventories Section in Sault Ste. Marie. The group includes seven full time interpreters (FRI Specialist) and one supervisor. Although all of their duties are related to photointerpretation, only 40% of their time is actually spent interpreting. Their other duties include field plot layout, preparation for field work, and field sampling to aid interpretation.

A systematic cruise plot system provides the interpreter with ground truth information required for calibration. Approximately 4000 to 5000 cruise plots, or one plot per 600 hectares are established in a year. This work is done either by contractors, or by seasonal staff who are often supplied by the Forest Districts. Forest companies and District Offices may also provide field data from other sources (e.g., operational cruise data) for ground truth information. This may result in a reduction of the annual number of cruise plots measured for calibration. Cruise plots are established subjectively in stands representing typical forest conditions or potential trouble areas. Cruise plots consist of 10 prism points or stations (BAF 2) spaced 20 meters apart along a 200 meter cruise line. At each prism point a tree count by species is determined by prism sweep. Age and height are measured for sample trees at three predetermined prism points. Species, age, and stocking are also determined for the understorey, shrubs, and regeneration. Soil conditions, stand origin, and disturbance are noted. Typically, 5 percent of all plots, chosen randomly, are checked (resampled) by the interpretation group during the same summer. The minimum check is 5 percent. This provides the interpreter with first hand knowledge of field conditions as well as providing confidence in the field data. These field data are compiled in the fall and are provided to the interpreter prior to interpretation. Data summaries, field notes, and the location of the field plots on photographs are all used by the interpreter to calibrate the interpretation. Photointerpretation begins in the second winter and concludes in the spring of the third year. Field plot data may be provided to the District Staff for their operational planning purposes, but are not acquired for this purpose.

The Ontario Basic Mapping Program (OBM) provides a common systematic digital base map series that gives the base map layer on which the forest thematic layer is added to create the forest type map. The OBM provides digital base maps at a scale of 1:20 000 in Northern Ontario and 1:10 000 in Southern Ontario. The majority of transfer, digitizing, and data entry is performed in-house. The transfer and digitizing is done by the Inventories Data Automation Unit which consists of 14 full time staff. Their time is divided into 50% digitizing and 50% in transfer and attribute keypunching. The section operates 11 manual digitizing workstations and an automatic digitizer (scanner). The forest thematic layer is created by transferring the forest stand boundaries from the photographs onto a blank sheet of chronoflex which is overlaid on a copy of the base map using a vertical sketchmaster. New base map information, ownership, and timber license boundaries are also

added to the chronoflex. Until recently, the inked chronoflex was digitized manually. Approximately three days were required to digitize one mapsheet (10 000 ha). This was broken down as follows:

- 6 hours digitizing forest stand boundaries which generally includes swamp polygons as well,
- nil hours digitizing new base map features such as roads, rivers and power lines (these features as well as lakes are on the OBM digital base maps),
- 2 hours digitizing administrative boundaries (e.g. forest management unit boundaries, ownership),
- 1 hours edgematching at the boundaries of map sheets,
- 7 hours editing and cleaning,
- 2 hours label placement,
- 3 hours quality control,
- 0.5 hours final map output.

Now the inked chronoflex is digitized by automatic scanning. This saves about 7 hours of time over the normal digitizing procedure.

Previous to digitizing, the compilation section transferred the forest type delineations to a paper work map, in pencil, and the drafting section produced the final inked chronoflex from the paper copy.

In a recent development, in areas of little change between inventories, existing stand boundaries may be maintained if there is agreement between the District and the forest company involved. These areas, which may range in size from a few scattered stands to the majority of a management unit, are marked on old maps by a District Office or company. In these areas the photographs are interpreted and only those attributes that require change are updated (e.g., age, height, and sometimes species composition). The Inventories Data Automation Unit receives a map with updated attributes and unchanged stand boundaries. Because these maps have not been previously computerized, the unchanged boundaries are transferred directly to the chronoflex for digitizing.

The role of the forest companies in the FRI is still evolving. Forest companies operating with larger land holdings under forest management agreements have some responsibility for forest inventory. In return for the inventory results, companies are often expected to undertake the field cruising and photointerpretation portion of the inventory. In these cases companies may choose to conduct their own survey or hire a contractor to do the survey. All work is checked by the Ministry interpretation group.

Volume sampling is not undertaken as part of the inventory process. The primary objectives of the inventory are to develop an accurate forest stand description and area estimation. Volume is determined by relating the area of each forest stand, from the map, to an existing yield table (i.e. Plonski's Normal Yield Tables (NYT), (Plonski 1974)).

Productive Forest Land Classification

Productive forest land in Ontario is defined as any forest area that will retain an adequate growth of timber on a sustained basis (i.e., all forest areas capable of growing commercial timber and which now support a stocking level of 30 percent on a site class 4 or better). A productive forest stand is defined as an homogeneous unit based on species composition, age, height, stocking, and site class. Working group is a concept used in the inventory and in forest management. A working group is defined as an aggregate of stands having the same predominant species. Stands with the same working group are managed under the same rotation and broad silvicultural system. Working group is a derived attribute. The rules to determine the 20 working groups are based on species composition within a stand. An example of a FRI forest type map and legend is shown in Figure 6.

Species composition consists of the most common tree species in the stand listed in descending order according to percentage of crown closure. Species content is given to the nearest 10 percent and all species contributing at least 10 percent to the canopy of the stand are listed. There is, therefore, a potential for 10 species in the stand description. A total of 40 tree species are recognized in Ontario. No information is interpreted or recorded for the understorey in a two-storied stand, except in special cases.

Ontario describes stand density based on the concept of normal stocking. Ontario defines normal stocking as the basal area that produces the maximum merchantable timber yield at rotation. Cruise plot data, from prism sweeps, contain information on age, height, and stem count by species. This stem count is used to derive actual basal area. The age and height are used to determine site class through the site class curves of the NYT. The stocking factor is then calculated as the actual basal area (determined from the stem count) relative to the normal basal area (from the NYT) for the appropriate species, age, and site class. In operation, however, stocking is interpreted directly from the photograph. The interpreter uses calculated stocking from

field measurements of ground plots for calibration and verification.

Stand height is an estimate, to the nearest meter, of the actual average height of the major tree species. Field measurements are used to help calibrate the interpretation.

Age class is interpreted based on the average age of the major species making up the working group. The interpreter uses a combination of factors, such as species, height, site, and history to aid the interpretation. Field measurements and ancillary data (e.g., fire records) are used to calibrate the interpretation. Stands are placed into 5-year age classes, except where more exact origins are known.

Site class is a derived attribute. It is determined from the age to height relationship defined in the NYT. Interpreted age and height of the major species are used to derive site class. Five classes are recognized: X (a super site), 1, 2, 3, and 4 (the poorest site).

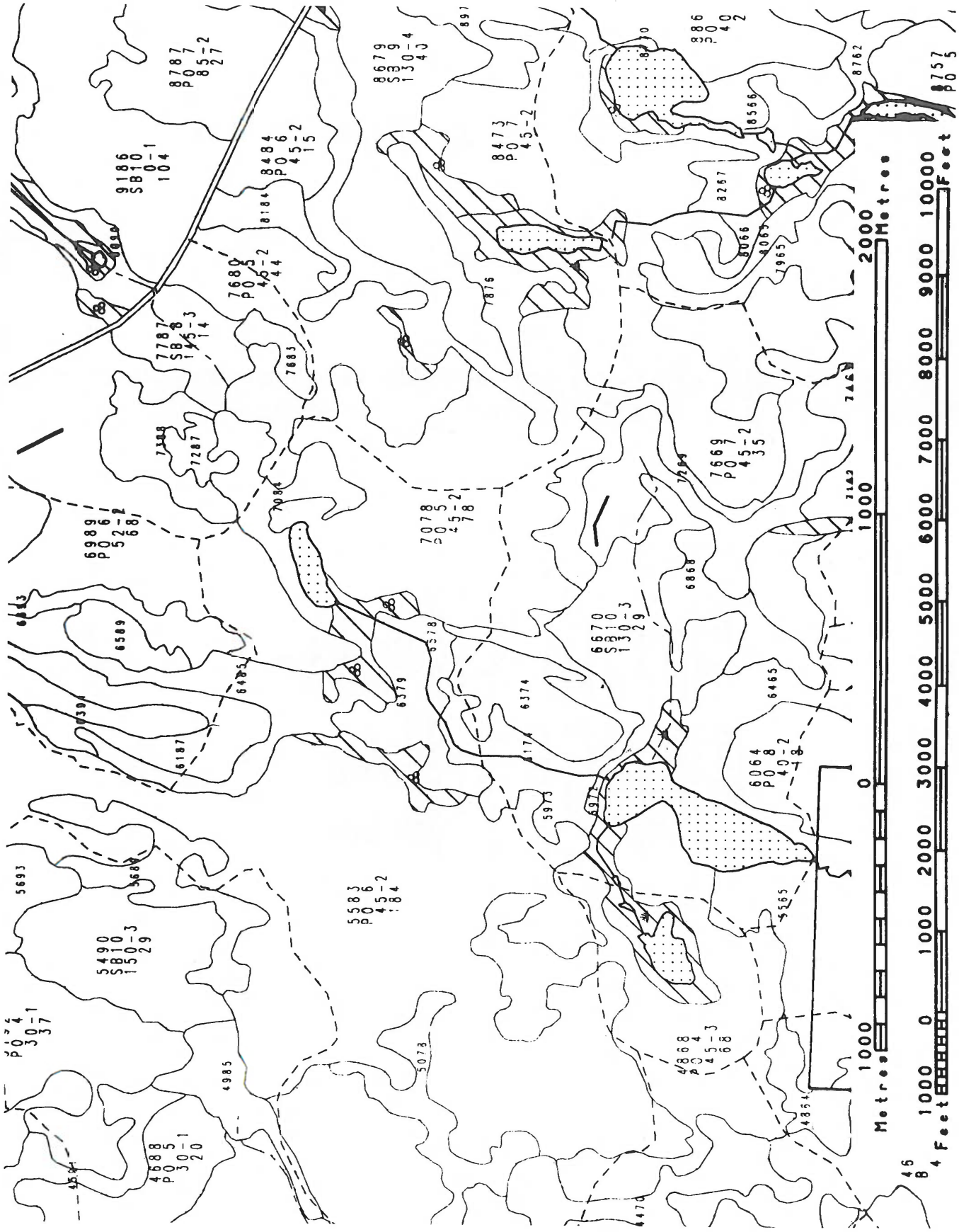


Figure 6. Example of forest type map and legend for Ontario.

ONTARIO FOREST RESOURCE INVENTORY MAP

Scale 1:20,000

STAND DESCRIPTION

2389	Stand identifier
SB6	Working group/occurence in stand
45-2	Age-site class
19	Area (hectares)

PRODUCTION FOREST

STAND	WG	AGE	HT	STG	AREA	SC	ALL SPECIES
65	SB	135	14.0	1.0		3	2-SB10
77	SB	140	13.0	1.0		3	3-SB10
87	SB	50	12.0	0.6		6	1-SB4BW2PO2B1SW1
89	SB	15	2.0	0.5	0.8	1	1-SB5PO2B2SW1
93	SB	143	13.0	1.0		6	3-SB10
112	B	40	10.0	0.7		11	1-B4SW2CE2PO1SB1
123	CE	110	13.0	0.6		13	2-CE4B2PO1SB1SW1BW1
155	SB	140	11.0	0.9		5	3-SB10
157	PO	45	16.0	0.7		10	3-PO5SW2CE1BW1SB1
161	PO	45	16.0	0.7		17	3-PO5SW2SB1CE1BW1
172	SB	140	11.0	1.0		13	3-SB9L1
179	SB	140	13.0	1.0		3	3-SB10
190	SB	20	3.0	0.5		10	2-SB6B2PO2
196	SB	15	2.0	0.5		6	1-SB5PO2B2SW1
199	SW	20	5.0	0.5		3	1-SW5PO3SB1B1
251	B	45	11.0	1.0		19	1-B5SB3CE1BW1
265	SB	140	11.0	0.9		7	3-SB10
288	SB	140	13.0	1.0	0.8	3	3-SB10
312	SB	140	20.0	0.3		9	1-SB4B2SW2CE1PO1
397	SB	20	4.0	0.7		5	1-SB4PO3SW2B1
455	SB	0	0.0	0.0		16	2-SB10
464	SB	0	0.0	0.0		7	3-SB10
475	S	45	12.0	0.6		81	X-PO3SB2B2SW2BW1
481	SB	20	2.0	0.6		25	2-SB9L1
500	SB	40	8.0	0.7		3	1-SB4PO4SW1B1
552	SB	140	12.0	0.9		12	3-SB10
561	PO	50	18.0	1.0		13	2-PO6BW2B1SW1
587	SB	140	13.0	1.0		14	3-SB10
592	SB	140	13.0	1.0		11	3-SB10
597	SB	15	2.0	0.5		14	1-SB7B2PO1
614	SB	140	20.0	0.3		32	1-SB4B2SW2CE1PO1
645	BW	45	14.0	0.8		20	2-BW4B3SB2PO1
650	SB	150	17.0	0.3		32	2-SB8CE1B1
697	SB	145	15.0	0.9		6	2-SB10
771	SB	140	12.0	1.0		16	3-SB10
900	PO	55	19.0	1.0		14	3-PO8BW1SW1
948	SB	140	13.0	0.9		6	3-SB10
970	SW	45	13.0	0.6		36	X-BW3SW3PO2B1SB1
994	SB	20	4.0	0.7		45	1-SB4PO3SW2B1

Manitoba

Overview

Forest inventory in Manitoba covers the wooded and aspen parkland areas of the province. The transition and tundra zones in the north are not covered. The inventory is conducted on a continuous cycle, with areas of high industrial activity (utilization) re-inventoried every 10 years. Manitoba is on its third cycle of inventory since 1958. Areas of low activity are inventoried on a 25-year cycle. A significant development during the current cycle of inventory was the use of a geographic information system.

The inventory map production procedure for a specific portion of the province takes approximately 2 years. Photography is flown in the summer and received by the Forestry Branch, Department of Natural Resources in the early fall. During the late fall and throughout the winter the photographs are interpreted. Base mapping also begins in the first winter. Field cruising for volume sampling takes place the following summer. This sampling doubles as a field check for photointerpretation. Following the summer field cruising, interpretation problems are corrected and the forest information is transferred to a base map. In the winter of the second year the base map with forest information is given a final check and converted to digital format to complete the forest map production process. Digitizing is generally completed within 6 months of the completion of the base map. Area and volume statistics are then compiled. Timing may be set back because the Forestry Branch has to accommodate extra work arising from unexpected situations such as bad forest fire years.

Scenario

Photointerpretation is done in the Forestry Branch office in Winnipeg by three full time, experienced interpreters, including a senior interpreter who is the supervisor. Delineation and interpretation begins as soon as the photographs are received. A preliminary field check may not be required because the interpreters were involved in the previous cycle of inventory and are familiar with the forest conditions over the whole province. Photointerpretation is not systematically ground truthed. Instead of a field check to verify the interpretation, the interpreters are involved in the volume sampling. The interpreters are responsible for the sample design (i.e., cruise plot layout) and the supervision of field work (i.e., cruising). As a result they are exposed to the field conditions which they have interpreted. The cruise plot data collected in volume sampling is fed back to the interpreters so that they can modify the interpretation in the fall of the second year. A typical year for an interpreter consists of approximately 70 percent photointerpretation and 30 percent activities associated with volume sampling.

New base maps, at a scale of 1:15 840, are produced each time the inventory is redone. These base maps are produced by the Forestry Branch using position control from previous forest inventory base maps originally developed by Surveys Branch using slotted template laydowns. Base map construction involves transferring control points and exterior boundaries from old base maps to a mylar. These control points (generally 12 per photograph) are also transferred from the old photographs, used for creating the old base map, to the new photographs. The points are used to achieve proper positioning in the transfer of information from new photographs to the base map. Linear features and forestry information are transferred from the air photographs onto the mylar, in pencil, using a vertical sketchmaster. The result is a new map constructed to the same cartographic coordinates as the old base map. The base map construction and data transfer are done in the Branch office in Winnipeg by three full time staff and one supervisor. Their duties also include stand numbering.

