Improving Regeneration Performance Standards: Comments Based on Early Experience With Three New Approaches In British Columbia

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Introduction

Regeneration performance standards are widely used across Canada. These standards specify the acceptable state of regeneration (or more broadly, of tree cover) on areas that have been harvested. Typically, the standards both specify the range of acceptable condition and define a number of years after harvest within which this condition must be achieved. Regeneration performance may be assessed at various times and for several different purposes. In this paper, we focus on the final assessment of the adequacy of regeneration that typically occurs 10 to 20 years post-harvest. In most provinces, the regeneration performance standards applicable at this time are termed free-growing or free-to-grow standards (e.g., BC Ministry of Forests 2000, Manitoba Conservation 2001, Saskatchewan Environment 2004) though they are termed performance standards in Alberta (Alberta Sustainable Resource Development 2004).

Across the country, interest in improving regeneration performance standards is high. In Alberta, regeneration standards were recently examined by an expert review panel (Alberta Reforestation Standards Science Council 2001) and subsequently revised (Alberta Sustainable Resource Development 2003). New regeneration standards have recently been released in Saskatchewan (Saskatchewan Environment 2004) and a major initiative to revise standards is underway in Ontario. Many provinces no longer prescribe the system with which regeneration standards must be set. In many provinces, forest licence holders are free to propose new formulations for regeneration performance standards.

Changing the system used to set standards and assess performance potentially has many significant impacts. System changes may result in changes in post-harvest condition that lead to changes in stand composition and structure through time, impacting future yields of timber and other values. Changes can have economic consequences, altering regeneration cost structure, the total cost to achieve a given outcome, and the cost-effectiveness of treatments. Changes may impact the work routine of those who prescribe regeneration treatments, survey regenerating areas, manage regeneration performance data, and verify that standards have been met.

Our objective in this paper is to contribute to improving regeneration performance standards and the associated methods of assessing regeneration performance. In this paper we first present a concept model of regeneration performance standards. Next, we review two methods traditionally used to set standards and assess regeneration performance in British Columbia (BC). Then, we briefly review three new approaches to setting regeneration standards that we have participated in developing. Last, based on our experience with both old and new approaches in BC, we offer comments on the design and implementation of new systems for specifying standards for regeneration performance.

Concept Model of Regeneration Performance Standards

A concept model and the definition of key terms will facilitate our discussion of regeneration performance standards. By regeneration performance, we mean the degree to which the achieved treed state approximates the goal state at the assessment date. The goal state is the post-harvest forest cover condition that will achieve the management objective. To measure performance, critical characteristics of the goal state are identified and then measures are selected that portray them. Regeneration performance standards specify threshold levels for those measures. Harvested areas are surveyed to estimate the achieved levels of the performance measures. When the performance measures are within the prescribed limits, regeneration performance is satisfactory – and it is assumed that the actual state approximates the goal state and thus the objective will be achieved. When the performance measures are outside of the prescribed limits, regeneration performance is unsatisfactory, and, typically, treatments are required to create the desired condition. A stand-level standard describes a condition that must be met on a portion of a cutblock or over an entire cutblock. If the standard describes a condition that must be met in a population comprising many cutblocks, we term it a multi-block standard. As illustrated below, measures may be input to a function to transform them into a new variable that we term a synthetic measure.

Within a single jurisdiction, one or at most a few different systems are used to specify regeneration performance standards. The concept of a widely applicable system for setting regeneration performance standards implies certain commonalties of goals, factors critical to goal achievement, and relevant measures for those factors, across a variety of sites, stands, and administrative settings.

Two Traditional Approaches in British Columbia

In BC, two systems are widely used to set regeneration performance standards and measure outcomes. As discussed above, in describing these systems it is useful to identify the performance measures, compliance thresholds, critical factors, goal, and scale of application.

The standards most widely used in BC measure regeneration performance in the units of free-growing trees per hectare. These standards are applied to young, even-aged stands. On mesic sites in the BC interior, the compliance threshold is 700 free-growing trees per hectare. At the final assessment, a cutblock must not contain a patch one hectare or larger with less than 700 free-growing trees per hectare. Thus, this is a stand-level standard. In this system, the critical factor is crop tree stocking, where a crop tree is a desirable species, exceeding some minimum height, healthy with good form and condition, unimpeded by brush, more than a certain distance (e.g., 2 m) from other tallied crop trees.

