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Silviculture Note 30

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The DFP Method of Stocking Assessment

The purpose of this extension note is to provide a brief overview of the Deviation From Potential (DFP) method of stocking assessment.

Introduction

Adequate re-stocking of harvested areas is essential for sustainable forest management.[1] Stocking can be defined as the degree of site occupancy.[2] Typically, an area is considered well-stocked when trees fully occupy the site. Many authors have studied stocking and created alternative measures of it.[3]

Three measures are used by silviculturists in British Columbia (BC) to assess stocking. The most widely used measure – well-spaced trees per hectare – is employed in young, even-aged stands. To assess stocking in uneven-aged stands, BC silviculturists estimate crop tree density in four tree size classes. In stands with a high level of mature tree retention, crop tree basal area per hectare often provides the measure of stocking. In BC, arguably the most important use of these measures is to specify the minimum level of stocking that is legally required following harvest. That is, these three measures are used to set stocking standards. To estimate achieved stocking, a standardised survey procedure (e.g., the free-growing survey, multi-layer survey, or basal area [intermediate cut] survey) is followed to ensure that the stocking statistic is calculated in a manner consistent with the stocking standard.[4]

The well-spaced density method (comprising the statistic well-spaced (or free-growing) trees per hectare, the survey procedure (stocking and free-growing surveys), and the associated stocking standards) is suitable for use in uniform young stands, like those regenerated following clearcutting (Figure 1A). The multi-layer method is suitable for use with the single-tree selection silvicultural system. The basal area method is suitable for use in uniform older stands, like those that have been thinned (Figure 1B). However, none of these methods work well in heterogeneous, partially cut areas.

Problems in Complex Stands

A high degree of within-stand variation in the size and density of retained trees is often created when beetle-infested trees are salvaged from a mixed species stand (Figure 1C and 1D). When used in these stand conditions, the three currently available methods can provide unreliable indications of stocking for the following reasons.

1. The well-spaced density method ignores (or underestimates) the impact of mature retained trees.
2. The multi-layer method treats all trees with diameter (dbh) ≥12.5 cm as equal, regardless of their size.
3. The basal area method ignores saplings and allows plots with high basal area to mask the presence of plots with low basal area.
4. All three methods ignore the impact of those retained trees that have no commercial value.
5. With all three methods stocking is indicated by the average of plot basal areas or tree counts. These averages only provide a reliable measure of stocking if the stand has been stratified into homogeneous areas, something that is operationally difficult in stands with a complex, irregular structure.[5]

