A results-based system for regulating reforestation obligations

by Patrick J. Martin[1], Shane Browne-Clayton[2] and Eleanor McWilliams[3]

A results-based system for the regulation of reforestation obligations is described. The system involves establishing performance targets for harvested areas, surveying areas after harvest to assess achieved performance, and maintaining a ledger to tally target and achieved performance over a large number of cutblocks. The obligation to reforest is considered met when total achieved performance exceeds total target performance evaluated over all cutblocks. Reforestation performance is indexed by predicted merchantable volume per hectare 80 years after harvest. To obtain these volume predictions, areas are surveyed 10 years after harvest and estimates of site quality, tree stocking, species composition, and stand height are input to a set of yield prediction tables. This results-based system, which we believe improves the regulatory framework governing the reforestation of harvested areas, will be tested in a management unit (TFL 49) in southern British Columbia in 2002.

Key words: results-based regulations, reforestation, yield prediction, silviculture

Cet article décrit un système reposant sur les résultats en matière de réglementation liée aux obligations de reboisement. Le système comprend la mise en place d'objectifs de performance dans les territoires exploités, le sondage des sites après la récolte pour évaluer la performance atteinte et la tenue d'un registre pour contrôler la performance visée et celle atteinte pour un grand nombre de blocs de coupe. L'obligation de reboiser est considérée comme étant satisfaite lorsque la performance totale atteinte est supérieure à la performance visée en totalité telle qu'évaluée pour tous les blocs de coupe. La performance en matière de reboisement est indexée en fonction du volume marchand projeté par hectare 80 ans après la récolte. Pour obtenir ces prévisions volumétriques, les sites sont sondés 10 ans après la récolte et les estimés de la qualité de la station, de la densité relative, de la distribution des espèces et de la hauteur du peuplement sont insérés dans un ensemble de tables de prédiction du rendement. Nous considérons que ce système reposant sur les résultats améliorera la cadre réglementaire régissant le reboisement des sites exploités et qui sera mis à l'essai dans une unité d'aménagement (TFL 49) du sud de la Colombie-Britannique au cours de 2002.

Mots-clés: règlements basés sur les résultats, reboisement, prévision de rendement, sylviculture

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Introduction

Recently in British Columbia, there has been much discussion of the possible consequences of shifting from "process-based" to "results-based" systems for managing forest land. A regulatory system that is process-based attempts to achieve desired outcomes by controlling procedure and process. Process-based reforestation regulations, for example, might require a reforestation plan for each harvested area with detail on the procedures that will be used to reforest the area, such as the site preparation method, seedling stock types, scheduled brushing, etc. Government agencies then enforce the process—ensuring that each procedure is executed in accordance with the plan. In contrast, a regulatory system that is results-based attempts to achieve desired outcomes by clearly articulating the desired result—and allowing freer choice around the methods that can be used to achieve the result. Results-based reforestation regulations, for example, might specify the desired result in terms of a minimum density of healthy, well-spaced, free-growing trees of appropriate species that exceed a minimum height at an assessment date. Government agencies then enforce the result—and are less concerned with the methods used to achieve it. Relative to process-based forest management, results-based forest management is promoted by some as more efficient and effective, less costly, and more flexible (Council of Forest Industries 1999, Pearse 2001, B.C. Ministry of Forests 2002). However, others are concerned that the transition from process-based to results-based forest management will be associated with "regulatory changes that reduce government oversight of corporate forestry" (Clogg 1999).

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When timber is harvested on crown land in British Columbia, the Forest Practices Code of B.C. Act assigns to the license holder a legal obligation to reforest the area. In 1999, to encourage the development of results-based regulatory systems, the B.C. government enabled the creation of Forest Practices Code Results-based Pilot Projects[4].

In the summer of 2002, Riverside Forest Products Ltd. is expected to seek government approval for a pilot project on Tree Farm Licence (TFL) 49. One small but important component of this pilot project is a new approach for regulating reforestation obligations. In this paper we describe the results-based approach to regulating reforestation obligations that is being contemplated for the TFL 49 pilot project area. It is not our intent to describe all technical details of this system or exactly how it may be applied in TFL 49. Rather, we want to describe the primary concepts of our system so that others attempting to devise results-based regulatory frameworks can adapt some of these concepts for use elsewhere.

