Fundamentals of Natural Lodgepole Pine Regeneration and Drag Scarification

B.C. Ministry of Forests: Forest Renewal Section
Silviculture Practices Branch
The post-harvest survey procedures for estimating the likelihood of successful regeneration of lodgepole pine described in this booklet differ from the procedures recommended in the Forest Practices Code *Silviculture Surveys Guidebook* (1995). The new procedures in this booklet replace those described in the guidebook. The next guidebook revision will incorporate these procedures. A summary of procedural changes is as follows:

**Silviculture Surveys Guidebook (1995)**

1. Satisfactory seedbed meets minimum size of 50 cm
2. Cones are categorized and recorded into five classes
3. Number of cones present on satisfactory seedbed was recorded
4. The per cent area occupied by each suitable seedbed class was recorded
5. LFH depth was recorded in each plot
6. Recommends counting up to 35 cones

**Fundamentals of Natural Pl Regeneration booklet**

- Record per cent of suitable seedbed to a minimum of 1% of a 5 m² plot area (22 cm × 22 cm)
- Cones are categorized into only two classes—countable or not countable
- Not recorded due to ability of seed to move once it has been released from the cone
- The per cent of total suitable seedbed is recorded
- LFH depth not recorded. However, where organic seedbed is acceptable, depth should be checked.
- Recommends a minimum count of 50 countable cones
Acknowledgements

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Under the *Forest Practices Code of British Columbia Act*, Section 50 (a) in the Operational Planning Regulation states:

50. When proposing the regeneration method for the purposes of section 39 (2)(x), a person must,

(a) if natural regeneration is being considered, demonstrate to the district manager that natural regeneration will reliably reforest the area by the regeneration date specified in the prescription.

This publication provides a method for predicting the success of natural regeneration of lodgepole pine based on: key aspects of lodgepole pine reproductive biology; critical planning steps for natural lodgepole pine regeneration; and post-harvest assessment data collection. It also discusses drag scarification as one tool for possibly enhancing Pl regeneration.

I believe Pl naturals can reforest this area but I need good data to support this prescription.
Successful natural regeneration of any species has three basic requirements. An abundant supply of viable seed, a suitable seedbed for germination, and conditions suited to survival and growth. The prescription maker will never have certainty over all three requirements. However, there are some key considerations that can be used to help predict natural regeneration of lodgepole pine.

Serotinous vs Non-serotinous

Lodgepole pine is unique in that its seeds are frequently held in cones while on the tree until the scales are opened by high temperatures. This is called serotiny. Not all lodgepole pine trees are serotinous. Often younger lodgepole pine (e.g., <20 years old) will have cones that open on the tree. As well, serotiny may vary throughout the range of lodgepole pine. If there are any generalities about the occurrence of serotiny, they are related to the frequency of natural fire and location. Thus in areas where fire frequency is higher, the frequency of serotiny is higher, and vice versa. Also the frequency of serotiny tends to be higher the more northerly and/or easterly the location in the province. However, we do not have good local data to indicate where cones are serotinous and where they are less so. Therefore, it is important to gauge whether the cones remain closed within the stand or if they are open. If they are open, seed has likely been released making cone counts misleading. Temperatures of approximately 45°C are needed to open serotinous cones. This occurs during wildfire and when the cones are near the ground after harvesting. Because most of B.C.’s lodgepole pine have serotinous cones, it is possible to assess the amount of seed on a site by counting cones after the area has been harvested.

While much of the seed is released in the first year after harvest, some seed is released for a period of up to ten years after harvest. This allows for ingrowth. Weather conditions will play a large role in survival rates of seed over that period.
Planning Steps for Natural Regeneration of Lodgepole Pine

The following procedure was created for estimating the success of lodgepole pine regeneration. The procedure assumes a linkage between the number of cones on site, the number of seeds per cone, cone distribution, the amount of suitable seedbed, and a relationship between the number of seeds and a fully established seedling.

Pre-harvest
• Identify the area, determine the health, structure, growth and serotiny of the stand;
• Stratify and determine candidate areas for natural regeneration;
• In the silviculture prescription (SP) ensure there is a clear description of the feasibility and likelihood for successful natural regeneration when it is prescribed;
• In the SP and logging plan indicate that it is critical that harvesting result in a sufficient number of cones distributed throughout the site for successful regeneration. This may require an added clause that requires lopping and scattering of tops to promote better cone distribution.1

Post-harvest
• Stratify the block and survey;
• Determine whether or not to site prepare;
• Site prepare if necessary to provide adequate suitable seedbed or to reduce fire hazard;
• Monitor for regeneration success.

