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NOTES

A MODEL FOR ESTIMATING THE NATURAL COMPOSITION AND DIVERSITY OF FOREST MOSAICS

APPLICATION TO THE BASSES-TERRES D'AMOS ECOREGION

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ISSUES

IN THE CONTEXT OF SUSTAINABLE FOREST DEVELOPMENT AND CERTIFICATION, THERE IS AN URGENT NEED TO DEVELOP PRACTICES THAT WILL ENSURE THE SUSTAINABILITY OF RESOURCES AND MAINTAIN

FOREST ECOSYSTEM FUNCTIONS. ONE OF THE CRITERIA FOR SUSTAINABLE FOREST MANAGEMENT RELATES TO THE CONSERVATION OF BIOLOGICAL DIVERSITY. FOREST BIODIVERSITY CAN BE MEASURED ON DIFFERENT SCALES: GENETICS, SPECIES AND LANDSCAPES. A NUMBER OF RESEARCHERS HAVE SUGGESTED THAT FOREST MANAGEMENT PRACTICES DESIGNED TO MAINTAIN FOREST MOSAIC DIVERSITY AT THE LANDSCAPE LEVEL ARE THE SUREST WAY TO PRESERVE A LARGE PART OF GENETIC AND SPECIES DIVERSITY, REGARDING WHICH THERE ARE STILL GAPS IN OUR KNOWLEDGE.

Under natural conditions, the diversity of the forest mosaic is determined not only by physical characteristics of the environment (topography, surficial deposits and hydrological regime) but also by the natural disturbance regime. For example, in the boreal forest, wildfires create a mosaic of stands of varying composition and age, thus contributing to the diversity observed at the landscape level. In view of this, it is believed that, by studying the forest mosaic diversity resulting from natural disturbance regimes, management approaches can be developed to ensure that biological

diversity is maintained. This is the concept of ecosystem management based on forest dynamics and natural disturbances.

Quebec government standards for public forests specify that at least 30% of the area of a reference land unit should at all times be composed of deciduous, mixedwood or coniferous stands over 7 metres in height. However, it is difficult to decide which composition and stand diversity should be maintained in these reference zones. So far, few methods have been developed for



Natural mosaic showing stands originating from several fires.



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Table 1.

Characteristics of the six ecodistricts of the Basses-Terres d'Amos ecoregion

DISTRICT			DEPOSIT (%)						
No.	NAME	AREA (km ²)	BEDROCK	TILL	SAND	CLAY	ORGANIC	WATER	OTHER
D06	Collines du lac D'Alembert	103	50	8	0	29	5	6	2
C22	Plaine du lac Surimau	362	4	59	1	23	9	2	0
B20	Coteaux du lac Joannès	248	4	23	40	14	14	3	2
L26	Plaine de la rivière Harricana	2,736	0	0	0	88	8	3	0
L40	Plaine de la rivière Promenade	602	2	9	9	14	63	0	3
L49	Coteaux de la rivière Magusi	309	13	14	2	48	11	12	0
Entire region	Basses-Terres d'Amos	15,758	7	11	6	53	16	7	0

assessing the natural composition and diversity of landscapes, yet these data are essential as a basis for defining applicable criteria. Hence, to be able to evaluate practices used for managing forest resources in a context of sustainable forest management, it is important to establish indicators that can be used to measure our success. It is with this goal in mind that the model described here was developed. This simple model can be used to obtain a first approximation of the forest mosaic composition and diversity under a natural disturbance regime, and thus provide a basis for planning forest management activities to maintain stand diversity in managed landscapes.

The proposed model has three components, which are described briefly below along with the associated results:

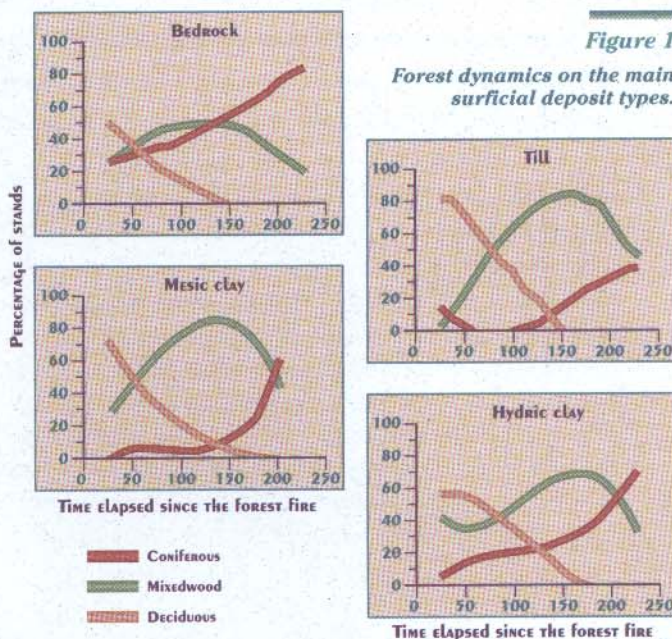
1.