The Pilot Project Area

The pilot project area (TFL 49) is located west of Okanagan Lake near Kelowna in the southern interior of B.C. The TFL comprises 143 760 hectares and supports a variety of commercial tree species including lodgepole pine (*Pinus contorta* Dougl. ex Loud.), interior spruce (*Picea engelmannii* x *glauca*), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), western larch (*Larix occidentalis* Nutt.), and ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.). The current allowable annual cut is 380 000 cubic meters with approximately 2000 hectares harvested annually. Clearcutting followed by planting and/or natural regeneration is the dominant silvicultural regime (Pedersen 1998).

Description of the System

Overview of Key Concepts

We wanted to develop a system for regulating reforestation obligations that would:

1. assess reforestation performance at a level of resolution above the individual cutblock—e.g., at the landscape level or at the level of a population of cutblocks;
2. free silviculturists to select from a wide variety of actions those that will achieve the desired results at least cost; and
3. highlight the relationship between silviculture and future yield.

With Forest Renewal B.C. funding, a team that included staff from Riverside Forest Products Ltd., the B.C. Ministry of Forests, and J.S. Thrower and Associates Ltd. developed a new system for results-based management of reforestation obligations. Conceptually, the proposed system involves:

1. establishing performance targets for harvested areas,
2. surveying areas after harvest to assess achieved performance, and
3. maintaining a ledger to tally both cumulative target performance and cumulative achieved performance.

Reforestation Performance Indicator

We selected predicted merchantable volume/ha 80 years after harvest as our indicator of reforestation performance.

[4]For more information on the B.C.'s Results-based Forest Practices Code Pilot Projects, refer to http://www.for.gov.bc.ca/hfp/rbpilot/

Table 1. Ten years after harvest, the field estimates of top height and site index are used to determine an "effective age" with juvenile height growth models. For example, lodgepole pine stands on site index 20 m with top heights of 1.6 and 4.2 m have effective ages of 7 and 13 years, respectively

Top height (m) by site index and age					
	Site index (m)				
Total age (years from seed)	…	19	20	21	…
…	…	…	…	…	…
7	…	1.5	1.6	1.7	
8	…	1.8	1.9	2.1	
9	…	2.1	2.3	2.5	
10	…	2.5	2.8	3.0	
11	…	2.9	3.2	3.5	
12	…	3.4	3.7	4.0	
13	…	3.8	4.2	4.6	
…	…	…	…	…	…

Source: Nigh and Love (1999)

Yield Prediction Tables

We identified four factors as the primary determinants of future yield: site quality, tree stocking, tree species composition, and stand development at the time of survey. We chose site index as our measure of site quality. We chose mean stocked quadrant (MSQ), a variation on the stocked quadrat plot system (Stein 1978), as our measure of tree stocking. Separate yield prediction tables were developed for three species groups: lodgepole pine (Pl)>80%, interior spruce (Sx)>80%, and Pl-Sx mixed stands. As our measure of stand development at the time of survey, we chose top height and expressed it as "effective age" (see below) in the yield prediction tables. Yield predictions from the stand growth model TASS (Mitchell 1975, Mitchell and Cameron 1985, Di Lucca 1999) were used to generate a set of tables that predict merchantable volume/ha 80 years after harvest (MVOL80) from site index, MSQ, species class, and effective age.

Details on the development of the regeneration survey, yield predictions and effective age calculations can be obtained from J.S. Thrower & Associates Ltd. (2002).

Regeneration Survey

Our system employs regeneration surveys conducted 10 years after harvest. The regeneration survey utilises 0.005-ha (3.99-m radius circular) plots divided into quarters (quadrants) along cardinal directions. In each plot, we count the number of quadrants that contain at least one acceptable tree. MSQ is the average of these counts from all of the plots in a defined stratum. For our purpose, an acceptable tree is of an ecologically appropriate species, healthy, and not impeded by brush. For a harvested area, the regeneration survey conducted 10 years after harvest provides estimates of site index, MSQ, species group, and top height (which is translated to effective age).

