VISUAL GUIDE

FOR IMPLEMENTING THE RESTORATION AND ESTABLISHMENT FRAMEWORK IN WOODLAND CARIBOU HABITAT IN ALBERTA

June 2017

Alberta

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ACKNOWLEDGEMENTS

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1. WHY THIS GUIDE?

Quality control and monitoring have become critical steps in habitat restoration programs in woodland caribou habitat in Alberta. This visual guide complements the *Provincial Restoration and Establishment Framework for Legacy Seismic Lines in Alberta* ("the framework") and is designed specifically for field personnel. **The approaches outlined in this guide are required for government-led programs and are encouraged for voluntary, industry-led programs**.

The guide clearly outlines data collection requirements during field visits and helps users visualize the various metrics and criteria included in the framework. It is intended to improve the quality and reliability of field monitoring programs.

NOTE: This guide is intended for field technicians and does not contain all the required information for developing field protocols. For information on required surveyor qualifications, sampling intensity calculations, and a more detailed description of all methodologies described in this guide, please see the *Provincial Restoration and Establishment Framework*.

Figure 1. A seismic line recovering to a functioning forest.

2. GUIDE TO QUALITY CONTROL PLOTS

2.1 WHY QUALITY CONTROL?

High-quality treatments are critical to the success of a restoration program. In the past, errors in treatment application have impeded regeneration or even caused it to fail. Planting trees in the wrong locations, creating too small of mounds in areas with high water tables, or poor protocols for transporting trees from the nursery to the field are all examples of errors that quality control programs should help to avoid.

Who does quality control: a third-party auditor who has an ecological understanding of site limiting factors, why treatments are being delivered, and what appropriate treatment delivery looks like.

When to do quality control: ideally, quality control assessments should be conducted during or immediately following treatment. This will facilitate quick payment to contractors, and allow the auditor to address any quality control concerns as early as possible.

Objective: ensure high quality treatments across a program.

> **Catching problems early**
> A good quality control program doesn't just identify problems—it prevents them. Quality control auditors should provide **regular feedback to operators** about what is going well and, more importantly, whether there are any issues that need correcting.

2.2 ESTABLISHING PLOTS

Plots will be established at regular intervals along the length of the line.

- Minimum of 1 plot per segment.
- If the treatment is greater than 1 km, establish at least 1 plot/km.
- Plot edge must be at least 25 m from a change in treatment/segment or advanced regeneration.

The quality control auditor may choose between two different types of 50 m^2 sampling plots (Figure 2):

- Circular plot with 3.99 m radius
- Rectangular plot measuring 5 m × 10 m

> **Calculating per-hectare densities**
> Using these plot sizes, values can easily be calculated on a per hectare basis by multiplying by 200. For example, 4 mounds in a plot is equal to 800 mounds/ha. Six planted trees in a plot is equivalent to 1200 stems/ha.

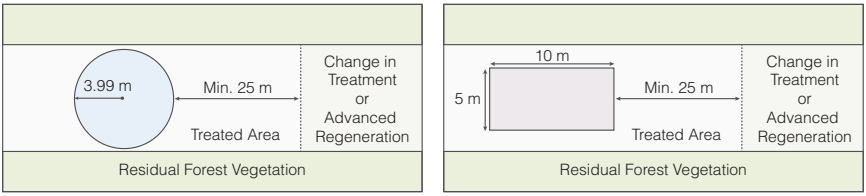


Figure 2. Quality control plot layout for either a 3.99 m radius circular plot or a 5 m × 10 m plot.

2.3 WHAT TO MEASURE AND WHY

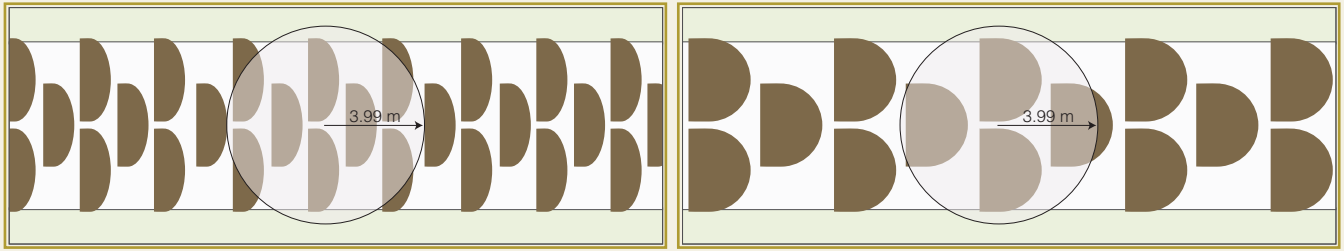
2.3.1 Site Preparation

Density, quality, coverage and pattern of site preparation treatments will be assessed (Table 1).

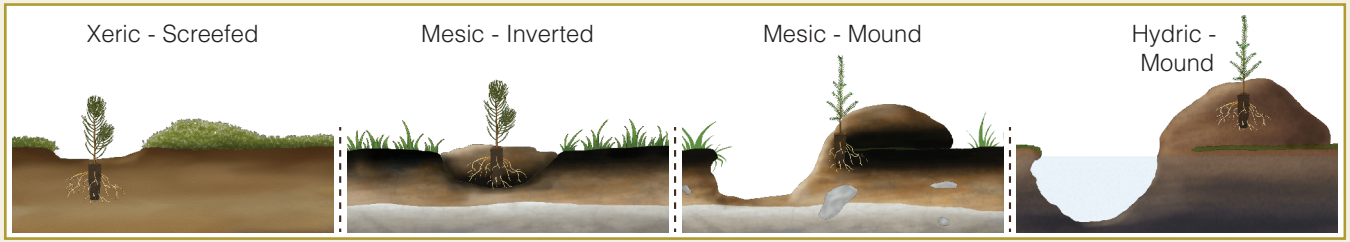
Table 1. Measures of success for site preparation during quality control assessment.

