Northwestern Ontario Forest Ecosystem Interpretations

by G. D. Racey, T. S. Whitfield and R. A. Sims

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About the Interpretations Guide and its Contents

This guide will assist in the application of the Northwestern Ontario Forest Ecosystem Classification (NWO FEC) to forest management in northwestern (NW) Ontario. The user should be familiar with the *Field Guide to the Forest Ecosystem Classification for Northwestern Ontario* (Sims et al 1989) and should approach the concept of ecosystem interpretations with an open mind.

Interpretations relate vegetation, soil, site and climatic factors to limitations or opportunities for forest management. These interpretations are "first approximations" and will be updated, or new interpretations developed as better information becomes available. These interpretations are not intended as formal guidelines or recommendations and are not a replacement for thoughtful forest management, but may help to provide ideas, options, and information on generally accepted or common practices in NW Ontario.

This guide begins by introducing the concept of forest ecosystem interpretations; Section 1 is essential for users who have not previously been introduced to this topic. Section 2 presents the concept as a method of applying the NWO FEC to site-specific management. It presents a set of generalized Treatment Units for NW Ontario which may be further adapted to accommodate local variations in site or climate. Section 3 describes some basic silvicultural interpretations, followed by interpretations for wildlife in Section 4. Section 5 deals with incorporation of the NWO FEC system into operational forestry surveys and Section 6 provides literature references.

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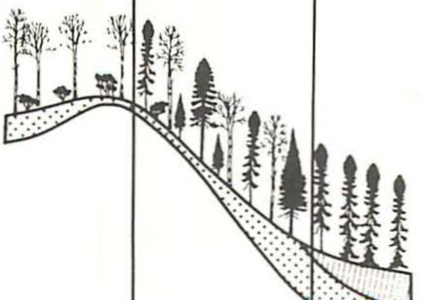
Section 1

Orientation



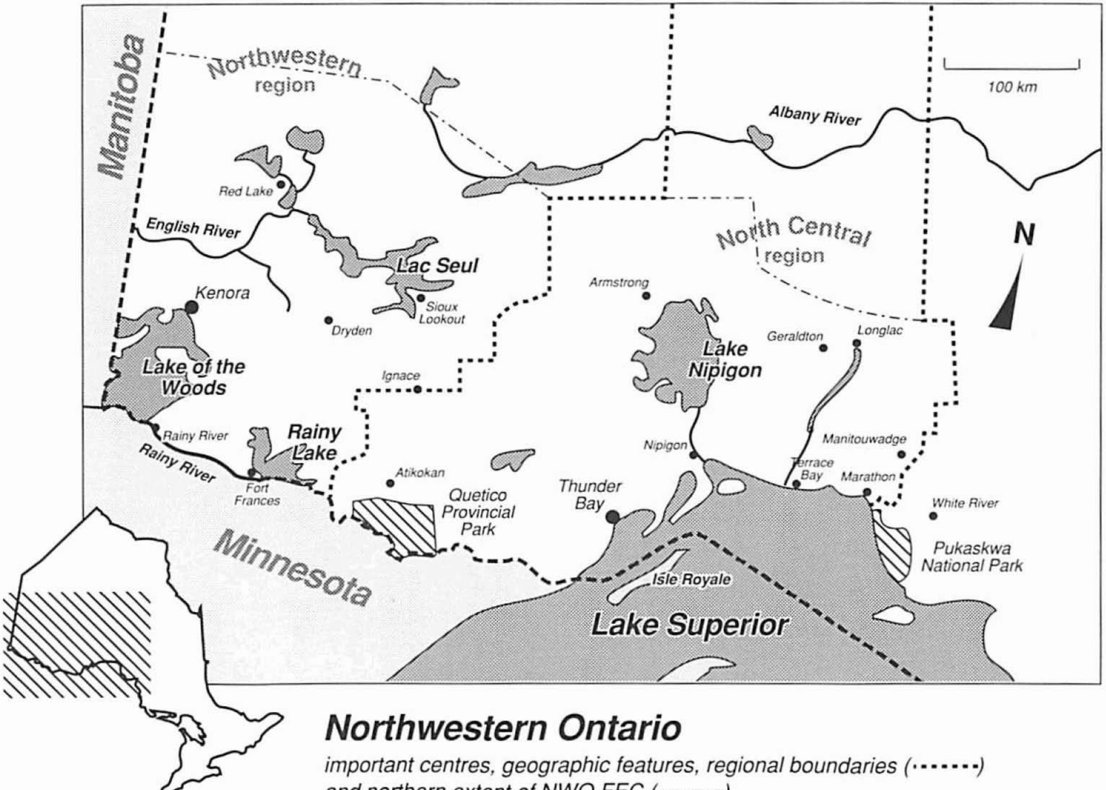
1. Orientation

1.1. Introduction to the Northwestern Ontario Forest Ecosystem Classification (NWO FEC)

Forest ecosystems are those forest / landscape units that resource managers must deal with during the planning and implementation stages of management. Forest ecosystems provide a basis for integrated, multi-use resource management which considers wildlife, recreation and other concerns along with timber harvesting. A clear and practical system for classifying these ecosystems is necessary if management knowledge and experience are to be organized, communicated and used effectively.

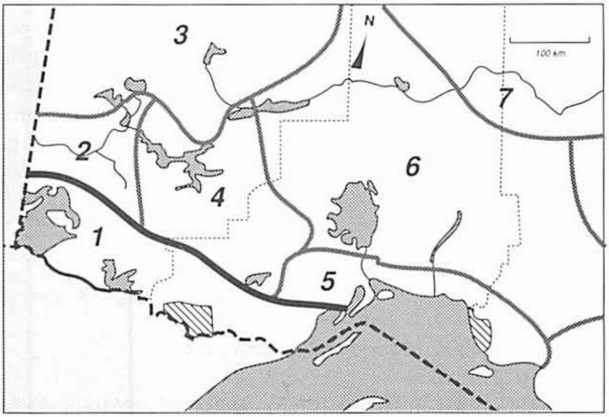
The NWO FEC system provides a method for classifying, identifying and naming distinct forest vegetation and soil conditions in northwestern (NW) Ontario. The classification was derived from collection and analysis of large amounts of quantitative vegetation and soil data from over 2,100 plot locations. The system is intended for application at the "stand level," normally within relatively small (less than 10 ha) forested areas (Sims 1989, Sims et al 1986, 1989).

This guide has been developed for application within NW Ontario, an area which includes two administrative regions of the Ontario Ministry of Natural Resources (OMNR): the North Central (NC) and Northwestern (NW) Regions. This large land area ranges from the Ontario - Manitoba border in the west to the general vicinity of Manitouwadge and White River in the east. The area of interest for this guide extends northward from the Ontario - U.S. border and the northern shore of Lake Superior as far as the limit of commercial forest in the province, a line which roughly coincides with the southern edge of the Hudson Bay Lowland physiographic zone. The total area exceeds some 184,000 sq km.



Northwestern Ontario

important centres, geographic features, regional boundaries (······) and northern extent of NWO FEC (·–·–·–)



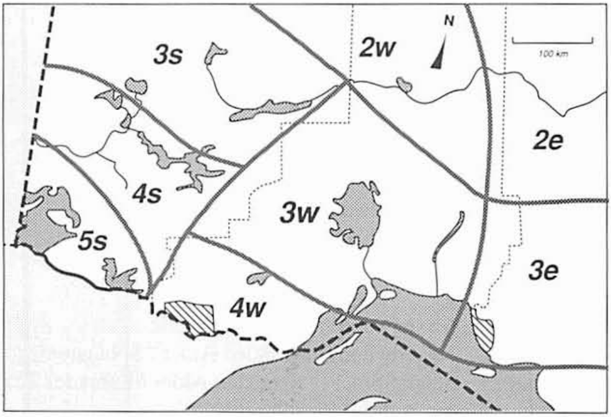
Forest Regions of Northwestern Ontario (after Rowe 1972)

Great Lakes - St. Lawrence Forest Region

1 Quetico - Rainy River

Boreal Forest Region

2 Lower English River
3 Northern Coniferous
4 Upper English River
5 Superior
6 Central Plateau
7 Hudson Bay Lowlands



Site Regions of Northwestern Ontario (after Hills 1961)

1.1.1. NWO FEC Vegetation Types

In the NWO FEC system, a forest stand is allocated to one of 38 Vegetation Types (V-Types). To assist in the stand allocation process, a vegetation field key has been developed based on general overstory composition, modified as necessary by the presence / absence or general abundance of a few important understory plants. There are three main groupings: ***Mainly Hardwood*** (11 V-Types), ***Conifer Mixedwood*** (9 V-Types) and ***Conifer*** (18 V-Types).

Mainly Hardwood

V1...........Balsam Poplar Hardwood and Mixedwood
V2...........Black Ash Hardwood and Mixedwood
V3...........Other Hardwoods and Mixedwoods
V4...........White Birch Hardwood and Mixedwood
V5...........Aspen Hardwood
V6...........Trembling Aspen (White Birch) - Balsam Fir / Mountain Maple
V7...........Trembling Aspen - Balsam Fir / Balsam Fir Shrub
V8...........Trembling Aspen (White Birch) / Mountain Maple
V9...........Trembling Aspen Mixedwood
V10.........Trembling Aspen - Black Spruce - Jack Pine / Low Shrub
V11.........Trembling Aspen - Conifer / Blueberry / Feathermoss

Conifer Mixedwood

V12.........White Pine Mixedwood
V13.........Red Pine Mixedwood
V14.........Balsam Fir Mixedwood
V15.........White Spruce Mixedwood
V16.........Balsam Fir - White Spruce Mixedwood / Feathermoss
V17.........Jack Pine Mixedwood / Shrub Rich
V18.........Jack Pine Mixedwood / Feathermoss
V19.........Black Spruce Mixedwood / Herb Rich
V20.........Black Spruce Mixedwood / Feathermoss

Conifer

V21.........Cedar (inc. Mixedwood) / Mountain Maple
V22.........Cedar (inc. Mixedwood) / Speckled Alder / Sphagnum
V23.........Tamarack (Black Spruce) / Speckled Alder / Labrador Tea
V24.........White Spruce - Balsam Fir / Shrub Rich
V25.........White Spruce - Balsam Fir / Feathermoss
V26.........White Pine Conifer

Conifer

V27.........Red Pine Conifer
V28.........Jack Pine / Low Shrub
V29.........Jack Pine / Ericaceous Shrub / Feathermoss
V30.........Jack Pine - Black Spruce / Blueberry / Lichen
V31.........Black Spruce - Jack Pine / Tall Shrub / Feathermoss
V32.........Jack Pine - Black Spruce / Ericaceous Shrub / Feathermoss
V33.........Black Spruce / Feathermoss
V34.........Black Spruce / Labrador Tea / Feathermoss (Sphagnum)
V35.........Black Spruce / Speckled Alder / Sphagnum
V36.........Black Spruce / Bunchberry / Sphagnum (Feathermoss)
V37.........Black Spruce / Ericaceous Shrub / Sphagnum
V38.........Black Spruce / Leatherleaf / Sphagnum

1.1.2. NWO FEC Soil Types

The soil is directly characterized by the NWO FEC system in terms of a few critical parameters (e.g. moisture regime, parent material texture, depth to bedrock). Two field keys are available: a deep soil key defining 13 S-Types (Soil Types with ≥ 100 cm of mineral or organic substrate), and a key to shallower soils defining 9 SS-Types (very shallow to moderately deep Soil Types with < 100 cm of mineral or organic substrate).

There are three main groupings of deep soils: ***Dry to Fresh Mineral*** (6 S-Types); ***Moist Mineral*** (5 S-Types) and ***Wet Organic*** (2 S-Types). There are four main groupings of shallow soils: ***Very Shallow*** (4 SS-Types); ***Dry to Fresh, Shallow to Moderately Deep*** (3 SS-Types); ***Moist, Shallow to Moderately Deep*** (1 SS-Type) and ***Wet Organic / Rock*** (1 SS-Type).

Deep Mineral

S1...........Dry / Coarse Sandy
S2...........Fresh / Fine Sandy
S3...........Fresh / Coarse Loamy
S4...........Fresh / Silty - Silt Loamy
S5...........Fresh / Fine Loamy
S6...........Fresh / Clayey

Deep Mineral	*S7*	Moist / Sandy
	S8	Moist / Coarse Loamy
	S9	Moist / Silty - Silt Loamy
	S10	Moist / Fine Loamy - Clayey
	S11	Moist / Peaty Phase
Deep Organic	*S12F*	Wet / Organic [Feathermoss]
	S12S	Wet / Organic [Sphagnum]
Very Shallow	*SS1*	Discontinuous Organic Mat on Bedrock
	SS2	Extremely Shallow Soil on Bedrock
	SS3	Very Shallow Soil on Bedrock
	SS4	Very Shallow Soil on Boulder Pavement
Shallow to Mod. Deep	*SS5*	Shallow - Moderately Deep / Sandy
	SS6	Shallow - Moderately Deep / Coarse Loamy
	SS7	Shallow - Moderately Deep / Silty - Fine Loamy - Clayey
	SS8	Shallow - Moderately Deep / Mottles - Gley
	SS9	Shallow - Moderately Deep / Organic - Peaty Phase

1.2. Introduction to NWO FEC Interpretations

This guide is the third volume in a series of publications which includes *Field Guide to the Forest Ecosystem Classification for Northwestern Ontario* (Sims et al 1989) and *Field Guide to the Common Forest Plants in Northwestern Ontario* (Baldwin and Sims 1989). Together these guides can be used to identify and make various interpretations about forest ecosystems of NW Ontario. Identification keys and detailed Factsheets for the Vegetation and Soil Types listed in Section 1.1 are found in Sims et al (1989).

The flexible nature of the NWO FEC is maintained by ensuring that vegetation and soil conditions do not become confounded with each other. This is accomplished by physically separating the V-Types, S-Types and their respective keys and Factsheets in the field guide (Sims et al 1989). Interpretations allow V- and S-Types to be either grouped or separated to recognize physical or biological properties. It is in the interpretations that relationships between V-Types and S-Types are considered for management purposes.

Over the last few years, site classification experts have successfully integrated a variety of forest management interpretations into site classification systems (e.g. Comeau et al 1982, Green et al 1984, Corns and Annas 1986, Coates and Haeussler 1987, Kotar et al 1988, Jones 1989, Zelazny et al 1989). Interpretations presented in this guide summarize some currently understood influences of soil, site, climate and vegetation on forest management practices in NW Ontario. These interpretations present collections of commonly accepted or established practices and concepts, and also incorporate, wherever possible, up-to-date technical and scientific knowledge. In most cases, the NWO FEC system provides the basic framework for adapting and developing these management interpretations for NW Ontario.

Some management interpretations will change dramatically with time, season of the year, economic conditions, existing technology, scale of application and silvicultural objectives (Still and Utzig 1982). Therefore, the user should be aware of the dynamic nature of these interpretations and be prepared to apply the information in a creative and intelligent manner. This not only ensures the best use of the information, but also offers greater flexibility in applying scientific knowledge to day-to-day management decisions. The user is challenged to test or evaluate the interpretations presented here and confirm or dispute their validity for specific sites, and under a variety of field conditions.

Under no circumstances should the information in this guide be construed as a formal recommendation or guideline for timber or resource management, or as a prescription for specific sites.

This guide organizes and presents operational concepts, procedures and ideas within a common framework. Some management interpretations in this guide may communicate ideas to a broad audience by relating new and perhaps unfamiliar technologies to NWO FEC Vegetation and Soil Types. Many of the interpretations presented here were based on reviews of pertinent literature and input from experienced foresters and biologists. Some of the more complex interpretations represent silvicultural considerations of harvest system, season of harvest, site preparation objectives, regeneration opportunities and requirements for competition control. Others, such as susceptibility to frost heaving, erosion, compaction, puddling and the suitability of sites for specific crop trees, are comparatively simple, and are based on only one or a few relatively stable ecosystem features.

1.3. Updating the Interpretations

Interpretations issued with the first (1989) printing of this guide should be considered as preliminary and first approximations. More interpretations will be developed and, as required, revisions to interpretations will be made available. The ring-binder format of this guide permits new sheets and sections to be easily inserted. Dates of issue will be clearly indicated on pages of all future additions and revisions so that users will be able to keep their guides organized and current.

Maintenance and update of this guide is the responsibility of the Northwestern Ontario Forest Technology Development Unit (NWOFTDU; see address on inside cover). Any comments, questions or suggestions concerning new interpretations or revisions to existing interpretations should be submitted to the NWOFTDU. Users who register their names and addresses with the NWOFTDU will automatically be sent updates as they become available.

1.4. Special Considerations

NWO FEC - related interpretations usually complement each other but because they often deal with complex and dynamic conditions, they may sometimes appear to contradict one another. The user is encouraged to select from the information presented and, while keeping management objectives in mind, direct the most appropriate management actions at specific sites. Use of the interpretations should foster adaptive management and improve communication of ideas and results.

A series of provincial publications summarize state-of-the-art information for managing the forest resource by *working group* (Anon. 1986, Arnup et al 1988, Davidson et al 1988). These silvicultural guides for working groups outline site and productivity factors in a general sense and describe various acceptable management options. Some overlap occurs, but it is not intended that the NWO FEC interpretations duplicate this information. Some information is restructured in the interpretations to make it compatible with NWO FEC terminology.

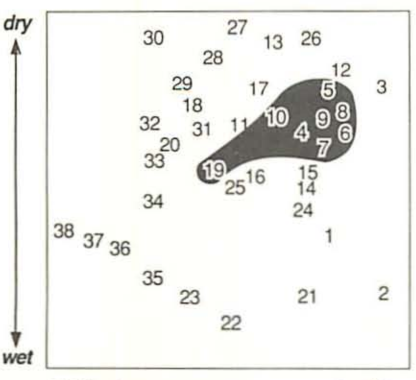
There is considerable diversity among vegetation components of NW Ontario forests. Typically, vegetation development is influenced by past disturbances (e.g. fire history of natural stands). Successional pathways can vary dramatically with the type or severity of the disturbance, and management treatments applied after harvest. Understory characteristics are often strongly influenced by overstory composition in mature forest stands. Therefore, the overstory layer is a major determinant when classifying the vegetation component of these ecosystems and is often treated as being independent of soils.

Soil Type texture classes are determined using samples from the C horizon or parent material (Sims et al 1989). Usually a strong correlation exists between C horizon texture and that of the A or B horizons. Some interpretations in this guide are based on A or B horizon textures. These soil layers are influenced directly by processes such as soil erosion and compaction and contribute to frost heaving risk. It is noted on the individual interpretations when this convention has been used.

Characteristics such as soil texture, moisture regime, drainage, coarse fragment content, mode of deposition of parent material, and physiographic features such as aspect and slope position, are relatively stable ecosystem components, even after timber harvest. A knowledge of surficial geology or glacial history of a management unit (see Sado and Carswell 1987) can provide useful background information for understanding local soil/site features.

Section 2

Treatment Units



2. Treatment Units

2.1. Introduction

Treatment Units are management-oriented aggregations of defined soil and vegetation conditions that possess similar species composition, productivity, macroclimatic or ecological properties. Treatment Units are easily identified in the field and represent broad landscape units which will respond similarly to a given silvicultural treatment regime. Treatment Units are the natural forest components for forest-level modelling of wood supply, habitat or treatment response. Definition of Treatment Units will differ with management objectives.

