Habitat Requirements and Biological Attributes of Proposed Indicator Species for the Algonquin Provincial Park Forest Management Plan

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Introduction

Forest management, by definition, to a greater or lesser extent changes the character of the forest and its ability to support wildlife species. Not all changes are negative and most are positive for some species but negative for others. The activities of removing wood fibre from forests are frequently positive for species that prefer younger forest but can be negative for species that prefer older forests. The lengthy period that can be needed to return a forest to older age classes results in greater public concern about old forests and the species that require old forest habitat. Because of this, Algonquin Eco Watch (n.d.) has proposed an objective for the Algonquin Provincial Park (APP) 2010 Forest Management Plan (FMP) of maintaining current levels and enhancing wildlife habitat during implementation of the FMP, particularly for species that prefer the older forest age classes and for species that are in decline and inhabit APP.

The measure of success for this objective must be provision of habitat both because it is very difficult to determine population density for many wildlife species and because many factors beyond the control of forest managers influence populations. A suite of indicator species that jointly require the older age classes of all the habitat types impacted by forestry operations has been selected to represent the needs of all species that use APP habitats.

Algonquin Eco Watch has further proposed that appropriate habitat should be available to support twice the minimum viable population of the selected species. Planning should provide habitat to allow population levels to be at least at the minimum viable number during Terms 1 and 2 of the plan with available habitat reaching the desired level of double the amount to support a minimum viable population by the end of Term 3.

The purpose of this report is to provide background information on the habitat preferences (including forest age class preferences) for the species (with the exception of American Marten, which is covered in another report) selected as indicators. Additional comments are provided on the ability of the APP Forest Management Plan to provide sufficient habitat to support a minimum viable population.

Proposed Indicator Species

The species proposed as indicators are shown in Table 1. The reasons for their selection were summarized in Algonquin Eco Watch's document (Algonquin Eco Watch n.d.) outlining proposed objectives for the APP FMP. Many of the proposed indicator species are representative of various types of older forest. However, several of the bird species were proposed because they are in decline or have been identified as priority species by various government and non-government agencies and have habitat in APP. Documentation of the reasons for selection are given for each species below but background information on the determination of why these species were selected is provided here.

The Breeding Bird Survey (BBS) is the longest running continent wide monitoring program for breeding bird species. Data are collected by volunteers and maintained and analysed by both the U.S. Fish and Wildlife Service and the Canadian Wildlife Service. Information on trends in bird populations for all of Canada and for Ontario is available via the internet (Downes and Collins 2007).

In Ontario specifically, there have been two data collection periods for the Ontario Breeding Bird Atlas which documents the occurrence of all bird species in the province at a 10 x 10 km scale. Results have recently been published (Cadman et al. 2007) and include analyses of changes in distribution (which mirror changes in abundance) between 1981-1985 and 2001-2005 for all of Ontario and five portions of Ontario including the Southern Shield region which encompasses APP.

A number of agencies have produced conservation plans in recent years that set species priorities [e.g. the Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004); Ontario Landbird Conservation Plan: Boreal Hardwood Transition (North American Bird Conservation Region 12) (Ontario Partners in Flight 2006)]. The species identified as priorities for either action or monitoring are based on two different sets of criteria: the extent to which the population of the species is deemed to be in danger of declining towards extinction and the level of responsibility for maintaining a species at healthy population levels held by the jurisdiction in which it occurs. Adapted from Dunn (1997) the two approaches are defined as follows:

> *Preservation Responsibility* uses information on each species' abundance, population trend and sensitivity to identify the most vulnerable species. "The highest priority species from this point of view are those for which we have high level of concern because of rarity, very limited distribution, loss of habitat or declining numbers."
>
> *Jurisdictional Responsibility* is "the extent to which a species is especially typical of a region, such that we have a special responsibility to ensure that human activities do not have a negative impact upon it. Often, high national priority species in this sense will be widespread and abundant in Canada; nonetheless it is important to recognize that we have a special duty to look after their habitat, because no one else can."

Table 1.Wildlife species proposed as indicators in the APP FMP.

Species	Scientific Name
Blue-spotted salamander	*Ambystoma laterale*
Broad-winged hawk	*Buteo platypterus*
Barred owl	*Strix varia*
Black-backed woodpecker	*Picoides arcticus*
Pileated woodpecker	*Dryocopus pileatus*
Boreal chickadee	*Poecile hundsonica*
Ruby-crowned kinglet	*Regulus calendula*
Bay-breasted warbler	*Dendroica castanea*
Canada warbler	*Wilsonia canademsis*
Red crossbill	*Loxia curvirostra*
Pine siskin	*Carduelis pinus*
Red squirrel	*Tamiasciurus hudsonicus*
American marten	*Martes americana*
Moose (winter habitat)	*Alces alces*
White-tailed Deer (winter habitat)	*Odocoileus virginiana*

Defining Habitat Requirements

Ideally, wildlife-habitat relationships would be defined by the specific features of habitat that permit successful reproduction and population survival for each species. In reality, most of our information about species-habitat relationships is based on inferences from observation of species density and is described largely in terms of type of tree canopy and a few other features (such as presence of snags). We assume that higher densities are associated with higher rates of reproductive success. This assumption may not always be true, (e.g., Van Horne 1983; Hannah et al. 2008). However, Bock and Jones (2004), in a meta-analysis of 109 studies, found that higher adult densities were indeed associated with both higher reproductive output per individual and number of young produced per unit area in most cases.

