SECTION 6: Evaluating Information in Silviculture Decision-making: Method and Error

6 EVALUATING INFORMATION IN SILVICULTURE DECISION-MAKING: METHOD AND ERROR

Making silviculture prescriptions is a challenging task; the four main factors that contribute to this are described below. First, reforestation sites are extremely complex. The following summarizes some of the variables driving site complexity:

1. Overarching site factors influencing reforestation chance include:
    - Edatopic grid position. Also referred to as moisture nutrient regime (MNR), which describes fundamental aspects of site capability and determines general suitability of the site for various tree species. MNR can change dramatically across a reforestation area. This is especially true when openings include more than one vegetation (AVI) type or are on topographically complex terrain.
    - Meso-topographic position. Includes slope and aspect, which may significantly affect the site potential described above. These factors can vary dramatically across a single reforestation area, especially since apparently minor variations in aspect can substantially change reforestation outcome.
2. Edaphic factors that alter or determine reforestation chance, including:
    - Soil drainage – in particular, impeded drainage which can limit reforestation success. Drainage can vary substantially with changes in elevation as small as a fraction of a meter.
    - Soil texture – helps determine site suitability for certain species. It is directly related to soil drainage but also contributes to potential for compaction.
3. Dense adjacent vegetation and the placement of openings can result in impeded cold air drainage thereby substantially increasing the risk of frost damage to seedlings if late spring frosts occur.

Second, vegetation, both pre-harvest and during the reforestation process, significantly impacts reforestation outcome. Vegetation present prior to harvest drives propagule availability for deciduous regeneration and competes with crop trees for site resources. Pre-harvest vegetation can be quite variable depending on stand history (including previous logging, low intensity fire, and windthrow), site gradients, and other industrial disturbances in or near the reforestation area.

Third, climatic variation can significantly alter community assembly trajectories. Drought or wet conditions at or near the time of planting determine seedling survival rates and the reproduction success of both competitors and crop species.

Fourth, forest soils in Alberta are frequently imperfectly drained which means even very minor variations in ground surface topography may result in seasonal flooding – particularly during the spring thaw. This generally occurs at a scale of a few meters. Because the flooding occurs during a time when trees are very vulnerable it frequently causes small patches of seedling mortality. This variability in reforestation success, while not likely to compromise reforestation success on its own, is additive with other stressors and can shift a marginally successful reforestation outcome to failure.

Confronted with these four factors (complexity of pre-harvest conditions, the variability in post- harvest vegetation, the stochastic influence of climate, and seasonal flooding), practitioners must collect information on the factors that drive reforestation effort toward success, or, potentially more importantly, cause reforestation failures. In addition to capturing this inherent natural variability, practitioners should understand the reliability of the information they collect. Proper decision-making requires effective, accurate information collection and processing. There are several different ways in which reliability of information can be eroded:

1. Poor implementation of sampling protocols – direct assessment errors in species identification, measurement, density counts, vegetation cover estimates, etc. This is the simplest form of accuracy erosion; effectively the information is without, or of lower, value because it is simply incorrect.
2. Error associated with insufficient sampling and or the poor selection of sample plots locations. This is a subtler form of information erosion and arises when sampling methods are inadequate to ensure the entire area is being assessed correctly (representatively). Sampling quality is eroded when assessors do not assess the entire area or when areas of potential difference are overlooked. Often expediency in reducing cost or increasing productivity causes this problem. This is especially important when assessing very complex sites or in areas containing environmental gradients. Another common cause of insufficient sampling is collection of substantial amounts of information at each assessment location – resulting in a great deal of detail at the plot level but making sampling broadly across the proposed opening extremely onerous. **Far better then, to collect critical information – edatopic grid position, risk of frost injury, seedling heaving or seasonal flooding, presence and abundance of critical competitive species and condition of aspen necessary to evaluate deciduous propagule potential – at each of several plots located to ensure the variability inherent in the proposed opening is adequately assessed.**
3. Assessing inappropriate parameters. Wherever possible, use information from direct assessments: for example, when assessing soil drainage, information from “scratch pits” is much more reliable than only using indicator species.

These problems associated with information gathering and assessment can quickly lead to decisions (prescriptions) that, although correctly based on the information, lead to failure when implemented because the information was incorrect or insufficient. For example, not capturing the range of site in an area contributes to making incorrect estimates of limitations or challenges, leading to either failure or inappropriate levels of silvicultural effort.

