# Salvage logging after wildfire in the boreal forest: Is it becoming a hot issue for wildlife?

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In recent years, the increase in wood demand, the reduction in the availability of timber resources and the northern expansion of timber harvesting, along with the general perception that wildfires create ecological disasters, have favoured an increase in salvage logging in burned boreal forests. Concurrently, pioneer studies have shown that these post-fire forests may represent important habitats for several wildlife species and that intensive salvage logging, by removing standing snags, has several impacts on wildlife. However, the effects of salvage logging on biodiversity have yet to be considered in post-fire management plans. We examine the issue of salvage logging for wildlife in the boreal forest, with particular reference to Québec as an example. We describe our current state of knowledge on the use of burned forests by some wildlife and on the impacts of salvage logging on these habitats. We conclude that snag retention at multiple spatial and temporal scales in recent burns, which will be salvage-logged, is a prescription that must be implemented to meet the principles of sustainable forest management and the maintenance of biodiversity in the boreal forest.

**Key words**: boreal forest, post-fire forests, salvage logging, snags, wildlife, birds, cavity-nesting birds, woodpeckers, mammals, invertebrates, xylophagous insects, biodiversity

Au cours des dernières années, la demande accrue en matière ligneuse et sa raréfaction, l'expansion nordique de la coupe forestière, ainsi que la perception générale que les feux créent des désastres écologiques ont favorisé l'intensification de la coupe de récupération dans les forêts brûlées de l'écosystème boréal. En parallèle, des études récentes ont montré que ces forêts brûlées peuvent constituer des habitats importants pour plusieurs espèces animales et que la coupe de récupération intensive, en éliminant les chicots debout, entraîne plusieurs impacts sur la faune associée à cet habitat. Jusqu'à maintenant, la problématique des effets de la coupe de récupération sur la diversité biologique a été peu considérée dans l'aménagement des forêts brûlées. Cet article présente la problématique de la coupe de récupération pour la faune en forêt boréale. Nous utilisons la situation du Québec comme un exemple de l'aménagement actuel des forêts brûlées dans l'est de la forêt boréale. Nous décrivons l'état actuel de nos connaissances quant à l'utilisation de ces forêts par la faune et quant aux impacts de la coupe de récupération sur ces habitats. Nous concluons que la rétention de chicots à différentes échelles spatiales et temporelles, dans les forêts récemment brûlées soumises à la coupe de récupération, constitue une pratique sylvicole qui se doit d'être implantée afin de rencontrer les principes d'un aménagement forestier durable et le maintien de la biodiversité de la forêt boréale.

**Mots clés :** forêt boréale, forêts brûlées, coupe de récupération, chicots, faune, oiseaux, oiseaux utilisateurs de cavités, pics, mammifères, invertébrés, insectes xylophages, biodiversité

## Introduction

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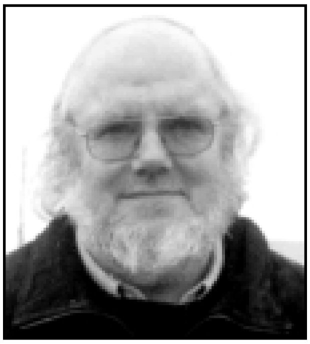

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Over the last century, wildfires have been mainly perceived by the public, forest managers and ecologists as catastrophic events (Kuuluvainen 2002). Because forest fires represent a threat for lives, property and forest resources, most of the attention has focused on preventing, detecting and fighting them (Blanchet 2002, Drolet 2002). While this threat is still of topical interest, the role of fire in forest ecology has undergone an important re-evaluation in recent years. In the boreal forest, as in many other North American forest ecosystems, fire is now recognized as a major process in forest dynamics (Rowe and Scotter 1973, Johnson 1992). For instance, in many pine ecosystems, prescribed burning is now a useful management tool to restore forests that were historically under a regime of frequent low-intensity understory fires (Ford *et al.* 1999, Conner *et al.* 2001, Quenneville and Thériault 2002). In the boreal forest, there is also an increasing interest in using natural disturbances as a guide for sustainable forest management (Bergeron and Harvey 1997, Bergeron *et al.* 2002).

