FOREST HERBICIDES AS A VEGETATION MANAGEMENT TOOL:

PERSPECTIVES ON THE FUTURE OF FOREST MANAGEMENT IN NOVA SCOTIA

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Abstract

Since 2003, the area of forest land treated with herbicides has been steadily increasing in the province of Nova Scotia. Several studies show that glyphosate, the most common forest herbicide in the province, can be an efficient and cost-effective way to control competition in plantations. Studies also show that glyphosate presents no significant risks to human health, though there is recent evidence of negative effects on human reproduction in specific scenarios. Nonetheless, glyphosate is an integral component of plantation silviculture and, as such, helps alter natural plant communities and successional trajectories which lead to a loss of structural diversity in the Acadian Forest. A survey of plantations not treated with herbicides conducted by the Nova Scotia Department of Natural Resources in 2004 concluded as little as 2.7% of surveyed areas met their criteria for plantation success. This report has since been cited to support the continued use and subsidy of herbicides throughout the province. In this paper, we have reviewed the findings of this report. Specifically, we discussed the success criteria selected by NSNDR and suggested the need to amend the definition of plantation success. In this paper, we show that although non-treated plantations do not meet the NSDNR criteria of success in terms of stocking of planted seedlings, they do attain a measure of success if naturally regenerated crop species are included. Specifically, total stocking levels in non-treated plantations are comparable to area-weighted averages of traditional plantations across the province where herbicides can be used. Our analysis suggests that natural regeneration, which NSDNR views as competition for planted stock, may be a natural alternative to planting or, in some cases, a natural complement to trees planted in lower densities. Our results suggest that it is possible to obtain comparable results with respect to total stocking of commercial species without the use of herbicides, thus we recommend that the government cease to fund herbicide use in Nova Scotia, and consider banning their use on Crown land.

Key Words: forestry, herbicide, glyphosate, Acadian forest, Nova Scotia, natural regeneration, succession, stocking, free-to-grow

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I. Introduction

Between 2003 and 2007, an average of 9 687 hectares of land in Nova Scotia were treated annually with forest herbicides (Canadian National Forestry Database 2007). During this period, herbicide use in the province has been steadily increasing, from 5 972 hectares in 2003 to 12 577 hectares in 2007. Though there are several herbicides currently being used in forestry in Canada (mainly: 2,4-D, glyphosate and hexazinone), in 2007, glyphosate accounted for 100% of all herbicide usage on public lands in Nova Scotia (Canadian National Forestry Database 2007).

Since 2001, the use of forest herbicides has been banned on Crown land in the province of Quebec (Thompson and Pitt 2003). The annual production from Crown land forestry in Quebec accounts for 80% of its wood supply, as compared to 8% in Nova Scotia (Rotherham 2003). The ban was the result of a series of public consultations concluding that a majority of the public opposed the use of any herbicide in forest operations and that alternative vegetation control methods could adequately replace herbicides (BAPE 1983; BAPE 1991; MRNFQ 1994). The arguments invoked in favour of eliminating herbicide use as a vegetation management tool can generally be divided into four categories: (1) human health risks, (2) environmental harm, (3) a preference for mechanical methods of vegetation management for job creation purposes, and (4) a desire for alternative forest management strategies (BAPE 1983; BAPE 1991).

The province of Nova Scotia recently underwent a public consultation similar to that of Quebec, referred to as the Natural Resources Strategy 2010, to "re-evaluate DNR's policies on forests, minerals, and parks, and to establish a policy on biodiversity that is in keeping with the Province's focus on sustainable prosperity and competitiveness, and the shift to a green economy" (NSDNR). One element of this evaluation process is the potential elimination of, or cessation of funding for, forest herbicide use in Nova Scotia.

i. Arguments in favour of herbicide use

There exists a wealth of information regarding potential health risks associated with glyphosate. The general consensus is that there is no indication of any human health concern (Anon. 1987; Anon. 1990; Walstad and Dost 1984). Studies also indicate that persistence of glyphosate in forest soil and watershed after aerial application is relatively short (12 ± 2 and 10 ± 3 days for 50% dissipation in Acadian forest floor matrix and mineral soil, respectively) (Feng and Thompson 1990a; Feng and Thompson 1990b; Thompson and others 2000).

