Top 10 Principles for Managing Competing Vegetation to Maximize Regeneration Success and Long-Term Yields

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Introduction

Vegetation (including trees, shrubs, grasses, and forbs) that rapidly establishes on newly disturbed forest sites often determines whether forest regeneration efforts will be successful. Although most plants growing on forest sites are a natural part of the forest, many plant species can invade or re-establish themselves in sufficient abundance and stature to threaten the survival and growth of desired tree species. This competing vegetation exerts its influence on resource availability and conditions in the environment of young trees. Seedling responses to vegetation management are influenced to a large degree by competition for light, water, and nutrients.

If harvested forest stands are to be returned to forests of a desired species composition, structure, and growth rate, strong consideration must be given to the vegetation that grows on all regenerating sites. Unlike protecting young forests from insects, diseases, or wildlife pests, which tend to be localized at certain times, vegetation is generally a problem on every forest site being regenerated. As a result, vegetation management must be an integral part of almost every forest regeneration prescription. In fact, few aspects of silviculture provide more control over the outcome of forest growth and development.

The vegetation associated with young forests is also a vital component of the forest ecosystem and plays an important role in the function, protection, and management of other forest resources. Good forest vegetation management, therefore, seeks to balance the negative effects of competing vegetation with the vital role that it serves in forest ecosystems.

So, what does the latest research indicate about the long-term yield gains associated with managing forest vegetation? Can significant financial returns be realized? Can focused regeneration and vegetation management efforts increase sustainable harvest levels and wood supplies? What principles should forest managers follow to ensure that the highest yield gains can be achieved? The following offers some insight into these questions.

Long-term yield gains from forest vegetation management

Over the past several decades, there has been a substantial amount of research quantifying increases in forest productivity associated with vegetation management in the North American forests. Most of this research, however, has reported growth responses for only several years following vegetation control treatments. Documenting the benefits of effective vegetation management on forest productivity, however, requires measurement over a significant portion of a stand's rotation to document the long-term growth and yield response associated with specific treatments. Toward that end, there is a growing body of longer-term studies for most North American forest types that have documented growth and yield changes over a significant portion of the forest rotation. Rotation-length data are now available for some trees species.

Wagner et al. (2004) recently examined the longest-term studies in North America that have documented gains in wood yield from effective forest vegetation management. Twenty-three replicated studies that included experiment controls (i.e., untreated plots) and a variety of vegetation control treatments from Pacific Northwestern, Southeastern, and Northern forests in the US and Canada were reviewed. Only studies with a minimum of 10 years of post-treatment growth measurements were included. Several studies had between 25 and 30 years of measured growth responses. Nearly all of the studies examined commercially-important conifer species. Percent gains in stand or individual-tree wood volumes from the most effective vegetation treatment relative to that of the corresponding untreated control were reported for each study. Eight studies were reviewed from the Pacific Northwest (primarily for Douglas-fir), ten from the Southeast (primarily loblolly pine), and five from northern forests that examined responses for a variety of northern conifers.

Results from these studies, which included from 10 to 30 years of growth response, revealed substantial increases in wood volume yield gains above untreated controls from effectively managing forest vegetation.

Most of these studies had used herbicides to control the vegetation. Increases from 30–450% were found in Pacific Northwestern forests, 10–150% increases in the Southeastern forests, and 50–450% increases in Northern forests. Most of the 23 studies examined indicated 30–300% increases in wood volume yield for major commercial tree species.

Financial returns from vegetation management

Studies documenting the financial returns associated with these yield gains are far less common. Recent analysis from one of the longer running experiments in northern Maine by Daggett (2003), however, projected 22 year stand-level growth responses through to financial rotation at 50 years for various combinations of aerial herbicide application and precommercial thinning (PCT). The net present value (NPV) using a 4% discount rate at 50 years was $1,549 US per ha for aerial glyphosate and triclopyr herbicide treatments, $1,337/ha for the phenoxy herbicide treatments, and $1,023/ha for the untreated control. The NPV for PCT alone was $890/ha. Combined herbicide + PCT treatments had NPVs around $717/ha. Mean internal rates of return were about 8% for herbicide treatment alone, 6.1% for PCT alone, and 5.8% for herbicide + PCT. Results from this study indicated that the long-term merchantable yields and financial returns from PCT required previous management of competing vegetation.

Influence of successful regeneration and vegetation management on wood supplies

Can effective vegetation management influence the wood supplies and sustainable harvest levels for large forest properties or regions? Wagner at al. (2003) conducted an analysis of the influence of various levels of herbicide and PCT application on the long-term sustainable harvest level and NPV for forestlands in the state of Maine. An optimal future treatment scenario that increased the amount of herbicide application and PCT was projected to increase the level of sustainable harvest for the state by 31% and the NPV of the state’s forestlands by 12% than a scenario that included no future silvicultural treatments. Management of competing vegetation was an assumption that made PCT feasible in this study.

