Ministry of Northern Development, Mines,
Natural Resources and Forestry

Northeast Region

Regeneration Assessment Program (RAP) Manual

Version 1.0

June 30, 2021

Lindsey Russell and Gordon Kayahara

Table of Contents

List of Tables

List of Figures

1.0 Introduction

Under Ontario's current regulatory framework, management of public forests in most cases are licensed to the private sector although licensing to boards which include a variety of stakeholders and Indigenous communities is growing. The government through the Ministry of Northern Development, Mines, Natural Resources and Forestry (the Ministry) is responsible for oversight of forest management on public lands, acting on behalf of the citizens of Ontario. A forest management plan (FMP) is written for each licensed forest and includes a plan to regenerate harvested areas; a plan, if carried out successfully, will help guarantee that forestry practices are implemented in such a way as to maintain sustainability. What silviculturalists do in the early post-harvest years of stand development sets the stand up on a trajectory which determines the future condition; therefore, a comprehensive and consistent regeneration assessment program is a critical component to ensure the sustainability of Ontario's forests. The objective of the regeneration assessment is to assess at a young age whether a regenerating stand has a high probability of achieving a condition as modeled in the FMP, and is one of the keys that demonstrates that the plan is on track to being implemented sustainably. This information is not only needed by the people and companies managing the forest but also by the public of Ontario.

Within a pre-determined time, after silvicultural treatments are completed (approximately 5-12 years post-harvest), the forest manager assesses the regeneration condition of all stands harvested and regenerated that have reached the end of this establishment stage. At this stage the trees that will play a key role in the development of the regenerating cohort are well-established, and a meaningful assessment of regeneration success and future stand development can be made. In addition, at this stage some evidence suggests that there is a high probability that the dominant regenerated trees will maintain dominance until crown closure (White et al. 2014), around 20-25 years of age, at which time the stand is subsequently tracked through the forest inventory process.

Given the importance of maintaining an efficient, transparent and robust regeneration assessment program, the forest manager and the Ministry form part of a quality control system that ensures that the public has confidence in the assessment and subsequent reporting of regeneration results. Forest managers hold responsibility to assess and report on regeneration of all harvested and regenerated areas in a self-compliance framework. As part of the quality control system, the Ministry provides oversight through a quality assurance check that ensures the forest managers' results are within an acceptable level of accuracy.

The Regeneration Assessment Program (RAP) Manual outlines the quality assurance procedure that the Ministry will undertake to assess whether the Ministry results are similar to the forest managers' reported results. The Manual focus is on the process and method the Ministry will use as a quality assurance check of the forest managers' results.

2.0 Regeneration Assessment Program Background and Objectives

Forest managers must assess and report the results of their regeneration efforts to confirm the establishment of regeneration within a specified timeframe, as outlined in the Silvicultural Ground Rules (SGRs) of the FMP. This assessment referred to as **establishment assessment** has replaced the former free-to-grow surveys. Regeneration standards defined in the SGRs provide a means to measure the level of achievement, determine whether a forest stand is on track to meet the management objective(s) and the future forest condition and indicate areas where improvement is needed.

In the boreal forest region, aerial reconnaissance is the most common assessment method used by the forest manager to measure regeneration results. These evaluations are ocular assessments conducted by experienced surveyors during low-altitude helicopter flights. This approach is a lower cost (per hectare) option than ground-based surveys and allows rapid assessment of inaccessible areas. This method is also used by some forest managers In the Great Lakes. St. Lawrence forest region on clearcut harvest areas. Uniform shelterwood harvest in both forest regions are typically assessed using intensive ground survey methods, however, more extensive, walkthrough estimates of regeneration within a stand are also used. Certainly, to an experienced eye, aerial ocular or a walk-through gives a general impression but whether that general impression translates into the necessary resolution needed to assess the detail of a regeneration standard has yet to be demonstrated. Both methods are largely unverified without the rigour of a formal evaluation. The one test for the aerial ocular method (White 2016) emphasized that caution needs to be used when implementing this method. In addition, comparison of results between the forest manager and the Ministry since 2001 where the Ministry has typically checked the forest manager regeneration assessments in the form of spot checks or a 10% audit of the areas submitted in the annual report, have shown that discrepancies are not uncommon. As a result, the Ministry will focus its efforts for the RAP on a quality check of the forest managers' assessment results using an intensive ground based field sampling approach.

The primary objectives for the regeneration assessment program are as follows:

1. **Validate** - Quality control of the forest manager establishment assessment results to provide confidence in the accuracy and precision of the data reported.
2. **Transparency** - Report and provide open access to results from the regeneration assessment program to the public, First Nations communities and all stakeholders of the Crown. As the Ontario government moves toward open data, the RAP program is set-up to share data collected through field assessments online.
3. **Due diligence and professional reliance** - To enable meaningful discussion which will help ensure the inputs into FMPs are accurate including silvicultural objectives and approaches, as well as modeling inputs (i.e., silviculture success rates, silvicultural treatments, regeneration standards, yield curves, etc.) [Lennon, 2016].

An ancillary objective for the regeneration assessment program is:

- **Enhance the knowledge of district forest practitioners** - The RAP provides the opportunity for district forester practitioners to gain experience and knowledge with silviculture practices implemented on their management unit. Experience gained in the field, 'boots on the ground', cannot be replaced by in office learning. This experience also lends to the credibility of district staff and helps put government staff on a level playing field with forest managers.

The establishment assessment method outlined in this manual has benefited from regeneration assessment procedures previously implemented throughout the province. Past procedures include the Well-spaced Free-growing (WSFG) Regeneration Assessment Procedure for Ontario used throughout the boreal forest (White et al. 2005); the Silviculture Treatment Assessment and Recording System (STARS) used in the Great Lakes St. Lawrence forest region since the early 2000's to approximately 2009 (Pinto et al. 2003); and the Site Occupancy Index and Silviculture Treatment Assessment and Recording System (SO_iSTARS; Smith et al. 2018). The field methodology presented here has combined elements from previous assessment methods for a streamlined approach. The ground-based assessment methodology is intended for even-aged silviculture systems, including both clearcut and uniform shelterwood. Differences between the clearcut and uniform shelterwood procedures will be laid out later in the manual, however, both procedures are based on similar concepts. These ground-based methods are intended to provide an accurate description of the dominant trees in the stand at the time of assessment, while providing the appropriate statistical reliability for stand level auditing.

3.0 Establishment Assessment Timelines

The series of actions associated with establishment assessments required by the forest manager and the Ministry are outlined in Figure 1. Relative timelines are also provided to demonstrate the distribution of work over a two-year timeframe. The requirements and timelines for the RAP are currently being revised, therefore, modifications to both the list of actions and timelines are anticipated. Figure 2 outlines some of the proposed changes previously discussed through the inception of the silviculture enhancement initiative. These changes offer improvements to the current RAP, however, there is still uncertainty related to the level of change that will follow and the associated timelines.

3.1 Current - Ministry Validation Timeline for Establishment Assessments

Note: Example displayed with dates for improved clarity.	Calendar Year								
	2019				2020	2021			
Establishment Assessment (EA) Related Action	**Jan. 1 - Mar. 31**	**Apr. 1 - June 30**	**July 1 - Sept. 30**	**Oct. 1 - Nov. 15**	**Jan. 1 - Nov. 15**	**Jan. 1 - Mar. 31**	**Apr. 1 - June 30**	**July 1 - Sept. 30**	**Oct. 1 - Nov. 15**
AWS - EA polygons identified									
EA polygons verified									
Establishment census									
Previous year (2018) establishment results submitted in Annual Report and data accepted									
Compile 2019 EA data for submission in 2020 Annual Report									
EA validation work planning for 2019 forest manager results									
Validate field sample of 2019 forest manager results									
Analyse and compare results for consistency; agree or disagree									
The Ministry provides feedback to forest manager; potential joint field inspection(s)									

* Currently there is no formal process written in policy to prohibit the submission of forest manager EA results in the Annual Report, despite potential discrepancies between the Ministry and the forest manager results. This process has to be worked out informally.

= Forest manager responsibility = Ministry responsibility

Figure 1. Current timeline for the Ministry validation of the forest manager's establishment assessment results.

3.2 Proposed - Ministry Validation Timeline for Establishment Assessments

Note: Example displayed with dates for improved clarity.	Calendar Year											
	2019				2020				2021		2022	
Establishment Assessment (EA) Related Action	**Jan. 1 - Mar. 31**	**Apr. 1 - June 30**	**July 1 - Sept. 30**	**Oct. 1 - Nov. 15**	**Jan. 1 - Mar. 31**	**Apr. 1 - June 30**	**July 1 - Sept. 30**	**Oct. 1 - Nov. 1**	**Apr. 1 - June 30**	**July 1 - Sept. 30**	**Jan. 1 - Mar. 31**	**July 1 - Sept. 30**
AWS - EA polygons identified												
EA polygons verified												
Establishment census												
Previous year (2018) establishment results submitted in Annual Report												
Compile 2019 EA data												
Share 2019 EA stratification and results with the Ministry												
EA validation work planning for 2019 forest manager results												
Validation field sample of 2019 forest manager results												
Analyse and compare results for consistency; agree or disagree												
The Ministry provides feedback to forest manager; potential joint field inspections												
Agreement between EA results = submit with Annual Report												
Disagreement between EA results = prohibit submission of results in Annual Report; joint field inspection(s) the following season, potential requirement for forest manager to re-do EAs												
If EAs are redone, forest manager shares results with the Ministry												
Ministry validates sample of re-submission												

= Forest manager responsibility = Ministry responsibility

Figure 2. Proposed timeline for the Ministry validation of the forest manager's establishment assessment results.

4.0 Establishment Assessment Procedure Outline

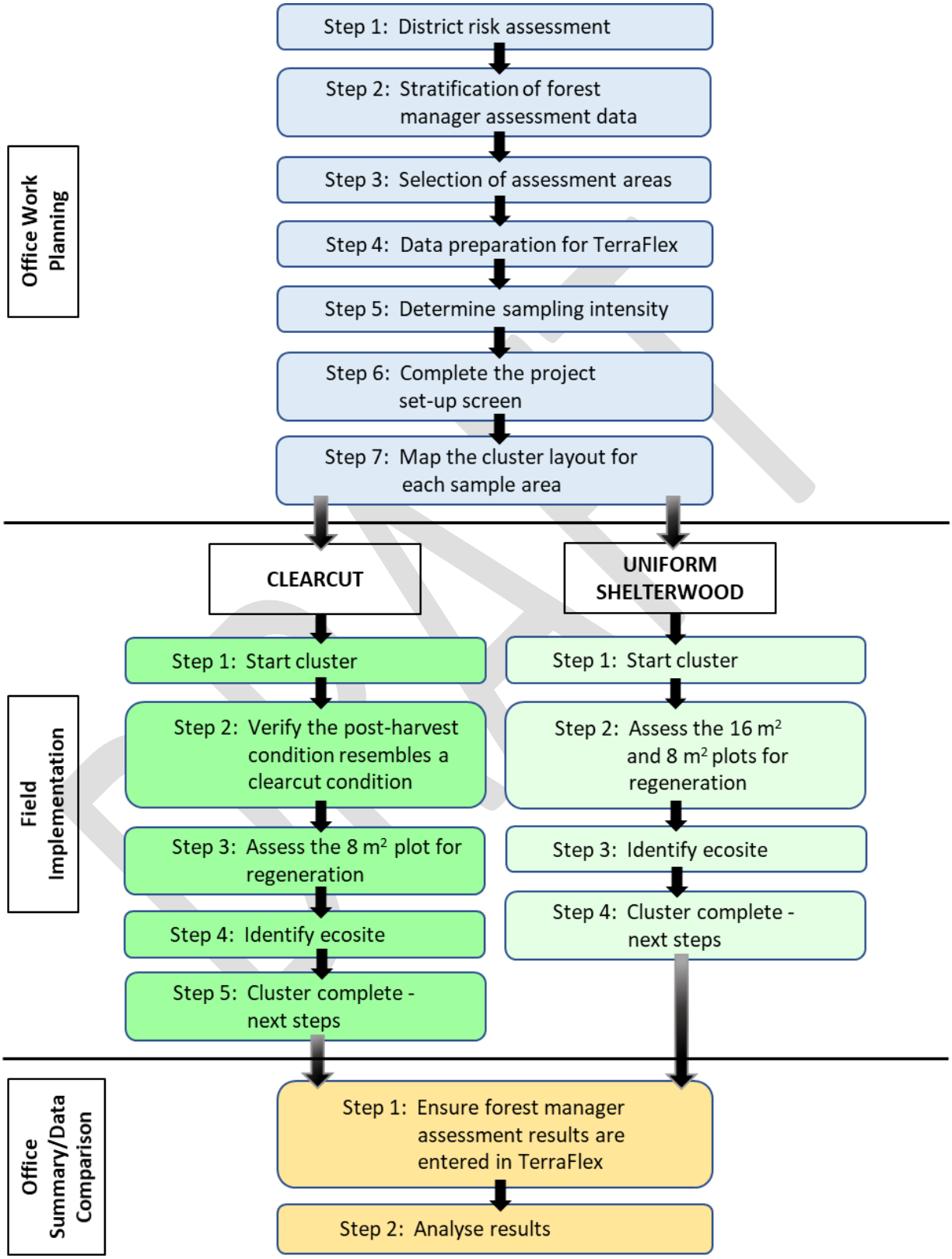


Figure 3. Establishment assessment procedure from start to finish.

5.0 Annual Preparation

Step 1 - District Risk Assessment

A risk assessment for each management unit is an important first step in determining the priority areas for conducting establishment assessments in any given year. The primary focus for high risk areas are forest units or silviculture ground rules (SGRs) where the Ministry field assessments often attain different results in comparison to the forest manager. Variation in assessment results may fall into three main categories:

a) **Site occupancy/stocking**: the difference in site occupancy (i.e., distribution of target trees) between the Ministry and the forest manager is consistently > 10% and the Ministry estimate is consistently less than the forest manager estimate;
b) **Species composition:** focusing on the target species, the species composition varies by > 10% or enough to result in a different forest unit call between the Ministry and the forest manager. It is not necessary to evaluate the differences in species for the entire species string.
c) **Effective density:** the number of trees growing in a stand (i.e., free growing trees) is significantly different in comparison between the Ministry and the forest manager results. Effective density is especially important in density regulated plantations targeting high yield and high product value. Focus on large differences, where the Ministry is consistently reporting lower effective density (e.g., >10% difference) in comparison to the forest manager, or where the differences reported result in a different yield (e.g., low vs. high yield or extensive vs. intensive yield).

When evaluating areas for risk, refer back to previous years' establishment (free-to-grow; FTG) assessment results (i.e., Silviculture Effectiveness Monitoring Core Task 1: Summary of the Ministry and forest manager FTG assessments). Highlight areas where forest units or specific SGRs have noticeable variation in site occupancy and species composition between the Ministry and the forest manager's results. When considering species, focus on notable differences in target species that define the forest unit. For example:

- Variation between combined conifer and hardwood species, leading to different forest unit calls (e.g., mixedwood vs. conifer dominated forest unit);
- Noticeable differences in combined black and white spruce in relation to balsam fir, whereby the Ministry results achieve a SF1 forest unit compared to the forest manager result of SP1;
- For the Great Lakes St. Lawrence forest region, also take note of areas showing differences in hardwood species versus white and red pine target species when

comparing the Ministry and forest manager results. Focus on large differences that result in shifts in forest unit or silviculture system (i.e., PWUS vs. PWST vs. MWUS forest units).