NOTE: Natural regeneration is traditionally patchy, therefore you may need to fill plant or control density once the regeneration has become established.

1 See Appendix 1 for examples of how to incorporate lop and scatter into the SP and logging plan.
NOTE: Please refer to the appropriate guidebooks as well as this reference when writing a silviculture prescription.
The success of natural regeneration can be influenced by logging practices, reducing regeneration costs significantly. A study\(^3\) comparing costs of planting to natural regeneration estimated savings between $340 to $730 per ha if natural regeneration was successful. The cost difference included topping stems on site over and above the normal harvesting costs to ensure an adequate seed source.

**Questions to ask about harvesting:**

What harvesting options do I have?
Can I log in any season or am I constrained somehow? – Winter logging may result in more cones left on site due to breakage, but it may also result in less ground disturbance.

Will I be processing at the stump or at the roadside? Will it matter? – Processing at the stump provides more cones on site but may leave slash too deep to allow successful germination and survival.

Are small mammals likely to be a problem with seed availability? If so, what can I do? – If this may be a problem, planting may be a better alternative, or harvesting could be delayed until after the small mammal population has peaked.

Will the presence of dwarf mistletoe limit my use of lodgepole pine? – If there is abundant mistletoe in surrounding forests, a border of an alternate species may be advisable.

**Harvesting – what can be done?**

\(^3\) D. Basaraba, Crestbrook Forest Industries Ltd., June, 1994, pers. comm.
Post-harvest Procedure

Post-harvest assessment

Now that the block has been harvested, I want to ensure that enough cones were left after logging and that there is a suitable seedbed for germination.

After walking through the block I still don’t feel completely comfortable going with natural regeneration. There doesn’t appear to be enough cones on suitable seedbed. I think the area should be surveyed.

I had better make this a priority so that if required, we can drag scarify before the cones release their seed.

Options

A detailed assessment may not be necessary for all blocks. When local knowledge and research strongly suggest an outcome, the prescription maker may wish to forgo any further assessment.

NOTE: Where local knowledge and research are limited, this approach may not be feasible. When a detailed assessment is required, the following systematic approach can be used.
Block Stratification

Stratify the block to provide accurate survey information.

Different factors will be important for stratification depending upon the geographic location of the block.

Some examples

Depressional areas

If depressional areas were not stratified out at the silviculture prescription stage, they should be now, as natural regeneration in depressions is often difficult due to thicker forest floor, more intense vegetation competition, colder soils, fewer pine cones and possibly less opportunities for the use of site preparation equipment. When either the number of cones or suitable seedbed are not in abundance, these areas will likely require planting.

Cone distribution

Due to the harvesting pattern, there may be distinct differences in cone distribution that warrant stratification. For example, when logs are full-tree harvested and yarded to the roadside, areas adjacent to the roadside may have abundant cones while areas within the block have fewer.
Slope and aspect

The effect of elevation, slope and aspect are area-specific and need to be considered based on local results and research.

- **IDFdk**
  - Interior Douglas-fir (dry/cool)
  - **South Facing**
    - Too hot and dry
  - **North Facing**
    - Cooler, more moisture

- **MSxv**
  - Montane Spruce (very dry/very cold)
  - **South Facing**
    - Adequate warming for seed expression and germination
  - **North Facing**
    - Cold, thick forest floor

Slope and steepness will affect the amount of heat retained on site. Steep south slopes can be very hot, while steep north facing slopes can be extremely shady and cool. Remember, depending upon elevation and latitude, this may either help or hinder your pine germination and survival. Thus slope and aspect may affect your stratification decisions both at the SP stage and possibly at the post-harvest survey stage.
The intent of the survey is to provide enough information to feel confident in following through with the prescription for natural regeneration. A plot density of 5 plots per ha is suggested (e.g., 20 by 100 m grid). Arrange the plots in such a way to provide good coverage of each predetermined standards unit or area stratified out at the time of the initial walk through. Some distinct areas may not become evident until after the survey is complete. Therefore, it is important to use the survey data to create post-survey stratification units where identified. Sort your data accordingly.