Effective Age

Many factors can impact top height 10 years after harvest, including the timing of planting and natural ingress, seedling age at planting, genetic worth of seed used, planting quality, microsite selection, and the use of site preparation and vegetation management. The resulting early growth differences can impact yield 80 years after harvest. We bring these factors into our yield prediction tables through the use of "effective age." Juvenile height growth models (Nigh and Love 1999, 2000) that

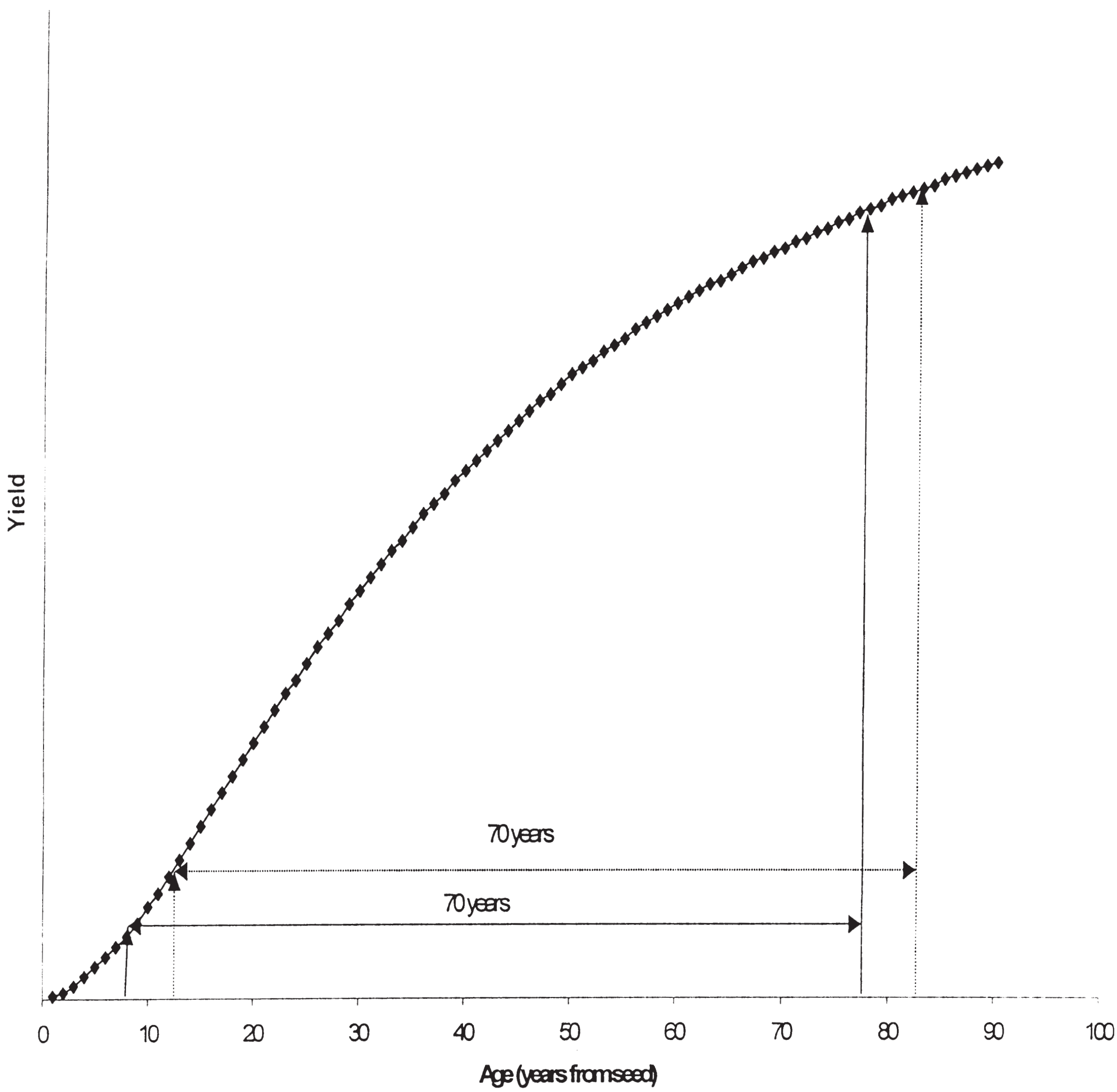

Fig. 1. Seventy years is added to effective age to determine the appropriate total age at which to extract the yield prediction. For example, when stands have effective ages of 7 and 13 years, yield is taken from the yield table at ages 77 and 83 years, respectively.