Other considerations for high risk areas could include forest units or treatments that have little to no data collected by the Ministry in the past.

Step 2 - Stratification of Forest Manager Assessment Data

Stratification of the forest manager's data is a critical step that must be completed prior to the selection of the Ministry assessment areas. This step is completed as a GIS exercise. The purpose of stratifying or grouping appropriate blocks (i.e., polygons) is as follows:

a) Ensure the Ministry is assessing the same area as the forest manager and not a subset of a larger block, and

b) Group areas that are homogenous in nature and likely to develop into the same future forest condition.

Stratification carried out by the forest manager is often a result of different treatments applied within the same block. For example, a block planted to upland spruce, SP1, may be split and submitted as three separate blocks if the middle portion was left to come back naturally to poplar and the two outer SP1 portions were no longer spatially attached. Assuming the forest manager assigned the same species composition and site occupancy to the two outer SP1 portions, the Ministry should assess these as one block, with one sampling design. In this SP1 example, the forest manager is typically treating and assigning attributes as one block, therefore, the Ministry should be assessing this entire area. In another example, the forest manager may divide a block intersected by a primary road (see Figure 4). Again, if the species composition and site occupancy are the same, the Ministry should be considering and assessing such divided areas as one block.

Figure 4. Two adjacent blocks with the same species composition and site occupancy on opposite sides of a primary road, should be merged to form one block.

the Ministry stratification is limited to blocks in relative close proximity to one another, in addition to having identical attributes.

In addition to ensuring a 1:1 comparison to the forest manager results, this process typically reduces the number of smaller blocks, which should help minimize the Ministry workload in the field. Refer to *RAP Preliminary Block Stratification GIS help v2*, located on the RAP SharePoint website, for step by step instructions for the stratification process.

Step 3 - Selection of Assessment Areas

The Ministry is required to conduct a 10% sample of the establishment assessments submitted by the forest manager from the most recent Annual Report (AR). Note, this process may change in the future, whereby the Ministry is assessing the forest manager data prior to submission in the AR; however, development of this direction is still ongoing with policy division. Selection of sample areas will be carried out using random sampling with probability proportional to size. With this type of sampling, areas are weighted, and the probability of an area being selected is determined by its relative size; larger areas or blocks have a greater probability of being selected. The random weighted selection tool provided can be used to complete this process.

When selecting areas for assessment, remember to focus on priority areas first (i.e., forest units or SGRs previously identified as high risk). If the assessment data submitted contains < 10% area in high risk, all high risk areas will be sampled; the remaining sample area will be randomly selected from the lower priority areas. For example, consider a district that has calculated their 10% sample area to be 500 ha and has identified SP1 plant SGRs as high risk. If the forest manager submitted 300 ha treated with SP1 plant SGR, all 300 ha would be included in the sample area. The remaining 200 ha would be randomly selected from all other areas submitted. Where high risk areas make up > 10% of the sample area, conduct the random selection on the high risk areas only. The random weighted selection tool provided can be used to complete this process.

In addition to implementing the above selection process, the Ministry should aim for a minimum block size or assessment area of ≥ 8 ha. This size is based on inventory guidelines contained in the Forest Information Manual, Forest Resource Inventory Technical Specifications 2009, for delineating productive forest land. Although forest management activities such as harvest and renewal can create polygons < 8 ha in size, this minimum size is more practical for the Ministry assessment purposes. With the sampling intensity required to obtain an adequate sample size in any given area, it is difficult to fit the required number of clusters in these smaller blocks. In the situation where a significant portion of the forest manager submission is < 8 ha in size, contact the regional forest science specialists for advice. A *random weighted selection tool* is available on the RAP SharePoint website.

Step 4 - Data Preparation for TerraFlex

After the selection of assessment areas is complete, create a geodatabase in ArcGIS that includes all project area (i.e., assessment area) boundaries, using the *geodatabase (gdb) template* located on the RAP SharePoint website. Refer to the *how2use project boundary template 20210401* document on the RAP SharePoint website for step by step instructions. Once complete, place the geodatabase on the regional share drive in the appropriate folder for your district; refer to the RAP SharePoint website for the appropriate path for this folder. Notify the appropriate regional resource analyst with the Regional Information Analysis Unit (RIAU) once the geodatabase has been placed on the regional share drive.

Each district project boundary file will be uploaded to TerraFlex. Upon completion of field assessments, an automated report will be generated to display the results.

Step 5 - Determine Sample Size

The sample size required for assessing the forest manager establishment assessments is provided in Table 1. The minimum sample size for a stand is 30 clusters. Although there are 8 plots included in each cluster, these plots are not independent samples. As such, the cluster is considered the primary unit for sampling and statistical and sampling considerations.

The objective of determining a sample size is to achieve a large enough sample to detect meaningful and significant differences between the forest manager and the Ministry results. The statistical procedures and sampling intensity for the RAP are still under investigation. Any changes to sampling intensity will be relayed to the districts.

Table 1. Sampling intensity by stand area.

Stand Area (ha)	Number of Clusters
8 to 30	30 (minimum)
≥ 30 to ≤ 60	1 cluster/ha
> 60	30 + 1 cluster/2 ha of the entire area (e.g., 70 ha stand = 30 clusters + 70/2 clusters, total of 65 clusters)

Step 6 - Map the cluster layout for each sample area

The cluster locations for each sample area should be mapped using GIS prior to field sampling. The pattern of cluster layout can follow a grid-like pattern with equal distance between plots or random placement of plots within the sample area. Where available, use aerial photography as a backdrop for the sample area to assist with layout. Observe the harvesting pattern in the aerial photos and number sequential clusters with the direction of travel between clusters perpendicular to harvesting corridors. Once the cluster layout is complete, prepare and print a hard copy map to help navigate in the field. A digital map using the Avenza Maps application must also be prepared and uploaded to the tablet prior to field assessment, as Avenza Maps works in combination with TerraFlex.

Step 7 - Complete the Project set-up screen

At this point, all project boundary files should be uploaded to TerraFlex. Check to ensure all projects are displayed in TerraFlex. Before heading to the field, fill out the *initial set-up screen* that lists the *Regeneration Assessment Details* for the stands to be surveyed.

6.0 Definitions

Definitions referred to throughout the manual and pertaining to establishment assessment are listed in the table below.

Table 2. Common terms related to establishment assessment.

Terminology	Definition
Clearcut	Most of the overstory trees are removed over a short period of time to create a fully exposed environment for the development of an even-aged future stand. Regeneration (and the release of advanced regeneration) is established in >70% full sunlight (OMNRF 2015).
Shelterwood	Most of the overstory trees are removed in a series of two or more harvests. The intent is to establish and shelter regeneration under a residual canopy, releasing the regeneration after the final harvest to create an even-aged future stand. Regeneration is established in 30 - 70% full sunlight (OMNRF 2015).
Target species	Target species sometimes referred to as crop species, are the key tree species outlined to meet the silvicultural objective and for renewing the stand to a specified forest unit. The 'regeneration standards' section of the SGR identifies the target species. These should be known prior to starting the establishment assessment. Older SGRs may identify acceptable species in addition to targets; these are not to be confused.
Site occupancy	Site occupancy is a measure of target tree spatial dispersion in a given area at the time of assessment. Where the density of a stand is not strictly controlled (i.e. non-density regulated) spatial dispersion is based on an 8 m^2 plot. During an establishment assessment, the presence or absence of a tree is noted (among other things) for each plot. To be occupied, there must be at least one free growing tree in a plot. Percent (%) site occupancy represents the % of the area growing trees and is an indicator of how well the stand has regenerated. Target site occupancy (referred to as target stocking in older SGRs), is specified in the regeneration standards of the SGR, either as a % or a number of well-distributed trees/hectare relative to the size of the growing space (i.e., plot size) being assessed. Target site occupancy aims for the appropriate dispersion of target species throughout a given area to meet the future forest objective.

Effective density	Effective density refers to the number of trees (i.e., all species) that have a high probability of successfully competing for the dominant and co-dominant canopy positions through to maturity (White et al. 2015). Trees contributing to effective density must be above the minimum height requirement. A target for effective density is specified in the SGR and varies depending on the objective of the future forest. Generally, a target effective density at establishment should be in the range of ≥ 2000 stems/ha for conifers and up to 10,000 stems/ha for poplar.
Free growing	Free growing refers to a tree that is likely to survive and grow to maturity. Free growing is also referred to as free of competition, meaning the tree is able to survive and dominate its environment despite the surrounding competition; however, competition can still impact the overall growth rate and vigour of the tree. Free growing is determined by evaluating a tree in relation to the surrounding vegetation within the assessment zone.
Assessment zone	An assessment zone is a defined area to assess the competition surrounding a tree; the competing vegetation in the assessment zone is evaluated to determine whether it is impacting a trees overall growth and survival. In the clearcut silviculture system the assessment zone is a 1.2 m radius cylinder **around** the tree being assessed; in the shelterwood silviculture system this zone is a 1.2 m radius cylinder **above** the tree being assessed.
Cluster	A sampling unit that contains a string of eight circular plots used to assess the establishment of regeneration. The plot size in the cluster varies depending on the silviculture system being assessed. Clusters in the clearcut system use 8 m^2 circular plots, compared to the nested 16 m^2 and 8 m^2 circular plots used in the shelterwood system.
Plot	An individual unit of measure within a larger sampling unit (i.e., cluster), used to assess the establishment of regeneration.
Quadrant	A quadrant is used to assess competing vegetation in the assessment zone. The circular zone is divided into four equal parts to assess the impact of competing vegetation on the tree being assessed.
Minimum height	The minimum height required for a tree species to be counted at establishment. A minimum height is specified in the regeneration standards of the SGRs. It is not uncommon to find different minimum height requirements for coniferous and deciduous species (e.g., minimum height for poplar = 2 m, minimum height for spruce species = 1 m). Establishing different minimum height requirements among species can be problematic and potentially lead to misinformation. As a general rule, the Ministry will follow one minimum height, 1 m for all species.
Inter-tree spacing	The minimum distance required between trees, to provide adequate growing space for the tree to survive and form the future canopy.

Healthy tree	A healthy tree is one that has a high probability of surviving to form part of the mature forest canopy. Trees suffering temporary defects (e.g., insect attack) but are otherwise healthy may be tallied as free growing. Trees with a broken leader but healthy lateral branches can still be considered free growing for the purpose of this survey (White 2015).
Residual tree	Trees remaining in a stand after harvest that are > 10 cm in diameter. In the clearcut silviculture system, residuals are often left as scattered individual wildlife trees throughout the area, or in clumps known as residual patches. In the uniform shelterwood silviculture system residual trees are retained at varying retention levels to shelter the developing regeneration under the mature canopy. Note, the 10 cm diameter threshold may vary in the shelterwood silviculture system, where white and red pine poles > 10 cm in diameter are retained to form part of the dominant future forest canopy.
Advanced regeneration	Young trees that have established naturally under an existing canopy that have the potential to become part of the future forest. Advanced regeneration must show evidence of good vigour to be tallied. This is a subjective call, but a factor that must be considered carefully. Examples of advanced regeneration with low vigour that should not be tallied include: advanced black spruce regeneration with stunted terminal growth (i.e., no signs of responding to release post-harvest); severe yellowing of the tree needles uniformly throughout the tree; trees with a severe lean which makes them susceptible to heavy snow loads and windthrow.
Crown closure	The proportion of ground area covered by the overhead tree crowns of all trees in a forest. Crown closure is often expressed as a percentage of the total area.
Basal area	The cross-sectional area of a tree at breast height (1.3 m above ground level). On a stand or forest level, basal area refers to the cross-sectional area of all trees expressed in m^2/ha. Basal area is an important metric in forestry often used to measure stand density, stand volume and growth.

7.0 Establishment Assessment Background Information - Clearcut Silviculture System

7.1 Cluster Layout

A sample cluster contains a string of eight, 8 m^2 circular plots with a 1.6 m radius and each circular plot at a distance of 4.52 m between plot centres (2 x 2.26 m; Figure 5). In efforts to

align with systematic random sampling, the layout of each cluster should follow the direction of travel toward the next cluster.

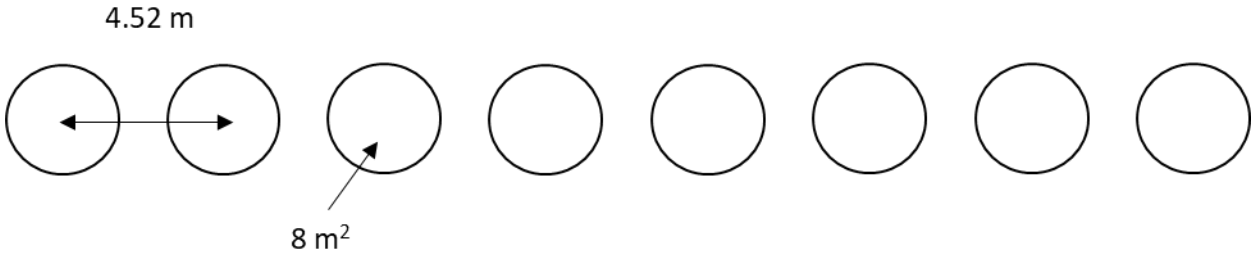


Figure 5. A cluster consists of a string of 8 circular plots, each plot measuring 8 m^2 and the centre of clusters 4.52 m apart.

7.2 Stand Attributes Measured

Stand attributes recorded in each plot 8 m^2 plot will focus on trees that are free growing. The tallest tree(s) in each plot will be considered first when assessing competition to determine if the tree is free growing. Subsequent trees assessed within each plot must be ≥ 1.2 m from other trees deemed free growing to be tallied; this is the minimum horizontal inter-tree distance between two trees (i.e., the distance between the main stem of the trees). Free growing trees at establishment have the greatest probability of forming the dominant and codominant species composition at crown closure. Long term monitoring across a range of forest types is required to confirm this hypothesis as well as future testing of the competition rules.

A stand with one tree tallied for every 8 m^2 plot equals 100% site occupancy or 1250 well distributed stems/ha based on an 8 m^2 plot. Site occupancy targets listed under the regeneration standards in an SGR are typically associated with target/crop trees (or acceptable trees with older SGRs). The additional trees tallied in each plot contribute toward effective density. Site occupancy and effective density work together to help characterize the growing conditions of the regenerating trees.

7.3 Field Equipment

Conduct an equipment check before heading to the field. The following will be required to carry out the establishment assessment:

- Field tablet (ideally with GPS capabilities and a camera); a digital map should be uploaded on the tablet with pre-determined clusters before heading to the field.

- Paper map with pre-numbered clusters identified. Aerial photograph of the stand is helpful.
- Compass and GPS unit (if tablet does not have GPS capabilities); extra batteries.
- SGR of the area to be assessed; background information or history of the stand/block should be known before starting the assessment.
- Plot measurement stick, 2.26 m in length with key markings to clearly indicate distances and heights used for the assessment (Figure 6). Markings should include 1.0 m (i.e., minimum height for a tree to be considered free growing), 1.2 m (i.e., minimum inter-tree distance) and 1.6 m (i.e., radius of 8 m^2 plot).
- Flagging tape to mark the plot centre of the first plot in every cluster.
- Permanent marker
- Appropriate personal protective equipment (PPE)
- Prism (basal area factor 2)
- Clinometer (for measuring slope) and horizontal limiting distance table
- Diameter tape
- Measuring tape (or logger's tape); 20m minimum

*Optional but may be required for assessing crown closure and measuring basal area.

Plot measurement stick, 2.26 m in length with key markings.