	Measures of Success			
Treatment	Density	Quality	Coverage	Pattern
Mounding	Matches operational plan (Y/N)	Hydric: Average mound height 0.7–1 m (Y/N) Mesic: Average mound height 30–50 cm (Y/N)	Across entire line (Y/N)	Matches operational plan (Y/N)
Screefing	Matches operational plan (Y/N)	Microsites created (Y/N)	Across entire line (Y/N)	Matches operational plan (Y/N)
Inversion	Matches operational plan (Y/N)	Organic layers intact (Y/N)	Across entire line (Y/N)	Matches operational plan (Y/N)
Other	Matches operational plan (Y/N)	As defined in operational plan	Across entire line (Y/N)	Matches operational plan (Y/N)
None	N/A	N/A	N/A	N/A

Density: Assessed by determining the number of treatment microsites per unit area (microsites/plot x 200). A microsite is counted when at least half its area falls within the plot. Left: example of a high-density treatment (1,600 mounds/ha). Right: example of a low-density treatment (800 mounds/ha).



Quality: Assessed by determining the height and/or composition of site preparation treatments. Note that mound height increases as the water table increases on a site.



Coverage: To restrict human and predator movement, treatments should cover the full width of a seismic line. Left: line with poor coverage, leaving travel lines along the edge. Centre: line with treatments extending beyond the edge. Right: line with stem-bending to block movement.

Pattern: Treatment application patterns should match the operational plan and avoid leaving clear movement lines for humans and predators. Left: line with poor pattern, leaving travel lines between mounds. Centre: line with 2/1 (“five of diamonds”) mound pattern. Right: Line with 4/3 mound pattern.

Figure 3. Example of site preparation with appropriate line coverage.

2.3.2 Planting/Seeding

Chain of custody documentation and planting density, depth, and quality are all measures of planting/seeding quality. If plants and seed are mishandled, or if they are planted on inappropriate microsites, this may lead to high mortality requiring fill-planting (Table 2).

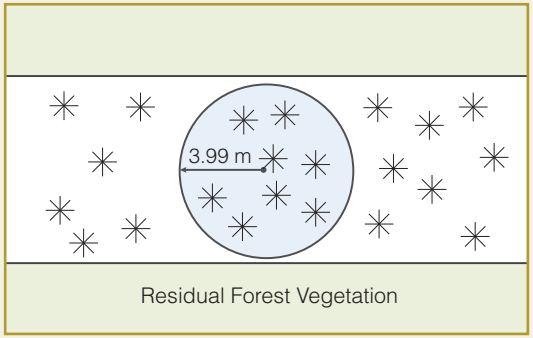
Table 2. Measures of success for planting/seeding during quality control assessment.

	Measures of Success			
Treatment	Chain of Custody	Density	Depth	Quality
Planting	Seedling chain of custody/nursery and field handling documented and followed.	Matches operational plan (Y/N)	Root collar up to 3–5 cm beneath surface (Y/N)	Assessed using protocol provided in operational plan (%).
Seeding	Signs of mold, pathogens, etc (Y/N). Seed chain of custody documented and followed.	Matches operational plan (Y/N)	N/A	Seeds present on available microsites and well dispersed (Y/N).

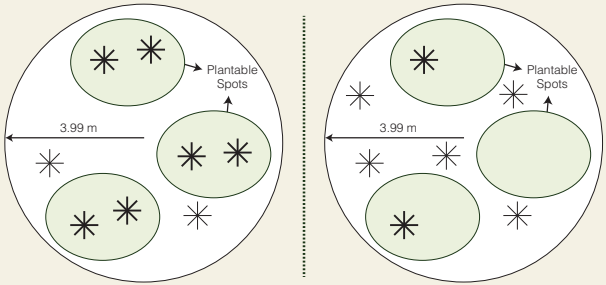
Chain of custody

The auditor must verify that the contractor has a documented protocol for transporting seedlings from the nursery to the field, or appropriate storage and handling of seeds, and whether this protocol was followed. Ensuring seedlings arrive to the field alive and in good condition remains one of the biggest challenges for linear restoration programs.

Density: Density is assessed within the 3.99 m circular or 5 m × 10 m rectangular plot. The density of trees within the plot should match the operational plan. Each asterisk represents a tree.

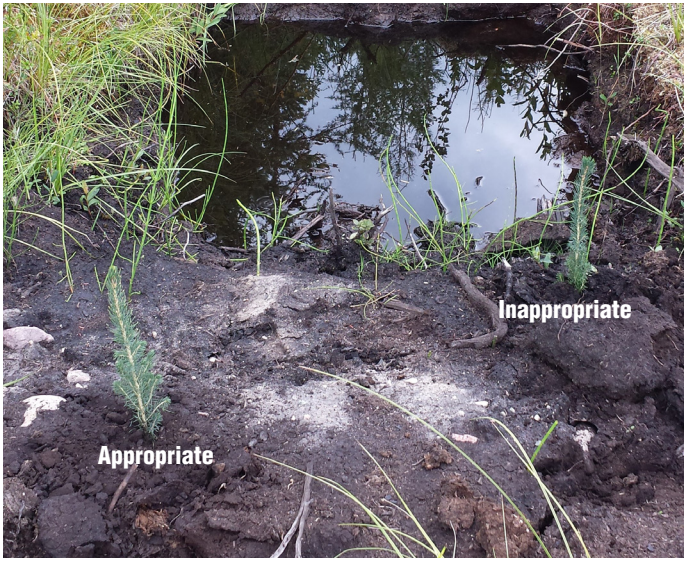


Quality: The degree to which planted trees occupy the plantable spots within a plot. The specific protocol/formula will be provided by the contractor. An example assessment is shown below. Each asterisk represents a tree.



Depth: The root plug should be at a sufficient depth below the microsite surface such that if the microsite erodes the root plug will not be exposed.