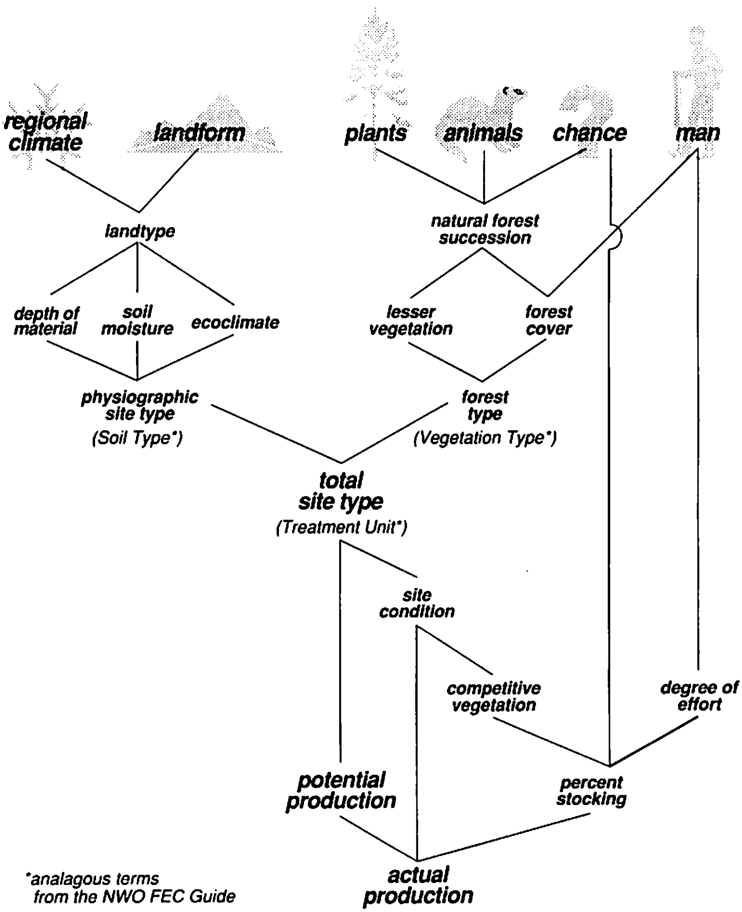
The notion of Treatment Units is not new. Hills and Pierpoint (1960) proposed a similar approach to forest site evaluation in Ontario, which integrated soils and vegetative components into ecological units. They defined Physiographic Site Types (comparable to NWO FEC Soil Types), and Forest Types (comparable to NWO FEC Vegetation Types) and suggested they be combined into ecological units called Total Site Types (comparable to Treatment Units). This concept (Hills 1960, 1961, Hills and Pierpoint 1960) contributed to our current thinking and approach to the field application of the NWO FEC.

Silvicultural treatment options in Ontario are primarily assigned according to the existing or previous working group occupying a site. Stratification by working group is convenient, as it corresponds to Ontario's *Forest Resource Inventory* (FRI). Often this stratification is not ecologically-based and the results of silvicultural treatments applied to a working group, even by site class, may not be easily predicted. For silvicultural planning, stratification of the land base into Treatment Units at either the *Annual Work Schedule* or *Management Plan* levels (Anon. 1986) will improve prediction of silvicultural responses and increase the effectiveness of silvicultural treatment allocation.

Treatment Units organize forest management practices on a management unit in an ecologically relevant manner. They are less precise in describing soil/site and vegetation characteristics than the original NWO FEC system, however, in most instances, it would be possible to work back through the Treatment Unit groupings to component NWO FEC Vegetation and Soil Types. Maintaining this link with the basic building blocks will encourage better communication among foresters responsible for different management units, smooth incorporation of new technology into practice, facilitate problem solving, improve assessment and recording of field data, and provide for more efficient training of new staff.

Ecological Relationships Determining Forest Production

(adapted from Hills and Pierpoint 1960)



*analagous terms from the NWO FEC Guide

Eleven Treatment Units, generalized for all of NW Ontario, are proposed in this guide. The user may wish to adopt these, or restructure them to better reflect the silvicultural objectives, logistical constraints and scale of operations within a district or management unit. Alternatively, users may wish to define their own Treatment Units (see Section 2.2).

Treatment Units may be divided into *Phases* where it is felt that secondary features of the Treatment Unit may influence certain specific responses to management. Phases may be defined in a number of ways, but should serve to focus management options. For the Treatment Units given here, several Phases were distinguished on the basis of some secondary site features: soil moisture regime groupings, general slope position, shrub richness or broad soil depth class.

Treatment Units and Phases may be referred to by short, descriptive names or alphabetic identifiers (the latter may be adaptable for air photo or map annotation):

A.........Miscellaneous Hardwoods and Mixedwoods
B.........Aspen Hardwood and Mixedwood
- ***B1***.......Dry - Fresh Soils
- ***B2***.......Moist Soils

C.........White Birch Hardwood and Mixedwood
D.........Balsam Fir - White Spruce Conifer and Mixedwood
- ***D1***.......Dry - Fresh Soils
- ***D2***.......Moist Soils

E.........Black Spruce - Jack Pine / Feathermoss
- ***E1***.......Dry Soils
- ***E2***.......Fresh Soils
- ***E3***.......Moist Soils

F.........Jack Pine / Feathermoss
G.........Jack Pine / Shrub Rich
H.........Red or White Pine Conifer and Mixedwood
I...........Jack Pine - Black Spruce / Blueberry / Lichen
- ***I1***........Very Shallow Soils
- ***I2***........Deep - Moderately Deep / Sandy Soils

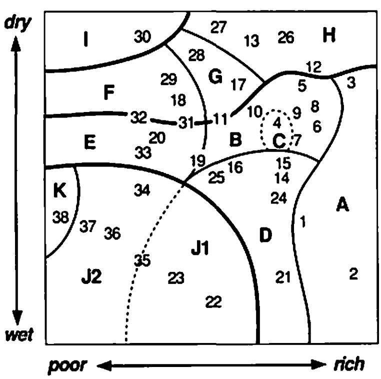
J..........Black Spruce / Wet Organic
- ***J1***.......Speckled Alder
- ***J2***.......Shrub Poor

K.........Black Spruce / Leatherleaf / Sphagnum

These Treatment Units may be depicted on the two-dimensional ordination of NWO FEC V-Types (Sims et al 1989). Each Treatment Unit is delineated from the others and labelled. The intensity of the lines separating the Treatment Units is proportional to the strength of the ecological arguments for assigning different treatment regimes. The dashed lines indicate a relatively weak separation of Units based on silvicultural interpretations.

Treatment Units should reflect limitations or opportunities for silviculture. For example, ***Treatment Unit J*** has moist to wet organic soils that seasonally restrict mechanical operations but often provide suitable seedbeds for natural seeding to black spruce. ***Phase J1*** is more likely to require tending to control speckled alder than ***Phase J2. Treatment Unit B*** provides conditions suitable for aspen suckering indicating either good natural regeneration potential for aspen or heavy aspen competition for regenerating conifers.

There are a variety of ways to practically extract, organize or present management information relative to Treatment Units. These include development of look-up tables, factsheets, flowcharts, hierarchical keys and NWO FEC vegetation ordination overlays. Many of these formats have been successfully applied during development of management interpretations related to other site classification systems in other parts of Canada (e.g. Green et al 1984, Corns and Annas 1986, Stanek and Orloci 1987, Coates and Haeussler 1987, Merchant et al 1989, Zelazny et al 1989). A number of these formats are used throughout this guide.



Treatment Unit groupings superimposed upon NWO FEC V-Types

2.2. How to Develop Treatment Units

2.2.1. General

Treatment Units should be defined to address management considerations within a specific management unit. Only a few NWO FEC Vegetation and Soil Types are usually abundant in any local area, and this may make the task of constructing Treatment Units much easier. Management considerations such as planting stock availability, labour force, equipment, wood utilization patterns and mill requirements will either be well established or will be under control of a long term strategy. A wide number of management variables should be weighed together in the development of Treatment Units.

A working knowledge of the diversity of the landbase and the range of forest stand conditions in an area is important for proper development of Treatment Units. Either through first-hand knowledge or by conduct of systematic preharvest surveys (Towill et al 1988) of an area, experienced foresters should be aware of the occurrence and relative importance of NWO FEC Vegetation and Soil Types on their management area. Such a general understanding is an important precursor to the development of the Treatment Units.

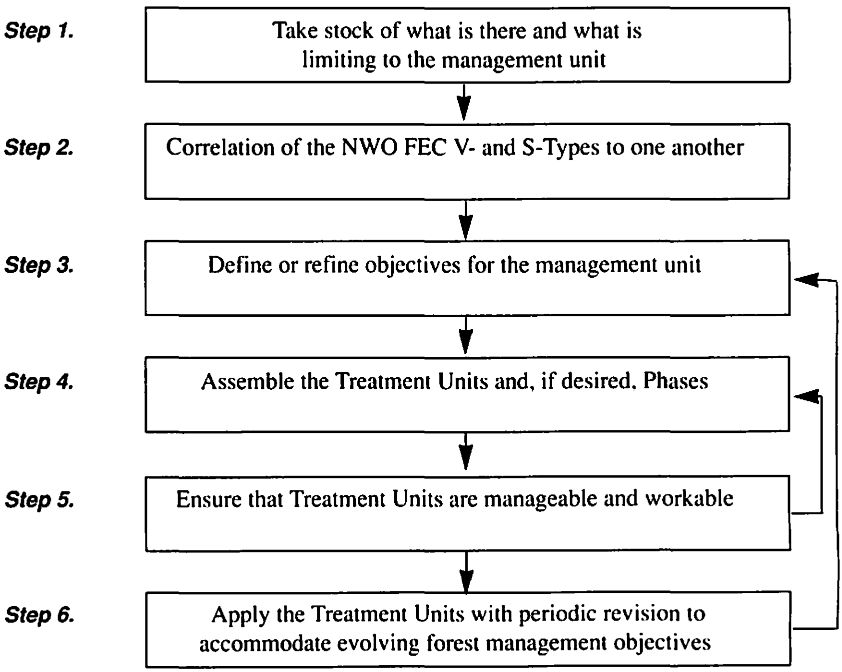
There are strong correlations between NWO FEC Vegetation Types and the species working group concept. As a result, it is often easy to translate FRI working groups and *site classes* into Treatment Units. However, there will not always be a close correlation between stands mapped using the FRI system and those mapped by Treatment Units. Aerial photograph interpretive keys of NWO FEC conditions may be developed to assist in mapping and in correlating FRI mapped polygons with mapped Treatment Unit polygons (see Section 2.2.3).

To develop Treatment Units, users should have some training and working experience with plant identification, soils description and field allocation to NWO FEC Vegetation and Soil Types.

2.2.2. Assembling Treatment Units

Treatment Unit development and refinement is an iterative and ongoing process. The six steps can be briefly summarized:

Flowchart for Treatment Unit Development



Step 1: Determine commonly occurring NWO FEC Vegetation Types and Soil Types on the management unit by conducting a preharvest survey (Towill et al 1988) or by reviewing existing data and knowledge. Determine what vegetation / site / soil factors are limiting in the management unit, thereby establishing what parameters are important for assembling Treatment Units. In the example Treatment Units described in Section 2.4, overstory vegetation, expected levels of competition, soil texture, moisture regime and depth were used to define Treatment Units. Supplementary information on the soils, stands and history of the unit would be beneficial, particularly if available in map form.

Step 2: Examine common soil - vegetation relationships associated with each of the dominant landform conditions. For example, ***V32*** can occur on many different soil conditions depending on the geological and ecological history of the area. What are the common S-Types and SS-Types in your management unit and what V-Types commonly occur on them?

Step 3: Management objectives vary dramatically from management unit to management unit and should reflect the priorities assigned to a specific area. Determine what factors limit forest management and decide how these will influence the treatments applied to specific sites. Distance to the mill, labour force availability, equipment availability and product demand may all influence Treatment Unit development. For example, vegetation cover influences a number of forest management considerations:

- site preparation treatment and/or equipment selection
- natural ingrowth of "desirable" species
- potential competition
- potential costs for silviculture; site preparation and planting difficulty
- percent coverage of silvicultural treatment (gross versus net area)
- important wildlife habitats
- seed source
- product mix

Step 4: Amalgamate V-Types which have similar overstory species, crop trees, potential competitors and expected density of residuals. For example, ***V14***, ***V15***, and ***V16*** might be a good combination because they will respond similarly to prescribed burn, plantation establishment and herbicide treatment. They will also produce stands of similar productivity and therefore can utilize the same yield tables. On a management unit of average size, with a normal range of diversity for NW Ontario, eight to twelve major vegetation groupings may be expected.

The unifying features of a Treatment Unit are usually its soil or vegetation characteristics, and potential productivity. For example, under current levels of management, ***V7 [Trembling Aspen - Balsam Fir / Balsam Fir Shrub]*** can be combined in the same Treatment Unit as ***V11 [Trembling Aspen - Conifer / Blueberry / Feathermoss]*** because they both offer the option of managing for aspen from natural regeneration, or they both produce heavy competition from aspen if regenerating the site to conifers. On the other hand, amalgamating ***V14 [Balsam Fir Mixedwood]*** and ***V28 [Jack Pine / Low Shrub]*** into a single Treatment Unit would not be recommended even if a similar silvicultural treatment could be applied because the physical characteristics and productivity of the two are very different.

If phasing is desired, choose which site parameters you consider meaningful on your management area. In this guide soil moisture, soil depth and expected levels of speckled alder competition were used; in others it may be drainage and soil texture. Parameters used for phasing Treatment Units should be easily identified in the field.

Relationships between Treatment Units proposed in this guide and NW Ontario soil texture / moisture regime classes are summarized in two tables found in this section.

Step 5: If the Treatment Units are not workable on an operational level, as determined by field evaluation, then further refinement is required. Normally this could be accomplished by a re-examination of the forest management objectives, particularly if these objectives are gradually evolving through time. For example, if balsam fir is to be managed as a pulpwood species and white spruce as a sawlog species, the amalgamation of ***V14*** and ***V15*** may not be acceptable. ***V14*** might be managed as short rotation for balsam pulp and ***V15*** could be used for longer rotation white spruce sawlogs.

Step 6: Apply the Treatment Units in the field and plan a periodic review of their utility and validity. Revise and update as new information and new management considerations become available (for example, every 5-10 years).

Percent occurrence of soil texture / moisture regime groupings on each of the Treatment Units.

Total occurrence for each Treatment Unit sums to 100 (read down). ***Treatment Units F, G*** and ***H*** are lumped together because of the similar soils on which they occur.

	Treatment Unit								
Soil Texture / Moisture Regime Grouping*	*I1 I2*	*FGH*	*E1 E2 E3*	*B1 B2*	*C*	*D1 D2*	*A*	*J1 J2*	*K*
Shallow / Dry	29	4	6	0	0	1	0	1	0
Sandy / Dry	14	27	12	11	7	9	0	0	0
Coarse Loamy / Dry	12	6	5	2	4	4	0	1	0
Shallow / Fresh	5	1	2	0	6	2	1	0	0
Sandy / Fresh	19	25	16	18	18	12	6	0	0
Coarse Loamy / Fresh	12	22	19	23	34	18	4	3	0
Silty / Fresh	0	3	6	9	1	9	5	2	0
Fine Loamy - Clayey / Fresh	2	5	9	19	3	19	23	3	0
Sandy / Moist	5	2	6	4	6	3	2	3	0
Coarse Loamy / Moist	2	2	11	7	17	8	15	10	5
Silty / Moist	0	1	3	2	3	4	8	1	0
Fine Loamy - Clayey / Moist	0	2	3	5	1	8	19	5	0
Organic / Moist	0	0	1	0	0	1	6	21	5
Organic / Wet	0	0	1	0	0	1	10	50	90

**Shallow*	***SS1, SS2, SS3, SS4***	*Sandy*	***S1, S2, S7, SS5***
Coarse Loamy	***S3, S8, SS6, SS8***	*Fine Loamy - Clayey*	***S5, S6, S10, SS7***
Silty	***S4, S9***	*Organic*	***S11, S12S, S12F, SS9***

Percent occurrence of each of the Treatment Units on soil texture / moisture regime groupings.

Total occurrence for each soil texture / moisture regime grouping sums to 100 (read across). ***Treatment Units F, G*** and ***H*** are lumped together because of the similar soils on which they occur.

Soil Texture / Moisture Regime Grouping*	*Treatment Unit*								
	I1 I2	*FGH*	*E1 E2 E3*	*B1 B2*	*C*	*D1 D2*	*A*	*J1 J2*	*K*
Shallow / Dry	17	24	53	1	0	3	0	3	0
Sandy / Dry	2	40	28	19	2	8	0	0	0
Coarse Loamy / Dry	7	31	35	10	4	10	0	3	0
Shallow / Fresh	7	11	50	0	14	14	4	0	0
Sandy / Fresh	2	30	29	23	4	9	2	0	0
Coarse Loamy / Fresh	1	22	30	25	7	11	1	2	0
Silty / Fresh	0	9	30	32	1	19	4	4	0
Fine Loamy - Clayey / Fresh	0	8	24	34	1	19	10	4	0
Sandy / Moist	2	8	42	20	5	8	2	12	0
Coarse Loamy Moist	1	4	37	16	7	10	8	17	0
Silty / Moist	0	6	36	13	4	19	15	8	0
Fine Loamy - Clayey / Moist	0	6	18	21	1	19	19	15	0
Organic / Moist	0	0	10	1	0	4	7	77	1
Organic / Wet	0	0	3	0	0	2	5	81	9

**Shallow*	***SS1, SS2, SS3, SS4***	*Sandy*	***S1, S2, S7, SS5***
Coarse Loamy	***S3, S8, SS6, SS8***	*Fine Loamy - Clayey*	***S5, S6, S10, SS7***
Silty	***S4, S9***	*Organic*	***S11, S12S, S12F, SS9***

2.2.3. Mapping and Photo Interpretation of Treatment Units

There are many aspects of mapping and photo interpretation which must be considered when dealing with Treatment Units on an operational basis. Some of these will be covered in detail in a separate report. One such consideration occurs when all V-Types within a stand do not necessarily conform to a single Treatment Unit. In this case, the silvicultural treatment used could be selected for either the dominant or the limiting factor (see Valentine 1986). If silviculture is applied to address the dominant factor, it could be based on a "75% rule". This means that if 75% of a block consists of a single Treatment Unit and the remainder of the block consists of several other Treatment Units in combination, then the block will be treated according to the objectives and options outlined for the Treatment Unit making up 75% of the area. On the other hand, if 25% of the area consists of a site condition or a Treatment Unit that is a limiting factor, then the silvicultural treatment required for this limiting factor may have to be applied to the entire block. This guide encourages site-specific silviculture to be applied to blocks of eight hectares or more with which a specific Treatment Unit can be associated.

Broad application of Treatment Units can also facilitate timber management planning. They may be used to help define *Annual Work Schedules* and silvicultural options in the *Timber Management Plan* (Anon. 1986). Treatment Units also provide a new ability to compare the economic efficiencies of silvicultural options.

2.3. Introduction to the Treatment Unit Factsheets

2.3.1. General

The Treatment Unit Factsheets describe each Treatment Unit in terms of V-Types, S- and SS-Types, other soil-related properties and silvicultural significance. These Factsheets are derived in a subjective manner and, therefore, a quantitative presentation of data would be misleading. However, the reader should be aware of the significance of, and how to interpret, each section of the Factsheet.

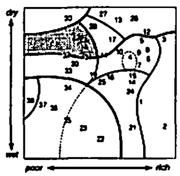
2.3.2. Layout of the Treatment Unit Factsheets

Example Treatment Unit Factsheet

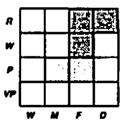
2 → ***Treatment Unit F***

1 → Jack Pine / Feathermoss

3 → ***Vegetation Types***
V18, V29, V31, V32. Typically even-aged jack pine or jack pine-black spruce stands with extensive feathermoss ground cover. Limited aspen or birch may be found in some stands. Jack pine dominates all stands.

4 →


Soil / Site Characteristics

5 →


6 → ***Common NWO FEC Soil Types: S1, S2, SS6, S3.*** Generally deep to moderately deep, moderately dry to fresh, sandy to coarse loamy soils.

7 → ***Mode of Deposition:*** glaciofluvial, morainal, lacustrine

8 → ***Drainage:*** v. rapid to well

Management Considerations

9 → ***Harvesting Constraints:*** No constraints to equipment or season. However, if natural regeneration is desired for these stands, care should be taken to ensure that a seed source remains on site; whole tree logging systems may reduce seed source.

10 → ***Competition:*** Competition may occur from *Alnus crispa* or trembling aspen, but typically it is not heavy and does not warrant control or tending.

11 → ***Diseases:*** No economically significant diseases.

12 → ***Insects:*** These sites may be prone to jack pine budworm *(Choristonuera pinus pinus)* infestations.

2-33

Treatment Unit F

16

13 *Regeneration:* These sites respond well to light drags for distribution of slash, as well as exposure of mineral soil for seeding or planting to jack pine. Tending will probably not be required. These sites are well suited for natural regeneration to jack pine because of the abundant seed source and little expected competition.

14 *Limitations to Equipment:* No limitations to equipment anticipated.

15 *Wildlife:* Low value for food production or shelter for most wildlife species. Cone feeding birds and mammals such as red squirrels or chipmunks may be abundant in some stands.

17 *Comments*

Whole tree harvesting may reduce the seed source. Low levels of competition, ease of regeneration and generally high yields make these sites desirable for jack pine management. These stands are typically well suited to extensive, even-aged management.

