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Natural Fire Regime: A Guide for Sustainable Forest Management of the Boreal Forest

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Natural Fire Regime : A Guide for Sustainable Forest Management of the Boreal Forest

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ABSTACT : Natural fire cycles in the eastern Canadian boreal forest allow a significant proportion of stands to develop beyond industrial forest rotations. Sustainable forest management must take this phenomenon into consideration if maintenance of ecosystem diversity and integrity is to be a serious objective. One possible approach is to adapt silvicultural strategies in order to recreate characteristics of the natural forest mosaic without changing rotation periods.

INTRODUCTION

The forest sector is currently looking for new models which conciliate economic fibre production and maintenance of biodiversity and productivity of forest ecosystems under management (Freedman et al. 1994 ; Kimmins 1992 ; Mc Kenney et al. 1994). One of the avenues being explored is the development of silvicultural systems that are inspired by and closely resemble natural ecosystem dynamics (Attiwill 1994 ; Galindo-Leil and Bunnell 1995 ; Bergeron and Harvey. 1997). In the boreal forest, fire is the disturbance agent having the greatest importance on forest dynamics (Engelmark et al. 1993). As some consequences of fire resemble the effects of industrial forest harvesting, forest management is often considered as a disturbance having effects similar to those of natural disturbances.

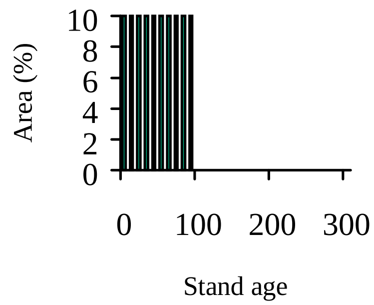
Although the analogy between forest management and fire disturbance in boreal ecosystems is partly founded, it is important to recognise that it has its limitations. The contrasting effects of fires and cutting on soils, on regeneration and on forest growth have already been raised (MacLean et al. 1983 ; Binkley and Richter 1987 ; Brais et al. 1995). More recently, we have seen an interest in the important differences that exist at the larger landscape scale in the composition and structure of forest mosaics issued from fire and from forest management regimes. This phenomenon takes on even greater importance for many organisms for which interventions at this scale are determinant for habitat quality (Rolstad 1991 ; Franklin 1993). In this article, we first demonstrate how natural forest mosaics created by fires are distinguished from those created by forest management. We will then illustrate how we propose to apply this knowledge of natural fire regime to forest management in the Lake Duparquet Research and Teaching Forest in northwestern Quebec.

FIRE CYCLE AND FOREST ROTATION

Forest rotation is determined primarily by the harvest age of stands. In a forest composed of even-aged stands, a normal forest structure occurs when all age classes of stands are evenly distributed over the territory. Thus, a forest having a rotation age of 100 years would theoretically have 1% of its land base in stands of 0 to 100 years (Fig.1a).

The same area subjected to forest fires will have, at equilibrium, a completely different age class distribution. In effect, in assuming that the probability of burning is independent of stand age (which is generally mentioned in studies on the boreal forest), the age class distribution of the burned area will follow a negative exponential distribution with close to 37% of the stands older than the fire cycle, that is 100 years (Fig.1b). For the same frequency of interventions, whereas forest harvesting will only occur at stand maturity, fire may occur several times in the same area while allowing some stands to survive beyond 100 years. This difference is fundamental because it implies, depending on the distribution, either a loss of over-mature stands, which may be essential for biodiversity maintenance, or inversely, fibre loss as a result of longer rotations. This dilemma is however not without a solution. In effect, silvicultural measures aimed at maintaining characteristics of over-mature stands while maintaining economically viable forest rotations are possible.

a)



b)

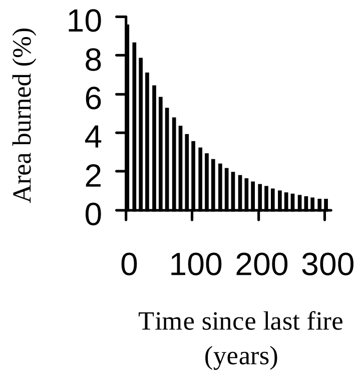


Figure 1 : Age class distribution (10 years) of stands as a function of a) 100 year forest rotation and b) a 100 year fire cycle.

THE EXAMPLE OF THE LAKE DUPARQUET RESEARCH AND TEACHING FOREST

The Lake Duparquet Research and Teaching Forest (LDRT) is located south of Lake Abitibi (48^o 30'N and 79^o 20'W, close to the Quebec - Ontario border. Forest vegetation is typical of the southeast boreal forest, characterized by an abundance of stands of mixed composition with intolerant hardwoods and conifers. The fire regime has been reconstructed for the last 300 years using dendroecological studies (Bergeron 1991 ; Dansereau and Bergeron, 1993). It is characterized by intense crown fires which cover large areas. The fire cycle for the period prior to 1870 has been estimated at 63 years and at over 99 years for the period since 1870.

Natural forest succession has been reconstructed using fires dating from different periods. Using integrated forest ecosystem maps (Harvey et al 1996), the proportion of different stand types in relation to abiotic characteristics was estimated for each fire year. It was thus possible to evaluate changes in forest composition as a function of time (Fig. 2). Thus, we can observe that, over the 300 year reconstructed chronosequence, stands vary in composition, passing from intolerant hardwood (trembling aspen and white birch) and jack pine - dominated stands to mixedwood stands and softwood (balsam fir and white cedar) - dominated stands.

