UNIVERSITÉ DU QUÉBEC À MONTRÉAL

DISTRIBUTION DES PICS ET UTILISATION DES ARBRES MORTS DANS LES FORÊTS SOUMISES AUX PERTURBATIONS NATURELLES EN PESSIÈRE À MOUSSES

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AVANT-PROPOS

Ce mémoire comporte deux chapitres rédigés sous forme d'articles. À titre de candidat à la maîtrise, j'ai procédé à la supervision et à la récolte des données, à l'analyse des résultas et à la rédaction des articles à titre de premier auteur. Ces deux articles seront soumis à des revues scientifiques arbitrées : 1) Woodpecker use of naturally disturbed landscapes in the eastern boreal black-spruce forest et 2) Snag use for foraging by the Black-backed Woodpecker in a recently-burned eastern boreal forest. Mon directeur de recherche, Pierre Drapeau, ainsi que mon codirecteur, Jean-François Giroux, en sont les coauteurs.

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RÉSUMÉ

En forêt boréale, plusieurs espèces d'oiseaux, notamment les pics, dépendent des arbres morts tant pour l'alimentation que la nidification. Plusieurs études menées ailleurs en Amérique du Nord ont montré que les forêts anciennes et les forêts ayant subi des perturbations naturelles récentes (épidémies d'insectes, feux) contribuent, par leur grande disponibilité en arbres morts, au maintien des populations de pics. Dans la zone de la pessière noire cependant, peu de connaissances sur la distribution des espèces de pics dans les mosaïques forestières naturelles ainsi que sur leurs exigences écologiques sont actuellement disponibles. Ce mémoire comporte deux volets. Le premier chapitre vise à documenter la distribution des espèces de pics et l'influence de la disponibilité en arbres morts dans des mosaïques forestières naturelles de différents âges après feu (1 an, 20 ans, 100 ans, >200 ans). Le deuxième chapitre porte sur utilisation des arbres morts pour l'alimentation du Pic à dos noir (*Picoides arcticus*) dans une mosaïque forestière récemment brûlée (1 an après feu). L'aire d'étude se situe dans le nord-ouest de l'Abitibi (49°02'N au 49°48'N; 78°27'O au 80°46'O), dans les secteurs dominés par l'épinette noire et le pin gris. L'avifaune a été recensée par la méthode des points d'écoute et par l'utilisation de vocalisations et tambourinages enregistrés (''playback''). Des quadrats (700 m^2) centrés sur les points d'écoute ont été utilisés pour l'échantillonnage des chicots > 5 cm pour lesquels étaient notés différentes caractéristiques telles que le diamètre (dhp), l'état de décomposition et l'utilisation par les pics pour l'alimentation (écorçage et excavations). Bien que les forêts anciennes soient habituellement considérées comme des habitats clés pour les pics en raison de leur grande disponibilité en arbres morts, nos résultats indiquent que la présence de pics et la disponibilité en arbres morts sont plus faibles dans celles-ci que dans les forêts matures. Les forêts récemment brûlées constituent la principale source d'arbres morts en forêt boréale et représentent, pour la région à l'étude, un habitat d'importance capitale pour les pics, en particulier pour le Pic à dos noir (*Picoides arcticus*). Dans cet habitat unique, le Pic à dos noir utilise pour s'alimenter les arbres morts de grand diamètre qui sont moins décomposés et pour lesquels l'abondance en longicornes (*Monochamus sp.*), sa principale ressource alimentaire, est la plus forte. Étant donné la très forte association du Pic à dos noir avec les brûlis récents ainsi que les exigences écologiques de l'espèce, l'intensification de la coupe de récupération dans les forêts récemment brûlées pourrait constituer un menace sérieuse au maintien des populations de Pic à dos noir à une échelle régionale.

Mots clés *: Écologie forestière, biodiversité, arbres morts, pics, Pic à dos noir*

INTRODUCTION

1.1 La forêt boréale naturelle et aménagée

Les grandes régions forestières de l'Amérique du Nord dominées par les conifères sont caractérisées par des régimes de perturbations naturelles qui varient en fréquence, en superficie affectée ainsi qu'en intensité (Eberhart et Woodard, 1987; Johnson, 1992; Dansereau et Bergeron, 1993; Hunter, 1993; Hutto, 1995; Spies et Turner, 1999). Au Québec, la forêt boréale comporte encore d'importantes superficies de peuplements forestiers issus de perturbations naturelles telles que les feux (Bergeron, 1991; Bergeron *et al.*, 1999a) et les épidémies d'insectes. Le feu, dont le cycle est estimé à plus d'une centaine d'années pour l'est de la forêt boréale (Foster, 1983; Payette *et al.*, 1989; Bergeron, 1991; Bergeron et Archambault, 1993; Bergeron *et al.*, 1999a ; Leduc *et al.* en prép.), constitue la principale perturbation naturelle (Kurz et Apps, 1996) et brûle périodiquement de grandes superficies du territoire forestier québécois. Lors du passage d'un feu, certaines régions sont épargnées à cause de la topographie, des variations dans les conditions climatiques, de la nature des sols, des étendues d'eau et de tout autre élément susceptible d'intervenir dans la propagation du feu (Rowe et Scotter, 1973; Foster, 1983). Ce sont les peuplements forestiers épargnés des feux qui vont constituer les forêts anciennes de la forêt boréale. Sans l'intervention humaine, les feux vont donc façonner le paysage en créant une mosaïque forestière composée de peuplements d'âges et de superficies variées (Rowe et Scotter, 1973; Eberhart et Woodard, 1987).

Au Québec, dans la zone de pessière noire à mousses, la mosaïque forestière est toutefois de plus en plus façonnée par l'aménagement forestier. En effet, la forte exploitation plus au sud de la forêt boréale mixte a favorisé, au cours des dernières années, une expansion de l'exploitation forestière vers cette portion plus septentrionale du territoire forestier québécois. Bien que l'aménagement forestier semble montrer des similitudes avec les perturbations naturelles, il diffère de celles-ci à plusieurs points de vue. Entre autres, en imposant des révolutions qui sont plus courtes que les cycles des feux (Spies *et al.*, 1994; Gauthier *et al.*,

1996) l'aménagement forestier entraîne à l'échelle régionale une diminution importante de la superficie des forêts matures et anciennes ainsi qu'une uniformisation des classes d'âge et un rajeunissement des peuplements qui se traduisent par un changement dans la complexité de la structure du couvert forestier (Rowe et Scotter, 1973; Bergeron *et al.*, 1999b). De plus, même lorsque les révolutions forestières sont inspirées par le cycle des feux, la presque totalité des peuplements à valeur commerciale d'un territoire aménagé seront coupés sur une révolution de 100 ans alors que le caractère aléatoire des feux maintient dans le paysage une proportion importante (environ 51% pour un cycle de feu de 150 ans) de peuplements > 100 ans qui échapperont aux feux (Van Wagner, 1978; Bergeron *et al.*, 1999a). Ces transformations de la mosaïque forestière jumelées à des pratiques telles que la suppression des incendies de forêts et la coupe de récupération dans les forêts récemment brûlées sont susceptibles d'avoir un impact direct sur la qualité et la quantité de débris ligneux morts, un attribut d'habitat reconnu essentiel à la faune (Virkkala, 1991; Angelstam et Mikusinski, 1994; Hutto, 1995; Murphy et Lehnhausen, 1998).

1.2 Importance des arbres morts pour la biodiversité

Les arbres morts, souvent appelés chicots, représentent des éléments clés pour différents processus écologiques en milieu naturel (Harmon *et al.*, 1986; McComb et Lindenmayer, 1999). En plus de leur apport en éléments nutritifs, les débris ligneux debout ou au sol, particulièrement ceux de gros diamètre, constituent des micro-habitats nécessaires à la survie d'une grande diversité d'organismes: bactéries, champignons, arthropodes, amphibiens, et autres vertébrés (Raphael et White, 1984; Bull *et al.*, 1997)

Pour l'avifaune, les chicots constituent un support essentiel à l'alimentation, au repos et à la nidification de bon nombre d'espèces (Mannan *et al.*, 1980; Raphael et White, 1984). Au Québec, plus d'une quinzaine d'espèces d'oiseaux (dont six espèces de pics) sont des utilisateurs potentiels des arbres morts en forêt boréale de pessière noire à mousses (Tableau 1). Cela représente près de 25% des espèces d'oiseaux forestiers présentes dans ce territoire forestier (Drapeau *et al.* en prép.). Certaines espèces excavatrices (pics et sittelles) vont

Tableau 1. Liste des espèces d'oiseaux utilisateurs d'arbres morts recensées en 1998 et 1999 dans la pessière à épinette noire et à mousses au nord-ouest de l'Abitibi.

Espèce	Statut	Aliment.	Zone d'aliment.	Zone de nid.
Chouette épervière (*Surnia ulula*)	Mc	V	S	C
Chouette rayée (*Strix varia*)	R	V	S	C
Crécerelle d'amérique (*Falco sparverius*)	Mc	I	S	C
Grand pic (*Dryocopus pileatus*)	R	I	T	C
Grimpereau brun (*Certhia americana*)	Ml	I	T	E
Hirondelle bicolore (*Tachycineta bicolor*)	Ml	I	A	C
Merle-bleu de l'est (*Sialia sialis*)	Mc	I	A	C
Mésange à tête brune (*Parus hudsonicus*)	R	I	T	C
Paruline noire et blanc (*Mniotilta varia*)	Ml	I	T	S
Pic à dos noir (*Picoides arcticus*)	R	I	T	C
Pic chevelu (*Picoides villosus*)	R	I	T	C
Pic flamboyant (*Colaptes auratus*)	Mc	I	S	C
Pic maculé (*Sphyrapicus varius*)	Mc	I	T	C
Pic tridactyle (*Picoides tridactylus*)	R	I	T	C
Sitelle à poitrine rousse (*Sitta canadensis*)	Mc	I	T	C
Troglodyte des forêts (*Troglodytes troglodytes*)	Mc	I	S	C

Statut: R= résident; Mc= migrateur de courte distance; Ml= migrateur de longue distance
Alimentation: I= insectes; V= vertébrés
Zone d'alimentation: A= air; S= sol; T= tronc
Zone de nidification: C= cavité; E= écorce; S= sol
Classification basée sur Ehrlich et al. (1988)

creuser elles-mêmes leur cavité. D'autres espèces (non-excavatrices), sont par contre dépendantes des cavités produites au préalable par les pics, les insectes (principalement les termites) ou la décomposition fongique (Newton, 1994). La disponibilité de ces cavités va constituer un facteur limitant à la nidification des oiseaux non-excavateurs (Von Haartman, 1957; Brawn et Balda, 1988; Newton, 1994).

Les pics représentent l'un des groupes d'oiseaux les plus dépendant des arbres morts car en plus de les utiliser à des fins de nidification, les chicots constituent également un substrat sur lequel les oiseaux s'alimentent des divers insectes. À ce niveau, les pics peuvent même jouer un rôle écologique et économique important dans le maintien des populations d'insectes à des niveaux endémiques, ce qui peut constituer un élément important dans la prévention d'épidémies d'insectes (Knight, 1958; Otvos, 1965; Solomon, 1969; McCambridge et Knight, 1972).

La disponibilité en débris ligneux morts dans les forêts naturelles est donc non seulement importante pour les pics mais elle est à la base d'un jeu de relations fonctionnelles entre un nombre élevé d'espèces. En procurant un substrat de qualité pour les espèces s'alimentant sur les arbres morts, les forêts comportant une grande concentration de chicots vont favoriser les espèces excavatrices telles que les pics qui à leur tour augmenteront le nombre de cavités disponibles pour d'autres espèces (Brawn et Balda, 1988; Newton, 1994; Bull *et al.*, 1997).