Figure 4. Example of a planted mound showing appropriate planting location (bottom left) and inappropriate planting location (centre right). The tree on the centre right does not capitalize on the raised microsite created by the mound.



2.3.3 Line Deactivation

Density, whether the line of travel was blocked, and access management are used to measure the quality of line deactivation treatments. Treatments should be applied in such a way that they block linear movement paths down the line, and should be applied at higher densities where the seismic line intersects with major travel corridors, e.g., roads (Table 3).

Table 3. Measures of success for line deactivation during quality control assessment.

	Measures of Success		
Treatment	Density	Line of travel blocked?	Access management
Coarse woody debris	Matches operational plan (Y/N)	N/A	Higher densities at intersections (Y/N)
Stem bending/tree felling/tree hinging	Matches operational plan (Y/N)	Ocular assessment of whether clear line of travel exists (Y/N)	Higher densities at intersections (Y/N)
Other	Matches operational plan (Y/N)	Per operational plan	Per operational plan
None	N/A	N/A	N/A

There are three quality control measures for line deactivation: density, whether the line of travel was blocked, and access management.

Density is an assessment of how much wood was applied, or stem bending occurred, compared to the prescription in the operational plan. Density may be assessed using a 3.99 m circular or 5 m × 10 m rectangular plot, or it may be an ocular assessment of how much wood was used relative to what was available on the line.

Blocking the **line of travel** on lines is important from both a wildlife use and human use perspective. Wood should be applied in sufficient densities to ensure that a clear line of travel is not present on a site.

For **access management**, a program should generally apply higher densities of woody materials or stem bending at the intersection with major roadways. This helps prevent human access on lines, facilitating more rapid vegetation recovery.

Example of stem-bending treatments that have sufficiently blocked the line of travel on a deactivated seismic line.

Example of higher densities of woody materials and mounding adjacent to a major roadway (i.e., access management).

3. GUIDE TO SURVIVAL ASSESSMENTS

3.1 WHY A SURVIVAL ASSESSMENT?

Objective:

- Confirm seedlings are surviving (planted sites) or have established at sufficient densities (seeded sites).
- Identify areas with low success that may need remedial actions.

Survey Timing:

- Acceptable: June 1–September 31
- Optimal: July 31–September 15

Why these timing windows?

- Vegetation will be greened-up.
- Conifers will have finished most of their growth.
- Easier to measure in the field.

3.2 ESTABLISHING PLOTS

Plot locations are pre-defined and will be provided in the operational plan.

At each plot, you will place the following subplots:

- Three circular subplots (1.78 m radius), see Figure 5.
    - Outside plots: within 2 m of edge of seismic line.
    - All plots: 5 m apart from each other.
- 30 m belt transect extending in one direction from the plot centre, see Figure 5.
    - The same width as the seismic line.
- Mark the plot as instructed in the *Provincial Restoration and Establishment Framework*.

The edge of a plot (e.g., the edge of the belt transect) should be at least 10 m from the end of the segment to buffer against any change in treatments in the adjacent segment (Figure 5).

When multiple plots are established in the same general location, plots must be 70 m from one another (Figure 6).

Why are the plots designed this way?

- The three circular subplots span the width of the line so that measurements capture conditions on both the sunny and shady sides of the line.
- The belt transects make overall estimates easier and more representative (e.g., stocking).

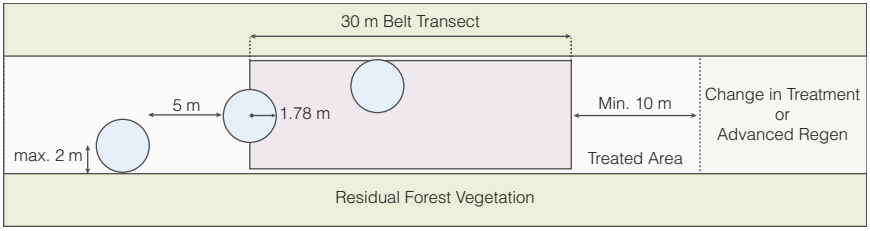


Figure 5. Sample plot layout for Survival Assessments.

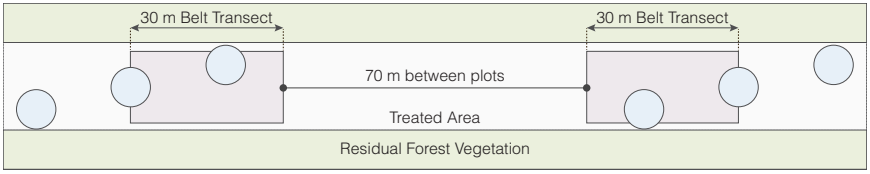


Figure 6. Minimum distance between plots when multiple Survival Assessment plots are established at the same general location.

3.3 ACCEPTABLE TREES

During the Survival Assessment, you will occasionally be required to limit your measurements to "acceptable trees." An acceptable tree is a tree that meets the following criteria:

- Seedling, sucker, or advanced regeneration
- Alive
- Has been on the site for at least 2 growing years (i.e., is not a germinant)
- Deciduous: height is at least 30 cm
- Coniferous: has a well-defined stem
- Is one of the tree species in Table 4

Table 4. List of tree species that are considered "acceptable."

Latin Name	Common Name	Code
Picea glauca	White spruce	Sw
Picea mariana	Black spruce	Sb
Picea engelmannii	Engelmann spruce	Se
Pinus contorta	Lodgepole pine	Pl
Pinus banksiana	Jack pine	Pj
Pinus contorta x banksiana	Pine hybrid	Px
Larix laricina	Tamarack	Lt
Abies balsamea	Balsam fir	Fb
Abies lasiocarpa	Subalpine fir	Fa
Pseudotsuga menziesii	Douglas fir	Fd
Populus balsamifera	Balsam poplar	Pb
Populus tremuloides	Trembling aspen	Aw
Betula papyrifera	White birch	Bw

3.4 WHAT TO MEASURE AND WHY

Some variables need to be recorded at every single plot (Table 5). Additional variables will be measured in each of the circular subplots (Table 6) and the belt transect (Table 8). Please note that variables must be measured at all sites (planted or seeded) unless otherwise indicated.