Predicted gains in experiments are interesting, but the influence of vegetation management and other effective regeneration practices on the long-term harvest levels of actual forest properties is another. Canada has such a model forest in this regard. The 189,000 ha Black Brook District owned J.D. Irving, Ltd. in northern New Brunswick has been intensively managed since the early 1960s. Projected sustainable harvest levels using a spatially-explicit management plan from 2002 to 2077 reveal the power of focused regeneration and vegetation management activities. Sustainable harvest levels today are roughly 2.5 times higher than if Irving had never initiated intensive silvicultural practices on Black Brook (personal communication, Blake Brunsdon, J.D Irving, Inc.). The most impressive part of the projection is that around 2020, sustainable harvest levels for Black Brook begin to ramp up significantly. By 2040, sustainable harvest levels are projected to be about 4.5 times higher than if intensive silviculture had never been practiced on the District. The landscape-level implications for Irving’s intensive management of the Black Brook District have been recently analyzed by Etheridge et al. (in press).

Top 10 principles for managing competing vegetation to maximize regeneration success and long-term yields

Substantial wisdom can be gained from the above studies and operational experience that foresters can apply when managing forest vegetation to maximize regeneration success and yield gains. Based on this research and experience, I offer the top 10 principles that should be strongly considered when developing prescriptions and plans for managing forest vegetation:

1. Plant high-quality seedlings as soon after harvest as possible – any delay can be deadly.

One of the most important principles for achieving successful artificial regeneration is to ensure that tree seedlings are planted as soon after harvest as possible. Competing vegetation on the site will be in its most suppressed state at this point and resource availability (light, water, nutrients) will be at the highest level for new seedlings. This early start gives young trees the greatest chance at achieving a place in the next stand.

Conversely, any delay in establishing desired trees gives unwanted shrubs and trees an opportunity to consume available growing space and competitively exclude desired tree species that might be planted later. Most competitive plants that establish following forest harvest have very rapid early growth rates. The early growth rates for planted tree seedlings are generally much slower, and therefore, put them at a competitive disadvantage in the beginning. Any delay in planting trees accentuates this difference and greatly increases the risk of regeneration failure. Many of the non-sufficiently restocked (NSR) lands I have seen in Canada have occurred due to time delays between harvest and planting.

2. Herbaceous vegetation in small amounts (<20% cover) substantially reduces early stand growth.

One of the most significant discoveries in forest vegetation management research during the 1980s and 90s was how competition from herbaceous vegetation (grasses and broadleaves) can suppress the growth of young trees. Despite substantial documentation of the strong negative effects of herbaceous vegetation in forests around the world, many foresters believe that it is not that competitive and therefore not an important management consideration.

Recent experiments from around North America suggest that the growth potential of young forest stands can be reduced from 50-70% or more by early competition from grass and broadleaved vegetation. Further, results indicate that fairly substantial levels of vegetation control are needed for there to be any freedom from the growth suppression of surrounding vegetation. A minimum-response threshold level of 20% cover has been suggested in a number of studies. That is to say, the abundance of herbaceous vegetation must be reduced below 20% cover before any increases in growth from vegetation control can be realized. These studies indicate that maximum growth occurs under nearly complete vegetation control and that the growth rate of young trees decreases rapidly with increasing cover. Above 20% cover, the full competitive influence of herbaceous vegetation is often achieved. Therefore, increasing the growth rates of young plantations from early vegetation control requires achieving levels of cover far below 20% during the early years of plantation development.

3. Only several years of good vegetation control immediately after planting may be needed.

Although achieving levels of vegetation control below 20% cover may seem daunting or impractical, results from several critical-period competition studies are suggesting that most of the early growth potential for plantations can be achieved with only several years of intensive vegetation control, provided that it occurs immediately after planting. Near maximum growth rates were achieved in an Ontario study if vegetation could be controlled for only two or three years following planting (Wagner et al. 1999). Additional years of control did not provide substantial yield gains. Any delays in achieving this early level of vegetation control after planting substantially reduced early stand growth.

4. Good site preparation is vital.

The most effective way to manage early successional vegetation, achieve levels of cover below 20%, and make available site resources (light, water, nutrients) available to young seedlings is through good site preparation. Site preparation provides a moment in time when foresters can exert the greatest influence over the seed and bud bank of plant propagules that will form the next forest stand. All of the available vegetation management tools (fire, herbicide, machines, manual cutting, grazing) in their varied forms are available and can be applied more economically and effectively during site preparation than at any other point in stand development. Overall regeneration success, achieving high rates of early stand growth, and determining the species composition of the next stand are all determined by how effectively the site was prepared before planting. Recommendations for achieving effective site preparation can be found in Dey and MacDonald (2001), Ryans and Sutherland (2001), McRae et al. (2001), and Campbell et al. (2001).