1.3 Caractéristiques des arbres morts utilisés par l'avifaune

Bien qu'ils représentent un élément clé pour l'alimentation et la nidification des pics, les arbres morts ne possèdent pas tous la même valeur ou le même potentiel faunique. De plus, les caractéristiques des chicots sélectionnés par les pics diffèrent souvent selon les espèces d'oiseaux impliquées.

Parmi ces caractéristiques, le diamètre des chicots est certes un des facteurs déterminant dans la sélection des arbres morts tant pour la nidification que pour l'alimentation des oiseaux

(Mannan *et al.*, 1980; Raphael et White, 1984; Soulliere, 1988; Harestad et Keisker, 1989). Bien que les diamètres des arbres sélectionnés par l'avifaune diffèrent selon les espèces d'oiseaux et selon l'étendue des diamètres des arbres disponibles dans les régions où les forêts ont été échantillonnées (ex. Raphael et White, 1984; Goggans *et al.*, 1988; Saab et Dudley, 1998), l'utilisation d'un chicot de grand diamètre présente des avantages multiples pour la nidification d'un nombre élevé d'espèces d'oiseaux: construction de cavités plus grandes favorisant ainsi une plus grande couvée (Karlsson et Nilsson, 1977; Rendell et Robertson, 1993); une protection accrue par des parois plus épaisses qui procurent un bon isolement de la cavité (Raphael et White, 1984); une utilisation variée par un plus grand nombre d'espèces (Newton, 1994; Bull *et al.*, 1997). De plus, les gros chicots supporteraient plus d'insectes que les petits (Raphael et White, 1984). À ce titre, Cline (1977) (dans Mannan *et al.* 1980) a observé une plus grande activité des larves de coléoptères ainsi qu'une fréquence plus élevée de fourmis charpentières et de termites dans les chicots de grand diamètre. Enfin, tant pour l'alimentation que pour la nidification, les chicots de grand diamètre sont susceptibles de rester debout plus longtemps, ce qui permet une utilisation prolongée de ces derniers par l'avifaune (Morrison et Raphael, 1993; Newton, 1994; Bull *et al.*, 1997).

L'état de décomposition des arbres morts représente également une caractéristique importante de l'utilisation de ceux-ci par les pics. Pour la nidification, les arbres utilisés sont généralement plus décomposés que les arbres disponibles dans le milieu, ce qui facilite l'excavation de cavités de nidification (Daily, 1993; Conner *et al.*, 1994; Saab et Dudley, 1998). La capacité d'excavation des espèces constitue également un facteur déterminant dans la sélection des chicots, les espèces robustes pouvant utiliser les chicots moins décomposés, contrairement aux espèces moins vigoureuses qui sont restreintes aux chicots plus décomposés (Raphael et White, 1984; Harestad et Keisker, 1989; Saab et Dudley, 1998).

Bien que cet aspect soit moins documenté, l'état de décomposition des arbres morts est également important pour l'alimentation des pics. Swallow et al (1988) ont montré que les pics, particulièrement le Grand Pic et le Pic chevelu, s'alimentent préférablement sur des chicots plus décomposés. Le Grand pic se nourrit principalement de fourmis charpentières, des insectes qui ne se retrouvent que dans les stades plus avancés de décomposition des arbres (Bull, 1987; Ehrlich *et al.*, 1988). À l'inverse, des espèces comme le Pic tridactyle ou le Pic à dos noir, qui se nourrissent respectivement de scolytes et de longicornes, utilisent davantage des arbres faiblement décomposés dans lesquels ces insectes sont plus abondants (Murphy et Lehnhausen, 1998). L'état de décomposition des arbres est donc un facteur indirect associé à la disponibilité de ressources alimentaires préférées par les pics.

1.4 Disponibilité des arbres morts dans la mosaïque forestière naturelle

En forêt boréale, les arbres morts constituent une composante importante de la diversité structurale des forêts. Leur présence dans les divers stades successionnels est associée à de multiples facteurs tels que le feu, les éclairs, le chablis, les épidémies d'insectes, les maladies ou la compétition inter-spécifique (Mannan *et al.*, 1980). Une forte disponibilité en chicots est certes favorable aux oiseaux utilisateurs d'arbres morts. Plusieurs études ont, en effet, montré que la densité des oiseaux utilisateurs d'arbres morts, particulièrement les pics, était fortement influencée par des changements dans la disponibilité de ceux-ci résultant soit de perturbations naturelles ou anthropiques (Flack, 1976; Scott, 1979; Dickson *et al.*, 1983; Westworth et Telfer, 1993; Hutto, 1995; Schieck *et al.*, 1995; Murphy et Lehnhausen, 1998).

En milieu naturel, les forêts anciennes sont reconnues comme étant un habitat important pour les oiseaux utilisateurs d'arbres morts compte tenu de la grande disponibilité en chicots de large diamètre typiquement utilisés par ces oiseaux (Mannan *et al.*, 1980; Raphael et White, 1984; Zarnowitz et Manuwal, 1985; Angelstam et Mikusinski, 1994; Schieck *et al.*, 1995). Plusieurs études ont également rapporté de fortes augmentations dans les densités de pics suivant de grandes perturbations telles que les épidémies d'insectes (Crockett et Hansley, 1978; Yunick, 1985; Goggans *et al.*, 1988) et les feux (Blackford, 1955; Hutto, 1995; Villard et Schieck, 1997; Murphy et Lehnhausen, 1998).

1.5 Importance de l’étude

Parce qu’ils sont particulièrement dépendants des arbres morts tant pour la nidification que pour l’alimentation (Mannan *et al.*, 1980; Raphael et White, 1984; Murphy et Lehnhausen, 1998), les pics constituent des bons indicateurs de la disponibilité en arbres morts. De plus, ces espèces parcourent habituellement de grands territoires à la recherche de chicots, ces aires pouvant regrouper un seul ou plusieurs fragments d’habitat (Gutzwiller et Anderson, 1987; Angelstam et Mikusinski, 1994). Ces oiseaux constituent donc de bons indicateurs des changements de disponibilité en chicots à l’échelle des paysages forestiers. Enfin, comme les débris ligneux morts représentent un attribut d’habitat fortement altéré par l’aménagement forestier intensif, Angelstam et Mikusinski (1994) ont suggéré que la présence de plusieurs espèces de pics pourrait être utilisée comme un indicateur de l’intégrité écologique de la forêt. Ils mentionnent toutefois qu’une telle utilisation nécessite une connaissance préalable 1) de la distribution des espèces de pics dans des mosaïques naturelles et 2) de leurs exigences écologiques.

En Amérique du Nord, plusieurs études ont documenté et caractérisé l’étroite association entre les pics et les arbres morts. Cependant, la plupart de ces connaissances proviennent d’études menées dans les forêts de l’ouest du continent (ex. Raphael et White, 1984; Hutto, 1995; Murphy et Lehnhausen, 1998). La structure, la composition de même que les régimes de feux qui caractérisent ces paysages forestiers diffèrent fortement de ceux de la forêt boréale de l’est du Canada. Par conséquent, les recommendations en matière de rétention d’arbres morts dans les territoires aménagés des forêts de l’ouest de l’Amérique du Nord ne sont pas nécessairement applicables à la forêt boréale de l’est. En zone de pessière noire à mousses, nous possédons peu de connaissances tant sur la distribution des pics dans les divers stades successionnels des forêts naturelles que sur leur utilisation des débris ligneux morts en rapport avec leurs exigences écologiques pour la nidification et l’alimentation. Dans le cadre d’un aménagement forestier durable visant le maintien de la biodiversité, il devient primordial de documenter les exigences de ce groupe d’espèces qui constitue une composante importante de la biodiversité.

1.6 Objectifs de l'étude

L'objectif général de l'étude vise à documenter la distribution et l'utilisation par les pics de différents paysages forestiers naturels en zone de pessière noire à mousses. Cette étude comporte deux chapitres qui sont présentés dans ce mémoire sous forme d'articles.

Le premier chapitre a pour objectif 1) de documenter la distribution des espèces de pics dans des mosaïques forestières naturelles de différents âges après feu (1 an, 20 ans, 100 ans, >200 ans), 2) de déterminer l'effet de la disponibilité et de la qualité des arbres morts sur l'utilisation de l'habitat par les pics et 3) de comparer la disponibilité et la qualité des arbres morts entre les différentes mosaïques forestières.

Le deuxième chapitre documente les facteurs influençant l'utilisation des arbres morts pour l'alimentation du Pic à dos noir (*Picoides arcticus*) dans une forêt récemment brûlée (1 an après feu). Ce volet de l'étude repose à la fois des données provenant des marques d'alimentation (écorçage et excavation) des pics, des observations directes faites sur des individus s'alimentant ainsi que sur une analyse de l'abondance des insectes xylophages dans les arbres.

WOODPECKER USE OF NATURALLY DISTURBED LANDSCAPES IN THE EASTERN BOREAL BLACK-SPRUCE FOREST

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Abstract: We assessed distribution patterns of woodpeckers and their use of snags in eastern black-spruce forest landscapes disturbed by large-scale fires that occurred at different time intervals: 1, 20, 100 and > 200 years after fire. The study was conducted in the black-spruce boreal forest in the northwestern part of the Abitibi region in Québec (49°02'N to 49°48'N; 78°27'W to 80°46W). Woodpeckers censuses were conducted using the point count (184 stations) and playback methods (90 stations). Snag characteristics and foraging activities were measured in 700-m^2 plots centered on each point count station. Our results show that the availability of snags, particularly large snags, was not significantly greater in old-growth forests (> 200 years) than in mature forests (100 years). Hence, occurrence of woodpeckers and their foraging activities were not significantly higher in landscapes dominated by old-growth forests. Availability of snags and abundance of woodpeckers reached a peak in the early post-fire forests (1 year). These forests were the main source of snag recruitment and a key habitat for woodpeckers, particularly the Black-backed Woodpecker, whose occurrence was more than 10 times higher than in the other forest landscapes. Since this species is nearly restricted to this habitat type, it may be sensitive to an intensification of salvage logging as burned areas become more accessible in the eastern black-spruce boreal forest.

Keywords: Old-growth forests, burned forests, woodpeckers, Black-backed Woodpecker

Introduction

In the boreal forest ecosystem, large-scale natural disturbances, especially fires, have historically played a major role in determining the structure of forest landscapes (Rowe and Scotter 1973, Van Wagner 1978, Johnson 1992). During the last 40 years, however, commercial timber management has become the prevalent perturbation in many parts of the north-american boreal forest (Spies et al. 1994, Enoksson et al. 1995, Drapeau et al. 2000). Although foresters have often argued that clearcutting may show similarities with natural disturbances (fire or insect outbreaks) particularly in terms of the spatial extent of disturbances, there are important ecological differences at the stand and landscape scales between these two types of disturbances (Hansen et al. 1991, Spies et al. 1994, Gauthier et al. 1996).

Among these differences, the reduction in availability of dead wood (standing snags and logs) have raised increasing concerns on the capacity of current forest management to generate appropriate ecological conditions for the maintenance of biodiversity in conifer forest ecosystems (Angelstam and Mikusinski 1994, Esseen et al. 1997). Cavity-nesting birds which represent an important component of biodiversity are good indicators of the availability of snags because they are highly dependent on dead wood (Mannan et al. 1980, Raphael and White 1984, Bull et al. 1997). In particular, woodpeckers play an important role in boreal ecosystems by creating a wide variety of holes that will be used by secondary cavity-nesting birds and other animal species (Newton 1994, Bull et al. 1997). Woodpeckers as a group may also help us to understand the changes caused by forest management because they not only depend on snags for nesting but also for feeding (Mannan et al. 1980, Raphael and White 1984, Murphy and Lehnhausen 1998). Moreover, snags are typically distributed across the landscape rather than within single habitat types (Gutzwiller and Anderson 1987, Angelstam and Mikusinski 1994). Because dead wood represents a structural component associated with the natural dynamics of boreal forests, Angelstam and Mikusinski (1994) have suggested that ‘‘the occurrence of many woodpecker species could be used as an indicator of a high degree naturalness of forests’’. However, this may not be assessed without previous knowledge of the woodpecker species distribution in natural landscapes which is still lacking for the eastern boreal forest.

