THE ROLE OF PHOTO INTERPRETATION IN PROVIDING FOREST RESOURCE INFORMATION FOR IRM

Integrated Resource Management Project

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Eastern Ontario Model Forest

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INTRODUCTION

Integrated Resource Management (IRM), like any management technique, needs good information on the resource base. This information should not only identify the values that exist in an area, but also describe where they are and how they are changing. The IRM Project is an Eastern Ontario Model Forest initiative dedicated to demonstrating how good information can be obtained and used to develop IRM strategies within the model forest.

The Forest Resource Inventory (FRI) is a principal source of information available to support macro-planning, including forest management planning, in eastern Ontario. However, the inventory methods currently used in the FRI do not fully address the needs of IRM. The purpose of this study was to identify key information requirements for IRM and to investigate the role of aerial photo interpretation in enhancing current inventory methods to supply this information. The results of the trial should provide input into decisions on what enhancements should be incorporated into a new inventory of the EOMF area. The investigation recognizes that the current FRI specifications must form a base upon which enhancements can be added without modifying or omitting any part of the current process. Also the enhancements should be compatible with the Ecological Land Classification (ELC) system currently under development for Southern Ontario. Although the ELC standards have yet to be finalized, their development to date was used to identify some areas where photo interpretation may have potential.

The trial was completed over two test sites, one within each of the two IRM Project areas. It included photo interpretation according to the developed criteria, field checking of the interpretation, production of digital maps of the sites (for later information system development work) and an evaluation of the trial results. The study was not intended to develop the final set of photo interpretation enhancements for a broader inventory program. The results of this trial will, however, prepare for these developments.

PHOTO INTERPRETATION IN THE CURRENT FRI

The FRI is a management-level inventory designed to provide a snapshot of forest conditions over large areas (>20,000 hectares) to support a variety of resource planning uses. The development and maintenance of the FRI for Ontario is the responsibility of the Natural Resource Inventories Section (NRIS) of the Ministry of Natural Resource (MNR). Inventories are conducted over the province on a continuous 20-year cycle. The current FRI for the EOMF area was generated in 1980.

FRI inventories are generally undertaken on a Management Unit basis, taking three years to complete. The process is described in varying detail by Gillis and Leckie (1993), Parry (1993) and Rosehart (1987). In the first year, aerial photos are acquired, historical inventory maps, soils maps and other ancillary information are compiled and stands are selected for field sampling. In the second year, field work is carried out and photo interpretation is completed. In the third year, mapping, digitizing and compilation are completed.

Inventory products provided by FRI generally include: forest stand maps, area summary reports, forest stand attribute files and digital map files.

Aerial Photography

Aerial photographs are the primary tool used in the FRI to identify and describe forest stands. The Inventories Data Acquisition Unit of NRIS is responsible for acquiring and interpreting the photographs. Generally, photography is contracted out to private aerial survey companies with specifications calling for 1:10,000 black and white panchromatic aerial photographs (1:20,000 in northern Ontario) taken in late spring or summer during leaf-on conditions.

Once the aerial photos have been obtained, NRIS photo interpreters (Inventory Specialists) work with MNR District or forest company staff to compile available information on the inventory area. This may include the old FRI maps, silvicultural summaries, soils maps and operational cruise data. The interpreters review the photographs and subjectively select representative stands for field sampling. These stands cover a wide range of forest types and are located within readily accessible areas. Field work is carried-out by either MNR staff or by private contractors. Within each selected stand, a field plot is established which consists of 10 prism points located 20 metres apart along a transect. At each

point, a prism sweep is conducted with trees tallied by species and diameter class. At pre-specified points, ages and heights are measured from representative trees of the working group species. The data from each plot is compiled to provide a description of the species composition, working group, age, height and stocking of the stand. A minimum of 5% of the plots are check cruised to assess data quality.

Photo Interpretation

Once field work is complete, the interpreters assemble all the necessary maps, reports and data on the inventory area. With this information and with field knowledge gained from the check cruising, they systematically delineate and classify the inventory area on the aerial photos according to the Specifications for Forest Resources Inventory Photo Interpretation (OMNR, 1991). These specifications were developed by NRIS as a guide to FRI interpretation and to provide a standard method for delineating, describing and classifying forested and non-forested lands. A copy of the specifications is provided in Appendix A. The basic classification system is as follows:

1. WATER

2. NON-FORESTED LAND
   - (I) Developed Agricultural Land
   - (Ii) Grass and Meadow
   - (Iii) Unclassified Land

3. Forested Land
   - (A) Non-productive Forested Land
     - (i) Treed Muskeg
     - (ii) Open Muskeg
     - (iii) Brush and Alder
     - (iv) Rock
   - (B) Productive Forested Land
     - (i) Stand
     - (ii) Barren and Scattered

   Productive forested land is separated on the following basis:
   - Ownership
   - Working Group
   - Stand Age
   - Stand Height
   - Stocking

Compilation

The Ontario Base Mapping Program (OBM) provides the base maps on which the information interpreted from the photographs is added to produce forest cover maps. OBM maps are available at scales of 1:10,000 and 1:20,000 for southern and northern Ontario respectively which are the same scales as the photographs acquired for the FRI. Since 1987, geographic information systems have been used to automate the mapping process in areas where OBM maps are available in computer (digital) format. The basic steps in the process are as follows:

Transfer: Forest stand boundaries are transferred from the aerial photographs to a chronoflex plot of selected OBM base features. Where required, new base features, such as ownership boundaries, are also added to the chronoflex.

Map Automation: The features added to the chronoflex are digitized using either manual digitizing or computer scanning. The resulting map files are validated through a sequence of checking, editing and cleaning. Once the line work is digitized, labels are assigned to each map polygon.

Attribute Compilation: Stand attributes interpreted from the photographs are transferred to coding sheets and key-entered into map attribute files using customized data entry programs. These programs also serve to validate the attributes as they are entered. Summary reports, plotted maps, computer map files and map attribute files are generated for the inventory area.

REQUIREMENTS FOR AN ENHANCED INVENTORY

IRM Requirements

A fundamental requirement for IRM is an up-to-date forest inventory that describes, classifies and maps forest units (stands) at a resolution and accuracy sufficient to support ecosystem-based resource planning and management. The sufficiency of the inventory for this role depends on how it is applied in local planning and management processes and on the complexity of the landscape inventoried.

The FRI is satisfactory for the macro-planning tasks it was designed for. However, in eastern Ontario, it is being called upon to serve an increasing variety of resource planning tasks. These tasks include IRM, official planning for upper and lower-tier municipalities, wood-supply analysis, habitat supply analysis and private land forestry. The information and resolution requirements vary from task to task. The current FRI suffices where information on individual stands are aggregated to provide a general picture or summary of the resource, such as regional wood-supply analysis, but is insufficient for applications that require information on the specific composition and structure of individual stands, such as habitat supply analysis.

Relative to the northern and central regions, the forest landscape of eastern Ontario is complex in its composition, structure and spatial arrangement. Much of it is fragmented, physically with a large portion consisting of small woodlots dispersed over landscapes dominated by agricultural areas, and administratively with the majority of land being privately owned. In the current FRI, all stands are characterized as even-aged groups of trees. There is no means of adequately describing the structure of the multi-tiered, multi-aged stands common in eastern Ontario. With a minimum stand size of 8 hectares, the spatial resolution of the FRI is not fine enough to accurately depict the largely fragmented forest of eastern Ontario. Also, the means of classifying and mapping small but ecologically significant features such as riparian strips, hedgerows or permanent openings within stands are inadequate. Nor is there a means for recording various natural and man-caused impacts on stands, such as natural disturbances, fires, silvicultural history, development features or physical characteristics which limit operations.

Inventory User Group

To support IRM in eastern Ontario, a new enhanced FRI is needed. In this trial, a number of these enhancements were identified and developed into a set of photo interpretation specifications which were applied to the two test sites. The results were then assessed to determine if the information could be acquired accurately, consistently and at an acceptable cost.