We have only qualitative perceptions of exactly what features of the forest most species use to select habitat and we do not know the threshold at which a forest characteristic becomes acceptable. For example, woodpeckers clearly do require dead or declining trees for both feeding and excavating nest holes. However, Gunn and Hagan (2000) found that number of dead and declining trees was not strongly related to presence or density of woodpeckers in Maine. They suggested that once the number of such trees available was above the threshold level required by woodpeckers additional snags made no difference. Similarly, Betts et al. (2007) found no threshold value for areal amount of habitat below which the probability of occurrence drops dramatically for bay-breasted warbler or ruby-crowned kinglet (among other species).

The proposed indicators for APP are mainly species that prefer mature and old forest stages. Characteristics of forest habitat that tend to change as a forest moves from an immature to a mature or old stage include:

- Amount of coarse woody debris on the forest floor
- Number of dead or declining standing trees
- Canopy closure (which may increase or decrease with age depending on the particular eco-site)
- Canopy volume
- Proportion of trees capable of producing seeds or volume of seed production by individual trees
- Forest floor micro-climate (moisture and temperature tend to become more stable as age increases)

However, most of the selected indicator species do not seem to distinguish between mature and old forest stages (i.e. their densities seem to be about the same in both). The threshold of their requirements may be met when the forest reaches a mature stage and continue to be met through the old growth stage.

Habitats of Indicator Species

As part of Ontario's efforts to ensure that habitat is available for wildlife species, habitat suitability matrices have been developed for both the Great Lakes-St. Lawrence forest and the boreal forest (D'Eon and Watt 1994; Bellhouse and Naylor 1997; Watkins and Davis 1999; Holloway et al. 2004). These matrices identify preferred habitat for a substantial number of forest-dependent vertebrate species based on age class and habitat type as described by the eco-site scale of the Ontario Provincial Ecosystem Classification (ELC Working Group 2001).

Eco-site classification takes into account both understory and overstory features as well as soil type and moisture regime. Wildlife species respond to a combination of some or all of these features (and other, unmeasured features) such that the requirements of individual species may be met in more than one eco-site type. The habitat suitability matrices, in effect, provide an overview of the habitat preferences of each wildlife species without specifying what attributes provide the actual needs of the species. Nevertheless, the habitat matrices provide the best information that was available at the time of their construction in a format that can be integrated in forest management planning.

Bellhouse and Naylor (1997) included all forest vertebrates in their habitat suitability matrix for central Ontario. Holloway et al. (2004) updated and validated the matrix for central and northeastern Ontario using Ontario wildlife density information to the degree possible. The updated matrix focused on the 92 species identified by the Ontario Wildlife Assessment Program (McLaren et al. 1998) as indicator species whose populations could be monitored as the ultimate measure of success of habitat provision.

Holmes et al. (2007) tested the reliability of the Ontario habitat suitability matrix for 22 bird species in the northeastern Ontario boreal forest. Although the ability of the matrix to predict actual occurrence of individual species in habitats predicted to be preferred was relatively poor, the suitability rankings correctly predicted habitat preference (as measured by greater abundance of the species).

Holmes et al. (2007) recommend a number of species that would be priorities for additional research but do not make any direct recommendations for adjusting the habitat suitability matrix. For the current review, recent literature was inspected to determine whether the habitat preferences reported in Holloway et al. (2004) and Bellhouse and Naylor (1997) required updating for the species proposed as Indicators for APP.

There have been numerous studies of the effects of habitat change caused by logging on both bird communities and individual species of birds and mammals in recent years (Hartley 2003; Smith 2003; Warren et al. 2005; Venier and Pearce 2005; Fisher and Bradbury 2006; Hadley 2006; Campbell et al. 2007; Betts et al. 2007; Holmes and Pitt 2007; Venier and Pearce 2007; St. Laurent et al. 2007; Vanderwel et al. 2007; Hadley and Desrocher 2008). All of these studies included consideration of one or more of the proposed indicator species and some provide recommendations for either changing forest harvest practices to improve habitat or for the kinds of information that may improve planning for wildlife habitat in the context of forest management planning.

For example, Fisher and Bradbury (2006) reported that structure of the forest was changed adversely for red squirrels for a period longer than the rotation age after clear cutting in mixedwood habitats and point out that forest management planning that emulates landscape patterns of fire will not provide adequate habitat if structure is not maintained. They also report that removal of an aspen overstory while maintaining spruce (*Picea* sp.) regeneration in the understory does provide at least adequate habitat for reproduction of red squirrels.