British Columbia
Ministry of Forests

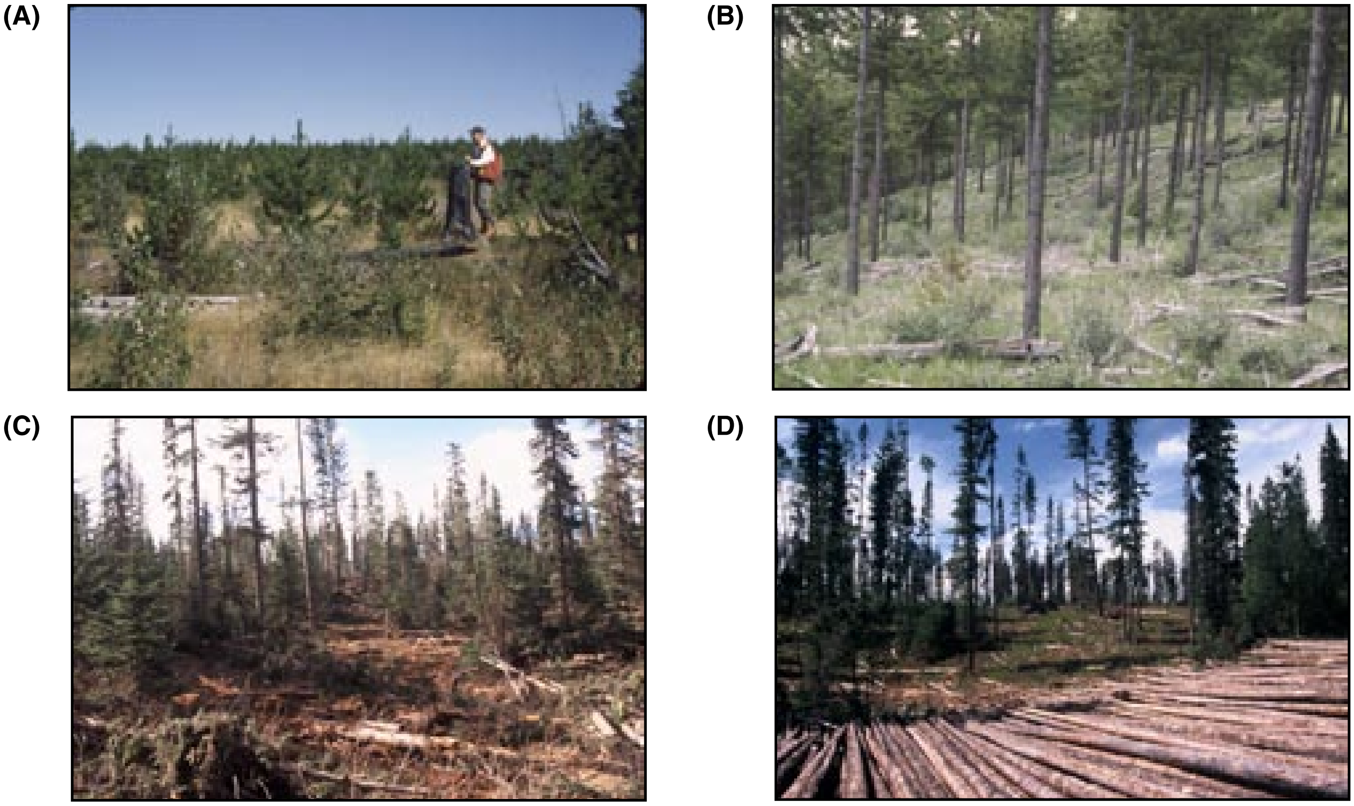

Figure 1. The stocking assessment method must suit the stand conditions. The well-spaced density method is well-suited for young, even-aged stands (A)**.** The basal area method is well-suited to stands with uniform retention of larger trees (B). The DFP method is well-suited to spatially and structurally complex stands (C and D).

In heterogeneous stands the unreliable stocking assessment produced by the three widely used methods is a significant problem. Partially cut areas are sometimes shown as adequately stocked when in fact they are not (and vice versa). The need for treatments (e.g., fill-planting) is sometimes signalled when in fact they are not necessary (Figure 2). In other cases where treatments are in fact required, the need is not always identified. Thus, in general, the three methods available for use in heterogeneous stands provide an unreliable basis for managing these stands, and stocking standards based on these methods provide unreliable protection for the timber resource.[6]

With funding by the Government of Canada through the Mountain Pine Beetle Initiative, a new method of stocking assessment – the DFP method – was developed. DFP is a new measure of site occupancy with which stocking can be assessed in stands with long-term retention, especially those with a complex residual structure.

Figure 2. Foresters need reliable methods of assessing stocking to guide reforestation activities, such as the tree planting shown here.