The mylar is the base for digitizing. There are seven full time staff involved in the digitizing process, five full time digitizers working at five digitizing tables, one person responsible for edge matching, and one supervisor. The digitizers are also responsible for keypunching the attribute information. Approximately 4 to 5 days are required to digitize and output an average map. This time is broken down as follows:

- 16 hours digitizing forest stand boundaries which includes water and nonproductive polygons, as well as, all base map features,
- 2 hours digitizing administrative boundaries (e.g. forest management unit boundaries, ownership),
- 2 hours edgematching at the boundaries of map sheets,
- 2 hours editing and cleaning,
- 8 hours label placement,
- 1 hours quality control, and
- 1 hours final map output.

The objective of the volume sampling program is to determine an estimate of volume for each type aggregate (stratum) by management unit. Interpreted photographs are used for the initial stratification and to locate sample plots within these strata. Volume sampling is not carried out extensively (typically 80 samples

or 500 prism points per year; one for every 18 750 hectares). Less sampling is deemed appropriate because sampling from the previous cycle is being used and the volume information is for a forest classification of a particular cutting class based on age and should remain current as time passes. Previously, approximately 1100 samples were measured each year (one every 1370 hectares). The survey is done with prism points along a cruise line of 25 points. The line includes between 2.5 and five stands (averaging five to 10 points per stand). Therefore a total of 6000 to 8000 points were measured each year. Sample plots have to be post-stratified when the final map is produced if stand boundaries or descriptions differ from the interpretation used for initial stratification. This may result in some strata not being sampled. When a stratum has no sample plots, plots from a similar, nearby inventoried area may be used, or the stratum will be changed to one with sample information (i.e., the stand description will be modified slightly). Plot data are used to construct stand and stock tables for each stratum. These are then applied to the area of the stratum, calculated from the map, to estimate volume.

Productive Forest Land Classification

Productive forest land in Manitoba is defined as all forest land capable of producing merchantable wood by rotation age regardless of its existing stage of productivity. The interpreter uses site information to guide the interpretation. All productive, or potentially productive, forest lands are classified into homogeneous units (stands) according to species composition, crown closure, cutting class, and site. The legend and a segment of a typical forest type map for Manitoba is given in Figure 7. Table 3 gives a description of the parameters in the legend.

A two-part designation, 'cover type' and 'subtype,' describes the composition of forest stands in general terms. There are four cover type classes based on the percent of the total basal area comprised of coniferous species. The classes are:

Softwood (S)	- greater than 75% softwood species
Mixedwood (M)	- greater than 50% and less than 76% softwood species
Mixedwood (N)	- greater than 25% and less than 51% softwood species
Hardwood (H)	- less than 26% softwood species.

Subtype is derived from interpreted species composition. Species composition is based on an estimate of the percent contribution of each individual species to the total basal area of all species. Species composition interpreted to the nearest 10 percent is applied to a set of rules to derive subtype. There are 22 different softwood subtypes (S), 24 different mixedwood (M) subtypes, nine different mixedwood (N) subtypes, and 15 different hardwood subtypes (H).

Crown closure is an estimate in percent of the ground area covered by a vertical projection of the tree crowns. There are four classes: 0-20%, 21-50%, 51-70%, and 71-100%.

Age and height classes are not used directly. A concept of cutting class based on size, vigour, state of development, and maturity of a stand for harvesting is used. Six cutting classes are derived from a set of rules based on interpreted data. Age class, site, stand height, and state of development for harvesting purposes (i.e., where a stand is related to a given growth rate, for example, young-rapid, immature-slowing, mature-nil, or overmature-volume loss) are interpreted and related to a table of rotation ages by species and site to derive cutting class. These tables may differ for different management units. The following are examples of two cutting classes:

Class 3	- Immature stands, with merchantable volume growing at or near their maximum rate, which definitely should not be cut. The average height of the stand should be over 10 m and the average diameter over 9.0 cm at breast height.
Class 4	- Mature stands which may be cut because they have reached rotation age ± 10 years for stands of site 1 or ± 20 years for certain species (e.g., black spruce, tamarack, and cedar) on site class 2.

Site class is also derived from interpreted data. Site class is assigned to each subtype on the basis of major species, how well the species are performing, landform characteristics, and the associated moisture regime. Stand height and density also reflect site and are considered when deriving site class for an individual stand. Site class is a qualitative judgment based on the above characteristics. In Manitoba, landform and moisture regime can provide good site classification but the addition of the other variables improves the classification.

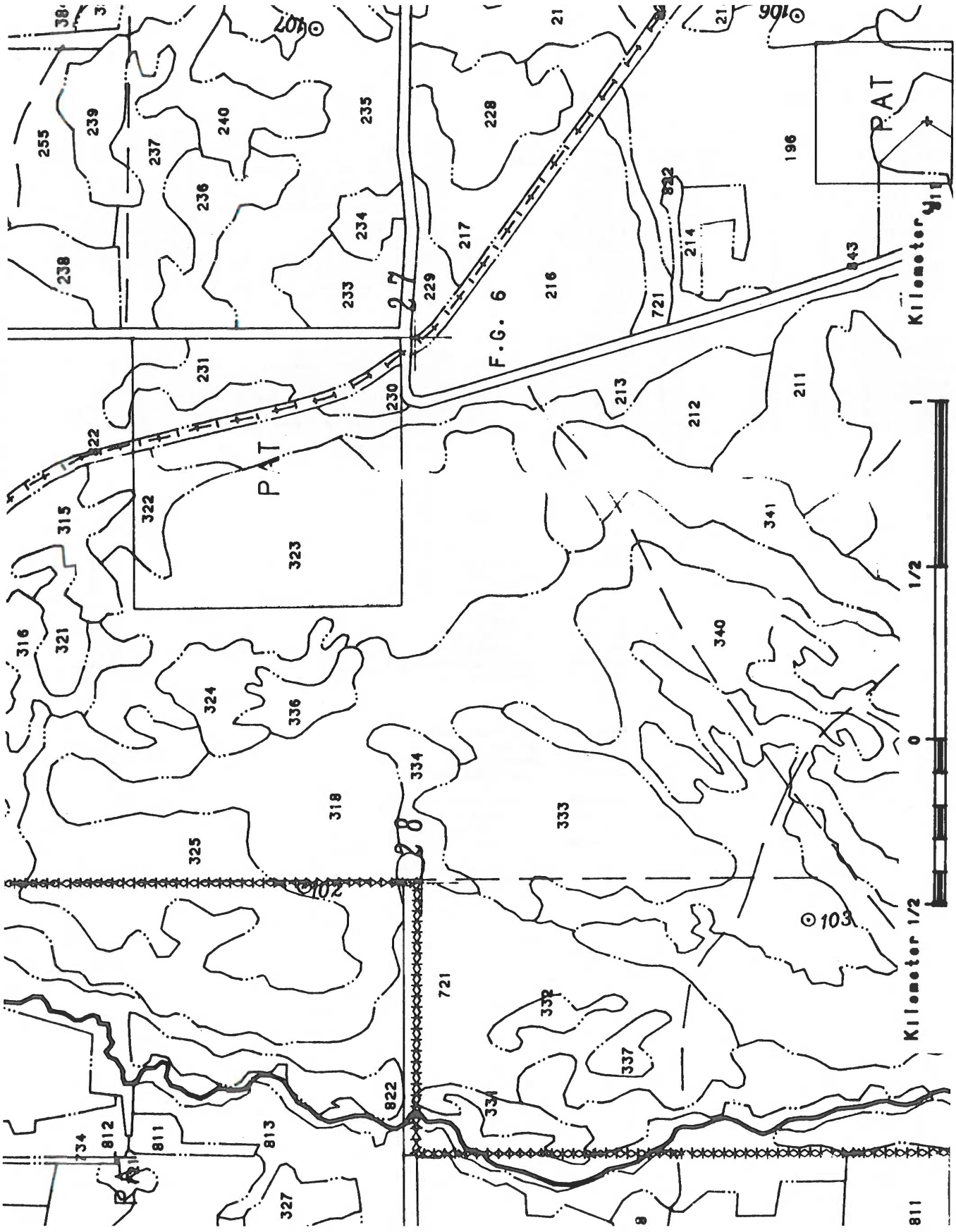


Figure 7. Example of forest type map and legend for Manitoba.

FOREST COVER MAP

SCALE: 1:15,840

STAND	COVER	STAT	OWN	HECTARES	SPECIES-COMP
196	90134	11	1	39.5	TA8WB2
196	90134	11	1	0.3	TA8WB2
196	90134	11	1	11.9	TA8WB2
196	90134	11	5	10.4	TA8WB2
197	44134	11	1	15.4	JP7TA2WB1
198	90134	11	1	4.6	TA10
199	90134	11	1	12.1	TA9WB1
200	01122	11	1	2.8	RP10
201	90134	11	1	9.0	TA9WB1
202	90134	11	1	14.5	TA7WB2JP1
203	04144	11	1	5.9	JP8TA2
204	90144	11	1	11.1	TA5WB3JP2
205	90144	11	1	2.2	TA8WB1JP1
206	90134	11	1	6.1	TA8JP2
207	44222	11	1	3.9	JP6TA4
208	04224	11	1	10.8	JP10
209	90124	11	1	3.7	TA10
210	04100	11	1	13.2	
210	04100	11	5	0.4	
211	17224	11	1	18.9	BS7EC3
212	57134	11	1	20.8	BS4EC2BA3TA1

STAND DEFINITION

001-699 PRODUCTIVE FOREST STAND NUMBERS
700-899 NON PRODUCTIVE STANDS

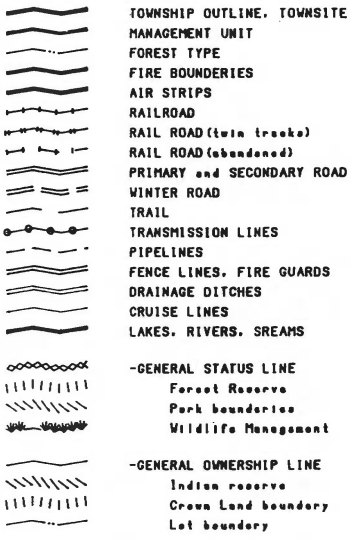
700- TREED MUSKEG (at least 10% of tree cover)

701 -Black Spruce Treed Muskeg -51% of species comp.
702 -Tamarack Larch Treed Muskeg-51% of species compo.
703 -Eastern Cedar Treed Muskeg -51% of species compo.
704 -Taiga (Northen Transition Forest)
711 -Jack Pine Treed Rock -51% of species compo.
712 -Black Spruce Treed Rock -51% of ground cover
713 -Hardwood Treed Rock -51% of species compo.
721 -Willow -51% of ground cover
722 -Alder -51% of ground cover
723 -Dwarf Birch -51% of ground cover
724 -Shrup -76% of ground cover
725 -Shrup/Prairie-Shrup Shrup -51% of ground cover
731 -Recreational sites
732 -Small Islands (less than 2 ha.)
733 -Precipitous slopes/Fragile sites
734 -Shelter Belts

800 BARREN-BARE ROCK (25% of tree cover or less)

801 -Barrens - Tundra
802 -Bare Rock -Igneous
803 -Bare Rock -Sedimentary
804 -Open Sand Dunes
811 -Hayland - Cultivated
812 -Cropland - cultivated
813 -Pastureland - domestic animals
815 -Land clearing in progress
816 -Abandoned cultivated land
821 -Dry Upland Ridge Prairie
822 -Moist Prairie
823 -Wet Prairie
824 -Sand Prairie

LINE SYMBOLS



POINT SYMBOLS

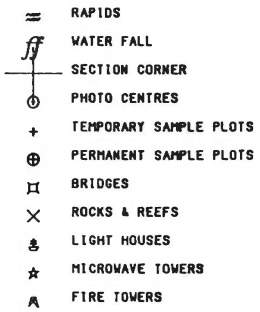


Table 3. Description of parameters in the Manitoba inventory map legend.

Stand	Cover[1]	Stat[2]	Own[3]	Hectares	Species Composition[4]
196[5]	90134	11	1	39.5	TA8WB2

[1] Cover:
- 9 - covertype - Hardwood, < 25% Softwood
- 0 - subtype - Trembling aspen
- 1 - Site 1
- 3 - Cutting Class 3 - Immature stands with merchantable volume growing at maximum rate.
- 4 - Crown Closure - 71% and over

[2] Status

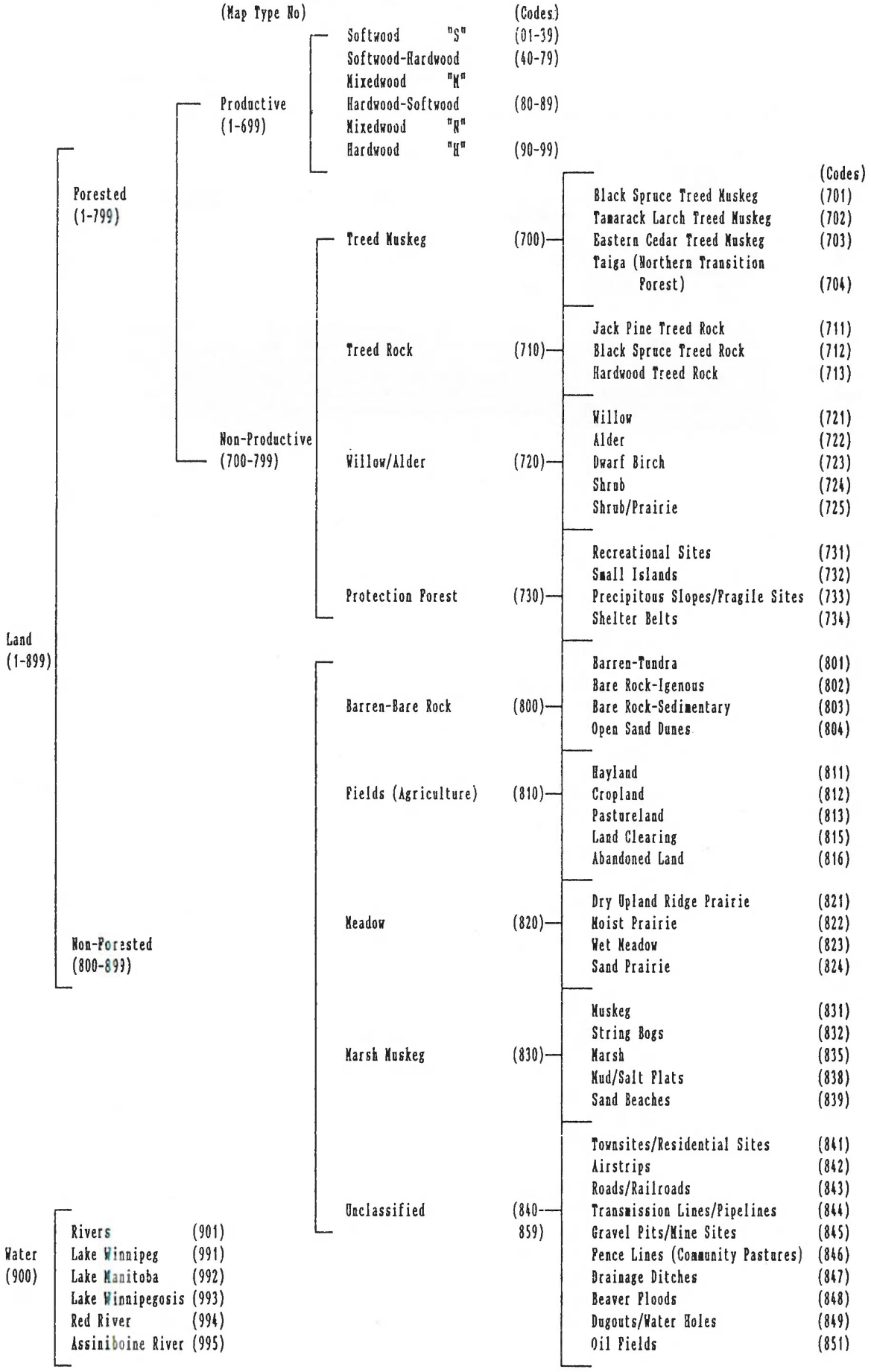
[3] Ownership

[4] Species Composition:

TA8	Trembling aspen	80%
WB2	White birch	20%

[5] A productive forested stand is numbered individually, in a township, from 1 to 699. When there are more than 699 stands in a township, then letters are used along with a number (e.g., 1a, 2a, 3a). Non-productive forest land is numbered from 700 to 799, non-forested land from 800 to 899, and water is identified by numbers 900, and 991 to 995. The following diagrams, from the Province of Manitoba, Department of Natural Resources 'Provincial Forest Inventory Guide for use of Forest Inventory Maps', indicate the productivity breakdown, covertype, subtype, site, cutting class and crown closure.