Venier and Pearce (2005, 2007) compared bird communities in the boreal forest of northeastern Ontario in various age classes after logging and also in mature habitats in logged landscapes compared to landscapes in Pukaskwa National Park. They found that they could distinguish bird communities that were statistically representative of different age classes and landscapes but no species was restricted to one age class or landscape. They also report that community response was highly variable and related to disturbance type and the specific bird community occurring in the geographic area under consideration. They conclude that community response can give general guidance to forest management planners but that relatively local knowledge is required and the specific responses of individual species must be taken into account in predicting the outcome of particular forest management prescriptions.

While these are important results for forest management in general, they do not change the habitat preferences given by Bellhouse and Naylor (1997) or Holloway et al. (2004). Two studies do provide updated information. Largely because there was no specific information available, neither Bellhouse and Naylor nor Holloway et al. considered winter habitat separately from breeding habitat for any bird species.

For the boreal chickadee, Bellhouse and Naylor (1997)considered the mature and old stages of appropriate eco-sites to be preferred habitat, whereas the updated preferences shown by Holloway et al. (2004) indicate that immature and mature but not old stages are preferred. The work of Hadley and Desrochers (2008) in Québec indicates that mature (>7 m tree height) are strongly preferred over immature stands (4-7 m) in winter. Hadley and Desrochers do not specifically report age classes of forests within their study area but it seems likely that the old age class would also be preferred by boreal chickadees in winter.

Holloway et al. (2004) indicate that preferred habitats harvests by uniform shelterwood continue to be preferred by red squirrels. However, Holloway and Malcolm (2006) found that red squirrel densities were reduced after uniform shelterwood harvests in pine (*Pinus* sp.) habitats, likely because of the reduction in admixed spruce in these habitats after harvest. Both Holloway and Malcolm (2006) and Fisher and Bradbury (2006) found that red squirrel abundance was correlated with numbers of large spruce.

Biological Factors Influencing Persistence of Species

Minimum Population for Survival

Minimum viable population (MVP) is a concept that became popular in conservation biology in the 1980s (e.g. Gilpin and Soule 1987). Defined quantitatively, the MVP for any species is the number below which the probability of survival over some specified lengthy period (e.g., 1000 years) drops below a (quantitatively specified) acceptable level. In an early attempt to assess minimum numbers of individuals required for viability, Lande and Barrowclough (1987) suggest that 500 individuals (or 250 pairs) is "about the right order of magnitude", although Grumbine (1990) points out that this could mean anywhere from 50 to 5000 individuals. The value of 500 individuals was used as an estimate of MVP in a background report (OMNR 2002) to Ontario's Old Growth Policy (OMNR 2003).

More recently, Reid et al. (2003) and Traill et al. (2007) conducted meta-analyses of published MVP reports considering over 200 species across all vertebrate classes. Both assessed extinction risk relative to 40 generations of the species in question rather than some specific period of time. Since the generation time of the taxa investigated varied considerably, the actual time span covered by 40 generations varied from 40 years to over 200 years. Nevertheless, the average MVP calculated for all taxa were similar: 5000 to 7000 breeding adults calculated by Reid et al. (2003) and 4000 calculated by Traill et al. (2007).

Reid et al. (2003) identified year to year variation in population size and rate of population growth per generation as the two most influential factors in determining MVP. They note that both of these are likely to vary between pristine and anthropogenically degraded habitats. Most published MVP analyses represent species that are at critically low population levels, which, in relative terms, show high year to year variability in population numbers. Populations at critically low levels may also have severely reduced growth rates for a variety of reasons (Courchamps et al. 1999). Both of these factors tend to increase estimated MVP. Reid et al. (2003) suggest that MVP in "pristine" (undefined) habitats could be as low as 2000 adults and as high as 13000 in severely degraded habitats.

Algonquin Provincial Park forest habitats are not pristine in the sense of having no human disturbance influences, but neither are they severely degraded. Nor are any of the species proposed as indicators at such low population levels that population growth rates would be expected to be significantly reduced from the natural range of variation. For purposes of this report, 2500 breeding adults is used as an estimate of MVP.

In the context of the APP FMP, and the species selected as indicators, the area of habitat required to support MVP can be approximately calculated for species with defined home ranges within a specific habitat type (which always encompasses more than one eco-site) and for which typical breeding densities are known. Several of the selected species do not fall within these parameters and the amount of habitat required by these species to meet the targets suggested by Algonquin Eco Watch are discussed separately in the species accounts.

Typical Density

It is very rare that suitable habitat for any species is occupied at the highest density that could be expected from its home range or territory size. Factors affecting density include variability across the landscape in actual suitability of even preferred habitats, patchy distribution of particular resources (such as food) within a broad habitat type and overall population size of the species. Typical densities often vary among seasons, especially for resident birds, which tend to use considerably larger areas in winter than in summer. However, there is very little information about density outside the breeding season for many species and the densities presented in this report, unless otherwise specified, represent spring and summer densities of breeding adults. For this report, 'typical' densities were selected from the literature based on densities reported from Ontario or adjacent jurisdictions (where these could be found; some densities are from more distant jurisdictions).