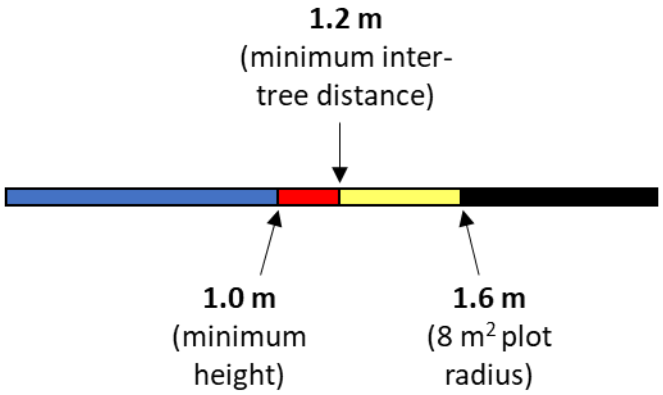


Figure 6. Plot measurement stick with key markings outlined to help with establishment assessments in clearcut harvest areas.

8.0 Establishment Assessment Process – Clearcut Silviculture System

Refer to Appendix 1 and 2 for the Field Key – Clearcut Free Growing Assessment Procedure.

Step 1 - Start cluster

a) Locate starting point or first cluster using GPS. Mark the centre of plot 1 with flagging tape and write the cluster number on the tape. Attach flagging tape to the closest tree to plot centre, on a sturdy branch.

b) Note the direction of travel to layout plots within the cluster. Plots should be established in the direction of travel toward the next cluster.

c) **Important:** take a photograph facing the direction of travel along the cluster to help characterize the site for future reference.

d) Determine the plot perimeter; start by marking the plot centre on the ground either with a piece of flagging tape or a boot screef. Using the plot measuring stick, extend the stick from plot centre outward 1.6 m; pivot around plot centre in a circular motion. Determine which trees are in the plot (see Figure 7). To be considered 'in', a tree must have at least 1/2 the diameter of the main stem inside the plot (see Figure 5).

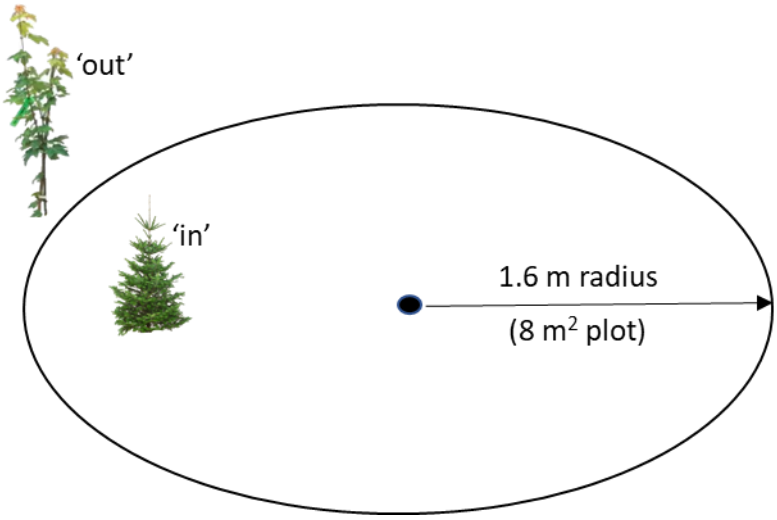


Figure 7. Each 8 m^2 plot has a radius of 1.6 m which is used to determine if trees are 'in' or 'out' when assessing if a tree is free of competition.

Step 2 - Verify the post-harvest condition resembles a clearcut condition

- The first consideration is crown closure. A clearcut is an even-aged future stand with regeneration established in >70% full sunlight (OMNR 2015). Assess whether the plot is

overtopped by residual trees remaining post-harvest with crown closure >30%; Appendix 5 provides more information on determining crown closure.

- If the answer is 'yes', this is not a clearcut condition and the regeneration is not free growing. Do not drop or move plots that have >30% crown closure (this includes a cluster or plot that lands in a residual patch); simply record the reason for being unoccupied with regeneration.
- If the answer is 'no', proceed to step 3.

Step 3 - Assess 8 m^2 plot for regeneration

a) Trees must be above minimum height to be considered free growing. Minimum height is included under the regeneration standards of the SGR; however, a general rule is to consider 1 m the minimum height for all species in the plot.
   - Trees must be healthy to be counted as regeneration.
   - Do not consider residual trees as regeneration (trees left behind after the harvest that have little potential of forming part of the dominant canopy in the future stand).
   - Advanced regeneration must show moderate to high vigour to be tallied as regeneration.

Assess tree to determine if it is free growing:

b) Determine the number of trees within the plot that are free growing (i.e., free of competition). Start with the tallest tree; when two trees are the same height, pick the target tree (refer to SGR for target species, listed under regeneration standards).

c) Identify the tree species being assessed. Appendix 8 provides a list of tree species and corresponding codes.

d) Assess whether the tree is free growing based on the concept of an **assessment zone.** This zone is a 1.2 m radius cylinder around the tree being assessed. The tree being assessed is the centre point of the cylinder. The assessment zone may extend outside the 8 m^2 plot for trees located close to the perimeter of the plot (Figure 8).

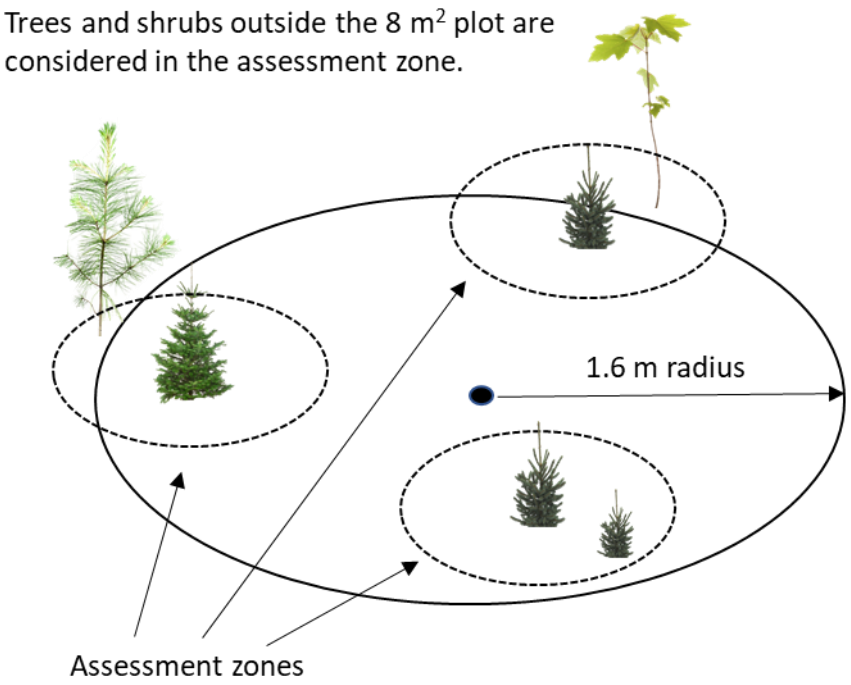


Figure 8. Assessment zone is a 1.2 m radius cylinder or zone around any tree being assessed to determine if it is free growing. The tree being assessed is the central pivot point of the zone. Depending on the location of the tree(s) being evaluated, the assessment zone may extend outside the 8 m^2 plot.

Trees as well as woody shrubs and brush will be considered when assessing competition within the assessment zone. Due to the different rate of growth between deciduous and coniferous tree species, the type of competition assessment will be dependent on the tree species being assessed. Proceed to (d) for deciduous trees or (e) for coniferous trees being assessed.

e) Competition assessment for deciduous trees:
   - Is the tallest deciduous tree ≥ the height of the competing tree(s) and woody shrubs or brush (Figure 9)?
     - If the answer is 'yes', the tree is considered free growing.
     - If the answer is 'no', the tree is considered <u>not</u> free growing.

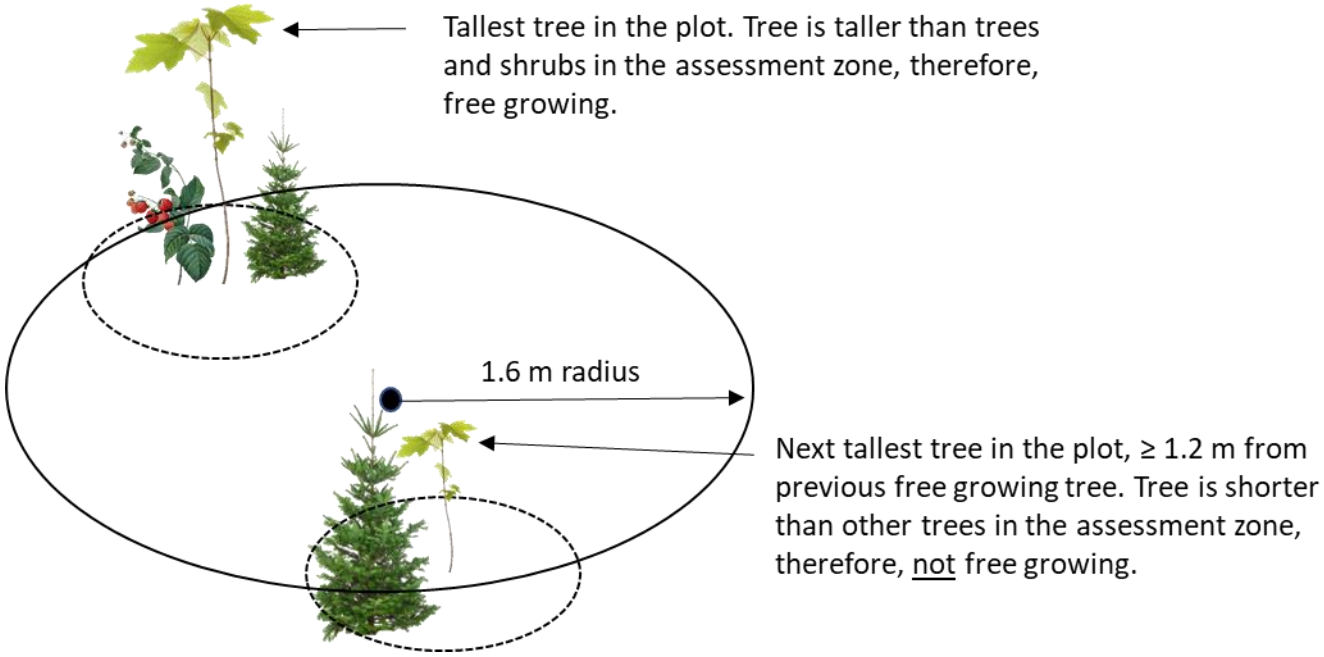


Figure 9. Assessing each plot for regeneration begins with identifying the tallest tree in the plot and assessing competition within the assessment zone. Remember the assessment zone may extend beyond the 8 m^2 plot, so there may be competition that is taller than the 'tallest' tree identified inside the plot.

f) Competition assessment for coniferous trees:
   - Is the tallest coniferous tree ≥ the height of deciduous tree(s)?
     - If the answer is 'no', the tree is considered not free growing.
     - If the answer is 'yes', proceed to the next step in the assessment.
   - Is the tallest coniferous tree ≥ the height of other conifer trees?
     - If the answer is 'no', the tree is considered not free growing.

- If the answer is 'yes', proceed to the shrub and brush competition assessment to determine if the shrubs and/or brush are deemed competition.

Shrub and brush competition assessment:

This procedure is only considered within the 'assessment zone'. To be considered competition, the stem(s) of the shrub or brush must be within the zone.

- Is the tallest tree ≥ 2.5 m?
  - If the answer is 'yes' there is no shrub or brush competition.
  - If the answer is 'no' proceed to the next step in the shrub and brush assessment.
- Within the assessment zone, is the tallest tree ≥ 1.5 m and the height of all non-*Rubus* (e.g., not raspberry or blackberry) shrubs?
  - If the answer is 'yes' there is no shrub or brush competition.
  - If the answer is 'no' proceed to the next step in the shrub and brush assessment.
- Is the tallest tree ≥ the height of shrub or brush competition?
  - If the answer is 'yes' there is no shrub or brush competition.
  - If the answer is 'no' the shrub or brush species present are deemed competition.

  - Once it is determined there is shrub or brush competition, assess the number of quadrants occupied by shrub or brush to determine if the tree is free growing (Figure 10). To do this, divide the assessment zone or cylinder into four equal quadrants (i.e., divide the zone into quadrants visually using the plot measuring stick). Try to minimize the number of quadrants with shrub or brush by rotating the position of the quadrants. Note, the stem(s) of the shrub or brush must be rooted within the assessment zone to count as competition.

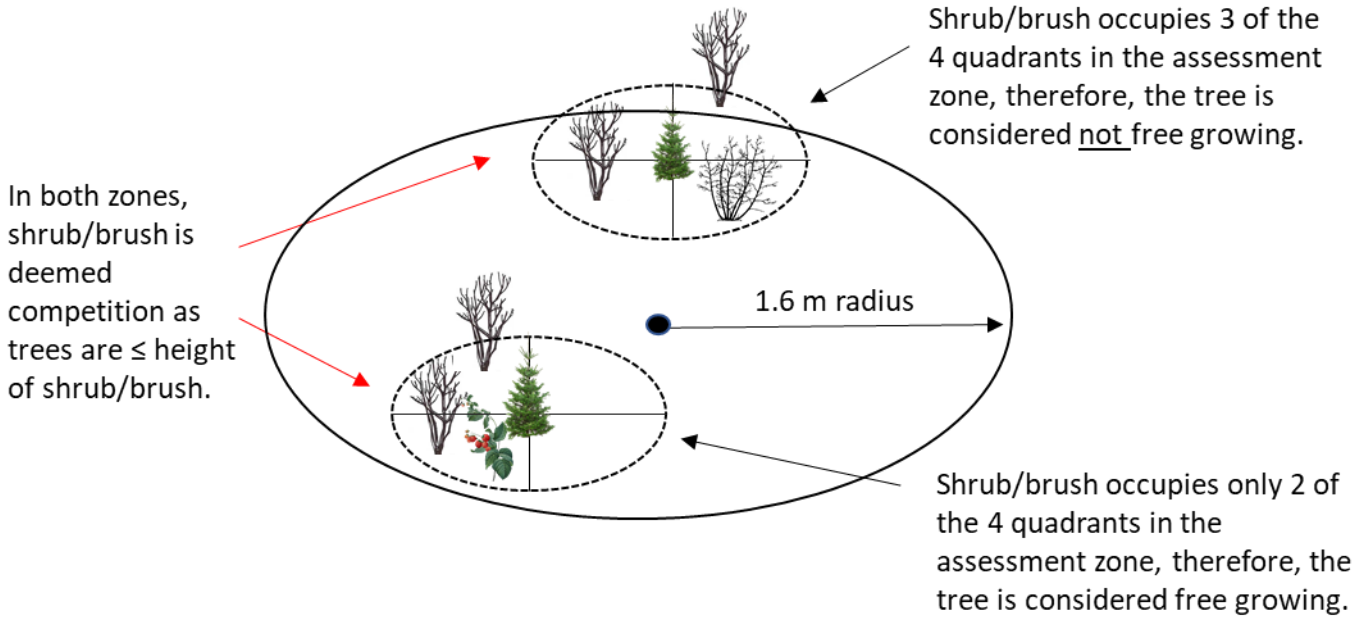


Figure 10. The quadrant assessment is specific to assessing shrub and brush competition within the 1.2 m radius assessment zone surrounding the tree being assessed. Where > 2 quadrants are occupied by shrub or brush competition, the tree being assessed is not free growing.