Several studies have shown that cavity-nesting birds, especially woodpeckers, respond strongly to changes in the availability of snags resulting from both natural (Mannan et al. 1980, Westworth and Telfer 1993, Hutto 1995) and human disturbances (Scott 1979, Dickson et al. 1983). In natural forest landscapes, mature and old-growth forests contributes mainly to the availability of large diameter snags (Mannan et al. 1980, Zarnowitz and Manuwal 1985, Schieck et al. 1995, Esseen et al. 1997, Esseen et al. 1997). Woodpecker density also increases in recently disturbed forests following natural perturbations such as insect outbreaks and fire (Blackford 1955, Crockett and Hansley 1978, Yunick 1985, Goggans et al. 1988, Hutto 1995, Murphy and Lehnhausen 1998).

In North America, most of our knowledge on the abundance and distribution of birds dependent on dead wood comes from studies conducted in the Pacific Northwest and in the Rocky Mountains forests (e.g. Mannan et al. 1980, Raphael and White 1984, Hutto 1995). Thus, recommendations and management guidelines are not necessarily applicable to eastern boreal forest landscapes. According to Freedman et al (1994), the relative contribution of forest types (by age-class) to biodiversity across landscapes in eastern boreal forest ecosystems remains poorly documented. Moreover, baseline data on woodpecker distribution patterns have mainly come from studies conducted at the stand level. We lack landscape scale information on the distribution patterns of these species across the range of forest conditions (from recently burned to old-growth forest) that are produced by large-scale natural disturbances such as fires.

In this paper, we examine the distribution patterns of woodpeckers and their use of snags across forest landscapes in the eastern black-spruce forest that have been disturbed by fire events that occurred at different time periods. More specifically, our objectives were, at the landscape level, to quantify the distribution of woodpeckers in natural forest landscapes disturbed by fire at four different time periods (1, 20, 100 and > 200 years) and to compare the availability and the quality of snags among the four forest landscapes. At the stand level, we assess the response of woodpeckers to snag characteristics and availability.

Study area

The study was conducted in the northwestern section of the black-spruce boreal forest of Québec (49°02'N to 49°48'N; 78°27'W to 80°46W). This area belongs to the *Picea mariana*-moss bioclimatic domain (Saucier et al. 1998) and is part of the northern Clay Belt of Ontario and Quebec, a broad physiographic region characterized by lacustrine deposits from the pro-glacial lakes Barlow and Objibway (Vincent and Hardy 1977). The topography is dominated by a flat landscape with scattered low-elevation hills (400 m maximum elevation). Surficial deposit is mainly composed of organic and clay deposits (Gauthier et al. in press) and vegetation is dominated by Black spruce (*Picea mariana*) and Jack pine (*Pinus banksiana*). In that region where fire is the natural perturbation in the black-spruce boreal forest (Rowe and Scotter 1973, Zackrisson 1979), the fire cycle increased from 65 years before 1850 (end of the Little Ice Age) to more than 165 years after 1850 (Gauthier et al. in press).

Methods

Study design

Based on forest cover maps and a fire reconstruction map (Bergeron *et al*. unpubl. data), we selected four forest landscapes (100 to 250 km^2) that were burned at different times: 1 year, 20 years, 100 years (mature) and > 200 years (old-growth). The 1-year and the 20-years forest landscapes had previously burned in 1911 and in the mid-18th century respectively and were, thus, composed of mature and over-mature forests. All these landscapes have been partially logged (ranging from 12 to 15 % of the area for the 20, 100 and >200 year-old forests and 70 % salvage logged in the 1 year-old burn). All sampling stations (point counts and vegetation sampling) were placed in unlogged black-spruce forest stands. They were grouped along 1.2-to 2.5-km linear transects disposed at least 1 km apart. A maximum of six stations were located 350 to 450 m apart along each transect to ensure independence between stations. No point was closer than 100 m from the edge of an open area (clear cuts or swamps). For the recently burned forest landscapes (1 year and 20 years), where only burned stands were sampled, the same minimal distance was used to separate stations from the edge of unburned stands. A total of 184 stations were sampled in the four landscapes (1 year: n = 49, 20 years: n = 21, 100 years: n = 53, > 200 years: n = 61).

Bird sampling

Woodpeckers' relative abundance was measured using the point count method (Hutto 1995, Drapeau et al. 1999). Using an unlimited radius, we recorded all woodpeckers detected by sight or sound at 5-min intervals for a 20-min period. Censuses were conducted from mid-May to early July between 05h00 and 09h00 during the breeding seasons of 1997 (20-years, 100-years and >200-years forests) and 1998 (1 year forest). Each sampling station was visited twice during the breeding season. The maximum count of the two visits was used to estimate the relative abundance of each species at each station. Biases were minimized by changing observers and reversing the order of stations at the second visit. We did not survey during rainy or windy mornings.

The relative abundance of the two main residents of the black-spruce boreal forest, the Three-toed and the Black-backed Woodpeckers, was also measured using territorial drumming and contact calls of the two species during 5-min periods (Villard et al. 1992). Playback points were located 800 m apart along road transects following the Breeding Bird Survey (BBS) method. A total of 90 playback points were distributed in the four forest landscapes (1 year: n = 26; 20 years: n = 21; 100 years: n = 21; > 200 years: n = 22). Each playback point was visited once during the breeding season.

Snag sampling

Snag abundance was measured using a single triangular plot of 40-m on a side (700 m^2) centered on each point count sampling station, for a total of 184 plots. Snags were defined as any completely dead tree (no green leaves) at least 2 m tall. Within sampling plots, only snags with a diameter at breast height (dbh) > 5cm were recorded. For each snag, we noted tree species, dbh and four decay characteristics based on a modified version (British Colombia Ministry of Forests 1995) of Thomas *et al.* (1979) criteria (ranging from low to high decay): a) visual appearance (1 = live tree appearance to 7 = standing stump > 2 m tall), b) crown condition (1 = all foliage to 7 = no branches or stubs), c) bark retention (1 = all bark present to 7 = no bark), d) wood condition (1 = no decay to 7 = no more hard wood). Foraging activities (small holes and/or bark flaking) were also recorded for each snag.

Statistical analyses

For each species, differences between frequency of occurrence among the four landscapes were assessed using the log likelihood ratio (G) test. This was done for both the point count and playback data sets. Principal component analysis (PCA) was used to derive a single component variable of the decay stage of snags described by the four variables measured in the field. The latter best described the state of decay of each snag and provided a quantitative value of the mean stage of decay of snags in each sampling station. Differences between forest landscapes in mean availability (density and basal area) and decay stages of snags (PC1 scores) were assessed using Kruskal-Wallis tests. Each significant Kruskal-Wallis test was followed by a Student-Newman-Keuls's (SNK) pairwise comparison procedure. Finally, we used multiple regression to assess the relationship between use of snags by woodpeckers (mean % of snags used in sampling plots) and dead wood conditions (density of snags and mean stage of decay). Separate multiple regression analyses were performed for different levels of dbh (5, 10, 15 and 20 cm) to determine thresholds in the use of snags by woodpeckers. All analyses were performed using SAS (SAS institute 1988).

Results

Distribution of woodpeckers

Overall, six woodpecker species were detected during the study. Three species were observed in the 1-year, 20-year and > 200-year post-fire forest landscapes, whereas all species were detected in the mature forest landscape (Fig. 1). The Yellow-bellied Sapsucker (*Sphyrapicus varius*) was restrained to the mature forest landscape (df = 3, G = 15.9, $P < 0.005$) while the Northern Flicker (*Colaptes auratus*) was found more frequently (df = 3, G = 17.2, $P < 0.005$) in the 1-year and 20-year post-fire forests. The Three-toed Woodpecker (*Picoides tridactylus*) was absent from the 20-year forest landscape only, but differences between the four forest landscapes were not significant (df = 3, G = 3.0, $P = 0.05$). The Black-backed Woodpecker (*Picoides arcticus*) was detected in all forest landscapes but its frequency of occurrence was significantly higher in the recently burned forest (df = 3, G = 139.8, $P < 0.005$). The Pileated Woodpecker (*Dryocopus pileatus*) was recorded only once in the mature forest (df = 3, G = 1.4, $P = 0.05$) and the Hairy Woodpecker (*Picoides villosus*) was recorded only once in the 20-years and 100-years-old forest landscapes (df = 3, G = 3.0, $P = 0.05$). When data were pooled for all woodpecker species, the proportion of point count stations with woodpeckers was highest in the early post-fire landscape (95.9 %) and lowest (14.8 %) in the old-growth forest landscape (df = 3, G = 90.0, $P < 0.005$).

The playback method used to detect the Black-backed Woodpecker and the Three-toed Woodpecker yielded similar results than point counts (Fig. 2). The Black-backed Woodpecker was detected significantly more often in the 1-year post-fire forest landscape (df = 3, G = 17.6, $P < 0.005$) than in the other landscapes while the Three-toed Woodpecker was equally infrequent in the four forest landscapes (df = 3, G = 2.6, $P = 0.05$).

Difference in snag availability and quality among landscapes

Snag availability differed among the four forest landscapes (Tab. 1). Availability of snags > 5 cm, > 10 cm, > 15 cm was highest in the 1-year post-burned forest landscape and lowest in the old-growth forest landscape. The 20-year and the mature forest landscapes had similar intermediate values. Large snags (> 20 cm) were rare in all the landscapes and their availability did not differ among landscapes.

From the four decay variables measured in the field, we derived a single component variable using PCA (Tab. 2). The first principal component accounted for 69 % of the total variance of the original variables and was used in the following analyses to represent the stage of decay of each dead tree. The decomposition stage of snags varied significantly among forest landscapes (Kruskal-Wallis: $\chi^2 = 27.7$, df = 3 , $P < 0.001$). Standing snags were lightly decayed in the 1-year post-burned forest landscape whereas the highest proportion of heavily decayed snags was observed in the 20-year forest landscape (Fig. 3). Decay stages were similar in the mature and old-growth forest landscapes where intermediate decay stages were predominant.

Snags used by woodpeckers

Woodpeckers tended to use more intensively areas where snags were abundant and the mean stage of decay was low (Fig. 4). R-square values of multiple regression models were higher for superior dbh threshold (≥ 10 cm, ≥ 15 cm and ≥ 20 cm) than for dbh ≥ 5 cm. Percentage of snags used by woodpeckers was significantly influenced by decay stage in all regression models while snag density only was a significant predictor when the dbh of used trees was higher than 10 cm and 15 cm (Tab. 3).

Discussion

Old-growth forest landscapes

Old-growth forests are usually considered key habitats for wildlife given their structural complexity, notably the availability of large live and standing dead trees (Spies et al. 1988, Hansen et al. 1991, Esseen et al. 1997). Several studies have reported increases in abundance and diversity of cavity-nesting birds, including woodpeckers, with an increase in stand age (Mannan et al. 1980, Zarnowitz and Manuwal 1985, Westworth and Telfer 1993, Schieck et al. 1995). For instance, Mannan et al. (1980) showed that density of hole-nesting birds and woodpecker foraging intensity in western Oregon reached their maximum in > 200 year-old forests. Concurrently, these old-growth forests supported the highest density of large diameter snags needed by cavity birds for nesting and feeding activities (Raphael and White 1984, Bull et al. 1997).