For some species there is considerable published literature on densities. When this is the case, usually a 'typical' density at the higher end of the range (but not necessarily the highest) was selected because we are interested in density in preferred habitat where we expect density to be relatively high. However, for a number of species this did not seem like the best approach:

- For black-backed woodpecker, density in old forest was taken over the higher densities that tend to occur in recently burned areas because the species must persist in this habitat when burns and other habitats supporting high densities are not available.
- For bird species that are known to respond numerically to spruce budworm (*Choristoneura fumiferana*) density, we selected density reports that specified no or low budworm densities (because the species must persist through budworm lows).
- For red squirrel, which can show order of magnitude population differences between years, a low density was used, since the population must persist into a growth phase.

Migratory Strategy

Migration strategy might be assumed to be important to assessment of the necessary spatial distribution of habitat to maintain species populations because it seems logical that migratory species would show a better ability to find newly suitable habitat patches. While there is certainly some evidence that migratory species do repeatedly go extinct and re-invade suitable habitat patches (e.g., Villard et al.1992), the median natal dispersal distance (distance between birth site and site of breeding) does not appear to be longer for migrant birds than for residents (Bowman 2003). Whether the situation is different for species that opportunistically exploit unpredictable habitats (e.g. crossbills exploiting unpredictably available conifer seed crops or black-backed woodpeckers invading burned areas in high densities) is unknown.

Home Range Size

Home range size is a potentially useful piece of information in that habitat patches must be big enough to supply at least one or two home ranges for the species in question. However, in terms of maintaining populations, the typical density at which a species occurs is probably of more value.

In addition, home range is a somewhat elusive term. For birds that defend a breeding territory but migrate out of Ontario in winter, 'home range size' can be defined as territory size. Similarly, small mammals (mice, squirrels) live in a defined area year round. Larger mammals range more widely, and, for many species, male home ranges are often considerably larger than and overlap with female home ranges (e.g., Sutherland et al. 2000). Nevertheless, the definition of home range is fairly straightforward for all of these groups of species. However, some species make seasonal migrations within Ontario (e.g., white-tailed deer) and others may defend breeding territories in summer but range more widely in winter. For species that expand their home ranges in winter, it is the winter home range size that would be of greatest interest and winter range is presented when it is known.

Home ranges reported in the literature can vary considerably depending on geographic location, what method was used to determine home range and whether the local population was high or low (perhaps depending, in turn, on whether food supply for the species in question was at a high or low point in a population cycle). For purposes of this report, we have generally used home range sizes reported for Ontario or adjacent jurisdictions, if available. When the published information on home range size is very variable, a range is given.

Dispersal Distance

Dispersal is an important process that affects the ability of a species to invade both newly suitable habitats (as the forest ages, for example) and to re-colonize habitats that may be suitable but unoccupied. The discussion below provides an amount (number of square kilometres) of preferred habitat to support 2500 breeding adults for nine of the selected species. Although a single number is given, that amount likely cannot and definitely should not (for conservation purposes – e.g. Groves et al. 2003) be located all in one place. Patches of preferred habitat should occur in a range of sizes but must be must be big enough to support at least a few home ranges of the species in question. Patches must also be close enough together that dispersal from occupied to unoccupied patches can occur.

Dispersal distance (defined as the distance between the location of birth and the location of first breeding) is correlated with body size (Sutherland et al. 2000) but there are anomalies with individual species dispersing both shorter and longer distances than would be expected. However, Bowman et al. (2002) have demonstrated that median and maximum natal dispersal distances for mammals (excluding bats) are linearly related to the square root of home range size across all body and home range sizes. The median natal dispersal distance for mammals can be estimated as 7 times the square root of the home range area while the maximum distance can be estimated as 40 times the square root of home range area. Bowman (2003) has also demonstrated that the relationship between home range size and median natal dispersal distance holds for birds (regardless of migratory status) with the multiplication factor being 12. For birds, the relationship for maximal dispersal distance was not consistent, possibly because of the difficulty in measuring maximum dispersal distance, especially for small birds.

These relationships allow us to estimate median dispersal distances for many species that have not been well-studied. In this report, estimates of median and maximum dispersal distance based on Bowman et al. (2002) and Bowman (2003) are given unless there is good published evidence that a different approach should be taken. While we cannot estimate dispersal distance for salamanders, it is expected to be small simply based on small body size.

While this report makes no specific recommendations about the spatial arrangement of preferred habitats of the proposed indicator species, dispersal distances should be taken into account in forest planning for the provision of habitat.

Presentation of Information

Explanation of Tables

Life history attributes for each of the selected species is presented in Tables 2 and 3, organized by species and by eco-site, respectively. The species table summarizes the available information in the categories discussed above for each species and gives the number of eco-sites preferred by individual species. The estimated area of preferred habitat required to support 2500 mature individuals (MVP, see above) is based on 'typical' density of the species. Since species occur at a wide variety of densities, one number was chosen to represent a typical density (see Typical Density above). In some cases, no area of habitat for MVP could be calculated. These species are discussed in the species accounts below.