The enhancements to the FRI were identified by a group of local inventory users from the MNR and Domtar Forest Products. The group included the following:

Martin Streit	Area forester for Lanark County, OMNR Carleton Place
Don Cuddy	Forest Ecologist, OMNR Kemptville
George Velema	Management Forester, Domtar Specialty Papers
Steve Rand	Forest Technologist, Domtar Specialty Papers
Greg Lawrance	Inventory Specialist, OMNR Sault Ste. Marie
Ian McKirdy	Remote Sensing Specialist, Dendron Resource Surveys
Andy Welch	Forestry Consultant, Dendron Resource Surveys

The group examined the type of information currently provided by the FRI and identified additional information needed by them to carry-out integrated resource management in the project areas. The results of this meeting were organized and reported in the document Proposed Photo Interpretation Specifications for an Enhanced FRI The proposed additions to the current FRI specifications are summarized below:

Forested Land - Non-Productive

- provide additional descriptions of treed muskeg and open muskeg
- identify and classify riparian zones
- identify and classify hedgerows

Forest Land - Productive

- include all species present in species composition
- describe the vertical and horizontal stand structure
- classify crown closure to 10%
- classify forest health/productivity
- describe understorey component of multi-storeyed stands
- delineate or describe small permanent openings
- classify soil moisture

Other

- identify and describe ownership features
- describe specific management activities ie. Shelterwood harvest

TESTING THE ENHANCEMENTS

Specifications Development

Once the requirements for an enhanced inventory had been identified, three photo interpreters from Dendron Resource Surveys, Domtar Specialty Papers and the MNR-Natural Resource Inventories Section (NRIS) met to further develop the specifications proposed by the users group. In this task the interpreters first assessed the likelihood of accurately extracting the requested information from 1:10,000 aerial photography and, where appropriate, propose a method for interpreting and classifying that information. The interpreters were also asked to review the current FRI specifications and comment on their suitability for a forest inventory of the model forest area. The interpreters included:

Elaine Read, Photo Interpreter	Dendron Resource Surveys
Steve Rand, Industrial Forestry Technician	Domtar Specialty Fibre Papers
John Cybulski, NRIS Inventory Specialist	OMNR Sault Ste. Marie

Proposed Specification

Through the process described above, NRIS's photo interpretation specifications were expanded to include standards for interpreting and recording the additional information identified by the user group. The intent was to use the current specifications as a base on which to build, without modifying or omitting any part of the current process. The results were assembled in the document Photo Interpretation Specifications Used in the Photo Interpretation Trial The current version of this document is provided in Appendix B

Interpretation Test

The first step in evaluating the proposed specifications was a review by a broad group of foresters, wildlife managers, planners, ecologists and inventory experts. Feedback from the reviewers was then used to further revise the proposed specifications.

The specifications were then tried and tested to determine if the information collected through their application provided the users with what they wanted, and if it could be provided accurately and consistently. The trial was carried out by applying the specifications to two test sites, each covering an area bounded by one 1;10,000 OBM sheet. These sites, shown in Figure 1, were selected because they were representative of the landscapes of each of the larger project areas. Recent aerial photographs (1991) were obtained from NRIS. The 1980 FRI maps and county soils maps were assembled and operational cruise (OPC) data was obtained from local MNR offices.

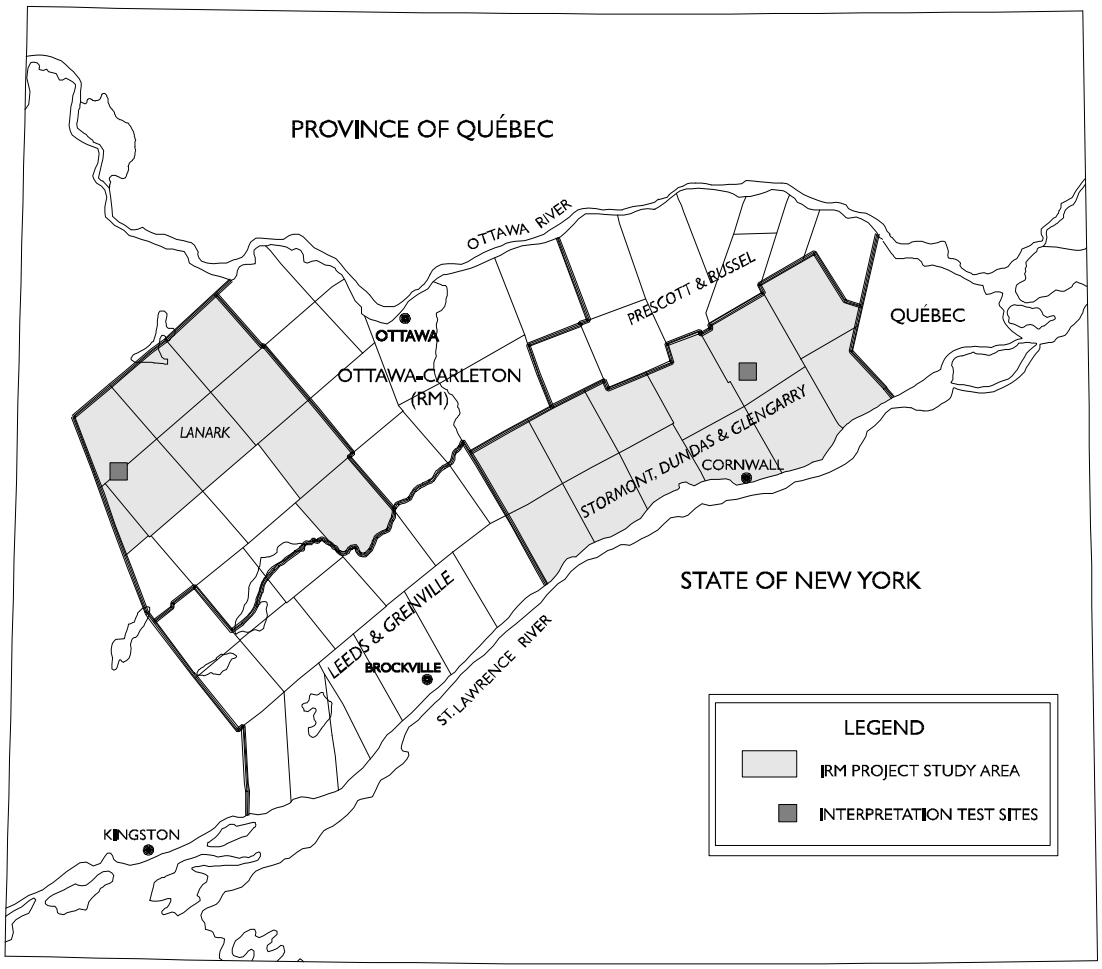

Figure 1. A map of the Eastern Ontario Model Forest showing the IRM Project Areas and the photo interpretation test sites.

Photo interpretation was carried out by Elaine Read, an experienced photo interpreter with Dendron. Her first step was to develop an approach for incorporating the proposed enhancements in her standard FRI photo interpretation methodology. This consisted of refining her personal interpretation key to accommodate changes in the basic FRI classification scheme and the development of new keys

to classify features under the enhanced specifications. Using her new key, Elaine interpreted all of the photographs covering each test block. Her interpretation was aided by information compiled from silvicultural records, operational cruise results and other data that had been previously collected for the areas.

As soon as the interpretation was completed, a field verification test was done to analyse how accurately the enhancements were interpreted from the 1:10,000 photographs. This test was conducted by sampling a number of stands on the ground in each area and comparing the field interpreted values to the photo interpreted values for each parameter. Where required, modifications to the interpretation were made following the testing.

A prototype Enhanced Forest Resource Inventory Map and accompanying database were generated for each area.

SUMMARY OF RESULTS

1. Non-productive Forest

1.1 Species Composition for treed muskeg

Objective:	Interpret species composition for all treed muskeg.
Procedure:	Treed muskegs were delineated and classified as per the current FRI specifications and species composition of the dominant tree components was interpreted for these areas.
Results:	The species composition of treed muskeg areas were accurately assessed from the 1:10,000 scale photography. In some cases muskeg areas were populated by standing dead trees. In these cases no species composition was assigned, however, the modifier CH (chicot) was added to the stand description.
Recommendation:	The species composition of treed muskeg areas should be included in the specifications for an Enhanced FRI for eastern Ontario. Under current specifications, all wetlands are classified as muskeg or treed muskeg. Consideration should be given to whether or not wetlands can and should be broken down further in the FRI. For instance a separation of wetlands into bog, fen, marsh or swamp may be useful for wetland evaluation and monitoring purposes. This type of enhancement was not evaluated in this

trial because the interpreters involved had limited experience with interpreting wetlands from aerial photos.