Table 5. Variables that are measured at every Survival Assessment plot.

Component	Variable	Description	Completed
General Information: upon arriving at the plot	Line ID	This field should auto-populate within LiRA. Confirm that it has been filled with the correct value.	☐
	Segment ID	This field should auto-populate within LiRA. Confirm that it has been filled with the correct value.	☐
	Plot ID	This field should auto-populate within LiRA. Confirm that it has been filled with the correct value.	☐
	Treatment type(s)	Record the treatment that was applied. There may be more than one treatment.	☐
	Line width	To the nearest half-metre.	☐
Basic plot info: measured at the middle of the centre circular plot	Plot Location (UTM NAD83)	According to your GPS.	☐
	Plot photos	Four photos taken using the LiRA mobile application. One photo each down the length of the line, and one each of the forest to either side of the line (Figure 7).	☐
	Line orientation	To the nearest 5°.	☐
	Stand composition	Tree species and their estimated composition to the nearest 10%. E.g., 70% white spruce and 30% trembling aspen = Sw7Aw3.	☐
	Stand height	Estimate the height of the adjacent stand to the nearest metre.	☐

Table 6. Variables measured at each Survival Assessment circular subplot. Variables will be measured on all sites (planted and seeded) unless otherwise indicated. Note the different seedling selection criteria for detailed measurements on planted versus seeded sites.

Site	Variable	Description	Completed
All	Number of germinants	Number of trees with a single year of growth (Figure 8).	☐
	Number of multi-year trees	Number of trees with multiple years of growth (Figure 8).	☐
	Competition estimate	Percent non-tree cover within the plot, to the nearest 10% (Figure 9).	☐
	Competition type	Overtops the seedlings (O), is at the same level (L), or is below the seedlings (B).	☐
Planted	Survival estimate	Percent survival estimate of planted seedlings.	☐
Detailed measurements: planted sites		Planted sites: conduct detailed measurements on all planted seedlings and up to 5 multi-year seedlings from natural ingress. See Figure 10 for seedling selection protocol.	
Detailed measurements: seeded sites		Seeded sites: conduct detailed measurements on up to five seedlings with multiple years of growth. See Figure 10 for seedling selection protocol.	
	Seedling origin	For each tree measured, record whether it originated from planting or seed.	☐
	Seedling height	Height to tip of leader, to nearest 1 cm. When measuring conifers before Aug. 1, do not include current year's growth. After Aug. 1, include current year's growth. (For deciduous trees, always include current year's growth.) See Figure 11.	☐
	Leader length	Measure to nearest 1 cm. Before Aug. 1, do not include current year's growth. After Aug. 1, include current year's growth. See Figure 11.	☐
	Microsite	Treated (T) or untreated (U).	☐
	Condition code	See Table 7.	☐
	Mortality	The sum of trees that received the dead tree code.	☐

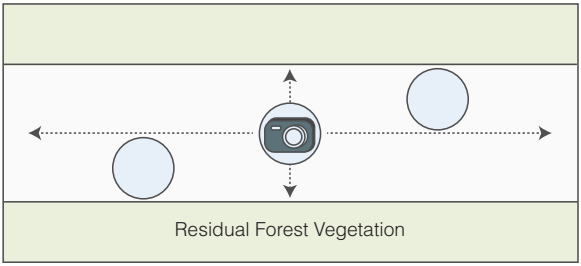


Figure 7. From the middle of the centre plot, take a photo down the length of the line in either direction, plus a photo of the forest on either side.

Figure 8. Visual differences between a germinant seedling and seedlings with multiple years of growth.

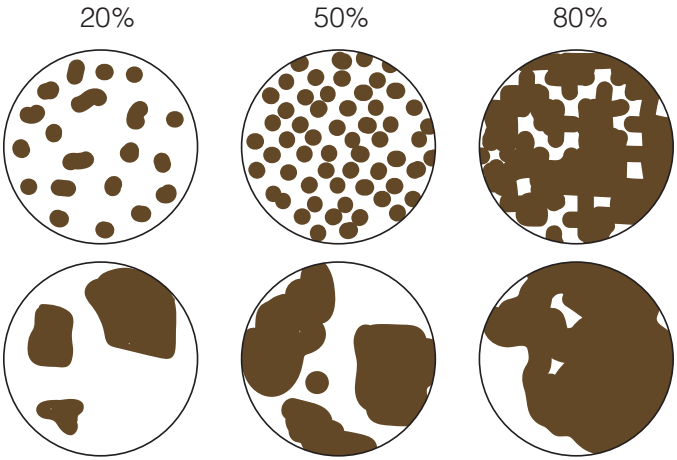


Figure 9. Visual guide to percent cover when it is dispersed (top) or aggregated (bottom).

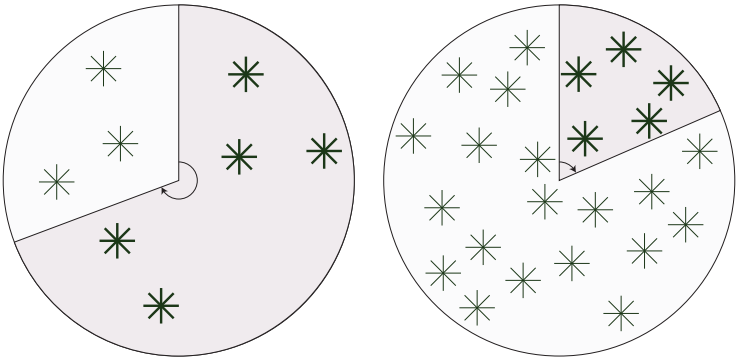


Figure 10. To select seedlings for detailed measurements, select the first five multi-year trees encountered by the plot's radius pointing North (0°) and rotating in a clockwise direction (e.g., the purple area in this Figure). If there are less than five trees within the plot, conduct detailed measurements on all of them.

