Extension Note

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Using OAF1 estimates to rank areas for supplemental planting

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Abstract

Supplemental planting (planting trees into areas of low stocking within young stands)—also known as fill-planting, blanking, or beeting—is a common silviculture practice. This extension note describes a method to rank areas for supplemental planting based on the yield gain expected from the treatment. The method uses a modified Type 1 Operational Adjustment Factor (OAF1) survey and yield estimates from the stand growth model called TIPSY (Table Interpolation Program for Stand Yields). OAF1 is a TIPSY input parameter that reduces predicted yield to account for small stocking gaps in the stand and other yield-reducing factors. The procedures for the survey method and subsequent runs of the TIPSY computer model are briefly described. The method is evaluated by comparing it to a review of the supplemental planting literature and to results obtained from the stand growth model TASS (Tree and Stand Simulator), as well as by testing it in the field.

The literature on supplemental planting indicates that the survival and growth of fill-planted trees increases as gap size increases, the size of pre-existing trees decreases, and the height growth rate of fill-planted trees increases. Limited comparisons to TASS suggest that when large differences in predicted gain separate the alternatives (e.g., differences ≥ 10 m^3/ha), both TASS and the new ranking method order the alternative fill-planting opportunities similarly. However, when the differences in predicted gain among alternatives are small (e.g., < 10 m^3/ha), the rankings differ. In addition, when the predicted gain is less than or equal to 20 m^3/ha, the new ranking method overestimates the yield gain from supplemental planting.

The method was field tested in 1998 and 1999 when Lignum Ltd. implemented the procedure to help rank areas for supplemental planting on cutovers naturally regenerated to lodgepole pine near Williams Lake, B.C. A field review of the method's performance concluded that it made a useful contribution to the problem of ranking areas for supplemental planting. However, this method does not provide all of the information required to make a good prescription for supplemental planting. To achieve success with supplemental planting, silviculture prescription writers must select optimal stands and sites for treatment and utilize appropriate species, stock types, and planting procedures.

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Introduction

The Type 1 Operational Adjustment Factor (OAF1) is used by the B.C. Ministry of Forests' growth and yield model, TIPSY (Table Interpolation Program for Stand Yields), as an input parameter. This parameter reduces the predicted yield in order to account for small stocking gaps in the stand (Mitchell and Grout 1995) and other factors.

The OAF1 Project was initiated in 1996 to develop methods for obtaining estimates of OAF1. From 1996 to 1998, Forest Renewal BC funded this work. This is the third published report from the project. The first OAF1 Project report provided background information on stocking gaps, their effect on yield, their relation to TIPSY OAF1, and the benefits of obtaining improved estimates of OAF1 (B.C. Ministry of Forests 1997). The second report provided detailed instructions for conducting a ground-based survey for estimating OAF1 (B.C. Ministry of Forests 1998). This report describes how OAF1 estimates can be used to rank areas for supplemental planting.

Stocking is an important determinant of yield. Large gaps in stocking within a stand reduce volume per hectare yields at harvest. In some stands where gaps in stocking occur, it is possible to increase yield by planting trees into these gaps. Supplemental planting—planting trees into areas of low stocking within young stands—is a common silviculture practice, which is also known as fill-planting, blanking, or beeting.

In this extension note, I present and evaluate a method to rank areas for supplemental planting. The ranking is based on the yield gain expected from the treatment. The method uses a modified OAF1 survey and yield estimates from TIPSY. The method is evaluated by comparing it to results obtained from the stand growth model TASS (Tree and Stand Simulator), and to a literature review on supplemental planting, as well as testing it in the field.

Description of the Method

The method to rank areas for supplemental planting consists of two steps: the survey and the TIPSY computer model simulations.

The Survey

The surveyor identifies an area (stratum) within an opening that may be suitable for supplemental planting. Within the stratum, the surveyor establishes 100 plots on a grid. At each plot, the surveyor collects the standard OAF1 data as described in the second OAF1 Project report (B.C. Ministry of Forests 1998). Two key data elements are total trees per hectare and whether or not the plot contains an acceptable tree (i.e., healthy, adequate size, and a species appropriate for the site). Then, at each plot the surveyor imagines that supplemental planting has just been completed. The surveyor collects the OAF1 data again—this time counting both existing and imaginary fill-planted trees in the plot (Figure 1).