Defining the goal that the system is designed to further is much more challenging. A careful reading of the system description (Wyeth 1984, BC Ministry of Forests 2000) suggests that BC's even-aged system was designed to control the level of conifer sawlog production. Recent studies have confirmed that when harvested areas are re-stocked to levels above the compliance threshold, most of the timber production potential of the site is captured (Bergreud 2002, Martin et al. 2005).

The second most commonly used system in BC sets regeneration performance standards for partial-cut stands that require some regeneration. In this multi-layer system, there are four performance measures: (1) the density of crop trees ≥ 30 cm height, (2) the density of crop trees ≥ 1.3 m height, (3) the density of crop trees ≥ 7.5 cm diameter (dbh), and (4) the density of crop trees ≥ 12.5 cm dbh. Multi-layer standards specify a set of four compliance threshold densities. At assessment, the density of crop trees exceeding the size limit is estimated for each of the four tree size groups. The performance standard is met when any one of the four observed densities exceed the associated compliance threshold.

Like BC's even-aged system, the critical factor in the multi-layer system is crop tree stocking, where a crop tree is a desirable species, exceeding some minimum size, healthy with good form and condition, and unimpeded by brush. Common compliance thresholds are 300 per hectare large trees (dbh ≥ 12.5 cm), 400 per hectare trees with dbh ≥ 7.5 cm, 500 per hectare trees with height ≥ 1.3 m, and 700 per hectare trees with height ≥ 30 cm. Note that the inclusion of trees retained at harvest (both advance regeneration and mature trees) is an expansion of the term and concept of regeneration performance. The goal driving the design of the system is to control the level of conifer timber production in stands managed under the selection silvicultural system (BC Ministry of Forests 1992). However, like the even-aged system previously described, BC's multi-layer system is used to set performance standards on sites where non-timber goals dominate. And, like BC's even-aged system, the multi-layer system specifies stand-level standards.

Three New Approaches in British Columbia

Over the last several years, we have been involved in the development of three new systems for setting standards for regeneration performance: (1) the multi-block volume system, (2) the DFP system, and (3) the boreal mixedwood system.

In the multi-block volume approach, a simple equation is developed to predict volume at harvest from silviculture survey estimates of the condition of regeneration. Model parameters correspond to the critical factors and measures: (1) site productivity as measured by site index, (2) stocking as measured by mean stocked quadrants, (3) degree of stand development as measured by height at assessment relative to expected height, and (4) species composition as indicated by species group. Values for the four measures are input to the volume equation to obtain predicted volume, the synthetic measure of regeneration performance. The explicit system goal is to control the level of conifer volume production. The standard must be met in a population comprising multiple cutblocks.

At the final assessment date, the cutblocks in the population are surveyed. The current values of the inputs to the yield prediction model are estimated. These values are input to the model to translate observed conditions into predicted future volume. Values are chosen for two model parameters, stocking and height, that define "potential performance." The compliance threshold is computed with the volume equation using the predefined values for potential stocking and height and the sample-based estimates of site index and species group. Minimum required regeneration performance is expressed as a percent of potential performance (e.g., 90% of potential). Achieved performance is required to exceed minimum acceptable performance. The method is fully described in several documents (Martin et al. 2002, 2004; Fort St John Pilot Project Participants 2004, J.S. Thrower and Associates Ltd. 2003, 2004). Additional information is available at http://www.for.gov.bc.ca/hfp/forsite/multi_block.htm.

The multi-block volume method is in operational use in the 4.7 million hectare Fort St John Timber Supply Area in northeastern BC. It has been proposed for use, with a variety of additional components, in a second management unit (TFL 49) near Kelowna, BC. The recently completed revision of BC's forest practice regulations allows other forest licence holders to adopt "multi-block" approaches, with Chief Forester approval (Province of BC 2004).

In the DFP approach, regeneration performance is measured in terms of the deviation from potential volume production that an observed condition represents. Deviation From Potential (DFP) ranges from 0 (full stocking) to 1 (unstocked). The compliance threshold is often established at a mean DFP of 0.20 (e.g., Przeczek 2004). The critical factors and associated performance measures are: (1) seedling and sapling stocking as measured by the number of free-growing trees in a 0.005 hectare plot, and (2) overstory tree amount as measured by basal area per hectare around the sample point (trees with dbh ≥ 12.5 cm). The tangible, physical measures (free-growing trees density and overstory basal area) are combined and transformed into the synthetic measure DFP. The system goal is seedling and sapling stocking adequate to achieve a desired proportion of potential volume production. DFP-based standards apply to individual stands.