1.2 Riparian zones

Objective: Delineate and classify riparian zones occurring in forested and non-forested area.

Procedure: Riparian zones less than 50 metres wide and 100 metres long were delineated with a line on the photographs and typed as R1 if the riparian zone is on one bank of a stream or river (or around a lake) or as R2 if the riparian zone covers on both banks of a stream or river.

In addition, one of the following modifiers was used to describe the vegetative composition of the riparian zone.

(C) -	Continuous treed	(tree cover >70 %)
(B) -	Broken treed	(tree cover 30 - 70%)
(S) -	Shrub	(predominantly shrubs, tree cover <30%)

Riparian zones wider than 50 metres were delineated and typed as regular forest stands to which a RZ stand modifier was attached.

Results: Riparian zones containing tree or shrub vegetation situated along the banks of rivers and streams occurring in non-forested areas are easily delineated and classified.

Riparian zones located within largely forested areas could not be easily delineated in most circumstances.

Recommendation: The actual width of a riparian strip is an important factor which impacts on how the area functions, including how it will be used by wildlife. Under the proposed specifications, narrow riparian strips, less than 10 metres wide, are not distinguished from broader strips of up to 50 metres wide. To address this, the classification system proposed should be modified to split riparian strips into different width classes. This may be accomplished as follows

Class	Cover Type		Width
1 - one bank	(C) -	Continuous treed	1 - 1-15 m
2 - both banks	(B) -	Broken treed	2 - 16-30 m
	(S) -	Shrub	3 - 31-50 m

eg. 2-C-3 *(2-sided, continuous treed, 31-50 metres wide)*

Riparian zones in forested areas cannot be delineated using photographs alone. However, important information on vegetative communities that occur

around water bodies can be captured by increasing the resolution of interpretation (reducing the minimum stand size from 4 to 2 hectares) within a set distance of aquatic areas (100 metres).

1.3 Hedgerows

Objective: Delineate and classify hedgerows (strips of shrub and/or tree vegetation in agricultural areas).

Procedure: Hedgerows less than 50 metres wide and more than 100 metres long were delineated on the photographs with a single line broken by an 'X' and were classified according to the following criteria:

(C) -	Continuous treed	(tree cover >70 %)
(B) -	Broken treed	(tree cover 30 - 70%)
(S) -	Shrub	(predominantly shrubs, tree cover <30%)

A dashed line was used where hedgerows did not divide polygons and a solid line was used to where hedgerows did divide polygons (ie developed agricultural land next to grass & meadow). Hedgerows greater than 50 metres wide were delineated and classified as regular forest stands.

Results: Hedgerows were easily delineated and classified correctly with the exception of very thin hedgerows consisting of short shrub cover.

Recommendation: The specifications for an enhanced FRI should include the delineation of hedgerows in a manner similar to the above. The classification of hedgerows should, however, include some breakdown of width such as the following:

Cover Type		Width
(C) -	Continuous treed	1 - 1-15 m
(B) -	Broken treed	2 - 16-30 m
(S) -	Shrub	3 - 31-50 m

eg. B-2 *(broken treed, 16-30 metres wide)*

2. Productive Forest

2.1 Stand structure

Objective: Classify the vertical and horizontal stand structure of productive forest stands.

Procedure: The Vertical Structure of stands was classified as either *simple*, *two-tiered* or *complex* according to the following criteria:

Single-tiered	have one single dominant canopy layer,
Two-tiered	have two distinct canopy layers differing in average height by at least 3 metres and with each tier having a crown cover density of more than 30%,
Complex	have more than two canopy layers differing in average height by 3 metres and each having a crown cover density of 30% or more.

The Horizontal Structure (the dispersal pattern of sub-components) of stands was classified as *even* or *clumped* according to the following criteria:

Even	generally homogenous dispersion of species/size components over the majority of the stand area.
Clumped	uneven mixture of species/size components which form small groups of distinctly different stands which are too small to be delineated on 1:10,000 scale photos.

Stand structure classifications were incorporated in the stand descriptions using stand modifiers appended to the regular stand descriptions.

Results:

Vertical Structure

The accuracy of the stand structure classification was checked by comparing the photo interpreted classes with field interpreted classes for selected stands in each site. Results showed that the vertical structure was classified correctly for 92% of the stands in the Lanark site and 86% of the stands in the Cornwall site. The majority of errors that occurred in both sites were with the classification of simple stands as complex. The classification matrix compiled from the field test is presented below. The rows in the table divide stands by structure classes interpreted from the aerial photos while the columns divide stands by the structure classes observed in the field. For instance, in the field 33 stands were observed to have a simple structure, of these, 30 were interpreted from the photos as simple and 3 as complex.

Horizontal Structure

The horizontal structure of most of the stands in both areas was classified as *Even* (uniform dispersal of sub-components). Difficulty was experienced in classifying the horizontal structure of the sub-components of pure deciduous or pure coniferous stands. Since horizontal structure is difficult to assess in the field, no classification matrix was compiled. The vertical structure of mixed stands (conifers and hardwoods) was more easily classified.

Recommendation: A vertical structure classification could be successfully incorporated into the specifications for an enhanced inventory using a system similar to the above.

The classification of the horizontal structure of stands should be limited to describing the conifer components of deciduous working groups and the deciduous component of mixed conifer working groups.

2.2 Species composition

Objective: Identify all species types occurring within the main storey of single-tiered stands and the upper storey of multi-tiered stands.

Procedure: The interpretation of species composition was carried out as per the current FRI specifications except that there was no intentional grouping of species (ie red maple and silver maple) and minor species, which made up less than 10% of the basal area of each stand, were also recorded.

The current FRI specifications for assigning working groups were not changed in the trial.

Results: Species that are traditionally grouped in the FRI (eg silver and red maple or green and white ash) could not be accurately discriminated on the 1:10,000 photos and were also grouped in this trial. If sufficient field data were available it may have been possible for the interpreter to calibrate or "train" his/her interpretation techniques to discriminate these species. The field data necessary to do this was not available for this trial.

Major species (each making up at least 10% of the stand) were accurately interpreted, with 85% of the checked stands typed to include all major species observed in the field. The interpretation of minor species (those which make up less than 10% of the stands) were less accurately interpreted with 64% of the checked stands typed to include all the minor species observed in the field. The classification tables for major and minor species are provided on the following page.

Recommendation: The enhanced specifications should include a species composition description that includes all species identified within a stand. This would be done recognizing that the error in typing the minor species (mainly omissions) of stands would be higher than that for the major species.

The inventory should include a mechanism to allow users to correct or update the species composition of any stand.

2.3 Crown cover density

Objective: Classify the crown cover density to the nearest 10 percent for the main canopy of single-tiered stands and the upper canopy of multi-tiered stands.

Procedure: In FRI photo interpretation, crown cover density is assessed to determine the stocking for a stand but only the stocking estimate is recorded. In the trial crown cover density was integrated into the stand descriptions.

Results: Crown density was classified accurately for most stands using the 1:10,000 photography. Photo interpreted classes matched field assessed classes for over 90%. It should be noted that crown cover density is difficult to assess in the field and that the photo assessments may be more accurate than the field assessments. The classification matrix for crown density is presented below.

Recommendation: Ten percent crown cover density classes should be included in the specifications for an enhanced inventory.

2.4 Understorey species composition

Objective: Identify all species types occurring within the lower tier of two-tiered stands.

Procedure: For stands classified as two-tiered, the interpreter attempted to key out individual species types and relative percentages for the lower tier described in 2.2 above.

Results: The ability of the photo interpreter to accurately type the lower tier of a stand was largely dependant on the density of the upper tier. Where the crown density of the upper tier was above 40%, generally too much of the lower tier was obscured for accurate interpretation.

Recommendation: The enhanced inventory specifications should include the interpretation of both tiers of two-tiered stands if the upper tier density is 40% or lower. Where the upper tier density is above 40%, the composition of the lower tier should be typed to broad classes such as deciduous or conifer, if possible.

The inventory should include a mechanism to allow users to input the full species composition of any two-tiered stand if field information is available.

2.5 Understorey age, height, stocking & crown density

Objective: Assess and classify the age, height, stocking and crown density of the lower tier of two-tiered stands.