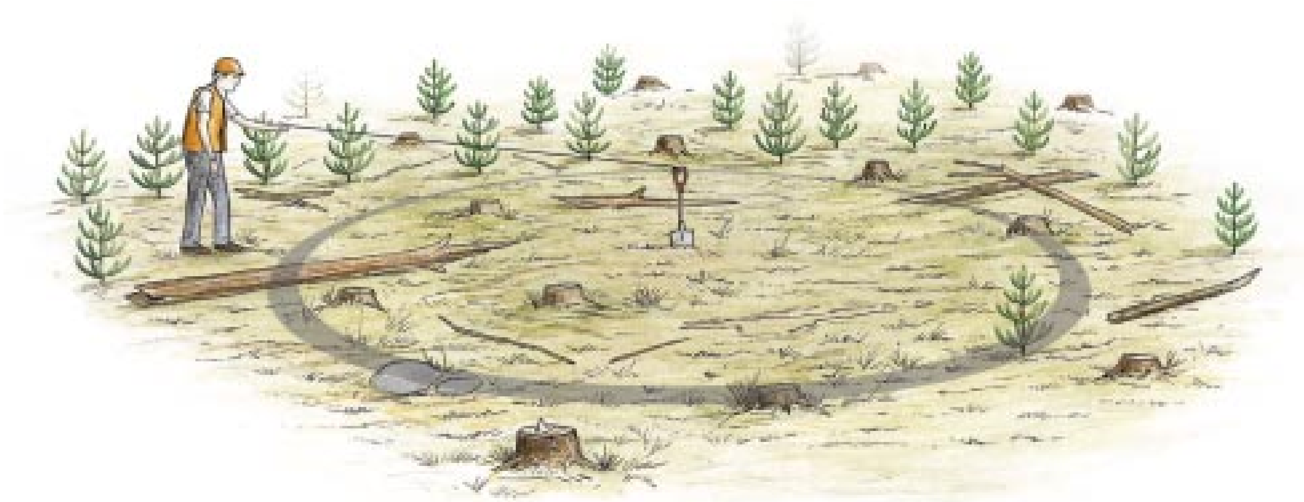

FIGURE 1. At each plot, the surveyor collects data to estimate current OAF1 and tree density, and the OAF1 and tree density that would be attained after supplemental planting.

The TIPSY Computer Simulations

After the survey is completed, the input values required to run the TIPSY computer model are compiled from the survey data. The survey data provide inputs for two TIPSY computer simulations: one representing the stand without supplemental planting and one representing the stand with supplemental planting. The following input values are held constant for the runs of the computer model: site index, natural regeneration, regeneration delay, and OAF2[1]. Species composition may change slightly with the addition of the fill-planted trees. The two TIPSY computer simulations differ in both initial density (trees per hectare) and OAF1. The procedure to compute initial density and OAF1 is described in the second OAF1 project report (B.C. Ministry of Forests 1998).

The difference between the two TIPSY computer runs in predicted volume per hectare at rotation indicates the yield gain possible with supplemental planting (Figure 2). Strata with the greatest potential gains are ranked highest for supplemental planting, subject to an operational evaluation.

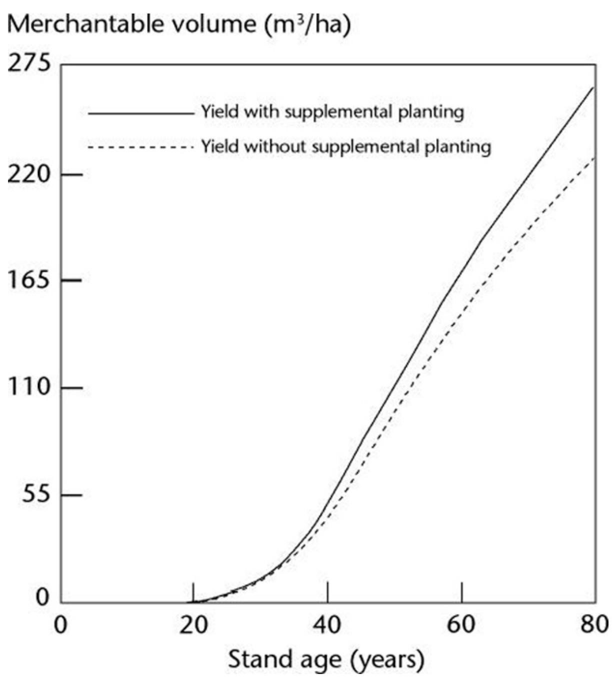

FIGURE 2. Example of TIPSY-predicted yield with, and without, supplemental planting.

. . . [this] method makes a useful contribution to the problem of selecting areas for supplemental planting . . .