Figure 11. Guide to measuring tree height and leader height.

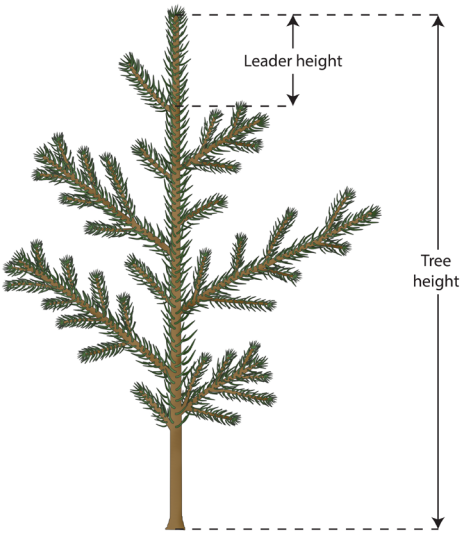


Table 7. Condition codes for seedlings.

Code	Description
0	Healthy
1	Insects
2	Disease
3	Browsing
4	Frost Heaving
5	Multiple Leader
6	Dead Top/Dieback
7	Dead Top/Dieback with new leader
8	Dying
9	Snow Press
10	Missing
11	Flooding
12	Poor Planting
13	Suppression
14	Dead Tree

Table 8. Variables to be measured at the Survival Assessment belt transect.

Site	Variable	Description	Completed
Planted	Stocking	Overall stocking of planted trees to nearest 5% and a visual estimate of density (stems/ha). See Figure 12.	☐
Planted	Survival	Overall survival of planted seedlings to nearest 5%.	☐
Planted	Photos (low-survival sites only)	**If survival of planted stock is low** (<70% winter-planted or <80% summer-planted): extract and photograph 3 dead seedlings to show root growth patterns.	☐
Seeded or natural regen	Stocking	Overall stocking of seedlings with multi-year growth (Figure 8) to nearest 5%.	☐
Seeded or natural regen	Stocking Comments	**If stocking is below 70%**, note poorly-stocked areas and indicate possible causes.	☐
Seeded	Density	Overall density of acceptable trees (stems/ha). See Section 3.3 for the definition of acceptable trees.	☐
All	Line use (human and/or wildlife)	None: no established path, no recent signs of access, any broken or cut vegetation is old. Low: trampled/broken vegetation, path can be followed but vegetation still present. Medium: clear path on some of the line but vegetation is still present in areas, bare earth in most areas, some removal/cutting of CWD. High: completely open line, soil eroded, rutting, woody debris cut and moved off path, access improvements may exist (e.g., bridges). See Figure 13.	☐
All	Coarse woody debris (CWD) cover	None: 0%; Low: 1–15%; Medium: 16–30%; High: >30%. See Figure 14.	☐

Figure 12. Visual guide to estimating stocking within the belt transect. Top: Fully stocked. Centre: 70% stocked. Bottom: 40% stocked.

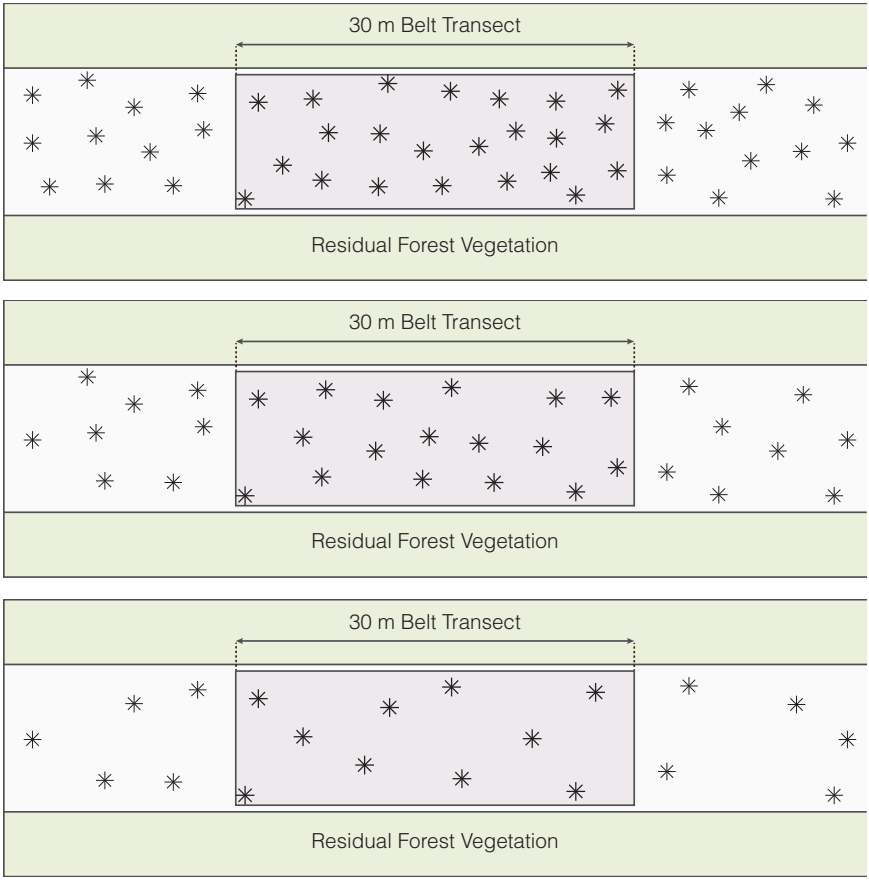


Figure 13. Visual comparison of lines with a) No use, b) Low use, c) Medium use, and d) High use.

Figure 14 Visual guide to estimating coarse woody debris cover as a) Low (0–15%), b) Medium (15–30%), or c) High (>30%).