Sample plot size

Diagram of a plot – 1.26 m radius circle (5 m²).
What data to collect within each plot

Countable cones – what are they?
See the next page for a description of what makes a countable cone and how to record it. For each plot, an estimate of suitable seedbed is also recorded.

Percentage of suitable seedbed.
The first step in assessing seedbed is to define what is appropriate for your stratum. Once that has been done, record the percentage of suitable seedbed per plot. This can be done in a number of ways but a simple method is to use square grids as estimators. Here are some useful dimensions to estimate percentage of a 5 m² area.

1% = 22 cm × 22 cm
5% = 50 cm × 50 cm
10% = 71 cm × 71 cm
20% = 100 cm × 100 cm
50% = 158 cm × 158 cm

The number of cones on appropriate seedbed has not been included from earlier procedures because of the ability of seed to move once it is released from the cone. Instead of counting the number of cones on seedbed, use the information on the amount of suitable seedbed to aid in determining the likelihood of a seed finding a suitable germination medium.

REMEMBER: Make good notes regarding cone distribution and the amount of suitable seedbed between plots. This information will help in deciding whether to proceed with natural regeneration or to plant.
Countable Cones – as potential seed providers

Not counted

- Olive-coloured immature
- Small sealed cones less than 2.5 cm

Counted

- Closed cones brown or grey
- Less than half open

Not counted

- Grey punky
- Bases
- Fully open

Seed Potential

Count all countable cones per plot up to 50. If more than 50, you may wish to make an estimate and keep notes on the number of plots with heavy accumulations. It should be noted that timing of the survey is critical. Brown fully open cones may have contributed a significant amount of seed to the site. Cones usually open after the first warm/hot days of spring (April – June) depending on location. If your survey is after this period, you may wish to factor in what seed has been provided by the open brown cones. The cone survey is meant to provide information on seed available on site. Open cones may have been open on the tree or have been moved from where they opened making them less dependable as a seed source for the plot you are in. Remember the survey is meant to help you recommend natural regeneration as the preferred method. If there are plentiful brown cones that are fully open and the conditions appear good for germination, you may still feel confident in the success of natural regeneration. Remember that relative humidity can close cones that were once open. It is important to examine the cones to see if their scales can be opened easily. If so, they have been opened earlier and seed may have been lost. Fingers are not strong enough to break the serotinous bonds.

NOTE: Weather before the survey and timing of the survey need to be factored into your recommendations.
Seed Potential

To determine the seed potential for your block, collect a representative sample of countable cones from throughout the block.

**Closed cones**

4–5 cm cone 4 cm cone 3 cm cone

**Open cones**

When more than half of the cone is open, most of the seed is gone.

**Seeds**

Remember, seeds only remain viable for one season once out of the cone.

Filled seed

Collection procedure

Because there are only two classes of cones, counted and not counted, it is up to the surveyor to determine the value of the cones found on site to provide future seed. Past collections have shown that the number of seeds per cone is highly variable.

Therefore, it is suggested that a minimum of 30 cones of the most common colour and level of openness be collected from throughout the block. The number of filled seeds per cone can then be determined. That average can then be used in the estimation procedure detailed on page 19.

Collect the cones in labeled bags. In dry weather, a paper bag will work; in wetter conditions, use a ‘zip-lock’ style baggie to avoid seed loss. Label and handle the cones with care—try to avoid overheating as seeds may be released and lost prior to assessment. Be sure to account for any seed found at the bottom of the bag when calculating your average number of seeds per cone.

If concerned with variability of seed per cone between strata, collections can be made by stratum. For greater accuracy, cones can be sorted by colour or degree of openness. Collections can be customized for your local situation. The suggested method is seen as the base level to provide useful information.
Seed Potential (continued)

Seed removal

Because the cones you collected are serotinous, heat is required to open the cone and release the seeds. The key is to break the bond that holds the scales together. To do this, many approaches have been used. Some successful methods are listed below:

- Microwave for 1–2 minutes on high—more if needed. Be careful—the cones will be hot when removed.

**NOTE:** If left in too long, a strong 'pine cone' aroma, which may not be desirable, will fill your microwave and room. Thus experimentation to find the required time is suggested (i.e., beginning with times less than 1 minute).