Example

Table 1 provides a hypothetical example to illustrate the method of ranking areas for supplemental planting. The survey data, TIPSY input values, and TIPSY yield predictions are provided for three polygons of pure, naturally regenerated lodgepole pine on site index 16 m. The yield predictions in Table 1 suggest a ranking of polygons A, B, and C from highest to lowest in terms of supplemental planting opportunity.

Assumptions Implicit in the Method

The method of ranking areas for supplemental planting uses TIPSY, a very simple stand growth model. As a result, the method assumes no ingrowth and only modest levels of damage and early mortality. The prediction for yield with supplemental planting is based on the assumption that supplemental planting is equivalent to achieving greater uniformity of stocking at establishment. The application of TIPSY to mixed species stands and stands with deciduous competition is problematic. The TIPSY-based yield predictions also assume that site quality is consistent across the stand.

To obtain an accurate estimate of volume per hectare at harvest for a stand with large stocking gaps, it is necessary to both inflate the initial density and apply a large OAF1 reduction (J.S. Thrower and Associates Ltd. 1997). The simultaneous adjustment of both OAF1 and initial density mimics the squeezing of a fixed number of trees into one portion of a hectare and creating gaps in the rest of the hectare. While this process produces good estimates of volume per hectare at harvest under a wide variety of stocking conditions, it has an undesirable property in this application. For two of the three polygons in Table 1, the initial density input for the simulation of supplemental planting is slightly less than the initial density input for the current (existing) stocking condition.

[1] OAF2 is an input parameter supplied by the user to reduce TIPSY's predicted yield to account for the effects of decay, waste, breakage, disease, and pests.

TABLE 1. Hypothetical example showing the method of ranking areas for supplemental planting

Condition	Survey data: Total trees at survey (no./ha)	Survey data: Empty OAF1 plots[a] (%)	OAF1 survey compiled values[a]: *Z*-value	OAF1 survey compiled values[a]: OAF1[c]	OAF1 survey compiled values[a]: Initial density for TIPSY run (no./ha)	TIPSY predictions[b]: Volume at 100 years (m^3/ha)	TIPSY predictions[b]: Volume increase from supplemental planting (m^3/ha)
Polygon A							
Current condition	1000	42.2	32	28	1522	233	94
After supplemental planting	1507	0	0	0	1563	327	
Polygon B							
Current condition	2000	17.75	16.75	14.4	2499	303	46
After supplemental planting	2213	0	0	0	2299	349	
Polygon C							
Current condition	2000	3	3	2.4	2143	337	7
After supplemental planting	2036	0	0	0	2115	344	

[a] For a full description, refer to the OAF1 Project Report No. 2 (B.C. Ministry of Forests 1998).
[b] TIPSY version 2.1.
[c] Though not necessary in this application, in most other cases OAF1 is further increased to account for yield reducing factors other than stocking gaps.

Evaluation of the Method

Evaluation Against TASS

Some insight into the performance of the new ranking method can be obtained by a comparison to TASS. For 27 scenarios, the yield gain expected from supplemental planting was estimated by the new ranking method and by TASS. Estimated yield gain was used to rank the scenarios and the TASS and TIPSY-based rankings were compared.

To provide results relevant to the field test sites, simulations were conducted for naturally regenerated lodgepole pine on site index 16 m. Three different tree spatial patterns were evaluated: random, slightly clumped, and very clumped. Three stand densities (before supplemental planting) were considered: 1000, 2000, and 3000 stems per hectare. Supplemental planting was simulated in TASS at a top height of 2 m with trees planted into one-third, two-thirds, or all of the gaps identified in the stand. The result was a 3 × 3 × 3 matrix of supplemental planting scenarios. Yield predictions were taken at 100 years (the approximate culmination age). Merchantable volume used a 12.5 cm minimum DBH, with 30-cm stump and 10-cm DIB top.

Figure 3 shows a comparison of the yield gain from supplemental planting predicted by TASS and the gain predicted by the new ranking method.

The ranking of the 27 supplemental planting opportunities produced by the two methods is compared in Figure 4.