Despite the potential benefits to forest regeneration, wildfires often represent an important economic loss for forest industries. In coniferous forests of North America, the increase in

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wood demand and the reduction in the availability of timber resources have led to increased salvage logging of burned forests. Under a regime of stand-replacement fires, salvage logging consists mainly of clearcutting all merchantable (and accessible) timber within recently burned areas. While salvage logging may be unavoidable for economic reasons, from a sustainable forest management standpoint, it raises several questions about how this forestry practice is conducted and its effects on soil, streams, vegetation and wildlife (Saab and Dudley 1998, Morissette *et al.* 2002, Purdon *et al*. 2002).

In this paper, we examine why salvage logging may become an important issue in the boreal forest. We first provide several examples regarding the use of burned forests by wildlife. We then use the case of salvage logging in Québec as an example of how these post-fire habitats are currently managed in the eastern boreal forest. Finally, we deal with some of the impacts of salvage logging on burned forests and suggest ideas on how salvage logging might meet the principles of sustainable forest management in the maintenance of biodiversity.

We focus on the salvaging of burned forests because stand-replacement fires represent the main natural disturbance in the Canadian boreal ecozone (Rowe and Scotter 1973, Johnson 1992, Bergeron *et al.* 2001). However, in the absence of fire for long periods, other large-scale disturbances, such as insect outbreaks, may exceed the importance of fire as a natural disturbance (MacLean 1980, Bergeron and Leduc 1998) and thereby become important targets for salvage. Whereas these stand-replacement disturbances may be different ecologically, they are managed similarly in Québec.

## Burned Forests: An Ecological Disaster or a Bonanza for Wildlife?

While wildfires vary in frequency, size or severity, the natural fire regime of the boreal forest is typically characterized by large-scale stand-replacement fires (Bergeron *et al.* 2002). These wildfires create a mosaic of forest cover types of varying age to which the regional biodiversity is closely linked. However, the short-term impacts of fires on wildlife have received very little and only recent attention.

When recent burns are compared to other forest types (including recent clearcuts) one of the most striking differences is the number of standing snags (Angelstam and Mikusinski 1994, Hutto 1995, Drapeau *et al.* 2002). At the landscape level, disturbances such as fires and insect outbreaks represent the main source of dead wood in the boreal forest of North America. In the western portion of Québec's boreal forest (northern clay belt), the contribution of fire is even more important because old forests contribute very little to the abundance of dead wood, especially large snags (Drapeau *et al.* 2002), and insect outbreaks are scarce (Blais 1983, Morin *et al.* 1993, Bergeron and Leduc 1998). Wildfires also create open stands with warm and exposed mineral soils, and eventually, an increased shrub cover, all of which can benefit the wildlife species that require these habitat structures. While current knowledge of the impacts of fire on boreal wildlife is limited for certain taxa, we present, in the following sections, several examples of the response of wildlife to wildfires.

### Invertebrates

Recent work on boreal invertebrates has shown that Coleoptera and spider assemblages in post-fire habitats are clearly distinct from those in other forest types (Buddle *et al.* 2000, Saint-Germain *et al.* 2004a). Several insect species greatly benefit from the conditions created by fire such as habitats free of competitors, exposed soils and high abundance of snags (Wikars 1992, 1994; Saint-Germain *et al*. 2004a). Burned forests are particularly important for wood-boring (Cerambycidae and Buprestidae) and bark (Scolytidae) beetles that rely on recently dead trees for their life cycles (Rose 1957, Ross 1960, Powell *et al.* 2002, Saint-Germain *et al.* 2004b). Some pyrophilous species have also developed adaptations, such as the capacity to detect smoke or heat generated by fire, that help them track post-fire habitats (Evans 1966, Schütz *et al.* 1999, Suckling *et al*. 2001). Some soil-dwelling species (Elateridae) associated with stressed roots and some subcortical predators may also be found in high numbers in burned forests (Muona and Rutanen 1994, Saint-Germain *et al.*2004a).

Because of within-burn variability, not all stands offer the same quality of habitat. For xylophagous insects, several stand characteristics such as tree diameter and vigour before tree death, fire severity or site have been shown to influence their choice of substratum (Nappi *et al.* 2003, Saint-Germain *et al.* 2004b).