The eco-site table summarizes attributes for the most conservative (but see caveat below) species (i.e. the species with the lowest typical density, largest home range and shortest median natal dispersal distance) that prefers the eco-site in question. Any species that prefers only the old age class of the eco-site is also shown as is the number of species that prefer that type.

Five species are excluded from Table 3. Blue-spotted salamander is excluded because there is essentially no information about its density or dispersal capabilities. Because it is a small species, it is quite likely that its natal dispersal distance is also small and could be the smallest among the indicator species. Red crossbill and pine siskin are not included in the table because they are nomadic species and there is no specific information on the extent of their wanderings. Moose and white-tailed deer are excluded because they move seasonally to a greater or lesser extent between different habitat types and require a variety of habitat types over the course of a year. A typical home range for these species includes an interspersion of habitat types.

The species accounts below expand on the information provided in the tables. Unless otherwise noted, information on habitat preferences and use of habitats logged by single-tree selection or uniform shelterwood are from Holloway et al. (2004).

Species Accounts

Blue-spotted Salamander

The blue-spotted salamander is common in Ontario. Because gas exchange takes place through the skin in salamanders, they require habitats with high humidity. Such habitats are normally provided by forest types with deep leaf litter and closed, shade-producing canopies. Blue-spotted salamanders are found in both deciduous and mixed forests, particularly those with sandy to loamy soils. Preferred eco-sites are: 17,18, 24 to 30 and 35.

Assessment by Holloway et al. (2004) suggests that blue-spotted salamanders continue to prefer appropriate eco-sites that have been managed under either single tree selection or uniform shelterwood systems. However, uniform shelterwood treatment can vary considerably. If a large proportion of the canopy is removed, resulting in very dry conditions on the forest floor, reduced use by blue-spotted salamanders could be expected.

Blue-spotted salamanders have both terrestrial and aquatic life stages. Eggs are laid in temporary or permanent pools in spring and larvae remain in these pools until they transform into adults in early summer. The distance that adult blue-spotted salamanders travel from their breeding ponds is not known but the closely related spotted salamander (*Ambystoma maculatum*) rarely moves more than 250 m (Petranka 1998).

Broad-winged Hawk

The broad-winged hawk is one of the most common hawks in Ontario. The species is migratory, occurring in Ontario from about May to early October. Canada-wide, the Breeding Bird Survey shows a significant decline in this species between 1968 and 2005. However, neither the BBS nor the 2001-2005 Breeding Bird Atlas (Cadman et al. 2007) show any change in population status in Ontario. This species was proposed as a candidate indicator species based on its status as a top predator and its use of large areas of mature forest.

This species prefers mature to old deciduous or mixed forests (eco-sites 11, 14, 17, 18 and 24 to 29). Large diameter trees (usually birch, poplar, maple or oak, but occasionally pines) are required for nesting. Single tree selection does not degrade habitat for broad-winged hawks.

Stands where uniform shelterwood cutting has occurred may be used by broad-winged hawks but such stands are not preferred habitat. There is no published information for home range size of broad-winged hawks and little information about typical densities. Home range sizes are likely to be in the same general range as home ranges of other sympatric forest buteos (50 –200 ha) (Preston and Beane 1993; Dykstra et al. 2008). In the Great Lakes states, densities of broad-winged hawks range from 0.2 to 0.5 pairs/km^2 (Goodrich et al. 1996). Based on the higher density, 2500 km^2 of preferred habitat would be required to support the estimated MVP of 1250 pairs.

Barred Owl

Barred owls are resident in Ontario. Their populations are stable to increasing with the 2001-2005 Breeding Bird Atlas (Cadman et al. 2007) showing significant increases in distribution in central Ontario. The species was selected as a candidate indicator species because it is a top predator requiring a variety of older forest types and representing mature ecosystems.

Barred owls prefer large blocks of continuous mixed or deciduous forest with a high degree of canopy closure, reached in the mature and old stages. Single tree selection does not reduce usage of preferred forests but uniform shelterwood cuts do, presumably because of this species' preference for closed canopy forest. Nests are usually placed in natural cavities in large diameter deciduous trees, although occasionally old squirrel or hawk nests may be used (Peck and James 1983).

Average home range during the breeding season is in the vicinity of 275 ha, but may considerably larger or smaller (90 ha to 270 ha) (Mazur and James 2000), presumably depending on availability of prey. Winter home ranges are considerably larger, up to 1200 ha. Maximum estimated density for barred owls is 1 pair/km^2 (Holloway et al. (2004). At this density, 1250 km^2 of preferred habitat would be required to support an estimated MVP of 1250 pairs.

Black-backed Woodpecker

The black-backed woodpecker is a relatively uncommon permanent resident in Ontario. The Breeding Bird Survey shows a marginally significant decrease in numbers in Ontario since 1968 but the Breeding Bird Atlas (Cadman et al. 2007) shows no significant changes. It was proposed as a candidate indicator species because of its need for old forests, particularly lowland conifer and its status as a species representative of old growth forest in Ontario's Old Growth Policy (OMNR 2003).