Herbicides are recognized to be an effective and affordable vegetation management tool (Bell and others 1997; Franklin and others 1994; Guynn and others 2004; Wagner and others 2004). Results from

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long-term North-American studies suggest that effective management of forest vegetation, which includes suppressing competition through forest herbicide use, have led to wood volume yield gains ranging from 30% to 450% (Miller and Miller 2004; Wagner and others 2004). In Acadian forests, under intensive management (planting, herbicide use and pre-commercial thinning), annual sustainable harvest levels were 31% higher than if no further management was applied (Wagner and others 2004). In a study on the Acadian forest in Maine, Daggett (2003) found that softwood volumes increased by 264% when plots treated with newer herbicides (glyphosate and tri-clopyr) were compared with untreated plots. Aerial herbicide treatments costs are approximately $250-$300 per ha, compared to $600-$700 for manual weeding. Furthermore, manually weeded vegetation will often coppice once cut, thus often requiring multiple treatments before preferred species outgrow competition (Dunster 1987).

A review of the literature shows that a substantial effort has been undertaken to assess the potential effects of herbicide use on biodiversity. The general view is that the effects of forest herbicides on biodiversity are negligible (Boyd and others 1995; Guynn and others 2004; Lautenschlager 2004; Sullivan and others 1998; Wagner and others 2004 to name a few). Studies indicate that herbicides may have deleterious effects, but these are restricted to relatively small spatial and temporal scales (DeCalesta and others 2002; Lautenschlager 1993; Lautenschlager and Sullivan 2002; Lautenschlager and Sullivan 2004; Miller and Miller 2004). Although glyphosate does not appear to have short-term negative impacts on biodiversity, it tends to be closely associated with intensive plantation forest management, which has been shown to negatively impact biodiversity (see Section iii).

ii. Arguments against herbicide use

Recent studies suggest that glyphosate may pose potential risks to human reproduction and foetal development as a result of exposure to glyphosate in the presence of adjuvants (Benachour and Séralini 2009; Benachour and others 2007; Richard and others 2005). However, these studies generally focus on agricultural use of glyphosate which generally use higher concentrations of herbicides and as such are of limited relevance in a forestry context.

It is often argued that herbicides are attractive from an environmental point of view as they would allow accrued yields in intensively managed sites to meet increasing demand, thus reducing pressure on other sites which could be set aside for conservation (Bell and others 1997; Flueck and Flueck 2006; Franklin and others 1994; Little and others 2006). However, this viewpoint supposes that the public supports increasing wood production to meet anticipated increasing demands, which may not be the case. It also supposes that as more land is being intensively managed, there would be an increase in lands set aside for conservation, which is also not necessarily the case.

Nova Scotia's Natural Resources Strategy 2010 Phase I final report clearly demonstrates a public desire for sustainable forestry practices and the prioritization of biodiversity (Voluntary Planning 2009, March). Although many studies show that herbicides have negligible effects on biodiversity, it has been suggested that studies over longer periods of time might provide different results (Lautenschlager and Sullivan 2002; Lautenschlager and Sullivan 2004). Indeed, herbicides can alter plant communities and successional trajectories (Brooks and others 1995; Freedman 1991; MacKinnon and Freedman 1993; Miller and Miller 2004) thus affecting plant and wildlife species in the long term.

Direct effects of herbicides on plant communities are generally short-term (Lautenschlager and Sullivan 2004; Miller and Miller 2004; Miller and Witt 1990; O'Connell and Miller 1994), but long-term changes in successional trajectories could influence future wildlife occupancy of herbicide-treated habitats (MacKinnon and Freedman 1993; Sullivan and Sullivan 1982). Although changes in community structure can decrease habitat quality for some species, it can also increase habitat quality for other species. As such, the literature contains examples of the overall impacts of community changes due to herbicide use ranging from negative (Borrecco and others 1979; Lautenschlager 1993; Santillo and others 1989a; Santillo and others 1989b) to neutral (Freedman and others 1988; Gruver and Guthery 1986; Hood and others 2002; Savidge 1978; Sullivan 1990), and even to positive (Anthony and Morrison 1985; Hurst 1987; Jones and Chamberlain 2004; Landes 1975; Lautenschlager 1993).

iii. Intensive forestry practices and herbicides

Biodiversity

Herbicides are often used in conjunction with plantations in intensive forest management. Indeed, as mentioned above, 12 577 hectares of land were treated with forest herbicides in Nova Scotia in 2007 (Canadian National Forestry Database 2007). In this same year, 10 260 hectares of plantations were established. Herbicide treatments usually occur only once, shortly after plantation establishment, though a second treatment is sometimes required (McCormack 1994). This suggests that a majority, if not all, of plantations established in 2007 were treated with herbicides for the first time and a portion of previously established plantations were treated a second time. Some naturally regenerated stands may also have been treated with herbicides (McGrath, personal communication 2010). As such, it is clear that issues related to herbicide use, specifically biodiversity issues, are necessarily linked with issues related to plantations and intensive forestry practices.