2-34

The identification banner includes the Treatment Unit name [1] and an alphabetic identifier [2]. The Treatment Unit name consists of a few important species or species groups, listed by stratum. Slashes are used to separate strata and dashes separate species or species groups within a stratum. The alphabetic identifier is unique and avoids confusion with the V-Type and S-Type numbers of the NWO FEC. One or more Treatment Unit Phases, based on soil or other conditions, may be identified below the banner. Each of the Phases has an alphanumeric identifier where the alphabetic portion refers to the Treatment Unit and the numeric portion refers to the Phase (e.g. ***Phase E2***).

The V-Types typically included within the Treatment Unit are listed along with a general description of the vegetation conditions [3]. Emphasis is placed on those plant species which are used for identification of the Treatment Unit. To the right, the V-Types which are typically included in the Treatment Unit are highlighted in the Vegetation Type ordination [4] (Sims et al 1989). Generalized soil drainage and moisture regime classes are summarized in a cross-tabulation [5]. Graphics conventions are defined in Section 2.3.3.

Some soil/site characteristics associated with the Treatment Unit are summarized below. These include common NWO FEC Soil Types [6], mode of deposition [7] and soil drainage [8]. These summaries were derived from the original NWO FEC dataset. Soil/site characteristics are listed in descending order of frequency of occurrence. Terms used in the soil/site summaries are defined in Section 2.3.4.

Several management considerations are briefly described for the Treatment Unit. These include harvesting constraints [9], competition [10], susceptibility to disease [11] and insect infestations [12], regeneration opportunities or constraints [13], limitations to equipment [14] and importance to wildlife [15].

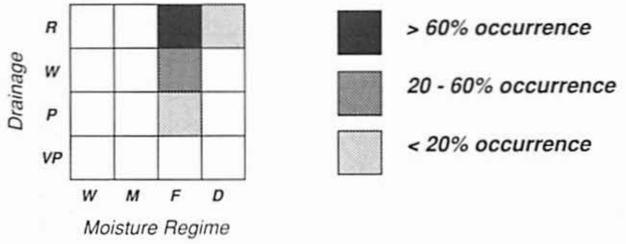
At the top of the second page, the Treatment Unit is illustrated by a schematic, cross-sectional diagram [16] depicting the degree of variation of vegetation and substrate which may be found within the Treatment Unit. Miscellaneous descriptive or interpretive notes are listed in the ***Comments*** section [17] at the end of the Factsheet. Individuals may wish to add other comments for their own use.

2.3.3. Conventions for Use of the Treatment Unit Factsheets

General Use: All Treatment Unit definitions and conventions are based on the assumption that silvicultural objectives are clearly identified by the user. Comparison, fine-tuning or pooling of Treatment Units should be undertaken only with specific objectives in mind and a first-hand knowledge of the management area. If specific information about the soils in the management area is not available, then it should be assumed that the Treatment Unit is primarily composed of the S-Types or SS-Types listed first and second on the Factsheet.

Phases: Phasing of Treatment Units was subjectively based on indicators of relative site productivity. Silviculturally relevant Phases were developed using factors such as soil texture, soil depth, soil drainage / moisture regime or shrub richness.

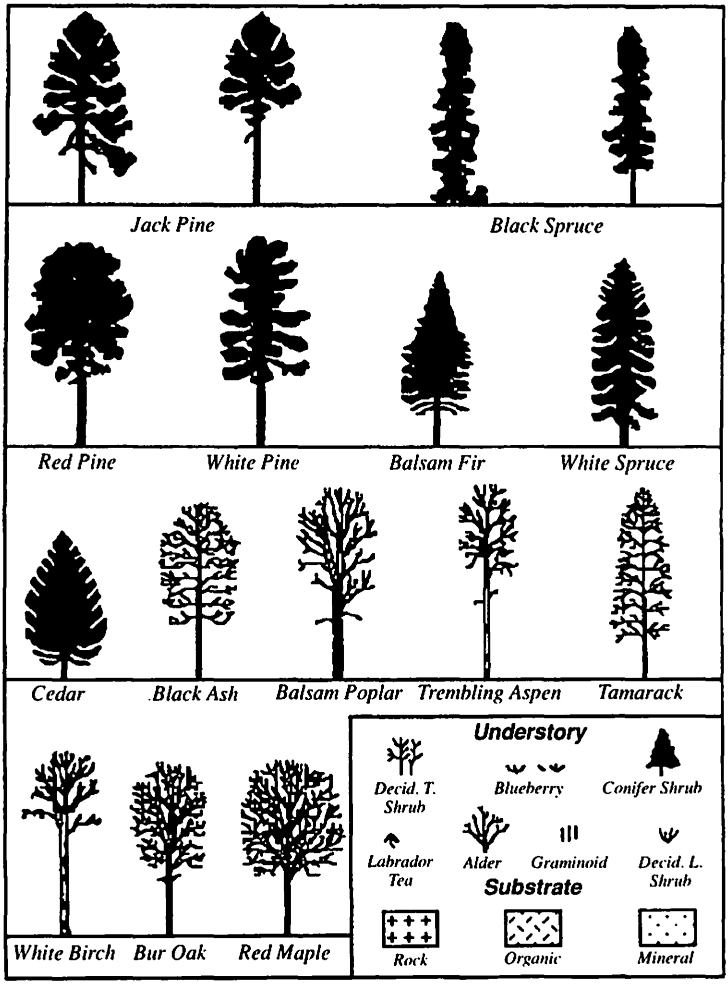
Cross-tabulations: Groupings of soil drainage and moisture regime classes are defined in Section 2.3.4. Graphic conventions are provided below.



Harvesting Constraints: Site-related factors that have a bearing on the selection of harvesting equipment, season of harvest or stand operability are listed as harvesting constraints.

Competition: Major competing species are listed in order of relative importance using their scientific names. Other factors that influence intensity of competition may also be listed or described in this section.

Cross-sectional Diagrams: Symbols used in the cross-sectional diagrams are defined in the chart below.



Major Insects and Diseases: Stand susceptibility to major insects and diseases is noted, as well as various site factors which enhance or diminish the occurrence, density or severity of infestation.

Regeneration: Regeneration opportunities or constraints for the Treatment Unit are identified with the recognition that actual decisions will be heavily dependent upon silvicultural objectives for the site.

Limitations to Equipment: Site characteristics that could limit equipment selection, skid-trail lay-out or equipment use are noted. In some cases suggestions are included about equipment usage which might enhance site protection.

Wildlife: Some of the significant wildlife considerations for the Treatment Unit are identified. Managers should be aware how silvicultural operations within the Treatment Unit may influence wildlife.

2.3.4. Terminology Used in the Treatment Unit Factsheets

Soil Groups: Groupings of NWO FEC S-Types (Sims et al 1989):

dry to fresh, deep (≥100 cm) mineral soils	***S1-S6***
moist, deep (≥100 cm) mineral soils	***S7-S11***
wet, deep (≥100 cm) organic soils	***S12F, S12S***
very shallow (≤20 cm) soils	***SS1-SS4***
shallow to mod. deep (21-99 cm) mineral soils	***SS5-SS8***
shallow to mod. deep (21-99 cm) wet organic soils	***SS9***

Soil Texture: Mineral soil texture classes (Ontario Institute of Pedology 1985, Working Group on Soil Survey Data 1978) are grouped in the Factsheets. The texture class groupings are:

coarse sandy	very coarse sand, coarse sand, medium sand, loamy very coarse sand, loamy coarse sand, loamy medium sand
fine sandy	fine sand, very fine sand, loamy fine sand
coarse loamy	loamy very fine sand, loam, all sandy loams, all silty sands
fine loamy	clay loam, silty clay loam, all sandy clay loams
silty	silt, silt loam
clayey	clay, silty clay, sandy clay

Moisture Regime / Drainage: Moisture regime and drainage classes, derived using standard tables (Ontario Institute of Pedology 1985, Sims et al 1989), are grouped for the Treatment Unit Factsheets:

Moisture Regime:

dry (D)	dry, moderately dry	MR Ø, 0
fresh (F)	moderately fresh, fresh, very fresh	MR 1, 2, 3
moist (M)	moderately moist, moist, very moist	MR 4, 5, 6
wet (W)	moderately wet, wet, very wet	MR 7, 8, 9

Soil Drainage:

rapid (R)	very rapid, rapid	Drainage Classes 1, 2
well (W)	well, moderately well	Drainage Classes 3, 4
poor (P)	imperfect, poor	Drainage Classes 5, 6
v. poor (VP)	very poor	Drainage Class 7

Mode of Deposition: Landform soil material and mode of deposition classes are based on those of the landform classification in *The Canadian System of Soil Classification* (Canada Soil Survey Committee, Subcommittee on Soil Classification 1978).

Mode of Deposition	***Description***
aeolian	well-sorted, poorly compacted sediments which have been transported and deposited by wind action
colluvial	heterogeneous mixture of materials which has reached its present position due to direct, gravity-induced movement; usually associated with steep slopes
fluvial	sediments, usually stratified and well-sorted, which have been transported and deposited by flowing water (i.e., rivers and streams)
glaciofluvial	fluvial materials which have been transported and deposited by streams flowing from, on, or under melting glacial ice
lacustrine	sediments, usually sorted and stratified, which have either settled from suspension in standing bodies of fresh water or have accumulated at their margins through wave action

morainal	heterogeneous mixture of materials, typically unsorted and unstratified, which has been transported and deposited directly by glacial ice
organic	soil materials which have developed dominantly from organic deposits (i.e., containing >17% organic carbon or approximately 30% organic matter by weight)
talus	sloping accumulation of fragmental rock (colluvial material) lying at the base of a cliff or steep slope
till	morainal materials

Herb or Shrub Rich / Poor: These descriptive terms incorporate information on both species diversity and overall abundance within a stratum. For example, a "shrub rich" understory would be expected to have a diversity of species as well as relatively dense development within the shrub layer.

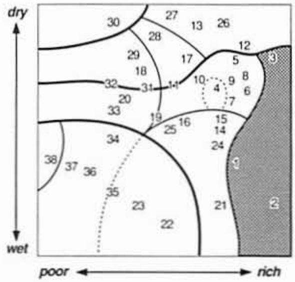
Graminoid: A collective term referring to grass-like vegetation. Species of grasses, sedges and rushes are included in the graminoid category.

Treatment Unit A

Miscellaneous Hardwoods and Mixedwoods

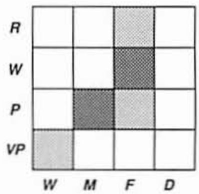
Vegetation Types

V1**, **V2**, **V3**.* A variety of hardwood and mixedwood stands, typically occurring in small, localized pockets in NW Ontario. Stands of this Treatment Unit may be of balsam poplar, black ash or a mixture of other hardwood species such as bur oak, red ash, red maple, yellow birch or basswood. ***Treatment Unit A is most prevalent in the vicinity of Lake of the Woods. In the NC Region it occurs primarily in depressions and lower slope positions.



Soil / Site Characteristics

Common NWO FEC Soil Types: S10, S6, S8, S12F, S9. These are typically rich, deep, fresh to very moist, fine-textured (often clayey) soils.



Mode of Deposition: lacustrine, morainal, organic

Drainage: poor to moderately well

Management Considerations

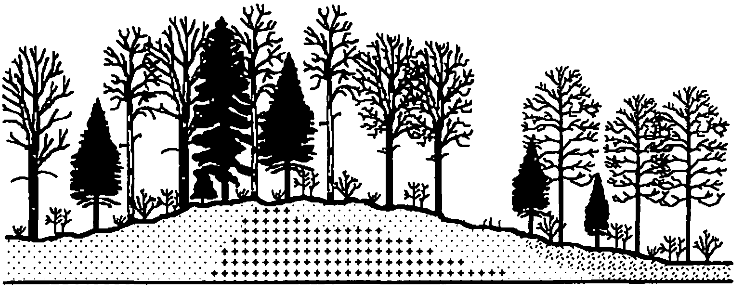
Harvesting Constraints: Wet, organic and fine-textured soils are subject to compaction, rutting and puddling. Widely spaced skid trails, winter harvest or late summer harvest under dry conditions will minimize site degradation.

Competition: Extremely heavy competition from trembling aspen, balsam poplar, *Acer spicatum*, *Cornus stolonifera*, *Alnus rugosa*, red maple, *Corylus cornuta* and *Calamagrostis canadensis* can be expected. Summer harvest may reduce suckering but is not usually an option on moist or wet sites. Less competition is expected on ***V3***.

Diseases: Susceptible to *Armillaria* spp., with increasing vulnerability to rot as the stand ages.

Insects: No economically significant insect pests.

Regeneration: Regeneration to original species has few limitations and coppice regeneration of balsam poplar, trembling aspen, black ash and yellow birch is easily accomplished. Expected high levels of competition and the high risk of frost heaving, particularly in the poorly drained soils, limit the use of small stock types or fall planting.



Limitations to Equipment: These wet, poorly drained soils are easily degraded; prime movers can become readily bogged down during the unfrozen season and depressions can fill with water. Vehicles with low load-bearing pressure may reduce risk of site degradation.

Wildlife: May be valuable browse production areas for deer or moose and may provide habitat for birds and mammals typically found in the Great Lakes - St. Lawrence Forest Region.

Comments

Generally, the local nature of these stands will mean that they are not harvested. Shelterwood harvest and small patch clearcutting will facilitate regeneration to the original species. Balsam poplar and black ash can be valuable products if this Treatment Unit is fairly common in the management unit or if it comprises large operating blocks.

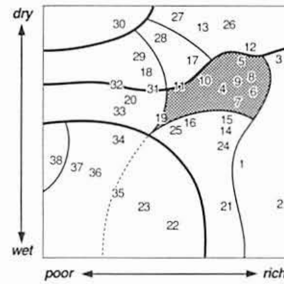
Treatment Unit B

Aspen Hardwood and Mixedwood

Phase B1 : Dry - Fresh Soils
Phase B2 : Moist Soils

Vegetation Types

V5, V6, V7, V8, V9, V10, V11, V19. Stands range from pure aspen to aspen mixed with white birch, balsam fir, jack pine, black spruce or white spruce. The understory is usually productive with a dense, tall and low shrub layer.

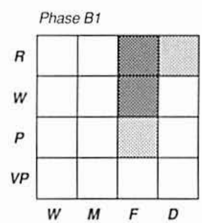


Soil / Site Characteristics

Common NWO FEC Soil Types:

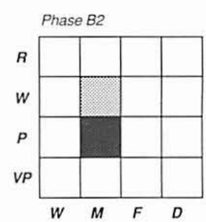
Phase B1 : ***S3, S6, S2, S1, S4.*** Deep, moderately dry to very fresh, sandy and coarse loamy, with some clayey, soils.

Phase B2 : ***S8, S7, S10, S9.*** Deep, moist to very moist, fine loamy and clayey soils (a wide range of textures).



Mode of Deposition:

Phase B1 : morainal, glaciofluvial, lacustrine
Phase B2 : lacustrine, morainal, glaciofluvial



Drainage:

Phase B1 : rapid to moderately well
Phase B2 : imperfect to poor

Management Considerations

Harvesting Constraints:

Phase B1 : No constraints due to season of harvest. Budworm mortality of balsam fir component could reduce harvest efficiency.

Phase B2 : Clayey and fine loamy soils are susceptible to compaction and erosion; winter or dry season harvest may mitigate these risks. Occasional large quantities of rapidly degrading trembling aspen may reduce harvest efficiency.

Competition:

Phase B1 : Woody shrub and tree competition from trembling aspen, *Acer spicatum*, *Alnus crispa*, *Corylus cornuta* and balsam fir can be expected. Herbaceous competitors include *Aster macrophyllus* and *Calamagrostis canadensis*. Chemical tending may be necessary. Hexazinone cannot be used on these sandy and coarse loamy soils.

Phase B2 : Expect "very heavy" competition from those species mentioned for ***Phase B1***. Chemical tending will be necessary if converting the stand to conifers.

Diseases: Highly susceptible to *Armillaria* spp. in ***Phase B1*** and to a lesser degree in ***Phase B2***. Balsam fir, white spruce and black spruce may also be susceptible to *Inonotus tomentosus* on the same sites where *Armillaria* spp. occurs.

Insects: Stands are vulnerable to spruce budworm if the proportion of balsam fir and white spruce in the stand exceeds 20% of total crown volume.

Regeneration: Regenerates to trembling aspen naturally after summer or winter harvest. Winter harvest of these sites will result in a greater density of suckering. Stand conversion to jack pine, white spruce or black spruce is an option on these sites. A mixedwood condition may be established by planting spruce in a patch-shelterwood situation. Large planting stock may be required for stand conversion.

Limitations to Equipment: Excessive slash from limbs or unmerchantable trees may hinder efforts to expose mineral soil through mechanical site preparation.

Wildlife: Value as moose cover is low in the pure hardwood stands but can increase with higher conifer composition in the understory. Browse production capacity is high, both before and after harvest. Important food source for beavers, other rodents and hare. Value for marten and fisher will increase with age, conifer composition, number of snags and structural diversity.

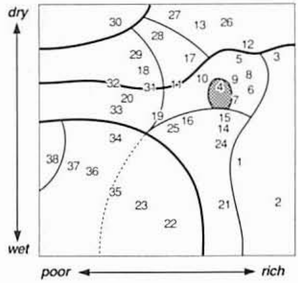
Comments

Excessive residual hardwood material (limbs, stumps and unmerchantable timber) may contribute to *Armillaria* spp. inoculum leading to infection of subsequent stand. Clonal variation among aspen stands makes soil productivity relationships very difficult to establish, and clonal quality must be considered in any decision on stand conversion. ***Phase B2*** can present serious competition levels and will require more effort to establish crop trees in a stand conversion program; productivity for black spruce, jack pine and trembling aspen will be fairly high.

White Birch Hardwood and Mixedwood

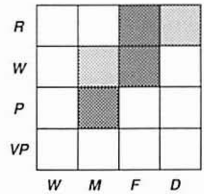
Vegetation Types

V4. Typically white birch dominated stands with a varying degree of white spruce, balsam fir, black spruce, jack pine and, occasionally, trembling aspen. These stands may vary from shrub rich to relatively shrub poor.



Soil / Site Characteristics

Common NWO FEC Soil Types: ***S3, SS6, S2, S1, S7, SS8.*** Usually on deep to moderately deep, moderately dry to fresh, non-calcareous, sandy and coarse loamy soils. High coarse fragment content is characteristic; these stands occasionally occur on shallow soils and talus slopes.



Mode of Deposition: morainal, glaciofluvial, lacustrine

Drainage: v. rapid to imperfect

Management Considerations

Harvesting Constraints: No harvesting constraints except when equipment is restricted by slope or high coarse fragment content.

Competition: Expect heavy competition from *Acer spicatum*, *Corylus cornuta* and *Salix* spp. on very fresh, imperfectly drained soils.

Diseases: Birch is highly susceptible to *Armillaria* spp.; vulnerability increases with stand age.

Insects: No economically significant insect pests.

Regeneration: Naturally regenerates by root collar coppice to white birch without site preparation. Mechanical site preparation or burning will provide suitable seedbed for the germination of birch seeds if a seed source is left. This Treatment Unit may also be suitable for conversion to jack pine and red pine on ***S1*** and ***S2*** soils or white spruce on ***S3*** or ***SS6*** soils, but some tending to control competition may be required.

Limitations to Equipment: Site preparation may be limited by coarse fragments and boulders on talus slopes or morainal deposits.

Wildlife: Low value as moose cover, but cover value may increase as the proportion of balsam fir or spruce increases. Moderate to good for summer browse production. Low value to most furbearers.

Comments

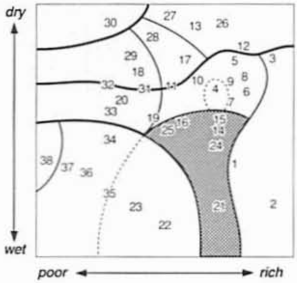
Mechanical damage to stems and roots as a result of harvesting or site preparation may encourage insect or disease infestations. This Treatment Unit may be combined with ***Treatment Unit B1*** if management for white birch is *not* an objective. White birch may be a valuable product in some areas. A higher proportion of coarse fragment content in the soil profile is usually associated with veneer-grade stands in the natural forest.

Balsam Fir - White Spruce Conifer and Mixedwood

Phase D1 : Dry - Fresh Soils
Phase D2 : Moist Soils

Vegetation Types

V14, V15, V16, V21, V24, V25. Highly diverse upland conifer and mixedwood stands containing merchantable balsam fir, white spruce and associated secondary species including white cedar, trembling aspen and black spruce. These sites are highly productive and tend to be shrub rich except where a dense canopy prevents light penetration.



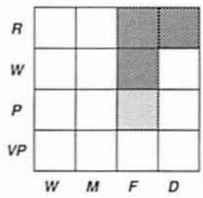
Soil / Site Characteristics

Common NWO FEC Soil Types:

Phase D1 : ***S6, S3, S1, SS6, S2***. Deep to moderately deep, moderately dry to very fresh, sandy, coarse loamy and occasionally clayey soils.

