Using Nature's Template to Best Advantage in the Canadian Boreal Forest

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1 Introduction

There is an increase in the use of our knowledge of natural disturbance dynamics as a basis for forest management policy directed towards maintaining biological diversity (Booth et al. 1993, Biodiversity guidebook… 1995). The underlying assumption is that the biota of a forest is adapted to the conditions created by natural disturbances and thus should cope more easily with the ecological changes associated with forest management activities if the pattern and structure created resemble those of natural disturbance (Hunter 1993, Swanson et al. 1993, Bunnell 1995, DeLong and Tanner 1996, Bergeron and Harvey 1997, Angelstam 1998, DeLong and Kessler 2000).

For a variety of reasons, past forest management policies and guidelines have been directed towards setting somewhat arbitrary limits. These limits often relate to maximizing timber volume or creating conditions that favour certain organisms (e.g., ungulates). Limits are often stated for things such as patch size, species composition, stand density, non-forested area and soil disturbance. Although well meaning and easily administered, they result in patterns bearing little relationship to those created by natural disturbances. Studies of natural disturbance in the boreal forest have demonstrated large ranges in disturbance patch size (Eberhart and Woodward 1987, DeLong and Tanner 1996), tree density (DeLong and Kessler 2000), and volume of coarse woody debris (CWD) (Clark et al. 1998, DeLong and Kessler 2000)

Successful implementation of forest management policies based on natural disturbance dynamics requires several steps. We must first understand natural disturbance regimes. We must then figure out how to practically apply the knowledge in a management context. The final step is to convince people that any proposed policy changes are in their best interest. This last step is sometimes the most challenging for researchers.

In this paper I will briefly discuss the results of four research studies which examine various aspects of natural disturbance dynamics. I will show how the results of each study demonstrate a need for more flexible policies. I will then discuss some potential ecological and economic advantages of implementing policies based on the results of the research. Finally, I will discuss some barriers to the implementation of new policies based on natural disturbance dynamics.

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2 Disturbance Patch Size

Natural disturbance patches can vary in size from individual tree-fall gaps to >100 000 ha wildfires. Some important characteristics of patch size are the range in size of patches, patch size frequency distribution, and amount of total disturbance area for different patch sizes. I will describe two research studies that examine patch size in the sub-boreal and boreal forest of British Columbia, Canada.

The first study examined differences and similarities between wildfire and harvested areas within a portion of the sub-boreal landscape. The study explored the hypotheses that: 1) wildfires were becoming smaller and less frequent; 2) clearcutting had supplanted wildfire as the dominant disturbance agent in terms of area affected; 3) individual clearcuts were spatially different from individual wildfires; and 4) the landscape mosaic produced by clearcutting differed from that produced by wildfire. Details of the study can be found in DeLong and Tanner (1996). The main conclusions of the study were: 1) wildfire frequency and size had decreased substantially after 1950; 2) clearcut harvesting had become the dominant stand replacement disturbance agent on the landscape after 1950; 3) large patches (i.e., >1000 ha) and small patches made up a higher proportion of the total disturbance area in a landscape disturbed by wildfire compared to a landscape disturbed by harvesting; 4) disturbance patches relating to wildfire were more irregular in shape than those relating to harvesting; and 5) 3–15% mature forest was left behind in wildfires as patches within the fire boundary.

The second study examined the variation in annual disturbance rate and patch size distribution between different areas of relatively homogeneous macroclimate and topography within forests of northern British Columbia. The study was designed to test the hypotheses that annual disturbance rate is significantly related to certain climatic variables, and that patch size distribution is significantly different among distinct units of homogeneous macroclimate and gross topography. Details of the study can be found in DeLong (1998). The main conclusions of the study were: 1) climate and topography had a significant impact on fire return and patch size; 2) mid-sized patches (50–100 ha) were rare in all landscapes examined; and 3) the amount of area in larger patches (>1000 ha) was greater than anticipated in areas of wet climate.

In many jurisdictions, a high proportion of the wood harvested comes from private land, which restricts larger patches due to the size of the holdings. In other jurisdictions, an allowable maximum patch size for harvesting is legislated. Policy in British Columbia prior to 1994 generally restricted patch size to 80 or 100 ha. The first of the studies described above was used as a basis for allowing larger patch sizes. Current policy in British Columbia allows larger blocks for a number of reasons. The two reasons most likely to be used are: if blocks are 'consistent with the structural characteristics and the temporal and spatial distribution of natural openings', or 'the higher level plan specifies that cutblocks may be larger' (Forest practices… 1994). The Biodiversity Guidebook (1995), an accompanying document to the Forest Practices Code of British Columbia, also states some objectives for patch size distribution relating to that found in nature. I could find no other documented policy within the forestry nations of North America or Europe that provides patch size distribution guidelines.