### Mammals

The response of small mammals to fire is principally associated with the structural complexity of the shrub cover, which is itself influenced by time since fire (Krefting and Ahlgren 1974, Crête *et al*. 1995), fire severity (Martell 1984, Kirkland *et al*. 1996, Ford *et al.* 1999) and the amount of coarse woody debris (Menzel *et al*. 1999, Simon *et al*. 2002). Small mammal diversity and abundance generally decrease immediately after fire and tend to increase with regeneration and increased shrub cover during the following years. However, some species, such as the deer mouse (*Peromyscus maniculatus*), take immediate advantage of the newly created habitat. Several studies show deer mice great increase in abundance in recently-burned areas in which they seem to greatly benefit from the abundant food resources provided by the massive seed bank of dead coniferous trees following fire (Sims and Buckner 1973, Krefting and Ahlgren 1974, Martell 1984, Crête *et al*. 1995). Years after a fire, changes in vegetation provide habitat conditions that are attractive for other species of mice, voles and shrews (Sims and Buckner 1973, Krefting and Ahlgren 1974, Crête *et al*. 1995, Simon *et al*. 2002). For instance, the red-backed vole (*Clethrionomys gapperi*), which typically feeds on fungi and lichens (Gliwicz and Glowacka 2000) associated with late successional forests, will gradually recolonize post-fire forests as habitats become more suitable.

Some large mammals also take advantage of recently-burned stands. In their study in the northern boreal forests of Québec, Crête *et al.* (1995) found more black bears (*Ursus americanus*) and Moose (*Alces alces*) in recently-burned stands than in older or unburned stands. Black bears' presence was mainly related to abundance of food such as berries—an important component of black bears' diet (Boileau *et al.* 1994)—which are usually abundant in burned forests. These young stands also provide abundant deciduous shrubs for Moose foraging (Crête and Jordan 1981). The abundance of small mammals may also provide good hunting opportunities for mammalian predators. Paragi *et al.* (1996) found higher marten abundance, hunting activity and small mammal biomass and diversity in a recent burn (6–9 years after fire) compared to older (25–28 years) or mature coniferous forests (100–115 years).

### Birds

Forest bird assemblages have been studied in several areas of the boreal or other coniferous forests to compare burned forests with other forest habitats such as unburned and harvested stands (Raphael *et al.* 1989, Hutto 1995, Hobson and Schieck 1999, Imbeau *et al.* 1999, Morissette *et al.* 2002). Whereas the results of these studies vary according to forest cover type and time elapsed since fire, a consistent finding is the relatively high abundance of ground-nesting birds (e.g., Hermit Thrush (*Catharus guttatus*), American Robin (*Turdus migratorius*), Dark-eye Junco (*Junco hyemalis*)), flycatchers (e.g., Olive-sided Flycatcher (*Contopus borealis*)) and cavity-nesters (e.g., woodpecker spp., bluebird spp.) in recently-burned forests. The main divergence in bird community patterns between post-fire and post-logged stands seems to occur during the first few years following disturbance (Hobson and Schieck 1999), partly due to the high abundance of woodpeckers (*Picoides* spp.), which are known to colonize recently disturbed forests following natural disturbances such as fire (Blackford 1955, Hutto 1995, Murphy and Lehnhausen 1998, Drapeau *et al.* 2002) and insect outbreaks (Crockett and Hansley 1978, Yunick 1985, Goggans *et al.* 1989).

One of the most striking and best-known examples of a burn-associated species is the Black-backed Woodpecker (*Picoides arcticus*). In different parts of North America where stand-replacement fires represent the main natural disturbance, this species is highly abundant during the first years following fire (e.g., Alaska (Murphy and Lehnhausen 1998); Rocky Mountains (Hutto 1995); Alberta (Hoyt and Hannon 2002); Québec (Imbeau *et al.* 1999, Nappi *et al.* 2003)). Its abundance is mainly linked to the increased availability of wood-boring (Cerambycidae and Buprestidae) and bark (Scolytidae) beetles on standing dead trees (Murphy and Lehnhausen 1998, Nappi *et al.* 2003).

Woodpeckers such as the Black-backed Woodpecker may play an important role in the nest web (Martin and Eadie 1999) by excavating cavities that can then be used by several secondary cavity nesting species (species that cannot build their own cavity but require one for breeding). Because of this link, the presence of secondary cavity nesters such as the Eastern Bluebird and the Tree Swallow may be closely tied to initial woodpecker abundance. As they may not rely on snags for food (contrary to woodpeckers), secondary cavity nesters may persist in post-fire habitats for a longer period and will constitute an important and constant component of the avifauna during post-fire succession (Taylor 1979).