First, changes in the composition of the forest cover over time since the fire (the cover type dynamics) are described. To this end, sampling data from 624 quadrats in district L49, divided into eight zones burned by fires at different times, were used to describe the vegetation composition of stands ranging in age from 30 to 230 years, for each of the ecological situations observed.

For the present example, only the forest cover types were modelled; however, results can be derived for different species or even stand types. Forest dynamics vary with the type of surficial deposit (*Figure 1*).

DESCRIPTION AND APPLICATION OF THE MODEL

The model was applied to six ecodistricts in the Basses-Terres d'Amos ecoregion of Abitibi, which is situated in the bioclimatic zone of balsam fir-white birch. The region, covering an area of 16,000 km², is located in the southern part of the boreal forest of northwestern Quebec. It can be subdivided into 42 ecological districts each characterized by a particular combination of surficial deposits and topography. The vegetation study was carried out in the district of the Collines de la Rivière Magusi (L49) in the vicinity of Lake Duparquet. This district typifies the entire ecoregion since the distribution of surficial deposit types found there corresponds to the distribution for the entire Basses-Terres d'Amos ecoregion (*Table 1*).



For the most part, deciduous forests composed of white birch and trembling aspen predominate during the first 75 to 100 years after a fire. Mixedwood forest tends to follow in the successional sequence, dominating the canopy until 150 years after the fire on rock outcrops, 200 years on mesic and hydric clay deposits, or even longer on till deposits, after which it is gradually replaced by coniferous forest.

2.

Second, the Van Wagner model (1978) was used in order to determine the distribution of stand age classes within the landscape under the applicable fire cycle, estimated to be about 100 years for the Basses-Terres d'Amos ecoregion. Van Wagner's model indicates that 63.2% of the forests are younger than this fire cycle period, whereas 36.8% are older (Figure 2). In addition, Van Wagner's model shows that the age-class distribution should follow a negative exponential function. Figure 2 illustrates this distribution for a 100-year fire cycle.

3.

The third stage involves taking into consideration the ecological characteristics of the various landscapes (districts) in the Basses-Terres d'Amos ecoregion. These are described using the ecological classification established by the ministère des Ressources naturelles

du Québec. For the purposes at hand, six ecodistricts were selected in the Basses-Terres d'Amos ecoregion. Table 1 summarizes the characteristics of the six districts. It shows that each district is dominated by a different type of surficial deposit. The ecological characteristics were combined with the output from the first two modelling stages in order to estimate the forest type composition of different landscapes under a 100-year fire cycle.

The results summarized in Figure 3 show that the landscape composition under a 100-year fire cycle differs among the six districts analyzed. It is estimated that 31% of the area of the typical district (L49) would be occupied by coniferous forest, 34% by mixedwood forest and 38% by deciduous forest. The districts dominated by till (C22) and clay (L26) deposits show similar trends with just over 20% of the total area occupied by coniferous forest, about 36% by mixedwood forest and 42% by deciduous forest. The district characterized by abundant rock outcrops (D06) has approximately equal proportions of the three cover types, whereas coniferous forests dominate the districts typified by sandy deposits (B20) and organic deposits (L40). This modelling approach can therefore be used to obtain a simplified picture of the cover type composition of these forest landscapes (districts in this case) under a natural fire regime.

The model can also be used to estimate mosaic diversity under a specific fire cycle (Figure 3). From the example illustrated, it can be seen that the estimated mosaic diversity differs from one landscape type to the next, with about 0.95 diversity for districts dominated by bedrock, till or clay, as well as for the typical district, compared with about 0.75 for districts with predominantly sandy deposits, and 0.55 for those with organic deposits. From these results, it is clear that when forest management activities are being planned for such landscapes, the different degrees of mosaic diversity should be taken into account. These data can therefore serve as a guide for defining the mosaic composition and diversity that should be maintained with a view to sustainable forest management.