Our results indicate that old-growth forests were not a critical habitat for woodpeckers in the black-spruce zone of the eastern boreal forest. We found the lowest number of species and a lower occurrence of woodpeckers (all species confounded) in the old-growth than in the mature forest landscape. Discrepancies between our results for this portion of the eastern black-spruce forest and those from other studies can partially be explained by the fact that snags were not more abundant in the old-growth forests.

Snags >10 and 15 cm, which had the greatest influence on habitat use by woodpeckers, were more important in the mature than in the old-growth forests. While such snags may be underutilized in Pacific Northwest forests, small diameter snags (10 to 20 cm) in our study area were commonly used for foraging by woodpeckers, while nests were found in snags as small as 15 cm dbh (Nappi et al, unpubl. data). Thus, this relatively higher abundance of snags in the mature forests may explain the fact that all six woodpecker species present in our study area were detected in the mature forests. These woodpeckers, even if they were not very frequent, may had benefit of a higher availability of snags.

The rarity of large (> 20 cm) snags in our study area may explain the low occurrence of the Pileated Woodpecker, which was found only in the mature forests where a few large trembling aspens were still standing. The Yellow-bellied Sapsucker which is particularly associated with mature forests (Westworth and Telfer 1993, Schieck et al. 1995) was only present in that landscape where it was also the dominant species. The Northern Flicker, which feeds on the ground and is typically associated with open habitats (Ehrlich et al. 1988, Westworth and Telfer 1993), reached its lower occurrence in the mature forest landscape. Its occurrence increased in the old-growth forests. In the black-spruce boreal forest of the northern Clay Belt, the open vegetation structure of these old-growth forests may have contributed positively to the presence of that species. *Picoides* woodpeckers (*arcticus, tridactylus* and *villosus*) do not seem to be abundant in both mature and old-growth forest landscapes in the eastern boreal black-spruce forest (see also Imbeau et al. in press).

Early post-fire forest landscapes

In most studies, the forest age gradient used for comparisons of bird distributions is usually truncated (e.g. Mannan et al. 1980, Westworth and Telfer 1993, Schieck et al. 1995, Thompson et al. 1999) limiting the generality of the results (Hejl et al. 1995). Because our study covered two extremes of the gradient, from recently-burned to old-growth forests, it provided a unique opportunity to examine the distribution of woodpeckers in different forest types. In this comparison, the relative occurrence of woodpeckers reached a peak in the recently-burned forest landscape. This pattern was mainly linked to the Black-backed Woodpecker for which the occurrence was more than 10 times higher in the recently-burned forest landscape than in the other forest landscapes. Distribution of this woodpecker species in early post-fire stands of eastern boreal forests is consistent with Hutto's (1995) results for Northern Rocky Mountain conifer forests. Throughout its geographic range, Black-backed Woodpecker appears to be clearly associated with recently burned forest landscapes.

These recently-burned forests represent a major source of snag recruitment and provide suitable foraging and nesting habitat for woodpeckers (Angelstam and Mikusinski 1994, Hutto 1995). In the boreal forest, where natural fire regimes play a major role in the mortality of trees, it is not surprising to see that recently-burned forests contribute the most to the availability of standing snags. Moreover, since old-growth forests contribute weakly in our area to the availability of snags (and large snags), recently-burned forests may be even more important for the persistence of woodpecker populations.

After fire, the loss of standing snags will, however, decrease the suitability of the habitat. For example, woodpecker abundance decreased considerably with the decline of snags following the first few years after fire in a burned forest in the Sierra Nevada (Bock and Lynch 1970, Raphael and White 1984). In our study, total woodpecker occurrence was only 33 % in the 20-year post-fire forest landscape which is concordant with the high reduction of snags. However, the Northern Flicker was equally abundant in these two younger forest landscapes where its occurrence reached a peak.

In addition to the total loss of standing snags, the increase in decay also reduces the suitability of these snags for feeding (Nappi et al. in prep.). In our study sites, woodpeckers used more intensively areas where the density of snags increased and the mean stage of snag decay was low, a characteristic of recently-burned habitats. Snags in the 20-year post-fire forest landscape were highly decayed and woodpeckers were much less present. Bock and Lynch (1970) suggested that the observed decrease in woodpecker densities over the years was a consequence of the lower abundance of wood-boring beetles resulting from the decay of burned trees. This particularly affects the Black-backed Woodpecker, which mainly feeds on white-spotted sawyers (*Monochamus scutellatus),* an epidemic wood-boring beetle abundant in burned trees (Murphy and Lehnhausen 1998). Murphy and Lehnausen (1998) reported an important decline of Black-backed woodpeckers as adult insects emerged two years post-fire and no woodpeckers were observed after the last remaining insect adults emerged 3 years later. Since high densities of low-decayed snags are mostly present in recently burned forests, this important and unique habitat is probably essential for the maintenance of woodpecker populations in the boreal forest.

Management implications

In northern Europe, regional expansion of intensive forest management over the last century has caused serious loss of over-mature and old-growth forests, greatly reducing dead wood availability. This in turn caused the decline of several bird species, especially hole-nesters that required older forests (Virkkala 1991, Angelstam and Mikusinski 1994). In the black-spruce boreal forests of the northern Clay Belt, we found that woodpecker abundance and species richness were not higher in old-growth forests than in mature forests and were not high in both landscapes. However, under a fire cycle which has been estimated at more than 165 years for our study area, more than 51 % of the stands may be older than 100 years at a regional scale (Bergeron et al. 1999). The northern expansion of timber harvesting in North American boreal forests may considerably rejuvenate the overall forest landscape. Hence, this could reduce the proportion of over-mature and old-growth forests, thus affecting woodpecker populations at a regional scale.

In our study area, occurrence of woodpeckers and availability of standing snags reached a peak in the recently-burned forest landscape. In this part of the black-spruce forest where fire is the major disturbance agent, recently-burned forests represent the most important source of snag recruitment. For woodpeckers, these recent burns may be even more important since old-growth forests only contribute weakly to the availability of snags. Increasing fire suppression and salvage logging could become a serious threat for primary cavity nesters, especially woodpeckers. In our study, Black-backed Woodpecker showed to be specifically restricted to recently-burned forests as it has been showed elsewhere in its geographic range (Hutto 1995, Villard and Schieck 1997, Murphy and Lehnhausen 1998). Because of its high association to burned forests and its sensibility to salvage logging (Saab and Dudley 1998), a better knowledge of its habitat requirements is clearly needed in order to develop conservation plans and provide management guidelines that will maintain Black-backed Woodpecker populations while allowing some salvage logging operations in recently-burned areas.

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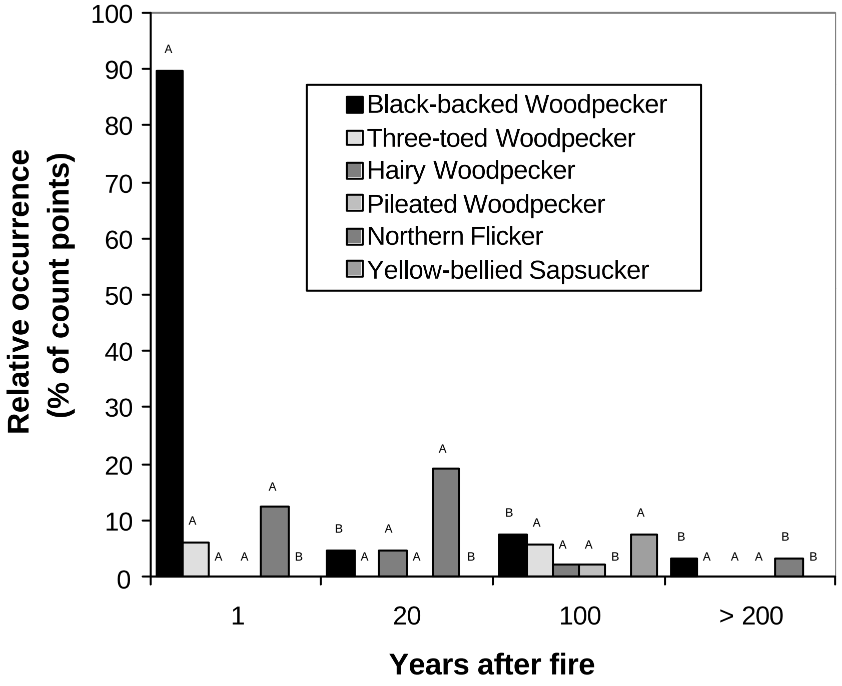
List of figures

Figure 1. Woodpecker occurrence in four natural forest landscapes in the eastern boreal black-spruce forest of Abitibi (Quebec) based on the point count method (1 year: n = 49; 20 years: n = 21; 100 years: n = 53; > 200 years: n = 61). Similar letters indicates no difference in the occurrence of a species among landscapes.

Figure 2. Black-backed Woodpecker and Three-toed Woodpecker occurrence in four natural forest landscapes in the eastern boreal black-spruce forest of Abitibi (Quebec) based on the playback method (1 year: n = 26; 20 years: n = 21; 100 years: n = 21; > 200 years: n = 22). Similar letters indicates no difference in the occurrence of a species among landscapes.

Figure 3. Distribution of snag decay in four natural forest landscapes in the eastern boreal black-spruce forest of Abitibi, Quebec (a = dbh 5-9.9 cm; b = dbh 10-14.9 cm; c = dbh 15-19.9 cm: d = dbh >20 cm) . Decay data was grouped in three equidistant classes. The ‘y’ axis represents the relative occurrence of each decay class for each forest landscape.

Figure 4. Variation in the mean proportion of snags used by woodpeckers in relation to density of snags and mean state of decay (a = dbh >5 cm; b = dbh >10 cm; c = dbh >15 cm: d = dbh >20 cm). Decay stage and snag densities were partitioned into equifrequent classes.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Relative occurrence
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Three-toed Woodpecker
Hairy Woodpecker
Pileated Woodpecker
Northern Flicker
Yellow-bellied Sapsucker
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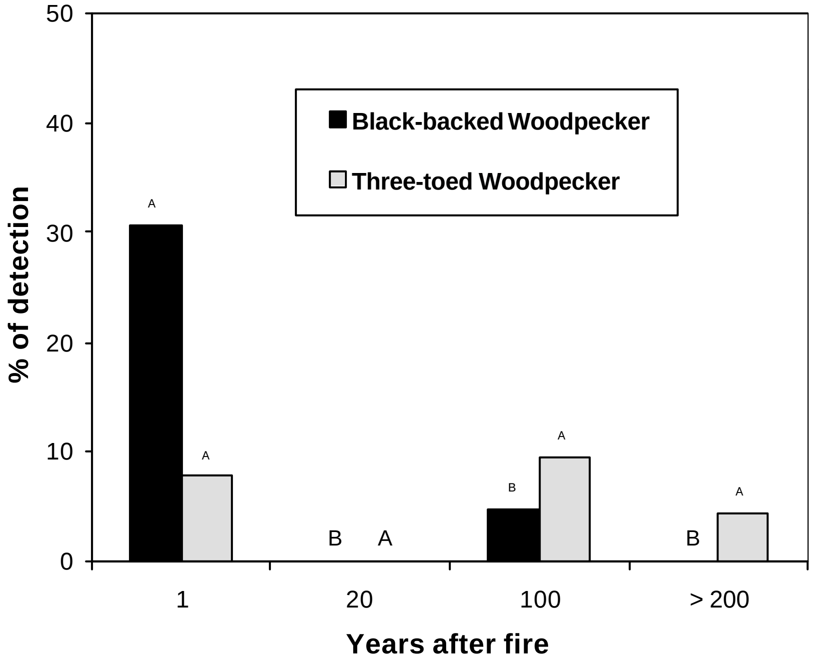
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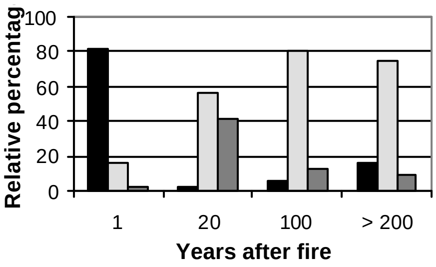
Years after fire

a)