Burned snags that remain standing for several years following fire likely facilitate the use of these areas by species that hunt from perches, such as small owls and accipiters, by allowing them to exploit the post-fire increase in small mammal populations (Lyon *et al*. 1978, Spires and Bendell 1982).

### Species relationships and population dynamics

As shown previously, recently-burned forests with their mass recruitment of standing dead trees not only provide habitat for several individual species, but also play a key role in the functional organization of food webs (predator-prey relationships) and nest-webs (*sensu* Martin and Eadie 1999) for cavity-nesting birds. Prey-predator relationships may be observed between xylophagous insects and insect predators and/or woodpeckers. Such relationships may also be observed between small mammal populations and mammalian predators (e.g., Mustelidae) and on birds of prey.

A frequently asked question of forest ecologists is whether species associated with burns are either 1) opportunistic species that rely on mass recruitment of snags but also use other post-disturbance habitats or 2) "pyrophilous" species that have evolved in the presence of fire and are now fire-dependent. Although the answer to this question is currently unknown, it is clear that stand-replacement fires lead to mass colonization by fire-associated species and that these fires represent the major natural disturbance in most of the boreal forest.

In parallel to this question is the interesting, but yet to be tested, hypothesis of source and sink dynamics (*sensu* Pulliam 1988). For the Black-backed Woodpecker for instance, Hutto (1995) suggested that populations of this species are maintained by a patchwork of recently-burned forests, whereas unburned forests support sink populations that emigrate from burns after they become less suitable (see also Murphy and Lehnhausen 1998). Such dynamics may apply as well to other fire-associated species such as wood-boring and bark beetles. High populations of these insects observed following recent forest fires would allow their persistence in sub-optimal unburned habitats until the next regional disturbance (Jonsell *et al.* 1998). Because of the relationships between some fire-associated species, recent burns do not contribute only to species diversity but they also may have a strong influence on the functional diversity of the boreal ecosystem, given that they are the template of complex trophic links between wildlife species that have evolved in a context of unpredictable, abundant but ephemeral resources (standing dead wood).

## Salvaging Burned Forests: The Québec Case

With the northern expansion of forestry into ecological zones where fire cycles are shorter (< 100 years) than in southern areas (Fig. 1), it is likely that forest industries will have to deal more and more with the reality of wildfires in the future. While fire suppression has had limited success in northern portions of the boreal forest in the last 30 years (Leduc 2002, Lemaire 2002), the development of the road network will probably help increase fire control and salvage logging in these areas.

Before the adoption of a legal framework in Québec, salvage logging of forests affected by fire or severe insect outbreaks was sporadic (Fig. 2). However, the Québec Forest Act of 1986 and its recent modifications have provided several incentives to intensify salvage logging (Québec Government 2003). Specifically, Article 79 of the Québec Forest Act states that land tenure holders must comply (under penalties of quota reduction) with special management plans created at the provincial government's discretion, to salvage forests after a natural disturbance. The law specifies that these special management plans are exempted from the obligation to apply current forest regulations (e.g., minimal buffer strips) normally used in undisturbed forests. In actuality, these plans primarily result in the clearcutting of burned stands with no retention of individual burned trees or patches within the logged areas, except those that are not merchantable or accessible. Forest companies have also adapted their management practices to optimize harvest operations in burned stands. For example, it is now pos-

