SECTION 2: Silviculture Strategies

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2 SILVICULTURE STRATEGIES

Integration of silvicultural treatments into a comprehensive strategy is a vital component of successful reforestation. Successful integration ensures that treatments coherently address site challenges and work together in additive and, potentially, synergistic ways. Synergy means that the silvicultural effects of integrated treatments may be greater than the sum of the individual treatment effects.

Wagner (2000) suggested that the current silvicultural paradigm attempts to guide plant community development in a desired direction. This may be best accomplished by a series of well-timed "nudges" rather than by a single "hammer blow." The integration of treatments into a strategy involves identifying a coherent series of potential nudges and anticipating when they might be used with best effect.

2.1 KEY COMPONENTS

Successful, integrated silviculture strategies rely on several critical principles including anticipation, proactivity, promptness, focus, balance, and cost effectiveness.

ANTICIPATION

Anticipation refers to the identification of potential challenges to reforestation success when formulating the silvicultural prescription. For example, reedgrass competition can be anticipated to pose a substantial problem to reforestation success on the site shown in Figure 2.1. In this instance, silviculturists should anticipate the need to overcome reedgrass competition when prescribing site adjustment treatments, selecting propagules, and planning stand tending treatments.

PROACTIVITY

Proactivity is acting on anticipated challenges before they can impact development of the plant community. That is, by anticipating the need for treatment **and acting to prevent, avoid or ameliorate the negative effect** before it can alter the successional or growth trajectory of a developing stand. As with most biological interventions, silvicultural treatments are more successful when used to maintain rather than shift a stand's trajectory.

PROMPTNESS

Promptness refers to the deployment of treatments in a timely manner. Promptness in implementing silvicultural treatments increases the probability that the treatment will have the desired outcome. Promptness is not "early" treatment; rather, it is treatment at the right time for maximum benefit to the development of the stand.

Figure 2.1 Reedgrass in the understory of an open mixedwood stand.

Promptness is of particular importance when using herbicides for herbaceous competition control in mixedwood management. The recovery of deciduous species from herbicide effects is far greater if the herbicide treatment occurs within three years of harvest (recovery in this context refers to density and presence not to recovery of individuals). Therefore, if a broadcast herbicide treatment is to be used for herbaceous vegetation control in openings where mixedwood composition is desired, it should occur within three-years post-harvest. This is not to imply that deciduous recovery from herbicide treatment will be complete, though it may suffice to meet mixedwood stocking and density requirements.

Another example of promptness is delaying vegetation management treatments intended to control aspen when white spruce is at risk of winter injury – until the white spruce is sufficiently established on site to cope with the drivers of winter injury. This approach accepts a certain reduction in growth of the white spruce due to aspen competition in exchange for a possible facilitative effect should conditions conducive to winter injury arise. This trade-off may be justified by the substantial negative impact of winter injury, which can include considerable mortality.

Thus, promptness in silviculture might be termed “right timing” of treatment or “just in time treatment”. Promptness integrates the likelihood (i.e. risk) of deleterious effects with benefits of treatment and is generally the mark of an experienced silviculturist. It may also present challenges, for example on sites where early herbaceous weed control will benefit white spruce but will compromise aspen facilitation of spruce should winter injury conditions arise. In such situations the silviculturist may choose to ‘straddle’ the challenge by targeting treatment to areas of herbaceous vegetation only thereby addressing the core of the challenge without substantially impacting what nurse effect the aspen offer.

FOCUS

Silvicultural effort should focus at two levels:

- First, effort should focus on the specific challenge or challenges being addressed by the current treatment and ensuring that the treatment is appropriate. For example, site adjustment treatments generally address both abiotic and biotic concerns. Therefore, when prescribing site adjustment treatments, silviculturists should ensure that treatments are appropriate to ameliorating the site's limiting factors. For example, elevated microsite treatments, while highly effective on sites with wet, cold soils, are an inappropriate choice for ameliorating a lack of soil nutrients on a dry site. Conversely, mixing with drags, while highly successful on dry, nutrient-poor sites, would not be chosen to address an over-abundance of soil moisture.
- Second, attention must be given to longer term and broader scope objectives. This ensures that treatments addressing current challenges do not compromise broader or longer term objectives. Managing for mixedwood composition puts considerable emphasis on this approach. It is difficult to replace deciduous saplings lost to silvicultural intervention because deciduous regeneration generally arises from a leave-for-natural regeneration strategy. Therefore, silvicultural treatments prescribed for coniferous benefit should be carefully evaluated prior to deployment for potential impacts on the deciduous crop. If treatments will have a negative impact on the deciduous crop, consideration should be given to adjusting how treatments are deployed and/or using ameliorative actions to ensure mixedwood objectives are not compromised.

BALANCE

Silviculture prescriptions should not rely entirely on the success of a single treatment. Instead, risk should be spread across treatments as this generally increases the probability of success. It also allows silviculturists to reduce the intensity of what would otherwise have been a critical treatment.

For example, on a site where reedgrass competition is anticipated to pose a substantial challenge to reforestation success, the silviculturist might choose glyphosate herbicide as the primary treatment to address this challenge. However, should the site be treated in a very dry year, effectiveness of the herbicide might be reduced and the entire silviculture prescription compromised. Conversely, failure of the herbicide treatment would not necessarily compromise success if the silviculture prescription relied on a sequence of treatments to address the reedgrass challenge, for example, site adjustment treatment using elevated microsites, medium size physiologically conditioned seedlings, and stand tending with glyphosate herbicide.

COST EFFECTIVENESS

The cost of reforestation is second only to transportation of mill furnish for most coniferous-based forest enterprises. Therefore, silviculturists are usually focused on cost management. Cost management can take the form of cost minimization or of maximizing cost effectiveness. Cost minimization is difficult to implement in the face of the many uncertainties that attend reforestation. For example, reducing site

adjustment costs by line mounding a hygric site may have little impact on reforestation success if establishment occurs over a period of dry years. Furthermore, such a cost minimization strategy may result in failure if establishment occurs over a wet period. Therefore, managing for cost effectiveness may be a better means of ensuring reforestation success at an acceptable cost than cost minimization. Cost effectiveness focuses on prescribing a suite of treatments that have an acceptable probability of achieving the desired silvicultural outcome while considering overall silvicultural cost. **A critical component of the cost effectiveness approach is ensuring that the silviculturist and woodlands management personnel have a similar understanding of what constitutes "an acceptable probability of success."**

Silviculturists are encouraged to engage management in a conversation about maximizing cost-effectiveness rather than minimizing cost on a philosophical or principle basis prior to discussing specific sites or prescriptions. This approach will likely require an adjustment on the part of both players; silviculturists will need to accept the possibility that sites do not achieve their specific target may be acceptable, while managers will need to accept that proactive expenditures to mitigate risk may be more cost effective overall. The performance-based approach to assessing reforestation outcomes in Alberta facilitates this approach. The critical assumption in taking this approach is that overall growth of the forest estate will not be compromised; for each site where the target is not achieved another site that over achieves reforestation performance must exist.

2.2 INTEGRATION

Integration is the vehicle whereby silviculturists develop coherent, long-term prescriptions (strategies) as discussed in Section 2.1. The Silviculture Guide is designed to integrate discrete treatments into encompassing prescriptions. There are several parallel flowcharts included in the Guide that provide silviculturists a vehicle to integrate prescriptions from a wide range of starting points.

Only by integrating discrete treatments is the silviculturist able to optimize treatment effectiveness with a cost effective silvicultural plan. Successful integration depends on several factors, including:

- Clarity in management objectives – regarding both the desired composition and structure of mixedwood stands and yield expectations (clarity on desired rotation length may be an adequate surrogate given the dearth of managed mixedwood yield data).
- Understanding component treatments and how they influence both deciduous and coniferous reforestation success.
- Understanding potential interactions between treatments and how trade-offs between them can be made. This is particularly important when considering site adjustment and propagule selections.
- A quantitative understanding of reforestation success on the silviculturist's own operating limits. This means silviculturists must monitor treatment success in terms of site, timing, and silvicultural context (i.e., other treatments, climatic conditions, and other biotic influences).
- Agreement between the silviculturist and woodlands management on acceptable levels of risk regarding both financial expenditure and silvicultural failure.