DFP – The Concept

The DFP method of stocking assessment recognises two stand components: overstorey trees (those with dbh ≥12.5 cm) and understorey trees (dbh <12.5 cm). DFP focuses on the future yield that will be produced by the understorey component. The concept underlying DFP is that a given understorey tree density results in a certain departure from potential understorey yield and the magnitude of departure is mediated by overstorey amount.[7]

To calibrate the concept model, predictions of the stand growth simulators TIPSY and TASS were used to relate current understorey density to future yield.[8] As understorey density increases, future yield increases rapidly and then levels off (Figure 3A).[9] TASS predictions, and published research on the growth impact of retained overstorey trees, were used to relate overstorey basal area to understorey yield reduction. As overstorey basal area increases, understorey yield potential decreases (Figure 3B).[10] These two relationships were combined (Figure 3C). DFP is given by the resulting relationship of future understorey yield to both current understorey density and current overstorey basal area (Figure 3D). Because DFP is constructed from these fundamental relationships, DFP provides a solid biological basis for stocking assessments and standards. The data, methods, and results of fitting the DFP model are presented in more detail in other documents.[11]

DFP ranges from 0 to 1. A DFP of 1 at a sample point indicates that the sample point is completely unstocked, no site resources are utilised by trees, and all of the growing space is available. This situation occurs when