Relative percentag
100
80
60
40
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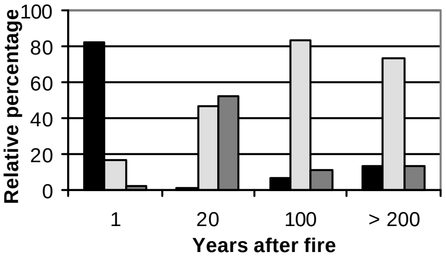
0
1
20
100
> 200
Years after fire

b)


Relative percentage
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80
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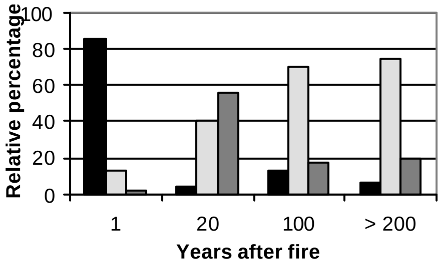
Years after fire

c)


Relative percentage
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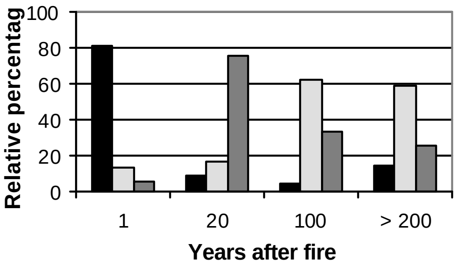
> 200
Years after fire

d)


Relative percentag
100
80
60
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20
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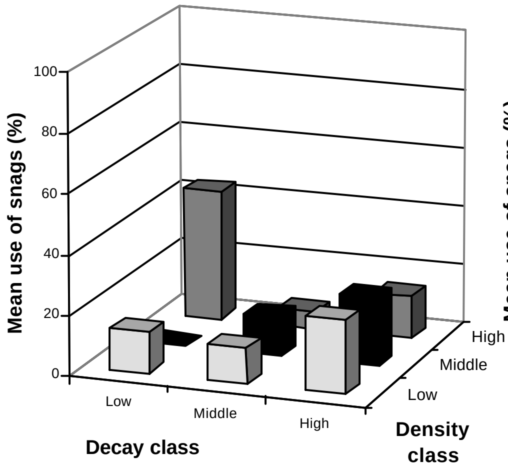
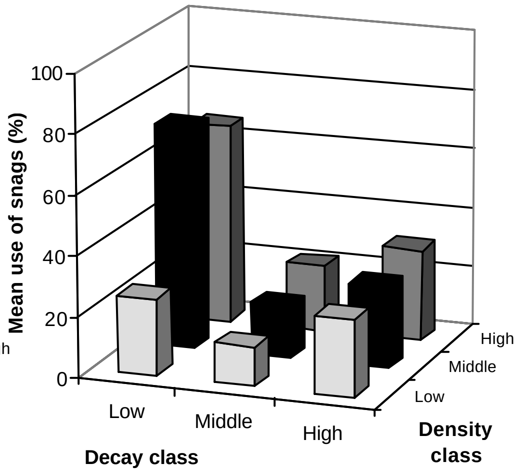
1
20
100
> 200
Years after fire

a)


Mean use of snags (%)
100
80
60
40
20
0
Low
Middle
High
Decay class
High
Middle
Low
Density class

b)


Mean use of snags (%)
100
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Low
Middle
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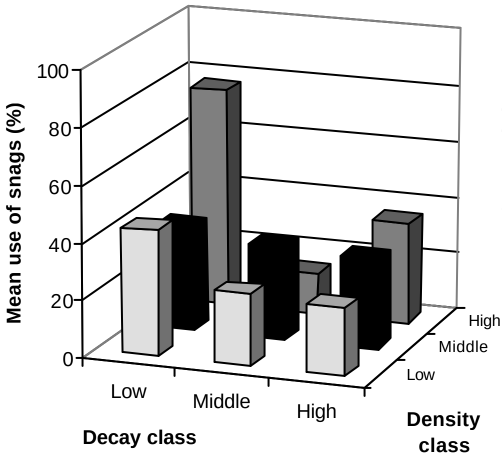
Decay class
High
Middle
Low
Density class

c)


Mean use of snags (%)
100
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Low
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High
Decay class
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Middle
Low
Density class

d)

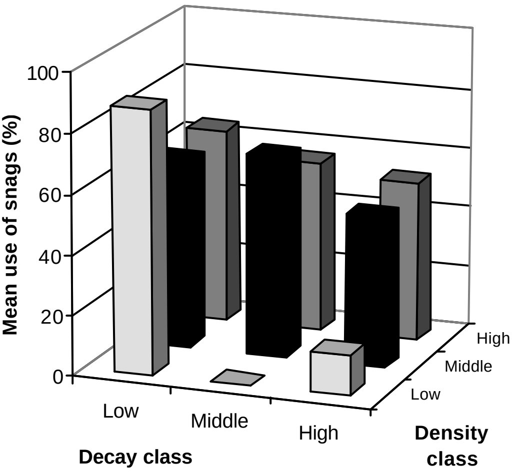
Mean use of snags (%)
100
80
60
40
20
0
Low
Middle
High
Decay class
High
Middle
Low
Density class

Table 1. Snag availability (ξ ± SE) in four forest landscapes of the eastern boreal black-spruce forest of Abitibi (Quebec) in relation to DBH. Results are expressed in basal area (m^2/ha) and density (snags/ha).

Years After Fire	Snags availability							
	≥ 5 cm		≥ 10 cm		≥ 15 cm		≥ 20 cm	
	Basal area	*Density*	*Basal area*	*Density*	*Basal area*	*Density*	*Basal area*	*Density*
1	12,8 ± 6,6 A[a]	1849 ± 878 A	7,6 ± 5,1 A	565 ± 323 A	2,8 ± 3,4 A	114 ± 133 A	0,6 ± 1,4 A	16 ± 37 A
20	3,1 ± 2,3 B	308 ± 237 B	2,4 ± 2,2 B	142 ± 123 B	1,3 ± 1,7 B, C	39 ± 43 B, C	0,6 ± 1,5 A	8 ± 14 A
100	3,0 ± 2,2 B	251 ± 151 B, C	2,5 ± 2,1 B	136 ± 80 B	1,5 ± 2,1 A, B	48 ± 53 B	0,8 ± 1,7 A	17 ± 35 A
>200	1,9 ± 1,5 C	188 ± 110 C	1,5 ± 1,5 C	99 ± 83 B	0,7 ± 1,2 C	30 ± 46 C	0,2 ± 0,7 A	6 ± 17 A

[a] Significant differences among landscape are indicated by different letters (Student-Newman-Keuls's pairwise comparisons, $P < 0.05$)

Table 2. Results of the PCA done on the decay variables of snags sampled in eastern black-spruce forests, in Abitibi region.

Component variable	Eigenvalue	Proportion	Eigenvectors			
			Visual appearance	Crown condition	Bark retention	Wood condition
PRIN1	2.76	0.69	0.56	0.55	0.43	0.46
PRIN2	0.65	0.16	(-) 0.15	0.01	0.80	(-) 0.57
PRIN3	0.47	0.12	(-) 0.38	(-) 0.49	0.41	0.67
PRIN4	0.12	0.03	(-) 0.72	0.68	(-) 0.06	0.12

Table 3. Results of multiple regression models showing the influence of decay and density of snags on the use of snags by woodpeckers in eastern black-spruce forests, in Abitibi region.

Minimum DBH threshold	Significant variables	F	R^2	p
5 cm	decay (-)	30.97	0.15	0.0001
10 cm	dbh (+), decay (-)	40.94	0.33	0.0001
15 cm	dbh (+), decay (-)	16.72	0.20	0.0001
20 cm	decay (-)	28.68	0.33	0.0001

SNAG USE FOR FORAGING BY THE BLACK-BACKED WOODPECKER IN A RECENTLY-BURNED EASTERN BOREAL FOREST

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Abstract: We examined the use of snags for feeding by woodpeckers one year after fire in an eastern black spruce forest in Quebec. The Black-backed Woodpecker (*Picoides arcticus*) was the most abundant primary cavity nesting bird in this landscape. We searched for foraging signs (small holes and bark flaking) on 6536 snags and made direct observations of foraging by Black-backed Woodpeckers on 119 trees. Densities of wood-boring beetles was measured on 30 snags of different size and decay stages. A logistic regression model was developed based on used (n = 2519) and unused snags (n = 4017). Field observations of individual Black-backed Woodpeckers feeding on snags were used to test the model. Snags used by woodpeckers for feeding were larger and less decayed than unused snags which was corroborated with higher densities of wood-boring beetles. Intensification of salvage logging in recently-burned forests may pose a serious threat to Black-backed Woodpeckers at a regional scale since it is mainly restricted to this habitat in the eastern boreal forest. Large blocks of unsalvaged forests with large and slightly-decayed snags must be preserved from logging operations in order to favor the persistence of Black-backed Woodpecker populations.

Keywords: Burned forests, Black-backed Woodpecker, foraging, wood-boring beetles

Introduction

Several studies have shown that the Black-backed Woodpecker (*Picoides arcticus*) is closely associated with recently-burned forests (Blackford 1955, Apfelbaum and Haney 1981, Hutto 1995, Villard and Schieck 1997, Murphy and Lehnhausen 1998). Early post-fire habitats are highly suitable for Black-backed Woodpeckers given the increased availability of wood-boring beetle larvae, particularly the white-spotted sawyer (*Monochamus scutellatus*), an important prey species (Murphy and Lehnhausen 1998). Few authors (Hutto 1995, Murphy and Lehnhausen 1998) have also suggested that these recently-burned forests may represent a key habitat for the maintenance of viable Black-backed Woodpecker populations. For the boreal black spruce forest of the northern Clay Belt where old-growth forests only contribute weakly to the availability of snags, recently-burned forests may be even more important for the persistence of Black-backed Woodpecker populations (Nappi et al. in prep.).

However, little is known about the specific foraging habitat requirements of the Black-backed Woodpecker in this important and unique habitat. The few studies that have provided information on the Black-backed Woodpecker foraging ecology were conducted in mature unburned forests (Goggans et al. 1988, Villard 1994) or have compared the foraging ecology of the Black-backed, Three-toed and Hairy Woodpeckers in burns without focusing on the specific foraging habitat requirements of Black-backed Woodpeckers (Villard and Beninger 1993, Murphy and Lehnhausen 1998). Moreover, the northern expansion of timber harvesting in the eastern boreal forest, where fire is the major natural disturbance (Rowe and Scotter 1973), will result in an increase of salvage logging as burned areas become more accessible. For the Black-backed Woodpecker, this could become a serious threat to the maintenance of viable populations at a regional scale (Hutto 1995, Murphy and Lehnhausen 1998, Saab and Dudley 1998). A better knowledge of the habitat requirements of this species could therefore help develop conservation plans and provide management guidelines to maintain populations while allowing some salvage logging operations in recently burned areas.