Procedure: The interpretation of age, height, stocking and crown density for the lower tier of two-tiered stands was carried out using the same procedures specified for single-tiered stands.

Results: The ability of the interpreter to accurately assess the age, height, stocking and crown density of the understorey was reduced when the overstorey density exceeded 40%. Accurate assessments were achieved in stands where the overstorey crown density was 40% or lower.

Recommendation: The enhanced inventory specifications should include the interpretation of age, height, stocking and crown density of both tiers of two-tiered stands if the upper tier stocking is 40% or lower. If the upper tier stocking is above 40%, no typing of these parameters for the lower tier should be done unless field data is available. The inventory should include a mechanism to allow users to input information on the age, height, stocking and crown density of the lower tier of any two-tiered stand.

2.6 Soil moisture regime

Objective: Assess and classify soil moisture for each productive forest stand.

Procedure: The soil moisture regime of a stand was inferred from slope, position-on-slope and the type and nature of vegetation in the stand area. Soils maps and field information were used to calibrate the interpretation of soil moisture. The soil moisture classifications applied in the trial are as follows:

Class	Code	OIP Class[1]	Description
Dry	d	Θ,0	very-rapid or rapidly drained, coarse textured soils on flats or upper position on steep-to-moderate slopes;
Dry-Mesic	dm	1	rapidly or well drained, coarse-to-medium textured soils on flats, finer textured soils on upper part of steep slopes;
Mesic	m	2-3	well or moderately-well drained, moderate-to-fine textured soils on slight slopes or flats.
Wet-Mesic	wm	4-5	moderately-well or imperfectly drained, medium-to-fine textured soils on very slight slopes or flats
Wet	w	5-6	imperfect or poorly drained, very fine textured soils on lower positions on slopes, or flat;
Very Wet	vw	7,8,9	poorly or very poorly drained, organic soils; flat or depression, frequently flooded, water table at or near the surface

[1] *Detailed description of the above classes are provided in the Field Manual for Describing Soils, 1985. Ont. Inst. Pedology publication no. 85-3, University of Guelph, Guelph Ontario.*

Results: The accuracy of soil moisture classification from aerial photos greatly relies on the interpreters knowledge of local soil conditions. In this trial soil moisture was more accurately interpreted in the Lanark site where the interpreter had a good knowledge of local forest conditions. The same interpreter had more difficulty typing soil moisture in the Cornwall site where she had less knowledge of local forest conditions. The classification matrix for soil moisture is presented below.

Recommendation: The enhanced inventory specifications should include the interpretation of soil moisture regime using a classification similar to the above.

Accurate classification of soil moisture regime from aerial photographs will rely on the availability of field data from the inventory area, the experience of the interpreter and his or hers knowledge of the relationships between soil moisture, land-form and vegetation types.

2.7 Site productivity

Objective: Assess and classify site productivity for each productive stand:

Procedure: Three site productivity classes were assigned for forest stands based on soil drainage, topography and the vigour of dominant and co-dominant trees. These classes were defined as follows:

Good	Stands on well-drained sites, exhibiting above average growth
Fair	Stands on poorly drained sites exhibiting average growth.
Poor	Stands on very poorly drained sites exhibiting below average growth and/or with a high incidence of mortality in the main canopy

Results: Site productivity was strongly related to the interaction between species composition and soil moisture regime. Where soil moisture and species types were interpreted accurately, site productivity was interpreted accurately. The classification matrix for site productivity is presented below.

Recommendation: The site productivity rating is intended to provide a relative assessment of the productive potential of a site by a means that incorporates factors such terrain, slope and soil moisture in addition to the height-age relationship of existing trees. It is essentially a derived parameter, as opposed to a directly interpreted parameter, and can be broken down into a series of algorithms based on directly interpreted parameters such as species composition, height, age and soil moisture. Also, site productivity ratings are often applicable only within local areas (i.e. management units). For example, the ratings devised for this trial were applied very differently between the two sites. For these

reasons, it is recommended that the enhanced FRI specifications include a mechanism that would allow users to develop and apply their own site productivity rating using the inventory database. Site productivity rating, and any other derived parameter, should not be included in the parameters initially interpreted on the photos.

2.8 Minimum polygon size

Objective: Increase the spatial resolution of interpretation typing so as to delineate and classify permanent forest openings, small woodlots and other small areas of forest which are not delineated in the current FRI but are important for forest management.

Procedure: No minimum polygon size was set for areas of permanent non-forested openings in forested areas, forest stands occurring in non-forested areas or riparian zone polygons.

In forested areas, the minimum polygon size was dependant on the differences in the descriptions of adjacent polygons. A minimum size of 2 ha was applied to:

- non-productive forested land occurring within productive forested land
- productive forested land within non-productive forested lands
- coniferous stands in hardwood forests or hardwood stands in coniferous forests
- stands of uncommon species
- stands with characteristics that the interpreter deems important enough to warrant their delineation from the adjacent forest.

Elsewhere a minimum polygon size of 4 hectares was applied

Results: The spatial resolution of the trial results was significantly increased relative to the 1981 interpretation in the same areas. In the Lanark area, approximately 420 stands were delineated in the trial compared to 215 stands delineated in the 1981 inventory of the same area

The smallest polygons were small permanent openings of 0.1 hectares created as landings in intensively managed forest areas. Several small woodlots under 0.5 hectares were also delineated.

Recommendations: The standards for minimum polygon size applied in this trial should be adapted to the broader inventory.

2.9 Stand modifiers

Objective: Interpret and record information on various natural and man-made features within the descriptions of forested and non-forested lands that have particular relevance for resource management.

Procedures: Two letter stand modifiers were appended to the polygon descriptions to indicate the presence of various features or characteristics of an area. The codes used in the trial are listed in the specifications provided in Appendix B.

Results: Many natural and man-made features and characteristics could be interpreted from the aerial photography. The two letter modifiers provide an efficient and effective means of flagging the occurrence of these features and characteristics within the stands.

Recommendation: A set of two-letter stand modifiers should be developed and applied in the broader inventory of eastern Ontario.

COST OF ENHANCEMENTS

The cost of the proposed enhancements, specified in Appendix B, were compared to the costs of a standard FRI over the two.

For the photo interpretation stage, the incremental costs associated with the enhancements were due to the additional time required to interpret the photographs. It took approximately twice as long to interpret the two areas under the enhanced specifications as it would have taken to apply the standard FRI specifications. This factor of 2 can be reduced to about **1.6** if adjustments are made for the interpreters lack of familiarity with the enhanced specifications and if the economies of scale of a broader inventory are considered. This additional effort could not be accurately broken down by individual enhancement items.

In a broader inventory the additional costs associated with the enhancements will be different for each major step in the process. Table 2 provides a rough estimate of these additional cost by each major task of the inventory process.

Table 2. Approximate inventory costs with and without enhancements applied in the interpretation trial.

Approximate Inventory Cost		$ /Km²	Fractional Increase
Photo interpretation	:Basic FRI	14	1.6
	:With Enhancements	22	
Ground Cruising	:Basic FRI	20	1.3
	:With Enhancements	25	
Basemap Preparation Transfer	:Basic FRI	6.5	1.2

	:With Enhancements	7.5	
Digitizing Checking & Editing	:Basic FRI	52	1.3
	:With Enhancements	70	
Database Compilation Checking & Editing	:Basic FRI	14.5	1.4
	:With Enhancements	21	
Mapping Support	:Basic FRI	1.5	1
	:With Enhancements	1.5	
Total	:Basic FRI	108.5	1.4
	:With Enhancements	147	

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Appendix A

Specifications for Forest Resources Inventory Photo Interpretation--The information in this appendix is unfortunately unavailable online due to poor quality of original text. It contains such information as Area Classification, working group information, photo interpretation procedure, factors in forest stand interpretation, stand data samples, principle tree samples and various site class tables for different species of trees. A copy of this information can be ordered from the Eastern Ontario Model Forest Office.

Appendix B

Photo Interpretation Specifications for an Enhanced Forest Resource Inventory--Integrated Resource Management Project, 880 Lady Ellen Place, Suite 206, Ottawa, ON, K1Z 5L9.

1.0 INTRODUCTION

The following specifications were developed for an enhanced forest inventory of the Eastern Ontario Model Forest. They are largely based on the *Specifications for Forest Resource Inventory Photo Interpretation (1991)* produced by the Ministry of Natural Resources, Natural Resource Inventory Section (NRIS). Modifications have been made to address the requirements identified by local inventory users.