4. GUIDE TO RECONNAISSANCE ESTABLISHMENT SURVEY

4.1 WHY ESTABLISHMENT SURVEY?

Establishment Surveys are the main tool to assess whether a site is on track to recovering to desirable vegetation and whether wildlife movement and human access concerns have been addressed.

4.2 ESTABLISHMENT SURVEY PROTOCOL

Based on the plan developed by the contractor, the reconnaissance Establishment Survey will be completed using one of the following methods:

- Aerial flight with visual assessment
- Aerial flight capturing high resolution photography or video followed by desktop analysis
- Desktop analysis of LiDAR or other remote sensing information
- Walking through the segments to visually assess them (small programs)

If an aerial flight with visual assessment is chosen, 50% of the programs should be filmed for auditing purposes including a complete recording of major lines.

Stratum/Strata: a combination of site type/moisture regime (e.g., mesic) and treatment (e.g., mounding). Hydric-mounded, xeric-screefed, and mesic-mounded-CWD are all examples of different strata.

4.3 WHAT TO MEASURE AND WHY

Before you conduct your survey, your supervisor should provide you with a map or other documentation delineating each line into segments based on the strata (moisture regime and treatment). As an aerial or desktop surveyor, you will record the following information for each line segment (stratum) (Table 9).

Minimum segment length

- There will be times where treatments and site types will change rapidly across the line. An individual line segment must be at least 50 m long to be considered separately in the survey.
- If small patches of a treatment (<50 m) are mixed in with large stretches of another treatment, stocking of the segment will be judged as a whole and the secondary treatment will be noted in the treatment codes.

Table 9. Variables that are recorded during the reconnaissance Establishment Survey.

Variable	Description	Completed
Summary info	Line ID, segment ID, and so on are recorded. Make any necessary adjustments to segment names or start and end points.	☐
Stocking	For low density, mesic, transitional and hydric sites: estimated stocking level (%) and a visual estimate of overall stocking density of acceptable trees (Section 3.3) on each line segment. For advanced regeneration sites: stocking level of woody species capable of reaching a height of 5.0 m.	☐
Line use (human and/or wildlife)	Presence or absence of wildlife and human access trails (see Figure 13).	☐
Coverage	Stocking density on each side of the line (Figure 15).	☐
Shadowing	Are shadows limiting assessment of part of the line?	☐

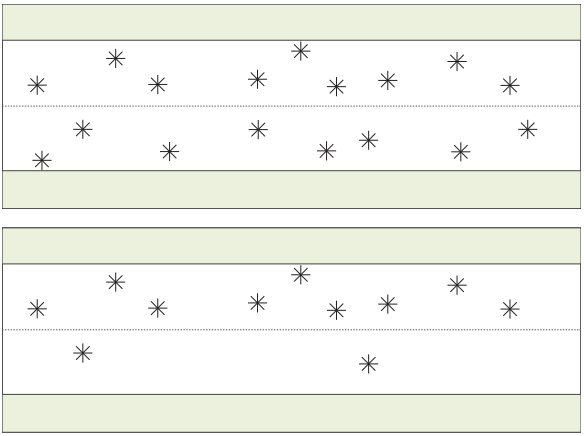


Figure 15. Examples of line coverage. Each asterisk represents a tree.
Top: even stocking on both sides of the line.
Bottom: uneven stocking and less than 50% stocking on one side of line.

Based on the information collected, each segment will be assigned either a pass, conditional pass or failure based on the below criteria (Table 10). If a line segment passes on all four criteria (stocking, coverage, line use, and shadowing), it is assigned a pass (SR). If it fails on one or more criteria, it is assigned a conditional pass (CSR) or failure (NSR) (Figure 16).

Table 10. Site-dependent requirements that must be met for a line segment to pass the reconnaissance Establishment Survey.

Criteria	Upland dry; Lowland low density treed	Upland and transitional; Lowland treed	Advanced regeneration sites
Stocking	> 50% stocked and ≥ 800 stems/ha acceptable trees **or** lower stocking but appropriate for the adjacent stand conditions.	> 70% stocked with acceptable trees with a minimum density of 1,000 stems/ha.	> 70% coverage of species capable of reaching 5.0 m height.
Coverage	At least 40% stocking of acceptable trees on both sides of the line.	At least 50% stocking of acceptable trees on both sides of the line.	At least 50% coverage on both sides of the line.
Line use	No visible wildlife trail or human access trail.		
Shadowing	No more than 20% of the line cannot be seen because of shadow.		

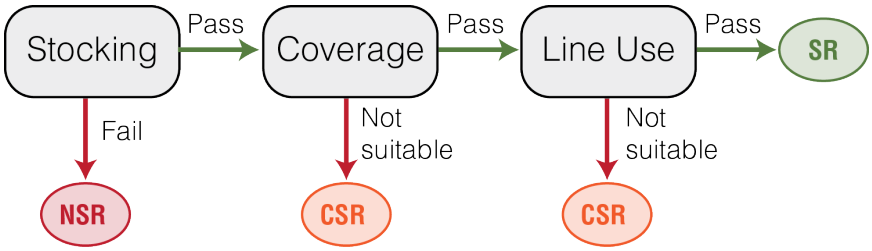


Figure 16. Flowchart for determining whether a line segment passes (SR), passes with conditions (CSR), or fails (NSR) the reconnaissance Establishment Survey.

5. GUIDE TO GROUND-BASED ESTABLISHMENT SURVEY

5.1 WHY GROUND-BASED ESTABLISHMENT SURVEY?

Objective:

- Serve as quality control for aerial reconnaissance surveys.
- Identify the reason for high variability in a stratum.
- Inform long-term monitoring and line trajectory calculations.

Survey Timing:

- Acceptable: June 1–September 31
- Optimal: July 31–September 15

Why these timing windows?

- Vegetation will be greened-up.
- Conifers will have finished most of their growth.
- Easier to measure in the field.