6.1 THE ROLE OF RISK IN SILVICULTURE DECISION MAKING

Silvicultural decisions are challenging. They trigger the expenditure of substantial amounts of money and carry with them the risk of failure. Good silviculture decision-making requires a thorough understanding of the biology underlying reforestation, the ability to weigh costs and benefits of specific silvicultural practices, and a clear understanding of risk.

With regards to risk, statisticians refer to two “types” of error made when accepting or rejecting hypotheses:

1. Type I errors occur when an incorrect hypothesis is accepted as correct. In a silvicultural sense, this suggests accepting levels of risk that create too great a likelihood of failure.
2. Type II errors occur when a correct hypothesis is rejected as incorrect. Type II errors are often due to setting too high a statistical significance hurdle. Silviculturally speaking, a Type II error occurs when the silviculturist “overbuilds” silviculture prescriptions or processes due to a perceived risk level that is over-estimated.

Typically, silviculturists make Type II errors; this is largely a function of there being little to no margin for silvicultural “failure”. That is, reforestation outcomes are generally subject to some form of regulatory “pass-fail” scrutiny. In order to routinely “pass” all openings in the face of environmental and climatic variability silviculturists tend to “overbuild” reforestation prescriptions.

6.1.1 “TYPE I” ERRORS DUE TO LACK OF INFORMATION

Variation in site factors can greatly influence silvicultural outcomes because the success of treatments, especially site adjustment and propagule selection, is strongly correlated with specific site conditions. If site conditions that are best met with a specific treatment regime vary across the reforestation area, it is imperative that the silvicultural prescription reflect this.

Treatment necessary for success under one set of conditions often prevents success elsewhere. For example, modal sites with imperfect drainage may require site adjustment to ensure that drainage is favorable to conifer seedling establishment. On these sites, mechanical site preparation should focus on a modestly raised microsite, simply sufficient to ensure drainage is maintained. A ripper is often an effective means of achieving the sort of modest increase in microsite elevation necessary to success. However, on poorly drained hygric sites, ripping is much less effective in improving drainage because it often physically impedes water movement off-site during the spring freshet, resulting in seasonal flooding.

If inadequate sampling, information, or knowledge of the general site leads to the reforestation area being assumed to have all the same site conditions due to when it does not, in effect a Type I error has occurred and reforestation efforts will fail on areas that do not match the assumed site conditions. This is demonstrated in Figure 6.1, in which inadequate knowledge of variation in site conditions resulted in a blanket treatment prescription for ripping. As a result, ripping was applied on both appropriate (modal – sub-hygric) and inappropriate (sub-hydric) sites within the same reforestation area.

Figure 1. Error in site adjustment due to lack of information about site variability.

6.1.2 OTHER FACTORS CAUSING "TYPE I" ERRORS

Several other factors can contribute to Type I errors (i.e., errors of omission) in silviculture. These include:

1. Delaying initiation of reforestation efforts in anticipation of natural regeneration. This frequently occurs in areas being managed for deciduous regeneration from suckers where silviculturists do not pay adequate attention to the distribution of ramets prior to harvest, resulting in gaps or holes in regeneration due to a lack of propagules.
2. Attempting to rely on a treatment to achieve objectives better met with a different component of the silvicultural regime, often simply because the treatment is being used elsewhere in the opening. An example is attempting to use large planting stock to obviate the need for a site adjustment treatment.
3. Not recognizing when the relationship between white spruce and aspen changes from commensal to competitive. While aspen performs a nurse function early in the establishment of white spruce, the relationship moves toward a more purely competitive status soon after the white spruce becomes fully established. At that point, spruce growth, and occasionally even survival, can be compromised by continued intimate mixing with aspen.
4. Underestimating risk or the impact of risk on silviculture success. For example, basing planting density on seedling numbers necessary at regeneration survey time without adjusting for likely mortality between planting and survey.

6.1.3 “TYPE II” ERRORS INFLUENCE ON SILVICULTURAL CHOICES

Silviculturists in the boreal forest work with long timelines between treatment and outcome, which means the inadequacy or unsuitability of treatments may not become apparent for several years. Wagner (2005) lists promptness as one of his ten principles for reforestation success.