The principle behind managing for a 'natural' patch size distribution is that organisms have become adapted to having patches of habitat of certain sizes in the landscape. With respect to forest harvesting, there are a number of additional benefits that result from some patches being large (i.e., >500 ha).

One of the main ecological benefits of allowing some large harvest patches is the reduction of roads. A good review of the negative ecological effects of roads is contained in Trombulak and Frissell (2000) and includes mortality relating to road construction and collision with vehicles, alteration of the physical and chemical environment, modification of animal behaviour, spread of exotics, and increased use of areas by humans. Fig. 1 illustrates two proposed harvesting plans for the same area. One of the plans is based on dispersed cutting with a 60 ha cutblock size limit, and the other on meeting a more natural patch size distribution. In this example, the amount of road per area harvested is reduced from 0.046 to 0.015 km/ha by adopting the plan that attempts to meet a more natural patch size distribution.

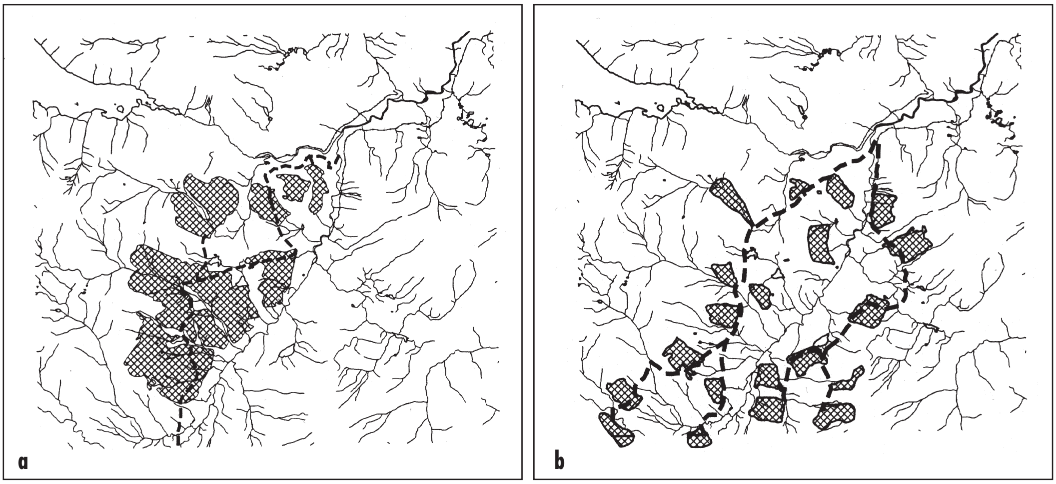

Fig. 1. Illustration of proposed harvest plans for the same area a) incorporating larger blocks and b) with a harvest block size restriction of 60 ha.

Another potential ecological benefit of a harvesting plan which attempts to emulate natural patch size distribution, compared to the dispersed medium sized (i.e., 40–80 ha) cutblock plan commonly employed, is reduced fragmentation (Franklin and Forman 1987, Li et al. 1993, DeLong and Tanner 1996, Baskent 1997). Allowing some larger blocks to be harvested allows for some large areas of unfragmented older forest to persist. In addition, salvage harvest operations required to recover timber damaged by blowdown and pests which often create large openings are more likely to become part of the harvesting plan rather than exceptions to it (DeLong and Tanner 1996).

It should be noted that any forest harvesting policy, which is based on the premise of emulating natural disturbance, should require within-patch mature forest reserves and irregular patch boundaries. Mature forest patches are consistently found within the boundaries of wildfires and appear to be an important landscape element (DeLong and Tanner 1996, DeLong and Kessler 2000). The ecological importance of retaining mature forest patches or individual trees within clearcuts has been demonstrated for a variety of organisms (Lesica et al. 1991, Amaranthus et al. 1994, Merrill et al. 1998). Having irregular boundaries helps to reduce the effect of decreasing edge due to area-to-perimeter relationships (i.e., reduced perimeter with increasing size given a similar shape).

Although the economic benefits of emulating natural patch size distribution have not been documented, there are a number of logically deduced benefits. The short-term economic benefit with respect to road building costs is immediately apparent if the example of road reduction illustrated by Fig. 1 is representative. Other potential benefits include: 1) reduced road maintenance and deactivation costs; 2) interest earned on money saved by deferring road building costs to the future; 3) reduced equipment transport costs to dispersed management units; and 4) less units (harvest blocks) to administer and monitor.