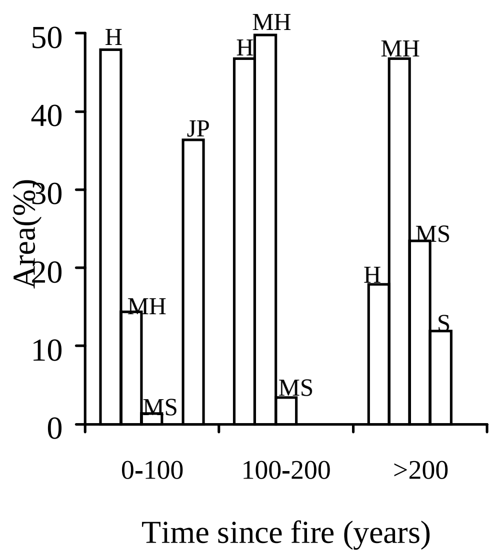


Figure 2 : Proportion of different stands as a function of time since the last fire (mesic clays). H : hardwood ; JP : jack pine ; MH : mixed-hardwood ; MS : mixed-softwood ; S : softwood.

By associating observed compositions with different age classes of the negative exponential model (Fig.1b) it is possible to reconstruct what the natural forest mosaic would be under constant fire cycles (Bergeron et Dansereau 1993; Gauthier et al. 1996). Thus, we can see that, for a 100 year fire cycle, a normalized landscape would be composed of 40% intolerant hardwood stands, 10% jack pine stands, 45% mixed stands and 5% softwood stands (Fig. 3).

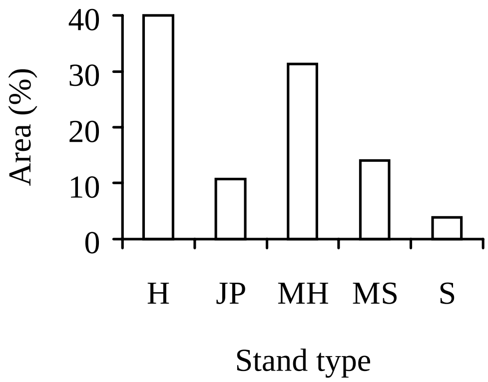


Figure 3 : Representation of the different stand types in the LDRTF for a 100-year fire cycle (mesic clays). See Fig. 3 for an explanation of abbreviations

Maintaining this composition on a long-term basis could constitute a management objective which would assure the maintenance of habitat diversity comparable to the natural mosaic. Creation and maintenance of this forest mosaic is constrained by the normal period of forest rotation, estimated here for demonstration purposes at 100 years. As a result, we propose a silvicultural strategy for the LDRTF involving the use of clear-cutting and partial cutting on the same site, similar to the processes of stand reinitiation by fire or natural succession (Fig.4)

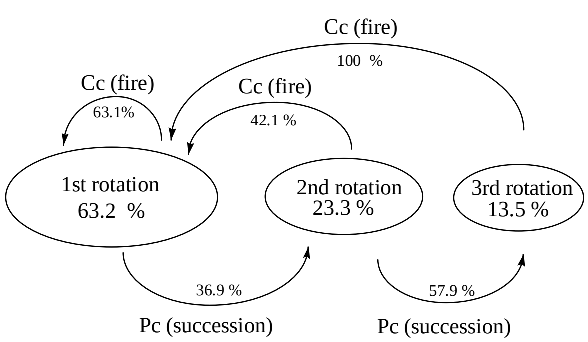


Figure 4. Silvicultural model proposed for the Lake Duparquet Research and Teaching Forest. Cc : clear-cut ; Pc : partial cut.

Thus, at each rotation a portion of stands will be returned to a pioneer stage by clear-cutting or educated toward compositions characteristic of the succeeding successional stage by selective partial cuts. The process is aimed at overlaying sub-groups of normal forests (Fig. 1a) made up of even-aged stands, but in decreasing proportions as a function of time since the last clear-cut. It will thus be possible to partially recreate not only the natural composition but also a forest age structure that approaches that of the typical distribution produced by fires (Fig.5).

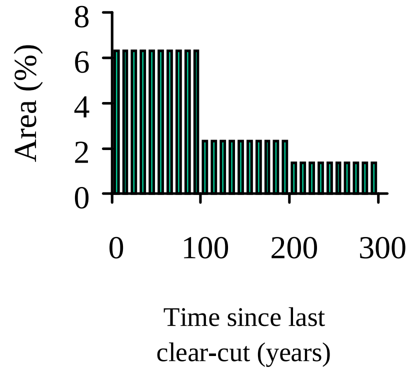


Figure 5 : Stand age class distribution (10 years) for decreasing rotations of 100 years.

CONCLUSION

It is theoretically possible to develop forest management systems that are inspired by natural disturbances. However, it is important to recognize that this approach can not justify the even-aged, (relatively) short-rotation regime that is currently the standard of boreal forestry. It is essential to go further and to attempt to reconstruct a forest mosaic that more closely resembles the natural composition. The exercise presented here constitutes a first step. It addresses the aspects of forest composition and temporal dynamics. The spatial aspect (the distribution of interventions over the landscape) is another challenge.

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