Phase D2 : ***S10, S8, S9, S7***. Deep, moderately moist to very moist, coarse to fine loamy and clayey soils.

Phase D1



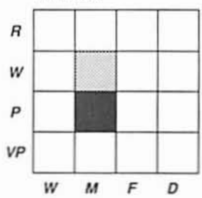
Mode of Deposition:

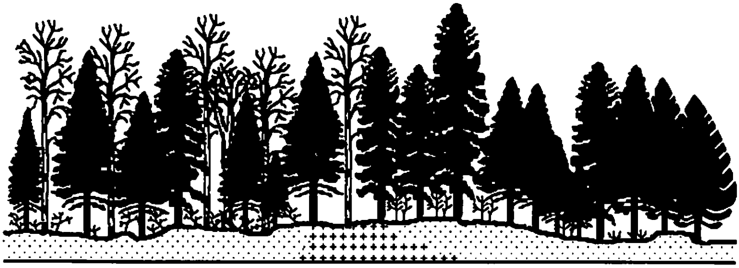
Phase D1 : morainal, lacustrine, glaciofluvial
Phase D2 : lacustrine, morainal, glaciofluvial

Drainage:

Phase D1 : v. rapid to moderately well
Phase D2 : imperfect to poor

Phase D2





Management Considerations

Harvesting Constraints:

Phase D1 : These sites may be harvested in any season.

Phase D2 : Fine-textured soils are susceptible to compaction, rutting and erosion on slopes greater than 10%. Harvesting during a dry time of year or when the ground is frozen will minimize the risk of site degradation.

Competition:

Phase D1 : Moderate to heavy levels of competition can be expected from trembling aspen, *Alnus crispa*, *Acer spicatum*, *Corylus cornuta*, white birch, balsam fir and *Calamagrostis canadensis*. Competition control may be required.

Phase D2 : Very heavy competition can be expected from white birch, trembling aspen, *Alnus rugosa*, *Acer spicatum*, balsam fir, *Corylus cornuta*, *Rubus idaeus*, *Calamagrostis canadensis* and other graminoids. Competition control will be required if converting stands to black or white spruce.

Diseases: Highly susceptible to *Armillaria* spp.

Insects: Extremely susceptible and vulnerable to spruce budworm *(Choristoneura fumiferana)* infestation and damage. Risk increases with stand age, proportion of balsam fir, proximity to infested stands and other factors.

Regeneration:

Phase D1 : Natural regeneration is usually influenced by balsam fir advance growth. Regeneration to jack or red pine will probably require large planting stock and competition control. Stand conversion to trembling aspen is a good option if the proportion of aspen in the stand prior to cutting indicates that sufficient suckering will take place.

Phase D2 : Stand conversion to black or white spruce will require large planting stock and competition control. Advance growth of balsam fir may sometimes impede regeneration to spruce.

Limitations to Equipment: Extensive slash resulting from residual balsam fir and understory species could limit the effectiveness of some site preparation equipment. Prescribed burning may be required for slash reduction. Compaction, rutting and puddling risk may be considerable on some sites.

Wildlife: These stands can be of high value to moose for browse production and winter shelter. They are also productive for small mammals, furbearers and a large number of songbirds. Prescribed burns that reduce slash but do not kill the roots of browse species can be effectively used to increase value to wildlife; a high burn intensity can reduce browse production. These stands usually have a high degree of structural diversity and are valued by many wildlife species.

Comments

Mixedwood management for white pine, white spruce and trembling aspen is a possibility on ***Phase D1***. ***D2*** sites are capable of producing high value products but frequently have limited supplies of high value wood due to extensive spruce budworm damage. Stand conversion in these sites is generally expensive, requiring extensive site preparation and tending. Potential for stand decadence and residual, non-merchantable material may limit operability. Prescribed burning may be necessary to make a site operable after harvest.

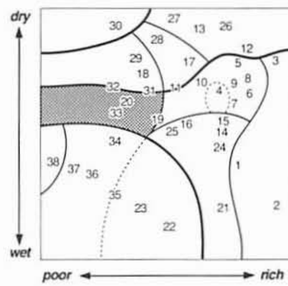
Treatment Unit E

Black Spruce - Jack Pine / Feathermoss

Phase E1: Dry soils
Phase E2: Fresh soils
Phase E3: Moist soils

Vegetation Types

V19, V20, V31, V32, V33. Even-aged, black spruce and jack pine stands with a poor to moderately well developed shrub layer. Feathermoss cover is often high. ***E3*** sites will have Sphagnum in localized, wet depressions.



Soil / Site Characteristics

Common NWO FEC Soil Types:

Phase E1: ***S1, SS6, SS3***. Shallow to deep, dry to moderately dry, sandy soils.

Phase E2: ***S2, S3, S6, SS6, S4***. Shallow to deep, moderately fresh to very fresh soils ranging widely in texture.

Phase E3: ***S8, S7, S9, S10, SS8***. Deep, moderately moist to very moist (occasionally wet organic), sandy, coarse loamy and some silty soils.

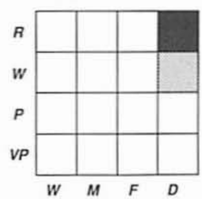
Mode of Deposition:

Phase E1: glaciofluvial, morainal
Phase E2: glaciofluvial, morainal, lacustrine
Phase E3: glaciofluvial, morainal, lacustrine

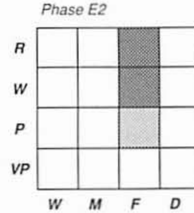
Drainage:

Phase E1: very rapid to rapid
Phase E2: rapid to imperfect
Phase E3: imperfect to poor

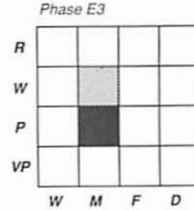
Phase E1



Phase E2



Phase E3



Management Considerations

Harvesting Constraints:

Phase E1: No constraints to harvesting on these sites.

Phase E2: Sites can be harvested at any time of the year. However, fine loamy and clayey soils are susceptible to compaction and are best harvested in the dry season.

Phase E3: These moist, poorly drained sites are prone to compaction or rutting problems. Winter harvest should be considered.

Competition:

Phase E1: Moderate competition can be expected from *Alnus crispa*, trembling aspen and *Salix* spp.

Phase E2: Moderate to heavy competition can be expected from *Calamagrostis canadensis*, trembling aspen, *Alnus rugosa* and *Alnus crispa*. Competition control will likely be required.

Phase E3: Some competition from *Alnus rugosa* can be expected. Competition control may not be necessary.

Diseases: Susceptibility to *Armillaria* spp. is enhanced on drier sites with coarse-textured soils. Such stands are also highly susceptible to *Inonotus tomentosus*.

Insects: ***E1*** and ***E2*** sites are moderately susceptible to spruce budworm infestation. Conifers on moist, poorly drained ***E3*** sites are highly susceptible to spruce budworm attack.

Regeneration:

Phase E1: Natural jack pine regeneration using cone scattering or aerial seeding can be effectively used to regenerate these sites. Tending should not be required.

Phase E2: Either jack pine or black spruce can be planted and regenerated on these sites. Strip or block cutting with exposure of mineral soil in the cutovers may be used to regenerate sites naturally. Often a "delicate scarification" is effective in maintaining site quality while producing suitable seedbeds and planting sites. Jack pine cone scattering on exposed mineral soil is another option.

Phase E3: These tend to be good sites for black spruce planting. Other appropriate options are black spruce seeding on compacted feathermoss, strip cutting to promote natural black spruce regeneration or jack pine seeding on exposed mineral soil.

Limitations to Equipment:

Phase E1: Very few limitations on these sites.

Phase E2: Sites can be susceptible to compaction and rutting, particularly on fine-textured soils of lacustrine or fluvial origin.

Phase E3: These sites are susceptible to compaction and rutting. Winter harvest or use of low load-bearing equipment may reduce the potential for site degradation.

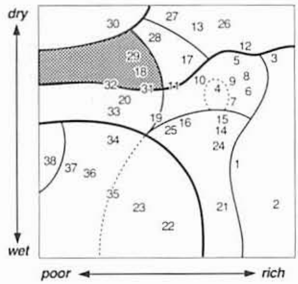
Wildlife: Extensive stands are generally of low value to many species of wildlife for food or shelter because of the absence of a well developed shrub layer and poor structural diversity. Stands belonging to this Treatment Unit may contribute valuable conifer cover if they are part of a larger habitat mosaic that includes other important stand types.

Comments

Moderately thin to thick ground cover by feathermoss may be subject to drying, thereby creating a poor seedbed. Exposure of mineral soil and the humus *(H)* layer may be required to produce a good seedbed. Natural or aerial seeding to black spruce or jack pine may be successful on shallow, compacted feathermoss. Winter blading may be a site preparation option on ***E3*** sites. Slash is seldom a problem on these sites.

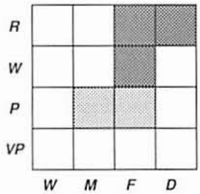
Jack Pine / Feathermoss

Vegetation Types



V18, V29, V31, V32. Typically even-aged jack pine or jack pine-black spruce stands with extensive feathermoss ground cover. Limited aspen or birch may be found in some stands. Jack pine dominates all stands.

Soil / Site Characteristics



Common NWO FEC Soil Types: S1, S2, SS6, S3. Generally deep to moderately deep, moderately dry to fresh, sandy to coarse loamy soils.

Mode of Deposition: glaciofluvial, morainal, lacustrine

Drainage: v. rapid to well

Management Considerations

Harvesting Constraints: No constraints to equipment or season. However, if natural regeneration is desired for these stands, care should be taken to ensure that a seed source remains on site; whole tree logging systems may reduce seed source.

Competition: Competition may occur from *Alnus crispa* or trembling aspen, but typically it is not heavy and does not warrant control or tending.

Diseases: No economically significant diseases.

Insects: These sites may be prone to jack pine budworm *(Choristoneura pinus pinus)* infestations.

Regeneration: These sites respond well to light drags for distribution of slash, as well as exposure of mineral soil for seeding or planting to jack pine. Tending will probably not be required. These sites are well suited for natural regeneration to jack pine because of the abundant seed source and little expected competition.

Limitations to Equipment: No limitations to equipment anticipated.

Wildlife: Low value for food production or shelter for most wildlife species. Cone feeding birds and mammals such as red squirrels or chipmunks may be abundant in some stands.

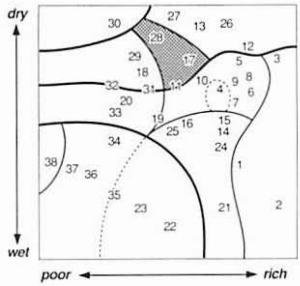
Comments

Whole tree harvesting may reduce the seed source. Low levels of competition, ease of regeneration and generally high yields make these sites desirable for jack pine management. These stands are typically well suited to extensive, even-aged management.

Jack Pine / Shrub Rich

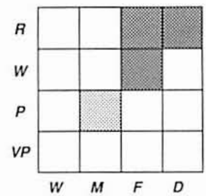
Vegetation Types

V11, V17, V28. Jack pine stands with some trembling aspen component and a generally rich, diverse low shrub component. Scattered feathermoss patches may at times be extensive. Ericaceous shrubs can be a major component of the low shrub layer, particularly in the NW Region.



Soil / Site Characteristics

Common NWO FEC Soil Types: S1, S3, SS6, S2. Typically deep to moderately deep, moderately dry to fresh, sandy and coarse loamy soils.



Mode of Deposition: morainal, glaciofluvial

Drainage: v. rapid to well

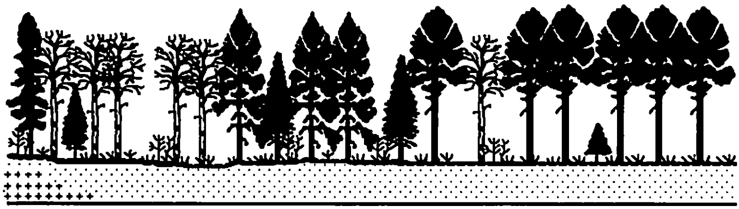
Management Considerations

Harvesting Constraints: Harvesting systems will influence the extent of cone distribution for natural seeding. Care taken to maintain a seed source on the site will facilitate natural regeneration. There are typically no limitations to the season of harvest.

Competition: *Corylus cornuta*, *Alnus crispa* and trembling aspen will occur to varying degrees, particularly on ***V11***. Competition will be more intense after winter harvest or if the root systems are broken up during mechanical site preparation.

Diseases: No economically significant diseases.

Insects: These sites may be prone to jack pine budworm infestations.



Regeneration: These sites are suited to planting with jack pine or red pine. Natural regeneration to jack pine is readily accomplished with exposure of the mineral soil and cone scattering or aerial seeding. Competition control may be required on some sites, particularly if regeneration is accomplished through seeding.

Limitations to Equipment: No limitations to equipment anticipated.

Wildlife: Low to fair value for the production of furbearers and low to fair value for moose shelter or browse production.

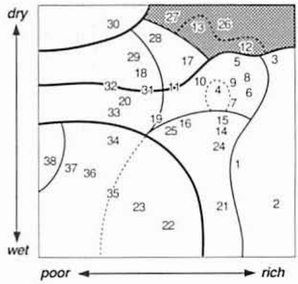
Comments

A good jack pine seed source is expected after harvest on these sites. Little or no site preparation may be required for planting. More slash is expected on these sites than on ***Treatment Unit F***. These stands have greater structural and species diversity than those in ***Treatment Unit F*** and therefore generally provide a wider range of values for wildlife.

Red or White Pine Conifer and Mixedwood

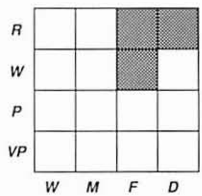
Vegetation Types

V12, V13, V26, V27. Red and white pine stands, ranging from pure conifer to mixedwoods, with varying degrees of shrub richness. Red pine stands are often shrub poor. Stands may contain a substantial component of trembling aspen, jack pine, white spruce or balsam fir.



Soil / Site Characteristics

Common NWO FEC Soil Types: S1, S3, SS6, S2. Deep to moderately deep, occasionally shallow, moderately dry to fresh, sandy and coarse loamy soils, often with considerable coarse fragment content.



Mode of Deposition: morainal, glaciofluvial

Drainage: very rapid to well

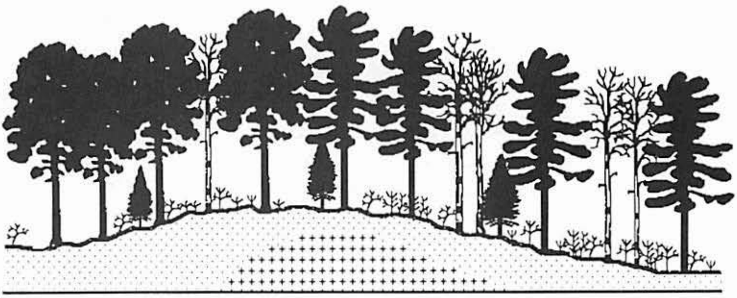
Management Considerations

Harvesting Constraints: No constraints except when slope exceeds 10% creating a higher erosion risk, or when coarse fragment content is high.

Competition: Typically low levels of competition can be expected but *Acer spicatum*, *Corylus cornuta* and trembling aspen may become abundant after harvest of ***V12*** and ***V13*** because of higher hardwood component and a more dense shrub layer.

Diseases: *Armillaria* spp. infestations may develop on sites with significant trembling aspen content (***V12, V13***) but generally will not be a problem on ***V26*** or ***V27***. White pine blister rust *(Cronartium ribicola)* is endemic and must be considered when managing white pine.

Insects: Partial cover provided by an aspen canopy may help to reduce occurrence of white pine weevil (*Pissodes strobi*) in regenerating stands. Stands with a significant component of balsam fir, white spruce or black spruce may be vulnerable to spruce budworm attack.



Regeneration: Selective harvest or small patch cuts followed by natural regeneration or underplanting may provide a continuing supply of uneven-aged white pine that is relatively free of white pine weevil. Red and white pine seed trees or shelterwood cutting could be used to regenerate ***V26*** and ***V27***. Clearcuts can often be successfully regenerated by planting red pine on exposed mineral soil. Stand conversion to jack pine is also a possibility on clearcut sites.

Limitations to Equipment: Shallow soils or considerable surface stoniness may limit some site preparation equipment.

Wildlife: Low to moderate value for moose except in shrub rich stands of ***V12*** and ***V13***, when browse production may be adequate. Old growth white pine may provide valuable nesting sites for cavity nesters, bald eagles and osprey.

Comments

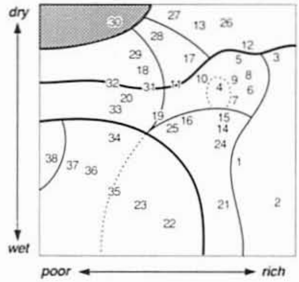
Regeneration to white pine is possible but may require underplanting to avoid weevil damage and blister rust. Minimal site disturbance may assist regeneration to red or white pine. ***V12*** and ***V13*** may be considered a separate phase if the mixedwood condition is extensive within the management unit.

Jack Pine - Black Spruce / Blueberry / Lichen

Phase I1: Very Shallow Soils
Phase I2: Deep - Moderately Deep / Sandy Soils

Vegetation Types

V30. These stands are poorly stocked, herb and shrub poor black spruce or jack pine stands. Forest floor cover is typically lichen and blueberry.

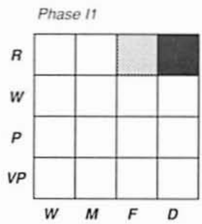


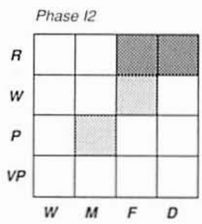
Soil / Site Characteristics

Common NWO FEC Soil Types:

Phase I1: ***SS3, SS1, SS2***. These are typically very shallow soils with considerable exposed bedrock or, occasionally, talus slope conditions. The terrain is often broken, irregular or rugged. The soil moisture regime is dry to moderately dry.

Phase I2: ***SS6, S2, S1, SS5***. Deep to moderately deep, moderately dry to moderately fresh, sandy and coarse loamy soils.





Mode of Deposition: glaciofluvial, morainal; occasionally, aeolian deposits are represented in ***Phase I2***

Drainage: very rapid to rapid

Management Considerations

Harvesting Constraints:

Phase I1: Very shallow soils are fragile, easily disturbed by summer logging, and are highly susceptible to erosion.

Phase I2: Deeper soils are resistant to compaction and have no limitations to harvest. Disturbance to ground cover should be minimized, particularly in caribou range.

Competition: Very little shrub competition is expected, particularly on deep, rapidly drained soils. Common vegetation species occurring on these sites after cutting include *Vaccinium* spp. and *Arctostaphylos uva-ursi*. These species, however, are not major competitors for moisture or nutrients. Competition control should not be required on ***Phase I2.***

Diseases: No economically significant diseases.

Insects: Stands on dry, very shallow soils may be vulnerable to jack pine budworm infestations.

Regeneration: Sites are well suited for aerial or natural seeding to jack pine, with a minimal amount of mineral soil exposure. Some natural black spruce seeding will occur from residuals left due to rugged terrain. ***Phase I1*** may not be suitable for site preparation or planting, because of shallow soils and extensive bedrock.

Limitations to Equipment: Very shallow or bouldery soils pose significant limitations to site preparation equipment, particularly on rugged terrain. Deep soils on level sites pose no limitations to site preparation equipment, however, site preparation may not be necessary.

Wildlife: High value as caribou habitat within caribou range, especially when combined with V-types ***V37*** and ***V38***.

Comments

Minimum soil disturbance accomplished by winter harvest or light site preparation will not only reduce risk of vegetation competition but will enhance opportunities for the regeneration of lichen in caribou range. Stands on broken upland terrain with shallow soils may be classified as *protection forest* or *protection forest reserve*.

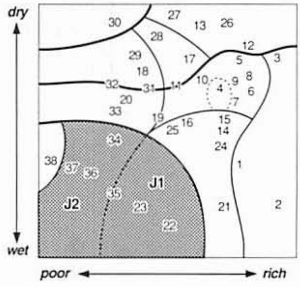
Black Spruce / Wet Organic

Phase J1: Speckled Alder
Phase J2: Shrub poor

Vegetation Types

Phase J1: ***V22, V23, V35.*** Lowland black spruce, white cedar or tamarack with a shrub layer of *Alnus rugosa*. Usually occurring on organic sites with extensive Sphagnum cover.