- Placing in near-boiling water for 1 to 2 minutes and left to air dry. The seeds are collected once dry.
- Heating in a conventional oven at 350ºF for about 20 minutes. The cones will open slowly using this technique.
- Combinations of the above.

Counting the seeds

- Once open, knock the cone on its top to dislodge the seeds (be sure the scales are open).
- Cut into the fattened end of the seed to determine if it has a white endosperm, indicating a filled seed.
- Count all the filled seeds and divide by the number of cones to get the average seeds per cone.
Post-harvest Survey Procedures

Seed-to-seedling ratio

NOTE: Germinants look similar to *Polytrichum juniperinum* moss (Juniper haircap moss) without the red tips.

### Seed to 5-year-old seedling ratio (R1)

The study of natural regeneration has used the seed-to-seedling ratio as a means of predicting regeneration success. Climate, substrate, predation and other local factors will influence the success that seed have in becoming established seedlings. Local research, operational information, and studies reported in the literature may help choose an appropriate ratio (or range of ratios) for your block. See Appendix 2 for a starting point based on B.C. information.

Generally, once a seedling reaches five years old on site it can be counted on to survive.
Total number of stems versus well spaced

Number of seedlings to make one well-spaced seedling (R2)

Any initial estimate using a seed/seedling ratio results in an approximation of total stems per hectare. To predict whether there will be sufficient well-spaced stems per hectare, a ratio of total to well spaced is needed. Information from regeneration surveys for similar blocks will provide a useful range of well-spaced stems to total stems. Numerous pine regeneration surveys have indicated that four total stems are tallied for each well-spaced stem (4/1). This ratio could be used as a starting point. Local information should be used when available.
Post-harvest Survey Procedures

Definition and recording of suitable seedbed

Suitable seedbed

While seedbed conditions change and there are no assurances that a seed released from a cone will end up on the appropriate microsite, collection of information on suitable seedbed provides further confidence when making the decision whether to carry on with natural regeneration, with or without added site preparation.

Satisfactory seedbed varies by biogeoclimatic zone, site series, and in some cases, aspect. In some areas of the province, intact forest floor, if relatively thin, is considered a suitable seedbed. In other areas, exposed mineral soil may be required for adequate germination and survival. Results of preliminary research suggest that compacted forest floor may provide a more effective medium for germination and survival than uncompacted forest floor. Where available, use local research, operational trails, or observations to describe suitable seedbed for your block.

When unsure whether intact forest floor is suitable, use mineral or mixed mineral/forest floor as a default. In areas where intact forest floor is considered suitable, be sure to provide a maximum thickness.

Once you determine and record on the survey form what constitutes a suitable seedbed, estimate the percentage of the plot with those characteristics and record it in the appropriate column on the form. See page 12 for estimating tips. Suitable seedlot should only be tallied when it occupies a continuous area exceeding 1% (22 cm × 22 cm) of the plot area.

The amount of suitable seedbed should be considered when choosing the seed/seeding ratio. In some cases, suitable seedbed will provide conditions where relatively low seed/seeding ratios occur. In the same site with little suitable seedbed, much higher ratios should be used.

NOTE: In some cases drag scarification could be used to increase the amount of suitable seedbed by increasing the area of mineral or mixed mineral/forest floor. Thus a lower seed/seeding ratio would be appropriate and natural regeneration may be feasible if the seedbed is modified.
Estimation of well-spaced seedlings

The calculation of well-spaced stems per ha is not meant to provide exact stocking levels. Instead it is meant to provide an estimation of future stocking.

Recommended procedure by stratum:
Determine the average number of filled seeds per cone from the cone collection = S (p 15).
Determine the number of countable cones per ha (C/ha). Take the total number of countable cones, divide by the number of plots, then multiply by 2000 (plot multiplier for 5 m² plots) = C/ha.
Multiply C/ha by S to get the total filled seed/ha = S/ha. Calculate the percentage of the block with suitable seedbed (SS) = average for all plots within the stratum.
Choose a seed to five-year-old seedling ratio = R1 (Consider (SS) value, also see Appendix 2 for suggested ratios). Choose a total to well-spaced ratio = R2.
Estimated total stocking per ha (ETS) = S/ha / R1.
Estimated well-spaced stocking per ha (EWS) = ETS / R2.

From these compilations, one of the following reforestation decisions will usually be made.