The DFP method was created to provide a reliable method of assessing seedling and sapling stocking in partially cut stands with heterogeneous structure. Development began in 2002 in response to general dissatisfaction with existing methods of assessing stocking in this stand type. The method has very recently been adopted for use in the southeastern portion of BC (BC Ministry of Forests 2004) and is being considered in other locations. The DFP method is fully described elsewhere (BC Ministry of Forests 2004, Martin et al. 2005a, b). See the DFP web site for more information: http://clients.tmnewmedia.com/mpbi/index.htm

To explore issues that should be addressed in the design of regeneration standards for the sustainable management of boreal mixedwoods, Martin (2005) proposed a new system for setting regeneration standards for boreal mixedwoods in western Canada. This method is not in use in BC. The system goal is to regulate the conditions necessary to produce the desired character of, and yield from, the mixedwood. The standards apply at the multi-block scale. The factors critical to achieving the goal and the associated measures are: (1) overall crop tree stocking as measured by stocking percent, (2) proportion of harvested area dominated by free-growing conifers as measured by percent of plots dominated by a free-growing conifer, and (3) proportion of harvested area in mixed (deciduous-coniferous) patches as measured by the percent of plots in mixed patches. The compliance thresholds depend on the nature of the harvested area and the objectives in the forest management plan. Thresholds could, for example, be set at 90% overall crop tree stocking, 20-40% area dominated by free-growing conifers, and 20-40% area in mixed patches.

Comments on Designing and Implementing New Systems

The three new approaches described above give us some experience designing and implementing new systems for specifying regeneration performance standards. When discussing improvements to standards, it is useful to distinguish among four alternative improvement paths: (1) changing the definition of key parameters of the existing system (e.g., updating the criteria used to assess a free-growing tree), (2) changing the level of the compliance minimum within the existing system, (3) changing the way in which the existing system is administered and enforced, and (4) a wholesale change to a completely new system. Our comments relate to the fourth path. Distilling experience to-date, and mindful of the hazards associated with drawing conclusions from short-term results of localised pilot projects, we offer the following comments.

Costs and benefits

The benefits expected from a new approach must justify the cost of the change. We have found that the cost to develop, test, obtain approval, and implement new systems can be substantial and is easily underestimated. New approaches create a workload and costs for many groups. Agency costs increase as new approaches must be reviewed and approved. Both surveyors and silviculturists must be trained in the new system. Existing hand-held data collectors, field forms, and central databases may need to be changed. Various business processes may need to be revised and new capacities may be required to obtain all of the potential benefits that a new system offers. Even when a new regeneration performance assessment system is designed to deliver cost-savings, our experience indicates that an increase in costs should be expected over the short-term. The savings, if they materialise, will come over the medium and longer terms.

In BC, the interest in alternative approaches is partly driven by dissatisfaction with the cost-effectiveness of existing standards. We have concluded that inefficiencies derive from both the structure and the implementation of the current regeneration performance standards. Current approaches restrict a forester's ability to find the least cost method to deliver a given outcome (Martin et al. 2004). We recommend that developers of new approaches identify the inefficiencies in their current systems and use this insight to design flexible new systems that allow efficient action (and do not force inefficient action).

In addition to direct costs (and benefits), developers should consider indirect costs (and benefits) of a change. For example, there is value in maintaining consistency over time, and throughout a jurisdiction, in the measure of performance – even if that measure is imperfect. In BC, new approaches have identified certain deficiencies in free-growing trees per hectare as the ultimate measure of success. The new approaches reject the traditional measure, thus breaking the time trend in performance reporting. In the rush to embrace new approaches, we caution against sacrificing the valuable information in performance trends over time. In some cases, it may be desirable to maintain the traditional measure (or possible to predict its value from a new measured variable) to maintain continuity of the long-term record.