Black-backed woodpeckers show a strong preference for old forest with a high conifer, especially spruce and jack pine (*Pinus banksiana*), component. In APP, they prefer eco-sites 16, 22, 33 and 34). They are specialized foragers on larvae of wood boring insects which are abundant only in old forests (or forests severely affected by insect outbreaks) with many dead and dying trees and in trees recently killed by fire (Murphy and Lenhausen 1998; Escott 2001).

Reported home range sizes for black-backed woodpeckers are very variable (61 to over 500 ha) and come almost entirely from burned areas (Dixon and Saab 2000; Dudley and Saab 2007). The smallest home range (61 ha, Lisi 1988 cited by Dixon and Saab 2000) is the only eastern estimate (from Vermont) and it is unclear whether this estimate is post-fire. Black-backed woodpeckers may occur at densities of 5 to over 30 pairs/km^2 in recently burned forests and forests with many trees dead and dying from insect attack. The only Ontario estimate (5 pairs/km^2) comes from an area affected by spruce budworm in the northwestern part of the province (Kendeigh 1947). Black-backed woodpeckers also use areas that have been selectively logged where recently downed coarse debris remains on the site (Thompson 2007) but there is no information on densities in such areas.

Salvage logging of burned areas considerably reduces suitability of these areas for this species. Dixon and Saab (2000) report that Oregon has proposed a management strategy for woodpeckers that includes delay in salvage logging after fire and maintenance of areas of at least 387 ha of undisturbed old forest for each pair of woodpeckers. This represents a density of about 0.25 pairs/km^2, considerably lower than the published density of 1.25 pairs/km^2 in old but unburned forests. Using the lower density, an area of 5000 km^2 would be needed to support 1250 pairs. Using the higher density, an area of at least 1000 km^2 would be required.

Pileated Woodpecker

Pileated woodpeckers are fairly common residents in Ontario. Both the Breeding Bird Survey and the Breeding Bird Atlas show significantly increasing populations in Ontario. The species was proposed as a candidate indicator because of its status as a featured species in forest management planning in Ontario and its need for mature and older forests.

Pileated woodpeckers eat primarily carpenter ants and larvae of wood-boring beetles, which they excavate from dead or declining large diameter standing trees and coarse woody debris (Bull and Jackson 1995). The species prefers habitats with a significant component of large diameter aspen and poplar (mature and old stages of eco-sites 11 to 14, 16 to 23, 27, 33 and 34). Uniform shelterwood cuts do not reduce usage by pileated woodpeckers, possibly because of additional food sources provided by invasion of slash by wood-boring insects and carpenter ants.

Home range size varies considerably. In the west, it averages somewhat over 400 ha. In the eastern North America home ranges tend to be smaller but may be over 200 ha (Bull and Jackson 1995; Holloway et al. 2004). Densities in eastern North America are usually 1-4 pairs/km^2. Using an average density of 2.5 pairs/km^2, an area of approximately 500 km^2 would be needed to support 1250 pairs.

Boreal Chickadee

APP and the immediately surrounding area supports a population of boreal chickadees separated from the continuous range of this primarily boreal species (McLaren 2007). The Breeding Bird Survey has found significant declines in populations of this species both in Ontario and across Canada but the Breeding Bird Atlas found no significant changes. The species was selected as a candidate indicator based on its apparent decline and its status as a species of northerly habitats occurring in APP.

The preferred breeding habitat for boreal chickadees consists of immature to old spruce and jack pine stands (eco-sites 15, 16 and 31-33). Immature stands must include snags and dead trees in advanced stages of decay to be preferred by this species which excavates its own nest holes in highly decayed wood (McLaren 1975). Although immature stands can be preferred habitat for breeding, Hadley and Desrocher (2008) found that winter flocks of this year-round resident strongly prefer mature (at least 7m) stands.

Territory size for this species is at least 5 ha (McLaren 1975) and winter flocks use an average range of 15 ha (Hadley and Desrochers 2008). Populations of the boreal chickadee increase during spruce budworm outbreaks (Gage et al. (1970). During non-budworm seasons, observed breeding densities of this species range from 2-7 pairs/km^2 (Erskine 1977). Based on an average of 4 pairs/km^2, about 300 km^2 of preferred habitat would be required to support 1250 pairs.

The amount of winter habitat required to maintain 2500 birds can be roughly calculated from the information presented in Hadley (2007). Hadley located 72 separate flocks averaging 4 birds in his 66km^2 study area but does not give any indication of what proportion of all flocks he detected. Although these flocks preferred mature forest, they did use immature forest within their home ranges. They avoided young forest and open areas. Mature and immature forest (in a ratio of approximately 2.5:1) covered 80% of the study area or 53km^2. If we assume that all flocks present were detected (probably unlikely), then about 800 km^2 of conifer habitat, with a preponderance of mature and old age classes could support 2500 birds through the winter.