In a recently-burned black-spruce forest landscape in northwestern Quebec, a previous study (Nappi et al. in prep.) have shown that Black-backed Woodpecker was, by far, the most abundant woodpecker species in comparison to the other two woodpecker species detected which were the Three-toed Woodpecker (*Picoides tridactylus*) and the Northern Flicker (*Colaptes auratus*). Furthermore, of the 27 active woodpecker nests found during that census (Nappi et al. unpubl. data), only two belonged to species other than Black-backed Woodpecker (both Three-toed Woodpecker nests). The high occurrence of Black-backed Woodpeckers in this forest landscape gave us a good opportunity to document its foraging habitat requirements.

In this study, we examined Black-backed Woodpecker use of snags for feeding in a recently burned forest (1 year after fire). Based on the presence or absence of foraging signs (bark flaking and/or foraging holes), we used logistic regression to predict the use of snags by Black-backed woodpeckers. This model was then tested using direct foraging observations of Black-backed Woodpeckers. Finally, we assessed the density of wood-boring beetles in relation to snag characteristics retained by the model.

Study area

The study area was located at the Ontario-Quebec border near Val-Paradis municipality, in northwestern Quebec (49°02'N to 49°12'N; 78°22'W to 79°32W). The area belongs to the *Picea mariana*-moss bioclimatic domain (Saucier et al. 1998) and is part of the northern Clay Belt of Ontario and Quebec, a broad physiographic region characterized by lacustrine deposits from the pro-glacial lakes Barlow and Objibway (Vincent and Hardy 1977). Fire started on June 5th 1997 after a lightning strike approximately 15 km northwest of Val-Paradis. When the fire was suppressed by June 12th, 12 540 ha of forest mainly composed of Black spruce (*Picea mariana*) and Jack pine (*Pinus banksiana*) had been burned (Bordeleau 1998). A small portion of the fire extended to Ontario.

The previous fire in the same region occurred in 1911. The 1997 fire therefore burned mature (87-year old) forest stands that had an average crown closure of 40% to 60% (Bordeleau 1998). The topography of the area is characterized by a gently rolling terrain with 4 to 5%

slopes. When the fire occurred in 1997, it was a normal fire season with precipitation in April and May (128 mm) within the 10-year average of 136 mm (Bordeleau 1998). Salvage logging began during the same summer. When salvage logging operations ended, about 70% of the burned area had been harvested. The unsalvaged stands were composed of patches reserved for research projects, unaccessible to forestry machinery, or with insufficient standing volumes to justify harvesting. A portion of them were also located in Ontario, where only a portion of the burned area was logged. Sampling plots were all located in > 4 ha unlogged patches.

Methods

Snag sampling

A total of 56 triangular plots (700 m^2) were used to sample standing snags and foraging signs. Snags were defined as any dead tree (no green leaves) at least 2 m tall. Within the plot, the diameter at breast height (dbh) of snags > 5 cm was measured with a caliper (± 5 mm). For each snag we recorded tree species and 4 decay characteristics based on a modified version (British Colombia Ministry of Forests 1995) of Thomas et al. (1979) criteria (ranging from low to high decay): a) visual appearance (1 = live tree appearance to 7 = standing stump >2 m tall), b) crown condition (1 = all foliage to 7 = no branches or stubs), c) bark retention (1 = all bark present to 7 = no bark), d) wood condition (1 = no decay to 7 = no more hard wood). For each snag, burn intensity (percentage of the tree surface that was burned) was classified as follows: 1) unburned, 2) 0-5 % burned, 3) 5-40 % burned, 4) 40-60 % burned, 5) 60-95 % burned and 6) totally burned.

Black-backed woodpecker feeding activity was determined by the observation of bark flaking and/or foraging holes. Although Villard (1994) and Murphy and Lehnhausen (1998) have shown differences in foraging techniques (pecking, flaking, excavating and licking) used by Black-backed, Three-toed and Hairy Woodpeckers, these species may co-occur in burns and overlap in their use of these techniques. For example, bark flaking may be used by the three species. However, since Black-backed Woodpecker was the dominant woodpecker species in the Val-Paradis burned forest landscape, foraging signs were assumed to represent evidence of Black-backed Woodpecker foraging activities.

Identifying post-fire foraging can be done only during the first or second year after fire. After that period, these signs may no longer represent the current use of snags by birds, but rather indices of their past utilization (maybe a few years before). Moreover, bark flaking signs may disappear following the natural loss of bark in the decay process. Since most of the snags were killed by fire, we were able to distinguish foraging marks made before (burned foraging holes) and after the fire (bark lifted up, exposing unburned hard wood and/or unburned foraging holes).

Woodpecker foraging observations

During June 1998, field observations of individual unmarked Black-backed Woodpeckers feeding on snags were conducted in the largest unlogged section of the burn (about 100 ha) located in Ontario. Woodpeckers were detected by walking along linear transects placed 200 m apart. When a bird was found, it was observed until it flew out of sight. For each tree used for foraging, the same characteristics as the snag sampling were recorded. Previous observations confirmed that this technique does not influence their foraging behavior, except when they are close to their nesting cavity (which was avoided during the field observations).

During the sampling, we found 15 active Black-backed Woodpecker nests in that same section of the burn (Nappi et al. unpubl. data). By distributing equally the amount of time spent to locate birds within the area, we tried to maximize the number of different individuals (a possibility of 30 different individuals) that could be involved in these observations.

Insect sampling

In the summer of 1999, we measured the abundance of wood-boring beetles in snags of varying dbh and decay stage. We selected and cut 30 snags (all black spruces) for which we measured the total number of larval entrance holes in the wood for the first meter and for all subsequent 2-meter intervals. That gave us an assessment of the third-instar larval population (Rose 1957). We also recorded the total number of foraging holes excavated by woodpeckers to assess the foraging intensity of woodpeckers on those trees. We calculated densities of wood-boring beetles and foraging holes for each tree section. Since we only measured dbh on the field, we used a stem profile model calibrated for black spruce (Zakrzewski 1999) to estimate the diameter at different heights which was then used to calculate densities. Characteristics of snags were also recorded as in the snag sampling.

Statistical analyses

We used logistic regression to determine which set of explanatory variables best predicts snag use for foraging by Black-backed woodpeckers. A total of 12 variables were included in the model (see Table 1). Because the four variables describing decay stages shared common information, principal component analysis (PCA) was used to summarize these variables into a single composite variable describing snag decay. This new variable (PC1) was also included in the logistic regression with the other four decay variables. Since these snags were sampled by plot, observations within each plot were not independent from each other. We thus weighed each snag by the ratio of the number of plots / total number of snags (sum of weights of the observations = 56) to allow the model to be more conservative in the acceptance of the alternative hypothesis.

We tested our model with an independent data set of foraging trees where Black-backed woodpecker foraging behavior was monitored. We entered the explanatory variable (obtained by the logistic regression) values of the foraging observations in the logistic regression model and examined the mean predicted value representing the probability to be used (0= unused and 1= used) and the proportion of snags that were correctly classified (predicted value $\geq$ 0.5).

For insects, the effects of variables selected by the logistic regression on the density of wood-boring beetles were assessed using analysis of variance. All analyses were performed using SAS (SAS institute 1988).

Results

Snag use

Of the 6536 snags sampled, 2519 (38.5%) showed foraging signs by woodpeckers. Almost all (95.9 %) of the used snags were lightly to highly burned. Two variables, dbh and crown condition (cc), were significant predictors of snag use for feeding (Table 1). The probability of a snag being used was positively related to an increase in dbh and negatively related to crown condition: $\mathrm{logit}(p_i) = -0.91 + 0.30\ \mathrm{dbh} - 0.75\ \mathrm{cc}$. Larger snags with less decayed crown condition were more likely to be used (Fig. 1).

Of the 5 decay variables that were used in the model, crown condition came out as the most significant feature to predict foraging use by woodpeckers. The first principal component, which accounted for 65 % of the total variance of the set of decay stage variables, was not a better predictor of snag use.

Black spruce, which represents 85 % of the snags sampled, was the dominant species in the study area while remaining snags were mainly jack pines (13 %). The other tree species were very uncommon (2%). Although tree species was not selected as part of the combination of best predictors in the logistic regression model (possibly due to the highly skewed ratio of black spruce snags), used and unused snags were compared among tree species. Not all tree species were selected in the same proportion (Table 2). A higher proportion of jack pines (45.0 %) and black spruces (41.2 %) were used for feeding compared to other tree species (goodness of fit test: df = 4, $\chi^2 = 12.0$, $p < 0.05$). However, no significant differences were found between the relative use of jack pines and black spruces (df = 1, $\chi^2 = 2.4$, $p = 0.05$).

Model validation

Forty-five individuals were followed to record their use of snags: 24 males, 15 females and 6 birds of unknown sex. A total of 119 trees were used for foraging. Most were black spruces (93 %). Dbh and crown condition of these trees were compared with the model's predictions. From these observations, 74 % had a predicted value ≥ 0.5 with a mean predicted value of 0.66 ± 0.24.

Insects

Based on the results of the logistic regression, the abundance of wood-boring beetles was assessed following different dbh and decay (as defined by crown condition: cc) classes. From a two-way contingency table of decay and dbh, we established categories that combined decay and dbh classes based on the proportion of snags that were used and not used for foraging (threshold : > 50 %). The combinations of decay and dbh were as follows: cc = low, dbh = 8; cc = moderate, dbh = 11; cc = high, dbh = 13. For each combination, 5 snags were sampled under and above the threshold, for a total of 30 trees.

Variation in the density of wood-boring beetles was both related to the diameter of snags and to decay (2-way anova, dbh effect: df = 1, $F = 7.28$, $p < 0.05$; cc effect: df = 2, $F = 3.98$, $p < 0.05$). Density of wood-boring beetles was lower for smaller and highly decayed snags (Table 3). Density of foraging holes was highly correlated to density of wood-boring beetles (Spearman correlation, R = 0.44).

Discussion

Recently-burned forests represent suitable habitat for Black-backed Woodpeckers since newly dead trees create favorable conditions for insects such as wood-boring beetles, on which these birds feed (Murphy and Lehnhausen 1998). In our burned area, about 38 % of the trees were showing fresh marks of feeding activities one year after the fire, which illustrates the importance of burned snags.

The size of snags has often been suggested to be a crucial element in the selection of nesting sites by cavity-nesting birds (Mannan et al. 1980, Raphael and White 1984). In the case of Black-backed Woodpecker which also rely on dead wood for feeding, larger snags also seem to be preferred for foraging as showed by our results. In Oregon, Goggans (1988) found that trees used by Black-backed Woodpeckers had a mean dbh > 37 cm. However, in our study area where trees of that size are rarely found, the mean dbh of used snags was relatively smaller (10.5 cm). Thus, trees used for foraging by the Black-backed woodpecker vary in size across the species' range of distribution and are more closely related to the overall regional availability of snags than to species-specific requirements for foraging.

Black-backed Woodpeckers also tended to forage on less decayed snags as our logistic regression model indicated. These snags mainly originated from live trees that had been killed by fire. Older snags that were already dead before the fire were highly decayed (e.g. broken tops and massive loss of bark), and were rarely used for feeding.

By assessing the abundance of wood-boring beetles in relation to the snag characteristics, dbh and decay, this study also examines the direct factors underlying the results obtained by the model. For example, Mannan et al. (1980) suggested that larger snags may be used more frequently because they may have more insects or larvae than smaller ones. Our results support this suggestion. The density of wood-boring beetles was positively related to the diameter of snags, thus confirming that diameter not only increases the abundance but also the density of insects inhabiting the dead wood.

