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Forest structure and composition at fire edges of different ages: Evidence of persistent structural features on the landscape

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ABSTRACT

Boreal forest landscapes are dynamic with stands in different stages of development following stand-replacing disturbances such as fire and insect outbreaks. Forest edges are an important component of these heterogeneous landscapes but there have been few studies on intermediate-aged forest edges which are needed for a comprehensive perspective on the spatiotemporal dynamics of forest edges. We described the structure, composition and extent of edge influence at 13, 25 and 39-year old fire edges in black spruce boreal forest in northwestern Québec and northeastern Ontario to characterize their structural development and to assess effects of edge development on the understorey. Forest structure and understorey composition were sampled along transects perpendicular to edges of the fires. Edge influence was assessed using randomization tests. Black spruce forest was relatively unaffected by edge influence beyond 5 m into the forest at all ages of edges studied. Edge influence on the understorey was weak and not extensive at intermediate-aged edges with few consistent responses of individual species. Less decayed snags and logs at 13 and 25-year old edges peaked in abundance at or near the edge with values higher than in either adjacent ecosystem. Overall, intermediate-aged fire edges in black spruce forest showed little evidence of further changes in canopy structure with time. Structural development of these edges as well as the regeneration of the disturbed areas also resulted in reduced edge influence on the understorey. A new insight from our study is that intermediate-aged forest edges may contribute unique structural features to landscapes such as a reservoir of deadwood that may be important for wildlife species.

1. Introduction

Boreal forest landscapes are mosaics of forest stands in different stages of development following stand-replacing disturbances such as forest fires. An increased amount of edge habitat has long been recognized as an important consequence of fragmentation from forest harvesting (Harper et al., 2005) and natural fire edges have been studied more recently for their unique qualities (Harper et al., 2004; Larrivée et al., 2008; Braithwaite and Mallik, 2012). Edge influence on vegetation generally extends less far in boreal forests (up to 20 m) compared to temperate and tropical forests (Harper et al., unpublished data). Complex fire boundaries create highly variable edges that may influence the structure and composition of the adjacent forest stand further into the forest creating a wider, more gradual transition zone (Harper et al., 2004; Larrivée et al., 2008). However, there remain few studies on intermediate-aged fire edges which are needed for a comprehensive perspective on the spatiotemporal dynamics of forest edges.

Edge structure changes over time, resulting in dynamic boundaries and subsequent effects on the adjacent plant communities. Successional processes at the forest side of created edges are driven by microclimatic effects and changes in resource availability, but usually in the absence of vegetation removal or soil disturbance. Tree mortality and regeneration are key processes in the development of created edges. At regenerating edges, edge influence is expected to decrease over time as the contrast between adjacent communities is reduced (Matlack, 1994; Harper and Macdonald, 2002), resulting in 'edge softening' (Harper et al., 2005). Changes in plant species composition occur as a result of this structural development at created edges such as an increase in the proportion of understorey species influenced by the edge over 16 years (Harper and Macdonald, 2002).

Abbreviations: DEI, distance of edge influence; MEI, magnitude of edge influence; RTEI, randomization test of edge influence.

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We assessed the structure, composition and extent of edge influence at 13, 25 and 39-year old edges in black spruce boreal forest. Our objectives were: (1) to characterize the structure of intermediate-aged fire edges, particularly for deadwood, and (2) to assess the effects of edge development on understorey composition and diversity. We compared the results of the present study with those of young fire edges in the same study area (Harper et al., 2004). We hypothesized that the magnitude and distance of edge influence decrease over time as the adjacent forest stand regenerates, blocking out edge influence on light and wind. However, structural changes may continue due to wind effects and changes to the understorey may persist before the adjacent forest regenerates.

2. Methods

2.1. Study sites

Our study site was in black spruce boreal forest in the Abitibi region in northwestern Québec and in northeastern Ontario (49°62′ to 49°87′N, 79°00′ to 79°50′W, Fig. 1). The area is part of the the northern Clay Belt, a broad physiographic unit characterized by lacustrine deposits from the proglacial lakes Barlow and Objibway (Vincent and Hardy, 1977). The topography is relatively flat at an elevation of approximately 300 m asl. Soils are predominantly organic, with clay deposits and some till (Gauthier et al., 2000). According to a nearby weather station in La Sarre, Québec (48°46′N; 79°06′W; Environment Canada, 1993), mean annual temperature is 0.8 °C, annual precipitation is 856 mm, and there are 64 frost-free days. The forest mosaic in our study area is part of the *Picea mariana*-moss bioclimatic domain (Saucier et al., 1998). *P. mariana* (Mill.) BSP (black spruce) is dominant in stands of all ages on clay and organic sites, and in old stands on sand sites (Harper et al., 2002). Other tree species include *Pinus banksiana* Lamb., *Abies balsamea* (L.) Mill, *Betula papyrifera* Marsh., *Populus tremuloides* Michx., *Populus balsamifera* L. and *Larix laricina* (Du Roi) Koch. The region is characterized by large crown fires that kill most of the trees and aboveground vegetation (Bergeron et al., 2002). All burned sites were naturally regenerated without any planting; we avoided areas that were salvage cut.