relate top height, total age (years from seed), and site index, are used to translate top height at survey to effective age. Effective age is the age that must be input (with the observed site index) to the juvenile height growth model to attain the observed top height. For example (Table 1), two lodgepole pine stands on site index 20 m with top heights of 1.6 and 4.2 m have effective ages of 7 and 13 years, respectively. Conceptually, we use effective age as follows. For a given stocking, species group and site index, we generate a yield table of volume/ha by total age. For a specific stand, we calculate effective age. Because our stands are surveyed 10 years after harvest, and we are interested in yield 80 years after harvest, we add 70 years to the effective age to obtain the total age at which we take yield from the yield table (Fig. 1). This procedure employs the assumption that reforestation practices may alter initial height growth rates, but that this response is exhausted by 10 years after harvest. After this time, the stand resumes growth as though it were a stand with the assumed effective age. That is, for the given site, species group and stocking, after 10 years, growth is determined by achieved height—not actual age.

Fig. 2 provides an example of the relationship of predicted volume/ha to MSQ and effective age in our yield prediction tables for lodgepole pine on site index 17 and 23 m.

Expected Yield and Target Yield

For a harvested area, the expected yield is the MVOL80 predicted for the area from the conditions (site index, MSQ, species group, and effective age) observed during the regeneration survey (Fig. 3).

The target yield expresses the standard of reforestation performance that is desired. When we set the target yield, we are making the clear statement of desired outcome that is

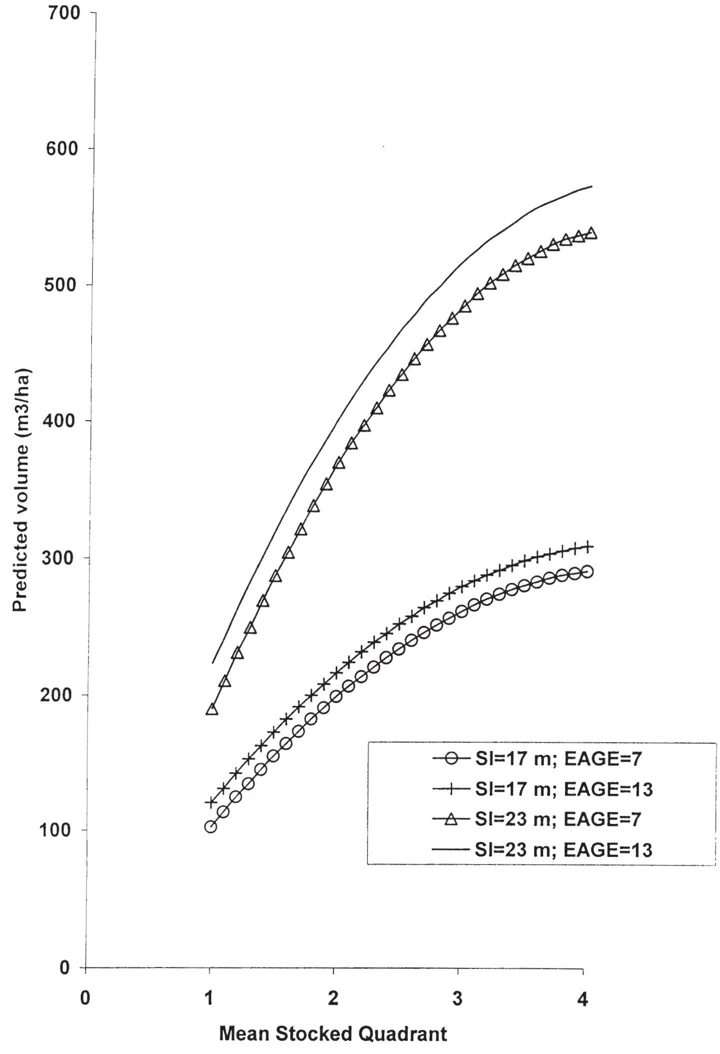

Fig. 2. Relationship of predicted volume/ha to mean stocked quadrant and effective age in the yield prediction tables for lodgepole pine on site index 17 and 23 m. SI=site index. EAGE=effective age.

required for results-based management. For a harvested area, the target yield is the MVOL80 that results from inputting to the yield prediction tables the observed site index and species group plus target values for MSQ and effective age. In the pilot project, the target value for effective age may be set at eight years and the target value for MSQ will vary with ecosystem and management emphasis. For example, the target MSQ will be set lower on dry sites than on mesic sites and lower on areas heavily used by cattle than on areas that are not intended for heavy cattle use. In the pilot project, the target MSQ may be set at 3.6 for many mesic sites. Note that on harvested areas where target MSQ is reduced, the associated target yield is therefore reduced.