These specifications define a system of classifying and describing forested and non-forested lands, but do not provide instruction on basic aerial photo interpretation techniques. They are intended as a guide for photo interpreters knowledgeable and experienced in standard FRI interpretation.

2.0 AREA CLASSIFICATION

The inventoried area is classified into one of eight broad area classes. The minimum polygon size standards for each class are outline in Section II-J.

2.1 Water

Water areas, such as lakes, rivers, streams and ponds are outlined on the Ontario Base Maps (OBMs) to the high water mark. Delineation of land and river shorelines are not required to be completed by the FRI interpreter.

The interpreter should be aware that water levels of ponds and lakes on the FRI photography may appear below those marked on the OBMs. Were such discrepancies exist, the OBM boundaries should be considered correct.

2.2 Non-forested Land

Non-forested area is land that is excluded from timber production for at least one rotation. This includes:

2.2.1. Developed Agricultural Land (symbol - DAL)

This includes cultivated land producing farm crops or devoted to market gardens, orchards, etc., and improved pasture lands planted with cultivated grasses and/or legumes . Active pasture areas will also be included in this category. Section 3.9.9 includes a list of descriptive modifiers which may be used to further describe these areas.

2.2.2. Grass & Meadows

Includes farm areas of unimproved or inactive. This type of area can be recognized from the occurrence of trees, shrubs, fallen trees and stones scattered across the fields and by fences in disrepair. Cultivation of these areas in recent years would require up-keep of fences and removal of obstructing trees and stones. Grass and Meadow areas are similar to Barren and Scattered (B&S) but will have less than 10% tree cover while B&S will have between 10% and 30% tree cover. This classification will include inactive pasture. It will also include conditions which would have been put into the Permanent Forest Opening modifier.

2.2.3. Unclassified Land (symbol - UCL)

Non-vegetated lands that are not clearly defined by other classifications. This includes municipalities, roads, rail roads, pipelines, mines, logging camps, and gravel pits, transmission line corridors, etc. A list of descriptive modifiers for unclassified lands is provided in Section 3.9.9.

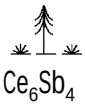
2.3 Forested Land - Non-Productive

This is land within a "forested" area that is currently incapable of commercial timber production because of high water table or shallow soil, a lack of mineral soil, or because of its vegetative cover . This classification reflects current status with no presumption about the future capability of an area. Forested land, non-productive includes:

2.3.1. Treed Wetland ( )

Treed wetlands include treed bogs, treed fens, swamps and other wet areas that support unmerchantable trees at stocking levels less than 0.3. Unmerchantable trees exhibit height growth at rates below those defined for Plonski's site Class 3 and are assigned to Site Class 4. Wetlands that support trees growing within the parameters of Site Class 4 but with stockings at or above are to be classified as Protection Forest (see section 3.4). Wetlands supporting merchantable trees, Site Class 3 or better, at stocking levels below 0.3 are considered productive and must be classified as Barren & Scattered..

Species composition of the tree cover should be interpreted and the stand labelled as follows.



2.3.2 Open Wetland (**)

The open wetland classification includes wet areas of mosses, grasses, sedges and small herbaceous plants, often interspersed with small areas of open water. This includes most marshes, open fens and open bogs. This category will also be used for small openings which are wet. It replaces the Permanent Forest Opening modifier.

2.3.3 Brush & Alder (& &)

Brush and alder areas includes wet and dry, non-productive, lands that are currently covered with non-commercial tree species, such as alder and willow. These areas often border streams, lakes or non-perennial streams and may be subjected to periodic flooding. Often productive lands, such as cut-over areas, and abandoned fields are covered by dense brush and willow. These areas will be classified as Barren & Scattered.

2.3.4 Rock (Rock or Rk)

Any area of barren rock (bedrock, a cliff face or talus slope) which may support a few scattered trees with a stocking less than 0.3. There may not be any other apparent vegetation, stand history or adjacent association to suggest that it is Productive Barren and Scattered.

2.3.5. Riparian Zones

Riparian zones are the transition areas between aquatic and upland ecosystems. They occur along all river banks, stream banks and shorelines, and are among the most diverse habitats in the forest. Their widths are highly variable, ranging from a few metres, to several hundred metres and, therefore, can be mapped as either polygons or lines. This inventory is designed to capture information on two basic types of riparian zones, riparian strips in non-forest areas and riparian stands in forested areas.

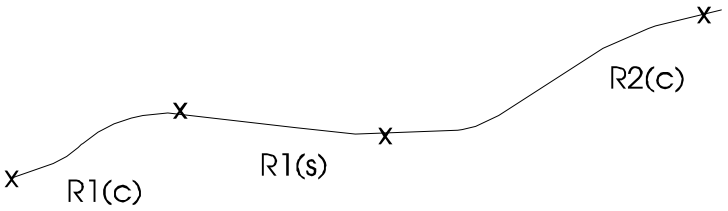
<u>Riparian Strips in Non-forested Areas</u>

In non-forested areas, riparian zones often occur as strips of trees or shrubs situated along water courses. These are easily distinguished on 1:10,000 aerial photographs delineated as polygons or lines depending on their width, and at least 100 metres long.

The following labelling is used for linear riparian strips:

R1 - riparian zone on one bank of a stream or river (or around a lake)
R2 - riparian zones on both banks of a stream or river
one of the following modifiers is also used
(C) - Continuous treed (tree cover >70 %)
(B) - Broken treed (tree cover 30 - 70%)
(S) - Shrub (predominantly shrubs, tree cover <30%)

Below is an example of how riparian zones may be labelled on the photos.



Polygons are used to delineate riparian zones that are wider than 30 metres. If the stocking is 0.3 or greater, these areas are interpreted and labelled as a Productive Forest stand to which the modifier "RZ". Delineation and description of riparian (RZ) polygons should be with a higher resolution than that of regular stands. Higher resolution means that there is no minimum polygon size and that an “RZ” stand may be delineated from other stands based on subtle differences in vegetative types, terrain or soil moisture class.

2.3.6. Hedgerows

Hedgerows are strips of shrub and/or tree vegetation dividing fields or cleared lots. In regions where much of the landscape has been cleared for agriculture, hedgerows may provide important habitat to many species of birds, reptiles and mammals.

Hedgerows that are at least 100 metres long and no more than 30 metres wide are delineated and mapped with a single line. Shorter hedgerows are ignored and wider hedgerows are to be delineated as forest polygons.

There are three basic hedgerow types which are defined by the kind of vegetation they consist of. These types are as follows:

Hedgerow Type

(C) - Continuous treed	(tree cover >70 %)
(B) - Broken treed	(tree cover 30 - 70%)
(S) - Shrub	(predominantly shrubs, tree cover <30%)

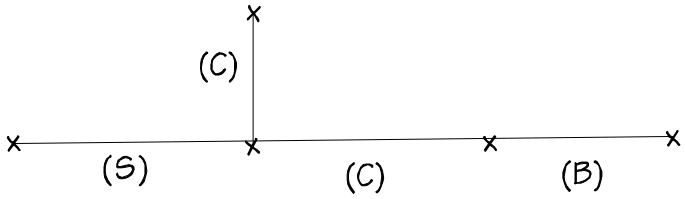
Hedgerows are also broken down into three width classes as follows:

Width Class

1- 1-10 metres wide
2- 11-20 metres wide
3- 21-30 metres wide

Hedgerows are delineated and labelled as shown in the example below. An 'X' is used to indicate where a hedgerow changes from one type to another.

eg.



In both the Riparian Zone and Hedgerows the width classes refer to total width. The RZ modifier shall be attached to the riparian polygon. Both Riparian Zones and Hedgerows will be typed if adjacent to DAL, Grass and Meadow or B-S, but not if adjacent to forested areas. The Riparian and Hedgerow information shall be a separate layer in the GIS and be represented as polygons rather than lines. The buffered feature shall have different buffer widths as follows:

Treed- midpoint of width (5m, 15m, 25m)
Shrub- low end (1m, 11m, 21m)

2.4 Forest Land-Productive

Productive Forest Land is any forest area that will retain an adequate growth of timber on a sustained yield basis and shall be classified as site class X,1,2,3,4 (PF), or *PFR(X,1,2,3)*.