<table>
<thead>
<tr>
<th>Seed</th>
<th>Seedbed</th>
<th>Prescription</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequate</td>
<td>Adequate</td>
<td>Adequate seed and seedbed is present. Manage for natural regeneration and monitor/survey as required.</td>
</tr>
<tr>
<td>Adequate</td>
<td>Inadequate</td>
<td>Adequate seed but inadequate seedbed. Prompt drag scarification followed by monitoring/surveys as required.</td>
</tr>
<tr>
<td>Inadequate</td>
<td>N/A</td>
<td>Inadequate seed. Plant or fill plant as required.</td>
</tr>
</tbody>
</table>

For completed examples, see Appendix 3.
Post-harvest Survey Procedures

Monitoring and follow-up

With any regeneration system, monitoring and follow-up is a critical component. While research has shown that a high proportion of the seed is released in the first year post-harvest, creating numerous germinants, ingress can occur for up to 10 years after harvest. Remember that germinants are very small (and look like individual moss stalks) and may not be readily observed for up to two years after germination. Thus, early evaluation of regeneration success may be conservative. In general, evaluation at five years after harvest will detect between 80 and 90% of the total final stocking. This may result in some sites being fill-planted that meet the minimum stocking at the time of planting. Because the stocking intent is to manage to targets, this should not limit the use of fill-planting when stocking is questionable.

Natural regeneration is a desirable option to manage lodgepole pine. It can be very cost effective, yet is somewhat unpredictable. The methodology presented in this document is meant to reduce that uncertainty and provide baseline data to which future stocking results can be compared.

At the time of the regeneration survey, it is suggested that the original cone and seedbed survey map be used to help stratify the block. Stocking results should be compared with the original cone and seedbed survey. Comments should be made on the relationships encountered. At that time the seed/seedling ratios should be revisited to check for their predictive capability. This feedback loop can then be used to create future prescriptions, hopefully with greater precision and confidence.
Drag scarification

When there are abundant cones on site and a lack of suitable seedbed, drag scarification is an option to create good germination medium.

The primary purpose of drag scarification is to provide mixing or partial scalping of the forest floor to increase the likelihood of seed finding suitable seedbed. It may also be useful to press cones closer to the ground, exposing the cones to the high temperatures required to open them. The distance above the ground that experiences these temperatures (45° C and up) varies depending upon location, but a rule of thumb is that the cones need to be within 40 to 50 cm of the ground.

Distribution – the myth of dragging

Dragging will not help distribute cones or seed to any great extent. There are two main reasons. First, dragging only moves cones a short distance from where they are encountered, usually less than five metres. Second, many cones may have already released a high proportion of their seed by the time the block is dragged, making cone movement fruitless (literally and figuratively).

The determination of whether dragging will help meet the natural stocking objectives is dependent on the amount of suitable seedbed present prior to dragging, whether there is adequate seed on site to warrant it, and whether dragging is able to create suitable conditions on the block. Some areas may be too rocky or too steep for safe and effective dragging.

Dragging should be done as soon as possible after logging to maximize its benefit for providing seedbed.

NOTE: Dragging in the second season post-harvest is for hazard abatement only—it is not recommended for site preparation.

The choice and size of drag must be matched to the site conditions. What follows are some of the parts used in making ‘typical drags.’ The combination you use will likely be unique based on local availability. Remember that the intent is to provide mixing and some scalping to increase germination and survival. What the drag is made of does not matter if it meets the site preparation objective.
Drag Scarification – The Parts

The following are descriptions of the various parts that make up a drag. The combinations and parts in use in B.C. vary widely. The ones described here have been used effectively and may be available in your area; ask around.

**Prime movers**
Both tracked and rubber-tired towing vehicles can be used depending upon the size of drag.

**V-bars**
The V-bar is seen to be the most efficient means of attaching either chain drags or drums. Spacing of attachments range from 245 cm apart with three chains, 150–180 cm for 4 settings, 90 or 120 cm with 5 settings, or closer with seven settings. A modification using telescoping arms on the V-bar allows for greater coverage but requires a larger prime mover and has less manoeuvrability.

**Links**
The choice of link size depends upon the forest floor depth and amount of slash. Each link can range from 8 to 55 kg (light to heavy chain).

**Dimensions:**
Grouser bars are bars welded to the chain link, either spirally across the middle of the anchor chain link (a), or to each side of the anchor chain link (b). Grouser bars are usually about 45 mm in diameter and between 60–80 cm in width.