3 Tree Species Succession

Mixed forests of deciduous species (e.g., *Populus* spp., *Betula* spp.) and spruce (*Picea* spp.) are common throughout the boreal forest. One of the more common pathways for the natural establishment of these mixed stands is for spruce to recruit gradually into the stands after an initial regeneration delay of approximately 20 years, when the deciduous stands are very dense (DeLong 1991, Lieffers et al. 1996). I will describe a study which examines the potential for emulating this natural stand developmental pathway by underplanting mid-aged (40–70 years) trembling aspen (*Populus tremuloides* Michx.) stands with white spruce (*Picea glauca* (Moench) Voss) in areas where pure aspen stands have replaced mixed stands in response to forestry and agricultural practices.

In 1993 a trial was established in the boreal forest approximately 80 km south-west of Dawson Creek, British Columbia (55°35´N, 120°50´W; 850–950 m elevation) to compare growth of spruce and seedling microclimate at sites that were recently clearcut and sites where a 40–70 year old aspen canopy was present. Details on research leading up to this study, the study itself, and some of the findings are reported in Tanner et al. (1996) and DeLong (2000). The major findings of the study to date are: 1) there is no difference in survival of planted spruce in clearcuts versus 40–70 year old aspen stands; 2) 40–70 year old aspen stands provide a less extreme environment for seedling establishment than clearcuts; 3) spruce perform better in the clearcuts after establishment; and 4) spruce growth under the aspen is adequate to meet current legislated performance standards. The findings of this study, plus others by Lieffers et al. (1996) and Man and Lieffers (1997), indicate that underplanting aspen stands with white spruce represents a feasible alternate silvicultural system for establishing mixed stands. The results may also be applicable to management of birch spruce stands in Fenno Scandinavia where the productivity and economics of two-storied spruce and birch stands has been demonstrated to be profitable (Valkonen and Valsta 2001).

One of the main ecological advantages of underplanting deciduous stands with spruce is that it should result in mixed stands similar to those which organisms have become adapted in mixedwood regions of the boreal forest. There is concern that current policies which tend to promote either deciduous or spruce but not both species on the same site will lead to a gradual segregation of the species (Lieffers and Beck 1994, Bergeron and Harvey 1997).

A number of documented silvicultural advantages of growing spruce under aspen are: 1) a less severe microenvironment during establishment, including fewer frost events (Groot and Carlson 1996, Man and Leiffers 1997), reduced overwinter injuries (Krasowski 1996), and reduced vapour pressure deficits (Marsden et al. 1997); 2) reduced white pine weevil (*Pissodes strobi* (Peck)) damage to spruce due to shading of leaders by aspen (Taylor et al. 1996) 3) reduced tomentosus root rot (*Inonotus tomentosus* ((Fr.:Fr.) S. Teng.) in spruce (pers. comm. Richard Reich, British Columbia Ministry of Forests pathologist); and 4) reduced site preparation and vegetation management costs (DeLong 2000). Other advantages of the proposed mixedwood silviculture system include: 1) reduced visual impact through continual maintenance of tree cover; and 2) improved winter thermal cover for ungulates once spruce becomes established. Similar benefits to those described above have been attributed to birch overstory on conifers (Heikurainen 1985, Morrison et al. 1988, Watt 1992).

4 Stand Structural Characteristics of Wet Montane Forests

Tree species composition, and vertical and horizontal structure within individual stands can affect animal and plant species diversity and abundance (Willson 1974, Alaback 1982, Carey et al. 1999). The project I describe investigated structural characteristics of forest stands along a post-fire successional chronosequence for wet montane sub-boreal and subalpine forests in the northern portion of the Rocky Mountains in British Columbia. The objective was to develop criteria that could be used to assess the extent to which managed stands approximate the structural characteristics of natural stands.

One of the major findings of this research is that the stands in this wet montane subregion never go through a stem exclusion stage and are very open and patchy during succession following fire. This is not uncommon for higher elevation forests but is atypical for lower elevation forests in suboreal and boreal regions. The young stands (< 70-year-old) also illustrated features associated with older forests such as a wide distribution of stem sizes and a reverse j-shaped diameter distribution of the most shade tolerant species, in this case subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.). Current reforestation standards result in managed stands being well stocked with even-aged planted spruce. The result is that the managed stands go through a stem exclusion stage and are horizontally and vertically much more uniform than the natural stands.