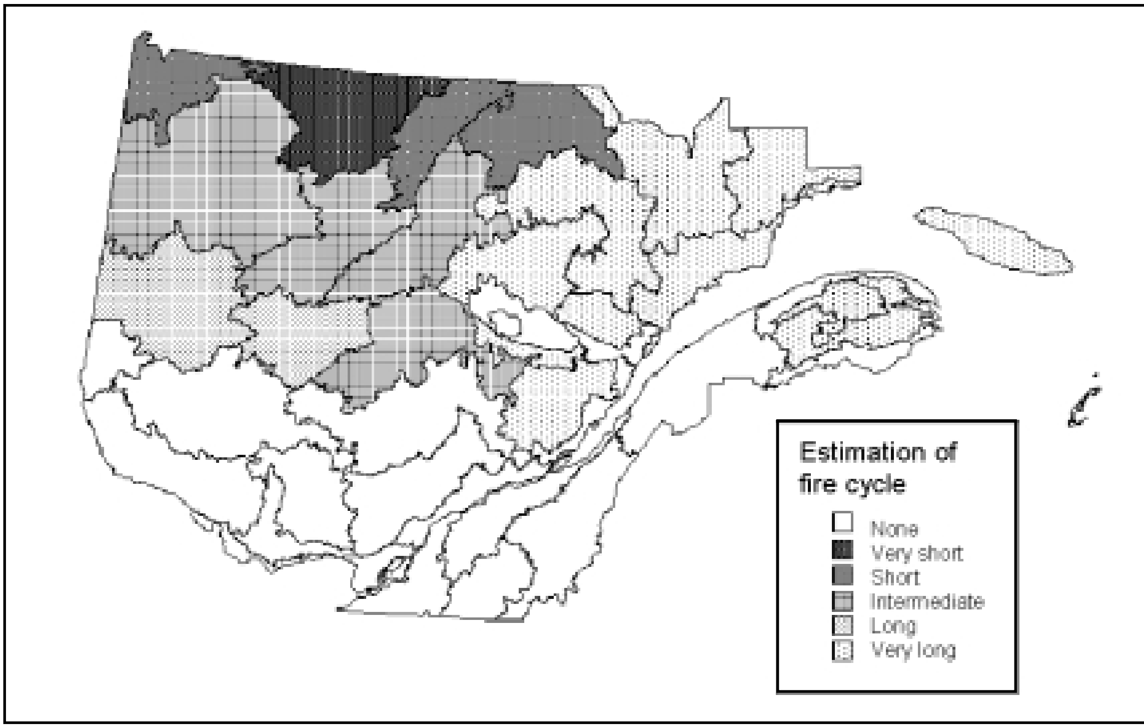


**Fig. 1**. Estimation of fire cycles in ecological boreal zones of Québec. Adapted from Gauthier *et al*. (2001) by permission from *Le Naturaliste Canadien*.

sible and economically feasible for forest companies to salvage-cut old burned forests up to 12 years after fire (data from Saint-Félicien management unit).

The combination of all these elements has already favoured an increase in salvage logging over the last decade (Fig. 2). The last four years of our data set illustrate situations where fires were abundant. In Québec's commercial forest, from 13 to 40% of large fires (> 1000 ha) within the management units were salvage logged, between 1995 and 1998. This period includes most of the total burned areas that have been salvaged up to then. During the same period, the intensity of salvaging within burned areas also increased: one third of these burned forests have been harvested on more than 50% of their burned areas, while this situation rarely occurred before 1995. While the proportion of burned forests that has been salvage-logged still remains low, it will likely increase as road access is developed. Until now, the limited access to burns has concentrated salvage logging mainly in the southern portions of the boreal forest (Fig. 3).

## How Should Burned Forests Be Managed? – An Emerging Challenge

Present knowledge of the use of burned forests by wildlife raises several concerns regarding the long-term maintenance of this habitat type. In the eastern boreal forests of North America, recent burns are still common on the natural landscape but their regional importance may decrease in the future due to a climate-related decrease in fire frequency, accompanied by an increased efficiency of fire suppression and intensity of salvage logging.

### The impacts of salvage logging

The emergence of the salvage logging issue has generated interest in evaluating the impacts of the practice (Saab and Dudley 1998, Purdon *et al.* 2002). However, the number and characteristics of fire-killed trees to be left in salvage cuts differs according to local and regional management prescriptions and social and economic conditions. For example, in a study that compared responses of cavity-nesting birds to different salvage-logging treatments (standard-cut salvage logged; wildlife-prescription salvage logged; unlogged controls) in Southwestern Idaho, even the most intensive standard-cut stands included the retention of 15 large trees (> 25 cm dbh) per hectare (Saab and Dudley 1998). When retention prescriptions are lacking, salvage logging may be more intensive. In Québec for example, all merchantable wood (> 8cm dbh) is harvested in burned forests that are accessible (Purdon *et al.* 2002). As a result, salvage-logged areas are clear-cuts and remaining patches or individual trees that are left are not merchantable.

It is doubtful that this level of retention will protect the structural attributes needed by wildlife. For instance, primary cavity nesters such as the Black-backed Woodpecker are known to use snags > 10 cm for foraging (Nappi *et al.* 2003) and mostly > 20 cm for nesting (Setterington *et al*. 2000). In their study on the effects of fire and salvage logging on birds, Morissette *et al*. (2002) found that salvage logging had a greater effect on the bird community than the fire alone. Species found in salvaged areas were mainly generalists, omnivores or shrub insectivores and ground and shrub nesters. Resident species, insectivores and canopy- and cavity-nesting birds, which were associated with unburned and/or burned forests, were less likely to be found in salvaged areas.