Sharkfin drums are constructed as watertight units with four spiral rows of blades or fins welded to the drum surface. They require a swivel in the front and rear to allow them to rotate freely. Recent versions use a separate swivel attached to a fixed bracket on the drum to reduce breakage. Sharkfins are used to orient slash and expose mineral soil in thicker forest floor conditions.

**Dimensions:**
- Diameter: 60 cm
- Length: 120 cm
- Drum wall: 12 mm
- Capacity: 275 l
- Fin ht: 15–20 cm
Configurations
The options are almost limitless. However, there are some rules of thumb. When using sharkfin drums, be sure the rear drums rotate outwards to prevent tangling.

Here are some common configurations:

BEWARE: Dragging beyond the first year post-harvest could uproot and kill established germinants. Drag only within one year post-harvest.

Summary
In 1995 dragging was used sparingly (<8000 ha within B.C.) as a form of site preparation. This may have been a consequence of a greater reliance on planting to meet administrative requirements sooner (e.g., free growing). It has been traditionally a relatively inexpensive treatment (1995 costs ranged from $70 to $200/ha). Its continued use will depend upon managers confidence levels in prescribing natural regeneration.

Dragging has the capability of creating a suitable germination medium for lodgepole pine. It is also a potential tool to reduce slash accumulations as part of a fuel management plan. Its use should be based on local knowledge of what constitutes a suitable seedbed and should not be relied upon to spread cones.
Appendix 1 – Lop and scatter wording

If you are planning on using a lop and scatter clause in your silviculture prescription (SP) there are two options:

**Option one – the need for lop and scatter is known prior to harvest.**
- You plan to lop and scatter tops to provide adequate cone coverage. You then record in the harvesting method section of the SP, something like this:
  To promote adequate cone distribution, tops should be cut off and scattered within the setting during harvesting.
- In the regeneration section of the SP add the following:

<table>
<thead>
<tr>
<th>treatments</th>
<th>alternate treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regeneration</td>
<td>Regeneration</td>
</tr>
<tr>
<td>SU Method Planned species Planned stock type Est. sph (k)</td>
<td>SU Method Planned species Planned stock type Est. sph (k)</td>
</tr>
<tr>
<td>A Natural Pl (Sx)</td>
<td>A Fill plant Pl PCT 1+0 0.7</td>
</tr>
</tbody>
</table>

**Special considerations**
To ensure adequate cone distribution lop and scatter tops subsequent with harvesting.

This information is also required in the logging plan.

**Option two – lopping and scattering of tops may be required but should be assessed during harvest.** For example, in a winter block there is expected to be sufficient cone distribution due to branch breakage during harvesting in cold weather. Warmer conditions may result in fewer than expected cones being left on site. At the time of harvest it may be appropriate to create a lop and scatter provision and amend the logging plan to reflect the need for enhanced cone distribution.

- In this scenario, do not include a lop and scatter clause in the harvesting method section of the SP.
- In the regeneration section of the SP, however, add lop and scatter as an alternate treatment.

<table>
<thead>
<tr>
<th>treatments</th>
<th>alternate treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regeneration</td>
<td>Regeneration</td>
</tr>
<tr>
<td>SU Method Planned species Planned stock type Est. sph (k)</td>
<td>SU Method Planned species Planned stock type Est. sph (k)</td>
</tr>
<tr>
<td>A Natural Pl (Sx)</td>
<td>A Fill plant Pl PCT 1+0 0.7</td>
</tr>
</tbody>
</table>

**Special considerations**
Natural regeneration is planned. Logging during the winter should provide adequate cone distribution.

If cone distribution appears inadequate to promote natural regeneration lop and scatter tops concurrent with harvesting. Amend the logging plan accordingly.

The logging plan would have to be amended to add the lop and scatter clause if it were seen to be necessary during the harvest phase.
# Appendix 2 – Seed to 5-year-old seedling ratio table (R1)

Fill in this table as information becomes available – consult your Regional Forest Sciences Section for local results.