Compromising promptness may allow some problems to become overwhelming, such as development of solid stands of reedgrass with the concomitant development of a deep, insulating thatch layer that act together to make reforestation almost unattainable.

Faced with these sorts of challenges silviculturists tend to “err on the side of caution” and apply a more robust silviculture regime than necessary to achieve success as unvalued insurance against failure. This is frequently compounded by the evolutionary nature of silviculture process development. Specific treatments or practices tend to evolve discretely and be included in silviculture regimes without considering how they impinge on other components of the silviculture regime.

A classic example is the evolution of reedgrass management in Alberta. Reedgrass has been an ongoing challenge to successful reforestation of boreal sites since clearcutting became prevalent in the mid to late 1960s. Early attempts to use blade scarification and artificial seeding frequently failed in the face of reedgrass competition. Progressively more aggressive site adjustment treatments were developed to “get trees by the grass”. At the same time, the growth of large, physiologically conditioned planting stock was being perfected as another reedgrass management strategy. Both strategies offered some measure of success but with little predictability. By the early to mid-1990s silviculturists routinely used substantial site adjustment treatments (e.g., excavator mounding) coupled with planting very high densities (1600 stems/ha plus) of large, physiologically conditioned white spruce seedlings in an effort to manage the risk of reedgrass competition. With the advent of operational use of glyphosate herbicide (in 1995), silviculturists were able to routinely achieve successful conifer reforestation on sites that were formerly almost impossible to manage because of reedgrass competition. However, silviculture regimes were amended by adding glyphosate to the previously evolved regime without examining intensity of site adjustment and propagule deployment, which might be reduced given the success associated with herbicide use. In effect, silviculturists were reluctant to accept that the reliability of silviculture regimes including glyphosate was sufficiently high that previous risk reduction strategies could be adjusted.

In practice, lacking quantitative understanding of risk, silviculturists tend to make “Type II” errors. That is, silviculture decisions are made very robustly – in effect overbuilding the silviculture system to guard against failure, regardless of the likelihood.

6.2 REDUCING ERROR IN SILVICULTURE INFORMATION COLLECTION

The following suggestions are offered as guidance in reducing error in collecting silviculture decision-making information. These suggestions do not offer a statistically rigorous approach to information gathering; rather, they offer practitioners guidance in conducting meaningful, accurate reconnaissance of silviculture conditions and challenges.

6.2.1 USING SAMPLING INTENSITY TO REDUCE ERROR

Sampling intensity should be determined prior to beginning data collection. If possible, the entire area being assessed should be viewed. This is especially useful in assessing variability of the subject area and works more effectively after harvest than before. Therefore, this approach may be best suited to Post-Harvest (T4) and vegetation assessments at Establishment (T6), Composition (T7) and Performance (T8) management phases.

When assessing the entire area is not possible, or when using defined assessment plots, sampling intensity should be pre-determined and given to assessors. Sampling intensity might be specified a number of ways:

- A fixed number of plots in each reforestation area;
- A diminishing sliding scale of plots per unit with multiple plots in larger units but with a wider spacing between plots as the area of the unit increases;
- A fixed number of plots per unit area; or
- A sliding scale of plots per unit area based on the overall area, with larger units receiving less plots per unit area than smaller ones.

When determining sampling intensity, it is often worthwhile to increase intensity if there are high risk indicators on the site (See Section 10 for site constraints and Sections 4 and 5 for biotic constraints). Given the high cost of silviculture failure and the similarly high cost of overbuilding treatments, identifying and understanding challenges prior to prescribing silviculture regimes or specific treatments is likely to be of great value.

6.2.2 MANAGING VARIABILITY TO REDUCE ERROR

While assessments cannot reduce site variability, it is possible to manage variability and thereby reduce the error associated with it. The best way to manage variability is to group like conditions and sample them as discrete units (Figure 6.2). Commonly referred to as stratification, dividing assessment areas into like “groups” should be based on similarity in the conditions or factors being sampled. To reduce error, stratification should be made prior to sampling.

Figure 6.2. Example of an opening stratified based on vegetation characteristics.