5. Focus investments on highest productivity sites.

Although several studies indicate that the proportional yield gains from controlling competing vegetation can be similar on high- and low-productivity sites, the actual or absolute yield gains are greatest on sites of high productivity. Some foresters believe that since the proportional gains are similar on sites of high and low productivity that the priority for vegetation management investments should be similar on good and poor sites. Since the cost of vegetation control treatments tend to be the same regardless of site productivity, the returns on investment are not. The highest financial returns come from absolute, not proportional, yield gains. Therefore, treatment priorities for limited vegetation management budgets should be focused on the most productive sites.

6. Target release treatments on tall shrubs and unwanted hardwoods as early as possible.

Although herbaceous vegetation can substantially reduce early stand growth, unwanted hardwoods and tall shrubs (especially those species with high dominance potential) have the greatest potential to reduce long-term yields since they can deny desired trees a place in the overstory. Wagner et al. (2001) identifies the dominance potential of various plant species in Canadian forests. As a result, when woody species of high dominance potential are abundant on newly regenerated sites, release treatments should be applied as early as possible. Early treatments are especially important on sites where shade intolerant tree species (e.g., pines) are being regenerated as most cannot survive more than two years of overtopping. Greatest long-term returns on investment from vegetation management will be achieved on such sites, especially when they are highly productive. There are some herbaceous species (such as *Calamagrostis canadensis*) with high short-term dominance potential that must receive equal treatment priority since they can also competitively exclude planted seedlings in a short time. Experience suggests that targeting vegetation control efforts during site preparation and during the first couple of years after planting will often reduce the longer-term abundance or delay the invasion of many unwanted shrubs and hardwoods.

7. Shade tolerant tree species benefit from vegetation management as much as intolerant species.

There is a myth among some foresters that shade tolerant tree species require some degree of overtopping or competition from surrounding vegetation to be successfully regenerated. The evidence from a number of controlled studies across North America, however, indicates that yield gains from early vegetation control are similar for both tolerant and intolerant tree species. In fact, results from one study suggest that tolerant species may require more intensive vegetation control to achieve the same yield gains as intolerant species (Wagner et al. 1999). The ability of shade tolerant tree species to survive overtopping for extended periods does not mean that they require or grow best under those conditions. As a general rule, vegetation management standards for achieving the highest growth rates in young stands are the same for both tolerant and intolerant tree species.

8. Few studies have demonstrated that tree seedlings benefit from surrounding vegetation.

It is common to find claims, particularly from those opposed to herbicides, that the growth and survival of tree seedlings is enhanced or requires the presence of surrounding vegetation. Hundreds of well-designed experiments have been conducted over the past 25 years that document the growth responses of tree seedlings following the removal of surrounding vegetation. Results from these studies overwhelmingly demonstrate that the growth and survival of tree seedlings are improved by the removal of surrounding vegetation. Rare exceptions can be found when neighbouring vegetation improves certain extreme microclimatic (e.g., topographic frost or direct sunlight) or biological (e.g., susceptibility to pests such as the white pine weevil) conditions. However, when these benefits do occur, they only appear to operate for a short period of time, after which the effects of vegetative competition become detrimental. When beneficial for a longer period, the ameliorating effects of vegetation merely exceed the negative effects of competition, and reflect extreme site conditions rather than general ecological relationships.

9. Stem diameter growth (not height growth) is the best indicator of competitive stress.

Many forest regeneration standards across North America focus on a minimum performance requirement for seedling height growth. While height growth is clearly important for achieving long-term site dominance, many of the studies described above have demonstrated clearly that height growth is far less sensitive to the effects of competing vegetation than stem diameter growth. This difference appears to be the result of a higher allocation priority for height growth in young trees. As a result, the best indicator of competitive stress in young trees is stem diameter growth. Diameter growth is the best predictor of overall root and leaf biomass, and therefore, tends to be the best predictor of future growth performance. Thus, forest managers should also base plantation performance standards for vegetation management on minimum requirements for diameter growth.

10. Natural regeneration benefits from early vegetation control as much as planted seedlings.

Another common belief is that vegetation management is required more for plantations than with natural regeneration. Although most of the vegetation management research has been done with plantations, a number of studies have been conducted in naturally-regenerated stands. The available data suggest that growth and survival increases from managing vegetation in natural regeneration are similar to those for plantations. The longer period of vulnerability for natural regeneration, in fact, suggests that vegetation management should probably be considered for a longer period of time in naturally-regenerated stands than in plantations.

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