The ecological implications of differences in successional development and horizontal and vertical structure between natural and managed stands could be significant. Recent detailed location data for grizzly bears (*Ursus arctos* L.) indicates that they utilize small openings (<0.25 ha) within forested sites for feeding whereas closed forests are only used for bedding (pers. comm. John Paczkowski, wildlife biologist, Prince George, British Columbia). The number of small openings would be reduced in the managed forest under current reforestation standards. Productivity of the stands could also be affected. Kimmins and Hawkes (1978) hypothesized that the abundant understory vegetation, which is both a cause and effect of the open structure of the stands in the wet montane subregion, contributes to nutrient conservation and rapid turnover of nutrients enabling productive stands to develop on poor soils.

Reducing required stocking levels in at least a portion of the managed stands would result in a considerable cost savings. However, the yield implications of managing some stands to approximate the structural characteristics of natural stands are uncertain. Current stand growth models do not account well for natural ingress or complex stand structure.

5 Barriers to Implementation

If changes in practices suggested by a better understanding of natural disturbance dynamics make ecological and economic sense, why have so few been implemented? The answer to this question lies in history, social psychology, and the lack of mechanisms for rapid change in large institutions.

Conditioned responses are common towards a number of constructs relating to forest practices. One example is the widespread perception that 'big cutblocks are bad'. Even well-seasoned scientists appear to have an upper limit to what they think is an 'acceptable' cutblock size, often based on hydrological impact or lack of public acceptance. I have found no evidence to suggest that disturbance patch size in any way relates to undesirable consequences. In other words, to date, there is no evidence that 10 000 one-hectare disturbances in a landscape are any more ecologically or socially desirable than one 10 000 hectare disturbance. On the contrary, for forest harvesting, I have provided some evidence that some amount of large cutblocks may be ecologically beneficial. Unfortunately, once a conditioned response is present within a population it is hard to counteract. Initial reaction to the concept of creating larger clearcuts is generally negative at public meetings I have attended. Making the task even harder is a lack of communication within large organizations such as a forest company or government. For example, a public relations portion of the organization could be promoting the fact that the organization is being environmentally responsible by reducing cutblock size, while simultaneously research within the same organization is demonstrating that allowing larger cutblocks is ecologically beneficial. On a positive note I have found that if well-documented, scientifically-based arguments, promoting a currently unpopular practice, are presented repeatedly to the same audience it often results in general acceptance. The problem is that this can take considerable time and energy.

Another common construct is that plantations should consist of trees in orderly, well-spaced rows with little debris or 'weeds'. This stems from the agricultural view of forestry, or the 'urban yard' mentality. Many people's perception of a well-managed forest relates to their perception of a well-managed yard, with a manicured lawn and orderly 'weed-free' flower and vegetable beds. There is a perception that something that looks 'nice' is somehow ecologically superior (Kimmins 1999). Trying to convince the general public that a well managed forest can consist of an unevenly spaced forest with multiple tree species and sizes, with gaps dominated by non-merchantable species and dead trees standing and lying haphazardly around on the ground is difficult.

The slow response time of large organizations to implementing changes based on new information is another significant impediment to adopting new forest practices based on natural disturbance research. The initial step of interpreting results of experiments with respect to policy may take a number of years due to the reluctance of most researchers to speculate on the implications of their results. Limitations due to the scale or controlled conditions of most experiments make researchers cautious about applying their findings to the 'real world.' Even once there is general agreement that a change is warranted, implementation is slow due to the time taken to discuss the implications, draft policy and procedures, and incorporate public review. The response time is especially slow with respect to incorporating any major changes. Progress is further exacerbated with respect to changes suggested by natural disturbance research because the recommended practices such as leaving behind merchantable trees or planting trees in widely spaced groups are foreign to the people who are implementing the new practices.

Reluctance towards change is another significant barrier to implementation. Often the application and approval of non-traditional practices requires additional work for the people involved. Unless a change to a practice becomes compulsory, it is easier to continue with the traditional practice.

Countering these barriers to implementation of new practices based on natural disturbance research requires a commitment by upper level forest company executives and government officials. Forest certification may be the appropriate incentive to generate this commitment. If the desired certification is ecologically-based and embraces the concept of 'natural disturbance' based forest practices, then more rapid adoption of new practices based on natural disturbance research could occur. This could be especially true for practices such as those identified in this paper, which are both environmentally and economically beneficial. However, it is important that less economically desirable practices such as retention of old forests not be omitted. We cannot be selective and only adopt the economically beneficial practices suggested by natural disturbance research. We must embrace all 'natural disturbance' based changes to forest practices and use those that are economically desirable to offset those that are not.

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