Recording Target and Expected Yield in the Ledger

The system is designed for application to a group of harvested areas. Reforestation performance is assessed for this group as a whole. Each harvested area in the group is surveyed. Expected yield and target yield are estimated for defined strata and recorded in a ledger. After all harvested areas are surveyed, overall totals for expected yield and target yield are calculated. Reforestation obligations on the entire group are deemed to be met if the cumulative expected yield equals or exceeds the cumulative target yield (Table 2).

Survey Design for Testing the System in 2002

The proposed system for regulating reforestation obligations will be field-tested in 2002 using a survey design that can be described as stratified systematic sampling. A simplified version of the proposed survey design is described below.

Objective

The objective of the survey is to estimate both total expected yield and total target yield for the population.

Population

For this test, the population is all of the net area to be reforested in a collection of cutblocks that were clearcut harvested 10 years ago.

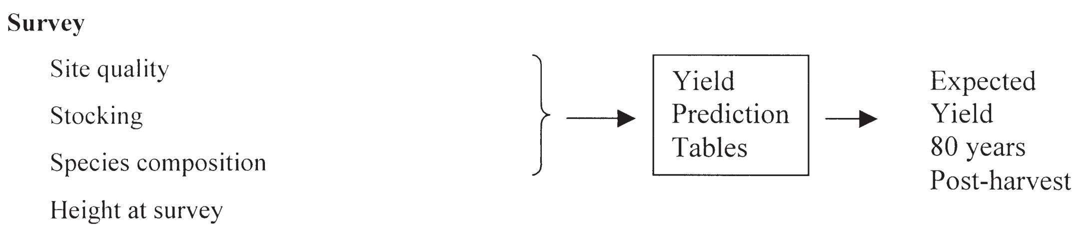

Fig. 3. Four factors are assessed 10 years after harvest to estimate expected yield 80 years after harvest.

Table 2. Target and expected yields are tracked in a ledger with the assessment of reforestation performance based on cumulative amounts

Stratum	Target yield (m3)	Expected yield (m3)
A	2 500	3 000
B	6 500	6 100
C	7 000	6 900
D	8 200	9 200
E	5 000	4 800
Total:	29 200	30 000

Sample selection

Every cutblock in the test population will be surveyed. Plots will be systematically established at an intensity of one plot per hectare over the entire population.

Stratification

The 2002 field-testing will include evaluating alternative stratification schemes. At this time, we anticipate stratifying the population by species group, density class, and target stocking class.

Data collection

At each plot, surveyors will record the stratum in which the plot fell (species-density-target stocking class) and site index, top height, and the stocked quadrant tally.

Data compilation

After the entire population is surveyed, all of the plots in each stratum will be pooled. For each stratum, MSQ will be computed. Mean site index and top height will also be computed and used to determine effective age. Mean site index, effective age, and MSQ will be input to the yield prediction table for the species group to obtain expected yield/ha for the stratum. The target yield/ha for the stratum will be obtained by inputting to the yield prediction tables the observed site index and species group plus target values for MSQ and effective age. Per hectare yield will be multiplied by stratum area (estimated by the number of plots that fell in the stratum) and total yields (target and expected) recorded in the ledger for each stratum. Overall totals will be computed.

Decision criterion

Reforestation obligations will be deemed to be met if total expected yield ≥ total target yield.

Discussion

Implications of Adopting the System

The system to administer reforestation obligations that we have presented here is truly a results-based system as it focuses on results—not processes, procedures and activities. However, we anticipate costs and risks associated with its implementation. There will be costs associated with becoming familiar with the new method. And as the proposed system is new and has not been tested, there is a risk that it may lead to problems that have not been anticipated.

If implemented, we expect that the system may lead to changes in the relative amounts of, and expenditures on, silviculture activities. Under this new system, silvicultural treatments can be deployed strategically. The choice of one treatment can be weighed against other silvicultural options that can also increase expected yield. On some sites, natural regeneration may be used, and so on other sites intensification of management may be required to ensure that the overall target yield is achieved. The new system facilitates a movement toward greater diversity of management intensity among sites. It provides a excellent basis for providing incentives for superior reforestation performance.