Phase J2: ***V34, V35, V36, V37.*** Typically black spruce / Sphagnum associations on organic soils. This phase is similar to ***J1***, but lacks a well-developed shrub layer of *Alnus rugosa*.



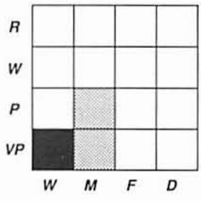
Soil / Site Characteristics

Common NWO FEC Soil Types:

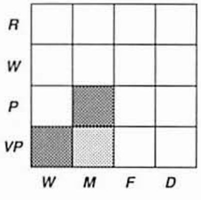
Phase J1: ***S12F, S12S.*** Typically deep, very moist to wet, organic soils.

Phase J2: ***S12S, S12F, S11, S8.*** Predominantly deep, very moist to wet, organic soils and peaty phase mineral soils. Deep, moderately moist and moist mineral soils occur more frequently than in ***Phase J1.***

Phase J1



Phase J2

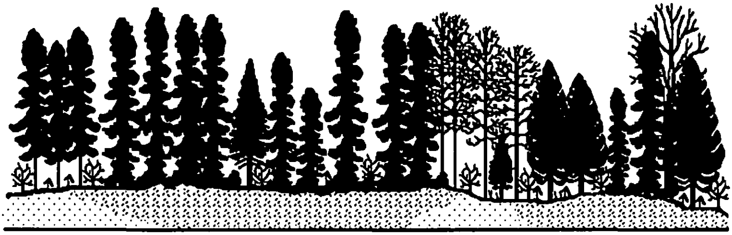


Mode of Deposition:

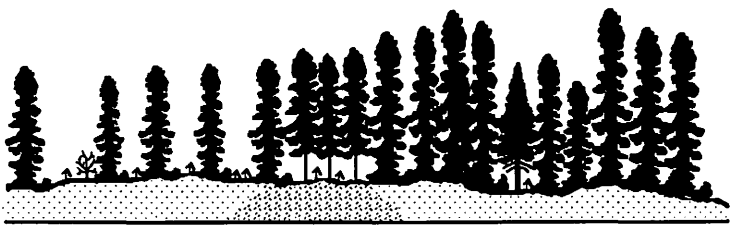
Phase J1: organic
Phase J2: organic, lacustrine, glaciofluvial

Drainage:

Phase J1: very poor
Phase J2: very poor to imperfect



Phase J1



Phase J2

Management Considerations

Harvesting Constraints: Winter harvest is preferred in order to avoid severe site degradation. Careful harvesting may preserve black spruce advance growth which may sometimes be abundant.

Competition:

Phase J1: Heavy competition from *Alnus rugosa, Rubus idaeus, Salix* spp. and *Calamagrostis canadensis* is expected. Competition control will probably be required.

Phase J2: Usually there are few competition problems. Competition control may not be required.

Diseases: High risk of *Inonotus tomentosus.*

Insects: Low to moderate susceptibility to spruce budworm. Larch sawfly *(Lygaeonematus erichsonii)* can be a major problem for tamarack management.

Regeneration: Natural or aerial seeding of black spruce directly onto Sphagnum seedbeds is a good option. ***V34*** has less Sphagnum and therefore has fewer black spruce seeding opportunities. Harvested tamarack and white cedar dominated stands present opportunities for black spruce production. Strip or block cuts for natural regeneration may be employed, but blowdown in leave strips may pose problems. Planting black spruce may be a preferred option on more productive sites, especially when they are close to the mill.

Limitations to Equipment: These sites are susceptible to puddling and rutting from most equipment.

Wildlife: These stands may provide summer thermoregulation or calving sites for moose. These stands may also have some value as winter shelter for moose, particularly if browse is available nearby.

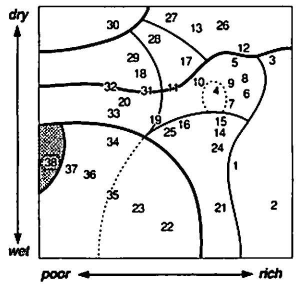
Comments

Prescribed burn opportunities for site preparation are low but fine fuels can effectively be removed with little disturbance of Sphagnum seedbed. Winter blading may be an appropriate method of mechanical site preparation on these sites, to prepare either seedbed or planting spots. Removal of existing vegetation may cause the water table to rise, altering the productivity of some sites.

Black Spruce / Leatherleaf / Sphagnum

Vegetation Types

V38. Small, widely spaced black spruce trees (average height less than 10 m) with a shrub layer of *Ledum groenlandicum* and *Chamaedaphne calyculata*. Ground cover is generally Sphagnum.

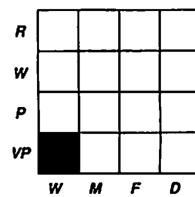


Soil / Site Characteristics

Common NWO FEC Soil Types: S12S. Typically deep, moderately wet to very wet, organic soils, often with a high water table.

Mode of Deposition: organic

Drainage: very poor



Management Considerations

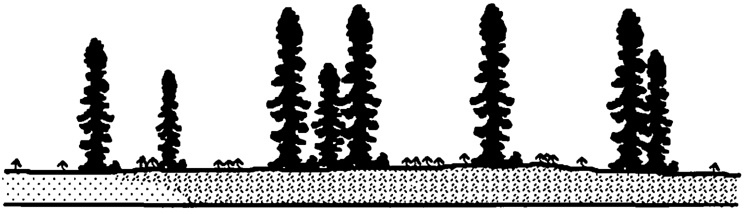
Harvesting Constraints: Winter harvest only, if at all. Strip or block cutting will allow for natural regeneration by seeding. Harvest carefully to preserve black spruce advance growth.

Competition: Typically there is little or no competition problem on these sites.

Diseases: Low risk of *Armillaria* spp. and high risk of *Inonotus tomentosus*.

Insects: No economically significant insect pests.

Regeneration: Regeneration options are restricted to natural seeding after winter harvest. Sometimes sufficient advance growth can be preserved to adequately stock the site.



Limitations to Equipment: Most equipment is limited by weight; winter may be the only opportunity to use equipment on these sites.

Wildlife: Low value to most wildlife. Caribou and snowshoe hare will feed in these areas in winter.

Comments

Forest stands are generally not merchantable in most areas because of low wood volumes and harvesting constraints. These are generally unproductive sites that are prone to organic soil compaction, rutting and altered groundwater regimes.

Section 3

Silvicultural Interpretations

3. Silvicultural Interpretations

3.1. Competing Vegetation

The occurrence, abundance and vigour of competitive vegetation in NW Ontario can be related to NWO FEC Vegetation and Soil Types. The growth response of these species will also vary with the harvesting methods and silvicultural treatments that are applied (Hapgood 1983). Knowledge of how site factors and management actions influence the degree and type of competition will help users anticipate site preparation, regeneration and tending requirements.

This Section provides summary information on a few commonly encountered competitive species in NW Ontario. Included are descriptions of NWO FEC Types associated with them, some overview information on how these species respond to site preparation or harvest, and their importance for wildlife. The autecology of each of these competing species and the mechanics of competition in NW Ontario are considered in more detail by Baldwin and Sims (1989) and Bell (in preparation).

Acer spicatum — Mountain Maple

(p. 48, Baldwin and Sims 1989)

NWO FEC Types on which Species Commonly Occurs

- ***V1-V19, V21-V28, V31***
- ***S1-S5, SS5-SS7***

Soil / Site Characteristics Conducive to Vigorous Growth

- dry, fresh and moist sites; high moisture and nutrient requirement for prolific growth (Baskerville 1961)
- fine loamy, till soils in partial shade (Krefting 1953)

Forestry Practices Which Stimulate Growth or Establishment

- winter harvesting followed by scarification promotes growth of dense clumps which may persist for up to 40 years (Baskerville 1961, Krefting 1953)
- exposed soil patches after disturbance provide a good seedbed for mountain maple (Krefting 1953)
- spraying of 2,4-D may induce sprouting if shrub is not completely killed (Krefting and Hansen 1958)
- often grows in a cutover with *Rubus idaeus* and *Corylus cornuta*, collectively creating serious competition problems for regenerating conifers (Baskerville 1961)

Forestry Practices Which Reduce Growth or Establishment

- a prescribed burn of high intensity can effectively control stem sprouting (Krefting 1953) and root suckering (Krefting et al 1956)

Wildlife Implications and Other Notes

- mountain maple is an important food for moose and deer (Krefting et al 1956, Euler 1979)
- cutting or breaking stems will increase browse production (Krefting 1953)
- if mountain maple have grown out of reach for wildlife, regrowth can be stimulated by application of 2,4-D to the upper portions of the shrubs (Krefting and Hansen 1958)

Alnus crispa | Green Alder

(p. 50, Baldwin and Sims 1989)

NWO FEC Types on which Species Commonly Occurs

- *V3-V20, V25-V33*
- *S1-S3, SS1-SS5*

Soil / Site Characteristics Conducive to Vigorous Growth

- dry to fresh, rapidly to well-drained upland mineral soils (Baldwin and Sims 1989)
- high light requirement (Euler 1979)

Forestry Practices Which Stimulate Growth or Establishment

- a severely disturbed humus layer will provide a good seedbed for an abundant supply of seeds
- green alder will readily sprout from stems broken during scarification or logging; sprouting is more prolific after winter disturbance
- prescribed burning will promote growth from buried green alder seeds (Haeussler and Coates 1986)

Forestry Practices Which Reduce Growth or Establishment

- 2,4-D herbicide is an effective control (Haeussler and Coates 1986)

Wildlife Implications and Other Notes

- green alder is a food source for a number of wildlife species, especially ruffed grouse (Euler 1979)
- green alder will fix atmospheric nitrogen and build up both the nutrient content and the organic composition of soils, when used as a nurse crop species (Daley 1966)

Alnus rugosa — Speckled Alder

(p. 52, Baldwin and Sims 1989)

NWO FEC Types on which Species Commonly Occurs

- ***V1, V2, V4-V10, V14-V19, V21-V25, V34-V38***
- wide range of Soil Types (both mineral and organic)

Soil / Site Characteristics Conducive to Vigorous Growth

- moist to wet sites; moderate to rich in nutrients (Baldwin and Sims 1989)

Forestry Practices Which Stimulate Growth or Establishment

- much exposed soil will provide a good seedbed for the abundant supply of seeds (Haeussler and Coates 1986)
- cutting or damaging of stems by logging or scarifying during the winter will produce rapid regrowth by suckering (Brown 1953, Vincent 1964)
- prescribed burning will induce suckering and promote growth from buried seeds
- in lowlands, forestry operations which disrupt drainage may raise the water table and stimulate growth of speckled alder (Vincent 1964, Haeussler and Coates 1986)

Forestry Practices Which Reduce Growth or Establishment

- easily controlled with low application rates of 2,4-D

Wildlife Implications and Other Notes

- a food source for many wildlife species, especially ruffed grouse (Euler 1979)
- will fix large amounts of atmospheric nitrogen and add a beneficial organic component to the soil, thereby increasing soil fertility
- can be used as a nurse crop to lessen risk of frost heaving on susceptible sites (Daley 1966)

Betula papyrifera — White Birch

(p. 22, Baldwin and Sims 1989)

NWO FEC Types on which Species Commonly Occurs

- all V-Types except ***V34*** and ***V38***
- ***S1-S4, SS5-SS7***

Soil / Site Characteristics Conducive to Vigorous Growth

- dry to moist, well-drained sites
- generally upland sites, moderate to rich in soil nutrients (Baldwin and Sims 1989)
- disturbed humus is a preferred seedbed but white birch will also germinate well on undisturbed humus

Forestry Practices Which Stimulate Growth or Establishment

- mechanical site preparation produces a good seedbed for white birch if it provides a thorough mixing of humus and mineral soil (Haeussler and Coates 1986)
- prescribed burning stimulates sucker growth (Haeussler and Coates 1986)
- cut stumps readily produce coppice growth (Haeussler and Coates 1986)

Forestry Practices which Reduce Growth or Establishment

- glyphosate, 2,4-D and hexazinone provide good control (Haeussler and Coates 1986)

Wildlife Implications and Other Notes

- deer and moose will browse on white birch but it is not a preferred food
- an important food for beaver (Euler 1979)

Calamagrostis canadensis — Bluejoint Grass

(p. 230, Baldwin and Sims 1989)

NWO FEC Types on which Species Commonly Occurs

- a wide range of V-Types
- ***S7-S10, S12F, S12S, SS8***

Soil / Site Characteristics Conducive to Vigorous Growth

- moist, imperfectly to poorly drained, organic or fine-textured soils (Baldwin and Sims 1989)
- sites which are disturbed or have a high water table (Chavasse 1980)

Forestry Practices Which Stimulate Growth or Establishment

- a raised water table resulting from logging operations may lead to vigorous and dense growth of bluejoint grass in open, wet areas
- altered drainage patterns from soil compaction (Chavasse 1980) or road construction may stimulate growth
- any harvesting or site preparation technique that results in exposed, disturbed soils may produce a receptive seedbed
- a light prescribed burning may enhance rhizome growth and activate germination of buried seeds (Hamilton and Yearsley 1988)

Forestry Practices Which Reduce Growth or Establishment

- maintenance of good site drainage; this species will not readily seed onto drier sites
- herbicides are the most effective means of control once establishment has occurred; best results are achieved by summer applications of glyphosate (Haeussler and Coates 1986, Carruthers and Towill 1988)

Wildlife Implications and Other Notes

- no specific value to wildlife other than a general forage species for herbivores
- commonly a major component of beaver meadows
- because of its spreading and fibrous rooting habit, bluejoint grass can be an effective soil stabilizer along roadsides and wherever erosion is a potential problem

Corylus cornuta — Beaked Hazel

(p. 70, Baldwin and Sims 1989)

NWO FEC Types on which Species Commonly Occurs

- ***V1-V17, V19, V21, V24-V28, V31***
- ***S3-S5, S10, SS6***

Soil / Site Characteristics Conducive to Vigorous Growth

- upland, rapidly to well-drained, fresh to moist soils; rich in nutrients (Baldwin and Sims 1989)

Forestry Practices Which Stimulate Growth or Establishment

- increased light resulting from clearcut logging may stimulate growth (Bakuzis and Hansen 1959)
- prolific sprouting of cut or damaged stems may occur after scarification or winter logging (Haeussler and Coates 1986)

Forestry Practices Which Reduce Growth or Establishment

- prescribed burning may eradicate this species if the humus is dry enough to be consumed along with shallow underground stems (Buckman and Blankenship 1965)
- application of glyphosate or 2,4-D in late August is an effective control measure (Haeussler and Coates 1986, Carruthers and Towill 1988)

Wildlife Implications and Other Notes

- an important food source for many wildlife species including moose, deer, rodents and birds

Populus tremuloides — Trembling Aspen

(p. 42, Baldwin and Sims 1989)

NWO FEC Types on which Species Commonly Occurs

- ***V1-V21, V24-V33***
- ***S3-S6***

Soil / Site Characteristics Conducive to Vigorous Growth

- well-drained, upland, fresh to very fresh loams and sandy loams (especially calcareous soils); medium to rich in nutrients (Baldwin and Sims 1989)
- germinates and grows well on a well-mixed humus and mineral soil, or on fairly shallow humus that will allow warming of the soil (Davidson et al 1988)
- high light availability (Bakuzis and Hansen 1959)

Forestry Practices Which Stimulate Growth or Establishment

- winter cutting will stimulate suckering
- clearcut logging resulting in high soil temperatures and full sunlight, or mechanical site preparation techniques resulting in great disturbance of the humus layer, may stimulate growth
- a rapid, very hot prescribed burn that does not significantly damage or destroy aspen roots but is sufficient to reduce humus depth or expose mineral soils, may facilitate suckering (Haeussler and Coates 1986)
- aspen regenerates most readily by suckering from shallow roots within 10 cm of the soil surface (Davidson et al 1988)

Forestry Practices Which Reduce Growth or Establishment

- summer logging and mechanical site preparation when conditions are dry will reduce suckering potential (Haeussler and Coates 1986)
- a slow-burning spring fire may effectively control aspen regeneration if it burns deeply enough to kill aspen roots and suckers (Buckman and Blankenship 1965); however, prolific suckering may result if aspen is not killed by the burn
- killing of trembling aspen by herbicides or girdling a few years prior to logging may result in reduced suckering following harvest (Haeussler and Coates 1986)
- strip cutting may reduce soil temperatures within adjacent leave strips and thereby lessen the extent of aspen suckering

Wildlife Implications and Other Notes

- aspen, as a shrub and in early successional stages, is important to moose for summer and early winter feeding
- young aspen stands are very good ruffed grouse habitat (Euler 1979)

Rubus idaeus — Raspberry

(p. 118, Baldwin and Sims 1989)

NWO FEC Types on which Species Commonly Occurs

- a wide range of V-Types (usually with low abundance in mature forest stands)
- ***S7-S10***

Soil / Site Characteristics Conducive to Vigorous Growth

- moist, imperfectly to poorly drained soils; medium to rich in nutrients (Baldwin and Sims 1989, Haeussler and Coates 1986)
- high moisture and light availability (Bakuzis and Hansen 1959)

Forestry Practices Which Stimulate Growth or Establishment

- mechanical site preparation will sever and scatter raspberry roots and stems which can lead to dense regrowth (Haeussler and Coates 1986)
- full sunlight in burned over or clearcut areas stimulates growth of raspberry
- light burning can promote the sprouting of underground stems and roots, and the growth of buried seeds (Hamilton and Yearsley 1988)
- exposed mineral soil is a receptive seedbed for raspberry

Forestry Practices Which Reduce Growth or Establishment

- a herbicide application, when stems are young and less than 15 cm tall, is an effective control (Haeussler and Coates 1986)
- this species will not successfully invade a site with an already-established dense shrub layer; early establishment of shrubs and trees will shade out raspberry (Haeussler and Coates 1986, Hamilton and Yearsley 1988)

Wildlife Implications and Other Notes

- an important and preferred food species for bear, furbearers, birds, small mammals and primates.

Salix spp. Willow

(p. 124 to 128, Baldwin and Sims 1989)

In NW Ontario, the most frequently encountered willow species in forest stands are *S. bebbiana*, *S. discolor*, and *S. humilis* (Baldwin and Sims 1989). Information below is correlated with these three species; several other *Salix* spp. occur in NW Ontario forests but are considered here only generally.

NWO FEC Types on which Species Commonly Occur

- ***V1, V2, V11, V16, V19, V21-V25, V33-V36***
- ***S1, S2, S7, S9, S12F, S12S, SS3, SS5-SS8***

Soil / Site Characteristics Conducive to Vigorous Growth

- fresh to wet soils, medium to rich in nutrients; both mineral and organic soils (Baldwin and Sims 1989, Hamilton and Yearsley 1988)
- common in riparian bottomlands and floodplains

Forestry Practices Which Stimulate Growth or Establishment

- logging, especially winter operations, and scarification practices that damage or cut off willow stems may result in vigorous resprouting
- windrowing slash may stimulate regrowth by layering (Haeussler and Coates 1986)
- a superficial burn may stimulate vigorous sprouting if the roots are not killed (Buckman and Blankenship 1965, Hamilton and Yearsley 1988)

Forestry Practices Which Reduce Growth or Establishment

- a slow, deep burn will cause more damage to willow roots, resulting in less sprouting (Buckman and Blankenship 1965)

Wildlife Implications and Other Notes

- an important food for moose, deer, hare, beaver, small mammals and birds (Euler 1979)
- windrowing of slash can be an effective method for browse production by layering (Haeussler and Coates 1986)
- willow may provide good erosion control along unstable riparian areas
- species of willow can be locally abundant, often growing with patchy or clumped distributions, however they are not a widespread competition problem throughout most of NW Ontario

3.2. Soil Considerations for Black Spruce Management

Black spruce occurs on a range of upland and lowland sites throughout NW Ontario. Upland V-Types include ***V19***, ***V20***, ***V30*** - ***V34***, and the lowland V-Types typically include ***V34***-***V38***. Several soil / site factors may influence black spruce growth; the most important of these are slope position and soil factors such as moisture regime, drainage, depth, and texture (Buse and Towill (in preparation)).

On mineral soils, better growth is achieved on soil depths greater than 30 cm, LFH horizons less than 15 cm thick, and soils with an Ah layer or a weakly developed Ae horizon. These conditions are associated with good rooting depths and relatively large amounts of available moisture and nutrients. Black spruce grows well on a variety of soil textures.