The following diagram indicates the productivity breakdown to be followed:



Cover Type

Four broad cover types are recognized - Softwood 'S', Softwood-Hardwood 'M', Hardwood-Softwood 'N', Hardwood 'H'. The first number of the sub-type code indicated the type aggregate.

CODE	
0-3	Softwood 'S' includes all stands where at least 76 percent of the total basal area consists of coniferous species.
4-7	Softwood-Hardwood Mixedwood 'M' includes all stands where the basal area of all the coniferous species is between 51 percent and 75 percent of the total basal area.
8	Hardwood-Softwood Mixedwood 'N' includes all stands where the basal area of all coniferous species is between 26 and 50 percent of the total basal area.
9	Hardwood 'H' includes all stands where the basal area of all coniferous species is less than 25 percent of total basal area.

The above cover types are therefore to be determined by the percent of the basal area of softwood tally in proportion to the total basal area found on all plots taken within a stand.

SUBTYPE CODE

Cover Type 'S' > 76% S	Code
Red Pine 71-100%	01
Red Pine 40-70%-jP	02
Jack Pine 71-100%	04
Jack Pine 40-70%-rP	05
Jack Pine 40-70% - Spruce	06
Scots Pine 71-100%	08
Scots Pine 40-70% -jP	09
White Spruce 71-100%	10
White Spruce 40-70%-bF,jP,bS	11
Black Spruce 71-100%	13
Black Spruce 40-70% -jP	14
Black Spruce 40-70% - bF,wS	15
Black Spruce 40-70% - tL	16
Black Spruce 40-70% - eC	17
Balsam Fir 71-100%	20
Balsam Fir 40-70% - Spruce	21
Balsam Fir 40-70% -eC	22
Tamarack 71-100%	30
Tamarack 40-70% - Spruce	31
Tamarack 40-70% -eC	32
Cedar 71-100%	36
Cedar 40-70%	37
Cover Type 'N' 26-50% S	
Trembling Aspen - rP	80
Trembling Aspen - jP	81
Trembling Aspen - Spruce,bF,tL	82
Birch - rP	85
Birch - jP	86
Birch - Spruce & bF	87
Balsam Poplar - Spruce,bF,tL	88
Northern Region & Lake Winnipeg East* **	
Hardwood - Pine	83
Hardwood - Spruce	84

Cover Type 'M' 51-75% S	Code
Red Pine 51%+	41
Red Pine 50% or less - jP	42
White Pine 51%+	43
Jack Pine 51%+	44
Jack Pine 50% or less - rP	45
Jack Pine 50% or less - Spruce	46
Scots Pine 51%+	48
Scots Pine 50% or less - jP	49
White Spruce 51%+	50
White Spruce 50% or less-bF,jP,bS	51
Black Spruce 51%+	53
Black Spruce 50% or less - jP	54
Black Spruce 50% or less - bF	55
Black Spruce 50% or less - tL	56
Black Spruce 50% or less - eC	57
Black Spruce 50% or less - wS	58
Balsam Fir 51%+	60
Balsam Fir 50% or less - Spruce	61
Balsam Fir 50% or less - eC	62
Tamarack 51%+	70
Tamarack 50% or less - Spruce	71
Tamarack 50% or less - eC	72
Cedar 51%+	76
Cedar 50% or less	77
Cover Type 'H' < 25% S	
Trembling Aspen	90*
Trembling Aspen <50%, WB (20%+)	91
Birch	92
Basswood	93
Ash	94
Elm	95
Oak	96
Manitoba Maple	97
Balsam Poplar	98**
Largetooth Aspen	9A
Eastern Cottonwood	9B
Hackberry	9C
Hop Hornbeam	9D
Willow	9E
Northern Region & Lake Winnipeg East ***	
All Hardwoods	99

* Code 90 - Where Aspen and Balsam Poplar together equal 51% and Aspen predominates

** If bA is 50% or less with 20% + wB then classify as 91

*** Special Note - Codes 83, 84 and 99 will remain in effect until such time as an area is re-inventoried, at that time the full range of Cover Type 'N' and 'H' codes will be implemented. Consult Appendix I.

MOISTURE REGIME	LANDFORM	INDICATOR PLANTS		SUBTYPE AND SITE CLASS					
		ABUNDANT	SCATTERED	JP	WS	BF	BS	TL	TA
ARID	rock outcrop, higher gravel beach ridges	reindeer moss, creeping savin	bearberry	2	3	--	--	--	3
DRY	higher beach, outwash and moraine ridges	bearberry, creeping savin, reindeer moss, slender mountain rice	common juniper, soapberry	2	3	3	3	--	2
MOIST (ground water and vadose water types)	low positions and flaring-out margins on beach and outwash OR till plains, lacustrine flats and higher flood plains	red-ozier dogwood, bunchberry, Ribes sp. naked miterwort, creeping snowberry	buffalo berry, common juniper, rough grained mountain rice, alder	1	1	1	1	--	1
VERY MOIST	depressional positions on beach and outwash and lacustrine deposits	red-ozier dogwood, naked miterwort, bunchberry, Ribes sp., alder	bog cranberry	1	1	1	1	1	1
WET	depressional positions on till and lacustrine material	alder, marsh marigold, bog cranberry		--	--	--	1	1	1
SATURATED	deep organic terrain	sphagnum sp., labrador tea, marsh marigold		--	--	--	2	2	--

NOTE: - Arid sites are generally devoid of tree cover.

Cutting Class

Cutting class is based on size, vigour, state of development and maturity of a stand for harvesting purposes.

a) Class 0 - Forest land not restocked following fire, cutting, windfall or other major disturbances (hence, potentially productive land). Some reproduction or scattered residual trees (with net merchantable volume less than 20 m^3 per hectare) may be present.

b) Class 1 - Stands which have been restocked either naturally or artificially. There may be scattered residual trees present as in Cutting Class 0. To be in Cutting Class 1 the average height of the stand must be less than 3 metres.

c) Class 2 - Advanced young growth of post size, with some merchantable volume. The average height of the stand must be over 3 metres in order to be in this cutting class.

d) Class 3 - Immature stands with merchantable volume growing at or near their maximum rate, which definitely should not be cut. The average height of the stand should be over 10 metres and the average diameter should be over 9.0 centimetre (9.0 cm) at Dbh (1.3 m).

e) Class 4 - Mature stands which may be cut as the have reached rotation age (+\-) 10 years on Site 1 or (+\-) 20 years on Site 2.

f) Class 5 - Overmature stands, which should be given priority in cutting.

Crown Closure Class

Code

0 - 0 % - 20% crown closure
2 - 21% - 50% crown closure
3 - 51% - 70% crown closure
4 - 71% and over

Saskatchewan

Overview

The crown forest of Saskatchewan has been identified in survey terms, under the Saskatchewan Forest Act, as the Provincial Forest. The Provincial Forest is divided into two zones, the Reconnaissance Zone and the Commercial Forest Zone, depending upon accessibility and proximity to markets. Inventory of the Provincial Forest has been carried out in 10- to 15-year cycles since 1947, using aerial photography of various scales depending upon the intensity of the survey. The fourth cycle is the most recent survey. It was initiated in 1984 and is scheduled to run over a 15-year period. Significant differences between the two most recent inventories include an expanded classification system, a wider coverage to include lands within the Provincial Forest not previously covered by inventory, and lands outside the Provincial Forest, and the use of computer mapping.

The production of a forest type map begins with the acquisition of aerial photography. Photography is undertaken in the summer and delivered to the Forestry Branch, Saskatchewan Parks and Renewable Resources by September. The interpretation team carry out an initial aerial reconnaissance survey soon after they receive the photographs and conduct field inspections the following summer. Photointerpretation begins in October of the second year and is completed the following October, two years after receipt of the photography. Field checking of problem areas takes place as problems arise. Base map production begins in the winter following photo acquisition and continues through the period of photointerpretation. Drafting the final forest type map begins when enough interpreted photographs have accumulated, approximately 6 months after the start of photointerpretation, and continues approximately 6 months beyond the completion of interpretation. The drafted maps are then digitized to complete the forest map production process. Digitizing takes place approximately a year after the drafting stage due to a backlog of drafted maps waiting to be digitized. The entire procedure takes approximately 3.5 years.

Scenario

Air photo interpretation is done centrally in the Prince Albert office of the Forestry Branch. There are four full time interpreters, including one supervisor, who were all trained on the job. The interpreters are responsible for both the air photo interpretation and the associated field work. Their annual responsibilities include approximately 25 percent in field preparation and field work related to the interpretation, and 75 percent interpreting photographs.

There are three components to the field work. The initial field inspection is an aerial reconnaissance survey by helicopter conducted along the centre of each (sometimes every second) photo acquisition flight line. Particular attention is paid to species composition, height, and the occurrence of understorey species. Some follow-up ground inspection is made in accessible areas. The second component of field inspection is conducted in the summer before the main interpretation and is meant to calibrate the interpreters. The interpreter takes the air photo to the field and visits sites of typical forest conditions as well as sites where the forest type changes, thus giving a good variety of forest types within a small area. Quality control data such as species composition, tree height, stand density, soil type, and minor ground vegetation are collected and used as references for photointerpretation. The interpreter aims towards a sampling intensity of one site for every square kilometer of accessible terrain. Volume sampling data, collected as part of a volume sampling program (Inventory Sampling Program (1976-1983)), and other historical data are also used for reference by the interpreter. A final field inspection (third field component) takes place during the interpretation when the individual interpreter requires checking of specific locations to verify conditions. All this information is assembled on a master field map for reference.

New base maps are produced each time the inventory is redone. The base map is constructed in-house using the control points established for the 1:50 000 National Topographic System (NTS) map series. The procedure involves: transferring the principle point and conjugate points of the 1:12 500 forest inventory photography to the 1:50 000 aerial photographs used in NTS mapping; running a block adjustment program, based upon the NTS control, to determine the UTM coordinates for all the points; and, transferring the UTM locations of the control points from the 1:12 500 inventory photographs manually onto the UTM base mylar. This base mylar is produced by a mapping unit consisting of a drafting staff of two people whose primary function is to produce the UTM base map mylar to coincide with the completion of air photointerpretation. The next step in the creation of the forest type map is the transfer of interpreted information from the photographs to the base map. Base map information (e.g., roads and rivers) and forestry data are transferred from the air photographs onto mylar using a vertical sketchmaster, with positioning achieved by matching the control points on

the photographs with the location of control points on the UTM base mylar. Transfer and drafting are carried out at the Branch office by a drafting unit consisting of seven people. Approximately 60 percent of their time is devoted to map production drafting, giving an unique number to each forest stand, and creating a list of stand attributes on paper. Their remaining time is devoted to map duplication to fill requests, map revision (update), supervision, and management.

The final drafted maps are digitized. There are four people dedicated to the task of digitizing, including editing map coverages. It takes approximately seven days to produce a typical map. The time can be broken down as follows:

- 26 hours digitizing forest stand boundaries, which generally includes lake and swamp polygons,
- 2 hours digitizing base map features such as roads, rivers, and power lines, nil hours digitizing administrative boundaries (e.g., forest management unit boundaries, ownership) (administrative boundary information is not collected at this time; ownership is an attribute assigned to each stand, not a digitized boundary),
- 8 hours edgematching at the boundaries of map sheets,
- 7 hours editing and cleaning,
- 4 hours label placement,
- 4 hours quality control, and
- 4 hours final map output.

The attributes listed by the drafting group are keyed by a separate group which is also responsible for retrieving forest inventory information for clients. In the past, before the present method of digitizing was in operation, stand area was estimated using a computer assisted dot counting technique, which took 35 hours per mapsheet. Now it is done automatically during digitizing.

Volume estimation is based on forest cover type (stratum) for the 11 Block Inventory Sampling Zones (based upon physiographic and ecological areas) of the Commercial Forest Zone. Currently, no volume sampling program is in place due to budgetary constraints. Volume estimates are based on a volume sampling and compilation survey conducted between 1976 and 1983. The most recent inventory maps were used for stratification and to locate sample plots within strata. Approximately 25 000 temporary sample plots were established (averaging 1 plot for every 635 hectares) within map strata by sampling region. These plots were used to develop representative stand and stock tables by stratum; these tables are applied to the area of the stratum to develop volume estimates. When an estimate is required for a stratum outside the original stratification, a weighted average volume per hectare is determined, based on the area occupied by existing strata and volume tables for those existing strata. This weighted average is applied to the area of the new stratum to estimate volume.

Productive Forest Land Classification

Productive forest land in Saskatchewan is defined as all productive lands that currently support stands of living trees and that can be expected to produce a merchantable stand within a reasonable length of time. Productive lands not currently supporting a stand of trees, are classified as non-forested productive lands. The interpreter considers site, drainage, aspect, and vegetation to decide if lands fall within the 'productive classification'. All productive forest lands are divided into homogeneous units (stands) according to species composition, height class, density class, as well as drainage, soil texture, and year of origin. Species designation is divided into species association and secondary species. Disturbance class is also specified where appropriate. Figure 8 is an example of a forest type map and legend for Saskatchewan.

Species association consists of two parts, a general designation of forest type and a specific designation of a primary species group. The designation is based on an estimate of the percent contribution of each individual species or paired species to stand volume (gross volume). Interpretation of percent of stand volume is calibrated by field visits and notes. There are four classes of general designation of forest types based on the percent of softwood volume:

Softwood (S)	- greater than 75% softwood volume
Mixedwood (SH)	- greater than 50% and less than 75% softwood volume
Mixedwood (HS)	- greater than 25% and less than 50% softwood volume
Hardwood (H)	- less than 25% softwood volume.

The determination of the specific primary species group is also based on percent of volume. There are eight different softwood types (i.e., forest type, primary species group combination); for example, SwS is a softwood forest type with white spruce as the primary species group, 84 possible mixedwood types, and seven different hardwood types recognized. Many of the possible groups do not actually occur, and others occur very infrequently. An example of a mixedwood type is:

SHwStA - White spruce and trembling aspen, where the % wS is greater than any other softwood species and the % tA is greater than any other hardwood species.

Secondary species are recognized if they contribute greater than 10 percent but less than 25 percent of the volume of the stand. If a species contributes more than 25 percent it will have been identified as present by the primary species designation. In softwood stands only softwood secondary species are recognized, in hardwood stands only hardwood secondary species are recognized, and in mixedwood stands any of the 13 commercial species may be listed as secondary species. Understorey species are designated in brackets.

There are four crown closure classes (10-30%, 31-55%, 56-80%, and 81-100%) based on the estimate in percent of the ground area covered by a vertical projection of tree crowns.

Height class is the average height of all living trees in the main canopy of the stand. Stands are placed into one of five 5m height classes symbolized by the class midpoint (e.g., the lowest class, 2.5m to 7.5m, is height class 5).

The age of a productive forest stand is based on year of origin. The interpreter uses the age from the previous inventory type map (i.e., updates age) if appropriate, plot data acquired from a special year of origin survey conducted between 1977 and 1983, field notes, cruise data, silvicultural records, harvesting, and fire records to assign the appropriate year of origin to individual stands. The special year of origin survey consisted of field plots in varying stand types, spatially distributed about a region. The plots were clustered in groups of three of different forest types per location and generally five locations per map sheet. This averaged one plot per 600 hectares. Age, species, height, and stand classification were recorded. These were then used to calibrate the interpreter in their age estimation. Year of stand origin is expressed in 10-year classes, designated by the middle two digits of the class midpoint. For example, a 72-year-old stand's year of origin would be 1993 - 72 = 1921, which is in the 1916 - 1925 range. The class midpoint is 1920, so the class designation is 92.

Drainage and texture are used to indicate a measure of site on the forest type map. The interpreter uses Saskatchewan Soils maps to determine soil texture class (5 classes), and a combination of soils maps and subjective interpretation to assign drainage class (7 classes) to individual stands. On the inventory map, stands of similar drainage and texture class are outlined with a thicker type line and the drainage and texture label is placed in this unit.