- Is there shrub or brush competition in > 2 quadrants?
  - If the answer is 'yes', the tree is considered not free growing.
  - If the answer is 'no', the tree is considered free growing.

g) After completing the assessment of competition for the first tree, move on to the next tallest tree in the plot that is ≥ 1.2 m from other trees tallied. Note, it is possible to have up to 3 trees tallied/plot, free of competition if trees are spaced around the perimeter of the plot (see Figure 11).

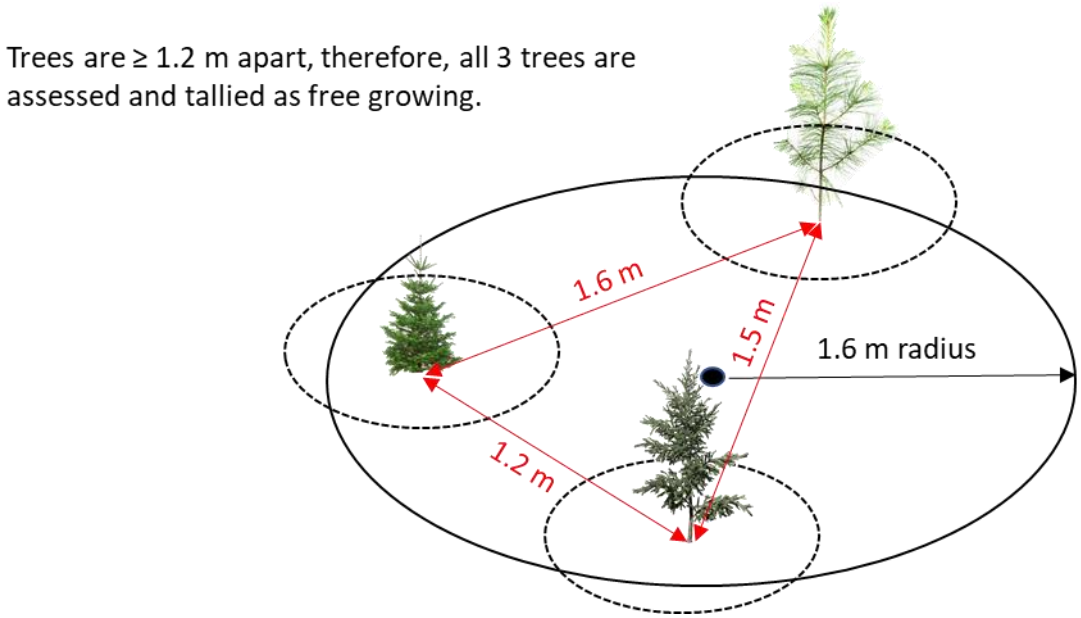


Figure 11. A maximum of 3 trees can be counted as free of competition per plot, if they are spaced accordingly around the perimeter of the 8 m^2 plot. Note, the minimum inter-tree spacing between trees is 1.2 m (i.e., distance between the main stem of the trees).

h) If there is no regeneration in the plot (i.e., 'unoccupied'), record the reason (dropdown provided in TerraFlex application); barren, shrubs, herbaceous or grass cover, rock, wet, slash, ruts, landing, skid trail, road, not free-growing (FG), crown closure (CC) > 30%. Documenting the reasons for unoccupied plots provides important insight for stands with low site occupancy.

i) After completing plot 1, move on to plots 2 through 8, following the same process as above (i.e., step 1 through step 3). Use the plot measuring stick to ensure the proper distance between plots. With the measuring stick extended from plot centre in the direction of travel toward the next cluster, flip the stick once to move to the centre of the next 8 m^2 plot (Figure 12).

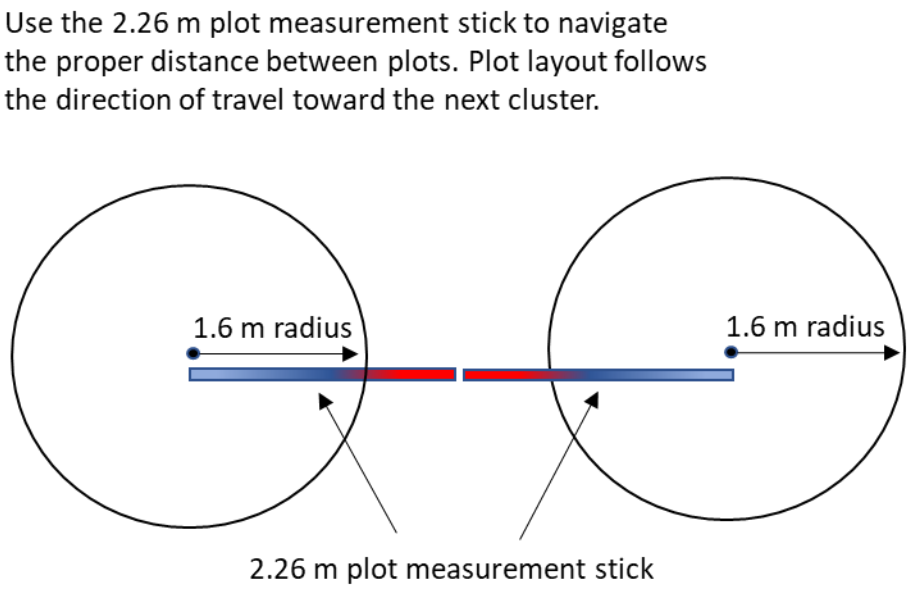


Figure 12. Use the 2.26 m plot measuring stick to navigate between plots to ensure plots are equally spaced. The distance between plot centres is twice the length of the plot measuring stick.

Step 4 - Identify ecosite

- Identify and record the soil moisture and nutrient regime at the end of each cluster (after plot 8). Refer to Appendix 7 for more information on ecosite and how to identify.

Step 5 - Complete cluster – next steps

- Proceed to the next cluster and start back at step 1. If this is the last cluster for the project, save field your work and sync the project in TerraFlex to upload project to the cloud.

9.0 Establishment Assessment Background Information - Uniform Shelterwood Silviculture System

9.1 Cluster Layout

A sample cluster contains a string of eight circular plots. Each plot consists of a 16 m^2 plot, with an 8 m^2 plot nested within. The 16 m^2 plot with a radius of 2.26 m is used to tally larger, pole size regeneration, > 6 m in height; however, the 8 m^2 plot with a radius of 1.6 m is intended to capture smaller sized regeneration, greater than minimum height (e.g., 1 m) and ≤ 6 m in height. The 16 m^2 plots are laid out adjacent to one another, with a distance of 4.52 m between plot centres (2 x 2.26 m; Figure 13). In efforts to align with systematic random

sampling, the layout of each cluster should follow the direction of travel toward the next cluster.

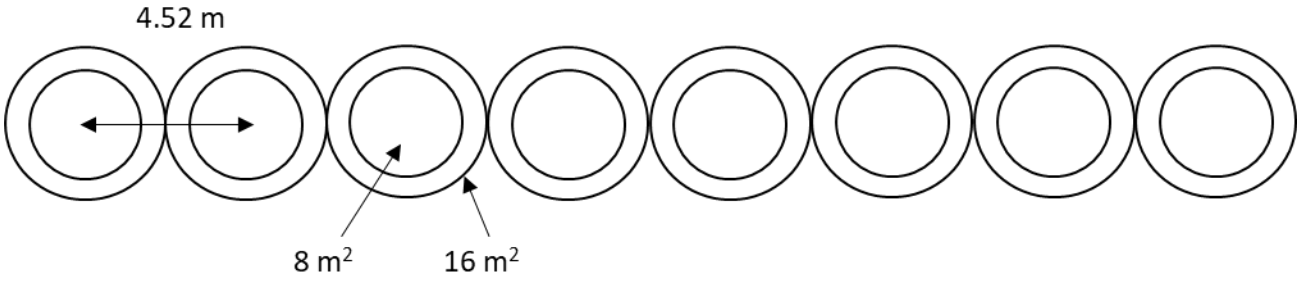


Figure 13. A cluster consists of a string of 8 circular plots. Each nested plot contains an outer 16 m^2 plot and a smaller 8 m^2 plot.

9.2 Stand Attributes Recorded

Stand attributes recorded in each nested 16 m^2 and 8 m^2 plot will concentrate on trees that are free growing. The 16 m^2 plot will be considered first, focusing on the tallest tree(s) > 6 m in height to determine whether the tree is free growing. Subsequent trees assessed within each plot must be ≥ 1.2 m from other trees deemed free growing to be tallied; this is the minimum horizontal inter-tree distance between two trees (i.e., the distance between the main stem of the trees). After considering trees in the 16 m^2 plot, trees over minimum height and ≤ 6 m in height will be assessed to determine whether the tree is free growing. More than 1 tree can be tallied in the 8 m^2 plot provided it is ≥ 1.2 m from other free growing trees. Free growing trees at establishment have the greatest probability of forming the dominant and codominant species composition at crown closure. Long term monitoring across a range of forest types is required to confirm this hypothesis as well as future testing of the competition rules.

A stand with one tree tallied for every plot equals 100% site occupancy or 1250 well distributed stems/ha based on an 8 m^2 plot. Trees recorded in the 16 m^2 plot count towards site occupancy based on an 8 m^2 plot as the larger tree can effectively occupy both plots. Site occupancy targets listed under the regeneration standards in an SGR are typically associated with target trees (or acceptable trees with older SGRs). The additional trees tallied in each plot contribute toward effective density; site occupancy and effective density work together to help characterize the growing conditions of the regenerating trees.

9.3 Field Equipment

Conduct an equipment check before heading to the field; the following will be required to carry out the establishment assessment:

- Field tablet (ideally with GPS capabilities and a camera); a digital map should be uploaded on the tablet with pre-determined clusters before heading to the field.
- Paper map with pre-numbered clusters identified. Aerial photograph of the stand is helpful.
- Compass and GPS unit (if tablet does not have GPS capabilities); extra batteries.
- SGR of the area to be assessed; background information or history of the stand/block should be known before starting the assessment.
- Plot measuring stick 2.26 m in length with key markings to clearly indicate distances and heights used for the assessment (Figure 14). Markings should include 1.0 m (i.e., minimum height for a tree to be considered free of competition), 1.2 m (i.e., minimum distance between trees) and 1.6 m (i.e., radius of 8 m^2 plot.
- Flagging tape to mark the plot centre of the first plot in every cluster.
- Permanent marker
- Prism (basal area factor 2)
- Appropriate personal protective equipment (PPE)

Plot measurement stick, 2.26 m in length with key markings.

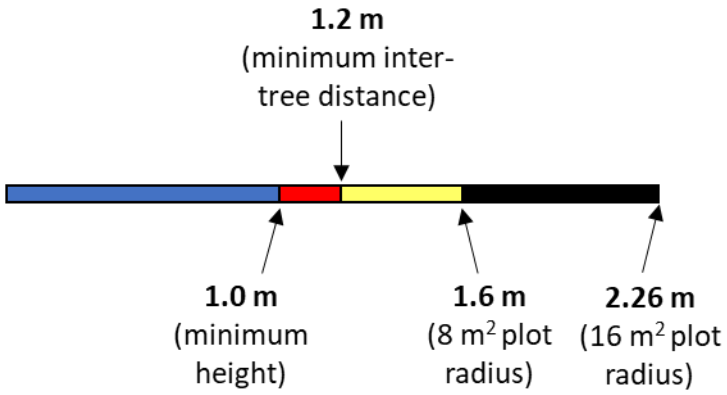


Figure 14. Plot measurement stick with key markings outlined to help with establishment assessments in uniform shelterwood harvest areas.

10.0 Establishment Assessment Process - Uniform Shelterwood Silviculture System

Refer to Appendix 3 and 4 for the Field Key - Uniform Shelterwood Free Growing Assessment Procedure.

Step 1 - Start cluster

a) Locate starting point or first cluster using GPS. Mark the centre of plot 1 with flagging tape and write the cluster number on the tape. Attach flagging tape to the closest tree to plot centre, on a sturdy branch.

b) Note the direction of travel to layout plots within the cluster. Plots should be established in the direction of travel toward the next cluster.

c) **Important:** take a photograph facing the direction of travel along the cluster to help characterize the site for future reference.

d) Determine the plot perimeter; start by marking the plot centre on the ground either with a piece of flagging tape or a boot screef. Start with the 16 m^2 plot. Using the plot measurement stick, extend the stick from plot centre outward 2.26 m (the full length of the stick); pivot around plot centre in a circular motion. Trees must be > 6 m in height to be considered (see Figure 2). To be counted 'in', a tree must have at least half the diameter of the main stem inside the plot.

e) After assessing trees in the 16 m^2 plot, move on to assessing trees in the inner 8 m^2 plot. Using the plot measurement stick, extend the stick from plot centre outward 1.6 m; pivot around plot centre in a circular motion. Trees in the 8 m^2 plot must be > minimum height and ≤ 6 m in height to be considered (see Figure 15).

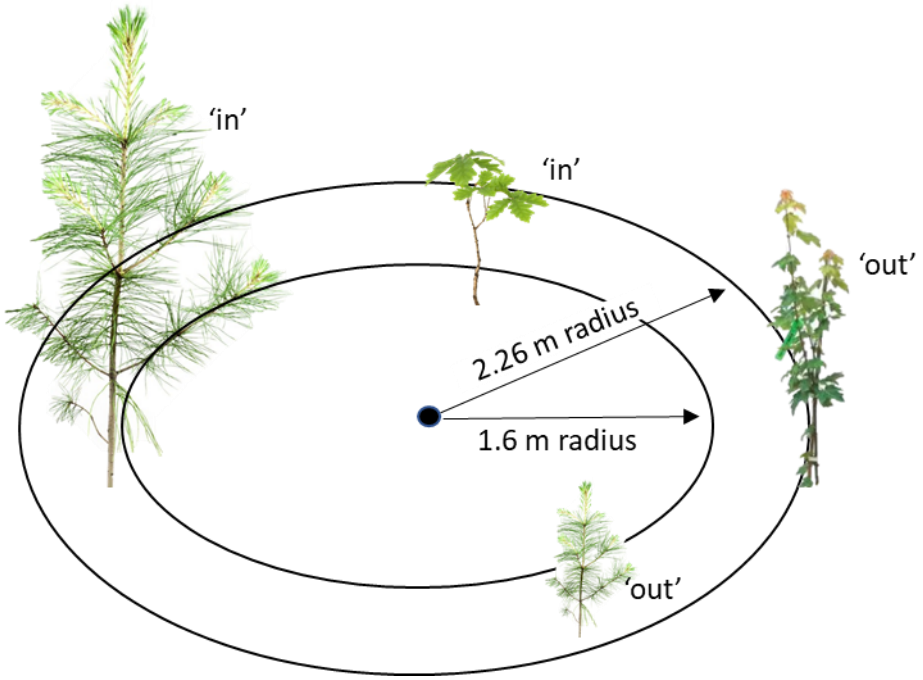


Figure 15. Trees in the 16 m^2 plot must be > 6 m in height to be counted as 'in'. Trees in the 8 m^2 plot must be > minimum height and ≤ 6 m in height to be counted as 'in'. Note, at least half the diameter of the main stem must be inside the plot to considered in.

Step 2 - Assess 16 m^2 and 8 m^2 plots for regeneration

- Trees must be young and healthy to be counted as regeneration. Characteristics of the bark often provide clues for the age of the tree. For example, a young white pine typically has smooth, thin, greyish-green bark; in comparison an older suppressed white pine in the understory typically has bark with rough, wide ridges grayish-brown in colour.