From a vegetation and wildlife point-of-view, salvage logging, such as practiced in Québec, has been shown to have several negative impacts. Among these impacts are the elimination of foraging and nesting habitat for wildlife, reduction of seed sources for regenerating species such as black spruce (*Picea*

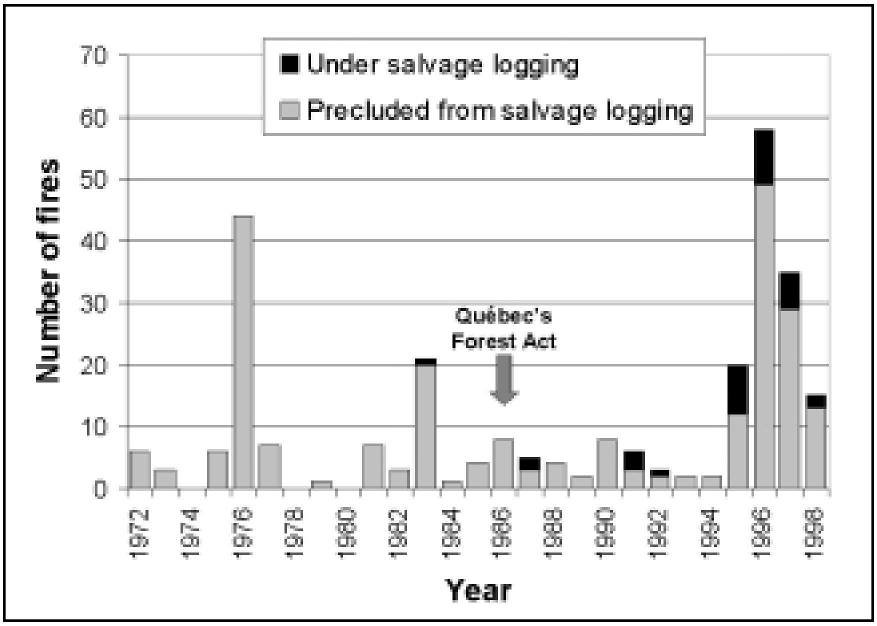


**Fig. 2**. Progression of salvage logging in Québec from 1972 to 1998: number of wildfires (> 1000 ha) precluded from or under salvage logging, south of the 52° parallel in Québec. The period covered corresponds to one of intensive fire suppression. The zone south of the 52° parallel corresponds to management units and includes the merchantable forests. Data for fires and salvage logging have been provided by the Québec's Ministry of Natural Resources (number of fires under salvage logging is minimum, information on salvage logging is missing for one management unit).

*mariana*) for several years after fire, unfavourable conditions for understory vegetation and seed establishment and growth, and reduction in nutrients (Purdon *et al.* 2002).

The past and present experience of intensive forestry in Fennoscandia provides some insights on the long-term effects of these kinds of management practices on wildlife (Imbeau *et al.* 2001). In Sweden and in Finland, efficient fire suppression is thought to be the cause of decline of several fire-associated invertebrates (Ahnlund and Lindhe 1992, Wikars 1992, Jonsell *et al.* 1998). Most woodpecker species in Sweden have declined in response to changes in forest structure, such as the decrease in the availability of large trees or dead wood (Angelstam and Mikusinski 1994). In North American boreal forests, these population trends are difficult to assess, even for relatively well-studied taxa such as birds because of limited access and few long-term data (Imbeau *et al.* 2001). For some species, however, some trends may be negative, such as that observed for Black-backed Woodpeckers in Canada (–9.0% for the period 1980–1996; Sauer *et al.* 1997). Currently, we have no understanding of the impact of salvage logging on long-term persistence of post-fire associated species. Until we learn more about wildfire-wildlife associations, a precautionary approach requires maintaining a good representation of the natural conditions within fires scheduled to be salvage-logged (Taylor 1991, Perrings 1995).

At a regional scale, the effect of salvage logging and fire suppression on the availability of post-fire habitats may be even more important in the context of a long-term decrease in fire frequency. Contrary to other parts of Canada, current climate change models predict a decrease in wildfire occurrence for eastern Ontario and western Québec (Flannigan *et al.* 2001). In western Québec, a decrease in fire frequency has already been observed, starting during the mid-19$^{th}$ century (Bergeron *et al.* 2001).