On organic soils, soil depth and the relative proportion of feathermoss to Sphagnum in the surface layer influence the performance of black spruce. Peaty-phase soils (***S11***) provide good natural seedbeds. Seedling survival and growth potential can be very good on such soils. Organic soils with less than 25 percent surface cover of Sphagnum (***S12F***, ***SS9***) provide good growth potential but generally a poor seedbed. In these cases, compacting the feathermoss may enhance seedbed quality and seedling growth. Organic soils more than 40 cm deep and with greater than 25 percent surface cover of Sphagnum (***S12S***, ***SS9***) provide a good black spruce seedbed because of available moisture, but have limited growth potential. If the thickness of the Of layer exceeds 10 cm or if the soil moisture regime (Ontario Institute of Pedology 1985) exceeds MR 7 (moderately wet) with low soil aeration and little water movement, then poor seedling survival and growth may be expected.

Soil moisture, drainage, texture and slope position factors as they relate to NWO FEC Soil Types and black spruce growth

(Buse and Towill (in prep), Arnup et al 1988)

	Soil Moisture Regime (MR)	*Soil Drainage Class (DC)*	*Slope Position*	*Soil Textures and NWO FEC Soil Types*
Best growth (SI >14 m at 50 yr.)*	Fresh to mod. moist (MR 2-4); best growth on fresh to v. fresh soils (MR 2-3)	Well to imperfect (DC 3-5); best growth on well drained soils (DC 3)	Middle, lower and toe slopes; best growth on middle and lower slopes	Coarse and fine loamy, clayey; ***S3, S4, S5, S6, S7, S8, S10***
Moderate growth (SI 10-14 m at 50 yr.)*	Mod. fresh (MR 1) or moist to mod.wet (MR 5-7)	Rapid (DC 2) or poor (DC 6)	Upper and toe slopes, or level positions	Fine sandy, silty, clayey, peaty phase, organic [feathermoss]; ***S2, S4, S8, S9, S10, S11, S12F, SS3, SS4, SS5, SS6, SS7*** and ***SS9*** [feathermoss]
Poorest growth (SI <10 m at 50 yr.)*	Dry to mod. dry (MR Ø-0) or wet to v. wet (MR 8-9)	V. rapid (DC 1) or v. poor (DC 7)	Upper and toe slopes,crest, level or depression positions	Coarse sandy, organic [Sphagnum]; ***S1, S12S, SS1, SS2, SS9*** [Sphagnum]

* Site index *(SI)* adapted from Normal Yield Tables (Plonski 1974).

3.3. Soil Considerations for Jack Pine Management

Jack pine performs well on a variety of soil conditions. Jack pine V-Types (***V17***, ***V18***, ***V28-V32***) occur predominantly on soils where competing vegetation is less vigorous due to coarse textures or moisture limitations. However, jack pine may also occur and perform well on fine-textured, productive soils when fire or silvicultural practices control competing vegetation until jack pine is established.

Generally, deep soils are preferable to shallow soils and acidic soils are preferable to calcareous soils for best growth (Anon. 1986). Volume of the rooting zone can limit jack pine productivity because of its relationship with moisture availability (Schmidt 1986, Schmidt and Carmean 1987).

There are some apparent discrepancies among results presented in the following two tables. These tables present preliminary information regarding general productivity of NWO FEC groupings; the information will be revised as more data becomes available. Note that the first table presents general trends for NW Ontario, while the second deals specifically with data obtained from the NC Region.

Soil moisture, drainage, texture and slope position factors as they relate to NWO FEC Soil Types and jack pine growth

(Anon. 1986, Schmidt and Carmean 1987, LeBlanc and Towill 1989)

	Soil Moisture Regime (MR)	*Soil Drainage Class* (DC)	*Slope Position*	*Soil Textures and NWO FEC Soil Types*
Best growth (SI 17-20 m at 50 yr.)*	Fresh to v. fresh (MR 2-3) with best growth on MR 3	Well to mod. well (DC 3-4)	Upper slopes; level positions	Fine sandy, coarse loamy, silty, especially fine sands with silty surface textures; ***S2, S3, S4, S6, S9***
Moderate growth (SI 14-17 m at 50 yr.)*	Mod. dry to mod.fresh (MR 0-1)	V. rapid to rapid (DC 1-2)	Upper slopes; level positions; undulating shallow soils over bedrock	Shallow, fine sandy, coarse loamy; ***SS3, SS5, SS6, SS7, SS8;*** sandy, clayey; ***S1, S5, S7, S8, S10***
Poorest growth (SI < 14 m at 50 yr.)*	Mod. moist, moist, v. moist or wet (MR≥4) or dry (MR Ø)	Imperfect to poor (DC 5-6); v. rapid (DC 1)	Toe slopes; depressions or level positions; upper slopes; shallow soils	Very shallow and organic; ***SS1, SS2, SS4, SS9, S11, S12F, S12S***

* Site index (*SI*) adapted from Normal Yield Tables (Plonski 1974).

Soil Type - site index relationships for jack pine in the North Central Region

(adapted from LeBlanc and Towill 1989)

NWO FEC Soil Type	Site Index at 50 yr (m)	Special Conditions
Shallow Soil (SS-Types) (<100cm)		
SS1, SS2	9.5 ± 0.3	
SS3	15.5 ± 0.5	Telluric influence
	10.2 ± 0.3	No telluric influence
SS6	15.9 ± 0.4	Soil depth ≥ 30 cm
	11.5 ± 0.8	Soil depth < 30 cm
SS5, SS7, SS8	17.2 ± 0.3	
SS4, SS9	no data	
Deep Soil (S-Types) (≥100cm)		
S1	17.2 ± 0.3	
S2, S3, S4	18.1 ± 0.3	
S6, S9	18.9 ± 0.4	
S7, S8, S10	16.8 ± 0.4	
S11, S5, S12F, S12S	no data	

3.4. Soil Considerations for Aspen Management

Aspen occurs on a wide range of Soil and Vegetation Types throughout NW Ontario. Growth of trembling aspen is best on deep, fine-textured soils with abundant nutrients and good drainage (Davidson et al 1988). Large-toothed aspen grows best on deep, well drained, coarse-textured soils. The best height growth and least amount of decay occurs on calcareous parent materials.

Natural regeneration possibilities are excellent in ***V5-V11***. Regeneration of aspen by suckering can be enhanced by clearcutting, light scarification or prescribed burning (Perala 1977).

Clonal variation in aspen confounds site - productivity relationships.

Soil moisture, drainage, texture and slope position factors as they relate to NWO FEC Soil Types and aspen growth

(Davidson et al 1988, Buse and Towill (in prep))

	Soil Moisture Regime (MR)	*Soil Drainage Class (DC)*	*Slope Position*	*Soil Textures and NWO FEC Soil Types*
Best Growth	Fresh to moist (MR 2-5 with MR 3-4 being best) for trembling aspen; mod. dry to fresh (MR 0-2) for large-toothed aspen	Mod. well (DC 4) for trembling aspen; well (DC 3) for large-toothed aspen	Upper to middle slopes	Coarse and fine loamy, silty and clayey for trembling aspen; ***S3, S4, S5, S6, SS6, S9, S10, SS7;*** sandy and coarse loamy for large-toothed aspen; ***S1, S2, S3, S7, S8, SS5, SS6***
Poorest Growth	Dry (MR Ø) and v. moist to wet (MR 6-8); a water table within 60 cm of surface may retard growth	V. rapid or rapid (DC 1-2); imperfect to v. poor (DC 5-7)	Toe slopes, crests, level positions and depressions	Medium to coarse sandy, very shallow soils over bedrock; ***SS1, SS2, SS3, SS4, SS8;*** clayey and organic soils ***S10, S11, S12S, S12F, SS9***

3.5. Soil Erosion Hazard

A number of factors can affect the soil erosion potential on a site, including the extent and type of residual vegetation, the thickness of the LFH layer, the type of forest humus form and surface and C horizon soil textures (Comeau et al 1982). Susceptibility to erosion is greater where slopes exceed 10 percent; long, steep, uniform slopes are particularly vulnerable to erosion (Mattice 1977). Soil erosion hazard decreases as clay or sand content increases, and increases as percent silt increases (Wischmeier and Meyers 1973). On a broader scale, the frequency, intensity and duration of rainfall influence an area's susceptibility to soil erosion.

Forest access roads, skid-trail layout, logging and site preparation activities can all create soil erosion problems. General adherence to accepted engineering guidelines, including the construction of ditches and the installation of culverts, can help minimize the erosion effects of logging roads (Carr 1982, 1987). Skid-trails may tend to concentrate precipitation and groundwater runoff, especially when trails converge on a slope, or strip away surface organic layers. Method and intensity of silvicultural activity can also influence the extent of soil erosion on a site. In cutovers, risk of erosion decreases with the amount of residual vegetation and slash left on a site, and increases with degree of disturbance to surface organic layers. Widespread root decay may also contribute to erosion potential of some boreal forest sites (Valentine 1986).

Soil conditions influencing erosion hazard

NWO FEC Soil Types*	Slope (%)	Erosion Hazard	Comments
S12F, S12S, SS9, S11		Low	
S2, S4, S9, S10, S11, SS1, SS2,SS3, SS4, SS7, SS8	≤10 >10	Low High	Fluvial materials or extensive surface disturbance will increase hazard
S1, S3, S5, S6, S7, S8, SS5, SS6	≤10 >10	Low Moderate	Morainal soil materials, variable particle sizes, coarse fragment content >35%, or thick surface organic layers may reduce the erosion hazard

*assumes a relatively close correlation between surface texture and C horizon texture

3.6. Planting Stock Frost Heave Hazard

Soils with a high silt or clay content present a frost heave hazard for newly planted trees. Sands and gravels, which have little ability to lift water by capillary action, are less prone to frost heaving (Hausenbuiller 1985).

Frost heave hazard is determined by soil particle size and bulk density in the surface soil layers (Heidmann 1976). Such factors influence soil permeability and water tension (Schramm 1958). Sandy soils are very permeable but exhibit low tension due to larger air spaces between particles. Conversely, pure clay soils exhibit high tension but low permeability. Silty soils are especially prone to frost heaving because they exhibit both relatively high permeability and water tension (Heidmann 1976).

Frost heave hazard may be reduced by maintaining brush and ground cover, or an intact organic layer around tree seedlings (Singh 1976, Comeau et al 1982). High hazards are associated with newly planted seedlings on bare soils with low organic content (Fraser and Wahl 1969) or on soils subject to rapid freeze-thaw cycles. Planting of spruce seedlings through the organic layer should reduce frost heave hazard.

Soil conditions influencing frost heave hazard

NWO FEC Soil Types*	Frost Heave Hazard	Planting Stock Considerations	Comments
S1, S2, S7, S8, S11, S12F S12S, SS1, SS2, SS5, SS6, SS9	Low	No limitations to stock-type selection or planting season based on frost heave hazard	Hazard is lower if coarse fragment content exceeds 35%. Hazard is greater if soils are compacted, soil moisture is temporarily high, or if the humus layer is severely disturbed
S3, SS3, SS4, SS8	Moderate	Avoid fall planting	
S4, S5, S6, S9, S10, SS7	High	Plant large, vigorous bareroot transplants or large containerized seedlings in spring to early summer	

*assumes a relatively close correlation between surface texture and C horizon texture

3.7. Soil Compaction and Puddling / Rutting Hazard

Soil factors such as texture, structure (range of particle sizes), thickness of the humus layer, and coarse fragment content influence soil compaction hazard. High moisture content, particularly close to field capacity, will greatly increase risk of compaction; if water can be squeezed out of clayey and fine loamy soils by hand, a severe hazard exists (McKee et al 1985).

Compaction alters soil aeration, water flow and temperature resulting in restricted seedling root penetration and nutrient uptake (Lull 1959). Increases in bulk density of 15-20 percent within the top 10 cm of soil may occur on skid trails and 50 percent or more on landings (Carr 1987). The first few trips over the soil produce the most compaction with about 70 percent having taken place after five trips (Froehlich and McNabb 1983). Machine vibration may also contribute to compaction (Froehlich and McNabb 1983). Severely compacted soils may require up to 40 years or more to recover naturally (Hatchell and Ralston 1971).

Puddling or rutting occurs when clay particles align parallel with one another preventing proper soil drainage. This is most common on saturated, fine-textured soils with few coarse fragments and a disturbed humus layer (Pritchett 1979, McKee et al 1985). Soil degradation can be mitigated by restricting machine bearing pressure according to hazard level. Low hazard sites can handle greater than 200 kPa tire pressure without damage. Soils with low to moderate hazard should be limited to 70-200 kPa bearing pressure, while soils with moderate to high hazard should be restricted to operations with high flotation tires or tracked skidders (40-70 kPa). High hazard soils have a bearing capacity of no more than 40 kPa and should only be harvested with tracked skidders or by winter logging. Many soils may have a higher risk of compaction or puddling / rutting in the spring and fall or after periods of heavy rainfall when soil moisture content is high (Carr 1982); saturated, susceptible soils should be avoided.

Soil conditions influencing soil compaction and puddling / rutting hazard

Soil Texture Class and NWO FEC Soil Types [1]	*Moisture Regime* (MR)	*Humus Layer Disturbance* [2]	*Compaction and Puddling / Rutting Hazard* [3]
Fine **S4, S5, S6, S10, SS7**	Dry (MR ≤ O)	high	moderate
		low	low
	Fresh (MR 1-3)	high	high
		low	moderate
	Moist (MR 4-6)	high	high
		low	moderate
Medium **S2, S3, S9, SS4, SS8**	Dry (MR ≤ O)	high	moderate
		low	low
	Fresh (MR 1-3)	high	high
		low	low
	Moist (MR 4-6)	high	high
		low	low
Coarse **S1, S7, S8, S11, SS3, SS5, SS6**	Dry (MR ≤ O)	any	low
	Fresh (MR 1-3)	any	low
	Moist (MR 4-6)	high	moderate
		low	low
Bedrock or Organic **SS1, SS2, SS9, S12F, S12S**	Dry (MR ≤ O)	any	low [4]
	Wet (MR 7-9)		

1 Assumes a relatively close correlation between surface texture and C horizon texture

2 Disturbance by mechanical disturbance or burning which removes or reduces the organic layer

3 Decrease the hazard rating by one level if:
- coarse fragment content of the soil exceeds 35%
- following harvesting, there is good coverage of slash throughout the site

Increase the hazard rating by one level if:
- harvesting takes place during or immediately after a heavy rainfall
- many trips are made over the ground surface for harvest, silviculture or other activities
- harvested by full tree method
- soil particles are rounded (of fluvial origin) as opposed to angular

4 Organic soils have low risk of compaction but high risk of rutting

3.8. Limitations to Herbicides

Complete eradication of competing vegetation is seldom necessary, desirable or practical when releasing conifer crop trees. However, suppression of competing vegetation will provide crop trees with an opportunity to overtop competition (Malik and Van den Born 1986), often while maintaining plant diversity for wildlife habitat and site protection.

The timing of application is reviewed by Carruthers and Towill (1988) and the autecology of many of the major competitive species is reviewed by Haeussler and Coates (1986) and Bell (1991). Sims et al (1990) briefly discuss the effects of herbicides on some of the major tree species in NW Ontario.

Commercial use of hexazinone is restricted on some soil textures in Ontario. Surface (0-25 cm) and C horizon textures are generally correlated with one another but occasionally, surface textures may vary significantly from the texture of the parent material. It is normally accepted that surface soil texture should be used for compliance with manufacturer's label directions when evaluating a site for hexazinone application. This interpretation relates NWO FEC Soil Types to the application of hexazinone. Shallow Soil Types (SS-Types) and stratified soils may have properties that alter the persistance, movement or efficacy of herbicides in the soil.

Site-specific considerations for the use of herbicides for forestry application in Ontario

Chemical Name	*Currently Registered Forestry Uses in Ontario*	*Site Limitations and Target Species**	*Residual Activity*
2,4-D	post-emergent silvicultural site preparation and conifer release	no limitations based on soil properties successfully controls white birch, alder, pin cherry, maple, hazel and willow; partial control of aspen	negligible
Glyphosate	post-emergent silvicultural site preparation and conifer release	no limitations based on soil properties successfully controls white birch, cherry, maple, aspen, raspberry, willow, alder, grass and hazel; not recommended for use in same year as planting	Nil
Hexazinone	pre- or early post-emergent weed control in reforestation	not registered for sandy and coarse loamy soils; ie. ***S1, S2, S7, SS5, SS6*** and ***S8*** (except loam) organic soils, ***S11, S12S, S12F, SS9*** or mineral soils with *MR,5-7* are too wet for use of hexazinone lower application rates should be used on fine loamy soils; ***S3, S4, S9*** higher concentrations, up to label maximum, may be used on clayey soils; ***S5, S6, S10, SS7*** broadcast application provides effective control of goldenrod, brome grass, blue joint grass and raspberry with spot applications for control of poplar, ash, maple, cherry and white birch; not recommended for use in same year as planting.	Half-life approximately 2 months in fine loamy soils ***S3, S4, S6, S9, SS3, SS4, SS5, SS7,SS8;*** full competition control may last 16 months on silty or clayey soils ***S5, S6, S8, S10***

* Common names as cited from label specifications

3.9 Susceptibility to Root Rot

Armillaria ostoyae (Romagn.) Herink and *Inonotus tomentosus* (Fr.) Gilbertson are the two most economically important root rots on spruce and fir in Ontario. Recognition of these diseases and avoidance through silvicultural practices are the best management tools for the forester (Gross 1970, Whitney 1976, 1978, 1988, 1989; Stanosz and Patton 1987a, 1987b, Basham 1991). Susceptibility is primarily related to age and species of tree, and source and amount of inoculum.

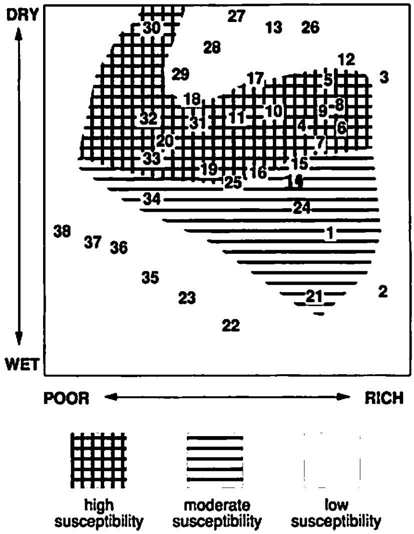
Many factors can increase the risk of infection. A dry to very fresh soil moisture regime (MR<4) may be related to an increased susceptibility of black spruce to *Armillaria* infection. Trees on fine-textured soils such as ***S4, S5, S6, S9, S10*** and ***SS7*** exhibit a reduced risk of *Armillaria* but an increased risk of *Inonotus*. Trees on coarse-textured soils exhibit an increased risk of *Armillaria* but a reduced risk of *Inonotus*.

Risk to stands of black spruce, white spruce and balsam fir increases after 25 years of age or after canopy closure occurs. Other factors which increase risk in older stands are root or trunk wounding resulting from thinning, loss of vigour resulting from insect or disease infestation, excessive tree sway resulting from less dense stands and / or greater than 35 percent coarse fragment content (Whitney 1988). Black spruce stands greater than 70 years of age are generally more susceptible than younger stands.

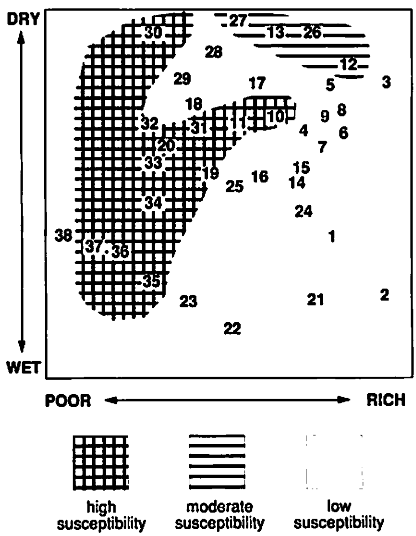
In young stands, risk is highest in large, even-aged, single species plantations, where trees suffer moisture stress, are of an unsuitable provenance, or occur on fine-textured soils subject to freeze-thaw cycles. Other contributing factors include insect or disease infestation and excessively deformed roots resulting from poor planting. Risk to young stands also increases as source of inoculum, such as dead material from herbicide application, increases. Herbicide-killed poplar acts as a reservoir for *Armillaria*. Large numbers of hardwood stumps in a stand conversion project may act as sources of inoculum, and may result in increased risk to young stands. Direct volume losses are not generally great unless confounded by other factors such as drought, insect or animal damage.

Root rot may be controlle by adhering to several management strategies: use a seed source adapted to the area; maintain tree vigour (by competition control or other means); minimize practices that lead to poor root development or root damage; selectively remove infected individual trees from healthy stands; select less susceptible species for higher-risk or previously-infected sites; and, manage for shorter rotations on higher-risk sites.