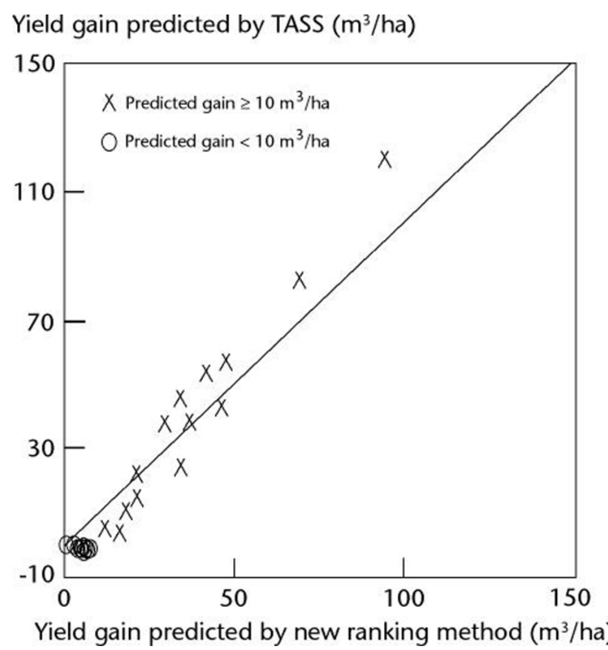

FIGURE 3. Yield gain from supplemental planting predicted by TASS compared to gain predicted by the new ranking method. Solid line is a 45-degree reference line to aid in visual comparison.

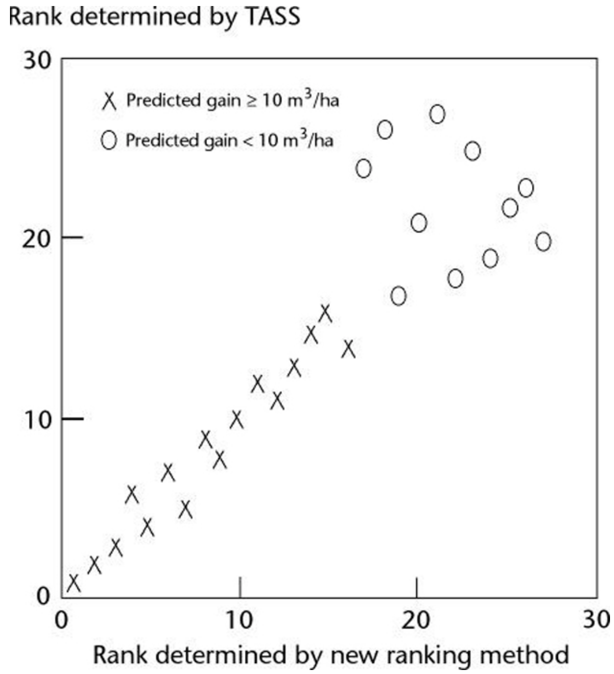

FIGURE 4. TASS ranking of 27 supplemental planting opportunities compared to the ranking determined by the new method.

For the range of conditions examined, visual inspection of Figures 3 and 4 suggests that when differences of at least 10 m^3/ha (predicted gain) separate the alternatives, the new method produces a ranking of supplemental planting opportunities consistent with TASS. When the alternatives differ in predicted gain by less than 10 m^3/ha, a poor correlation is evident between the rankings by TASS and those of the new method. A group of 11 fill-planting alternatives (indicated by "O" in Figures 3 and 4) illustrate this point. Predicted gains are very similar for each alternative in this group (Figure 3). Within this group, the new ranking method does not rank consistently with TASS (Figure 4).

The new method is better at ranking than at estimating the absolute amount of yield gain. For the range of conditions examined, when the predicted gain is less than or equal to 20 m^3/ha, the new ranking method overestimates gains in yield.

Evaluation Against Supplemental Planting Literature

Several reviewers have reported that the survival and growth of trees planted into gaps in existing stands vary from very poor to good (Gemmel 1987; Braathe 1992; Saarenmaa and Leppala 1995). The survival and growth of fill-planted trees improve as:

- the size of the gap increases,
- the size of existing trees around the gap decreases,
- the time between stand disturbance and fill-planting decreases, and
- the juvenile height growth rate of the fill-planted trees increases relative to pre-existing trees (Gemmel 1988b; Braathe 1992).

In several experiments, animal and frost damage to fill-planted trees was very common. Gemmel (1988a) noted that gaps are frequently areas of poor environment for tree growth. Chavasse *et al.* (1981) stressed that if the management objective is uniform tree stocking, it is best achieved promptly after harvest—not with a partial regeneration followed by supplemental planting.

This review of the supplemental planting literature suggests that the new ranking method does not provide all of the information required to fully assess a supplemental planting opportunity. When implementing the new ranking method, surveyors should also record observations on the size of gaps, size of adjacent trees, probability of damage to fill-planted trees, tree growth environment in gaps, and spot treatments that could be undertaken to improve survival and accelerate the height growth rate of fill-planted trees.