Assess tree to determine if it is free growing:

a) Start the assessment of regeneration in the 16 m^2 plot.

b) Determine the number of trees within the plot that are free growing (i.e., free of competition). Start with the tallest tree; when two trees are the same height, pick the target tree (refer to SGR for target species, listed under regeneration standards).

c) Identify the tree species being assessed. Appendix 8 provides a list of tree species and corresponding codes.

d) Assess whether the tree is free growing based on the concept of an **assessment zone.** The assessment zone is a 1.2 m radius cylinder extending 2 m above the top of the

tree. The tree being assessed is the centre point of the cylinder. Depending on the location of the tree(s) being evaluated, the assessment zone may extend outside the 16 m^2 plot (Figure 16).

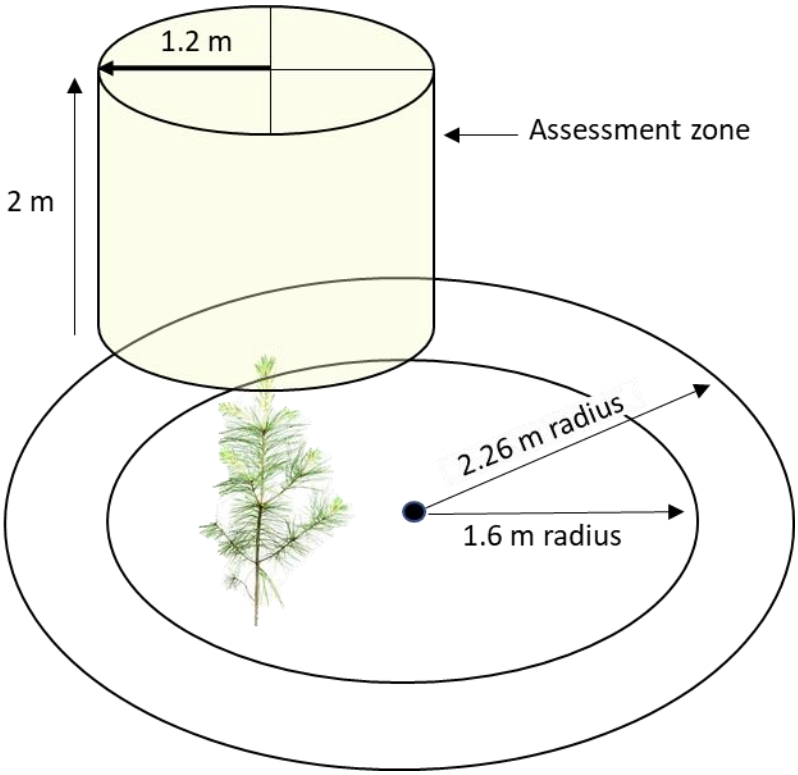


Figure 16. The assessment zone is a 1.2 m radius cylinder or zone above the tree, used to determine if the tree is free growing. The tree being assessed is the central pivot point of the zone. The zone is placed at the tip of the terminal shoot, extending 2 m above the tree, with a radius of 1.2 m. The cylinder is divided into four quadrants; a quadrant is considered occupied when foliage or branches from competing trees are present in any part of the quadrant.

- Is the tree being assessed ≥ the height of the competing tree(s) (Figure 17)?
  - If the answer is 'yes', the tree is considered free growing.
  - If the answer is 'no', proceed to the **shade tolerance table** (see Table 3) to help determine whether the tree is free growing.

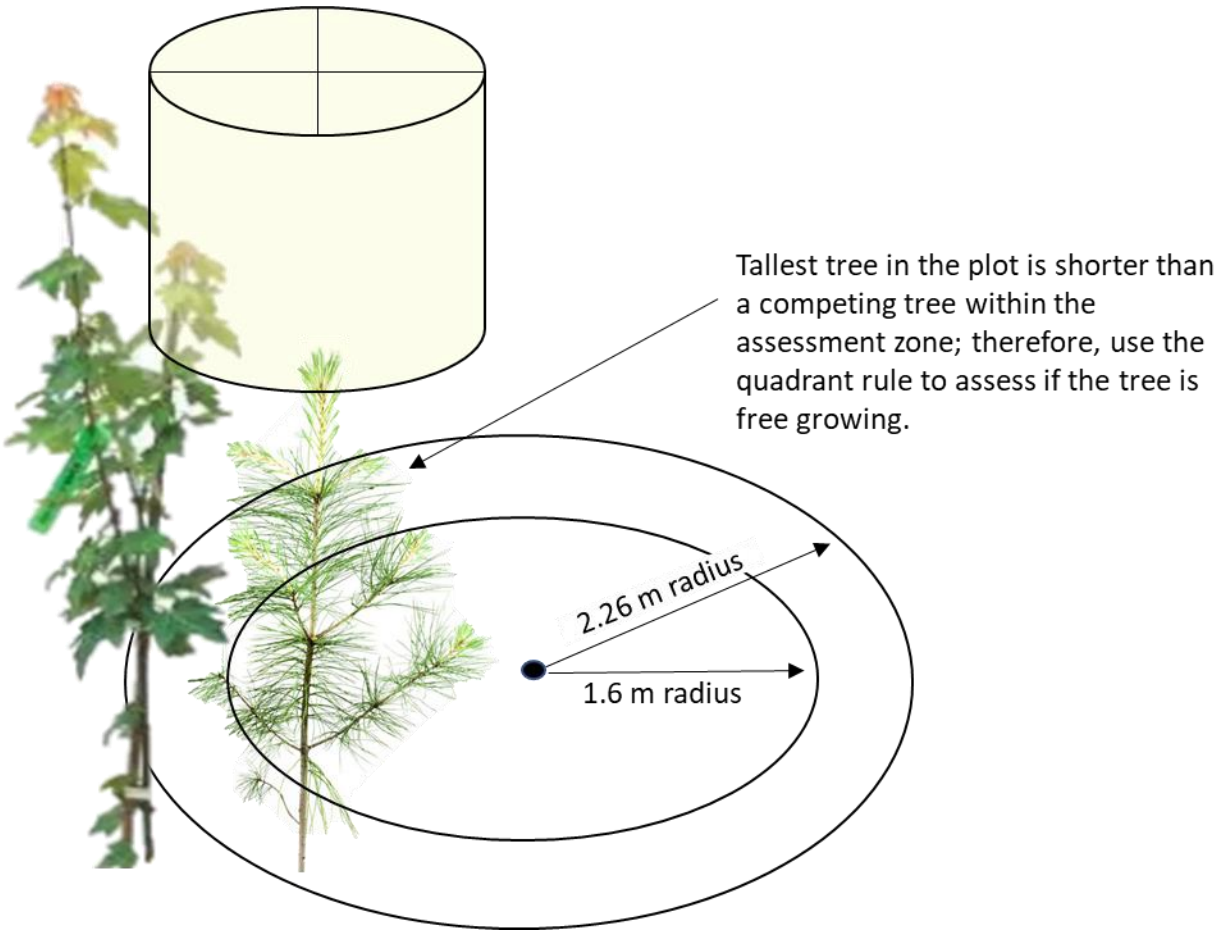


Figure 17. Assessing each plot for regeneration begins with identifying the tallest tree in the plot and assessing competition within the assessment zone. Remember the assessment zone may extend beyond the 16 m^2 or 8 m^2 plot; as such, it is possible to have competition that is taller than the 'tallest' tree identified inside the plot.

Table 3. Shade tolerance table characterizing tree species' ability to tolerate low light levels; summarizing the maximum number of quadrants allowed with overtopping foliage from competing species.

Very shade intolerant	**Shade intolerant**	**Intermediate shade intolerant**	**Shade tolerant**	**Very shade tolerant**
0 quadrants	1 quadrant	2 quadrants	3 quadrants	4 quadrants (no limit)
Jack pine	Black spruce	Eastern white pine	Eastern white cedar	Sugar maple
Red pine	Eastern larch	White spruce	Balsam fir	Ironwood
Scots pine	White birch	Yellow birch	Eastern hemlock	
Trembling aspen	Black ash	Red maple	Red spruce	
Largetooth aspen	Black cherry	Red oak	White ash	
Balsam poplar	Butternut	White oak	American beech	
	Black walnut	Bur oak	Basswood	
	Bitternut hickory	Shumard oak		
	Shagbark hickory	White elm		
	Silver maple	Green ash		

- Does the presence of overtopping foliage above the tree species being assessed exceed the maximum number of quadrants permitted (see Table 3)?
  - If the answer is 'yes', the tree is considered <u>not</u> free growing.
  - If the answer is 'no', the tree is considered free growing.

e) After completing the assessment of competition for the initial tree, move on to the next tallest tree in the plot that is ≥ 1.2 m from free growing tree previously tallied. Note, it is possible to have multiple free growing trees tallied in each nested plot, if trees are spaced accordingly around the plot (see Figure 18).

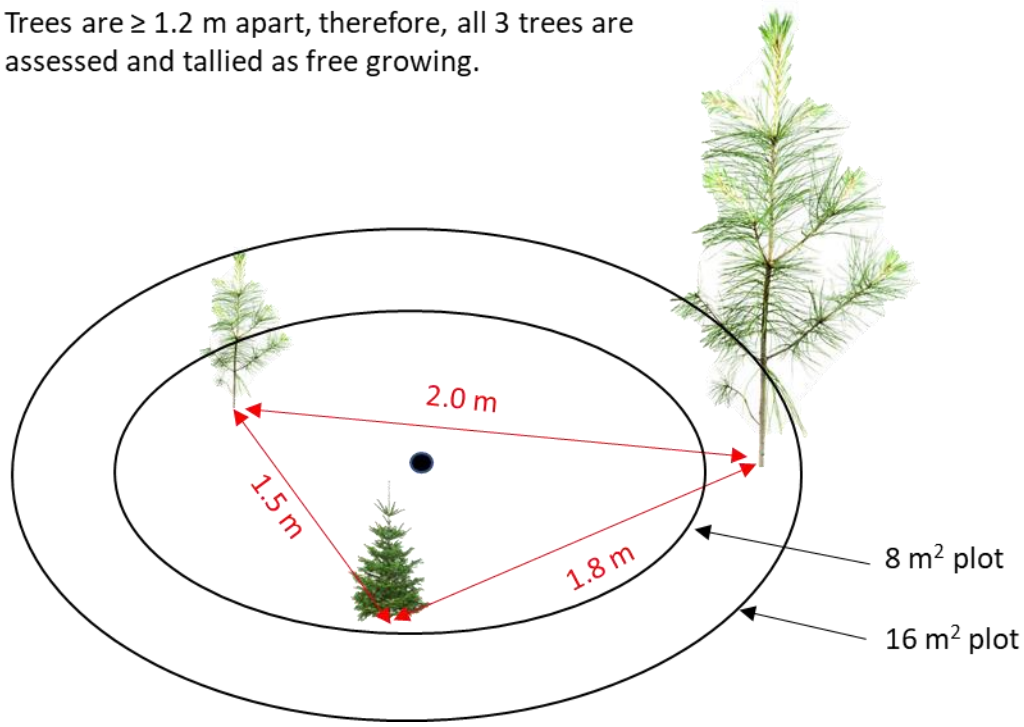


Figure 18. Multiple trees can be tallied in the plots if they are spaced accordingly around the 16 m^2 and 8 m^2 plots. Note, the minimum inter-tree spacing between trees is 1.2 m (i.e., distance between the main stem of the trees).

f) Once the assessment of the 16 m^2 is complete, move on to assess the 8 m^2 plot for free growing trees and start back at step 2 (c) working through to step 2 (e). Remember, all free growing trees, whether in the 16 m^2 or 8 m^2 plot must be have a minimum 1.2 m inter-tree spacing between trees.

g) If there is no regeneration in the plot (i.e., 'unoccupied'), record the reason (dropdown provided in TerraFlex application); barren, shrubs, herbaceous or grass cover, rock, wet, slash, ruts, landing, skid trail, road, not free-to-grow (FTG), crown closure (CC) > 30%. Documenting the reasons for unoccupied plots provides important insight for stands with low site occupancy.

h) After completing plot 1, move on to plots 2 through 8, following the same process as above (i.e., step 1 through step 3). Use the plot measuring stick to ensure the proper distance between plots. With the measuring stick extended from plot centre in the direction of travel toward the next cluster, flip the stick once to move to the centre of the next 16 m^2 and 8 m^2 plot (see Figure 19).

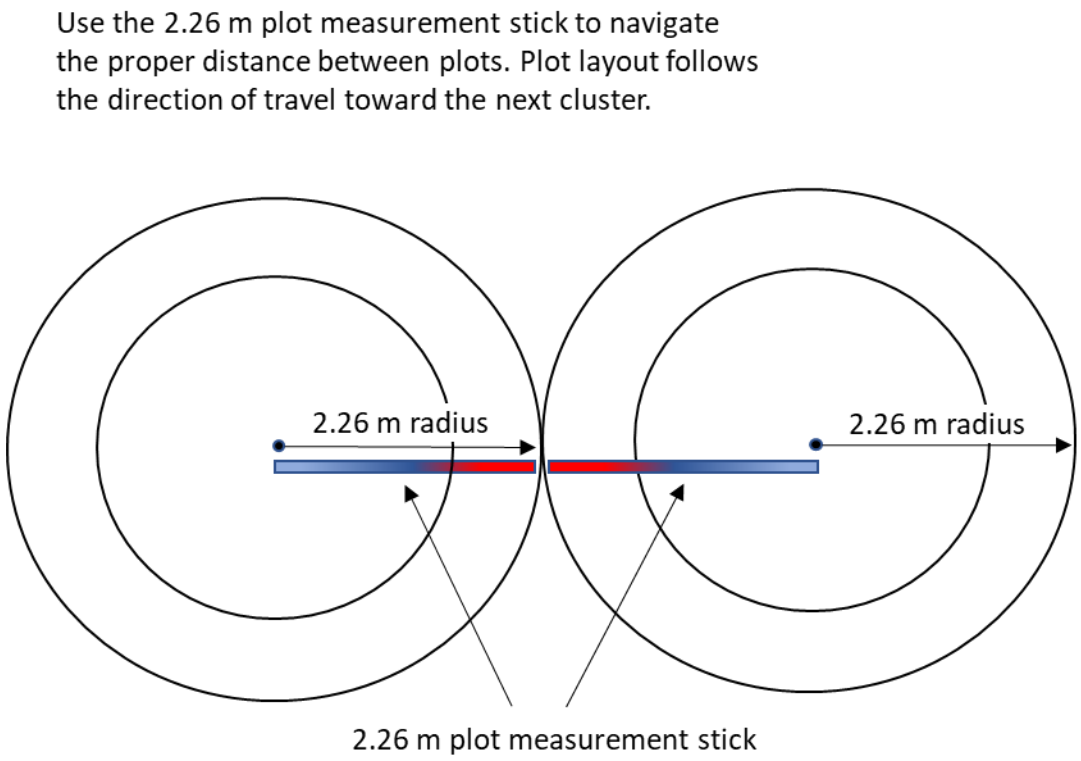


Figure 19. Use the 2.26 m plot measurement stick to navigate between plots to ensure equal spacing. The distance between plot centres is twice the length of the plot measurement stick.

Step 3 - Cluster complete - next steps

- Proceed to the next cluster and start back at step 1. If this is the last cluster for the project, save field your work and sync the project in TerraFlex to upload project to the cloud.