Armillaria



Inonotus

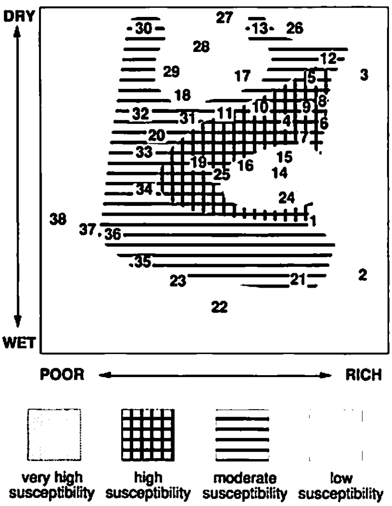


3.10. Susceptibility to Spruce Budworm Attack

Key factors influencing spruce budworm (*Choristoneura fumiferana* Clem.) susceptibility are stand composition, stand age and stand structure (Hix et al 1987, Gagnon and Chabot 1989). Vulnerability increases with repeated attacks. Balsam fir is the primary host and generally suffers heavy mortality during infestations. White spruce and black spruce mortality is usually low to moderate depending on intensity and duration of infestation.

Large, or contiguous stands greater than 60 years of age are at much higher risk than younger stands and susceptibility to attack increases substantially between 40 and 60 years of age. Small, isolated stands have considerably reduced risk of infestation. Stand vulnerability estimates can be facilitated by computerized mapping (Wickware and Sims 1990).

Stands composed of trees with reduced vigour resulting from site-induced stress may be more vulnerable to mortality from budworm attack (Hix et al 1987). Stands located on dry and well-drained soils (***SS1, SS2, SS3, SS4***) and very wet and poorly-drained soils (***S12F, S12S, SS9***) may have increased vulnerability. Likewise, weather-induced moisture stress may contribute to increased mortality.

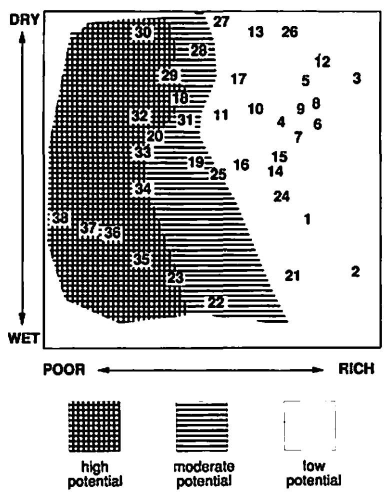


3.11. Potential for Black Spruce Advance Growth

Desirable crop tree species remaining on a site after timber harvest are referred to as advance growth. Black spruce advance growth may contribute substantially to the stocking of the new forest although the quality of advance growth as crop trees is, as yet, uncertain. The quantity and quality of the advance growth is related to both preharvest vegetation conditions and soils and harvest methods (Groot 1984, Wickware 1990). Most pine and black spruce dominated ecosystems in NW Ontario provide some degree of black spruce advance growth (Wickware 1990, Wickware et al 1990).

Vegetation Types in NW Ontario with the greatest potential for black spruce advance growth are typically located on wet, Sphagnum-dominated organic soils (***V34, V35, V36, V37*** and ***V38***). Black spruce advance growth may also be common on conifer-dominated, nutrient-poor upland stands (***V20, V29, V30, V32***, and ***V33***) on shallow soils with less than 20 cm of mineral soil (SS-Types) and a 5-20 cm LFH horizon. Mainly Hardwood or Conifer Mixedwood V-Types with diverse and abundant herb and shrub components generally have low potential for black spruce advance growth.

Layering accounts for 96% of black spruce advance growth in NW Ontario (Wickware et al 1990). Conditions that encourage layering, such as low stocking, thick LFH horizons and low levels of hardwood competition may provide enhanced opportunities for black spruce advance growth. Highest potential for advance growth occurs on *S12S* and *SS9* where soil surfaces are dominated by *Sphagnum* spp.; *SS2* and *SS3*. Soil Types *S11* and *S12F*, and to a lesser degree *S1*, *S2*, *S3* and *S10*, may support high black spruce stem densities, but these stems tend to be clumped, and stocking levels are usually below 40% (Wickware 1990). Actual abundance, distribution and quality of advance growth on these sites may be determined from a pre-harvest survey.



3.12. Windthrow Hazard

Windthrow, or blowdown, refers to the process where trees are uprooted by wind. Windthrow is widespread in NW Ontario and results in significant losses of timber. Two types of windthrow are recognized: catastrophic, which results from a severe storm and endemic, which is related to site conditions and silvicultural practices (Miller 1985, Fleming and Crossfield 1983). Endemic windthrow is of particular interest to forest managers because this form of windthrow may be controlled and minimized by proper management.

Some stand-level factors affecting windfirmness are root form, stand density, tree height, species mix, fluctuating water table, soil texture, and the incidence and extent of root rot and insect infestations. Root and stem damage, and the length and configuration of stand edge resulting from harvest may also influence the windfirmness of trees. Dense, tall stands with high, full crowns and a restricted rooting zone have the highest susceptibility to windthrow (Moore 1977). Shallow-rooted species such as black spruce and balsam fir are most at risk (Heinselman 1957; Batzer 1960) on moist, fine-textured soils (***S9, S10***), peaty phase soils (***S11***) and shallow, fine-textured soils (***SS7, SS8***) that inhibit the formation of structural roots. Local topography can have an effect on wind patterns when combined with particular cutting practices (Gordon 1973).

Local topography can increase the opportunity for windthrow (Gordon 1973) by creating a venturi effect (an increase in wind speed as it passes over or between hills). Susceptible stands with cut edges along skylines, or oriented perpendicular to prevailing winds in valleys will have increased risk of windthrow (Alexander 1986).

When a portion of a dense stand is cut, the stability created by the interlocking crowns and roots is reduced and these stands become vulnerable to windthrow (Alexander 1974). Harvest operations should be carried out from the leeward edge, whenever practical. Windthrow risk may be more closely related to wind fluctuation or turbulence than to total wind speed. Edges of dense, pure stands are more susceptible to wind turbulence, hence windthrow risk, than mixed stands (Fosberg 1986). Thinned stands allow greater wind penetration and are better able to dissipate wind than dense stands, but are more prone to windthrow from strong gusts (Fosberg 1986).

Overmature trees and trees infected with butt or root rots are especially susceptible to both uprooting and stem breakage (Heinselman 1955). Smaller trees are less likely to be uprooted than larger trees (Neustein 1968; Miller 1985). In Ontario's Clay Belt, black spruce stands growing on peaty phase, clayey mineral soils demonstrated increasing susceptibility to windthrow with increasing age and height; trees of 20 to 21 meters in height were highly susceptible to windthrow (Smith et al 1987).

Windthrow around the perimeter of clearcuts may be minimized by:

1. avoiding cut faces on the windward side of stands;
2. locating cut boudaries in stands with low susceptibility to windthrow; and,
3. avoiding irregular edges along the cut perimeter of susceptible stands.

Certain NWO FEC Vegetation and Soil Type combinations are predisposed to windthrow identification of potential windthrow hazard (low, moderate, high) during planning may help in the avoidance of windthrow losses.

Windthrow hazard based on combinations of NWO FEC Soil and Vegetation Types (after Vold 1981, Zelazny et al 1989)

S- and SS-Types	*V-Types*	*Hazard*
S1, S2, S3, S4, S5, S6, S7, S8	All	Low to Moderate
S9, S10, S11	*V14, V16, V33, V34*	High
S12F, S12S	*V33, V34, V35, V36*	Moderate to High
SS1, SS2, SS3, SS4, SS5, SS6	*V17, V18, V19, V20, V28, V29, V30, V32*	Moderate
SS7, SS8	*V33, V34, V35, V36*	Moderate to High
SS9	*V35, V36, V37*	Moderate

3.13. Prescribed Burn Opportunity

Prescribed burning is the deliberate application of fire to achieve specific management objectives such as slash reduction, wildfire hazard reduction, disease control, site preparation for regeneration, wildlife habitat improvement or any combination of these or other objectives. Planning for prescribed burns should consider all relevant site factors, including expected fuel loading, substrate, soil moisture and physiography (Chrosiewicz 1978, 1989, 1990, Isherwood and McQuarrie 1985, Hawkes et al 1990). Harvest systems should be selected to leave the site with enough fuel to carry combustion. This interpretation relates NWO FEC units to some of the vegetation and soil conditions which should be considered when planning for prescribed burning. Fuel loading and wildfire potential of V-Types are estimated by Stocks et al (1990).

Vegetation Considerations

Aspen slash has relatively low flammability (McRae 1985) and requires an even distribution of cured fuels (Perala 1977) to support combustion. Mixedwood V-Types that produce heavy aspen slash (***V5-V11***) typically support low-intensity burns that may stimulate suckering. Prescribed burns to effectively control aspen suckering require additional fuels or higher fire indices.

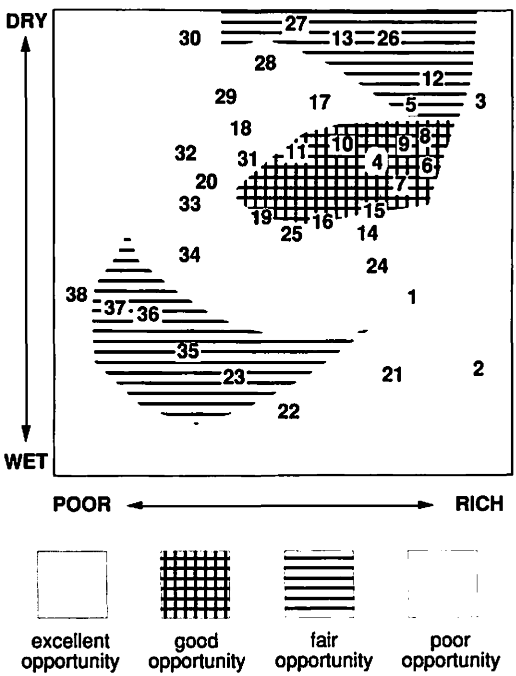
Sites that support black spruce V-Types (***V20, V31, V33*** and ***V34***) on fresh to moist, fine textured, deep to moderately deep S-Types (***S5-S10, SS7*** and ***SS8***) generally benefit from prescribed burning after harvest due to an increase in nutrients and a decrease in vegetative competition, especially balsam fir (Arnup 1989). Prescribed burning is not recommended, unless slash reduction is the primary objective, on sites with advance growth stocking levels greater than 40% (Arnup et al 1988) or where organic soils (***S11, S12F, S12S*** and ***SS9***) provide a suitable black spruce seedbed (Archibald and Baker 1988).

Jack pine V-Types (***V17, V18, V28, V29, V30*** and ***V32***) that have been tree-length harvested may leave considerable amounts of slash on a site and may be particularly well suited for prescribed burning. Full-tree harvested, jack pine / feathermoss V-Types (***V18, V29*** and ***V32***) require continuous feathermoss cover to carry adequate combustion for a prescribed burn (McRae 1986). Prescribed burning can promote natural regeneration by releasing jack pine seeds from their serotinous cones.

Balsam fir slash and residuals are highly flammable and easily eliminated from sites dominated by ***V6, V7, V14, V15, V16, V24*** and ***V25*** (Stocks et al 1990). Balsam fir does not effectively reproduce on burned sites and is usually eradicated by fire (Arnup 1989).

Soil Considerations

On dry (***S1, S2***) and very shallow (***SS1-SS4***) soils with a high coarse fragment content, fire can destroy the organic layer. This may significantly decrease the water holding capacity and moisture content of the soil (Kimmins 1987, Chrosziewicz 1989), and lower nutrient availability, impairing the long term productivity of a site (Taylor and Feller 1986, MacAdam 1987, Hawkes et al 1990). Maintenance of a thick humus layer may help a site to immobilize nitrogen and other essential nutrients, and may help in keeping moisture near the soil surface. On the other hand, fire may stimulate microbial activity and aid in nutrient cycling (Kimmins 1987). Other potential benefits of moderate-intensity prescribed burns include increased soil temperature (McMinn 1983) and pH (Alban 1977).



Section 4

Wildlife Habitat Interpretations

4. Wildlife Habitat Interpretations

4.1. Background

Habitat is the place in which an animal, or a population of animals, lives. It includes all the biotic and abiotic life requirements of an animal, or animal population. Vegetation and soil are both major components of habitat.

Effective habitat management for wildlife requires a system for organizing habitat information in such a way that thoughts and ideas can be easily communicated (Marcot et al 1988). For vegetation and soil information, the NWO FEC provides a classification system which is relevant in describing present habitat quality for some species, and habitat potential for others.

The NWO FEC classifies stands on the basis of both overstory and understory characteristics. It was developed from data on naturally occurring stands of a harvestable age and consequently some important factors meaningful to many wildlife species cannot be put in terms of the NWO FEC system. Some of these factors include stand age, occurrence of snags, stand structure, amount of edge and size or interspersion of stands. In addition, wetlands and very young stands are not defined by the NWO FEC. These limitations of using the NWO FEC for description of wildlife habitat are recognized in the wildlife interpretations presented in this publication.

As mentioned elsewhere in this guide, interpretations presented here should in no way be considered as formal guidelines for management. They demonstrate how NWO FEC V-Types can be used to associate relative habitat values of naturally occurring forest ecosystems to selected wildlife species. As well, timber and wildlife management objectives can be integrated more effectively by sharing a common site classification system.

4.2. White-tailed Deer Habitat

White-tailed deer are restricted to the southwest corner of NW Ontario, particularly Fort Frances, Atikokan and Thunder Bay Districts. Therefore, habitat requirements reflect the stand conditions found in that area. This interpretation identifies NWO FEC V-Types that are usually capable of producing preferred browse species or winter shelter if managed for that purpose.

Winter Shelter

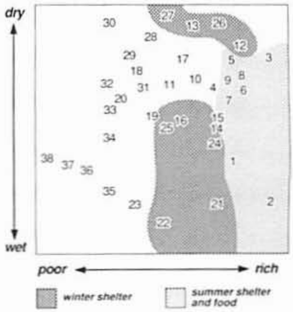
The limiting factor for white-tailed deer in NW Ontario is usually considered to be winter severity. Tree cover that offers protection from severe cold and deep winter snow is essential. The value of this cover is enhanced if abundant winter browse, such as *Acer spicatum*, trembling aspen, *Corylus cornuta*, *Cornus stolonifera* or *Fraxinus nigra*, exists in adjacent areas. V-Types which have significant composition of white spruce or balsam fir (***V14-V16**, **V24**, **V25***), cedar (***V21**, **V22***), black spruce (***V19***) or white and red pine (***V12**,**V13**, **V26**, **V27***) are most likely to be selected for winter shelter in areas which support white-tailed deer populations.

Summer Shelter and Food

White-tailed deer are generalist herbivores with rather critical energy requirements, particularly during the winter. However, most of their energy intake occurs during the snow-free period. Important spring and summer foods include grasses, deciduous leaves and various components of a herb rich understory. These foods are particularly abundant in rich hardwood dominated V-Types (***V1-V9***).

Special Considerations

Habitat suitability for white-tailed deer may be enhanced by interspersing small (<50 ha) blocks of shelter and early successional stages suitable for food production. A fine-grained environment where all life requirements can be found within 50 to 100 ha produces excellent habitat. Diverse topography can also enhance habitat suitability.



4.3. Moose Habitat

Habitat quality for moose is determined as much by stand age or structure as by species composition. It may also be strongly influenced by topography and soil productivity, and by the spatial arrangement and diversity of habitat conditions across the landscape. Moose have large home ranges which may exceed 1500 ha and are sometimes subject to large seasonal or even random movements. A moose may depend on a relatively small proportion of its home range to meet most of its habitat requirements.

The best food production areas will be young, regenerating stands, 3 to 10 years of age, with abundant, high quality browse. However, most of the life requirements of moose can be defined in terms of older stands of harvestable age. This interpretation describes four life requirements for moose in terms of NWO FEC V-Types.

Summer Feeding

Summer feeding areas can include a variety of stands, ranging from pure deciduous to conifer mixedwoods, with an abundant shrub and herb rich understory featuring desirable browse species such as trembling aspen, *Acer spicatum*, *Salix* spp., balsam fir, *Corylus cornuta* and *Sorbus* spp. Requirements for shelter are minimal although topography and proximity to aquatic feeding areas or thermoregulation sites often determine extent of use. These V-Types often occur on soils that are capable of producing more abundant browse after harvest.

Early Winter

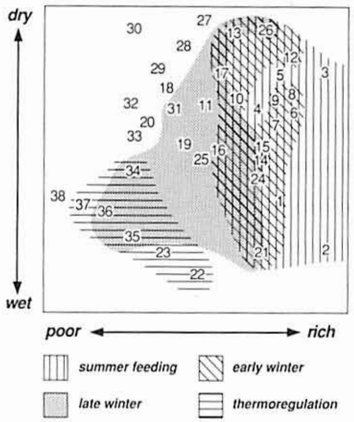
Early winter areas feature varying degrees of horizontal and vertical cover with moderate levels of conifer composition. Abundant browse of aspen, *Acer spicatum*, trembling aspen, *Salix* spp., balsam fir, *Sorbus* spp. and *Corylus cornuta* are essential. Heavy feeding by both sexes make moose dependent upon areas of high browse productivity until deep snow or cold temperatures restrict use.

Late Winter Shelter

Late winter shelter is characterized by abundant vertical and horizontal cover, a high degree of canopy closure and stocking of 0.7 to 0.8 or greater. Protection from wind and deep snow is of primary importance. Generally, these stands will not provide an adequate supply of food on their own so that close proximity to young stands or cutovers will enhance value. The application of the *Timber Management Guidelines for the Provision of Moose Habitat* (Anon. 1988) may enhance the value of these stands to moose by providing food in close proximity to shelter.

Thermoregulation

Stands with fairly complete overhead cover and a deep, moist Sphagnum mat provide excellent opportunities for thermoregulation on hot summer days. These stands will be of maximum value when near aquatic feeding areas, available browse and a supply of water. Many other stand types may have thermoregulatory value to a lesser degree.



4.4. Marten and Fisher Habitat

Marten and fisher have habitat requirements which are often defined in terms of conifer composition, stand age and stand structure. Although these furbearers occur occasionally in all stand types, stands which are most likely to exhibit desirable habitat attributes can be described in terms of NWO FEC V-Types.

Good Habitat

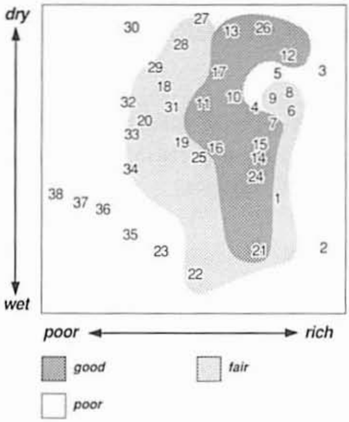
Good habitat is typically mature or old-growth forest with numerous standing snags, deadfalls and high structural diversity. Other criteria include 25-80 percent conifer composition, greater than 50 percent canopy closure, a diversity of tree species and a multi-level canopy. A diverse understory with abundant herb and shrub vegetation supports an abundance of prey species such as voles, chipmunks, shrews, red squirrels and snowshoe hare (Allen 1982, 1983).

Fair Habitat

Fair habitat is lacking in at least one of the criteria necessary for "good" habitat. The criteria most easily described by the NWO FEC are conifer composition, shrub richness and species composition. These stands should have maximum value as part of a habitat mosaic that also includes stands with all the attributes of "good" habitat.

Poor Habitat

Poor habitat generally has low diversity or low conifer composition. Stands of "poor" habitat may be used by marten or fisher when interspersed with stands of "good" habitat, but only on an opportunistic basis. Uniform, low-diversity, jack pine stands may be heavily used if prey is present.



Special Considerations

Habitat quality will vary with stand age and interspersion. Mature stages of "good" and "fair" stand types on at least 25 percent of the land base on each 150 ha block of land should help to maintain marten and fisher populations (Racey and Hessey 1989). Minimum block sizes of uncut stands are unknown.

4.5. Caribou Range Suitability

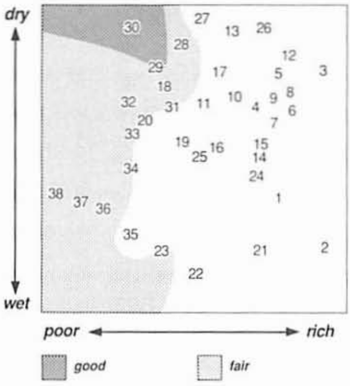
Caribou, unlike moose, are habitat specialists. The limiting habitat factors are probably winter range and calving sites. This interpretation deals with general range suitability and is only applicable where suitable habitat is found over extensive areas and where caribou are present.