### Management prescriptions

Considering that burned forests are ecologically important and salvage logging is likely to increase in the future, sustainable management of post-fire habitats should thus integrate ecological and economic values. To achieve the goal of maintaining biodiversity, management guidelines should be based on, and updated with, recent research results.

As shown previously, current knowledge on wildfire-wildlife associations is still incomplete for several taxa. Future effort should be directed towards a more comprehensive understanding of habitat use and population dynamics for the whole spectrum of wildlife species associated with post-fire habitats. For instance, using "umbrella" species, such as the Black-backed Woodpecker, for burned forests may be quite attractive and useful from a wildlife monitoring perspective. However, managing for this species alone may not necessarily maintain all the biodiversity associated with burned forests.

Filling data gaps may be challenging for some areas of the boreal forest. In Québec for instance, access to burns is limited by the poor road network in northern portions of the boreal forest. When accessible, burned forests (or parts that are accessible within the burn) are often intensively salvage-logged. Stands that remain are often less representative of what has been salvaged (unmerchantable stands) or too small to maintain large territorial species. Because of limited access, it is also difficult to sample more than one fire, which is often needed for comparative studies requiring replication.

In this perspective, we should take the opportunity, while burned areas are still available, to increase our knowledge of species associations with burned forests and implement innovative retention strategies. To answer the question "how much should be left, where, and how?" such strategies should be designed to assess their effectiveness in the maintenance of biodiversity. It is crucial that this objective addresses both stand and landscape scales as well as multiple temporal scales.

**Within burn retention** – Because wildlife species may be associated with different habitat features, retained snags should represent the full range of structure present before and after fire. This includes characteristics such as diameter (including large merchantable trees that are also used by wildlife), tree species composition, before-fire decay conditions and fire severity. Field