5.2 ESTABLISHING PLOTS

Plots will have previously been surveyed and marked as part of the Survival Assessment.

At each plot, you will place the following subplots:

- Three circular subplots (1.78 m radius), see Figure 17.
    - Outside plots: within 2 m of edge of seismic line.
    - All plots: 5 m apart from each other.
- 30 m belt transect extending in one direction from the plot centre, see Figure 17.
    - The same width as the seismic line.

The edge of a plot (e.g., the edge of the belt transect) should be at least 10 m from the end of the segment to buffer against any change in treatments in the adjacent segment (Figure 17).

When multiple plots are established in the same general location, plots must be 70 m from one another (Figure 18).

Why are the plots designed this way?

- The three circular subplots span the width of the line so that measurements capture conditions on both the sunny and shady sides of the line.
- The belt transects make overall estimates easier and more representative (e.g., stocking).

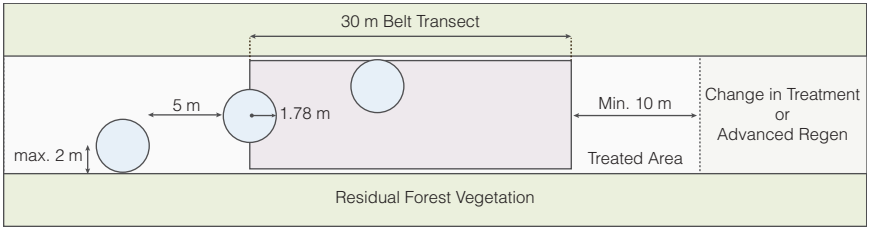


Figure17. Sample plot layout for ground-based Establishment Surveys.

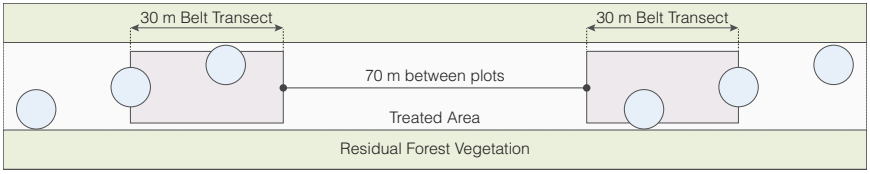


Figure18. Minimum distance between ground-based Establishment Survey plots when multiple plots are established at a single location.

5.3 ACCEPTABLE TREES

During the ground-based Establishment Survey, you will occasionally be required to limit your measurements to "acceptable trees." An acceptable tree is a tree that meets the following criteria:

- Seedling, sucker, or advanced regeneration
- Alive
- Has been on the site for at least 2 growing years (i.e., is not a germinant)
- Deciduous: height is at least 30 cm
- Coniferous: has a well-defined stem
- Is one of the tree species in Table 11

Table 11. List of tree species that are considered "acceptable."

Latin Name	Common Name	Code
Picea glauca	White spruce	Sw
Picea mariana	Black spruce	Sb
Picea engelmannii	Engelmann spruce	Se
Pinus contorta	Lodgepole pine	Pl
Pinus banksiana	Jack pine	Pj
Pinus contorta x banksiana	Pine hybrid	Px
Larix laricina	Tamarack	Lt
Abies balsamea	Balsam fir	Fb
Abies lasiocarpa	Subalpine fir	Fa
Pseudotsuga menziesii	Douglas fir	Fd
Populus balsamifera	Balsam poplar	Pb
Populus tremuloides	Trembling aspen	Aw
Betula papyrifera	White birch	Bw

5.4 WHAT TO MEASURE AND WHY

Some variables need to be recorded at every single plot (Table 12). Additional variables will be measured in each of the circular subplots (Table 13) and the rectangular belt transect (Table 15). Please note that variables must be measured at all sites (planted or seeded) unless otherwise indicated.

Table 12. Variables that are measured at every ground-based Establishment Survey plot.

Component	Variable	Description	Completed
General Information: upon arriving at the plot	Line ID	This field should auto-populate within LiRA. Confirm that it has been filled with the correct value.	☐
	Segment ID	This field should auto-populate within LiRA. Confirm that it has been filled with the correct value.	☐
	Plot ID	This field should auto-populate within LiRA. Confirm that it has been filled with the correct value.	☐
Basic plot info: measured at the middle of the centre circular plot	Plot Location (UTM NAD83)	According to your GPS.	☐
	Plot photos	Four photos taken using the LiRA mobile application. One photo each down the length of the line, and one each of the forest to either side of the line (Figure 19).	☐
	Stand composition	Tree species and their estimated composition to the nearest 10%. E.g., 70% white spruce and 30% trembling aspen = Sw7Aw3.	Only if a natural disturbance or harvesting event has occurred since the Survival Assessment.
	Stand height	Estimate the height of the adjacent stand to the nearest metre.	

Table 13. Variables measured at each ground-based Establishment Survey circular subplot. Variables will be measured on all sites (planted or seeded) unless otherwise indicated. Note the different seedling selection criteria for detailed measurements on planted versus seeded sites.

Variable	Description	Completed
Number of germinants	Number of trees with a single year of growth (Figure 20).	☐
Number of multi-year trees	Number of trees with multiple years of growth (Figure 20).	☐
Competition estimate	Percent non-tree cover within the plot, to the nearest 10% (Figure 21).	☐
Competition type	Overtops the seedlings (O), is at the same level (L), or is below the seedlings (B).	☐
Detailed measurements	Conduct detailed measurements of up to five of the tallest acceptable tree species in the plot that have multiple years of growth (i.e., are not germinants).	
Seedling height	Height to tip of leader, to nearest 1 cm. When measuring conifers before Aug. 1, do not include current year's growth. After Aug. 1, include current year's growth. (For deciduous trees, always include current year's growth.) See Figure 22.	☐
Leader length	Measure to nearest 1 cm. Before Aug. 1, do not include current year's growth. After Aug. 1, include current year's growth. See Figure 22.	☐
Microsite	Treated (T) or untreated (U).	☐
Condition code	See Table 14.	☐
Mortality	The sum of trees that received the dead tree code.	☐

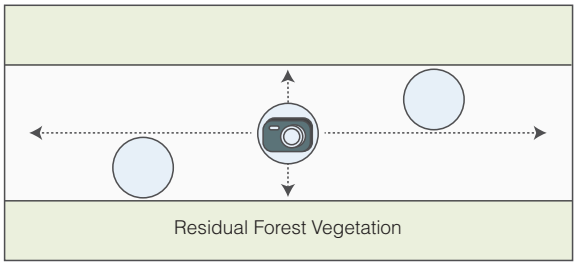


Figure 19. From the middle of the centre plot, take a photo down the length of the line in either direction, plus a photo of the forest on either side.