Best results from supplemental planting will likely be achieved in stands with low density and large gaps, where gaps are due to chance—not harsh environment, and where the likelihood of animal damage, frost damage, and heavy brush competition is low. Trees planted in close proximity to large established trees will not contribute much volume at harvest. Actions to improve the early growth of fill-planted trees (such as appropriate species and stock type selection, planting spot preparation, and control of competing vegetation) will improve the success of supplemental planting.

The overestimation of yield gain by the new ranking method is probably because the trees planted in very small gaps were rapidly suppressed and killed by the larger, pre-existing, adjacent trees. In contrast, if the fill-planted trees were established in these same locations at the same time as the main stand, they would survive, grow, and contribute at harvest. The new ranking method overestimates yield gain because it assumes the same germination date for fill-planted and original trees. This assumption does not produce significant error when the fill-planted trees are added to large gaps that are free from influence by the surrounding original trees. However, the error becomes significant in fill-planting scenarios where trees are planted into very small gaps. When gaps are small, surrounding trees are large, and fill-planted trees grow slowly, the yield predictions of the new ranking method will overestimate the gain from supplemental planting.

Evaluation in a Field Test

The new ranking method was tested in large cutovers naturally regenerated to lodgepole pine near Williams Lake, B.C. The method was integrated into a comprehensive survey system developed to identify supplemental planting opportunities. A description of the complete survey system is available in a field manual (Lignum Ltd. 1997). In April 1999, regional and district Forest Service staff, licensee staff, and consultants met for a field review and the following issues related to the new ranking method were discussed.

- The new ranking method relies on the ability of survey crews to predict whether seedlings will survive and grow in the various gaps encountered in a stand. This ability was questioned in the field review.
- The new ranking method does not provide a map location of the stocking gaps. Will planting crews be able to locate small, dispersed areas of low stocking within large polygons? Potential benefits were noted of integrating the new method with aerial photography or remote sensing imagery to stratify large blocks, to provide gap location coordinates for planting crews, and possibly, to directly provide the survey data for the new ranking method. Supplemental planting opportunities will not be detected if inadequate stratification results in the pooling of samples in areas of low stocking with those in areas of high stocking.
- Range values are high in the field test area. Should small gaps be filled with trees that will rapidly reduce forage production, or do these gaps have a greater value unplanted?
- As the new ranking method uses estimates of OAF1, it would be desirable to develop a method to estimate OAF1 from standard stocking survey data.
- To determine the optimal amount of supplemental planting in a management unit, it is important to evaluate the effect of supplemental planting on forest-level harvest flow relative to other silviculture treatments that could be undertaken (B.C. Ministry of Forests 1999). The new ranking method does not consider this larger context to the supplemental planting decision. Before undertaking a supplemental planting program, an economic analysis should be conducted to ensure that supplemental planting treatments are fiscally responsible relative to other silviculture treatments.
- The new ranking method is essentially a TIPSY-based analysis of supplemental planting. In many of the stands visited in the field review, aspen is common. The TIPSY model, and therefore the new TIPSY-based ranking method, does not handle deciduous species. Conifer mixtures occurring in the field test area are also poorly handled by TIPSY. Similarly, TIPSY and the new ranking method do not handle ingrowth. In some stands, ingrowth of lodgepole pine may gradually fill existing gaps, thus decreasing the gain from supplemental planting. Some unstocked areas may occur in pockets of very low site quality. The new ranking method treats these areas as if their site productivity was equal to the rest of the site.

Conclusion

The OAF1 Project has developed a method to rank supplemental planting opportunities. An evaluation of the method based on a literature review, a comparison to TASS, and a field test suggests that the method makes a useful contribution to the problem of selecting areas for supplemental planting. The method allows foresters to bring a consideration of the yield implications of the treatment into the decision-making process. The method uses two tools widely available to foresters: the TIPSY computer model and the OAF1 survey.

The new ranking method has disadvantages common to other TIPSY-based analyses, including problems handling deciduous species, ingrowth, high levels of tree damage, residual overstorey trees, and variation in site quality within a polygon. This method employs the assumption that the yield with supplemental planting is equal to the yield that would be attained by achieving uniform stocking at establishment. The evaluation suggests that estimates of yield gain which are based on this assumption will overestimate supplemental planting gain when gaps are small, when surrounding trees are large, and when fill-planted trees grow more slowly than the adjacent original trees.

To achieve success with supplemental planting, silviculture prescription writers must select optimal stands and sites for treatment and use appropriate species, stock types, and planting procedures.

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