A review of scientific literature shows that intensive forest management methods can significantly impact biodiversity by affecting a wide range of taxa (lichens (Lesica 1991), bryophytes (Andersson and Hytteborn 1991; Fenton 2001; Frisvoll and Prestø 1997; Lesica 1991; Peterson 1999; Rambo and Muir 1998a; Rambo and Muir 1998b; Söderström 1988), vascular plants (Roberts 2002; Thomas and others

1999; Timoney and others 1997; Zhu 1998), nematodes (Paresar and others 2000), amphibians (Naughton and others 2000; Waldick 1994), birds (Gjerde and Saetersdal 1997; Lambert and Hannon 2000), and mammals (Lomolino and Perault 2000)).

Nutrient export

Natural ecosystems are characterized by negligible nutrient export levels (Berger and Mohry 1989; DeAngelis 1992; Dobrovolsky 1994; Helyar 1987). As stated above (see Arguments in favour of herbicide use), the use of herbicides will most likely lead to an increase in yield. However, increased productivity accelerates the exportation of biomass (i.e. nutrients) from harvest sites and will ultimately result in the depletion of soil nutrients. Furthermore, as a result of mineral depletion of the soil, acidification can occur which will lead to leaching and further nutrient loss (Federer and others 1989; Flueck and Flueck 2006; Haynes 1986; Lovett and others 2002).

Structural diversity

Diversity in community types and structural diversity are also central to the definition of biodiversity (Noss and Cooperrider 1994). Studies in the Acadian Forest on structural attributes (e.g., snags, coarse woody debris) (Freedman and others 1994), birds (Parker and others 1994), amphibians (Waldick and others 1999), herbaceous plants (Ramovs and Roberts 2003), and bryophytes (Ross-Davis and Frego 2002) report reduced stand-level diversity as a result of softwood plantation. Reductions in the density of snags and coarse woody material have been demonstrated to have negative effects on birds and on many other organisms (Esseen 1997; Siitonen 2001).

In a recent study comparing species composition, age-class distribution and stand structure between 1945 and 2002 in a 190 000 ha industrial forest in New Brunswick, Etheridge *et al.* (2005) indicate that, over the past 57 years, intensive forest management has maintained similar softwood species compositions (softwood area in 1945 and 2002, 40% and 42% respectively) but has significantly raised the area of hardwoods to the detriment of the areas of mixedwoods (from 10% to 25% and 37% to 18%, respectively). A shift towards purer stands and a reduction of mixedwoods results in a clear loss of heterogeneity. As environments of mixed structure or composition promote accrued biological diversity, the reduction of mixedwoods through intensive forest management will likely lead to an overall reduction in diversity (Franklin and others 1989).

Though there is limited information regarding long-term changes in the Acadian forest, additional studies do show increased frequency of relatively young, often even-aged, early successional forest types (balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), red maple (*Acer rubrum*), white birch (*Betula papyrifera*), and trembling aspen (*Populus tremuloides* Michx.)) (Loo and Ives 2003; Lorimer

1977). Etheridge *et al.* (2005) also show a tendency towards younger forests (85% of the trees >70 years old in 1945 versus 44% in 2002). An additional study indicates that as much as 50% of the Acadian forest could, at one time, have been dominated by late-successional old-growth forest types, as compared to 1-5% of the present forest cover that is older than 100 years (Mosseler and others 2003). We know that diversity is generally greater in old-growth forests than in young plantations (Schowalter 1989). Franklin *et al.* (1989) add that an incredible diversity of invertebrates live in old-growth forests, which could also act as sources of diversity to adjacent young forests. Etheridge *et al.* (2005) suggest that retention of trees of diverse ages in managed forests would be of great value.

iv. Context

Since 1998, Stora Enso (now NewPage Corp.), one of the largest forest managers in Nova Scotia, has not used forest herbicides as a vegetation management tool. In order to assess the effectiveness of plantations not treated with herbicides, the Nova Scotia Department of Natural Resources (NSDNR) published a report (Nicholson 2007) taking a close look at plantation success 6-8 years after establishment without herbicides. The report paints a grim picture for the future of the province's future wood supply, concluding that as little as 2.7% of plantation areas surveyed met NSNDR's criteria for success. As a result, this report has been cited in support of continued forest herbicide use in Nova Scotia (NSDNR 2009).