2.2.1 SETTING MIXEDWOOD COMPOSITION AND STRUCTURAL OBJECTIVES

It is beyond the scope of this Guide to provide forest management objectives; the silviculturist must refer to the Detailed Forest Management Plan that applies to the area for which prescriptions are being made. However, the following terminology has been developed to help silviculturists use the Guide to meet mixedwood objectives. Note that percent composition is in terms of density.

- Coniferous – refers to a stand condition with at least 80 % coniferous composition.
- Conifer leading – refers to a stand with more than 50 % but less than 80 % coniferous composition.
- Deciduous leading – refers to a stand with more than 50 % but less than 80 % deciduous composition.
- Deciduous – refers to a stand with at least 80 % deciduous composition.
- Intimate mixedwood (salt and pepper) – a mixture where spatial separation of species is on the scale of a few meters or less (Kabzems *et al*. 2007).
- Aggregated mixedwood – a condition wherein white spruce and aspen are managed as discrete, separate entities within an opening. Within aggregations some influence of each species on the other is maintained.

2.2.2 MONITORING

Like management objectives, monitoring is beyond the scope of this guide. However, a sound monitoring program is critical to reforestation success. Operational monitoring of silviculture strategies and treatments provides a quantitative basis for estimating reforestation success and the ability to quantify the probability of failure. This can be done from operational treatments if the following conditions are met:

1. Detailed treatment records are maintained on both temporal and spatial criteria. With the advent of GIS-based silviculture tracking systems, this means reporting treatments in both tabular and spatial formats. This ensures that silviculturists will know what they are monitoring.
2. Documentation of silviculture strategies takes place. Silviculturists must explicitly document silviculture strategies either at the site level (i.e., define strategies by moisture and nutrient regime or by ecosite) or at the block level. For ease of workload, site level documentation accompanied by block level site classification is suggested. This provides structure for linking silviculture strategies to openings.
3. When testing or adopting a new treatment a small untreated area should be left in larger treatment units. Leaving small untreated areas provides a reference as to specific treatment effectiveness, which is particularly useful in assigning value to a treatment. Effectiveness versus cost provides an excellent ranking system for disparate treatments. It is especially important to leave untreated areas on the same site type as the bulk of the treated area lest the evaluation of treatment effectiveness be flawed.

2.3 SETTING SILVICULTURAL STRATEGIES

This section offers some guidance in setting silvicultural strategies. It is offered as an example and follows the same logical flow as the more site–specific prescription flowcharts in Section 3 of the Guide. The primary focus of this section is to help practitioners integrate the strategic concepts offered in Sections 2.1 and 2.2 above. Other approaches to setting strategies are viable and may be more appropriate to specific circumstances. In fact, it is suggested silviculturists use this example only as a model to expand or refine the generic strategies in Section 3 making them more coherent with their forest management practice.

Silviculture strategies must be adaptive and iterative; however, a step-wise approach to strategy development is offered as it provides greater clarity in decision-making and data needs. Figure 2.2 is a flowchart of the strategy-setting example.

2.4 STRATEGY CAPTURE AND EVALUATION

Silviculturists should record or capture and retain silviculture strategies to facilitate monitoring and process improvement. Capture should be at the ecosite–edatope level as this approach aligns with the approach to prescription development taken in the Guide.

Regardless of its format, strategy capture should be associated with specific openings in a GIS, in block files, or both. As regeneration success is measured using survival surveys, assessment surveys, regulatory surveys, and, ultimately, a comparison of reforested stand growth to forest management planning expectations, the silviculturist should evaluate the effectiveness of the captured strategies. This process would likely be facilitated by compiling both strategies and success in a GIS environment. Once sufficient data is accumulated, silviculture success by site condition and strategy could be analyzed using the Boolean logic (true-false, present-absent) inherent to GIS systems. Thus, capturing decisions at all stages, beginning with the pre-harvest stage, fosters iterative decision-making around strategy development and creating effective, quantitative feedback loops from silvicultural outcomes to process.