III. WORKING GROUP

3.1 Definition

A working group is an aggregate of forest stands that have the same predominant species (Policy FR 15 01 01).

3.2 Purpose

Working Group is a term of convenience used to classify all Productive Forest lands in Ontario for the purpose of Forest Resources Inventory. District, regional and provincial inventory summaries require that relatively few well recognized working groups be used o summarize the large and diverse areas that are involved. Stands that are declared Free-to-Grow are assigned a working group designation.

Within the FRI the following working groups are currently recognized.

Working Group	Symbol	Species in a Working Group
white pine	Pw	Pw
Red Pine	Pr	Pr
Jack Pine	Pj	Pj, Ps
White Spruce	Sw	Sw, Sr
Black Spruce	Sb	Sb
Spruce (all)	S	Sw, Sb, Sr
Balsam	B	B
Hemlock	He	He
Other Conifer	C	(Those conifers not listed)
Cedar	Ce	Ce, Cer
Larch	L	L
Hard Maple	Mh	Mh
Soft Maple	Ms	Ms
Yellow Birch	By	By
Oak	O	Or, Ow
Ash	A	Aw, Ab
Poplar	Po	Pt, Pl, Pb
Balsam Poplar	Pb	Pb
White Birch	Bw	Bw
Other hardwoods	H	Be, Bd, Bn, Cb, Che, Ew, Gb, Hi, Iw, Lo, Pa, Sa, Sy, Tt, Wb
Protection Forest	PF	All species
Production Forest Reserve	PFR	All species

3.3 Combined Working Groups

Certain species are always added together to form a working group. These are as follows:

White Spruce (Sw) + Red Spruce (Sr) = Sw
Cedar (Ce) + Red Cedar (Cer) = Ce
Black Ash (Ab) + White Ash (Aw) = A
Red Oak (Or) + White Oak (Ow) = O

Other species are sometimes added together to forma working group. This occurs if the total percentage of these combined species is greater or equal to any other species in the species composition. For example:

White Spruce (Sw) + Black Spruce (Sb) = S Spruce (all)
Trembling Aspen + Large Tooth Aspen + Balsam Poplar = Po Poplar (all)

Spruces, Maples, Oaks, and Ashes are the major species which are commonly combined to make a working group. In all cases the percentage of the two or more of these species are totalled to make a combined species content within the stand and this total percentage mush be equal to or greater than the associated species within that stand. In the case of the combined Spruce working group, there are three variations which can occur. Whit Spruce or Black Spruce or a combination of the two can be taken as the working group. When White Spruce is the working group, the Sw has a higher percentage of content withing the stand than the associated species.
For Example:

$Sw_5B_3Sb_1Bw_1$
$Sw_4Sb_3B_2Ce_1$
$Sw_3Po_3Bw_3B_1$

In the same manner, if Black Spruce is substituted for Sw and white Spruce for Sb in the descriptions above, then Sb is the working group.

A working group of Spruce (all) is a combination of Sb and Sw, and the total of their percentages has to be greater or equal to that of the associated species. For example:

S $Sw_2Sb_2Po_4B_2$
S $Sb_3Sw_2Po_5$
S $Sb_3Sw_1B_3Bw_3$

Both Hard Maple and Soft Maple have their own working group provided that their individual percent is greater than or equal to that of the other associated species. For example:

$\underline{Ms}_5Ab_3Po_2$
$\underline{Mh}_4Bd_2Aw_2Be_2$

In the same manner as the Spruce working group, there are three poplar species which can be combined as one working group; namely Trembling Aspen, Largetooth Aspen and Balsam Poplar. However, if the different poplars are being combined, without distinguishing Pt and P1 from Pb then the symbol used is Po. If Pb is to be separated from Pb the other two poplars, then it is assigned its own working group of Pb. For example:

All poplars combined. $Po_6Bw_3Sb_1$

Balsam Poplar separated. $Pb_4Po_3Ab_2Ms_1$

The above have been examples of species which sometimes are combined to form the working group or can stand alone as their own working group.

Examples of the working groups of Ce, A and O are as follows:

Cedar working group:

$Ce_7L_2Sb_1$
Ce_8Po_2 *

**This example is the result of combining Cer_4 and Ce_4 as the working group of Ce.*

Oak working group:

$\underline{O}\ Or_3Ow_1Hi_2Mh_2Pw_1He_1$
$\underline{O}\ Or_2Ow_2Mh_4Be_2$
$\underline{O}\ Or_5Mh_4Be_1$
$\underline{O}\ Ow_6Pw_3Bw_1$

Ash working group:

$\underline{A}\ Aw_2Ab_2Ms_4Ce_2$
$\underline{A}\ Ab_3Aw_1L2Ms_2Ce_1B_1$

The Other Hardwoods (H) working group is another condition where several species' percentages are totalled together. And again like the Spruce or Maple working groups, the combinations of their total percentage must be equal or greater to that of the individual associated species content. The following are examples of the Other Hardwood (H) working group.

H $Be_3H1_2Iw_1Mh_4$
H $Bd_4He_3Mh_3$
H $Hi_2Be_1Bd_1Cb_1Mh_3Aw_2$

One species may also make up the H working group.

H Be_6Mh_4
H $Iw_5Mh_3Ms_1Aw_1$
H Bn_6Mh_4

The Other Hardwoods (H) working group includes those species which do not occur frequently enough to require a working group of their own. Including their percentage with any other working group would distort the basal area and volume estimate. A list of the species making up the H working group can be found in Section 3.2. The age and height of the H working group is for the species that has the highest individual percentage in the H category. The Tolerant hardwoods table is used to determine a site class for the H species with the highest individual percentage. However, since some of the working groups recognized are not covered by individual yield tables, the following table are to be applied:

Black Spruce	)	
White Spruce	)	
Balsam Fir	)	Black Spruce Tables
Cedar	)	
Larch		
Jack Pine	)	Jack Pine Tables
Scots Pine	)	
Trembling Aspen	)	
Largetooth Aspen	)	Poplar Tables
Balsam Poplar	)	
White Birch	)	White Birch Tables

Hard Maple	)	
Soft Maple	)	
Yellow Birch	)	
Ash	)	Tolerant Hardwood Tables
Oak	)	
Hemlock	)	
Other Hardwoods	)	
White Pine	)	White Pine Tables
Red Pine	)	Red Pine Tables

3.4 Protection Forest

A Protection Forest (PF) Site 4 classification is assigned to stands with height growth rates below those defined in Plonski's Site Class 3. This can be as a result of low site productivity, its' stand history, or as a result of an "off-site" species. Stocking for this site class must be equal to or greater than 0.25 (rounded to 0.3). If the stocking is below 0.25 (rounded to 0.3), then this area will be classified as non-productive and labelled treed wetland (exclude islands from this condition).

3.5. Protection Forest Island

Islands which are between 4 and 40 hectares are included in this classification. Unlike site 4 Protection Forest (PF), the stand description will maintain its appropriate site class (site X, 1, 2, 3 or 4). Islands under 4 ha will be ignored and those over 40 ha will be considered mainland.

3.6. Production Forest Reserve

The Production Forest Reserve (PFR) classification suggests that special attention should be paid to Site Class X, 1, 2, 3 areas by the forest managers when they are allocating areas for forest operations. This may be due to one or more factors which may either impede operations or make the site sensitive to damage from operations. The trees on these sites have an age/height relationship, such that the mensurational site class of X, 1, 2 or 3 is used.

The PFR classification should be underlined and placed preceding the stand descriptions. In addition to the PFR label, a stand modifier will be added to the stand description to indicate the reason why it is designated as such. These modifiers are describe in Section I.10., Stand Description.

eg. ($\underline{PFR}Sb_6Po_3Bw_1$).

The production Forest Reserve category may include such areas as:

1. Steep slope.
2. Shallow soil over bedrock.
3. Rocky areas with pockets of mineral oil or fissures.
4. Water courses (ravines).
5. Poorly drained areas that have very little mineral soil.

The above factors should be considered during the delineation of any forest stand. Thirty (30) percent of a stand must have one or more of the above conditions present, before PFR is affixed to the stand description. The delineation of a PFR forest stand shall conform to the conditions as set out in the definition of a forest stand.