To stratify vegetation prior to assessment, make sure the following parameters are similar:

1. Species composition – at least the main species making up the plant community in each stratum should be the same.
2. Species abundance – should be broadly similar whether measured as cover or density.
3. Species distribution – spatial distribution of key species should be similar whether assessed as percent distribution or broadly described as uniform, clumped, voids, etc.
4. Size of key species – should be similar within a stratum (for example height of deciduous or tall shrub species).

Each stratum identified should be sampled as an individual unit, following the same rules for numbers of plots and location of plots as if it were a separate assessment unit. Stratification should be confirmed once results of sampling have been assembled.

It may not be possible to stratify if extremely mixed vegetation is encountered (Figure 6.3). In cases like this it is best to increase sample size when using plots. If assessing and prescribing without using plots, another approach to addressing this sort of complexity is to describe the vegetation compositions and structures present, and then assess the extent (proportion) of the opening covered by each.

Figure 6.3. Example of two intermingled strata.

6.2.3 REDUCING ERROR ASSOCIATED WITH QUALITATIVE ASSESSMENTS

Error associated with qualitative assessments can best be reduced by making the assessment quantitative. For example, instead of using a cover based assessment of competition when aspen heights exceed two to three meters, one could use the light threshold tool to assess aspen impact on light based on two quantitative parameters, density and quadratic mean diameter (see Section 5).

Another approach is to use carefully calibrated assessments to set treatment thresholds, then retrospectively quantify key variables and use them as surrogate thresholds. For example, use the Comeau Herbaceous Competition Index first to determine where vegetation management thresholds occur for specific compositional objectives and then count aspen density and assess reedgrass cover to set density and cover based thresholds. These new density and cover thresholds could replace the competition index, which requires assessment of aspen cover.

Another approach to managing error arising from qualitative assessments is to carefully calibrate the assessor. If making ocular estimates of density, the assessor can simply verify calls by stopping and counting density in the area assessed. If making cover calls, the assessor can look at a small area (less than 1 m on a side) and carefully validate the cover call by breaking the small area into smaller patches and adding up the cover.

Calibration of assessors is most important when multiple assessors are making qualitative assessments. In this case, the team making assessments should calibrate as a group on a single site prior to making any assessments. It is also valuable to have a “keeper of the method”, a well calibrated individual who makes spot checks on qualitative calls and adjusts assessor calibration as needed.

6.2.4 REDUCING BIAS INDUCED ERROR

Bias is best reduced by using randomization and sample placement control. Randomization ensures the assessor will not skew the starting point of the assessment. This often occurs unintentionally as the assessor chooses a starting or assessment point based on a factor that makes assessment simpler or faster without regard for the impact that selection has on assessment outcome. Similarly, using a pre-defined grid or sequential sampling regime prevents the assessor from introducing bias.

6.2.5 AN EXAMPLE OF REDUCING ERROR

As an example, consider the need to assess approximately 3000 ha for possible vegetation management at the Establishment Phase (T6). The following steps describe how a process might be developed to do this efficiently and with minimal error:

1. Define a specific time for assessment: years after harvest and season of assessment.
2. Set treatment threshold values for the herbaceous competition index based on desired long-term compositions.
3. Develop a treatment flowchart based on thresholds and treatments appropriate to the composition objectives pursued.
4. Survey several openings in each compositional class using the Comeau Herbaceous Competition Index; use high sample intensity and well calibrated assessors.
5. Link Herbaceous Competition Index outcomes to reedgrass cover values and or deciduous density.
6. Translate the thresholds in the prescription flowchart to cover and density values.
7. Conduct future assessments by air:
    1. Stratify openings into like units. If stratification is difficult, note if the assessed community is highly complex, and use extent of plant life forms to describe the complexity.
    2. Assess reedgrass cover and extent in each unit.
    3. Assess deciduous density and extent in each unit.
    4. Make prescriptions based on the flowcharts.

6.3 LITERATURE CITED

Wagner, R.G. 2005. Top 10 Principles for Managing Competing Vegetation to Maximize Regeneration Success and Long-term Yields. Forest Research Information Paper No.160, *In* The Thin Green Line: A Symposium on the State-of-the-art in Reforestation Proceedings, 26-28 July 2005, Thunder Bay, Ont. *Compiled by* S.J. Colombo. Ontario Forest Research Institute, Sault Ste. Marie, Ont. Pp. 31-35.