Our study also support Bock and Lynch (1970) suggestion that increased decay of burned trees may influence negatively the density of wood-boring beetles. These insects are known to lay their eggs in humid portions of snags (mostly in or under the bark). Thus, loss of bark through increased decay will likely reduce the availability of potential micro-habitats for these insects. Even within a limited comparison (classes cc = 5 to cc = 7 were excluded from the analysis), our results showed that density of wood-boring beetles decrease with an increase in snag decay. The lower density of wood-boring beetles observed in the low decay class (cc = 2) compared to the moderate decay class (cc = 3) may have been influenced by fire. Since the initial decay stage of these snags is, in part, related to fire intensity, the less-decayed snags selected to measure wood-boring insect abundance may have been too lightly burned and were thus less colonized by wood-boring beetles. Gardiner (1957) noted that the severity of fire injury, by influencing the time of death, influences the infestation of trees by borer beetles. In his study, he found that the proportion of holes by *Monochamus* species was greater in pines that were killed faster than in those that died later.

Fire intensity may greatly influence the use of snags by woodpeckers. Murphy and Lehnhausen (1998) explained the marginal use of heavily burned trees by the initially low abundance of cerambicyd eggs and the poor larval survival caused by the quick dessication of the sapwood. Fire intensity did not come out as a significant variable in our model. However, fire intensity may have been reflected by the stage of decay. Highly burned snags were also more decayed according to the characteristics we recorded and were less often used for foraging by woodpeckers.

Tree species selection for foraging by woodpeckers has been examined in several studies. In pure Lodgepole pine forest stands in Oregon, Goggans et al (1988) reported that 97 % of the foraging observations of the Black-backed Woodpecker were made on lodgepole pines. However, only 0.2 % of lodgepole pines were used by woodpeckers in recently-burned forests in Montana whereas Ponderosa pine, Western larch and Douglas-fir were the most selected tree species (Hutto 1995). Murphy and Lenhausen (1998) noted that Black-backed Woodpeckers fed almost exclusively on spruce (white and black) in Alaska, while they selected Jack pine in Minnesota (Apfelbaum and Haney 1981) and White pine in an other study in Quebec (Villard and Beninger 1993). Thus, Black-backed Woodpeckers seem to select a wide variety of tree species, which selection is largely influenced by their regional availability.

In our study area, jack pines that are usually larger than black spruces should represent a higher potential for woodpeckers. Moreover, the bark of large trees like jack pines is more resistant to fire and, thus, may create more microhabitats for wood-boring beetles. In our study however, Black-backed Woodpeckers did not forage more frequently on Jack pine than on Black spruce. This result may be attribute to the lower availability of bigger Jack pine snags which have been preferentially logged during salvage cutting, leaving more black spruces which were mostly restricted to swamps, depressions and unproductive stands.

Using the presence or absence of foraging signs (bark flaking and/or foraging holes) as an indication of the foraging activities of the Black-backed woodpecker showed to be a good way to investigate its foraging ecology. This has been confirmed by our model validation. Moreover, the high correlation between density of wood-boring beetles and density of foraging holes also confirmed the fact that woodpeckers selection of snags is not at random. They tend to select snags with a high availability of insects.

Because it is clearly restricted to recently-burned forests, the Black-backed Woodpecker may be negatively affected by efficient fire suppression and increased salvage logging in recently burned forest landscapes (Hutto 1995, Murphy and Lehnhausen 1998). Under Quebec Ministry of Natural Resources current regulation, forest industries are required to undertake intensive salvage logging in recently burned areas within their forest management units. In the eastern boreal black-spruce forest, intense salvage logging such as in the Val-Paradis burned forest will increase as large burned areas become more accessible. Conservation of large tracts of recently-burned forests may, therefore, be a key issue for the persistence of Black-backed Woodpecker populations in eastern boreal forests.

Owing to the fast decay of snags, recently-burned forests may represent suitable habitats only in the first years following a fire (Murphy and Lehnhausen 1998). Large unlogged portions of the burned forests should, thus, be preserved from timber harvesting in order to maintain the highest number of woodpeckers in the burns. In our study, the burned stand (around 100 ha) we sampled for our foraging observations was used both for foraging and nesting by 15 Black-backed Woodpecker nesting pairs. However, this study can not provide the threshold as for the minimal stand area under which nesting and foraging requirements may not be met.

These high quality areas should, however, contain large and low decayed snags suitable for feeding and nesting purposes.

Fire intensity should also be taken into account in management strategies. In natural burned forests, a wide variety of fire intensity conditions may be encountered. Managers should thus keep sectors of different burn intensity away from logging operations. In the case of the Black-backed Woodpecker, heavily burned trees are less used for foraging because they represent a less favorable habitat for wood-boring beetles. Moreover, less severely burned trees which will be infested later by insects will maintain the potential of a burned forest to be used by woodpeckers over a longer period of time. Peripheral portions of fires may offer habitats of various fire intensity conditions, including less severely burned trees. They are also an important link to the surrounding forests. Thus, these portions of burned forests should receive priority attention in conservation plans.

This study provides new information about the foraging habitat requirements of the Black-backed Woodpecker in recently burned forests. This is a key information in the elaboration of conservation plans and management guidelines that will maintain populations of woodpeckers while allowing some salvage logging operations in recently burned areas. A better understanding of wood-boring beetle biology and Black-backed Woodpecker nesting habitat requirements would therefore improve these management strategies in this key habitat.

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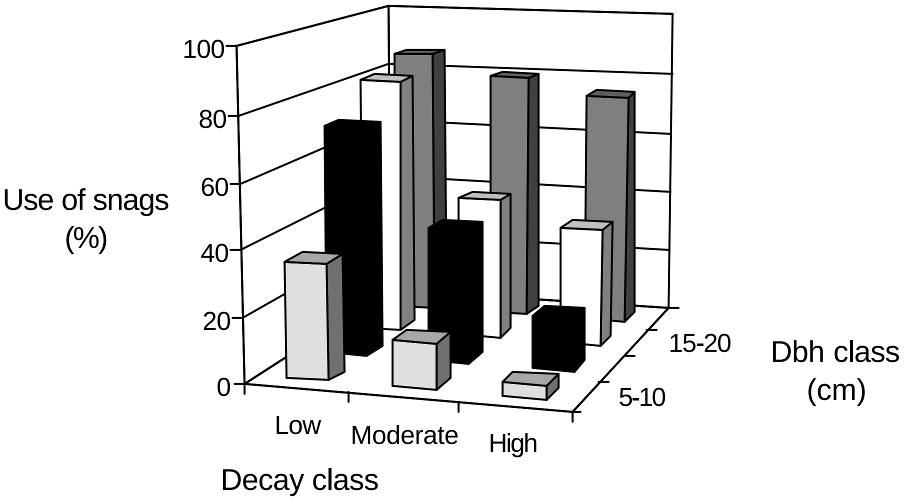
List of figures

Figure 1. Snag use by the Black-backed Woodpecker in relation to dbh and decay (crown condition = cc) in the Val-Paradis burned forest landscape, Quebec (n = 6536). Decay values were grouped in 3 classes (Low = cc1 to cc3, Moderate = cc4 and cc5; High = cc6 and cc7).

Figure 2. Mean wood-boring beetle densities in relation to DBH and crown condition classes based on 30 snags sampled in the Val-Paradis burned forest landscape, Québec. Errors bars represent SD values. The "small < 8 cm" and large > 8 cm" classes were based on 4 and 6 snags, respectively. For other categories, n = 5 snags. Letters indicate significant differences among classes (Kruskall-Wallis tests followed by Dunnett's T3 tests for multiple comparisons)

*** La figure 2 remplace le tableau 3 de la version déposée de ce mémoire ***


Use of snags (%)
100
80
60
40
20
0
Low
Moderate
High
Decay class
15-20
5-10
Dbh class (cm)

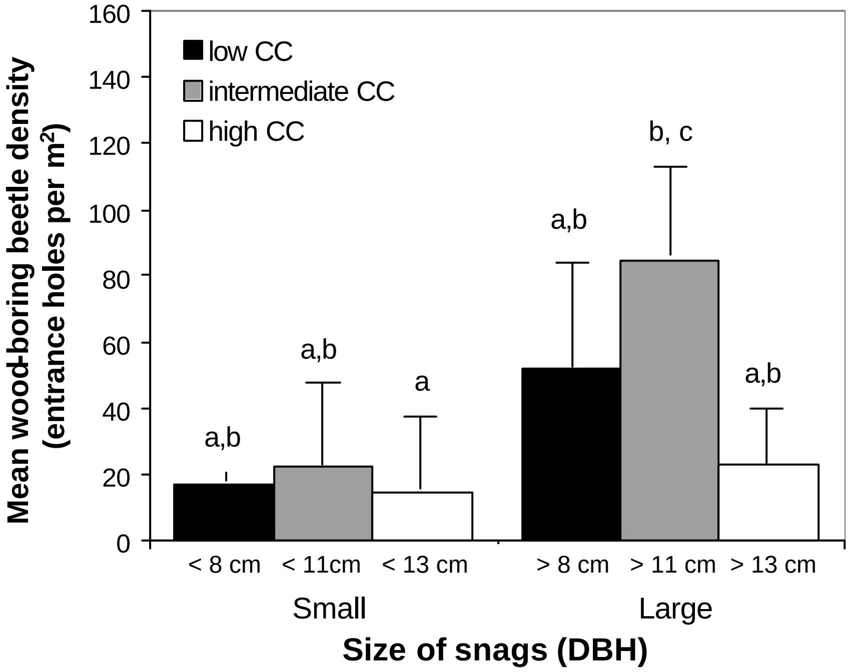

160
140
120
100
80
60
40
20
0
Mean wood-boring beetle density (entrance holes per m²)
■ low CC
▨ intermediate CC
☐ high CC
a,b
a,b
a
a,b
b, c
a,b
< 8 cm
< 11cm
< 13 cm
> 8 cm
> 11 cm
> 13 cm
Small
Large
Size of snags (DBH)

Table 1. Characteristics of snags used and unused by woodpeckers one year after fire in the Val-Paradis burned forest landscape, Quebec.

Variable	Used snags (n = 2519)		Unused snags (n = 4017)		P > Chi-Square [a]
	Mean	S.D.	Mean	S.D.	
DBH (cm)	10.5	3.6	7.8	2.6	0.003
Tree species [b]	--	--	--	--	0.757
Snag decay					
Visual appearance	3.2	0.6	3.7	1.0	0.960
Crown condition	2.6	0.9	3.5	1.4	0.032
Bark retention	2.1	0.6	2.3	1.5	0.228
Wood condition	1.1	0.5	1.2	0.6	0.697
Decay (PC1)	-0.5	1	0.3	1.8	0.594
Density of snags [c]					
> 5 cm	141.3	60	160.9	66.2	0.296
> 10 cm	43.8	23.8	47.7	24.5	0.225
> 15 cm	8.6	9.9	8.9	9.2	0.276
> 20 cm	1.1	2.5	1.0	2.1	0.415
Fire intensity	5.7	1.9	5.5	2.3	0.346

[a] Significance of each variable as predictors of the snag use for foraging

[b] Tree species are expressed as dummy variables

[c] Density of snags in the sampled plot

Table 2. Availability and relative use of snags of different tree species for foraging by woodpeckers in the Val-Paradis burned forest landscape, Quebec.