<table>
<thead>
<tr>
<th>BEC site series with modifiers</th>
<th>Seedbed¹</th>
<th>Ratio (R1)</th>
<th>Reference/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBSdk mesic and drier (flat sites)</td>
<td>FF &lt;4 cm</td>
<td>150/1</td>
<td>Brian Walker Fraser Lake Sawmill (pers. com. 9/94)</td>
</tr>
<tr>
<td>SBSdk north and south slopes and wetter site series</td>
<td>MS, MMO</td>
<td>~400/1</td>
<td>as above</td>
</tr>
<tr>
<td>ESSF</td>
<td>n/a</td>
<td>n/a</td>
<td>as above</td>
</tr>
<tr>
<td>SBPSxc mesic (zonal)</td>
<td>MS, MMO</td>
<td>45/1</td>
<td>Ordell Steen, Forest Sciences preliminary research results (1/96)</td>
</tr>
<tr>
<td>SBPSxc mesic (zonal)</td>
<td>FF &gt;2 cm</td>
<td>92/1</td>
<td>as above</td>
</tr>
<tr>
<td>SBPSmk mesic (zonal)</td>
<td>MS, MMO</td>
<td>73/1</td>
<td>as above</td>
</tr>
<tr>
<td>SBPSmk mesic (zonal)</td>
<td>FF &gt;2 cm</td>
<td>187/1</td>
<td>as above</td>
</tr>
<tr>
<td>MSxv mesic (zonal)</td>
<td>MS, MMO</td>
<td>56/1</td>
<td>as above</td>
</tr>
<tr>
<td>MSxv mesic (zonal)</td>
<td>FF &gt;2 cm</td>
<td>309/1</td>
<td>as above</td>
</tr>
<tr>
<td>MSDK mesic and drier</td>
<td>MS, MMO, FF 0–3 cm</td>
<td>~100/1</td>
<td>John Przeczek, Interior Reforestation Co. Ltd. (pers. com. 9/94)</td>
</tr>
</tbody>
</table>

Codes for appropriate seedbed – FF = forest floor (with depth in cm); MS = mineral soil; MMO = mixed mineral soil and organics; n/a = not applicable.
Calculation procedure – EXAMPLE 1

Block size 25 ha. The block is located in the Montane Spruce (dry/mild) MSdm2; it was summer logged with a feller buncher and processed at the road edge.

Stratum A (22 ha) – Mesic site series, gentle south slope, cones relatively well distributed throughout.

Stratum B (3 ha) is composed of depressional areas and has been prescribed for planting. This area was not surveyed.

Survey summary (see summary table on page 29)

- Total number of plots = 110
- Total number of countable cones in all plots = 3300
- Total number of countable cones per plot = $\frac{3300}{110} = 30$ countable cones per plot
- Total number of countable cones per ha (C/ha) = $\frac{3300}{110} \times 2000 = 60\,000$ countable cones per ha
- Total filled seed per cone = 16 (480 seed from 30 cones)
- Total filled seed per ha (S/ha) = $60\,000 \times 16 = 960\,000$ seeds per ha
- Proportion of block with suitable seedbed = 27% (suitable seedbed defined as forest floor less than 3 cm, mixed mineral and mineral).
- R1 is estimated to be 100 (based on local knowledge and extrapolation of data from other MS subzones). This ratio is relatively low for this area and was chosen due to the high proportion of suitable seedbed throughout the block.
- R2 is 5/1 from local regeneration survey information.

ETS (estimated total stocking) = $960\,000/100 = 9600$ total stems per ha

EWS (estimated well-spaced stocking) = $9600/5.0 = 1920$ stems per ha

Stratum A: From our survey results it appears that there is sufficient seed and seedbed on the block to stay with natural regeneration as our preferred alternative. The stocking calculation suggests the site may exceed maximum density values (approx. 9600 sph). The block will be surveyed two years prior to the regeneration delay date to determine stocking status. Spacing may be prescribed at that time.

Map

A map should accompany any survey report showing stratification, plot locations, and cone density. Different shapes can be used to indicate relative cone abundance. For example, a square would indicate abundant cones (to be defined for each block)(e.g., >20), a triangle, an intermediate number of cones (e.g., 5–19) and a circle as too few cones (e.g., >5). Another method is to use a circle with the total number of cones within the circle.

Note that due to the calculation process involved in deriving EWS, it is possible that the EWS value may exceed the target stocking standard (TSS) for the site. In this example, the TSS in the silviculture prescription would be 1200 well-spaced stems per hectare. The important point is the interpretative value of EWS. In this example, the EWS indicates that there is a good potential to manage towards TSS with natural regeneration.
Appendix 3 – Completed survey examples

Map (continued)

Shading or colouring can be used to customize maps to aid interpretation. The percentage of suitable seedbed can be shown also, either in brackets or under the total cone number separated by a /.