The interpreter uses historical records and local knowledge to assign a disturbance class to a stand. The year of disturbance is also indicated in the stand label. For example, BO-79 indicates a fire which occurred in 1979. Burned-over and cutover designations are only assigned to productive forest lands capable of producing stands of living trees.

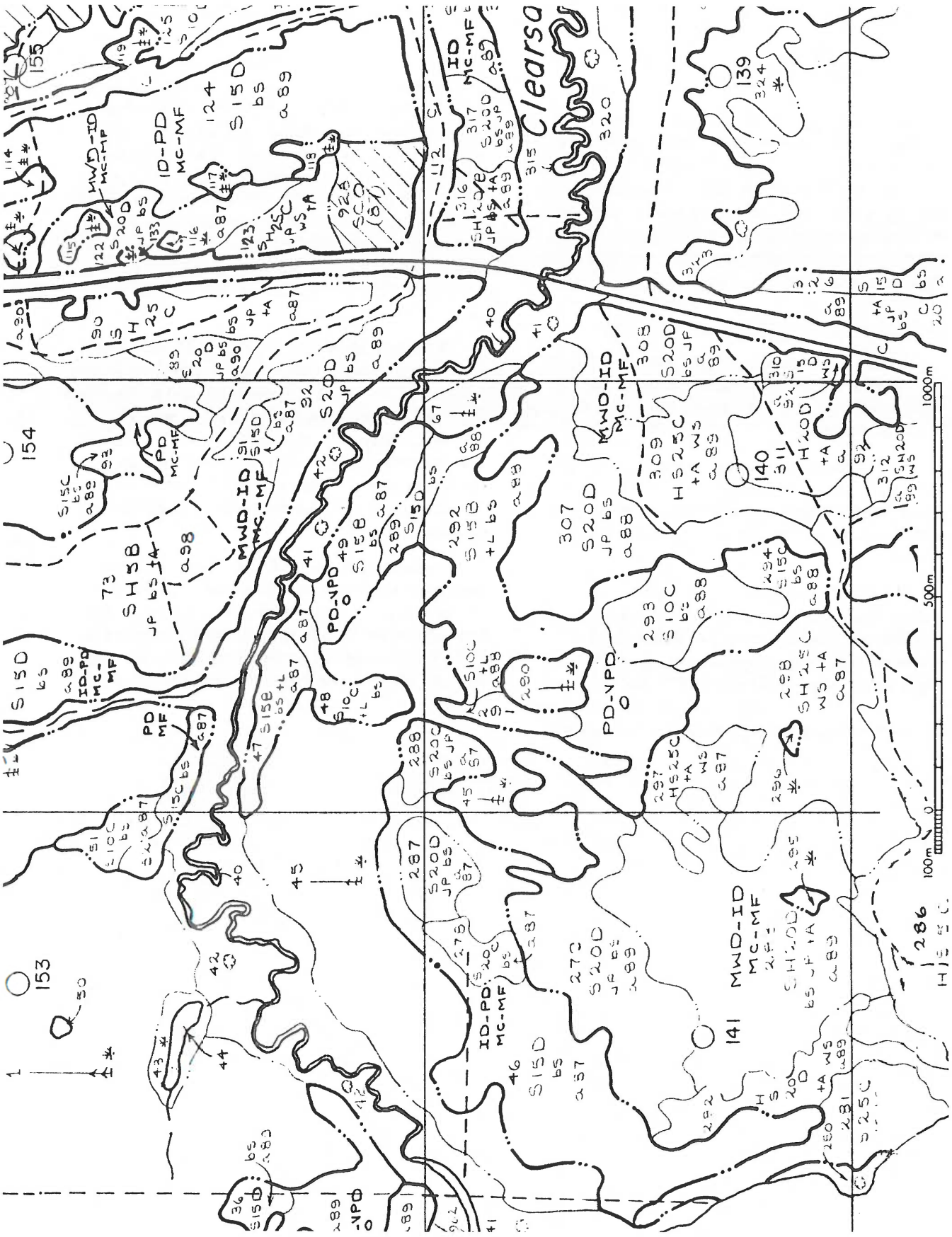


Figure 8. Example of forest type map and legend for Saskatchewan.

INVENTORY MAINTENANCE MAP

U.T.M. SERIES

SCALE 1:12500

FOREST REFERENCE

SPECIES ASSOCIATION

Softwood (over 75% softwoods by volume) - - - - - S
Hardwood (less than 25% softwoods by volume) - - - H
Mixedwood (50% to 75% softwoods by volume) - - - SH
Mixedwood (25% to 50% softwoods by volume) - - - HS

CROWN CLOSURE	HEIGHT
10% to 30% - - - - - - A	2.5 to 7.5 metres - - - - 5
30% to 55% - - - - - - B	7.5 to 12.5 metres - - - 10
55% to 80% - - - - - - C	12.5 to 17.5 metres - - - 15
80% + - - - - - - - - - - D	17.5 to 22.5 metres - - 20
	22.5 + metres - - - - - - 25

SPECIES

White Spruce - - - - - wS	Trembling Aspen - - - tA
Black Spruce - - - - - - bS	Balsam Poplar - - - - - bPo
Jack Pine - - - - - - - - jP	White Birch - - - - - - wB
Balsam Fir - - - - - - - bF	Manitoba Maple - - - mM
Tamarack - - - - - - - tL	White Elm - - - - - - - wE
Lodgepole Pine - - - - lP	Green Ash - - - - - - gAs
	Bur Oak - - - - - - - - bO

Each forest sub-division is denoted by a letter, numeral, and letter showing respectively the species association, height, and crown closure.

Burned over - - - - - - - B.O.	Clear rock - - - - - - ✓
Open land - - - - - - - O.P.	Clearing - - - - - - - C.
Scrub - - - - - - - - - - S.B.	Sand - - - - - - - - -
Cut over - - - - - - - -	Flooded - - - - - - -
Fen, bog, open muskeg	Meadow - - - - - - -
Treed muskeg - - - - - -	Brushland - - - - - - O
Treed rock - - - - - - - ✓	Partial cut over - - - -

SITE REFERENCE

DRAINAGE	TEXTURE
Very Rapidly Drained - - - -VRD	Coarse - - - - - - - -C
Rapidly Drained - - - - - - - - -RD	Moderately Coarse - MC
Well Drained - - - - - - - - -WD	Moderately Fine - - -MF
Moderately Well Drained - -MWD	Fine - - - - - - - - -F
Imperfectly Drained - - - - -ID	Organic - - - - - - - -O
Poorly Drained - - - - - - - -PD	
Very Poorly Drained - - - - -VPD	

Note: A combination of two Drainage Classes and/or two Texture Classes may be used to characterize a site.

FOREST AGE CLASS REFERENCE

Forest age is determined from the year of origin. The year of origin of each forest stand is coded, using the midpoint of a 20 year age class.
The map code may be followed by a minus (-) sign indicating that the year of origin was in the first 10 year period of the class, or by a plus (+) sign, indicating the year of origin was in the last 10 year period.

YEAR OF ORIGIN	MAP CODE
1801 - (1810) - 1820 - - - - - - - - - - - -	a81
1821 - (1830) - 1840 - - - - - - - - - - - -	a83
⋮	⋮
1961 - (1970) - 1980 - - - - - - - - - - - -	a97

Note:
Maps displaying age data are available only on request.

MAP REFERENCE

Main road/highway

Secondary road

Cutline or trail

Portage

Railway

Forest cover type boundary

River or creek

Intermittent stream

Rapids R

Grid lines(1000m)

Projected township lines

Aerial photo centre 7502 65

Sand beach

Height in metres above sea level .1925

Provincial forest boundary

Indian reserve boundary

Forest reserve boundary

Reef +

Lake

Building or cabin

Fire tower

RESERVE REFERENCE

Forest reserves

Provincial parks — as named

Recreation area — as named

Protected area — as named

Protected heritage resources

Parkways — as named

Day use

Camping

Regional parks — as named or

Permanent sample plot

Experimental area — EXP

Canadian Forestry Service plot — CFS

Silvicultural treatment — SILV

Alberta

Introduction

Forest inventory in Alberta is not conducted on a continual cycle; there is a break between inventory phases. There have been three phases of forest inventory conducted in Alberta in the past 40 years. The first phase conducted between 1949 and 1956 was a 'Broad Inventory' of most publicly owned forest lands. The second phase conducted between 1956 and 1966 was a 'Detailed Inventory' of lands with commercial timber commitments not covered in the Broad Inventory. A more recent forest inventory of publicly owned lands in Alberta was the 'Phase 3' inventory. It was initiated in 1970 and completed in 1986, with most activity taking place between 1976 and 1984. It was more detailed than the previous inventories. The Alberta Vegetation Inventory (AVI) is a new integrated inventory initiative that covered a pilot area of approximately 545 townships in the forest transition zone between boreal forest and aspen parkland/prairie grasslands. This integrated approach has the cooperation of Forest Management Agreement holders. The AVI began in 1988 and is expected to form the standard for future forest inventory activities in the province. Both the Phase 3 inventory and AVI are described below.

Scenario (Phase 3 Inventory)

Two Divisions of the Department of Forestry, Lands and Wildlife were responsible for the activities of the Phase 3 inventory. The Resource Information Branch (RIB) (formerly Resource Evaluation Branch) of Land Information Services Division was responsible for mapping and the initial loading of stand attribute information, and the Timber Management Branch of the Alberta Forest Service was responsible for volume sampling, compilation, and inventory data storage and maintenance. Alberta Forest Service (AFS) field staff were responsible for the ground truthing associated with photointerpretation. The mapping procedure for a specific block of photography required 3 years. Aerial photographs were taken during the summer and received by the RIB in the fall. The RIB assessed quality, and annotated the negatives before producing photographic prints. Photointerpretation began as soon as the prints were received, in October and November. The interpretation was verified and calibrated by frequent field visits during the interpretation. A formal ground truthing of the interpreted photographs followed the interpretation and was done the following fall. Ground truth data were used to revise the interpretation between October and December. The final delineations were transferred to an orthophoto base, which was then drafted to create forest type map. The transfer, drafting, and loading of attributes took place between January of the second year and December of the third year.

Photointerpretation was done by RIB staff in Edmonton. Interpreters prepared for the interpretation by gathering and examining existing data, such as previous inventory maps for species associations, silviculture records and fire incidence maps for age information, and Canada Land Inventory maps for site information. The interpreters also met with AFS field staff to define 'Grey Zones,' critical stands or conditions to which the field staff wanted particular attention directed (e.g., stands that are borderline between two classes or conditions). The interpreters then delineated and interpreted stands, using all available information as a guide. The interpreters conducted four to five day field trips once a month in order to verify the interpretation. Data were gathered to verify all components of the classification, with particular attention being paid to age, site, and commercialism (the suitability of the stand for producing different forest products). The interpretation was revised based on information collected on the ground.

Photographed copies of the interpreted photograph (Iteks), along with a list of 'Grey Zone' stands and conditions, were then sent out to AFS field offices for ground truthing or verification. This ground truthing was a special feature of the Phase 3 inventory. The objectives were to enhance photointerpretation through field checks by local forest management staff. Ground truthing provided forest management staff an opportunity to participate early in the production process, allowing them to become familiar with the inventory and more confident with the results. This local involvement also provided an opportunity for the local forest staff to acquire additional information for their own use. Ground truthing consisted of both aerial and ground checks. Visual estimates (air checks) from helicopter were often sufficient to verify the interpretation. Ground measurements were only required if any component of the cover type was questionable. Species, height, commercialism, and age were determined at each site. The proportion of air checks to ground checks varied with the information required. For example, species composition could often be determined from the air whereas age and commercialism had to be determined from the ground. Air checks were calibrated by periodic landings to check the accuracy of the estimate. The Iteks, with ground truth data, comments, and sug-

gestions, were returned to the interpreter and were used in a final revision of the interpretation. The interpretation was completed in the fall, approximately a year following receipt of the prints.

The maps produced early in the Phase 3 inventory were based on National Topographic Series (NTS) maps or existing provincial base maps. Both of these were enlarged to a 1:15 000 scale and base map update information (i.e., new roads, hydrography) was transferred from the aerial photographs to mylars using common air photo transfer devices (e.g., sketchmasters or Zoom Transfer Scopes). The majority of mapping, however, was positionally based on information from orthophotos. Current black and white 1:60 000 aerial photographs were used to create 1:15 000 orthophotos. These orthophotos, spatially correct to existing survey points, were used to create new base maps specifically for the Phase 3 inventory. The transfer and drafting stages of the map production process were undertaken almost entirely by contractors/cartographic firms. Contractors were provided with the orthophotos and were required to transfer information from the typed photos to the orthophotos, draft the base map and forest type information from the orthophoto, keypunch stand attributes, and to determine the area of each stand. All information was transferred using conventional devices. Maps were drafted directly from the orthophoto in a series of separate overlays, first a layer containing base map information (e.g., roads, rivers, and hydro lines), then a layer containing stand boundaries and attributes. All drafting included freehand lettering. Areas were determined using electronic planimeter or by digitizing stand boundaries; however, boundary coordinates were not retained in the computer. Finally, stand attribute lists were keypunched. The stand attribute information was given a thorough edit check by RIB and only accepted into the data base management system once all stands were error free. Inventory maps were modified by incorporating all changes from the edit process.

Volume sampling was done to satisfy two requirements: to provide key volume statistics for broad cover groups by administrative area (management unit) and to obtain an estimate of the current standing volume at the stand level. For the first requirement, old inventory maps were used to identify broad cover groups and their amount and to locate inventory sample plots in stand conditions representative of the cover group. Volume was compiled directly from the sample plot data. Large scale photography was used as part of the sampling program. The second requirement was met by dividing the province into volume sampling regions (VSR), a combination of management units with similar ecological characteristics. A list of all the forest types within a VSR, from the new Phase 3 map, was used to stratify the sample plot data. Volume tables created for each forest type were applied to the area of the forest type to estimate volume. The sample data for the construction of volume tables included the inventory sample plots collected to meet the first requirement and any operational cruise plots which met Phase 3 specifications. A minimum of 30 sample plots were required to construct a volume table for a forest type. In forest types with less than 30 plots, guidelines were established to allow suitable substitutions of plots from similar forest types in the same VSR or from another similar VSR.

Productive Forest Land Classification (Phase 3 Inventory)

There are two classes of productive forest land in Alberta, productive and potentially productive land. Productive forest land is defined as land capable of yielding at least 50 m^3 per hectare of gross roundwood volume, with a stand density of at least 6 percent within 120 years, without productivity enhancement by man. Potentially productive forest land is land disturbed by logging, forest fires, or insect and disease, where crown closure has been reduced to less than 6 percent, but which is capable of producing a productive forest stand within 120 years The interpretation is based on landform and surrounding vegetation. A productive forest stand is a homogeneous unit based on species composition, stand density, height, stand origin, site index, and commercialism. Stands may also be described by slope, stand disturbance, and stand condition where appropriate. An example of a forest type map and legend for Alberta Phase 3 Inventory is shown in Figure 9.

Species composition is a list of all tree species in the stand in decreasing order of content. Composition is based on the percentage of gross roundwood volume for species greater than 12 meters in height and crown closure for species less than 12 meters in height. The description consists of up to four species, with each contributing a minimum of 10 percent of the stand content. Species contributing less than 10 percent may contribute to the overall percent of a similar species in order to increase the similar species content and rank. There is a provision to record the presence of minor species by including it in the stand label, but in brackets (see Figure 9). There were 12 softwood and three hardwood species recognized. An undifferentiated species group was used to classify stands containing deciduous

species which were hard to differentiate and which were not confirmed through field checking.

Stand density (crown closure) is the percent of ground area covered by a vertical projection of tree crowns. The interpreter uses a crown density scale as a comparator to help estimate crown closure from aerial photographs. There are four density classes for stands greater than 6 meters in height. These are: 6-30%, 31-50%, 51-70%, and 71-100% crown closure. There are also four density classes that apply to coniferous and mixedwood regeneration. These are: 6-19% or sparse, 20-39% or inadequate, 40-59% or adequate, and 60% + or overstocked.

Stand height is estimated based on the average height of the dominant and codominant trees in a forest stand. The interpreter used field measurements to calibrate height estimation. Stands were placed into six 6-meter height classes, viz. 0-6, 6.1-12, 12.1-18, 18.1-24, 24.1-30, and 31+. Stands that were borderline between two height classes were assigned to the lower class.