3.7 Barren and Scattered

A productive forest site that has a stocking less than 0.25 (rounded to 0.3) as a result of fire, forest operations, insect damage or disease infiltration with or without shrub cover and very little regeneration, is described as Barren and Scattered (B-S). The stand classification Barren and Scattered is to be assigned to a specific species on the basis of it's topographic location or to a species that is growing in the adjacent stand. A modifier will define the area as either agriculture (A) or forest (F) with a breakdown of the tree cover by percentage (i.e. 10.20 or 30 percent). The percentage sign does not have to be marked on the photo.

Barren and Scattered shall have 3 Crown Closure descriptions as shown below:

Percentage of Tree Cover	FRI Descriptions
0-10%	B-S (10%)
11-20%	B-S (20%)
21-30%	B-S (30%)

Note: *all three classes will be used for forested B-S. Agricultural lands with 0-10% tree cover are described as Grass & Meadow with only two classes, 11-20% and 21-30%.*

If the sites and trees do NOT meet the criteria for the Free-to-Grow (FTG), but there are trees there, then the stand is labelled as B-S and is assigned to a specific working group and described, as much as possible, according to the specifications in Section I. During interpretation of these areas the physiological site should be considered and for standardization use site class 2 for a good site and site class 3 for those that are somewhat poorer. Barren and Scattered areas can be classified as PFR provided that these sites meet the criteria for Production Forest Reserve areas. If field data (regeneration, FTG or fire information) is available for the barren and scattered areas, then the appropriate stand description shall be used to fully implement this data.

3.8 Forest Stand

A forest stand is a community of trees possessing sufficient uniformity in composition, constitution, age, arrangement or condition to be distinguishable from adjacent communities, so forming a silvicultural or management entity.

3.9 Stand Description

The stand description of a delineated area will consist of the species composition, working group designation, age, height, stocking, crown closure class, class and soil moisture class. The description may also include one or more modifiers to describe various other characteristics of the stand.

3.9.1. Working Group

Working group is assigned according to species composition of the main canopy as described in the FRI Section 3.2.

3.9.2. Species Composition

Species composition is interpreted for the main canopy in single-story stands, for both canopy layers in two-tiered stands and for the general canopy in complex stands. The composition of the upper and lower canopies are separated with / for two-tiered stands. All individual species occurring in the stand are listed in the composition description. Components are listed in descending order according to percentage content. Those species with crown covers of at least 10% of the total stand crown covers are listed with their relative weighting. Those species with crown covers less than 10% of the total stand crown cover are listed in parentheses.

One example is a stand in the Hardwood working group that is 50% beech, 40% hard maple and 10% yellow birch also containing hemlock and basswood components which together make up less than 10% of the stand.

eg $H\ Be_5Mh_4By_1(He,Bd)$

A second example is two-tiered stand with a white pine stand canopy dominate over a balsam fir hemlock canopy

eg. $\frac{Pw_2}{Bf\ Hp}$

NOTE: See Stand Structure Modifiers Table 1., Section 3.9.9.

3.9.3 Stand Age

In single-story stands, the average age of the dominant canopy will be determined to the nearest 5 years. In two-tiered stands, the average age of both canopy layers will be determined to the nearest 5 years and separated in the stand description by a slash. In complex stands, the average age of the tallest tier will be determined to the nearest 5 years.

3.9.4. Stand Height

In single-story stands, the average height of the dominant canopy will be determined to the nearest 1 metre. In two-tiered stands, the average height of both canopy layers will be determined to the nearest 1 metre and separated in the stand description by a slash. In complex stands, the average height of the tallest tier will be determined to the nearest 1 metre.

3.9.5. Stand Stocking

Stand stocking for all types of stands will be assessed and recorded according the current FRI practices.

3.9.6. Crown Closure

Crown Closure is the percentage of ground area covered by the crowns of all trees within a canopy layer. Crown closure is assessed in 10 percent classes. For single-storey and complex stands, crown closure class is determined for the entire stand. For two-tiered stands, crown closure is determined for both canopy layers, where possible. A horizontal vertical line is used to separate the closure class for each layer in the stand description. Interpreting the crown closure for an undertstorey layer, may not be possible when the over storey has a high crown closure.

The crown cover density classes are as follows:

Crown Cover Density	
0 - 10 %	51 - 60 %
11 - 20 %	61 - 70 %
21 - 30 %	71 - 80 %
31 - 40 %	81 - 90 %
41 - 50 %	91 - 100 %

3.9.7. Soil Moisture Regime

The soil moisture regime of a stand may be inferred from slope, position-on-slope and the type and nature of vegetation in the stand area. Accurate classification of soil moisture regime for a stand will rely on field data from the inventory area, the experience of the interpreter and his or her's knowledge of the relationships between soil moisture, land-form and vegetation types. Three broad classes are applied in the inventory; these are described below:

Class	Code	OIP*	Class Description
Dry	D	Θ,0	very rapidly to rapidly drained, coarse textured soils (coarse and medium sands) on flats; or finer textured soils on shallow sites, upper slopes and hill crests.
Dry-Mesic	dM	1	rapidly drained, medium textured soils (medium sands and silty medium sands) on slopes or flats.
Mesic	M	2-3	rapidly to moderately well drained, medium-to-fine textured soils (fine sands to silty very fine sands) on slopes or flats.
Wet-Mesic	wM	4-5	moderately-well or imperfectly drained, fine-to-very fine textured soils (loams, silty loams to silty clays and clays) on flats or lower slopes.
Wet	W	5-6	poorly drained, very fine textured soils (silty clays and clays) on lower organic soils, often in depressions, flats or lower slopes.

**Detailed description of the above classes are provided in the Field Manual for Describing Soils, 1985. Ontario Institute of Pedology (OIP) publication no. 85-3, University of Guelph, Guelph, ON)*

3.9.8. Site Class

Site class for all stand types will be determined from the working group species in the dominant canopy layer.

3.9.9. Stand Modifiers

A stand modifier is used a combination of one or more two character codes which are used to identify various characteristics of a forested and non-forested areas that have particular relevance for the management of that area. The following tables list some potential modifiers.

Table 1. Stand Structure Modifiers

Vertical Stand Structure Modifiers	
--	Single-story Stands: have dominant canopy layer (inferred no code)
TT	Two-tiered Stands: have two distinct canopy layers differing in average height by a least 3 metres and with each tier having a crown cover density of more than 30%
CX	Complex Stands: have more than two canopy layers differing in (average) height by 3 metres and each having a crown cover density of 30% or more.
Horizontal Stand Structure Modifiers: (horizontal dispersal pattern of species sub-components)	
--	Even Dispersal: generally homogenous dispersion of species/size components over the majority of the stand area (inferred, no-code).
CL	Clumped Dispersal: uneven mixture of species/size components which form small groups distinctly different stands which are too small to be delineated on 1;10,000 scale photos. *Note emphasis should be put on dispersion of conifer components in hardwood dominated stands and hardwood components in conifer dominated stands

Table 2. Modifiers for Forested Lands

Modifiers for Protection Forest Reserve (PFR) stands	
SL	Steep Slopes
SH	Shallow Soils
RK	Rocky area
PR	Poorly drained or periodically flooded area
WA	Water Course (ravine)

OD	Other damage
Modifiers for Stand Health and Condition	
DD	Disease damaged
ID	Insect damaged
WF	Windfall (significant amount)
FL	Flooded area
CH	Chicots: numerous standing dead trees
BU	Burn or Partial Burn
Modifiers for Forest Treatments	
CC	Clearcut
CS	Clearcut with seed trees
SU	Shelterwood - uniform
SG	Shelterwood - group/strip
SC	Selection cut - single tree
LG	Selection cut - group
UT	Uniform Thinning
TR	Thinning by rows
PL	Plantation
OT	Other treatments

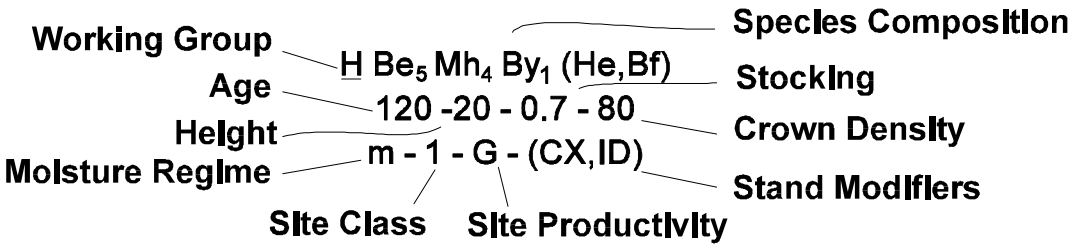
Table 3. Modifiers for Non-forested Lands

Modifiers for DAL and UCL areas	
DU	Developed, urban residential/commercial
DR	Developed, rural residential/commercial
DI	Developed, industrial
TC	Transportation corridor, road or rail
FR	Farm
ME	Mineral extraction, gravel pit, mine site etc.
LD	Permanent Landing or other opening
HL	Hydro Line Corridor

3.10 Stand Label

All stands will be labelled on the 1;10,000 scale photographs as illustrated in the following two examples.