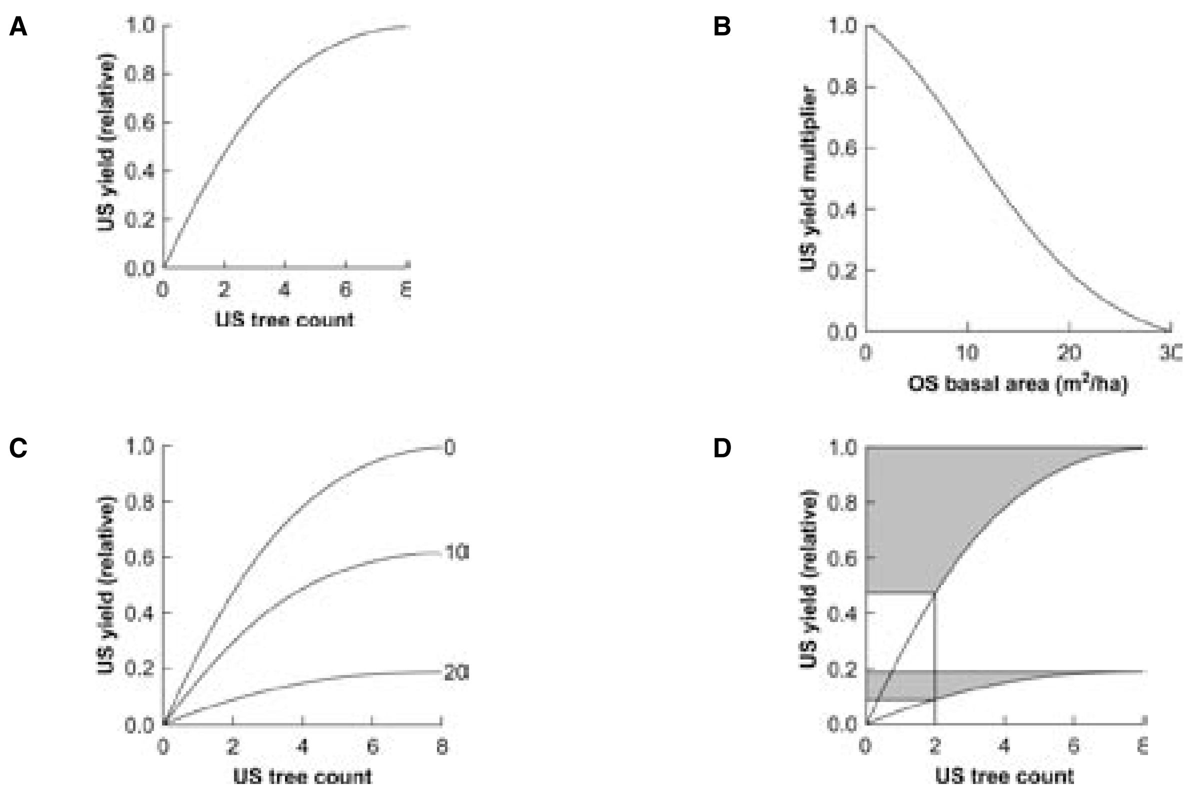

Figure 3. The yield relationships underpinning DFP. The relationship between the number of well-spaced acceptable understorey (US) trees in the survey plot (US tree count) and the future yield of the US component in the absence of overstorey (OS), expressed on a relative (0–1) scale (A). The relationship between OS basal area and US yield impact, expressed as a US yield multiplier (B). These two relationships are combined to relate future US yield to current US tree count and current OS basal area. This combined relationship is demonstrated for three levels of overstorey: 0 m^2/ha, 10 m^2/ha and 20 m^2/ha (C). DFP is the difference, on this relative scale, between expected US yield and the potential US yield as limited by current overstorey basal area. For example, the DFP with 2 US trees and no overstorey is 0.52 (1.0–0.48, upper shaded area), while the DFP with 2 US trees and 20 m^2/ha overstorey is 0.10 (0.19–0.09, lower shaded area).

there are neither overstorey nor understorey trees in the vicinity of the sample point. A DFP of 0 indicates that the sample point is fully stocked, there is no unoccupied growing space, and adding seedlings will not add to future yield. This situation occurs when there is 30 m^2/ha of overstorey, or eight well-spaced crop trees in the regeneration plot, or combinations of overstorey and understorey trees that completely occupy the site. Intermediate values of DFP indicate intermediate degrees of stocking. For example, a DFP of 0.4 indicates a lot of vacant growing space. Understorey yield will fall below potential. The loss (the "deviation from potential") is 40% of the yield that would be produced in a clear-cut with optimum seedling density.

Data Collection

The surveyor in the field obtains the DFP at a sample point by first measuring with a prism overstorey tree basal area around the sample point (Figure 4). Next, the surveyor counts the number of well-spaced (or free-growing) trees in a 3.99 m radius regeneration plot centred on the sample point. DFP is read off a simple table based on the observed basal area and tree count at the sample point. After the survey, mean DFP is computed for the stratum. Typically, stocking in the stratum is assessed in terms of mean DFP.[12] Though it is not required to calculate DFP, users are strongly advised to collect additional information on the overstorey, including observations on overstorey tree species, size, form, health, and vigour.

Figure 4. The DFP at a sample point is determined by the basal area per hectare around the sample point and the tally of well-spaced trees in a regeneration plot centred on the sample point.

Applications

DFP can be used to assess the current level of stocking, the stocking expected following various treatments (such as harvesting, brushing, and planting), and the gain anticipated from a treatment. This information can help describe stand condition, analyse treatment options, and guide the location and intensity of treatments. DFP can provide insight into the yield implications of a given understorey density.

DFP can be used to specify a stocking standard in numerous ways.[13] One way that appears to have wide applicability is to specify a set of three separate requirements:

1. a standard for understorey crop tree stocking,
2. a standard for understorey species composition, and
3. a standard for overstorey timber quality.

Several groups are experimenting with this format for DFP-based stocking standards with minimum requirements set at the following levels:

1. stratum mean DFP ≤0.2,
2. understorey trees of preferred species ≥50% of all tallied understorey crop trees, and
3. overstorey basal area ≥80% desirable timber quality.

On sites with reduced stockability, in locations where non-timber goals dominate, and otherwise where situations warrant, different minimum levels are appropriate.

Aligning the Measure to the Goal

In most partial cut stands in BC, a generally accepted goal for reforestation is to achieve the understorey crop tree density and distribution required to capture the residual volume growth potential of the site. With DFP, understorey crop tree density and distribution is evaluated in terms of its impact on volume production. With this formulation, the stocking measure directly relates to the timber goal. The short-term result (understorey density) is evaluated in terms of its impact on the long-term goal (timber production). Thus, DFP provides a better basis for aligning reforestation actions to the timber goal. When guided by DFP, seedlings are only required where they will contribute to timber production.