Age is designated by year of origin. Origin was assigned on the basis of existing data (e.g., silvicultural, harvesting and fire records, and cruise, permanent sample plot, and regeneration survey data) as well as information gathered from field checks. The interpreter reviewed all existing information, delineated stands of common fire origin, and located critical stands to check. A more detailed stand delineation followed field checking. Remaining areas of uncertainty were marked as 'Grey Zones' on the Iteks and sent to the AFS field offices for ground truthing. A final revision of the interpretation was made based on the ground truth data. Origin of a stand is expressed in 10-year classes, designated by the birth year less the first and last digits of that year. For example, an origin class of 91 means a stand originated between 1910 and 1919.

Site index is an expression of forest site quality and is based on the average height, at a certain age, of the dominant and codominant trees in the stand. The interpreter uses site index curves relating interpreted height and year of origin to assign stands to one of three classes, good, medium, or fair. Site index curves were developed for four major tree species in the province, viz. white spruce, lodgepole pine, aspen and black spruce. The most appropriate (equivalent) curve of these four were used for other species (e.g., aspen curves were used for balsam poplar).

Stand commercialism was an assessment of the commercial utilization of the timber in a forest stand. There were four classes: lumber, roundwood, high uncommercial, and low uncommercial. These are based on gross coniferous volume production for certain utilization specifications. The uncommercial classes are based on gross volume production for both coniferous and deciduous species, where the gross coniferous volume is insufficient for the stand to be classed as 'roundwood.' The photointerpreter assigned the highest applicable commercialism class to each stand, regardless of other stand attributes such as height, age, and operability. The interpreter relied on field checking and AFS field staff ground truthing to calibrate and verify the interpretation. During the time of the Phase 3 inventory there was little or no market value for deciduous timber so deciduous stands were generally classified as uncommercial.

The interpreter also assigns several other parameters to stands, as appropriate. These include a steep slope designation for stands on a slope greater than 45%, stand disturbance and severity, and stand condition. Stand disturbance is a two-part designation indicating the type and the severity of the disturbance (e.g., X2 added to the stand description would indicate a cut and a loss of 26 to 50 percent of the stand volume). Stand condition indicates the type of treatment applied to a stand and is based on silvicultural records.

Scenario (The Alberta Vegetation Inventory)

The Alberta Vegetation Inventory (AVI) is a new integrated inventory system that has been tested on 545 townships in the transition zone between boreal forest and prairie grasslands. Detailed vegetation information was gathered to provide for integrated resource management planning (e.g., to accommodate wildlife habitat classifications and timber management). The 545 townships were surveyed between 1988 to 1990. Approximately 350 additional townships within the forested area have since been completed by the Resource Information Branch (RIB) and by the Forest Management Agreement holders. This inventory procedure continues to be enhanced and is intended to form the new standard for vegetation inventory in Alberta.

For the AVI pilot area, aerial photographs were taken in the summer and received by the RIB in the fall. During the winter a single contract for photointerpretation and volume sampling was drawn up and contract supplies, such as orthophotographs, were assembled. Photointerpretation was done by subcontractors beginning in the spring and extending into the following winter, such that interpretation was a continuous year round process. The interpreter completed one inven-

tory block and had it checked before continuing to another block. The interpretation was checked by both the contractor and government inspectors. The information from typed photographs was transferred onto an orthophoto following acceptance of the interpretation and then digitized by the Resource Mapping Section of RIB to produce a final map.

The contractor was responsible for all functions associated with the interpretation, except for the quality check which was conducted by RIB. There was a single contract for interpretation let and supervised by RIB, but all interpretation was done by individual subcontractors. The main contractor oversaw interpretation and ensured that the interpretation met defined standards. The interpreters became familiar with the area by establishing ground plots in a variety of conditions. A minimum of 10 sites were examined in each township. At each site, species composition was determined and tree height and age measured for three sample trees, one dominant and two codominants. The ground plot locations were then transferred to the photos and the plots, with their field notes, were used as aids to interpretation. A quality control procedure followed the interpretation. First, all interpretation was checked by an experienced photointerpreter employed by the main contractor. When the contractor was satisfied with the results, they were submitted to the RIB, four townships at a time, for another series of checks. The field plot data and photographs showing the location of the field plots were also supplied. There were seven contract interpreters and two interpreters at the RIB checking the interpretation. The RIB interpreters carried out spot checks, where they went to the contractors' field plots and checked ground data as well as the interpretation; set up independent plots to check the interpretation; and used helicopter flights to check the interpretation from the air. In addition, the RIB interpreters audited all interpretation by scanning 10 percent of the stands on each four-township block. Initially, the amount of checking depended on the contract interpreter. Resource Information Branch interpreters were able to determine the strengths and weaknesses of each contract interpreter through the scanning process. As a result, more effort could be spent on weaknesses, thus improving the final interpretation. In order to avoid bias in the check and the process becoming too personal, the checks were later made blind, with the RIB interpreters not knowing the source contractor of the interpretations.

Orthophotos are produced under contract at a scale of 1:20 000. They are derived from the same 1:60 000 scale photographs being used to produce a provincial base map series, in digital format, at a scale of 1:20 000. The interpretation was typed onto the 1:20 000 black and white infrared inventory aerial photographs. This information was transferred directly to an orthophoto using a 'pseudo-stereo' method (i.e., the interpreter aligns the interpreted photo on one side of the stereo pair with the orthophoto on the other side and transfers the lines from one to the other using a stereoscope). The transfer was done by the interpreters as part of the interpretation process. The main contractor was also responsible for keypunching attribute information.

Forest polygons were digitized directly from the orthophoto. No base map features such as roads, rivers, and power lines were digitized at that time. The orthophotos have the same cartographic control as the new provincial digital base maps and, therefore, the new base map will be combined with the forest polygons as it becomes available. All digitizing was done in-house by a staff of 12 using nine digitizing stations. These stations are in operation for two 5-hour shifts per day. The staff spend 5 hours digitizing and 2.5 hours of their 7.5 hour day on other database functions (e.g., linking polygon numbers to attribute files). It takes approximately 5 days to digitize and assemble a township map in the GIS. The breakdown is as follows:

- 12 hours digitizing forest stand boundaries,
- nil hours digitizing base map features such as roads, rivers and power lines,
- 2.5 hours digitizing geo-administrative boundaries (e.g., forest management unit boundaries, ownership),
- 1 hours edgematching at the boundaries of map sheets,
- 2 hours editing and cleaning,
- 2 hours label placement,
- 2 hours quality control,
- 2 hours final map output,

plus 1 hour data management (e.g., archiving) per mapsheet, 7 hours miscellaneous data processing, and 3.5 hours supervision and administration. Intergraph software is used for digitizing, polygon storage, and final map production while ARC/INFO is used to establish topological structures, label placement, and for attribute management and data storage. A total of 12 townships were produced per week. Plans call for all digitizing to be done by contract.

Volume sampling was done to satisfy the same two requirements as the Phase 3 Inventory. The new AVI map was the basis for the sample design. Fixed area plots were established randomly within randomly selected stands and stand selection was weighted by

area or stand size. Volume tables were compiled directly from the sample plot data for each forest type and applied to the area of the forest type to estimate volume. Differences between the AVI and the Phase 3 inventories include the use of a random design based on the new AVI map and larger, fixed-area sample plots to provide more information on the structure of the forest.

Productive Forest Land Classification (AVI)

The classification of forest stands differs somewhat from that of Phase 3. Each forest stand is assigned a six-part description including species composition, crown closure, height, stand origin, site class, and moisture regime. The stand structure (e.g., single story or multi-layer canopy), treatment, disturbance, and understorey are also described when appropriate. Figure 10 gives an example of a forest type map and legend for the AVI.

Species composition is a list of all tree species in the stand in decreasing order of content. Composition is based on the percent crown closure. The description consists of up to five species, in 10 percent classes, with each contributing a minimum of 10 percent of the stand content. Species may be combined for stands containing more than five species.

Crown closure is the percent of ground area covered by a vertical projection of the tree crowns. The interpreter uses a crown density scale as a guide and there are four classes: 6-30%, 31-50%, 51-70%, and 71-100% crown closure.

Stand height is estimated based on the average height of the dominant and codominant trees in a forest stand. The interpreter uses field measurements to calibrate the height, which is estimated to the nearest metre. Adjacent stands are separated into different stands if there is a height difference of 3 metres or greater between them.

Year of origin is assigned similar to the Phase 3 inventory. Where the actual stand origin is known it is coded in the database. Site index is an expression of forest site quality and is based on the average height, at a certain age, of the dominant and codominant trees in the stand, similar to the Phase 3.

Moisture regime is a new attribute. There are five classes: upland-undifferentiated, upland-rapidly drained, upland/mesic-moderately well drained, wet-water table at or near surface, and aquatic-permanent deep water.

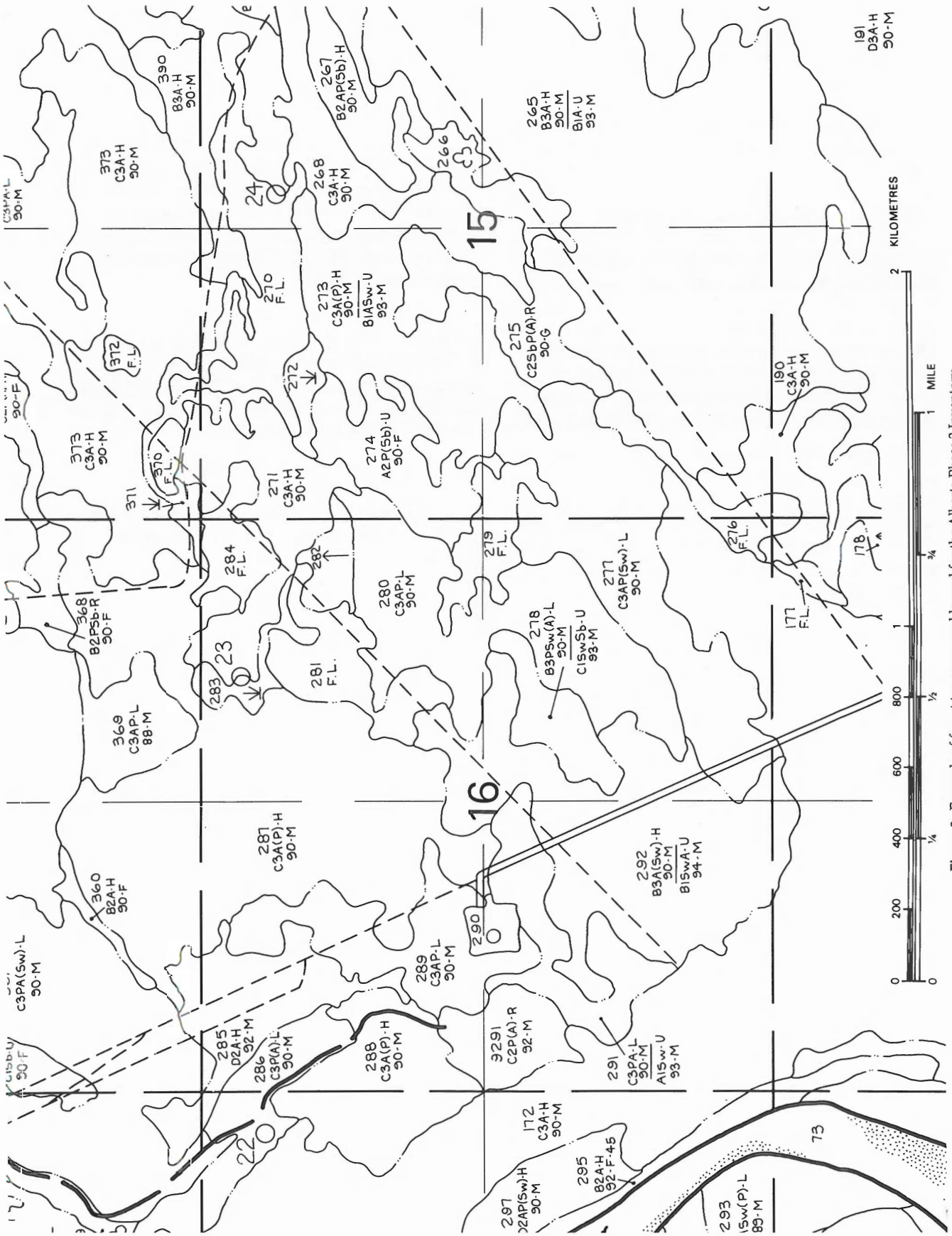


Figure 9. Example of forest type map and legend for the Alberta Phase 3 Inventory.

PHASE 3 FOREST INVENTORY

SCALE 1 : 15 000

LEGEND

STOCKED PRODUCTIVE FOREST LAND

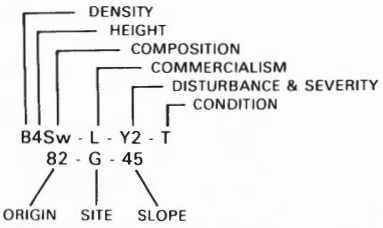
FOREST TYPE EXAMPLES

STANDARD

B3Sw - L
86 - M

ADDITIONAL INFORMATION

B4SwA(P) - L - Y2 - T
82 - G - 45



DENSITY

CROWN DENSITY

ALL STANDS, EXCEPT HEIGHT CLASS O WITH SOME CONIFEROUS CONTENT

6 - 30%	**A**
31 - 50%	**B**
51 - 70%	**C**
71 - 100%	**D**

CONIFEROUS REGENERATION STOCKING

CONIFEROUS AND MIXED WOOD STANDS IN HEIGHT CLASS O (% OF 4m² PLOTS)

6 - 19%	**A**
20 - 39%	**B**
40 - 59%	**C**
60%+	**D**

HEIGHT

AVERAGE HEIGHT OF DOMINANT AND CO-DOMINANT TREES

.0 - 6.0m (1' - 20')	**0**	18.1 - 24.0m (61' - 80')	**3**
6.1 - 12.0m (21' - 40')	**1**	24.1 - 30.0m (81' - 100')	**4**
12.1 - 18.0m (41' - 60')	**2**	30.1m + (101' +)	**5**

COMPOSITION

STAND COMPOSITION IS A LISTING OF SPECIES IN ORDER OF DECREASING CONTENT. SPECIES UP TO 10% ARE IGNORED. SPECIES 11 - 20% ARE IN BRACKETS. e.g. SwA(Sb)

WHITE SPRUCE	**Sw**	TREMBLING ASPEN	**A** or **Aw**
BLACK SPRUCE	**Sb**	BALSAM POPLAR	**A** or **Pb**
LODGEPOLE or JACK PINE	**P**	WHITE BIRCH	**A** or **Bw**
BALSAM or ALPINE FIR	**Fb**		
DOUGLAS FIR	**Fd**		
TAMARACK or OTHER LARCH	**Lt**		

CONIFEROUS COMMERCIALISM

LUMBER - 50m³/ha (700cu.ft./ac.) + GROSS CONIFEROUS SAWLOG 20+/13 (8+/5) AND AT LEAST 60% OF STEMS OF SAWLOG SIZE ..... **L**

ROUNDWOOD - 50m³/ha (700cu.ft./ac.) + GROSS CONIFEROUS ROUNDWOOD 13+/7 (5+/3) ..... **R**

HIGH UNCOMMERCIAL - 50m³/ha (700cu.ft./ac.) + GROSS ROUNDWOOD ALL SPECIES 13+/7 (5+/3) ..... **H**

LOW UNCOMMERCIAL - LESS THAN 50m³/ha (700cu.ft./ac.) + GROSS ROUNDWOOD ALL SPECIES 13+/7 (5+/3) ..... **U**

DISTURBANCE

FACTOR		SEVERITY		%LOSS
VARIOUS	**V**	LIGHT	**1**	1 - 25
WINDFALL	**W**	MODERATE	**2**	26 - 50
CUT	**X**	HEAVY	**3**	51 - 75
BURN	**Y**	SEVERE	**4**	76+
INSECT and DISEASE	**Z**			

CONDITION

SITE IMPROVED ..... **A**
SEEDBED PREPARED ..... **B**
PLANTED and/or SEEDED ..... **C**
THINNED ..... **D**
STAGNANT ..... **S**
TERMINATING and DECADENT ..... **T**

ORIGIN

10 YEAR INTERVALS		20 YEAR INTERVALS	
1980 - 89	**98**	1971 - 90	**98**
1970 - 79	**97**	1951 - 70	**96**
1960 - 69	**96**	1931 - 50	**94**
ETC.		ETC.	