In a groundbreaking paper entitled "Toward a New Forestry", Franklin (1989) outlines alternative silvicultural practices which utilize the concepts of ecosystem complexity, biological legacies and viable landscapes to retain ecological values. In line with this philosophy, the current director of forestry at Nova Scotia Department of Natural Resources, Jorg Beyeler, states that "Nova Scotia Department of Natural Resources is directing most of its planning and research program towards development of ecologically based planning systems and tools with a specific focus on principal Acadian Forest ecosystems" (Beyeler 2002).

We are currently in a unique situation regarding the future of natural resources policy in Nova Scotia. There is a desire, from the public as well as from decision-makers, to move towards a more ecosystem-based approach to forestry. In this paper, we critically assess the findings of the NSDNR report (Nicholson 2007) and suggest an alternative definition of "successful plantations" that focuses on adequate site regeneration of commercial species, rather than limiting the definition to only planted seedlings. We believe this paper provides support for new policies to eliminate the use of, or to justify the cessation of funding for, forest herbicide use in Nova Scotia.

II. Results & Discussion

The NSDNR report (Nicholson 2007) seeks to evaluate plantation success on sites not treated with herbicides 6-8 years after establishment. The report states that a plantation is deemed successful when (1) stocking of planted trees with crop potential is at least 60%, (2) total stocking (i.e. stocking of all planted trees and naturally regenerated yellow birch (*Betula alleghaniensis*), sugar maple (*Acer saccharum*) and commercial softwoods is at least 80% and (3) crop trees are deemed free-to-grow (FTG). The results of the NSDNR report (Nicholson 2007) indicate that 12.9% of areas surveyed meet the stocking criteria and 2.7% meet both the stocking and the FTG criteria. In the following section, we review Nicholson's (2007) conclusions and consider them in light of additional results from this same report and other NSDNR reports relating to plantation success across the province.

As far as we know, the criteria for plantation success established by the NSDNR are not based on a review of scientific literature, but rather are a measure of what they believe is an accurate measure of success, based on their internal research (McGrath, personal communication 2009). From this perspective, we firstly review Nicholson's (2007) stocking results in plantations not treated with herbicides and compare them to the results of previous NSDNR surveys where herbicides were used as vegetation management tools. Secondly, we discuss the validity of the free-to-grow requirement as well as review the specific criteria selected by Nicholson (2007) which must be met in order to be deemed free-to-grow.

i. Stocking

Nicholson (2007) reports that the area-weighted average stocking of planted trees with future crop potential is 48%, and is 54% if all planted trees are included, regardless of crop potential. If natural replacements are included (softwoods, plus yellow birch and sugar maple), average stocking is 76% for trees with crop potential and 78% regardless of crop potential. The report goes on to indicate that 13% of all areas not treated with herbicides considered in the report meet the stocking criteria of >60% stocking of planted trees with crop potential and >80% total stocking. In the following sections, we put these results into perspective by looking at (1) the accuracy of the measure of crop potential, (2) the relevance of a minimal stocking of planted trees criterion and (3) the exclusion of other commercially important hardwoods such as white birch and red maple in total stocking.

a. Crop potential

Crop potential, a visual estimation of future commercial value, is a subjective measure and, as such, is subject to caution. In light of this, as well as the fact that there is little difference between average stocking of trees with crop potential and stocking of trees regardless of crop potential (48% versus 54% for planted stock and 76% versus 78% for total stock), we will set aside any such distinction from this point on and always include all trees, regardless of estimated crop potential. Thus, areas with at least 60% stocking of planted trees regardless of crop potential represent 29% of the total area and areas with at least 80% total stocking represent 42% of the total area. Overall, 20% of total area meets both stocking criteria if crop potential is set aside.

a. Minimal stocking of planted trees

Previous surveys conducted by NSDNR (Anon. 1988; O'Keefe and others 2004), in similarly aged plantations treated with herbicides when necessary, show stocking (planted and total) results similar to those obtained in the survey of plantations not treated with herbicides (Nicholson 2007). Specifically, O'Keefe *et al.* (2004) report 73.2% stocking of planted trees and 81.6% total stocking (only softwoods were included in total stocking) in plantations established 9-14 years prior to the survey. A previous report (Anon. 1988) shows a range of 63.9% - 67.7% stocking of planted trees and 66.9% -78.8% total stocking (only softwoods) in plantations aged 6-8 years. It is clear from these results that the main discrepancy between stocking results obtained with NewPage Corp.'s current practice of non-treated plantations and the results obtained in traditional plantations where herbicides may be used lies in the stocking of planted trees.