Tree species [a]	n	% of trees used
Black spruce (*Picea mariana*)	5004	41.2
Jack pine (*Pinus banksiana*)	764	45.0
Tamarack (*Larix laricina*)	65	29.2
Balsam fir (*Abies balsamea*)	25	28.0
Deciduous trees [b]	20	10.0

[a] 658 snags were not identifiable to the species

[b] Deciduous trees include trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*)

CONCLUSION

2.1 Distribution des pics

En Amérique du Nord, la plupart de nos connaissances sur l'abondance et la distribution des oiseaux associés aux arbres morts proviennent d'études qui ont été effectuées dans les montagnes Rocheuses de l'ouest américain (ex. Raphael et White, 1984; Hutto, 1995; Murphy et Lehnhausen, 1998). Les recommendations en aménagement forestier qui en découlent ne sont pas nécessairement applicables à la forêt boréale de l'est. De plus, les comparaisons sur la distribution des espèces d'oiseaux dans ces études ne portent souvent que sur une portion restreinte du gradient d'âge des forêts (voir Mannan *et al.*, 1980; Westworth et Telfer, 1993; Schieck *et al.*, 1995; Thompson *et al.*, 1999). Comme l'ont noté Hejl *et al.* (1995), ceci restreint la portée des conclusions que l'on peut tirer de ces comparaisons. La présente étude est l'une des rares à couvrir un large gradient successionnel qui s'étend des forêts récemments brûlées aux forêts anciennes. En outre, en documentant la distribution des pics dans des mosaïques forestières naturelles, les connaissances acquisesconstituent des points de référence en milieu naturel qui permettront de vérifier l'impact de l'aménagement forestier sur le maintien des populations de pics, une composante importante de la diversité biologique.

Dans les régions tempérées et boréales, les forêts anciennes sont habituellement considérées comme des habitats clés pour la faune (Mannan *et al.*, 1980; Hansen *et al.*, 1991; Esseen *et al.*, 1997). Celles-ci sont plus complexes en termes de structure forestière, contiennent des arbres vivants et morts de plus grand diamètre ainsi qu'une plus grande abondance de débris ligneux morts debout et au sol (Spies *et al.*, 1988; Hansen *et al.*, 1991; Esseen *et al.*, 1997). Plusieurs études ont montré l'importance des forêts plus âgées pour les oiseaux utilisateurs d'arbres morts, en particulier les pics, et ce notamment en raison de la plus grande disponibilité de ces arbres morts (spécialement ceux de grand diamètre) (Mannan *et al.*, 1980; Zarnowitz et Manuwal, 1985; Westworth et Telfer, 1993). Nos résultats en zone de pessière à mousses diffèrent de cette tendance. En effet, dans la grande région de la ceinture d'argile qui recoupe une portion importante des forêts nordiques commerciales de l'Ontario et du Québec au sud de la Baie-James, la richesse et l'abondance des pics est plus faible dans les forêts anciennes que dans les forêts naturelles matures, cette différence étant en grande partie imputable à la plus faible disponibilité d'arbres morts dans les forêts anciennes.

Bien que notre étude révèle qu'à l'échelle de l'habitat, les forêts anciennes sont moins fréquentées par les pics que les forêts matures, à l'échelle régionale, la contribution des forêts surannées et anciennes au maintien des populations de pics pour le territoire de l'ouest de l'Abitibi peut néanmoins être très importante. En effet, sous un régime naturel de feu, une forte proportion du territoire forestier est constituée de forêts dont l'âge dépasse la maturité commerciale (Van Wagner, 1978; Bergeron *et al.*, 1999a). Dans un système conventionnel d'aménagement forestier qui vise la normalisation de la structure d'âge sur une révolution de 100 ans, aucune forêt ne dépasserait 100 ans. La disparition des forêts surannées et anciennes dans un contexte d'aménagement forestier et ses conséquences sur la biodiversité ont été documentés dans les forêts boréales du nord de l'Europe (Angelstam et Mikusinski, 1994; Esseen *et al.*, 1997). L'aménagement intensif pratiqué dans ces forêts depuis le siècle dernier a contribué à une nette diminution de la disponibilité en arbres morts et, en corollaire, à un important déclin des populations de nombreuses espèces d'oiseaux, en particulier les oiseaux utilisateurs d'arbres morts dont les pics (Virkkala, 1991; Angelstam et Mikusinski, 1994). De la même façon, l'effet cumulatif de la disparition des forêts surannées et anciennes dans un contexte d'aménagement selon des principes conventionnels de normalisation forestière pourrait contribuer à une diminution substantielle de la disponibilité régionale en arbres morts, et ainsi compromettre la viabilité des populations de pics dans notre secteur d'étude.

Bergeron *et al.* (1999b) ont récemment proposé un système d'aménagement forestier basé sur la dynamique naturelle des forêts boréales. Cette approche d'aménagement vise à diversifier sur un même territoire les pratiques forestières (coupe totale CPRS, coupe partielle et coupe sélective) de façon à simuler l'évolution naturelle des forêts pour maintenir, dans des proportions équivalentes aux forêts naturelles, des forêts qui posséderaient des caractéristiques structurales de forêts surannées et anciennes. Pour répondre aux exigences de la faune associée aux arbres morts, cette approche d'aménagement devra toutefois tenir compte davantage des conditions de recrutement et de maintien de la disponibilité en arbres morts debout et au sol.

À l'autre extrémité du gradient d'âge des forêts suivies dans notre étude, les habitats récemment brûlés sont de loin les plus fréquentés par les pics, en particulier par le Pic à dos noir (*Picoides arcticus*). Ces forêts représentent la principale source de recrutement d'arbres morts en forêt boréale et crée des habitats favorables à l'alimentation et à la nidification de plusieurs espèces de pics (Angelstam et Mikusinski, 1994; Hutto, 1995; Murphy et Lehnhausen, 1998). Pour la région à l'étude, ces brûlis récents sont d'autant plus importants que les forêts anciennes contribuent faiblement à la disponibilité en arbres morts ainsi qu'à l'abondance des pics.

Bien que le Pic à dos noir soit responsable de la très forte occurrence en pics dans ce type d'habitat, d'autres espèces peuvent également utiliser les brûlis récents (Murphy et Lehnhausen, 1998). Dans notre secteur d'étude, le Pic tridactyle et le Pic flamboyant fréquentaient également le territoire brûlé. Alors que le Pic tridactyle était présent plutôt dans les peuplements moins brûlés tels que les îlots résiduels et les bordures du feu, le Pic flamboyant tirait profit de l'ouverture des peuplements créée par le feu ainsi que par la coupe de récupération qui a eu lieu dans le secteur.

La forte association du Pic à dos noir avec les brûlis récents corrobore les résultats de Hutto (1995) pour les forêts des montagnes rocheuses, ainsi que les études menées ailleurs en Amérique du Nord (Blackford, 1955; Villard et Beninger, 1993; Villard et Schieck, 1997; Murphy et Lehnhausen, 1998) et confirme que le Pic à dos noir est clairement associé aux forêts récemment brûlées dans l'ensemble de son aire de répartition.

2.2 Activité alimentaire du Pic à dos noir dans les brûlis récents

Dans les brûlis récents, qui constituent un habitat de prédilection pour le Pic à dos noir, les exigences écologiques de l'espèce quant aux substrats d'alimentation restent, cependant, encore peu connues. Ce ne sont évidemment pas tous les arbres morts à l'intérieur de ces brûlis qui constituent un substrat alimentaire intéressant pour le Pic à dos noir. Certains types de chicots contiennent une plus grande abondance d'insectes xylophages tels les longicornes. Ces insectes ''foreurs de bois'', en particulier le longicorne noir (*Monochamus scutellatus*), envahissent le système pendant les premières années après feu (Rose, 1957; Gardiner, 1957) et constituent une ressource alimentaire importante pour le Pic à dos noir (Murphy et Lehnhausen, 1998).

Le deuxième chapitre a mis en évidence l'importance du diamètre et de l'état de décomposition dans l'utilisation des arbres morts à des fins d'alimentation. Les arbres sélectionnés par le Pic à dos noir pour son alimentation sont principalement ceux de gros diamètre qui contiennent une plus grande densité d'insectes que les chicots de plus petit diamètre. De plus, le Pic à dos noir s'alimente principalement sur des arbres peu décomposés qui correspondent en grande partie à des arbres qui ont été modérément brûlés.

Dans des conditions naturelles, la variabilité rencontrée à l'intérieur d'un secteur brûlé peut généralement combler les exigences des différentes espèces de pics. Une forêt récemment brûlée sera habituellement composée de secteurs brûlés à différentes intensités, des zones périphériques non brûlées, des îlots épargnés par le feu, des secteurs dominés par différentes essences d'arbres, des arbres de diamètres variés, etc. Cependant, des interventions humaines telles que les coupes de récupération sont susceptibles d'entraîner des changements majeurs dans les conditions d'habitat habituellement retrouvées dans ce type de forêt. La forte association du Pic à dos noir aux brûlis récents ainsi que ses exigences écologiques au niveau de l'alimentation en font une espèce particulièrement vulnérable à la récupération du bois dans cet habitat (Saab et Dudley, 1998).

Avec l'expansion nordique de l'exploitation forestière dans la forêt boréale, l'augmentation des accès aux territoires brûlés risque de contribuer à une intensification de la coupe de récupération au cours des prochaines années. Dans la récente mise à jour de son régime forestier, le Ministère des Ressources Naturelles du Québec (MRNQ) vise à accroître la récupération du bois dans les brûlis récents. Tel que définis à l'article 79 de la Loi sur les

Forêts (Gouvernement du Québec, 1998), les plans spéciaux de récupération des bois dans les brûlis ne prévoient aucune mesure de protection de la biodiversité. Dans la même loi, le MRNQ s'engage pourtant à maintenir la biodiversité des forêts. En conséquence, les plans d'aménagement visant les secteurs incendiés devront prévoir la protection d'habitats fauniques en laissant intactes des portions significatives de forêts récemment brûlées. Une connaissance des exigences écologiques de l'espèce telles que les exigences alimentaires documentées dans le cadre du deuxième chapitre de cette maîtrise constitue certes un élément important dans la mise en place de stratégies visant la préservation de certaines portions des territoires brûlées.

2.3 Le Pic à dos noir- une espèce indicatrice des forêts récemment brûlées

Dans la liste des Critères et Indicateurs proposée par le Conseil canadien des ministres des forêts (Conseil canadien des ministres des forêts, 1997), le Pic à dos noir figure dans deux des huit indicateurs de la Conservation de la diversité biologique pour l'écozone du Bouclier boréal (nord): 1.2b) Espèces animales indicatrices des écozones forestières, selon l'âge des peuplements et 1.2c) Espèces qui dépendent de la forêt et n'occupent plus qu'une petite partie de leur aire antérieure. Dans le premier indicateur cependant (1.2b), le Pic à dos noir est une espèce indicatrice des vieilles forêts. Bien que l'espèce soit présente également dans les forêts plus âgées et que celles-ci sont essentielles au maintien des populations de pics à l'échelle régionale, il serait urgent de reconnaître que cette espèce est également associée aux forêts récemment brûlées.

2.4 Projets futurs

Cette étude a permis de mettre en lumière l'utilisation des divers types d'habitats forestiers par les pics en pessière à mousses. À cet égard, il importe de souligner la contribution importante des forêts récemment brûlées tant en ce qui a trait à l'abondance des pics, en particulier le Pic à dos noir, qu'à l'importante disponibilité en arbres morts. De plus, cette étude a permis d'enrichir nos connaissances sur les exigences alimentaires du Pic à dos noir dans ce type d'habitat unique que sont les brûlis récents. De futurs travaux de recherche devront être menés pour accroître notre compréhension de l'écologie des pics dans les brûlis. Parmi ceux-ci, retenons un approfondissement des connaissances sur 1) la dynamique temporelle des arbres morts, des insectes et des espèces aviaires prédatrices dans les brûlis ainsi que des interactions entre ces trois composantes du système, 2) l'influence en milieu naturel des différentes caractéristiques du feu telles que l'intensité, la superficie, la variabilité, la fréquence et la période sur la disponibilité en arbres morts et leur utilisation par les insectes et les oiseaux, 3) l'impact de la coupe de récupération sur la dynamique naturelle de cet habitat et sur sa faune, 4) les exigences des espèces utilisatrices d'arbres morts pour leur alimentation et leur nidification et enfin, 5) les mouvements et dispersion, à grande échelle, du Pic à dos noir.

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