SITE

GOOD ..... **G**
MEDIUM ..... **M**
FAIR ..... **F**

SLOPE

45% SLOPE or MORE **45**

UNDERSTORY

EACH PART OF A TWO STORY STAND IS GIVEN AN INDEPENDENT DESCRIPTION AND IS RECOGNIZED ONLY WHEN EACH COMPONENT IS TWO OR MORE HEIGHT CLASSES DIFFERENT.

e.g. B3A-H 90-M — OVERSTORY

B1Sw-U 94-G — UNDERSTORY

POTENTIALLY PRODUCTIVE FOREST LAND

BRUSH ..... **Brush**
BURN ..... **Burn**
CLEAR CUT ..... **C.C.**
INSECT and DISEASE KILL ..... **I.K.**
VARIOUS KILL ..... **V.K.**
WINDFALL ..... **W.F.**

NON-PRODUCTIVE FOREST LAND

SCRUB (CONIFEFOUS) .....
SCRUB (DECIDUOUS) .....
TREED MUSKEG .....

NON-FOREST LAND

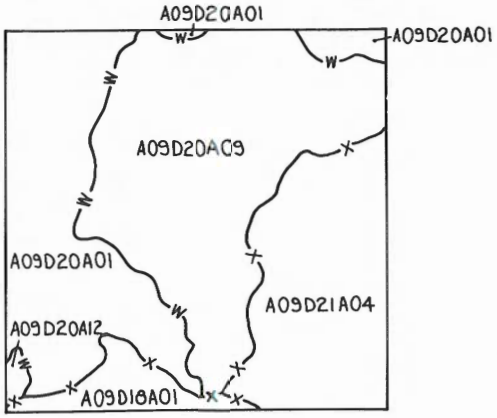
GRASSLAND .....
CUTBANK .....
OPEN MUSKEG, BOG, MARSH .....
SAND, SILT or GRAVEL .....
ROCK BARREN .....
SOIL BARREN (BEYOND TREELINE) .....
FLOODED LAND ..... **F.L.**
WATER ..... **W.**
CLEARED LAND ..... **Clg.**
CULTIVATED LAND ..... **Cult.**
UNCLASSIFIED LAND ..... **Uncl.**

PLANIMETRIC

TOWNSHIP LINE
SURVEYED
UNSURVEYED
SECTION LINE
SURVEYED
UNSURVEYED
QUARTER SECTION LINE
PRIMARY HIGHWAY (2)
SECONDARY ROAD (560)
HARD SURFACE ALL WEATHER (4 LANES / 2 LANES)
LOOSE or STABILIZED SURFACE ALL WEATHER
LOOSE or STABILIZED SURFACE
LOOSE SURFACE DRY WEATHER
TRUCK TRAIL
SEISMOGRAPH LINE or TRAIL
BRIDGE
FERRY (Fy)
FORD CROSSING SUBJECT TO CONDITION
RAILWAY
RAILWAY STATION - SIDING
PIPELINE - MAJOR
TRANSMISSION LINE
INVENTORY BOUNDARY
GREEN AREA BOUNDARY
FOREST BOUNDARY
FOREST MANAGEMENT UNIT BOUNDARY
PATENTED LAND
PARK BOUNDARY
FOREST RESERVE BOUNDARY
RIVER OVER 20 METRES WIDE
CREEK UNDER 20 METRES WIDE

INTERMITTENT CREEK
DAM
DITCH, CANAL or FLUME
LAKE
INTERMITTENT LAKE
GRAVEL BAR, SAND or MUD
HAMLET, POST OFFICE or LOCALITY
BUILDING
FOREST HEADQUARTERS
RANGER STATION
FORESTRY CABIN
LOOKOUT PRIMARY
SECONDARY (S)
LOOKOUT POINT or CRAWL TOWER
COMMUNICATION TOWER (T)
A.F.S. RECREATION AREA CLASS I or II - DEVELOPED
CLASS III - PARTIAL or UNDEVELOPED
ALBERTA TRANSPORTATION CAMPGROUND - SHELTER (A T)
AIRSTRIP (AIRSTRIP)
HELIPORT
HELIPAD
FLOAT LANDING
MINE or QUARRY
GRAVEL PIT (G P)
MILL SITE (M S)
SAWDUST PILE (S P)
WELL SITE
STORAGE TANKS or BATTERY SITE
SLUMP or SLIDE AREA and DIRECTION OF MOVEMENT
PERMANENT SAMPLE PLOT (P S P 150)

WATERSHED KEY



WATERSHEDS

XXXX
XXX
XX
X
WW
W

e.g. A 12 B 23 C 34

OCEAN DRAINAGE
MAJOR RIVER BASIN
BASIN SUBDIVISION
WATERSHED
MINOR WATERSHED
SUB-WATERSHED

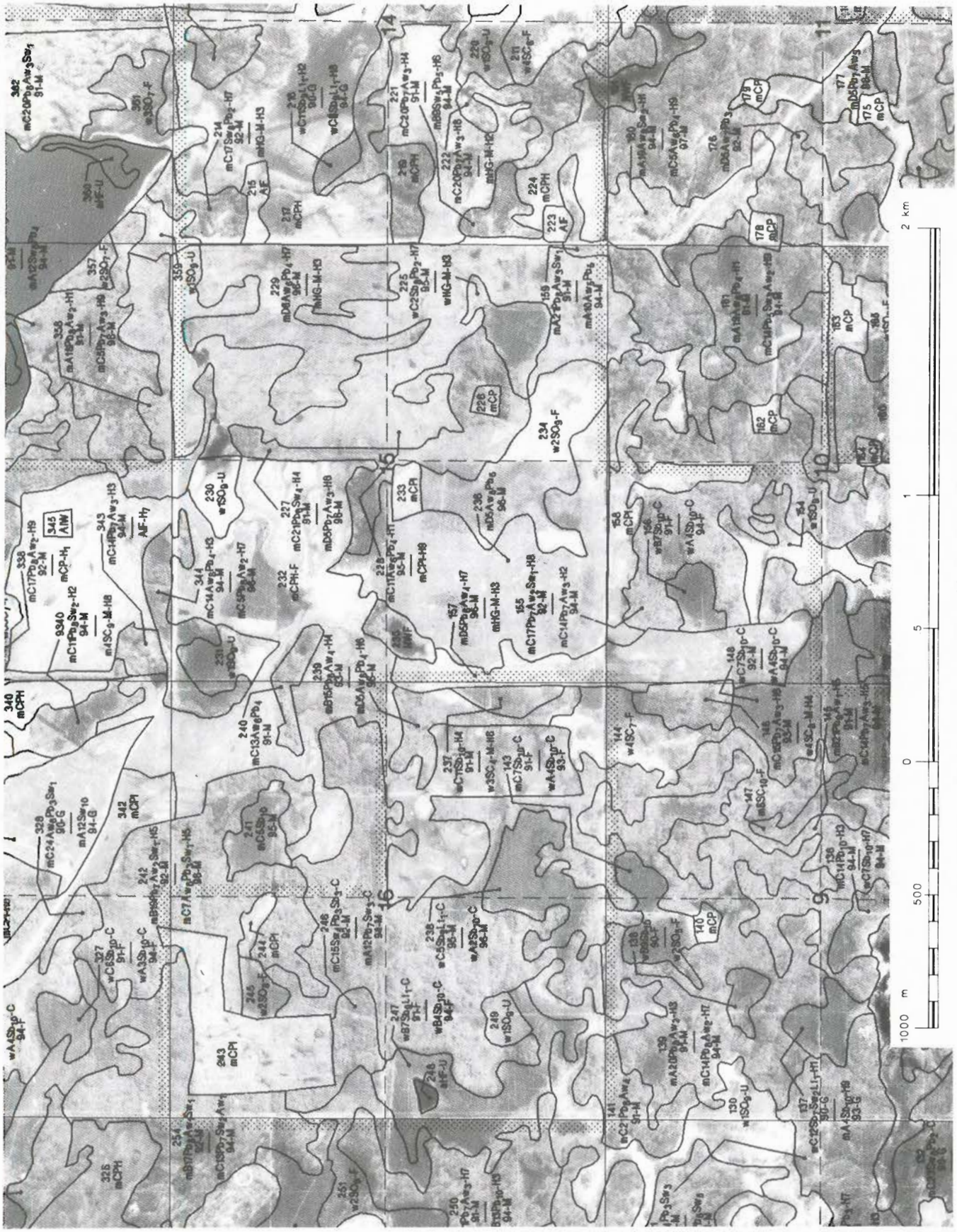
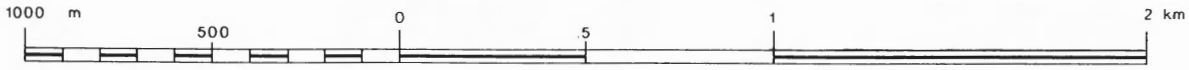


Figure 10. Example of forest type map and legend for the Alberta Vegetation Inventory.

INTEGRATED VEGETATION COVER MAP

SCALE 1 : 20 000



LEGEND

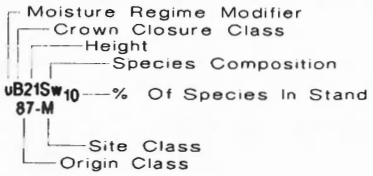
VEGETATED LAND

FOREST LAND

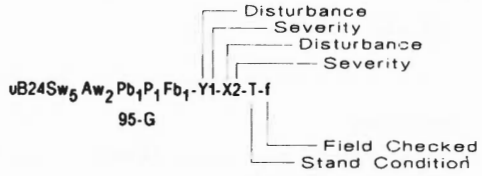
LAND SUPPORTING TREE COVER (INCLUDES SEEDLINGS AND SAPLINGS) WITH A CROWN CLOSURE OF ≥6% OF TREE SPECIES (SEE BELOW)

FOREST STAND DESCRIPTIONS

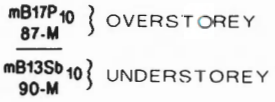
BASIC - SINGLE STOREY



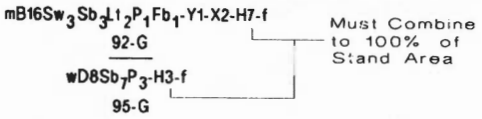
MAXIMUM LABEL - SINGLE STOREY



BASIC - TWO-STOREY



MAXIMUM LABEL - TWO-STOREY HORIZONTAL STRUCTURE



A MINIMUM OF A 3 METRE DIFFERENCE IN HEIGHT MUST OCCUR BETWEEN THE OVERSTOREY AND UNDERSTOREY BEFORE A STAND IS IDENTIFIED AS " TWO-STOREY " (DOES NOT APPLY TO STANDS WITH HORIZONTAL STRUCTURE).

MOISTURE REGIME MODIFIERS

APPLIES TO ALL VEGETATED LAND COVER TYPES

MODIFIER	CODE
UPLAND UNDIFFERENTIATED	u
UPLAND DRY	d
UPLAND MESIC	m
WET	w
AQUATIC	a

CROWN CLOSURE

PERCENTAGE OF GROUND AREA COVERED BY A VERTICAL PROJECTION OF CROWNS ONTO GROUND

CROWN CLOSURE (%)	CODE
6 - 30	A
31 - 50	B
51 - 70	C
71 -100	D

HEIGHT

STAND HEIGHT IS THE AVERAGE OF ONLY THE DOMINANT AND CO-DOMINANT TREES, ALL SPECIES AND IS ESTIMATED TO THE NEAREST METRE. ADJACENT STANDS SEPARATED ON THE BASIS OF HEIGHT ALONE MUST HAVE A HEIGHT DIFFERENCE OF GREATER THAN 3m.

SPECIES COMPOSITION

STAND COMPOSITION LISTS SPECIES (TO A MAXIMUM OF 5) IN DECREASING ORDER BASED ON CROWN CLOSURE. THE PERCENTAGE OF EACH SPECIES IS INDICATED TO THE NEAREST 10% WITH A SUBSCRIPT. THE SUBSCRIPTS MUST ADD UP TO 10 (i.e. 100%).

TREE SPECIES	CODE
WHITE SPRUCE	Sw
ENGLEMAN SPRUCE	Sw
BLACK SPRUCE	Sb
LODGEPOLE PINE	P
JACK PINE	P
WHITEBARK PINE	P
LIMBER PINE	P
BALSAM FIR	Fb
ALPINE FIR	Fb

TREE SPECIES	CODE
DOUGLAS FIR	Fd
WESTERN LARCH	Lt
EASTERN LARCH	Lt
ALPINE LARCH	Lt
TREMBLING ASPEN	Aw
BALSAM POPLAR	Pb
PAPER (WHITE) BIRCH	Bw
POPULUS SPECIES (UNDIFFERRENTIATED)	A

DISTURBANCES

DISTURBANCE FACTOR	CODE
DISEASE	V
WEATHER (e.g. WIND REDBELT)	W
PARTIAL CUT	X
PARTIAL BURN	Y
INSECT	Z

DISTURBANCE SEVERITY	CODE
LIGHT- 1-25% LOSS	1
MODERATE- 26-50% LOSS	2
HEAVY- 51-75% LOSS	3
SEVERE- 76 + % LOSS	4

CONDITION

CONDITION	CODE
SITE IMPROVED (AMELIORATION)	A
SEEDBED PREPARED (BED)	B
PLANTED AND/OR SEEDED (PLANTED)	P
THINNED (DENSITY CONTROL)	D
STAGNANT (STAGNANT)	S
TERMINATING (TERMINATING)	T
DEVELOPED FOR GRAZING (GRAZING)	G

STAND STRUCTURE

STRUCTURE	CODE
COMPLEX	C
- NO DISCRETE LAYERS VISIBLE OR MOSAIC PATTERN OF VARYING HEIGHTS. ALSO WHEN MANY LAYERS (INTERMIXED) PRESENT. 3m HEIGHT DIFFERENCE MUST BE PRESENT BETWEEN EACH STRUCTURE.	
HORIZONTAL	H
- HORIZONTAL RELATIONSHIP BETWEEN THE SUBSTANDS INSTEAD OF A TWO-STOREY OR COMPLEX STRUCTURE. 3m HEIGHT DIFFERENCE IS NOT REQUIRED BETWEEN EACH STRUCTURE.	

FIELD CHECKED

WHEN ALL ATTRIBUTES WITHIN A FOREST STAND DESCRIPTION HAVE BEEN CONFIRMED THROUGH INTERPRETER FIELD CHECKING, THE CODE "**f**" IS LABELLED IN THE STAND DESCRIPTION.

ORIGIN

BIRTH YEAR (10 YEAR INTERVALS)	CODE
1980-89	98
1970-79	97
1960-69	96
ETC.	ETC

FOREST SITE CLASS

CLASS	CODE
GOOD	G
MEDIUM	M
FAIR	F
UNPRODUCTIVE	U

NON-FOREST LAND

VEGETATED COVERTYPES WITH ≥ 6% PLANT COVER BUT < 6% TREE COVER

CLASSIFICATIONS	CODE
CLOSED SHRUB (CROWNS INTERLOCKING)	SC
OPEN SHRUB (CROWNS NOT TOUCHING)	SO
HERBACEOUS (GRASSLAND)	HG
HERBACEOUS (FORBS)	HF
BRYOPHYTE (MOSSES AND OR BRYOPHYTES)	BR

SHRUB HEIGHT AND CROWN CLOSURE	CODE
HEIGHT DESCRIPTORS OF 1-6 m (APPLIES ONLY TO SHRUB COVER)	1 - 6
PERCENTAGE OF SHRUB CROWN CLOSURE (WITH POLYGON AND INDICATED TO THE NEAREST 10% BY A SUBSCRIPT)	1 -10

MODIFIERS	CODE
CLEARCUT	CC
PARTIAL CUT	PC
IRRIGATED	IR
BURN	BU
WINDFALL	WF
CLEARING	CL
DISEASE/INSECT KILL	IK
UNKNOWN KILL	UK

A SITE INDEX **G, M, F,** OR **U** IF KNOWN IS APPLIED TO ALL NON-FOREST COVERTYPES. THIS MAY BE DERIVED FROM SIMILAR ADJACENT AREAS. THE DATE OF THE MODIFIER, IF KNOWNIS ALSO SHOWN. e.g. **m3SC$_7$ (CC-1951-M)**

THESE CLASSIFICATIONS AND MODIFIERS MAY BE USED IN CONJUNCTION WITH FOREST LANDS WHEN DESCRIBED IN A HORIZONTAL **(H)** TYPE OF STRUCTURE, OR A STANDARD TWO STOREY STAND.