These results lead us to question the importance of a criterion for minimal stocking of planted trees in establishing plantation success. This criterion is only important if planted seedlings are valued more highly than natural seedlings. If, on the other hand, regeneration success can be defined more broadly as a combination of both planted and natural seedlings of commercial species, then a minimum bar for planted seedlings is unnecessary. In previous surveys conducted by NSDNR (O'Keefe and others 2004) in similarly aged plantations, results show that total stocking between non-treated plantations and traditional plantations where herbicides can be used is quite comparable (76% - 78% in non-treated plantations versus 66.9% -78.8% in plantations 6-8 years old and 81.6% in plantations 9-14 years old).

In a survey of plantations aged 1-3 years, Beyeler (2003) shows an area-weighted average of 84% stocking of planted trees (81% when only NewPage Corp. leased land is considered) and 85% total stocking. A recent survey by NewPage Corp. on 2-year-old non-treated plantations shows a survival rate of 71% of planted trees and 95% of planted trees plus natural softwood regeneration (Unpublished data provided by NewPage Corp.). Although planted trees seem to have a lower survival rate in non-treated plantations than in treated plantations, natural regeneration seems to offset loss due to competition and even compensate beyond that loss.

b. Other commercially important hardwoods

Although prior surveys conducted by the NSDNR limit the scope of acceptable natural replacements to softwoods, Nicholson (2007) chose to include yellow birch and sugar maple, both commercially valuable hardwoods (Burns and Honkala 1990), in the NSDNR report on the success of plantations not treated with herbicides. The inclusion of hardwoods of commercial value to total stocking is in keeping with a progressive move to more ecosystem-based forest management. From this viewpoint, it would be pertinent to also include white ash (*Fraxinus americana*), and red oak (*Quercus rubra*), which are also commercially valuable and highly prevalent in Acadian forest natural regeneration (Burns and Honkala 1990; NSDNR 2008). White birch (*Betula papyrifera*) and red maple (*Acer rubrum*) are also commercial species, and may be considered acceptable stocking in some cases.

ii. Free-to-grow

Most regeneration establishment standards are based on traditional practices with the emphasis on getting the site to the free-to-grow stage as quickly as possible (Willcocks and Bell 1995). Although there is no explicit definition of free-to-grow based on scientific experimentation in the literature (Wagner 1993), Nicholson (2007) states that plantations were deemed free-to-grow if excess stem density is less than 6000 stems/ha and if the competition index (Eq. 1) is less than 60. As there is no evident basis for selecting these criteria, we will proceed by examining their validity. Specifically we will evaluate the relevance of the measure of minimal excess stem density and the Competition Index (CI).

$$\textit{Competition Index (CI)} = \frac{Sp.1\ (\%\ Cover * Avg.height) + Sp.n\ (\%\ Cover * Avg.height)}{Avg.Height\ of\ Planted\ Stock}$$

Eq. 1: Competition Index

Nicholson (2007) reports that 52.8% of the surveyed area meets the <60 CI criterion and 56.0% meets the <6000 stem/Ha excess stem density criterion. Furthermore, 37.4% of the surveyed area meets both of these criteria, thus are considered by Nicholson (2007) as being Free-To-Grow.

Excess stem density

The measure of excess stem density seeks to quantify the competition surrounding crop trees. However, as we have seen when discussing the relevance of a minimum planted tree stocking criterion, there is evidence that natural regeneration might increase total stocking of desired species. Bowling *et* *al.* (1997) indicate that, in many cases, trees are planted where natural regeneration alone would have resulted in overstocked new forests. Furthermore, Smith (1962) states:

> The total production of cubic volume by a stand on a given site is, for all practical purposes, constant and optimum for a wide range of density or stocking. It can be decreased, but not increased, by altering the amount of growing stock to levels outside this range.

Simply put, a manager can only grow one maximum level of gross total volume on a site, but this volume can consist of a lot of little trees, a few big ones, or any number of variations between (Willcocks and Bell 1995).