Scope, Limitations, and Cautions

The DFP method is designed to be quick, inexpensive and generally applicable over a wide range of sites and stands. The method can be characterised as robust but not precise. To obtain more accurate yield predictions, growth and yield model simulations are recommended. The method is calibrated for typical stand and site conditions in the interior of BC. It is not calibrated for coastal sites, parkland sites, or other special sites with reduced stockability. Many factors are known to impact the accuracy of DFP including variation in understorey tree size, spatial arrangement, and species composition; overstorey tree size, vigour, crown condition, spatial location, and species composition; and survey parameters such as minimum inter-tree distance.[14]

By itself, DFP does not distinguish between desirable and undesirable retained overstorey trees. Additional observations on the overstorey are required to make this assessment (see **Data collection**). A small DFP indicates that adding seedlings will not add to volume production; it does not confirm that whole stand volume and value growth is optimal, all management objectives will be met, or that the stand is well-managed.

Improper partial cutting can result in areas stocked with damaged, diseased, slow-growing trees whose low residual volume and value precludes further harvest.[15] However, when well executed, partial cutting can salvage value from beetle-attacked stands, conserve green trees for future harvest, and create conditions that meet biodiversity, visual quality, and habitat objectives. Good partial cutting requires, among other things, good forest, landscape, and stand level planning, and well trained staff backstopped by appropriate government regulation, monitoring and enforcement. When used in this setting, DFP provides a flexible decision-support tool that can contribute to sustainable forest management.

More Information

For more information, contact one of the project contributors, or the project leader, Pat Martin, at tel: 250-356-0305, fax: 250-387-2136, or email: Pat.Martin@gems8.gov.bc.ca. Project documents are available on the project web site, currently located at: http://clients.tmnewmedia.com/MPBI/index.htm.

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Endnotes

1 See, for example, Forest Stewardship Council (2004) and Sustainable Forestry Initiative (2004).
2 Other definitions of stocking include 1) a measure of the proportion of the area actually occupied by trees and 2) stand density expressed as a percent of a reference density that reflects the management objective.
3 For a sampling of the extensive literature on this topic, see Bickford et al. (1957), Gingrich (1967), Ernst and Knapp (1985), Long (1996), Lutze et al. (2004), and O'Hara and Gersonde (2004). Many relative density measures, often used in stocking assessment, have been developed (e.g., Reineke 1933, Drew and Flewelling 1979, Curtis 1982, and Stout and Nyland 1986).
4 See BC Ministry of Forests (2000) for stocking standards and BC Ministry of Forests (2002) for standardized surveys.
5 For a more complete discussion of the root causes of unreliable stocking assessments, see BC Ministry of Forests (2004) and Martin et al. (2005 a, b).
6 See endnote 5.
7 For further discussion on evaluating regeneration in terms of its impact on future yield, see Staebler (1949), Bickford et al. (1957), Clutter et al. (1983, p. 64), Matney and Hodges (1991), and Lutze et al. (2004).
8 TASS is the Tree and Stand Simulator. TIPSY is the Table Interpolation Program for Stand Yields. Refer to Mitchell (1975), Mitchell and Cameron (1985), and DiLucca (1999) for more information on these models.
9 For information on the relationship of well-spaced tree density to future yield, see Bergerud (2002) and Martin et al. (2005 a, b).
10 For a recent review of the impact of retained trees on the long-term, understorey yield, see Temesgen et al. (2004).
11 For a description of the concept and the initial calibration of the DFP model, see Martin et al. (2005a). The initial model was subsequently revised. This revision produced the current version that is termed the second approximation DFP model, as described in Martin et al. (2005b).
12 However, some users also assess the distribution of DFP values. In the Rocky Mountain Forest District, the percent of the surveyed area with DFP ≤ 0.2, $0.2 < DFP \leq 0.4$, and $DFP > 0.4$ is also evaluated (Przeczek 2004).
13 See the DFP training workbook for more discussion (BC Ministry of Forests 2004).
14 For a more complete discussion, see Martin et al. (2005a, b).
15 For discussion, see Oliver and Larson (1996, pp. 295–314).

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