ANTHROPOGENIC VEGETATED LAND

COVERTYPES THAT HAVE BEEN INFLUENCED BY MAN, USUALLY AREAS THAT HAVE BEEN PLANTED WITH CULTIVATED SPECIES (i.e. CROPS IN FIELDS).

AGRICULTURE	CODE
ANNUAL CROPS	CA
PERENNIAL FORAGE CROPS	CP

AGRICULTURE	CODE
HAYLAND	CPH
IMPROVED PASTURE	CPI
ROUGH PASTURE	CPR

THESE CATEGORIES MAY BE USED IN CONJUNCTION WITH OTHER VEGETATED AND NON-VEGETATED LANDS AS HORIZONTAL STRUCTURES.

NON-VEGETATED LAND

ANTHROPOGENIC NON-VEGETATED LAND

COVERTYPES CREATED BY MAN WITH <6% PLANT COVER.

SETTLEMENT AREAS	CODE
CITIES, TOWNS, VILLAGES & HAMLETS	ASC
RIBBON DEVELOPMENT, RURAL & RECREATION (i.e. RURAL STORES, ISOLATED HOUSING SUBDIVISIONS, COTTAGES, RURAL RESIDENTIAL, ACREAGE OWNERS). AGRICULTURE IS NOT THE PRIMARY INCOME SOURCE.	ASR

INDUSTRIAL DEVELOPMENT	CODE
PERMANENT RIGHT OF WAYS (i.e. AIRSTRIPS, MICROWAVE TOWERS SITES etc.)	AIP
PEAT EXTRACTIONS	AIE
GRAVEL PITS I/C BORROW PITS	AIG
FARMSTEADS (AGRICULTURE)	AIF
CULTIVATED (AGRICULTURE)	AIC
RECENT CLEARING AGRICULTURE	AIR
SURFACE MINES	AIM
GEOPHYSICAL ACTIVITIES I/C WELL SITES	AIW
RECENT LOGGING, CLEARCUT	AIL
INDUSTRIAL SITES	AII

NATURALLY NON-VEGETATED LAND

NATURAL COVERTYPES THAT HAVE <6% PLANT COVER

WATER	CODE
PERMANENT ICE/SNOW	NWI
SEASONAL THAWS: LAKES & PONDS	NWL
RIVER	NWR
FLOODED (AREAS PERIODICALLY INUNDATED WITH WATER)	NWF

MINERAL	CODE
RECENT BURN I/C NUMBER OF SNAGS (TO DATE NO RECOVERY OF VEGETATION)	NMB
CUTBANK	NMC
ROCK BARREN	NMR
SAND	NMS

THE ABOVE NON-VEGETATED LANDS MAY ALSO BE USED IN A HORIZONTAL STRUCTURE WITH VEGETATED LANDS.

GEOADMINISTRATIVE BOUNDARIES & SYMBOLOGY

CITY
TOWN
VILLAGE
SUMMER VILLAGE
SETTLEMENT
INDIAN RESERVE
METIS SETTLEMENT
PATENTED LAND
NATIONAL PARK
PROVINCIAL PARK
WILDERNESS AREA
NATURAL AREA
A.F.S. RECREATION AREA (FRA)
PARKS RECREATION AREA (PPR)
GRAZING RESERVE
ECOLOGICAL RESERVE
PHOTOGRAMMETRIC CONTROL POINT

MILITARY BASE
MILITARY RANGE
INTEGRATED RESOURCE PLAN (IRP)
EASTERN SLOPES INTEGRATED PLANNING AREA (ESIP)
INVENTORY BOUNDARY
GREEN AREA
FOREST RESERVE
FOREST BOUNDARY
FOREST MANAGEMENT UNIT
FOREST MANAGEMENT AGREEMENT AREA (FMA)
QUOTA AREA
PROVISIONAL RESERVES
MISCELLANEOUS TIMBER USE AREA
COMMUNITY FARM WOODLOT
EXPERIMENTAL FOREST

British Columbia

Overview

Forest inventory of Crown Lands in British Columbia has followed a 10- to 15-year cycle. The first inventory was from 1953 to 1960. The second cycle was completed between 1961 and 1976. A third cycle began in 1978 with the objective of improving the cost effectiveness of the inventory system by making use of modern computer technology and existing forest cover data. The initial emphasis was on upgrading volume information on populations previously sampled inadequately, digitizing existing forest cover type maps, and map update. Inventory mapping was conducted from 1978 to 1982 but ceased after that due to limited funding. In 1988 funds were made available for a fourth cycle of provincial inventory. This program is on a 10-year schedule and is to be completed by 1998. A special feature of the new cycle is that part of the previous inventory is on a GIS, and it is the first time a new inventory cycle is being conducted for maps already in digital format.

Approximately 2.5 years are required to produce forest type maps of a particular area. Aerial photographs are acquired in the summer and received by the Inventory Branch, British Columbia Ministry of Forests, in early winter. During the winter the photographs are reviewed for quality, historical data are assembled, and interpretation and digitizing contracts are prepared. Interpretation begins in the spring of the year following photo acquisition with the transfer of historical data to the new photography. This is followed, between May and November, by the delineation of stand boundaries and field work to provide information to help calibrate the interpretation. After field work, stand boundaries are confirmed or refined and forest cover attributes are interpreted for each stand. Final stand boundaries are then transferred onto a base map to conclude the interpretation contract, in March, of the second year. Stand boundaries are digitized under a separate contract. This contract overlaps the interpretation contract to allow digitizing to begin as soon as products from the interpretation contract have been quality checked and accepted. Digitizing is generally completed and quality checked by March of the third year. Volume sampling is ongoing following the production of the forest type map.

Scenario

All photointerpretation is done under contract. The interpretation contractor is responsible for historical data transfer, stand boundary delineations (stratification), field work, attribute interpretation, creating the attribute list, and transferring the interpretation to the base map. Historical data (e.g., old maps and plot data, as well as silviculture records) are reviewed and transferred to the new photographs to assist interpretation. Interpretation is unique in that delineation of stand boundaries is a separate process from ascribing attributes to the stand. Photointerpretation begins with a delineation of stand boundaries, followed by field work to confirm the location of stand boundaries and to gather information for calibration. There are three types of field observations: ground observations, in which just the stand attributes are estimated; air calls, which are observations of stand attributes from helicopter; and formal ground calls, which are plots of up to three prism points. Species, height, and age are measured. Air calls are more predominant in isolated areas whereas more ground checks are established in accessible areas. Sampling priority is placed on forest types that cause problems during interpretation. The number and type of field observations depend on the complexity of the area and budget and are agreed on between the contractor and the Inventory Branch. In general, approximately 1.5 days per mapsheet area are required for field checking, one day for ground work, including both observations and plots, and half a day for air calls, which will usually include 30 calls. Field work results and historical data are used by interpreters to modify the original type lines and to guide the interpretation of forest stand attributes.

There are several types of base maps used, depending on availability: TRIM (Terrain Resource Information Management) maps, old Ministry of Environment base maps, and the base maps from the previous forest inventory. The TRIM maps are new base maps produced in digital format. In some cases base maps had already been digitized for the previous inventory. The contractor is required to add new base map information (e.g., new roads and changing river channel boundaries) as well as new boundary information (e.g., new ownership boundaries) before adding interpreted features. Stand boundaries are transferred to the base map using conventional vertical projection equipment (e.g., sketchmaster). Finally, the contractor keypunches the stand attribute data into a computer file and delivers the map products and the data file to the Inventory Branch.

The Inventory Branch maintains a quality check role. There are four full time staff dedicated to support contract activities. They work with the contractor at each stage of the inventory contract (interpretation,

field work, base map, and transfer) to ensure procedures are being followed and to take care of problems as they arise. The Inventory Branch relies heavily on Regional and District inventory staff for assistance. A quality check of the final maps is conducted on approximately 5% of the mapped area (e.g., one photo flight line per mapsheet randomly selected). This check consists of Inventory Branch personnel looking at the photographs (generally along a flight line) and checking the stand delineations and attributes. Checking begins when a block of maps has been completed and continues until the completion of the project. If the quality of work is not up to standard the intensity of checking increases. There is also a check of the interpretation field work conducted by the contractor. A sample (the aim is to achieve 5 percent) of ground observations, air calls, and formal ground calls are visited and results checked with those of the contractor. The procedure is currently being modified to replace the percentage check with a statistically-based quality control process.

Digitizing of the final forest type map is also done by private contractors. They are required to digitize the various layers, from 1 to 18 depending on the amount of digital data already present in the system, and the amount of change since the map was digitized. For example, if digital data does not exist for a particular mapsheet, all 18 layers would have to be digitized; whereas if the 18 layers have been previously digitized and only the forest type layer has changed, then only the forest type layer would be digitized. The digitizing contractor is responsible for the final map product. The contractor produces a check copy of the map which is submitted to the Forest Resource GIS Section of the Inventory Branch for quality assessment. Checks are done by visual inspection plus a check of the attributes and summary data through automated computer check programs. Following quality check approval the contractor produces a final map for Branch approval. There are approximately 40 companies available for digitizing contracts. They range in size from 1 employee to over 100 employees and use a variety of hardware/software configurations.

The objective of the volume sampling portion of the inventory is to sample only those strata that are currently undersampled (i.e., inventory data from previous inventory cycles are used and only supplemented by new data). Volume sampling follows the production of the forest type map. Existing sample plots are assigned to a stratum according to the new forest type boundaries and descriptions. Sample data are used to determine stratum statistics, such as the number of sample plots required to achieve inventory objectives. In this manner, existing sample plot data are used to identify strata with an insufficient number of sample plots. New sample plots are measured and added to the database of existing plots to compile stand and stock tables by stratum for a forest inventory zone. These tables are applied to the area of the stratum, determined from the forest type map, to estimate volume for the stratum.

Productive Forest Land Classification

Land in British Columbia is defined and classified as forest land if it can be considered that it will provide the greatest contribution to the social and economic welfare of the province if it is predominantly maintained, under forest management, in successive crops of trees. All forest lands are classified into homogeneous units defined according to distinct differences in species composition, age, height, crown closure, stand structure, environmentally sensitive areas (ESA), operability, and history. An example of a forest type map and legend for British Columbia is provided in Figure 11.

Species composition is the percentage of each recognized commercial species based upon gross volume. All tree species that contribute to the main crown canopy are listed to the nearest 10 percent based on volume, in decreasing order, to a maximum of five species. For young stands, species composition is based on relative number of stems per hectare. A listed species must contribute a minimum of 6 percent to the canopy. The stand total must add up to 100 percent. A total of 27 commercial and 11 non-commercial tree species are recognized. A new stand is delineated if there is a 20 percent difference in major species.

Crown closure is the percent of the ground area covered by a vertical projection of the tree crowns. It is estimated to the nearest percentage, where possible, or to the nearest 10 percent. The interpreter is aided by use of a crown density scale as a comparator where the target stand is compared to a crown closure pattern of known value. An estimate of crown closure is made for each layer in the stand. Stands are defined by differences in closure of greater than 20 percent.

Stand height is estimated based on the average height of the dominant and codominant trees of the leading species in the stand. Height is estimated to the nearest 10 cm when possible, otherwise to the nearest meter. Ground or photo-measured heights are used by the interpreter for calibration.

Age is interpreted based on the average age of the dominant and codominant major species in the stand canopy. Age is determined to the nearest year or

assigned to a 10-year age class. Age is based on measurements, historic data, silviculture records, and on estimates. Stands are classified as even or uneven aged. Evenaged stands are stands with a small age difference, usually less than 20 years. For uneven-aged stands, age is specified as the average age of the dominants and codominants, plus an age range for all stems represented in the main crown canopy (e.g., 100 (50/150) would represent a stand age of 100 and an age range for the stand of 50 to 150).

Site quality is a derived attribute. The interpreter relates interpreted height and age to a site index curve or equation to determine site quality. Four classes of site quality are recognized: good, medium, poor, and low.

The interpreter also assigns a stand structure class, an environmentally sensitive area (ESA) category, an operability class, and history. Stand structure is the physical arrangement or pattern of the stand and is classified according to the organizational arrangement of age, height, and crown closure. Four classes are used: evenaged, uneven-aged, single layer, and multilayered.

Land may not be available for sustained timber harvest due to environmental sensitivities such as soil conditions, recreational activities, wildlife, and other factors. There are seven categories of ESA and each category has two classes: high, where land is not available, and moderate, where land may be available under certain circumstances. In order to assign ESA, the interpreter uses other resource maps (e.g., soil, wildlife, and recreation surveys and maps), as well as interpretation of factors such as shallow soils, steep rocky slopes, and indicators of erosion such as slides.

Inoperable areas are lands which contain merchantable timber but are not available for timber production using current harvesting practices. An area may be inoperable due to some disturbance or silvicultural activity. This information generally comes from historical records or local knowledge.

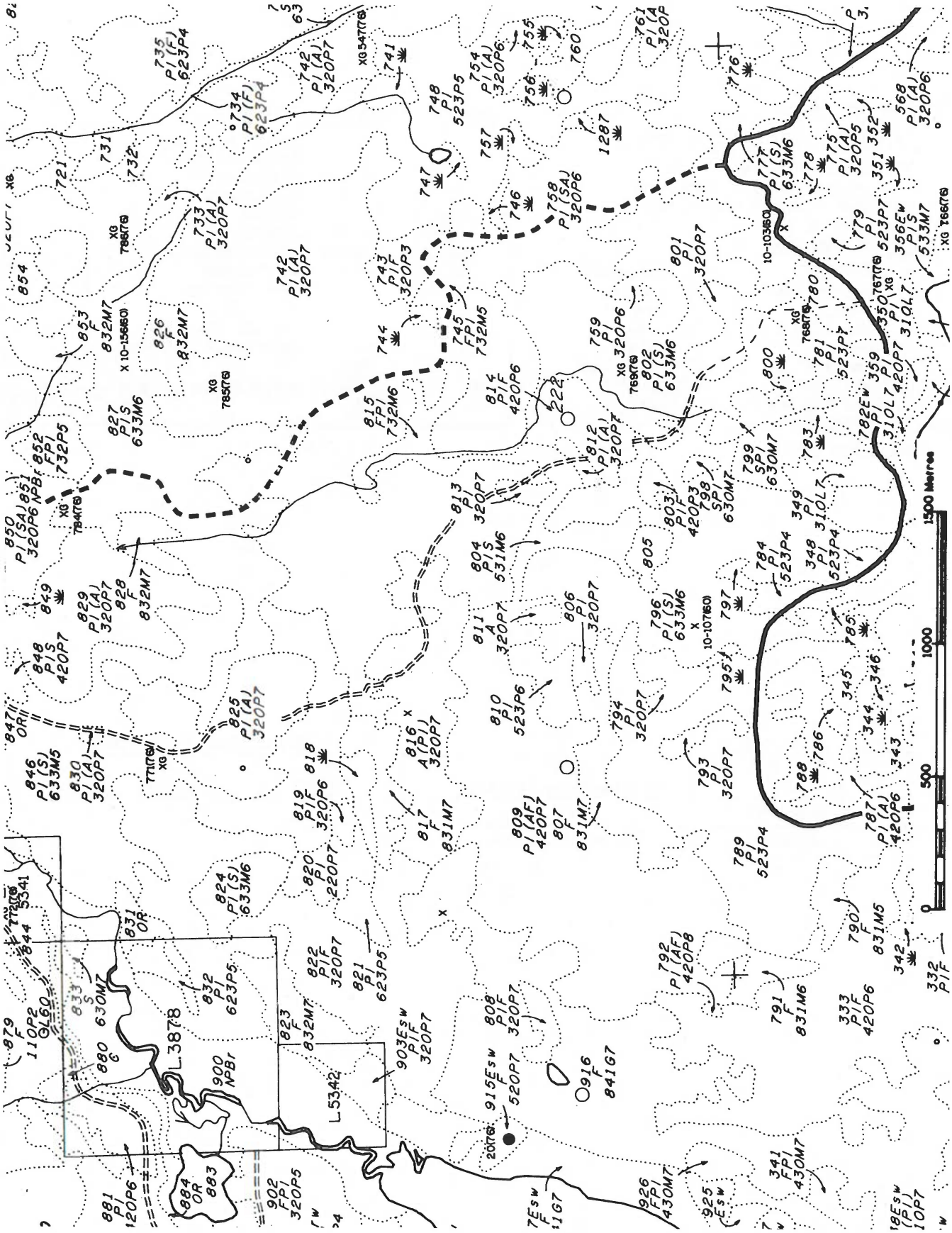


Figure 11. Example of forest type map and legend for British Columbia.