11.0 Data Comparison

Step 1 - Ensure forest manager assessment results are entered in TerraFlex

The data and results from the forest managers' establishment assessments (i.e., block name, species composition, site occupancy and effective density, if available) need to be entered into the appropriate project/block ID in TerraFlex. Ideally, this should be completed prior to the Ministry conducting field assessments; however, districts may choose to complete this step after the Ministry assessment is complete. Each district is required to compile an annual summary of establishment assessment data that includes the results of the Ministry assessments alongside the forest manager data, using an excel spreadsheet. In addition, a summary of all establishment assessment results submitted by the forest manager are

required and can be included under a separate tab. *A template for summarizing district and forest manager data is available on the RAP SharePoint website*. Summarized data should be sent to the regional RAP lead once complete, which will later be stored on the RAP SharePoint website. This information will be used in the statistical analysis and for regional reporting.

Step 2 - Analyse results

District leads for the RAP should notify the regional lead upon completion of the season's establishment assessments. Regional specialists are responsible for comparing and analyzing the establishment assessment data. Statistical analysis of the district and forest manager datasets will identify inconsistencies between assessment results. The results of this analysis will be shared and discussed with the district forester and/or lead forest practitioner for each management unit. The district forester or lead forest practitioner is responsible for providing feedback to the forest manager to discuss the commonalities and differences among establishment assessments. Regional specialists may take part in these discussions at the request of the district.

Literature Cited

ELCWG (Ecological Land Classification Working Group). 2009. Ecosites of Ontario. Ontario Ministry of Natural Resources, Sault Ste Marie, ON. Operational Draft. 532 pp.

Lennon, K. 2016. Post-renewal forest succession: Suggested pathways for northeast standard forest units. OMNR, Northeast Science and Research., TR-005. 41 pp.

OMNR, 2004. Ontario Tree Marking Guide, Version 1.1. Ontario Ministry of Natural Resources. Queen's Printer for Ontario. Toronto. 252 pp.

OMNRF, 2015. Forest Management Guide to Silviculture in the Great Lakes-St. Lawrence and Boreal Forests of Ontario. Ontario Ministry of Natural Resources and Forestry. Queen's Printer for Ontario. Peterborough. 397 pp.

Parker, W.C., and Sharma, M. 2018. Influence of post-harvesting residual stand structure on canopy light transmittance in Ontario's boreal mixedwood forests. Forestry Chronicle. Vol. 94, No 1.

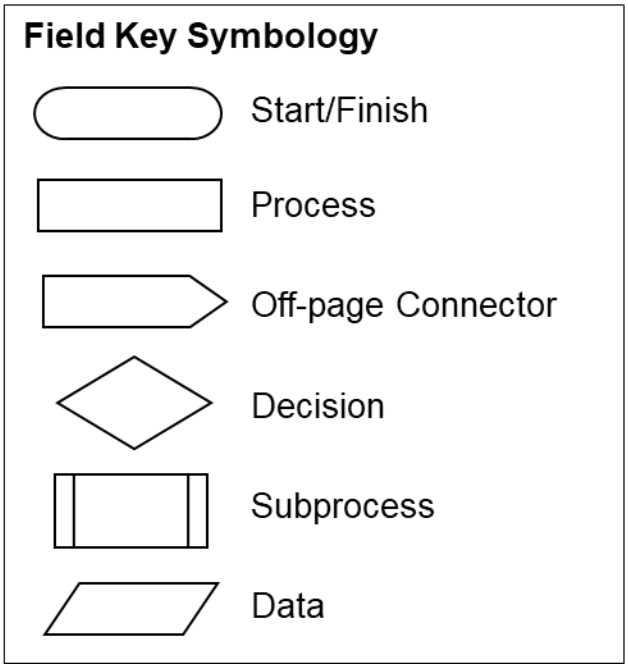
White, R.G., F.W. Bell, K. Lennon, A. Morneault, M. Sharma, N. Subedi and W.D. Towill. 2014. Free-growing Assessments: Evaluating assessment criteria using Ontario's Vegetation Management Alternatives Program (VMAP) database. Ministry of Natural Resources, Science and Research Branch, Northwest Biodiversity and Monitoring Section, Thunder Bay, ON. Technical Report TR-149. 11 pp.

White, R.G., C.L. Bowling, W.J. Parton and W.D. Towill. 2005. Well-spaced free-growing regeneration assessment procedure for Ontario. OMNR, Northwest Science and Information, NWSI Technical Manual TM-007. 39 pp.

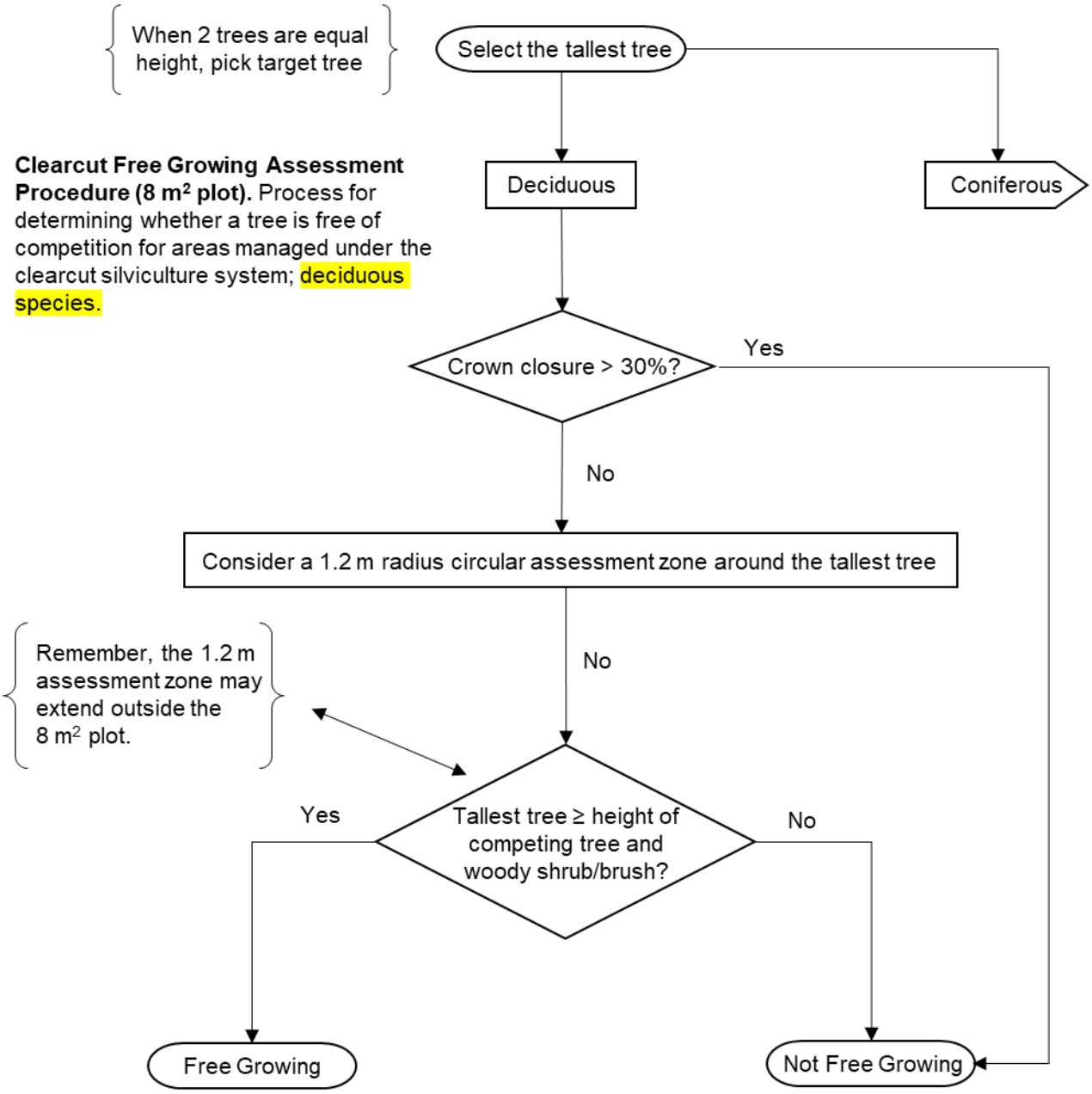
Appendices

Appendix 1 - Field Key: Clearcut Assessment Procedure Notes

- When there is no free growing tree to record after following the assessment procedures, record the reason.
- Important: take a photograph at the beginning of plot 1 for each cluster. Photographs should be taken facing the direction of travel toward the next cluster. Photos are invaluable in support of the data being collected.
- Remember to do a prism sweep at plot 4 for each cluster. The intent for clearcut is to get an indication of residual wildlife trees remaining. The intent for shelterwood is to get an indication of the residual basal area (and crown closure) remaining to shelter regeneration.

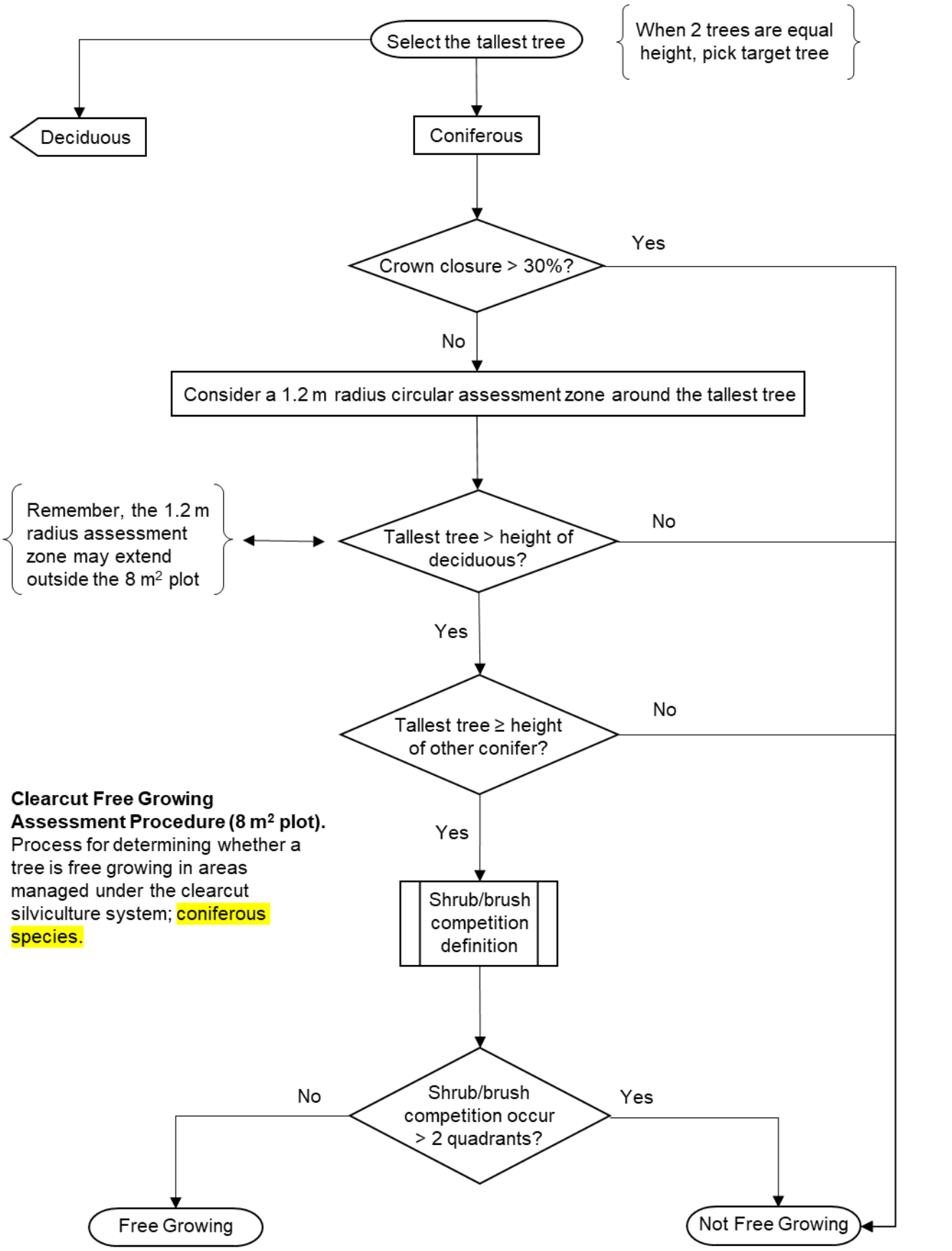


Appendix 2 - Field Key: Clearcut Free Growing Assessment Procedure



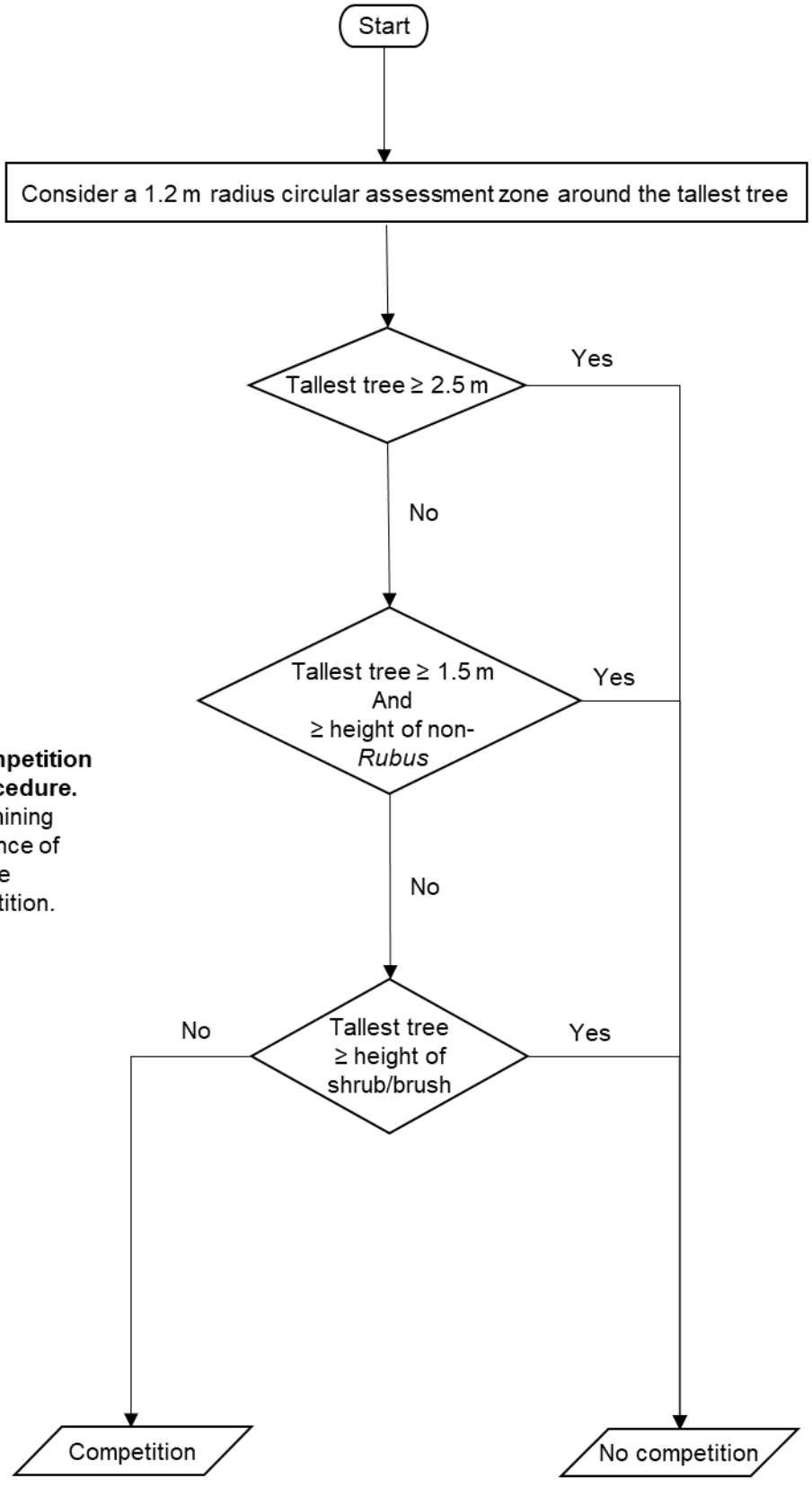
Clearcut Free Growing Assessment Procedure (8 m² plot). Process for determining whether a tree is free of competition for areas managed under the clearcut silviculture system; deciduous species.