Critical factors and measures of performance

The new approaches confirm crop tree stocking as a critical performance driver. However, each new approach challenges the prevailing view that crop tree stocking is the only critical factor. With the goal to sustain the boreal mixedwood, for example, the new mixedwood approach recognises three critical factors: (1) overall stocking, (2) proportion of free-growing, conifer-dominated area, and (3) proportion of area in mixed (conifer-deciduous) patches. We suggest that efforts to improve regeneration performance standards should not assume that crop tree stocking (whether represented by stocking percent or well-distributed trees per hectare) is the sole determinant of the adequacy of regeneration.

Performance standards can directly control one or more physical characteristics of the regeneration (e.g., mean height, stocking percent, etc) or the physical measures can be combined to form a synthetic measure, and the standard can control this variable. For example, in the multi-block volume approach four observable characteristics (site index, stocking, height, and species composition) are combined into a synthetic measure – predicted volume per hectare at harvest. A single synthetic measure can account for the combined effect of multiple physical measures on the goal. Synthetic measures link short-term observables to the long-term goal and handle curvilinear relationships between measures and the goal. Two of our new approaches utilise the synthetic measure predicted volume per hectare at harvest age. This synthetic measure improves the alignment of regeneration assessment with the timber production goal – but further improvements seem possible. Synthetic measures of board-foot volume (or net value) at harvest, for example, should be considered by developers of new regeneration performance standards.

We fully endorse the concept of setting regeneration standards in terms of predicted yield and coupling survey simulation with distance-dependent individual-tree growth model simulation to relate silviculture survey parameters, such as stocking percent, to future yield (e.g., Bergerud 2002, J.S. Thrower and Associates Ltd. 2003, 2004). For the timber production goal, this approach helps address the common criticism of the short-term focus, and apparent arbitrariness, of current regeneration standards.

Scale of application

Two of our new approaches raise the issue of scale of application. BC's existing standards must be met on individual cutblocks or portions thereof. The multi-block volume and mixedwood approaches are constructed to apply to a population of cutblocks. At which scale (or scales) is regeneration performance best assessed? Our experience with new approaches suggests that some aspects of desired performance may only be relevant - and are best controlled - at a level of resolution above the individual cutblock. For example, it has been argued that species composition should be loosely controlled at the individual cutblock level with more stringent controls operating at the landscape level (Kneeshaw et al. 2000, Greene et al. 2002). Initiatives to improve regeneration performance standards should consider the optimal scale of application. We increasingly believe that it is often at a level above that of the individual cutblock.

Design

Our new approaches tend to make greater use of new tools (e.g., stand growth models, site index estimation methods, and juvenile height growth curves), more advanced sample designs (e.g., sub-sampling and combinations of fixed and variable radius plots), and improved methods (e.g., the use of GPS units to navigate to sample points located on 100 m UTM grid). In BC, the existing standards are implemented with province-wide, standardised survey protocols (BC Ministry of Forests 2002) developed many years ago that are less advanced. Our experience suggests that in the process of developing new formulations for standards it is possible to incorporate new knowledge and tools and employ more accurate - and efficient - measurement methods and sample designs. While it is theoretically possible to upgrade the existing approaches, it appears easier to reach all affected parties and institutionalise changes through the introduction of new systems.

Early in the design phase, it is necessary to decide what the new system must do. A common objective is that the system must ensure that the post-harvest condition matches the condition assumed in the management plan – or more particularly, the condition assumed in the forest-level simulation, fully or partially represented by the yield curves assigned to regenerated areas. We have not made this a mandatory design specification for our new approaches. We have taken the view that when significant opportunities to improve current standards are identified, improvements should be made - even if these improvements do not assure that management plan assumptions are being met. This choice must be made by all development teams: will only those new systems be considered that provide assurance that management plan assumptions are met?

To some degree, our experiments with new approaches can be viewed as a search for formulations that better reflect the biology of tree and stand growth. Our experience suggests that the biological basis for current regeneration standards can be improved. New assessment systems, designed to more closely reflect stand growth principles, can provide a better basis for setting performance standards.