A detailed look at species composition of the excess stems (regeneration) in the NSDNR report (Nicholson 2007) shows that softwoods represent 19% of the area-weighted average density of excess stems. If yellow birch is included (sugar maple is not included as it represents <1% of species composition) this would account for 47% of the species composition of excess stem density and as much as 88% if white birch and red maple are included (20% white birch, 21% red maple). Interestingly, when managing for hardwood quality, it is important not to release hardwood trees before they have a chance to self prune. Nicholson *et al.* (2010) suggest that a balance between growth and quality can be achieved by waiting until trees are between six and nine metres in height before thinning hardwood species.

a. Competition Index

Uncontrolled or "natural" experiments use a retrospective analysis of operational plantations with naturally occurring differences in vegetation abundance around sample trees (Brand 1986a; Brand 1986b; Glover and Zutter 1993; Howard and Newton 1984; MacDonald and others 1990; Morris and Forslund 1991; Morris and others 1990; Simard 1990).

Competition indices derived from uncontrolled experiments have substantial limitations. Differences in vegetation densities are often correlated with unknown environmental or disturbance factors. Therefore, spurious correlations between vegetation abundance and tree performance can result. This potential for experimental bias can affect hypothesis tests and interpretations about the effects of competing vegetation (Connell 1983; Underwood 1986).

Nearly all studies to develop competition indices have been short term (one to several years) and only within the early stages of stand development. Wagner (1989) states that the best competition indices can change with time, and may depend on the shifting structure of successional plant communities.

iii. Overview of non-treated plantations

In the preceding sections, we have shown that, although non-treated plantations do not meet the NSDNR criteria of success, they do attain a measure of success. Specifically, total stocking (planted and natural regeneration) levels in non-treated plantations are comparable to area-weighted averages of traditional plantations across the province where herbicides can be used. Although stocking of planted trees is generally lower in non-treated plantations, total stocking in on par with stocking in traditional plantations. Recent survival rate data from NewPage Corp. supports this idea. This might simply indicate that natural regeneration can compensate for less competitive planted trees and perhaps suggests a shift away from plantation forestry and herbicide use. One hypothesis to explain this might be that plantation genetic stock might be less competitive than natural regeneration (Lambeth and McCullough 1997). Other possible hypotheses include (1) moisture challenges for planted stock: seedlings planted during dry conditions could be at risk of moisture stress, (2) microsite choice: planted stock might be planted in unfavorable microsites, whereas seeds of natural stock tend to blanket an area and (3) symbiotic fungi associated with natural stock: natural stock might have better developed beneficial fungi relationships than planted stock.

III. Conclusion

As we have seen, the general view is that herbicides are an efficient and cost-effective vegetation management tool. Furthermore, many studies agree that glyphosate, the only herbicide currently used in Nova Scotia, presents no significant risks to human health. However, recent studies suggest that glyphosate may pose potential risks to human reproduction and foetal development in certain specific scenarios (notably in agricultural applications).

While glyphosate may have negligible effects on wildlife, glyphosate has been an integral component of plantation silviculture in Nova Scotia. As such, glyphosate helps alter natural plant communities and successional trajectories, shifting the Acadian forest to a less structurally diverse environment and, as such, a less stable environment.

It is often argued that herbicide use could potentially benefit the environment by increasing yield in intensively managed forests to meet future demand, thus leaving more areas that could be protected. However, this assumes that the public wishes to increase wood production to meet demand and that increased areas of intensively managed forests would consequently lead to an increase in conservation areas, both of which are questionable assumptions.

A recent survey of plantations that were not treated with herbicides was conducted by NSDNR in 2004. It concluded that as little as 2.7% of surveyed areas met their plantation success criteria. This report has since been cited to support the continued use and subsidy of herbicides throughout the province. In this paper, we have reviewed the findings of this report. Specifically, we discussed the success criteria selected by NSNDR and suggested the need to amend the definition of plantation success.

In this paper, we have shown that although non-treated plantations do not meet the NSDNR criteria of success, they do attain a measure of success. Specifically, total stocking levels in non-treated plantations are comparable to area-weighted averages of traditional plantations across the province where herbicides can be used. Furthermore, our analysis suggests that natural regeneration, which NSDNR views as competition for planted stock, may be a natural alternative to planting or, in some cases, a natural complement to trees planted in lower densities.

There are arguments in the literature both in favour of and against the use of herbicides in forestry. We suggest that if it is possible to obtain comparable stocking levels of commercial species without the use of herbicides, the principle of parsimony dictates that herbicides not be used. We feel that our preliminary results suggest that this is the case. Therefore, we recommend that the government cease to fund herbicide use in Nova Scotia, and consider banning their use on Crown land, as has been done in Quebec since 2001.

We are aware that our results are still at a preliminary stage and as such are subject to caution. The results so far are promising and seem to point to a potentially valuable avenue of research.

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