Repeat process for additional trees in the 8 m² plot, with a minimum inter-tree distance of 1.2 m from free growing tree(s).



Clearcut Free Growing Assessment Procedure (8 m² plot). Process for determining whether a tree is free growing in areas managed under the clearcut silviculture system; coniferous species.

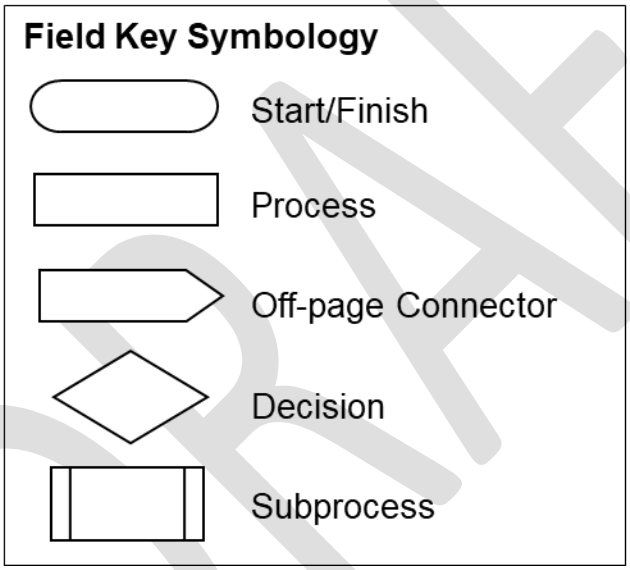
Repeat process for additional trees, with a minimum inter-tree distance of 1.2 m from free growing tree(s).



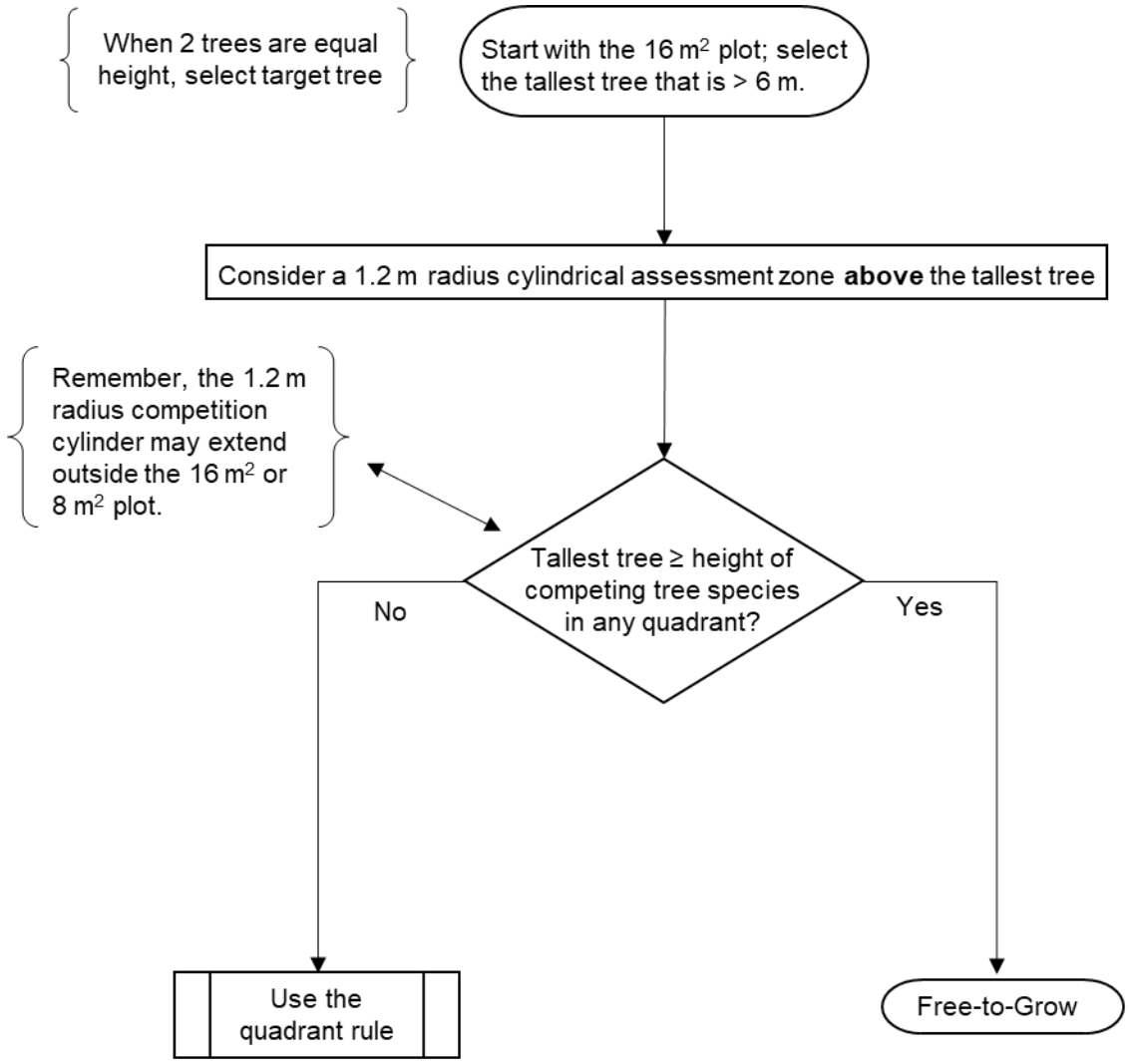
Shrub/brush Competition Assessment Procedure. Process for determining whether the presence of shrubs or brush are considered competition.

Appendix 3 - Field Key: Uniform Shelterwood Assessment Procedure Notes

- When there is no free growing tree to record after following the assessment procedures, record the reason.
- Important: take a photograph at the beginning of plot 1 for each cluster. Photographs should be taken facing the direction of travel toward the next cluster. Photos are invaluable in support of the data being collected.
- Remember to do a prism sweep at plot 4 for each cluster. The intent for clearcut is to get an indication of residual wildlife trees remaining. The intent for shelterwood is to get an indication of the residual basal area (and crown closure) remaining to shelter regeneration.



Appendix 4 - Field Key: Uniform Shelterwood Free Growing Assessment Procedure

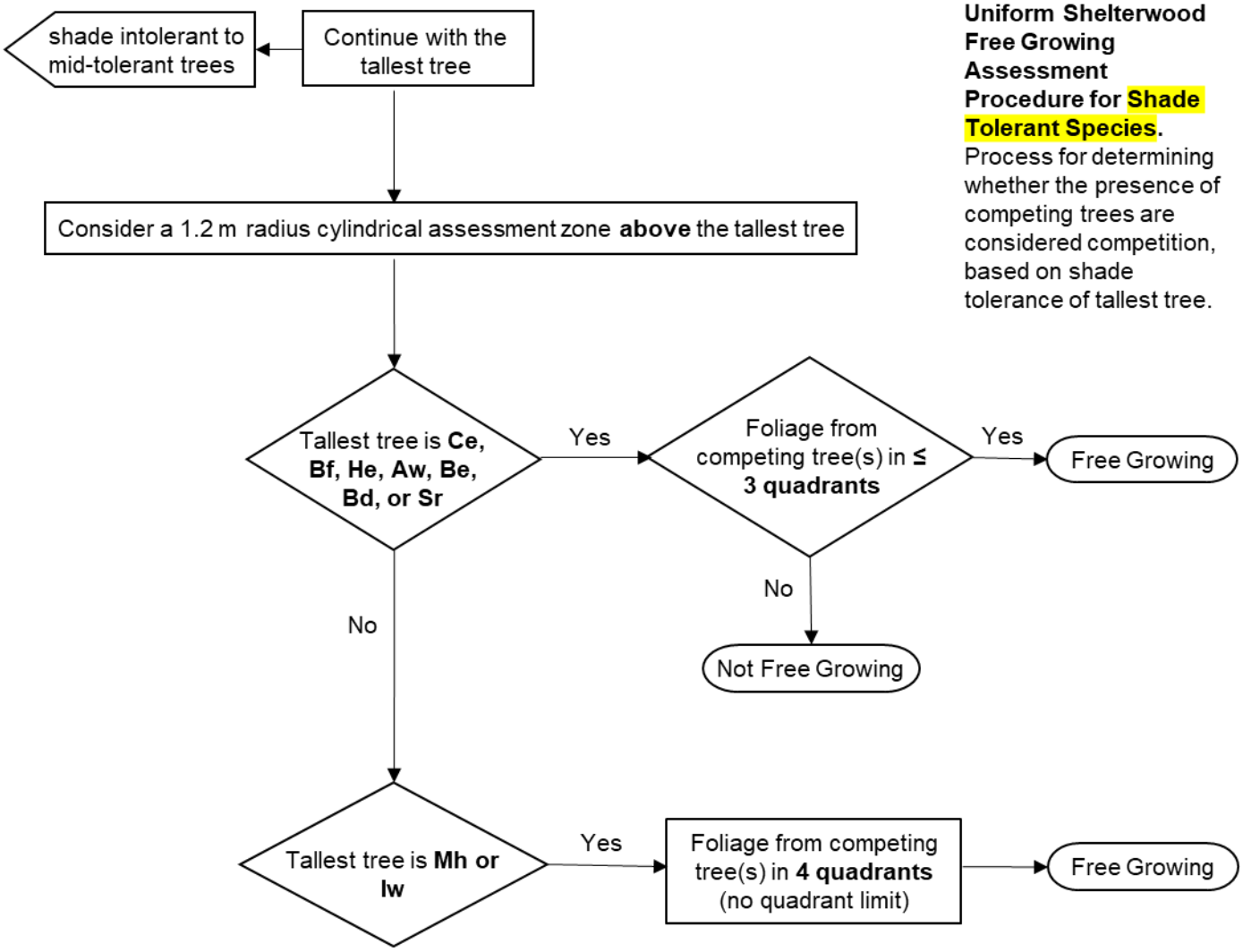


Repeat process for additional trees in the 16 m² plot ≥ 6 m,. Next, assess the tallest tree(s) in the 8 m² plot that are < 6 m but ≥ minimum height. Note, all trees considered free growing must have a minimum 1.2 m inter-tree distance from other free growing trees.

Uniform Shelterwood Free Growing Assessment Procedure (16 m² and 8 m² plot).
Process for determining whether a tree is free growing (i.e., free of competition) for areas managed under the uniform shelterwood silviculture system.

Uniform Shelterwood Free Growing Assessment Procedure by Species for Shade Intolerant to mid-tolerant Species. Process for determining whether the presence of competing trees are considered competition, based on shade tolerance of tallest tree.

Uniform Shelterwood Free Growing Assessment Procedure for Shade Tolerant Species. Process for determining whether the presence of competing trees are considered competition, based on shade tolerance of tallest tree.



Return to Uniform Shelterwood Free Growing Assessment Procedure to consider whether additional trees are free growing in the 16 m^2 plot. Next, assess trees in the 8 m^2 plot. Note, all trees considered free growing must have a minimum 1.2 m inter-tree distance from other free growing trees.

Appendix 5 - Evaluating Crown Closure

Part of the assessment method outlined for the clearcut silviculture system involves estimating the crown closure above the plots to ensure the light conditions meet the definition of a clearcut. Tree species accustomed to growing in clearcut conditions under full light levels typically do not do well under a partial canopy where light is restricted. As outlined in the Silviculture Guide (OMNR 2015) >70% full sunlight is required for trees regenerating under the clearcut silviculture system.

Evaluating crown closure when conducting establishment assessments is intended to be a relatively quick estimate. Stands where excessive retention of residuals remain post-harvest as a result of poor market conditions or otherwise are the most likely to fall below the threshold light levels in a clearcut harvest.

Research carried out by Parker and Sharma (2018) looking at the relationship between basal area and crown closure can help when estimating crown closure in clearcut conditions (see Table 4). However, this operational tool is specific to boreal mixedwood sites, to measure understory light from poplar and white birch retention only. Where it is suspected that crown closure is >30% as a result of residual poplar and white birch trees overtopping the plot, follow the steps below to determine residual basal area (BA):

a) Conduct a prism sweep to count the number of residual stems by species (see Appendix 6 for information on conducting a prism sweep).
b) Multiply the number of stems for each species by 2 (i.e., prisms typically used throughout Ontario are calibrated to a factor of 2) to determine the BA. For example, 3 white birch tallied in your prism sweep is equivalent to a BA of 6.
c) Refer to table 4 to determine if the residual BA is acceptable for clearcut conditions.

Table 4. Maximum BA (m^2/ha) by species to achieve the appropriate crown closure in clearcuts harvest areas.

Tree Species	**Maximum BA (m^2/ha) (≤30% crown closure)**
White birch	5
Poplar	10

If a plot is in a residual patch of uncut timber, there is no need to estimate crown closure. In this situation, there will be no regeneration to assess. Document the reason for unoccupied as ‘crown closure > 30%.’

A field method for estimating crown closure and light levels for residual conifer species in a clearcut is TBD.

It is recognized that the focus of an establishment assessment in on regeneration; however, assessing crown closure comes into play as it affects the overall growth and success of regeneration. Where there is uncertainty whether the stand is by definition a clearcut, continue assessing regeneration and contact a district technician responsible for compliance inspections for further discussion and investigation.

Appendix 6 - Conducting a Prism Sweep to Measure Basal Area

Basal area (BA) is the cross-sectional area of a tree measured in square metres 1.3 m above the ground (breast height). Basal area is most commonly used as an indicator of stand density, standing timber volume or growth and is expressed in square metres per hectare (m^2/ha). Measuring BA in a clearcut post-harvest provides an indication of the residual BA. In the shelterwood silviculture system, a target residual BA is often specified to achieve a specific management objective (e.g., optimal light levels in the understory).

A wedge prism is an efficient tool used to measure the BA. A prism plot or 'sweep' is a measure of BA at a given point and is carried out by conducting a 360° sweep around a central point to determine the trees in the plot. The correct procedure for completing a prism sweep is outlined below:

a) Mark a spot on the ground at the centre of the plot or hold a wooden stake over plot centre.
b) Hold the prism at an arms' length with the bottom edge parallel to the ground over the centre of the plot.
c) Move around the prism in a complete circle, looking at every tree at breast height through the prism.
d) A tree is counted as 'in' if the offset section of the tree overlaps the bole of the tree (see Figure x). A tree is 'out' if the offset section of the tree does <u>not</u> overlap with the bole of the tree.