Ruby-crowned Kinglet

The ruby-crowned kinglet is a migratory species that breeds across the forested portions of Ontario. The Breeding Bird Survey shows a significant decline in this species in Ontario. The Breeding Bird Atlas shows an increase in the province as a whole but a significant decrease in central Ontario. This species was selected as a candidate indicator based on its preference for old forests and its declining population in central Ontario. It is a species representing old forests in the Ontario Old Growth Policy (OMNR 2003).

This species prefers spruce and pine forests for nesting and, in much of its range, uses age classes varying from immature to old. However, in central Ontario it seems to show a preference for the old age class and nests preferentially in eco-sites 11-13, 15, 16 20-22 and 31-33. The species is near the southern edge of its geographic range in central Ontario and occurs at lower densities than further north (Crins 2007). The stronger preference for old forest in central Ontario may be a reflection of greater selectivity where it occurs at low densities.

Territory size is large for a small bird, ranging from about 1 to 5 ha and averaging about 3 ha (Ingold and Wallace 1994). Although higher densities have been recorded in western forests, densities in eastern Canada range from about 10 to 30 pairs/km^2 (Erskine 1977). Using a value of 25 pairs/km^2, 50 km^2 of preferred habitat would be required to support 1250 pairs.

Bay-breasted Warbler

The bay-breasted warbler is considered to be a budworm specialist with its numbers increasing dramatically during budworm outbreaks (e.g. Kendeigh 1947). The Breeding Bird Survey shows a significant decline in this species across Canada and a small but non-significant decline in Ontario. The species is listed on the Partners in Flight continental watch list because of its declining population North America-wide. The Breeding Bird Atlas shows a stable population in Ontario as a whole but a significant decline in central Ontario.

The bay-breasted warbler is another species near the southern edge of its range in APP. The species nests in black spruce (*Picea mariana*) or balsam fir (*Abies balsamifera*) and prefers habitats in which these species are abundant in either the understory or the canopy. Other habitats, including deciduous forests may be used extensively during insect outbreaks, including forest tent caterpillar (*Malacosoma disstria*) outbreaks (McLaren et al. 2006). Nevertheless, like the black-backed woodpecker, populations must be sustained through periods when food is not superabundant. During low food periods its preferred habits are immature to mature stages of eco-sites 6-22 and 33-35.

Territory size for this species is not well known and is reported by only one study at 1.5 ha (Williams 1996). Densities vary widely from about 2 to 50 territories/km^2 even in the absence of budworm (Erskine 1977). Based on work in the northeastern Ontario, Holloway et al. (2004) indicate that density in preferred habitat in Ontario is somewhat over 100 pairs/ km^2 in normal years. Given the rather sparse occurrence of the bay-breasted warbler in APP (Zimmerling and Nicoll 2007), this density seems high. Using a value of 25 pairs/km^2 (as reported for western Quebec and Ontario by Erskine 1977), 50 km^2 of preferred habitat would support 1250 pairs.

Canada Warbler

The Canada warbler is a relatively uncommon migratory species that has declined significantly across Canada, although the decrease is not significant for Ontario alone. It is listed on the Partners in Flight continental watch list because of its declining population across North America and is a priority species in the Ontario Bird Conservation Region 12 Plan both because its population is declining and because Ontario has a high jurisdictional responsibility. The Breeding Bird Atlas shows a stable distribution in Ontario as a whole but shows a significant decrease in central Ontario.

The Canada warbler prefers moist, mixed coniferous-deciduous forests with a well-developed understory and is often most abundant near wetlands and other watersources (Conway 1999). Preferred habitats in APP are immature, mature and old stages of ecosites 14, 17, 18, 20-22, 26, 28 to 31, 33 and 34.

Territiory size has been estimated to be 0.2 to 1.2 ha (Conway 1999) but the species is generally uncommon. Most reported densities are less than 20 pairs/km^2 (Erskine 1977; Conway 1999). Using a value of 15 pairs/km^2, 80 km^2 of preferred habitat would be required to support 1250 pairs.

Red Crossbill

The taxonomic status of the red crossbill is uncertain. Parcheman et al. (2006) recognized nine sibling types that may be separate species. Previous workers have distinguished eight types based on call type and food preferences for different conifer seeds (see Adkisson 1996). Type 2, which specializes on white pine cones is thought to be the most abundant in Ontario (Simard 2007). The Breeding Bird Survey shows significant declines in red crossbills across Canada but the number detected in Ontario is too small to provide useful information about trends in this province. The Breeding Bird Atlas shows no change provincially but a significant decline in central Ontario.

Red crossbills are widely nomadic and may breed at any time of year if a wandering flock encounters an area with good seed production (Adkisson 1996). Because of their dependence on seed production for successful breeding, they prefer mature to old forest and, to the extent that increasing age of trees results in greater seed production, their requirements will be better met in old stands. Work in eastern Ontario suggests that a density of at least 50 big, old pines per hectare is required for breeding by red crossbills (I.D. Thompson, pers. comm.). In APP they breed only in eco-sites 11 and 20 and do not use other eco-sites to any extent. If a minimum number of large pines (at least 50/ha, as note above) are retained they will use sites after harvesting by uniform shelterwood or single tree selection.