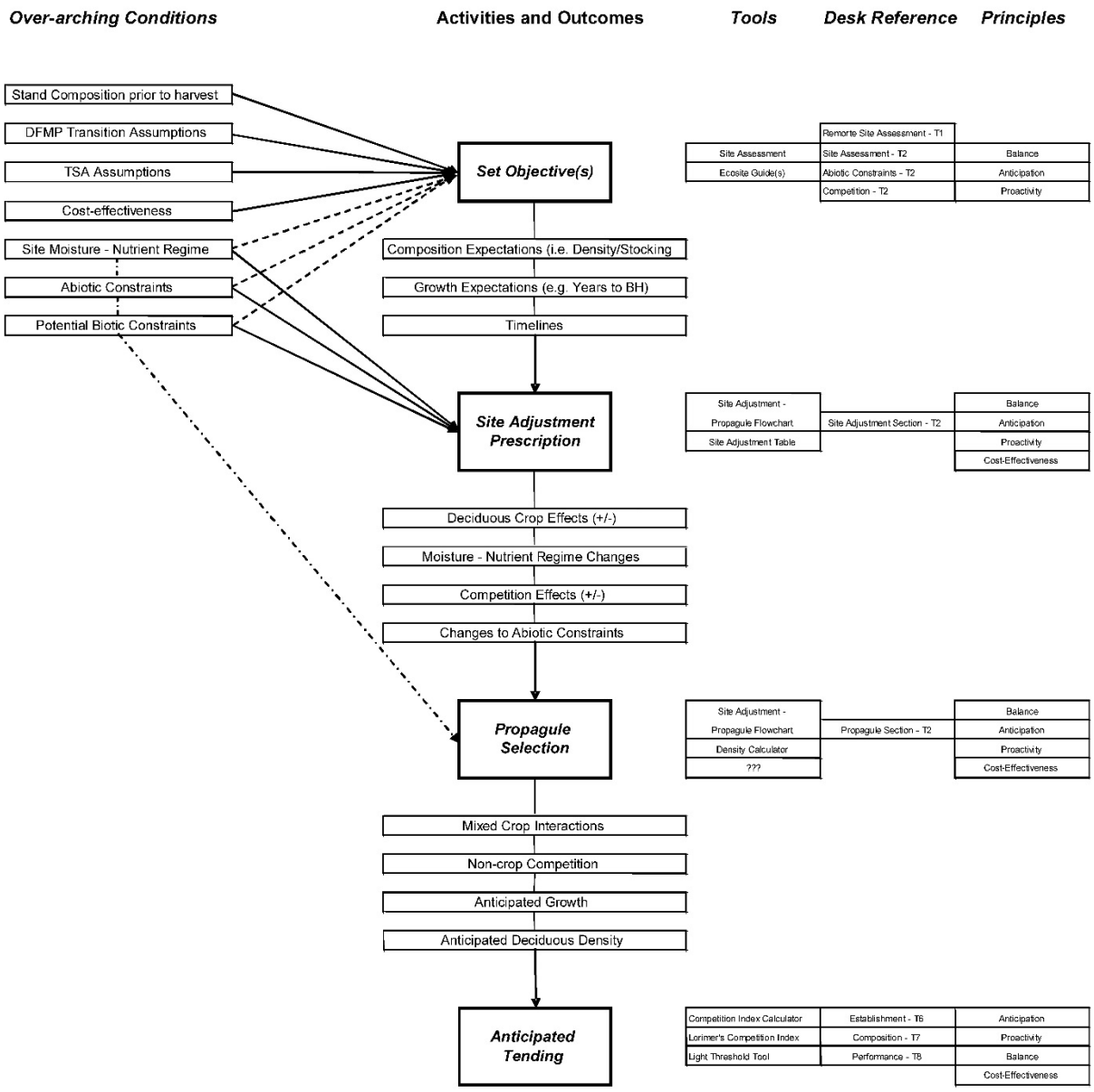

Figure 2.1 Example Process for Setting Silvicultural Strategies.