Mixed hardwood stand with a complex horizontal structure and simple vertical structure.



Two-tiered white pine / mixed hardwood stand with a patched horizontal structure

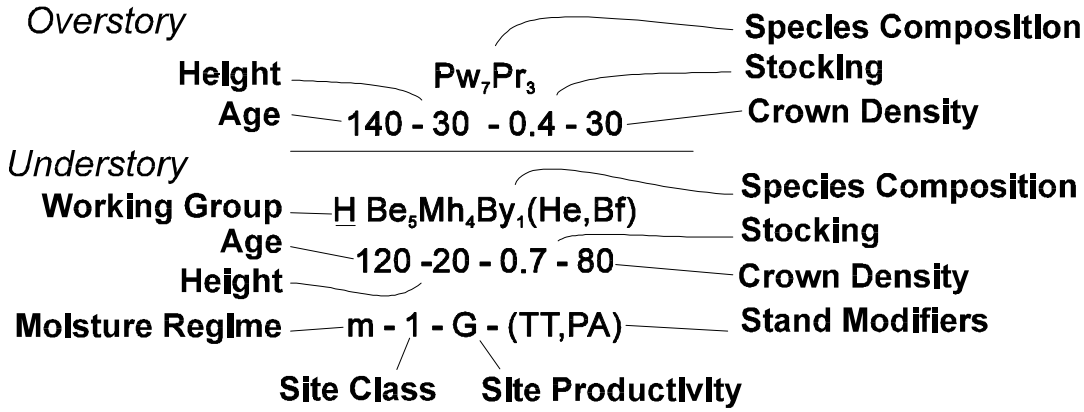


Figure 8

4.0 POLYGON SIZE

No minimum polygon size will apply to following areas:

-permanent non-forested openings in forested areas
-forest stands occurring in non-forested areas
-riparian zone polygons
-non-productive forested land occurring within productive forested land
-productive forested land occurring within non-productive forested lands
-coniferous stands in hardwood forests or hardwood stands in coniferous forests
-stands of uncommon species
-a stands with characteristics that the interpreter deems important enough to warrant their delineation from the adjacent forest.

Elsewhere a minimum polygon size of 4 hectares is be applied. *As per discussions on December 7, 1994, the size of the polygon will be decided by the interpreters to identify "significant" features at an increased resolution.*

5.0 PHOTO INTERPRETATION PROCEDURE

A. A double zero (00) tip nib and non-waterproof soluble india ink is used for all delineation work on the photo.

B. All interpretation work shall be done within the centre portion of the photography bounded on the left by a straight line that is 6.35 cm from and parallel to the left hand border. This line shall be easily recognized or distinguished from the delineated black lines of the stand boundaries by being a contrasting colour of blue or red.

C. All delineation and descriptions shall be written to the right of this coloured line of each aerial photo over to a point where the line on the adjacent stereo photo can be seen stereoscopically.

D. All stand delineation and descriptions shall not extend to the extreme top or bottom of the aerial photography. The upper and lower extremities of these lines shall not extend higher or lower than 2.54 cm from the top or bottom border of the photo. However, if side overlap of the photo coverage of an area is not within these limits, then extension of these lines will be allowed.

E. All descriptions shall be printed in a clear legible script which can be easily read without any optical aid. These descriptions shall be centrally placed within the stand boundaries so that there is not any confusion as to where the stand description belongs. If the stand description does not fit legibly within the stand boundary, then an arrow may be used to indicate where the stand description belongs and the printed description may be placed outside the boundaries as close to the indicated stand as possible. It must not interfere with or cause confusion to the stand description or symbol.

F. Every stand must have a complete description or symbol to avoid any delays in subsequent stages of the inventory process.

G. Eliminate duplication on adjacent photos of stand information within a stand boundary. This saves time in interpretation and also eliminates confusion during compilation when the information is transferred from the photo to the work map.

H. Stand delineation with its accompanying description shall be tied-in from the top most flight line of a base map of photos to the flight line directly below with a red or blue stabilo (or similar type pencil) in such a manner that there is not any confusion as to where the stand boundaries exist on the upper flight line of photos. Areas within these coloured tie-in lines shall have an X or check mark to indicate that there is a printed stand description or symbol on the photograph above. Be careful not to omit any stand descriptions for polygons within this tie-in area.

I. Plot lines shall be carried over from the back of the photo to the front of the photo and marked in black india ink in the exact location that the plots were run in the field. This inked line shall join the two pin-pricked points on the photograph in a straight and neat fashion and the stand description shall be printed legible and neatly beside it. Stand delineation lines shall be one continuous line without any breaks in it. Major highways, lakes and large rivers will be used as one side of a stand delineation.

J. Hydro lines shall be outlined if they pass through any forested areas, and they shall be labelled as Power Lines. Hydro lines passing over grassland or developed agricultural lands do not need to be shown on the photo in any manner.

K. Delineated areas which are separated by highways, rivers or hydro lines shall be joined by an (<--//-->) if the areas on either side of the aforementioned features are alike in stand description. Areas that are non-productive in nature shall have an individual symbol printed in them.

L. Use the height limits by Site Class tables to ensure the correct site classification.

M. The Other Hardwoods working group symbol (H) or abbreviation (OH) shall not be used within the species composition description (i.e. $\underline{Po}^{7}OH^{3}$). The proper hardwood species abbreviation and percentage will be used (i.e. $Po^{7}Ew^{3}$).

N. Species compositions should include all distinguishable species, OH, H, or any other group should not be used in the composition description.

O. Areas that have NSR information which is not yet Free-to-Grow (supplied on map format by Districts) and have an over-story of Poplar or another mature species shall be interpreted as the mature stand provided the crown density is over 30%. The NSR description shall be indicated with a modifier that will be in-addition to the regular description. If the area has been cut-over and does not have any recognizable regeneration the stand shall be interpreted and designated as the species that the District indicated as planted or regenerated. The area in this case shall be classified

as barren and scattered to a specific working group with an appropriate site type. Also if F.T.G. information meets interpretation standards the F.T.G. description shall be indicated by a modifier and year (FTG-87).

P. OPC cruise data that meets all FRI standards for stand description format and which is provided on a map supplied by either a District or Forest Company shall be used either as the stand description or as reference material in interpreting a forest stand. An agreement between the District and NRIS will determine which method shall be used. If the FRI stand boundaries are to be kept as per the previous inventory, the stand description information shall be used as indicated by the District (unless otherwise indicated). If the interpreter while viewing the photos stereoscopically does not fully agree with the information provided by the District, he/she may use the data as a guide to interpret the stand area. Also if the OPC cruise data meets standards, the OPC description shall be indicated by a modifier and year of cruise and labelled (OPC-87).

Q. All photos are to be returned to the appropriate base map docket after the interpretation is completed.

R. Normally when interpreting a block of base map photographs, the interpreter shall start work with the top flight line in the most northwesterly docket and work lower by flight line and easterly by docket, unless otherwise instructed.

S. All work shall be neat, complete and accurate before submission to the Ministry.

T. Missing photos must be reported to the Ministry.

U. Any discrepancies in plot information shall be brought to the attention of the Ministry of clarification.

V. All photo interpretation shall be monitored as specified in the FRI Standards of Practice for Aerial Photo Interpretation (1991).

W. The interpreter shall make use of all other information such as field plot data, satellite imagery, OPC data, regeneration or FTG surveys, disturbance maps etc., to make decisions or stand descriptions and delineations. Any questionable information shall be referred to unit foresters or technicians to accept or reject.