Implementation

New ways to measure the adequacy of regeneration sometimes challenge conventional concepts and elicit strong negative reactions as concepts to which some individuals have a long-standing and deep attachment are openly challenged. The prohibition against NSR (not satisfactorily reforested areas) is one such “sacred cow” that has been challenged by two of our new approaches. Our experience indicates that developers of new approaches should not under-estimate the negative reaction that can be triggered if new approaches threaten conventional views. Engagement in the development of new systems provides both a challenge and an opportunity to critically re-examine beliefs and assumptions. The soft, people management skills of leadership, negotiation, and communication can help gain acceptance for new ideas. Nevertheless, when resistance to change remains, we believe that implementation of new systems should proceed if it is clear that they use the best available science, lead to better management decisions, and provide better outcomes per dollar expended.

When a new system is implemented the appropriate level for the compliance minimum must be established. Typically, agency staff fear that the level will be set too low and industry staff fear that the level will be set too high. To address these concerns, proponents of new systems should consider an annual review and revision of minimums for the first few years of system operation.

Verification is a key component of forest certification (e.g., Sustainable Forestry Initiative 2004) and a core function within public agencies. We advise developers of new systems to work with those responsible for verifying that standards have been met. Work areas may include creating new inspection procedures, completing agreements on the content, format and schedule for information transfer between industry and government, developing new procedures for assessing conformance with the new requirements, and creating processes for compelling compliance, or assessing penalties, when standards are not met.

Goals

Our new systems result from either (1) a re-statement of the current goal in terms more conducive to quantifying the relationship between the measures and the goal, or (2) promulgating a new goal. In the multi-block volume approach, the traditional goal of conifer sawlog production is simply re-stated as the new goal to achieve a specified percent of potential volume production. In contrast, the mixedwood approach demonstrates that a change in the dominant goal can require a change in regeneration performance standards.

In building and describing new systems, we have found it useful to specify a single goal around which a new system is organised. In two of our systems, we adopted some form of a timber production goal. However, a system developed to serve a timber production goal can also be used to set standards and assess performance in harvested areas where goals other than timber production are important. It is useful to distinguish between a system allowing a non-timber goal to be achieved and a system providing assurance that a non-timber goal will be achieved. Several situations arise. First, some non-timber goals are achieved by the same conditions that are necessary to achieve the timber production goal. In these cases, the same system is usually sufficient to protect the non-timber values. Second, some non-timber goals can be achieved by setting system parameters at levels that allow - but do not specifically assure - that the conditions necessary to achieve these other goals are realised. For example, BC's even-aged system has been used to set regeneration standards on sites where a key objective is to "maintain or enhance grizzly bear forage supply" (BC Ministry of Forests 2001). The desired condition can be created when the minimum stocking threshold is reduced and the definition of the area to be reforested is changed. Third, in some cases, the factors critical for achieving a non-timber goal are so different that additional standards and/or alternative systems are required. For example, post-harvest forest cover characteristics such as structural complexity and spatial heterogeneity are not specifically controlled by most systems designed around a timber production goal. However, these characteristics have been identified as important for some goals, such as sustaining mule deer winter range (Dawson and Armleder 2000) and restoring biodiversity (Carey 2003).

New systems can be designed to make it easier for foresters to accommodate non-timber goals and to provide them with better information for making treatment decisions. New multi-block systems (such as our multi-block volume and boreal mixedwood systems) provide increased flexibility to implementing foresters, allowing them greater freedom to accommodate non-timber goals. Frequently, some timber production must be sacrificed to achieve a non-timber goal. By providing estimates of volume production foregone, the multi-block volume system provides an estimate of the opportunity cost of a given accommodation, improving the information base supporting the balancing of competing goals.

Conclusion

When a problem with existing regeneration performance standards has been identified, changes to the administration, compliance threshold, or definition of key system parameters sometimes will be sufficient to rectify the problem. However, in other cases, it will be necessary to design and implement an entirely new system for specifying regeneration performance standards. We suggest that individuals contemplating new systems should consider the following questions. Have the goals changed? Of the many goals, which ones must the system specifically address? For this set of goals, what are the critical characteristics of forest cover at assessment that determine the degree to which the goals are achieved? What variables should be used to measure these critical factors? Within what range must the measures be maintained to produce the desired levels of these goals? Can a synthetic measure be created to expose the relation of short-term condition to long-term outcome? What opportunities exist to incorporate improved tools, sample designs, and measurement methods? Will the benefits of a new system exceed the development and implementation costs? Is there an implementation plan to help all affected parties and to resolve linkages to inventory, forest-level planning, and various databases? What is the appropriate scale of application for the new standard?

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