FOREST COVER MAP LEGEND

SCALE 1:20 000

I. FOREST LAND

A. FOREST LAND (FORESTED)

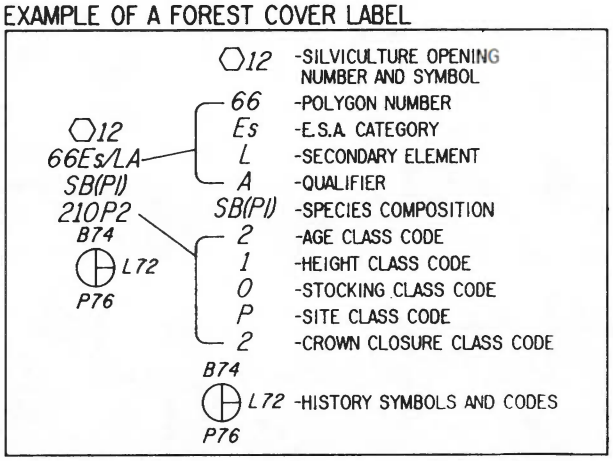
SPECIES COMPOSITION

Species are listed in their order of predominance. Major species are listed first followed by minor species in brackets.

SPECIES SYMBOLS

F -Douglas-fir.
C -Western red cedar.
H -Hemlock.
B -Balsam (True fir).
S -Spruce.
Sb -Black spruce.
Cy -Yellow cedar.
Pw -Western white pine.
Pa -Whitebark pine.
Pl -Lodgepole pine.
Py -Yellow pine.
L -Larch.
Ct -Cottonwood.
D -Red alder.
Mb -Broadleaf maple.
Bi -Birch.
A -Aspen.

EXAMPLE OF A FOREST COVER LABEL



AGE CLASS CODES

CODE	LIMITS (years)
1	1-20
2	21-40
3	41-60
4	61-80
5	81-100
6	101-120
7	121-140
8	141-250
9	251+

HEIGHT CLASS CODES

CODE	LIMITS (metres)
1	0-10.4
2	10.5-19.4
3	19.5-28.4
4	28.5-37.4
5	37.5-46.4
6	46.5-55.4
7	55.5-64.4
8	64.5+

SITE CLASS CODES

CODE	SITE
L	Low
P	Poor
M	Medium
G	Good

STOCKING CLASS CODES

CODE		APPLIES TO	LIMITS No. of trees/hectare, d.b.h. limits
0		all immature *	N.A.
1		all mature *	≥76/ ha, 27.5 cm+ d.b.h.
2		all mature	<76/ ha, 27.5 cm+ d.b.h.
Subdivision of 2	3	mature, with leading species Pl	≥311/ ha, 17.5 cm+ d.b.h. and ≥50% of stems 7.5 cm+ d.b.h. are ≥12.5 cm d.b.h.
	4		<311/ ha, 17.5 cm+ d.b.h., or ≥311/ ha, 17.5 cm+ d.b.h. and <50% of stems 7.5 cm+ d.b.h. are ≥12.5 cm d.b.h.

*

	All deciduous species; *Pl* ; *Pa.*	All coniferous species except *Pl* and *Pa.*
Immature	1-80 yrs.	1-120 yrs.
Mature	≥81 yrs.	≥121 yrs.

CROWN CLOSURE CLASS CODES

CODE	LIMITS (percentage)
0	0-5
1	6-15
2	16-25
3	26-35
4	36-45
5	46-55
6	56-65
7	66-75
8	76-85
9	86-95
10	96-100

SECONDARY ELEMENTS

L -Multi-layered stand.
S -Separate silviculture description is available in the data base.
V -Veteran component.

QUALIFIERS

A -Complex stand.
E -Environmentally sensitive area. (See below)
I -Inoperable.

ENVIRONMENTALLY SENSITIVE AREA (E.S.A.) CATEGORIES

CONSTRAINT CLASS	E.S.A. CATEGORY	E.S.A. DESCRIPTION
High	*Es*	Areas having severe soil and steepness problems.
	Ep	Areas having severe regeneration problems.
	Ea	Areas having severe snow chute and avalanche problems.
	Er	Areas where recreational values are exceptionally high.
	Ew	Areas of critical importance to wildlife.
	Eh	Areas where water values are exceptionally high.
Moderate	*E2r*	Areas where recreational values are high but less than *Er*.
	E2w ¥	Areas where wildlife values are important but less than *Ew*.
	E2h	Areas where water values are important but less than *Eh*.
Nil		Management practices on these lands are subject only to operational constraints consistent with the policies of the Forest Region.
	¥ Important areas for grizzly bears along salmon producing streams are identified by ⟨*E2wb*⟩.	

	SYMBOL	STREAM VALUE TO FISH AND STREAM SENSITIVITY TO HARVESTING
Fisheries	▲	Nil
	■	Low
	●	Moderate
	◆	High
Note: Absence of fisheries symbols indicates information not available.		

HISTORY SYMBOLS

CLASS AND SYMBOL	CODE	HISTORY
Stand Tending ⊖	*J*	Juvenile spacing
	M	Mistletoe control
	W	Brushing + weeding
	R	Conifer release
	S	Sanitation spacing
	P	Pruning
	T	Commercial thinning
	F	Fertilization
Site Preparation ⊖	*M*	Mechanical
	B	Broadcast burn
	S	Spot burn
	C	Chemical
	G	Grass seeded
	MS	Mechanical + spot burn

CLASS AND SYMBOL	CODE	HISTORY
Disturbance ⊖	*L*	Logging
	B	Wildfire
	W	Windthrow
	I	Insect
	D	Disease
	K	Fume kill
	S	Slide
	F	Flooding
Regeneration ⊖	*P*	Planted

B. FOREST LAND (NON-FORESTED)

NSR -Not satisfactorily restocked.
DSD -Disturbed, stocking doubtful.
NCBr -Non-commercial brush.

NCBr SPECIES SYMBOLS

D -Alder. *G* -Dogwood. *W* -Willow.
E -Birch. *M* -Maple.

C. FOREST LAND (UNPRODUCTIVE)

A For -Alpine forest (no forest description).
A + Forest Description.
NP + Forest Description.

II. NON-FOREST LAND

A -Alpine.
R -Rock.
-Slide.
NPCB -Non-productive burn.
NPBr -Non-productive brush.
NP -Miscellaneous non-productive.
-Swamp or muskeg.
C -Cultivated, cleared.
U -Urban.
OR -Open range.
M -Wild hay meadow.

Note: Other categories of non-forest land are written out in full or abbreviated. e.g. Claybank or Clay, Hayfield or Hay.

III. DATA SOURCES

●5(61)	-Ground sample, number (year) :pre-1979.
●7(67)G	-Growth sample, number (year) :pre-1979.
●8(68)V	-Volume and/or decay sample :pre-1979.
▮⟶18(79)	-Phase 1 -70 mm sample.
▯⟩6(79)	-Phase 2 -Ground sample.
▮▯⟩6(79)	-Phase 2 -With a Phase 1 sample.
▯▮⟩7(79)	-Phase 3 -Phase 2 with: growth plots.
▯▮▮8(79)	: decay plots.
▮▮▮9(79)	: growth+decay plots.

[o]7(80) I	-Intensive forestry sample.
[o]8(80)M	-Productivity sample.
X	-Air call.
XG	-Ground call with measurements.
XE	-E.S.A. air call.
XGE	-E.S.A. ground call.
XGR	-Regeneration survey ground call.
XGB	-Ecological research ground sample.
XGC	-Valuation cruise plots.
XL	-70 mm photography (pre-1979).
X⟶ L66-261(79)	-70 mm air call (1979+).

IV. MAP LABEL DESCRIPTIONS

A separate forest cover attribute list is available for each map sheet. Individual polygon details such as layered stands, rank, non-productive forest or non-forest descriptors, species composition to the nearest percent, age to the nearest year (or 10 yrs), age range, height to the nearest metre (or 0.1 m), reference year, special site, crown closure class to the nearest 10 percent, stocking (stems / ha), E.S.A., I(Inoperable), and data source are identified. The history attribute list shows the year and type of activity associated with that polygon. All forest information is updated to the year the map and attribute list are published.

A. EXAMPLES OF FOREST AND NON-FOREST MAP LABELS

1) *FH(C)*
94M'6
-A stand with F(Douglas-fir) and H(hemlock) as the major species and C(western red cedar) as the minor species. The stand is age class 9(251+ yrs), height class 4(28.5-37.4 m), site class M(medium), and crown closure code 6(estimated area occupied by the canopy through vertical projection is 56-65 %).

2) *≠H*
92-2
-An alpine forest stand with H(hemlock) as the only species. The stand is age class 9(251+ yrs), height class 2 (10.5-19.4 m), and crown closure code 2. Note that site is excluded for all non-productive forest types.

3) *NCBr*
W-P4
-A non-commercial species of W(willow) growing on a productive P(poor) site with crown closure code of 4.

4) *NSR-M*
⊖L78
-A not satisfactorily restocked area on a M(medium) site. The area was logged in 1978.

5) *NP*
⊖B71
-A non-productive site burned in 1971.

6) *E2w/L*
FPy
83P3
⊖L62
-A multi-layered stand (L) with an environmentally sensitive area classification of E2w(wildlife: moderate constraint). The most important layer is described as F(Douglas-fir) and Py(yellow pine). The stand is age class 8(141-250 yrs), height class 3(19.5-28.4 m), site class P(poor), crown closure class 3(26-35 %) and was logged in 1962.

7) *B*
31L/P4
⊖L72
-A residual stand of B(balsam), age class 3(41-60 yrs), height class 1(0-10.4 m), site class L(low), and followed by special site class P(poor), crown closure class 4(36-45 %), and logged in 1972. The special site class expresses the current rate of growth for a suppressed stand released by logging.

V. CARTOGRAPHIC SYMBOLS

.....	-Timber Supply Area boundary
.....	-Timber Supply Block boundary
- - - - - - - - - - - -	-P.S.Y.U. boundary
—·—·—·—	-Forest Region boundary
—·—·—·—	-Forest District boundary
———————	-Inventory Region boundary
- - - - - - - - - - - -	-Inventory Compartment boundary
.....	-Forest type line
- • • • — — — • • • -	-International boundary
- - • • — — — • • - -	-Interprovincial boundary
—·—·—·—	-Land District boundary
———————	-Township boundary
.....	-Municipal boundary
O^5 BC 4094 O^6	-Flight line, photo centres

═══════	-Main road
═ ═ ═ ═ :	-Secondary road
==========	-Other: e.g. logging, industrial, etc.
- - - - - - - - - - - -	-Trail
——+——+——	-Railroad
→——→——→	-Flume, ditch
→»——»——»	-Pipeline
——•——•——	-Powerline
⛏	-Mine
L·	-Lookout
⊔⊔⊔	-Dam
■P.O.	-Post office
(FS)	-Forest Service Office

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References

Gillis, M.D.; Edwards, J.D. 1988. Volume compilation procedures in forest management inventories. Inf. Rep. PI-X-79. Petawawa Natl. For. Inst., Forestry Canada, Chalk River, Ont.

Haddon, B.D., ed. 1989. Forest inventory terms in Canada, third edition. Canadian Govt. Publ. Centre, Ottawa, Ont.

Leckie, D.G.; Gillis, M.D. 1993. Forest inventory in Canada with emphasis on map production. (In preparation).

Plonski, W.L. 1974. Normal yield tables (metric). Ont. Min. Nat. Res.

Bibliography

Alberta

Alberta Department of Energy and Nat. Res. 1985. Alberta Phase 3 forest inventory: An overview. Rep. No. I/86.

Alberta Department of Energy and Nat. Res. 1985. Alberta Phase 3 forest inventory: Forest cover type specifications. Rep. No. 58.

Alberta Department of Energy and Nat. Res. 1985. Alberta Phase 3 forest inventory: Ground truthing procedures. Rep. No. 53.

Alberta Department of Energy and Nat. Res. 1985. Alberta Phase 3 forest inventory: Map cover type measurement specifications. Rep. No. 54.

Alberta Department of Energy and Nat. Res. 1985. Alberta Phase 3 forest inventory: Mapping specifications. Rep. No. 57.

Alberta Forestry, Lands, and Wildlife. 1989. Alberta vegetation inventory photo interpretation procedures.

Alberta Forestry, Lands, and Wildlife. 1990. Collective vegetation inventory standards manual. Pub. No. Ref. 38.

British Columbia

McLellan, J.F. 1988. Forest Classification. *In* B.C. Min. For. 1980. Forest and range inventory manual. Internal Report.

British Columbia Ministry of Forests. 1980. Forest and range inventory in British Columbia. Internal Report.

Hegyi, F. 1988. Overview of the inventory program. *In* Minutes of the Fourteenth Meeting, Canadian Forest Inventory Committee, Sault Ste. Marie, Ontario. Internal Report.

Manitoba

Manitoba Department of Natural Resources. 1989. Forest inventory field instruction manual. Internal Report.

Manitoba Department of Natural Resources. 1981. Forest inventory data compilation procedure. Internal Report.

Manitoba Department of Natural Resources. 1989. Five year report on the status of forestry. Vol.1.

New Brunswick

New Brunswick Department of Natural Resources. 1983. New Brunswick forest development survey field manual.

New Brunswick Department of Natural Resources. 1981. Technical specifications for vertical colour aerial photography for forest inventory purposes in the province of New Brunswick. Internal Report.

New Brunswick Department of Natural Resources. 1985. Tender call for aerial photointerpretation of Northeastern New Brunswick and transfer of photointerpretation to orthophoto mylar maps. Internal Report.

Newfoundland

Dunphy, A. 1976. Forest management inventory user requirements. Nfld. Dept. For. Agr. Internal Report.

Hutcheson, F.J. 1976. Labrador intensive inventory methods. Nfld. Dept. For. Agr., Int. Rep. FI-I-25.

Delaney, B.B.; Osmond, S.M. 1975. Manual of the design for the management inventory. Nfld. Dept. For. Agr., Int. Rep. FI-I-20.

Newfoundland Department of Forestry. 1990. Tender for land class identification and forest type classification Management District 19. Internal Report.

Nova Scotia

Wellings, F. ; Barron, B. 1984. Multistage integrated forest inventory field specifications. Nova Scotia Department of Lands and Forests.

Nova Scotia Department of Lands and Forests. 1989. Forest data base specifications. Internal Report.

Ontario

Ontario Ministry of Natural Resources. 1988. Cruising instructions (specifications) for the forest resources inventory. Internal Report.

Ontario Ministry of Natural Resources. 1987. Revised specifications for forest resources inventory photo interpretation. Internal Report.

Ontario Ministry of Natural Resources. 1987. Ontario government specifications for digital topographic data and cartographic representation at medium scales (1:10 000 and 1:20 000). Internal Report.

Prince Edward Island

Dendron Resources Surveys Ltd. 1982. Forest/biomass inventory of Prince Edward Island. Vol. 1.: Methodology. Internal Report.

J. Sewall Co. 1980. Specifications forest/biomass inventory Province of Prince Edward Island 1980. Internal Report.

Quebec

Ministre de l'Energie et des ressources du Québec. 1983. Normes d'inventaire forestier. Internal Report.

Saskatchewan

Benson, J.A. 1979. Changing technology in the Saskatchewan forest inventory. Pages 97-106 *in* Practical applications of remote sensing to timber inventory. Nor. For. Cen. Inf. Rep. NOR-X-224.

Lindenas, D.J. 1985. Specifications for the interpretation and mapping of aerial photographs in the Forest Inventory Section. Sask. Dept. Parks and Renew. Res. Internal Report.