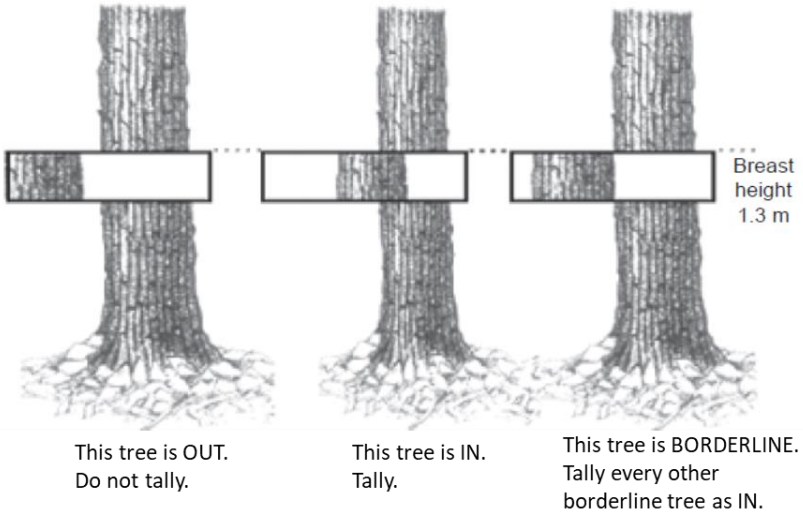


Figure 18. A prism view when determining if trees are 'in' or 'out' of a prism plot (OMNR 2004).

When a borderline tree is encountered, count half a tree or every other borderline tree as one tree ‘in’. If including the borderline tree means the difference between a clearcut and a partial harvest (e.g., the maximum BA for residual poplar trees is 10 m^2/ha to be defined as a clearcut), a series of measurements can be taken to determine if the tree is ‘in’ or ‘out’. Measure the horizontal distance from plot centre to the centre of the tree using a measuring tape. Also, measure the tree diameter at breast height (dbh) using a diameter tape. If the horizontal distance is less than or equal to the limiting distance (see Table 5), the borderline tree is ‘in’ and counted as one tree.

Table 5. Horizontal limiting distance for trees according to diameter for a prism with a basal area factor of 2 (OMNR 2004).

dbh (cm)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	0.00	0.04	0.07	0.11	0.14	0.18	0.21	0.25	0.28	0.32
1	0.35	0.39	0.42	0.46	0.49	0.53	0.57	0.60	0.64	0.67
2	0.71	0.74	0.78	0.81	0.85	0.88	0.92	0.95	0.99	1.03
3	1.06	1.10	1.13	1.17	1.20	1.24	1.27	1.31	1.34	1.38
4	1.41	1.45	1.48	1.52	1.56	1.59	1.63	1.66	1.70	1.73
5	1.77	1.80	1.84	1.87	1.91	1.94	1.98	2.02	2.05	2.09
6	2.12	2.16	2.19	2.23	2.26	2.30	2.33	2.37	2.40	2.44
7	2.47	2.51	2.55	2.58	2.62	2.65	2.69	2.72	2.76	2.79
8	2.83	2.86	2.90	2.93	2.97	3.01	3.04	3.08	3.11	3.15
9	3.18	3.22	3.25	3.29	3.32	3.36	3.39	3.43	3.46	3.50
10	3.54	3.57	3.61	3.64	3.68	3.71	3.75	3.78	3.82	3.85
11	3.89	3.92	3.96	4.00	4.03	4.07	4.10	4.14	4.17	4.21
12	4.24	4.28	4.31	4.35	4.38	4.42	4.45	4.49	4.53	4.56
13	4.60	4.63	4.67	4.70	4.74	4.77	4.81	4.84	4.88	4.91
14	4.95	4.99	5.02	5.06	5.09	5.13	5.16	5.20	5.23	5.27
15	5.30	5.34	5.37	5.41	5.44	5.48	5.52	5.55	5.59	5.62
16	5.66	5.69	5.73	5.76	5.80	5.83	5.87	5.90	5.94	5.98
17	6.01	6.05	6.08	6.12	6.15	6.19	6.22	6.26	6.29	6.33
18	6.36	6.40	6.43	6.47	6.51	6.54	6.58	6.61	6.65	6.68
19	6.72	6.75	6.79	6.82	6.86	6.89	6.93	6.97	7.00	7.04
20	7.07	7.11	7.14	7.18	7.21	7.25	7.28	7.32	7.35	7.39
21	7.42	7.46	7.50	7.53	7.57	7.60	7.64	7.67	7.71	7.74
22	7.78	7.81	7.85	7.88	7.92	7.95	7.99	8.03	8.06	8.10
23	8.13	8.17	8.20	8.24	8.27	8.31	8.34	8.38	8.41	8.45
24	8.49	8.52	8.56	8.59	8.63	8.66	8.70	8.73	8.77	8.80
25	8.84	8.87	8.91	8.94	8.98	9.02	9.05	9.09	9.12	9.16
26	9.19	9.23	9.26	9.30	9.33	9.37	9.40	9.44	9.48	9.51
27	9.55	9.58	9.62	9.65	9.69	9.72	9.76	9.79	9.83	9.86
28	9.90	9.93	9.97	10.01	10.04	10.08	10.11	10.15	10.18	10.22
29	10.25	10.29	10.32	10.36	10.39	10.43	10.47	10.50	10.54	10.57
30	10.61	10.64	10.68	10.71	10.75	10.78	10.82	10.85	10.89	10.92
31	10.96	11.00	11.03	11.07	11.10	11.14	11.17	11.21	11.24	11.28
32	11.31	11.35	11.38	11.42	11.46	11.49	11.53	11.56	11.60	11.63
33	11.67	11.70	11.74	11.77	11.81	11.84	11.88	11.91	11.95	11.99
34	12.02	12.06	12.09	12.13	12.16	12.20	12.23	12.27	12.30	12.34
35	12.37	12.41	12.45	12.48	12.52	12.55	12.59	12.62	12.66	12.69
36	12.73	12.76	12.80	12.83	12.87	12.90	12.94	12.98	13.01	13.05
37	13.08	13.12	13.15	13.19	13.22	13.26	13.29	13.33	13.36	13.40
38	13.44	13.47	13.51	13.54	13.58	13.61	13.65	13.68	13.72	13.75
39	13.79	13.82	13.86	13.89	13.93	13.97	14.00	14.04	14.07	14.11
40	14.14	14.18	14.21	14.25	14.28	14.32	14.35	14.39	14.42	14.46
41	14.50	14.53	14.57	14.60	14.64	14.67	14.71	14.74	14.78	14.81
42	14.85	14.88	14.92	14.96	14.99	15.03	15.06	15.10	15.13	15.17
43	15.20	15.24	15.27	15.31	15.34	15.38	15.41	15.45	15.49	15.52
44	15.56	15.59	15.63	15.66	15.70	15.73	15.77	15.80	15.84	15.87
45	15.91	15.95	15.98	16.02	16.05	16.09	16.12	16.16	16.19	16.23
46	16.26	16.30	16.33	16.37	16.40	16.44	16.48	16.51	16.55	16.58
47	16.62	16.65	16.69	16.72	16.76	16.79	16.83	16.86	16.90	16.94
48	16.97	17.01	17.04	17.08	17.11	17.15	17.18	17.22	17.25	17.29
49	17.32	17.36	17.39	17.43	17.47	17.50	17.54	17.57	17.61	17.64
50	17.68	17.71	17.75	17.78	17.82	17.85	17.89	17.93	17.96	18.00
51	18.03	18.07	18.10	18.14	18.17	18.21	18.24	18.28	18.31	18.35
52	18.38	18.42	18.46	18.49	18.53	18.56	18.60	18.63	18.67	18.70
53	18.74	18.77	18.81	18.84	18.88	18.92	18.95	18.99	19.02	19.06
54	19.09	19.13	19.16	19.20	19.23	19.27	19.30	19.34	19.37	19.41
55	19.45	19.48	19.52	19.55	19.59	19.62	19.66	19.69	19.73	19.76
56	19.80	19.83	19.87	19.91	19.94	19.98	20.01	20.05	20.08	20.12
57	20.15	20.19	20.22	20.26	20.29	20.33	20.36	20.40	20.44	20.47
58	20.51	20.54	20.58	20.61	20.65	20.68	20.72	20.75	20.79	20.82
59	20.86	20.90	20.93	20.97	21.00	21.04	21.07	21.11	21.14	21.18
60	21.21	21.25	21.28	21.32	21.35	21.39	21.43	21.46	21.50	21.53

Plot Radius Factor used: For each 1 cm in dbh allow 0.35355339 metres maximum distance to target.

To estimate BA per hectare, multiply the number of trees tallied by the basal area factor (BAF) of 2. For example, if 6 trees are tallied, the BA is 6 x 2 = 12 m^2/ha. An average BA for the stand is determined by averaging all the estimates.

When conducting a prism sweep on a slope, it is necessary to correct for the angle of the slope with an increase in the BA estimate. Correcting for slope is done by applying a correction factor (secant) to the BA tallied. Correction factors are outlined in Table 6. For example, measure the angle of the slope using a clinometer (e.g., Suunto). Using the factor that corresponds to the angle measured (refer to Table 6) multiply the factor by the BA. For example, assuming a BA of 10 m^2/ha, with a slope measuring 20°, the corrected BA would be, 10 x 1.0353 = 10.6 m^2/ha.

Table 6. Slope correction factors when measuring basal area (OMNR 2004).

Prism Plot Slope Correction

Slope angle	Factor (secant)
5	1.0038
7.5	1.0086
10	1.0154
12.5	1.0243
15	1.0353
17.5	1.0485
20	1.0642
22.5	1.0824
25	1.1034
30	1.1547
35	1.2208
45	1.4142
60	2.0000

Appendix 7 - Ecosite - Identifying Soil Moisture and Nutrient Regimes

Ecosite refers to the local conditions of a site that influence the overall productivity and the ecological functions. Ecosites are based on the physical features of the environment such as substrate depth, texture, landform and nutrient regimes (OMNR 2015) and directly influence the vegetation communities that inhabit an area.

The availability of soil moisture and soil nutrients are key indicators that influence site productivity and vegetation of a site. As such, similar geographic locations that have comparable soil moisture and nutrient regimes are typically occupied by similar plant communities.

The edatopic grid, a diagram describing a gradient of moisture and nutrient ranges is a useful tool to identify the soil moisture and nutrient regime for a given location, see Figure 19. For instructions on how to identify moisture and nutrient regimes, refer to the Ecological Land Classification field guide (ELCWG 2009).

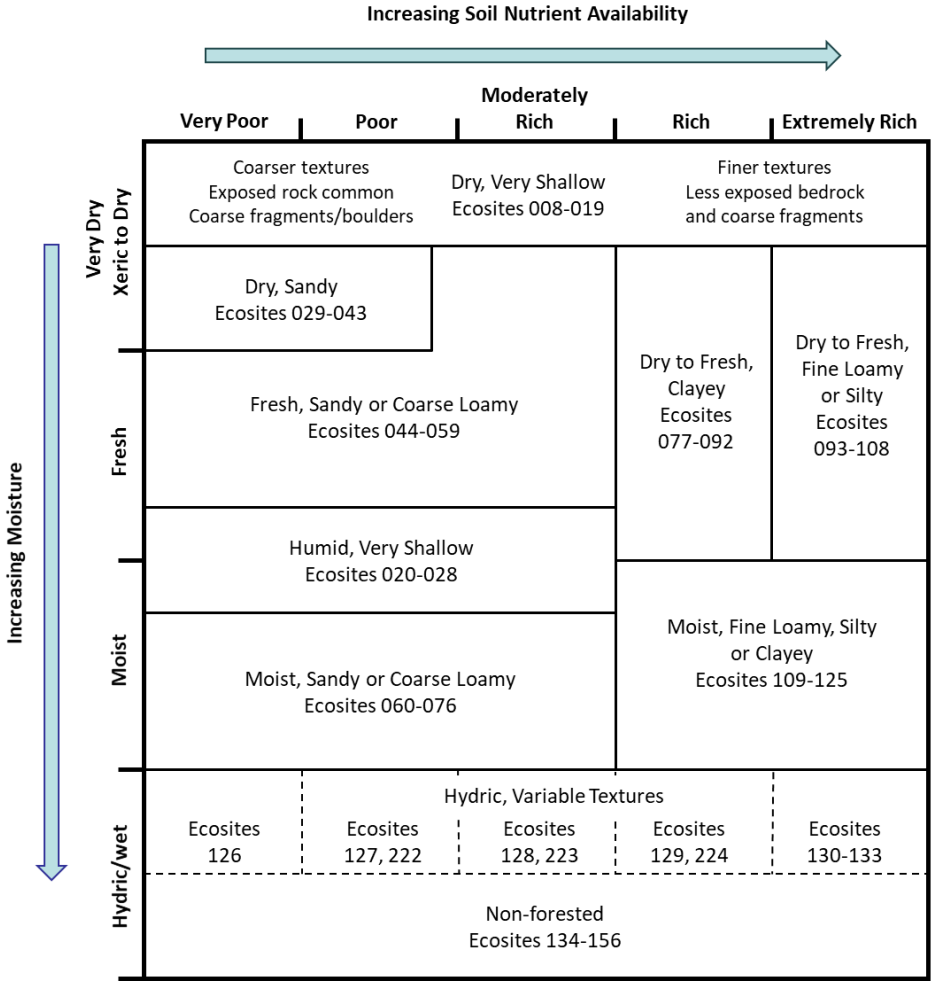


Figure 19. Edaptopic grid showing a range of soil moisture and nutrient regimes with associated Ontario Ecosystem Land Classification codes.

Appendix 8 - Tree Species Names and Codes

Common Name	Species Code	Scientific Name
black spruce	Sb	Picea mariana (Mill.) BSP
white spruce	Sw	Picea glauca (Moench) Voss
red spruce	Sr	Picea rubens Sarg.
Norway spruce	Sn	Picea abies (L.) Karst.
jack pine	Pj	Pinus banksiana Lamb.
eastern white pine	Pw	Pinus strobus L.
red pine	Pr	Pinus resinosa Alt.
scots pine	Ps	Pinus sylvestris L.
balsam fir	Bf	Abies balsamea (L.) Mill.
eastern white cedar	Cw	Thuja occidentalis L.
eastern hemlock	He	Tsuga canadensis (L.) Carrière
tamarack (eastern larch)	La	Larix laricina (Du Roi) K. Koch
poplar	Po	Populus L.
trembling aspen	At	Populus tremuloides Michx.
largetooth aspen	Al	Populus grandidentata Michx.
balsam poplar	Pb	Populus balsamifera L.
white birch	Bw	Betula papyrifera Marsh.
yellow birch	By	Betula alleghaniensis Britt.
gray birch	Bg	Betula populifolia Marsh.
red maple (soft maple)	Mr	Acer rubrum L.
sugar maple (hard maple)	Mh	Acer saccharum Marsh.
silver maple	Ms	Acer Saccharinum L.
red oak	Or	Quercus rubra L.
white oak	Ow	Quercus alba L.
bur oak	Ob	Quercus macrocarpa Michx.
shumard oak	Os	Quercus shumardii Buckl.
white ash	Aw	Fraxinus americana L.
black ash	Ab	Fraxinus nigra Marsh.
green ash	Ag	Fraxinus pennsylvanica var. subintegerrima (Vahl) Fern.
red ash	Ar	Fraxinus pennsylvanica Marsh.
American beech	Be	Fagus grandifolia Ehrh.
white elm	Ew	Ulmus americana L.
basswood	Bd	Tilia americana L.
ironwood	Id	Ostrya virginiana (Mill.) K. Koch
black cherry	Cb	Prunus serotina Ehrh.
butternut	Bn	Juglans cinerea L.
bitternut hickory	Hb	Carya cordiformis (Wangenh.) K. Koch
shagbark hickory	Hs	Carya ovata (Mill.) K. Koch
American chestnut	Cd	Castanea dentata (Marsh.) Borkh.