The Definition of Desired Results

Today's silviculture must meet multiple objectives such as providing future harvest volume, sustaining biodiversity, protecting visual quality, and so on. However, our system is built around a single indicator (predicted merchantable volume/ha 80 years after harvest) that only relates to the future harvest volume objective. To ensure that silviculture operations meet the broader objectives of sustainable forest management, the use of our system must be constrained—controlled by over-arching policies and a commitment to good forest stewardship.

Yield Predictions

Our yield prediction tables do not cover the full range of species and after harvest stand structures that are present on the pilot area. Douglas-fir, subalpine fir, western larch, ponderosa pine and deciduous tree species are common in the pilot area, but our system is only calibrated for lodgepole pine and interior spruce. We will work around this deficiency with species substitutions—e.g., subalpine fir will be considered as interior spruce. Also, our system is developed for regeneration following clearcutting. The system needs to be expanded to handle partial harvest situations and residual stand structures.

Our yield prediction tables derive from TASS, which is calibrated to match the yields observed on research plots. As the research plots tend to be uniform in site and stocking, with healthy and undamaged trees, TASS yield predictions, and the yields predicted by our system, should be considered as "potential" yield. Mitchell and Cameron (1985) suggest that a reduction of 5–25% is required to adjust TASS predictions to match the volume/ha expected from the average operational stand. A 20% reduction is commonly used in B.C. That our system predicts potential and not average operational yield poses little problem for our application. We do not use the predicted yield; we use the difference between two predicted yields (target and expected) estimated by the same yield prediction tables. It is the difference between target and expected yield that drives our system—and the integrity of our system is not defeated by a consistent bias in yield predictions.

Without access to a spatially explicit, individual-tree growth model (TASS), we would not have been able to develop yield predictions tables that relate MSQ to predicted future yield.

The effective age algorithm employs the assumption that response to the various reforestation treatments is exhausted by the survey date and that growth thereafter is determined by the size that was achieved at the survey date. That is, we assume that after accounting for species, site and stocking, the response to reforestation treatments is a Type I treatment response (Snowdon and Waring 1984). The growth response to reforestation treatments (e.g., site preparation, planting and stock quality, and weed control) is typically—but not always—a Type I response (Snowdon and Khanna 1989, Mason and Milne 1999)[5].

In proposing a simple method to evaluate establishment treatments, Garcia (1996) assumed that the response to reforestation treatments was a Type I treatment response. In a series of experiments in northern B.C., lodgepole pine exhibited a Type I response to site preparation (Lorne Bedford, B.C. Ministry of Forests, personal communication).

Field-testing and further investigation this summer will help us determine whether our yield prediction algorithm needs modification to better predict the yield expected from genetically improved seedlings.

Survey Design

A very simple survey design is contemplated for the test of the system in 2002. In subsequent years, more sophisticated survey designs may be employed that allow us to vary the sample intensity among strata and free us from sampling all cutblocks. Because the inputs to our yield prediction tables are mean values for the stratum, it is difficult to construct confidence intervals around the estimates of total yields. Thus, at this time our decision rule is based on a comparison of sample statistics without regard to the precision of these estimates. We hope to refine this in the future.

Results-based Regulation of Forest Practices

A search of the Internet, with the Google search engine, for "results-based forestry regulations" returned 1070 results—many pertaining to the B.C. government's current initiative to revise the existing suite of Acts, regulations and policies that regulate forest practices. The recent interest in putting forest practices regulations on a more results-based footing can be viewed as part of a broader movement, widespread in North America (for a review see Liner *et al*. 2001), that aims to make all public-sector activities more results-based. The merits of moving from process-based to results-based systems for forest management are being debated. However, it is difficult to advance the debate beyond vague generalities without descriptions of the specific mechanisms that can be employed to accomplish the transition. We hope to sharpen the debate by providing in this paper a detailed description of one mechanism that could be used to put the regulation of reforestation obligations into a results-based framework.

[5]Dr. Euan Mason provides an excellent overview of Type I and II responses on his homepage at http://www.fore.canterbury.ac.nz/euan/siteprep.htm

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