2.5 SILVICULTURAL FAILURES

Despite the best efforts of silviculturists, silviculture treatments and strategies may fail. This section addresses how to deal with feedback from failures, and using silvicultural treatments to remedy failure.

2.5.1 ADJUSTMENTS TO SILVICULTURAL PROCESSES

When failure occurs silviculturists should consider the following questions:

1. Is the failure a result of a treatment failing or a result of the strategy failing?
    a. Treatment failures can be described as treatments not achieving the desired effect.
    b. Strategy failures can be described as treatments achieved the desired effects but the strategy did not achieve the silvicultural objective.
2. If the failure is the result of a treatment failure, why did the failure occur?
    a. Was failure a result of untoward conditions compromising treatment effectiveness? For example, deep frost could prevent successful site adjustment, or drought could compromise herbicide efficacy.
    b. Was failure a result of inadequate delivery of the treatment? For example, poor tree planting quality.
    c. Was the failure a result of tardy delivery of the treatment? For example, a stand tending treatment delivery after considerable competition-induced mortality of the conifer component of the stand.
    d. Was failure a result of the treatment being used inappropriately? For example, use of mixing site preparation with heavy drags on a hygric site with a deep organic matt.
3. If failure was the result of a strategy failing, what factors caused the failure?

By answering these questions the silviculturist will be guided to adjustments in strategy development, treatment selection, or treatment implementation.

For treatment failures:

- An affirmative answer to question 2a demonstrates a limitation to the treatment in question thereby helping the silviculturist better focus use of the treatment.
- An affirmative answer to question 2b or 2c demonstrates an operational failure that suggests improvements to operational procedures should be explored.
- An affirmative answer to question 2d demonstrates a failure in prescription which should be explored to determine if the limitation that was not overcome, was not identified when making the prescription, or if the silviculturist misapprehended the effectiveness of the treatment prescribed.

For strategy failures, the silviculturist should revisit the decision-making process. This information should be examined in light of the failure to determine if the potential negative impact of constraints was underestimated, treatment (or combined treatment) effectiveness was overestimated, or elements critical to success such as anticipation and promptness were missed in making or implementing the prescription.

Once causal factors are identified the silviculturist should refine the silviculture strategy and/or treatment prescription/implementation processes, as appropriate.

2.5.2 REMEDIAL TREATMENTS

Once the cause of failure has been identified, the silviculturist is equipped to prescribe remedial treatment(s). Remedial treatments are more limited in scope, more demanding to implement, and less likely to succeed than initial treatments. Therefore, the silviculturist may wish to consider changing the silvicultural objective to better match site conditions instead of pursuing remedial treatment.

Unless they are due to selection of an inappropriate treatment, treatment failures should be addressed differently than failures in strategy. If identified promptly, failed treatments may simply be repeated, provided adjustments are made to ensure the desired effect will be achieved. For example, if frozen soil prevented a successful mixing site adjustment with a power disk trencher, mixing might be repeated using a ripper plough. Note that should site adjustment or propagule deployment (planting or seeding) treatments require repeating, all subsequent treatments in the silviculture strategy will likely need to be repeated as well.

When repeating treatments due to failure, silviculturists should consider the impact of previous treatments on the site. For example, if a site was previously treated with raised microsite site adjustment treatment with a large excavator, this may prevent a remedial site adjustment treatment such as a linear or mixing treatment. In cases like this the silviculturist may be forced to use a treatment that addresses only a part of the challenge posed by the site. In the previous example, if part of the site adjustment treatment failure was due to poor competition control, the silviculturist may choose to control competition with herbicide rather than re-deploy a site adjustment treatment.

It is particularly important to carefully monitor the success of remedial treatments, as prompt post-treatment corrections to possible failures becomes even more critical when failed treatments have already compromised desired silvicultural outcomes.

2.6 LITERATURE CITED

Kabzems, R., Nemec, A.L. and Farnden, C. 2007. Growing trembling aspen and white spruce in intimate mixtures: Early results (13-17 years) and future projections. JEM 8: 1-15.

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