Good Habitat

Caribou in NW Ontario are usually associated with old, open black spruce or jack pine upland stands (***V30***) with shallow soils (***SS1***, ***SS2***), exposed bedrock, moderately open canopy and abundant lichen ground cover. Rapidly drained sandy soils (***S1***, ***S2***) may also support shrub poor jack pine stands which provide some protection from deep snow, but also provide an abundant supply of lichens and ericaceous shrubs which are preferred foods.

Fair Habitat

In broken or undulating terrain, lichen-rich stands may be associated with poorly drained, moist or wet, organic or peaty phase soils (***SS9***, ***S11***, ***S12S***) which support open spruce or tamarack stands. These stands may provide escape from insects and predators while providing a source of ericaceous shrubs, a winter staple. Stands with very low canopy closure may not be used in late winter.



Special Considerations

When these stand conditions occur over relatively large areas in known caribou range, timber harvest can be made more compatible with caribou habitat by producing large cutovers, well separated from each other by large uncut blocks of good or fair habitat (Darby et al 1989).

Caribou do not make extensive use of woody browse species and therefore can exist in areas with relatively low plant productivity. Sites that generally support caribou populations may not produce sufficient browse to support a vigorous moose population.

Predation frequently plays a major role in determining habitat - use strategies by caribou.

4.6. Song Bird Habitat

The preferred habitat of forest bird species may overlap several forest stand types. The size of stands, the structure and degree of variability within stands and the attributes of adjacent stands all influence the abundance and diversity of breeding birds that utilize Vegetation Types. A bird species' habitat can be described in terms of V-Types by relating its relative abundance at a sampling station to the V-Types surrounding the station. Data collected during NW Ontario field surveys in the spring and summer of 1989 were used to develop interpretations for songbird habitat, a sample of which are presented here (D. Welsh, Canadian Wildlife Service, Ottawa, unpublished data).

As songbird territories are much larger than the single 10m x 10m plots on which V-Types are determined, territories were described according to the range of V-Types occurring at the sampling station. Therefore, instead of the ordination representing 38 discrete V-Types, the analytical procedures treated the ordination as a continuous Cartesian plane. Sampling station locations did not have to fall directly on a V-Type location and results were mapped on the whole ordination surface.

The ordinations presented as examples describe how the relative abundance of four songbird species vary with NWO FEC V-Types. The four species, Blackburnian warbler (*Dendroica fusca*), Chipping sparrow (*Spizella passerina*), Connecticut warbler (*Oporornis agilis*) and Swainson's thrush (*Catharus ustulatus*), select habitat on the basis of different environmental cues.

Blackburnian warbler: forages in upper crowns of conifers in coniferous and mixedwood stands.

Chipping sparrow: widespread occurrence in open woodlands, especially pine.

Connecticut warbler: prefers extensive shrub rich spruce bogs and tamarack fens.

Swainson's thrush: flexible habitat requirements in spruce and fir dominated forests with sparse ground cover.

A number of advantages or potential applications for this technique are evident:

- Planning for the needs of a broad range of wildlife species like forest songbirds requires specific knowledge of their distribution and abundance. This approach describes some habitat attributes and relative songbird density in NWO FEC terms; facilitating incorporation into land management planning.

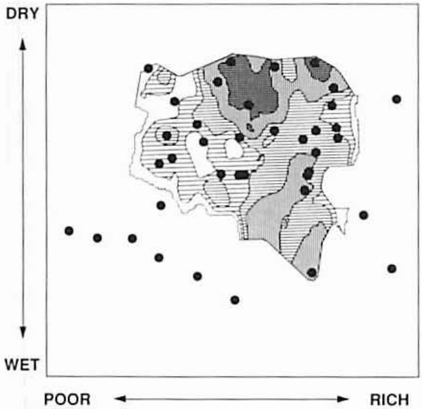
- In a table including all bird species, the data gives precise information on the relative importance of individual V-Types for a bird species and of the relative importance of individual bird species within a V-Type.

- NWO FEC provides a suitable framework for bird monitoring programs which require a standardized system of classifying habitat in terms of vegetation composition and stand condition.

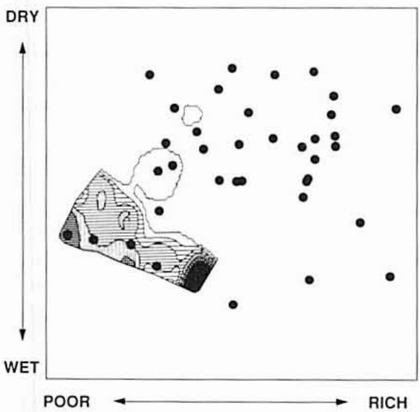
- NWO FEC may also be used as an ecosystem planning tool to identify those V-Types which contribute significantly to songbird populations; it also provides an inventory tool to forecast populations based upon habitat availability.

On the other hand, the NWO FEC has limitations for the description of habitat for some songbirds. The NWO FEC does not specifically describe natural forest successional stages, wetlands and "non productive" forest land. Other landbase classifcation, for example , wetlands classifications (Jeglum et al 1974), may also have value for describing songbird habtitats. Some songbird species will not be strongly associated with V-Types because they use micro-habitat features not used for differentiating V-Types.

The minimum size of stand required by each songbird species varies with territory size and the suitability of the habitat. Scale of mapping NWO FEC data will influence the suitability of this technique for mapping or describing songbird habitats.

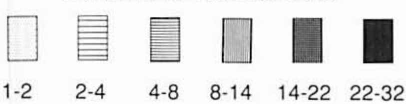


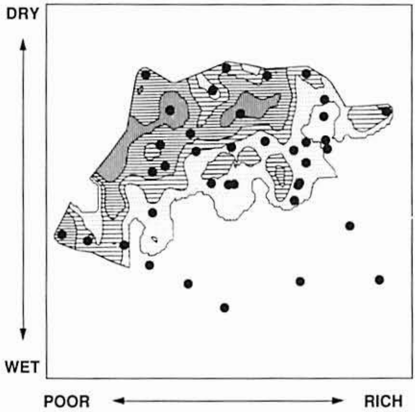
Blackburnian Warbler



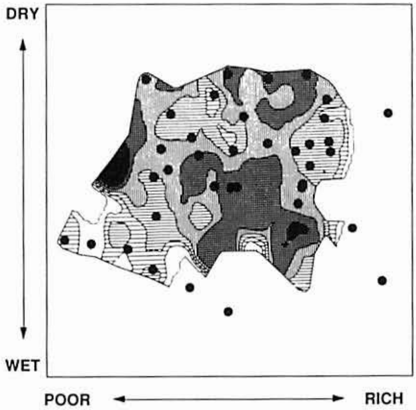
Connecticut Warbler

Relative Abundance Class



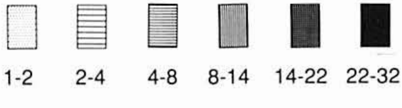


Chipping Sparrow



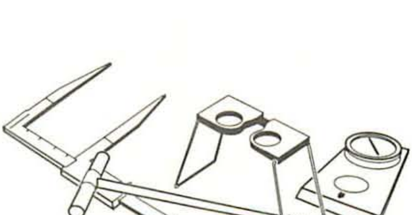
Swainson's Thrush

Relative Abundance Class



Section 5

Forest Management Applications



5. Forest Management Applications

The NWO FEC was developed as a forest management tool because many of the techniques, properties or values associated with forest management are dependant upon site-specific attributes. This is true for the production of timber, the conservation of wildlife, maintenance of aesthetic values, and for environmental protection.

This section summarizes some techniques to assist with application of the NWO FEC for integrated forest management. This section is not definitive because there will always be innovative ways of applying the NWO FEC to forest management problems. Forest management applications include a wide variety of topics such as collection of NWO FEC field data through a pre-harvest assessment, and the application of Treatment Units to a range of currently-evolving silvicultural planning and forest management tools. Such tools may include silvicultural ground rules, crop planning and wood supply models, and wildlife habitat supply analyses. New applications will be added to this and other sections as they become available and are tested.

In NW Ontario, the NWO FEC may be used to describe silvicultural ground rules, and as a standardized vocabulary for describing site-specific features for research trials and silvicultural records. NWO FEC data collection may also be incorporated into existing data collection procedures such as operational cruises. Implementation will require some guidance on methods of data collection and data summary.

5.1. Introduction to Pre-harvest Surveys

Historically, harvestable stands are allocated using Forest Resource Inventory (FRI) information, sometimes augmented in NW Ontario by volume estimates obtained from an operational cruise. A pre-harvest survey in which NWO FEC data is collected (Towill et al 1988) provides additional information useful for identifying harvest and regeneration constraints and opportunities, and opportunities for integrated resource management.

Forest ecosystem interpretations based on scientific literature and expert opinion will facilitate the development of pre-harvest silvicultural prescriptions which maximize benefits and minimize economic and ecological costs. These interpretations require sufficient information about NWO FEC Soil and Vegetation Types collected on the ground (Sections 5.1.1 to 5.1.3), or from air photo interpretation combined with data from other sources (Section 5.1.4).

Volume estimation obtained by cruising may also be combined with a pre-harvest assessment on small blocks of land (150 ha or less) or where very precise estimates of volume or wood products are required. This might be the case in Crown Management Units where contractors operate on small blocks of land.

5.1.1. Stratification and Sampling

Stratification for sampling is usually based on FRI stands. However, subdivision of large stands may be warranted if air photo interpretation or other evidence suggests large-scale systematic variation. A minimum polygon size of 8 ha is recommended. However, other criteria based on landforms, significant ecological features, silvicultural opportunities or management objectives may justify the sampling and unique classification of smaller land units.

Sampling intensity is determined by the specific objectives of the manager, and the size of the area to be sampled. Proficiency at stratifying the land base into units of relatively uniform economic, landform, soil and vegetative zones will permit a reduction of sampling intensity and the associated cost with little reduction of data integrity. Reduction of sampling intensity typically increases the risk of misclassification and reduces the sensitivity of the assessment to site variability. Increasing the sampling intensity increases the cost. Selection of a sampling methodology and sampling intensity will require the user to balance the needs for information, the potential benefits and the cost of collecting the data.

Three possible sample intensity levels (SIL) are suitable for use when collecting NWO FEC data during a pre-harvest survey. The SIL selected will reflect specific objectives and financial resources available.

SIL 1. This sampling intensity is consistent with mapping at a scale of 1:5000 and combining the collection of NWO FEC data with the estimation of timber volume. The estimation of volumes may require fixed length transects. This SIL is compatable with volume estimation or NWO FEC sample plots every 1-3 ha. Volume estimation plots based on prism sweeps or other estimation methods occur about every 3 chains with NWO FEC plots approximately every 9 chains. More heterogeneous or smaller stands may require NWO FEC plots every 5 or 6 chains. NWO FEC information is generally summarized on 1 tally sheet per plot. This SIL is appropriate for the development of detailed soils maps for establishment of seed orchards, intensive forest management areas and small blocks where greater than average accuracy is required in volume estimation or soils mapping.

SIL 2. This sampling intensity is consistent with mapping on the FRI scale (1:15,840 or 1:20,000) to provide basic soil and forest stand ecosystem information. Volume estimations taken at sample points or between sample points may be used to verify volume estimates obtained from an operational cruise, or from the FRI. This SIL requires NWO FEC sample plots every 10 ha or 1 plot every 15 chains. A minimum of 2 plots is recommended to ensure adequate documentation of small, unique stands. NWO FEC data collected at this SIL is generally summarized on 1 tally sheet per plot.

SIL 3. This sampling intensity is consistent with a general pre-harvest inspection for confirmation of volumes estimated by an operational cruise and with mapping on the FRI scale or smaller (1:15,000 to 1:25,000). This SIL requires sample plots every 20 ha or 1 plot approximately every 22 chains. Plot location must be representative of the stand as determined by general observations. Sampling at this scale is susceptible to sampling error but can be readily accomplished by experienced surveyors. NWO FEC information collected at this SIL is generally summarized on 1 tally sheet per stand.

A combination of SILs may be used for sampling areas which feature stands that vary from extremely uniform to extremely heterogeneous. It is neither necessary nor always desirable to sample NWO FEC data on a rigid, statistically based sampling design. Often the vegetation will be more variable than the soils information and it is therefore often necessary to sample vegetation more intensively than soils. This is compatable with the relative cost of sampling; vegetation plots are substantially less time consuming than soil plots. Soil texture, depth and moisture regime are usually very uniform on lacustrine, outwash and some morainal landforms. On these landforms, it is often possible to collect detailed soils information from a soils pit and not have to repeat the procedure until an obvious change in vegetatation, relief or slope indicates that soil conditions are different.

5.1.2. Interpretation and Use

Pre-harvest surveys involving the collection of NWO FEC data can provide information capable of enhancing forest management decisions through application of some of the forest ecosystem interpretations presented in this guide or elsewhere. Site-specific decision-making may be facilitated by interpreting NWO FEC data collected during an on-site inspection. Some of these decisions include:

- method of harvest (strip, clearcut, block cuts).
- season of harvest for minimum site disturbance and maximum efficiency.
- equipment selection for harvest with minimum site disturbance.
- early identification of unmerchantable stands.
- selection of silvicultural treatments such as natural *versus* artificial regeneration, stock type selection, and site preparation equipment.
- estimation of advance growth for area-based planting.
- species-selection for site; forecasting competition control and tending requirements.
- estimation of environmental risk factors such as areas with high erosion risk.
- road building or stream crossing opportunities.
- early conflict resolution with other forest users (integrated resource management issues).
- annual work schedule planning.

Efficient forest management prescriptions can be made on-site by experienced field staff but the pre-harvest survey information including NWO FEC data may be collected by less highly trained individuals and interpreted in the office by qualified personnel. User-defined Treatment Units which suggest silvicultural treatments based on Vegetation and Soil Types will augment the process of setting prescriptions. The long term benefit of performing a pre-harvest survey at the highest level of intensity possible (e.g. SIL 1) is that the data can be used to generate a detailed soils map of the management area, whether it is a crown unit or a company licence.

5.1.3. Pre-harvest Survey Tally Sheets

Good tally sheets are essential for efficient, and thorough pre-harvest surveys. The type of information collected is important, but the order and form in which data is collected increases the efficiency of data collection, ease of interpretation and reduces the number of errors during data summary or transcription. An example tally sheet suitable for data collection at SIL 2 is included in this guide, adapted from Towill et al (1988). The use of this tally sheet is described by Towill et al (1988). Thoughtful notes should also be taken in the field, including observation of other significant silvicultural or ecological features.

Users may "customize" tally sheets to include spaces for special data required for specific purposes. We recommend that existing standardized codes be adopted where possible to describe soils-related information. Some standardized codes for recording site-specific information are found in the *Field Manual for Describing Soils* (Ontario Institute of Pedology 1985) and the *Field Guide to the Forest Ecosystem Classification for Northwestern Ontario* (Sims et al 1989).

Variations to the tally sheets may have to be made if the SIL changes. For example, at SIL 1, the number of observations recorded on the sample plots is relatively high and the tally sheet and stand summary sheets reflect this. The following information might be collected on a plot:

- V-Type from FEC keys based on 10m X 10m plot.
- S-Type from FEC keys based on a soil sample taken within the 10m X 10m plot.
- The occurrence of rock outcrop.
- Degree of slope.
- Position on slope.
- Stand composition: Assemble a visual impression of stand composition to compare with FRI typology and working group definitions.
- Volume estimation:
  a) Prism sweeps
    - basal area factor.
    - dot tally for each species.
    - total number of basal area plots sampled.

b) Wood volume estimates

Good (G)	> 225 m^3/ha
Fair to good (F-G)	179-225 m^3/ha
Fair (F)	179 m^3/ha
Fair to poor (F-P)	135-179 m^3/ha
Poor (P)	90 m^3/ha
Nonmerchantable (NM)	< 70 m^3/ha

- Proportion of volume suitable for pulp, veneer or sawlog products.

Some information may be collected during the walk-through of the stand, but recorded on the plot sample sheets; the walk-through is the travel between sample plots. It provides an opportunity to observe the lay of the land, vegetation patterns and factors that may influence timber management operations. Some typical observations made during the walk-through on a SIL 1 survey are:

- Landforms.
- Road building potential.
- Stand condition.
- Limitations to season of harvest.
- Wildlife values; for example, raptor or heron nesting areas, significant snag nesting habitat, or animal trails that might indicate wildlife concentration areas, presence of mineral licks or major travel corridors.

A pre-harvest survey at SIL 3 is more general in its data collection requirements. It resembles a general field reconnaissance with some sample plots inserted to collect NWO FEC vegetation and soil information. The plot data would verify V-Type, soil depth, texture, moisture regime and S-Type by using a soil auger. The remainder of the relevant observations would be observed during the general walk-through. This information might include:

- Stoniness.
- Occurrence of rock outcrops.
- Degree of slope.
- Stand composition.
- Visual impression of wood volume and type of product.
- Landforms.
- Road building potential.
- Stand condition.
- Abundant competing species.
- Factors that could affect season of harvest.
- Wildlife values.

Pre-Cut Survey Tally Form

Front Side

Admin

Basemap/Township	Stand No./Stratum
Management Unit	Area
Date	Surveyors

NWO FEC

V-Type	S-Type

Stand Description

Sp. Comp. FRI	Ocular ☐ Opc ☐
Stocking FRI	Sweep ☐ Crown Density ☐

Species	Stand Condition (disease, insects, blowdown, form, vigour)
Age	
Height	
DBH avg-r	
Veneer % S. Log Pulp	
Understory and Veg.	

Physical Aspects

Terrain	
Stoniness	Rock Outcrops
Moisture	Drainage

Stocking

BAF

No. of Pts.

Pre-Cut Survey Tally Form

Reverse Side

Operational Aspects

Season
Residuals
Access - Road Chance Map Attached ☐
Wildlife Habitat Potential
Other Comments

5.1.4. Integration with Other Resource Material

Collection of NWO FEC data during a pre-harvest survey has greater value when the data can be integrated with or used to augment information on existing data bases. Some of these databases such as the Surficial Geology of Northern Ontario (Zoltai 1965a, 1965b), the Northern Ontario Engineering Geology Terrain Study (NOEGTS) maps (Gartner et al 1981) and the Ontario Land Inventory (OLI) maps (OMNR 1977) can be extremely useful in stratifying the land base into sampling units or identifying physiography or underlying landforms. Stratification by these methods, when combined with an understanding of landform toposequences (Baldwin et al 1990), will help users apply air photo interpretation techniques to classify large areas inexpensively (Anonymous 1989).

NWO FEC information collected during a pre-harvest survey on the ground, or by air photo interpretation will augment information currently available on Ontario Forest Resources Inventory (FRI) maps (OMNR 1978). One approach to integrating the data bases is to use the NWO FEC information to annotate the existing FRI polygons. In some cases, subdivision or amalgamation of polygons is warranted to suit the scale or intensity of management. One of several suitable annotation methods is to identify the proportional representation within a polygon of NWO FEC S-Types or V-Types. For example:

SS3 60%, ***SS6*** 40%

V14 40%, ***V7*** 30%, ***V10*** 20%, ***V6*** 10%

This annotation method not only provides the species composition of the stand, but also describes some of the structural variation and tree species distribution within the stand. Additional information gathered during the pre-harvest survey will be useful for interpreting the data, assigning a Treatment Unit and formulating a prescription. This method of annotation is also compatable with record keeping on a stand by stand basis, using the FRI stand numbers for reference.

5.1.5. Equipment

NWO FEC data collection during a pre-harvest survey may require equipment not normally carried on a field inspection. Soil sampling will require a soil auger and possibly a shovel for very stony soils, a bottle of 10% HCl solution to test for soil carbonates, a tape measure, and a copy of the *Field Guide to the Forest Ecosystem Classification for Northwestern Ontario.* Vegetation sampling will require only the *Field Guide to the Forest Ecosystem Classification for Northwestern Ontario*, although a reliable plant guide may be necessary until individuals develop their skills at plant identification. Some training in the skills of soil and vegetation classification using the NWO FEC is an important pre-requisite.

5.1.6. Training

Collection of NWO FEC data during a pre-harvest survey requires skills that are normally obtained through specialized training. Training in soils and vegetation classification should emphasize skills development in soil texturing, determination of moisture regime, soil mottle and gley identification, identification of important plants, and use and interpretation of NWO FEC classification keys and factsheets. Training is best achieved through a combination of classroom lessons and field experience.

Section 6

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6. Literature Cited

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