Figure 20. Visual differences between a germinant seedling and seedlings with multiple years of growth.

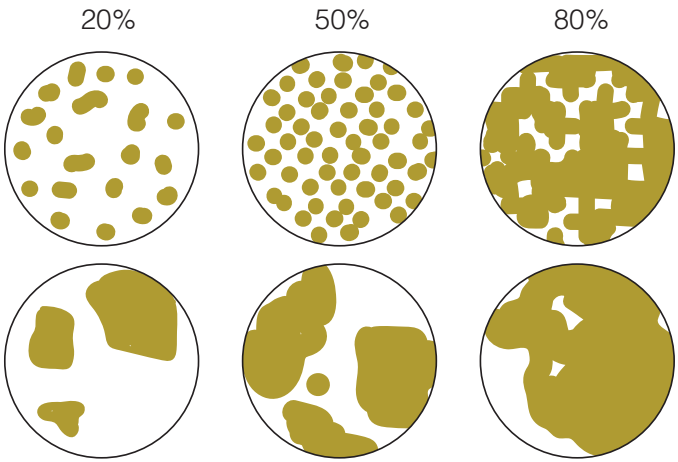


Figure 21. Visual guide to percent cover when it is dispersed (top) or aggregated (bottom).

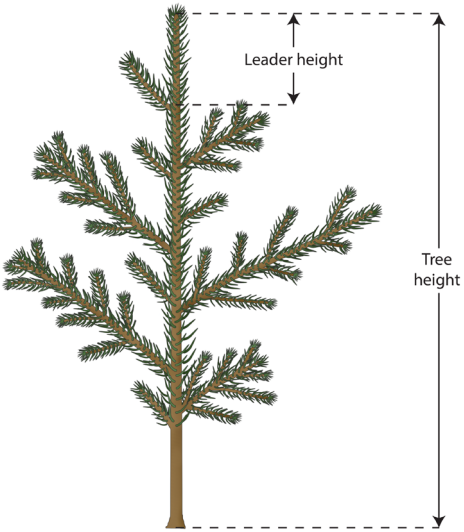


Figure 22. Guide to measuring tree height and leader height.

Table 14. Condition codes for seedlings.

Code	Description
0	Healthy
1	Insects
2	Disease
3	Browsing
4	Frost Heaving
5	Multiple Leader
6	Dead Top/Dieback
7	Dead Top/Dieback with new leader
8	Dying
9	Snow Press
10	Missing
11	Flooding
12	Poor Planting
13	Suppression
14	Dead Tree

Table 15. Variables to be measured at the ground-based Establishment Survey belt transect. Variables will be measured on all sites (planted or seeded) unless otherwise indicated. See Section 5.3 for the definition of acceptable trees (characteristics and species).

Variable	Description	Completed
Stocking	Overall stocking of acceptable trees to nearest 10% and a visual estimate of overall stocking density of acceptable treees. Only seedlings with multi-year growth should be counted towards this estimate (Figure 20).	☐
Stocking Comments	**If stocking is below 70%**, note poorly-stocked areas and indicate possible causes.	☐
Line use (human and/or wildlife)	None: no established path, no recent signs of access, any broken or cut vegetation is old. Low: trampled/broken vegetation, path can be followed but vegetation still present. Medium: clear path on some of the line but vegetation is still present in areas, bare earth in most areas, some removal/cutting of CWD. High: completely open line, soil eroded, rutting, woody debris cut and moved off path, access improvements may exist (e.g., bridges). See Figure 23.	☐
Line use – photo	Photograph evidence of wildlife or human use using the LiRA mobile application.	☐
Shrub cover	Total shrub cover estimated to nearest 20%.	☐
Palatable shrub cover	Estimate of palatable shrub cover as a percentage of total shrub cover, to the nearest 10% (see Table 16 for list of palatable species).	☐
Shrub browsing intensity	None: no signs of recent browsing Low: occasional signs of new browsing, most areas show no signs of browsing Moderate: browsing occurring through much of the belt transect, majority of palatable shrubs so some sign of browsing High: almost all shrubs so some signs of browsing, many shrubs have had almost all leaders browsed. See Figure 24.	☐
Coarse woody debris (CWD) cover	None: 0%; Low: 1–15%; Medium: 16–30%; High: >30%. See Figure 25.	☐

Figure 23. Visual comparison of lines with a) No use, b) Low use, c) Medium use, and d) High use.

Figure 24. Example of a heavily-browsed willow.

Figure 25 Visual guide to estimating coarse woody debris cover as a) Low (1–15%), b) Medium (16–30%), or c) High (>30%).

Table 16. Shrub species considered palatable by ungulates in the framework (adapted from Strong and Gates, 2006).

Common name	Latin name
Willow	*Salix* spp.
Trembling aspen	*Populus tremuloides*
Balsam poplar	*Populus balsamifera*
Wild prickly rose	*Rosa acicularis*
Saskatoon berry	*Amelanchier alnifolia*
Red-osier dogwood	*Cornus sericea*
Choke cherry	*Prunus virginiana*
Highbush cranberry	*Viburnum edule*
Bracted honeysuckle	*Lonicera involucrata*