Figure 2
Stand age-class distribution under
a 100-year fire cycle.

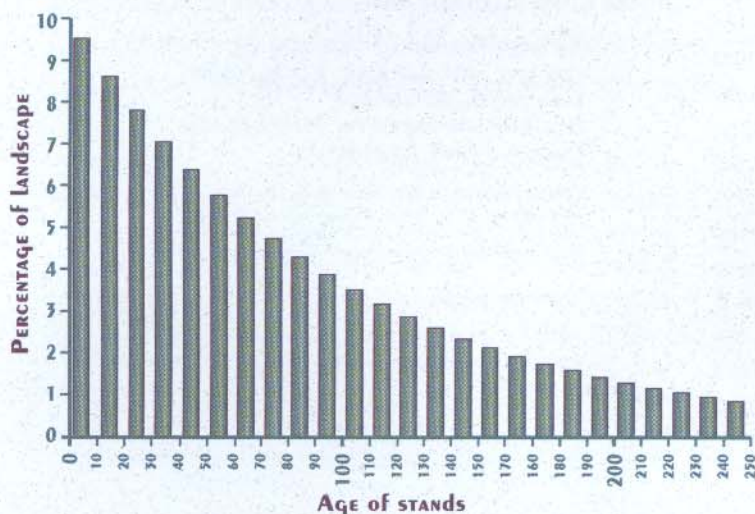
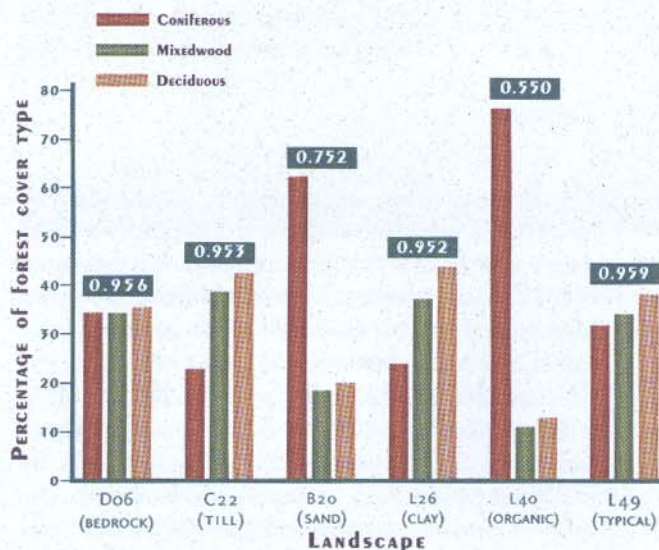


Figure 3

Forest composition and mosaic diversity (numbers above the bars) of six landscapes estimated under a 100-year fire cycle.



CONCLUSION AND FUTURE DEVELOPMENTS

Since the model is able to provide a picture of the natural composition and diversity of forest cover on landscapes of the Basses-Terres d'Amos ecoregion, it holds promise as a tool for setting targets for the forest composition and diversity to be maintained in landscapes that are under management. Given the model's simplicity, it should be possible to extend the results to other sectors of the boreal forest, provided the corresponding forest dynamics and fire regime information is available. For example, this tool could be used to define what type of stands over 7 metres tall should be maintained in reference land units. Although the model is simple and has some shortcomings, the estimates obtained represent a first step toward compiling baseline data that can be used in planning forest management activities to preserve the natural diversity of the forest mosaic. Work is continuing to refine the model, for example, with the aim of characterizing the fire regime and natural forest dynamics of a number of other ecoregions in western Quebec.

Additional information

GAUTHIER, S., A. LEDUC and Y. BERGERON. 1996. Forest dynamics modelling under natural fire cycles: a tool to define natural mosaic diversity for forest management. *Environmental Monitoring and Assessment* 39: 417-434.

LEDUC, A., S. GAUTHIER and Y. BERGERON. 1995. Prédiction de la composition de la mosaïque forestière naturelle soumise à un régime de feu: proposition d'un modèle empirique pour le nord-ouest du Québec. In Domon, G. et J. Falardeau. *Méthodes et réalisations de l'écologie du paysage pour l'aménagement du territoire*. Sélection de texte du Quatrième Congrès de la Société canadienne d'écologie et d'aménagement du paysage: Université Laval, Québec, June 1994, pp. 197-203.

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