2.2. Sampling design and data collection

We established four transects each at edges of single 13, 25 and 39-year old fires (Fig. 1, Table 1). Sampling was conducted between June and August 2001; spring ephemerals are rare in black spruce forests. Transects were at least 100 m away from other transects, major forest openings and any salvage-cut burned areas. Because we required sites with no salvage cutting, the number of possible transect locations was very limited since most of the fires that were easily accessible were partially or entirely salvage cut. Therefore, we could not control for edge aspect which spanned a range of orientations. Likewise, very few intermediate-aged fires were available leading to only one fire sampled for each age. We accounted for this unavoidable imbalanced sampling design by limiting direct statistical comparisons among different edge ages. Edges were created in forests dominated by *P. mariana* (>88% trees *P. mariana*) with some co-dominance by *A. balsamea*. All edges were located within stands of similar composition and structure; therefore, fire edges did not appear to be the result of pre-existing composition. Stand age, canopy cover and height varied among forest stands next to fire edges; averages for all transects at different edge ages were 50–62% for canopy cover and 10–15 m for height.

For each transect, we located plots at various distances from both sides of the edge to cover the full extent of the edge. Rectangular plots 20 × 5 m, length parallel to the forest edge, were centred at the following distances along each transect: −50, −15, −5, 0, 5, 10, 20, 40, 60, 100, 150 and 200 m from the edge into the adjacent forest (negative distances indicate the burned side of the edge). The plot at 0 m straddled the forest edge which was located at the edge of the continuous forest canopy; in this ecosystem, fire edges were distinct and easy to delineate. Plots were included on the disturbance side of the edge to encompass the entire transition zone since the extent of edge influence may only be found within the disturbed area. We used data collected at 100, 150 and 200 m to characterize interior forest; however, five of

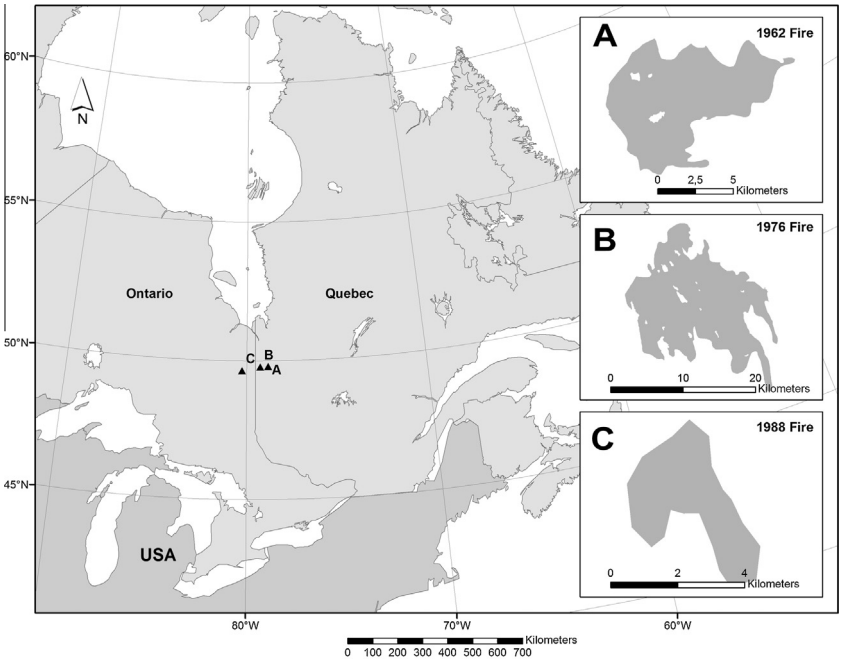

Fig. 1. Map showing the location of the study area and enlargements of the 1962 (A), 1988 (B) and 1976 (C) fires where edges were sampled.