This technique should never be used to replace an initial walk through and stratification before survey. However, it can be a useful approach when combined with consideration of written observations of conditions between plots to highlight areas of potential concern, confirm stratification, and for comparison of predicted, versus actual outcome in later surveys.
Appendix 3 – Completed survey examples

## Cone and Seedbed Survey Card

<table>
<thead>
<tr>
<th>Plot no.</th>
<th>Distance/ direction (degrees)</th>
<th>Countable cones</th>
<th>Suitable seedbed %</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20 m/100</td>
<td>34</td>
<td>45</td>
<td>one branch with numerous cones, lots of good seedbed</td>
</tr>
<tr>
<td>2</td>
<td>20 m/100</td>
<td>23</td>
<td>22</td>
<td>most of the cones are brown and closed</td>
</tr>
<tr>
<td>3</td>
<td>20 m/100</td>
<td>33</td>
<td>15</td>
<td>mainly thick duff -</td>
</tr>
<tr>
<td>110</td>
<td>20 m/100</td>
<td>39</td>
<td>20</td>
<td>mixed mineral, abundant brown/closed cones</td>
</tr>
</tbody>
</table>

### Suggested summary table

<table>
<thead>
<tr>
<th>Block-stratum (size)</th>
<th>Total no. of plots</th>
<th>Total counted cones (average per plot)</th>
<th>Cones per ha (C/ha)</th>
<th>Number of filled seed/cone (S)</th>
<th>Seed/ha S/ha (000)</th>
<th>Average % suitable seedbed</th>
<th>Seed/seedling ratio (R1)</th>
<th>Estimated total stocking per ha (ETS)</th>
<th>Estimated total to well-spaced stocking (R2)</th>
<th>Estimated well-spaced stocking (EWS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stratum A (22 ha)</td>
<td>110</td>
<td>3300</td>
<td>60 000</td>
<td>16</td>
<td>960</td>
<td>27</td>
<td>100</td>
<td>9600</td>
<td>5/1</td>
<td>1920</td>
</tr>
</tbody>
</table>
Appendix 3 – Completed survey examples

Calculation procedure – EXAMPLE 2

Block size 25 ha. The block is located in the Sub-Boreal Pine-Spruce (moist/cool) SBPSmk on a gentle north aspect. It was winter logged using a feller buncher and processed at the road edge. The cones were relatively well distributed throughout the block.

The block is homogeneous enough to be classed as a single stratum.

Survey summary

• Total number of plots = 125
• Total number of countable cones in all plots = 1960 (range from 0 to 19 per plot) countable cones
• Total number of countable cones per plot = 1960/125 = 15.25 countable cones per plot
• Total number of countable cones per ha (C/ha) = 15.25 \times 2000 = 30 500 countable cones per ha
• Total filled seed per cone = 15 (452 seed from 30 cones)
• Total filled seed per ha (S/ha) = 30 500 \times 15 = 457 500 seeds per ha
• Proportion of block with suitable seedbed = 5% (suitable seedbed defined as duff less than 1 cm, mixed mineral and mineral)
• R1 is 200. This ratio is relatively high and was chosen due to the low proportion of suitable seedbed throughout the block and early research information.
• R2 is 4/1 from local regeneration survey information.

ETS (estimated total stocking) = 457 500/200 = 2288 total stems per ha

EWS (estimated well-spaced stocking) = 2288/4.0 = 572 sph

If the area were drag scarified, it is estimated that the suitable seedbed would increase to 35% and that a seed/seedling ratio of 100 would be appropriate. The calculations are as follows:

ETS (estimated total stocking) = 457 500/100 = 4575 total stems per ha

EWS (estimated well-spaced stocking) = 4575/4.0 = 1143 sph

From our survey results it would appear that natural regeneration would not even achieve minimum stocking standards (MSS) without altering the seedbed. When a reduced seed/seedling ratio is used, assuming drag scarification will provide an increase in suitable seedbed, the estimated well-spaced stocking nears the target. We prescribe prompt drag scarification this growing season prior to seed release using a medium weight chain drag. Resurvey at year 5. If stocking is not sufficiently above the MSS, fill plant with suitable numbers.