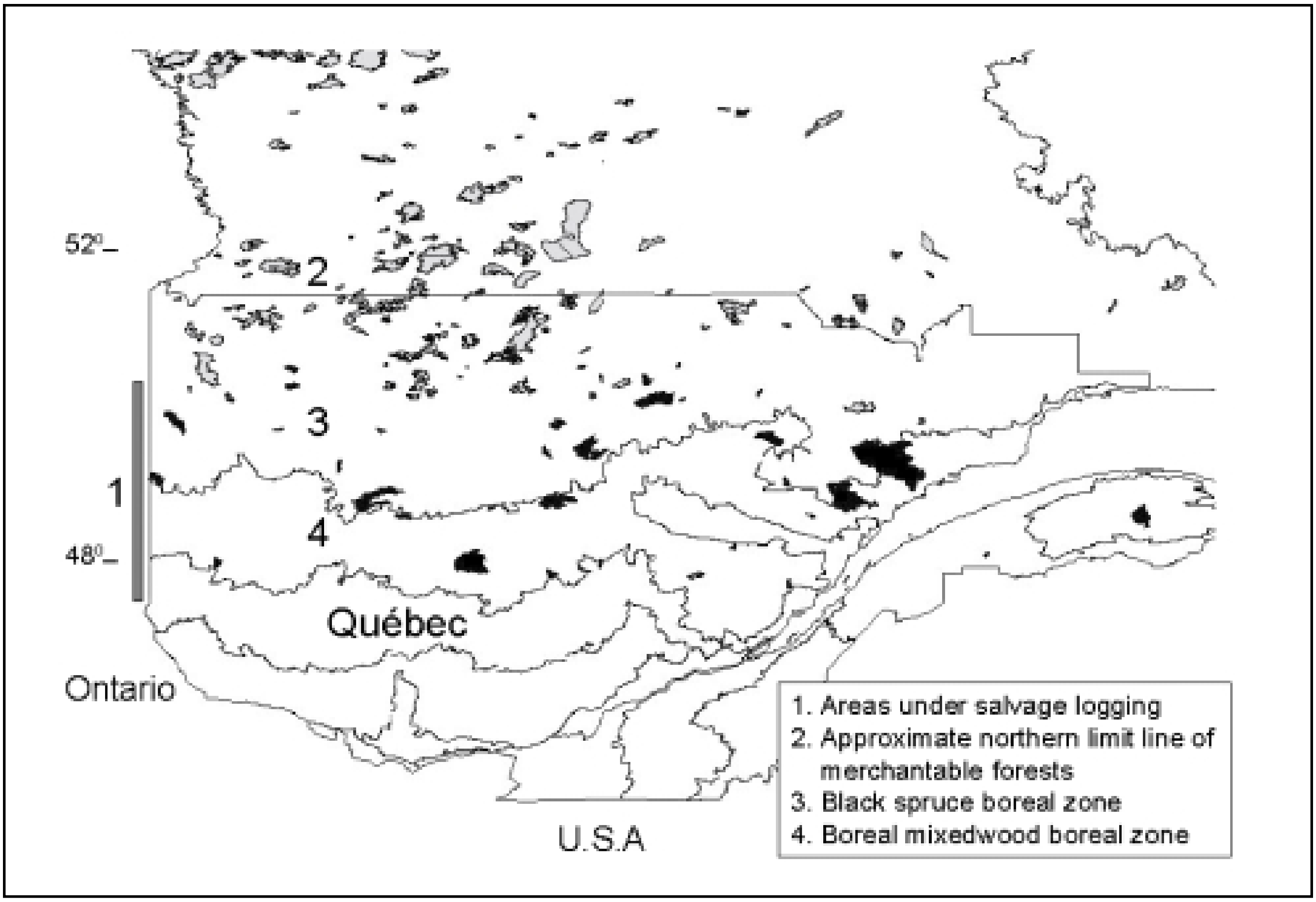


**Fig. 3**. Spatial distribution of salvage logging for burned forests (> 1000 ha) in Québec. In black: burned forests that have been under salvage logging. In grey: burned forests precluded from salvage logging.

experiments should be designed to test the effectiveness of different levels of retention (from individual or clumped snags to large patches) on different wildlife species or group of species.

The use of a *xylophagous insect spatial model* is an example of what could be done at this spatial scale to help in the selection of burned forest stands to be maintained. The spatial pattern of wood-boring beetle colonization, such as for the widespread *Monochamus* species, could help in the identification of areas to be precluded from salvage logging. On the one hand, this would help to identify high-conservation value burned stands for *Monochamus* species and other fire-associated insects with similar ecological requirements (as well as for woodpeckers and other secondary cavity nesters). On the other hand, this could help forest managers in the identification of areas that are less affected by wood-boring beetles, which are known to affect the quality of timber products.

**Delayed salvaging** – Rapid changes occur in species composition and dynamics in the early stages following fire (e.g., loss and decay of standing snags, accumulation of coarse woody debris, and regeneration of fire-adapted species such as jack pine). These first post-fire years are particularly important for several burn-associated species such as woodpeckers and xylophagous insects. However, to warrant harvesting that involves considerable field costs, forest companies need to promptly salvage burned stands before xylophagous insects significantly reduce timber value. In the cases where forest companies can harvest burned areas for pulp wood rather than saw logs or other timber products, delayed-salvaging can be a good alternative for both economic and ecological values. First, it increases the window of habitat availability for species that require post-fire structures. Second, it allows forest managers to reduce regeneration costs by providing the time needed to identify areas that regenerate well and thereafter implement harvesting practices that protect established regeneration.

**Regional considerations** – It is often argued that salvage logging does not affect biodiversity because large burns remain mostly unsalvaged in northern areas of the boreal forest. First, the issue is not only how much burned habitat remains unsalvaged, but rather how salvage-logged areas comply with principles of sustainable forest management. Second, it is dangerous to rest the maintenance of biodiversity on the assumption that northern burned forests may compensate for the intensive salvaging of southern burns. We still know little about species composition and dynamics, and even less about the influence of a north and south gradient on species associated with post-fire habitats. In this perspective, it may be cautious to maintain burned habitat across regions.

## Conclusions

The current state of knowledge and data gaps on the importance of burned forests for wildlife implies that forest managers need to be cautious in the management of post-fire habitats. The current intensification of salvage logging in several parts of the boreal forest, such as in Québec, may not meet the principles of sustainable forest management, including the maintenance of biodiversity. It is critical to seize the opportunity, while unsalvaged burned areas may still be available, to better document the diversity and dynamics of fire-associated species and thereby foster the development and implementation of innovative retention strategies that meet both ecological and economic objectives in this neglected but important habitat type for boreal wildlife.

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