Red crossbills are not territorial and there is no information on amount of habitat required to maintain populations. The species is believed to have declined considerably during the 19th century as white pine was extensively logged and to have recovered somewhat by the later 20th century as second growth pine matured (Dickerman 1987). Given the nomadic nature of the species and the irregular occurrence of strong seed production, it would seem wise to maintain or increase the amount of preferred habitat for the red crossbill in APP.

Pine Siskin

Like the red crossbill, the pine siskin is nomadic and breeds in coniferous forests. However, this species uses mostly conifers other than pine and is less dependent on conifer seeds. Seeds of a wide variety of plants as well as some insects are taken (Dawson 1997). It is also considerably more abundant than the red crossbill (Cadman et al. 2007). Nevertheless, the Breeding Bird Survey shows significant declines for Canada and marginally significant declines for Ontario.

Again like the red crossbill, this species does not show a decline for the province as a whole in the Breeding Bird Atlas data but does show a significant decline in central Ontario.

The pine siskin prefers the mature and old stages of eco-sites 16, 17, 21, 22 and 30-34. This species often nests in loose colonies but there is no information on how many birds nest in any given colony nor on the area required to support one or more breeding colonies.

Red Squirrel

The red squirrel is a proposed indicator species based on its need for older forest and also its status as prey for a variety of forest predators. Preferred habitats for red squirrels are the mature and old stages of conifer dominated eco-sites (1-16, 20-22 and 30-33). Holloway et al. (2004) reported that red squirrels continued to prefer these eco-sites after uniform shelterwood harvest. However, Holloway and Malcolm (2006) found that red squirrel abundance was significantly lower 3-10 years after uniform shelterwood cuts in APP. They recommend retention of larger numbers of large spruce than is present practice to maintain habitat quality for red squirrels.

Reported red squirrel home range sizes in preferred habitat vary from 0.2 ha to 2.15 ha (Obbard 1987; Fisher and Bradbury 2006). Obbard (1987) used published accounts to estimate maximum red squirrel densities (based on home range size and habitat saturation) of about 100 to 500 (with most estimates in the 200-250 range)squirrels/km^2. However, red squirrel densities can vary by an order of magnitude (138 to 12 squirrels/km^2) between years in Arizona (Salafsky et al 2005), presumably as a result of variation in cone and, therefore food, production. The natural range of variation in APP is unknown but since populations must be maintained through their low points, a value of 50 squirrels/km^2 has been used to estimate the area of preferred habitat (50 km^2) required to support 2500 squirrels.

White-tailed Deer

White-tailed deer require old forest only in winter. Deer have difficulty moving in deep snow and have adapted to Ontario conditions by developing a tradition of migrating to wintering areas known as ‘deer yards’. Deer yards are typified by mature and old stands with dense conifer canopy interspersed with stands with more open canopy. The conifer canopy intercepts sufficient snow to allow deer to move about without excessive energy use while the areas with less dense canopy permit sufficient light to penetrate to encourage production of woody browse (Voigt et al 1997). The locations of major yards are well-known but deer may also winter in small groups whose locations may need to be determined.

Because of their need for interspersion of young and old habitats, deer benefit from a certain degree of forest harvest activity. Single tree selection can enhance habitat for this species. The eco-sites that provide preferred winter habitat for white-tailed deer are 16, 22, 30 and 33. In forested habitats, dispersal distances for deer are low, usually less that 12 km (Long et al. 2005). Typical density of deer in Ontario wintering areas are in the vicinity of 20 deer/km^2 (Voigt et al. 1997).

The traditional usage of deer yards as well as the benefit that deer derive from some forest harvest means that designating an amount of preferred wintering habitat for protection is not a particularly effective way of providing habitat. Some deer that inhabit APP in the summer migrate to winter yards outside the park but others remain in the park in winter. The locations of aggregations of wintering deer need to be identified so that appropriate planning for their protection can take place. The Forest Management Guidelines for the Provision of White-tailed Deer Habitat (Voigt et al. 1997) give detailed instructions for management of deer wintering habitat during forest management planning. These guidelines must be followed in regions where deer occur at high densities and provide protection for deer winter habitat. Because of this, no specific quantity of habitat is designated for white-tailed deer in this report.

Moose

Habitat types used by moose change over the course of winter (OMNR 1988), with habitat used in late winter (approximately mid February through March), being more critical to survival than habitat used in early winter. In early winter moose prefer areas with mature or old, open canopied mixedwood stands. These areas supply abundant woody browse as well as provide some thermal cover.

In late winter, deep and/or crusted snow may hinder moose movements from shelter to feeding areas and, especially in March as the strength of the sun increases, moose in open areas may suffer from heat stress (Schwartz and Renecker 1998). At this season moose move to well-stocked stands of mature conifers or mixedwood stands with dense pockets of coniferous trees. Ideal late winter habitat is a mosaic of old coniferous stands or pockets interspersed with hardwood or mixedwood stands that provide abundant woody browse In late winter moose preferentially use the mature and late stages of closed canopy conifer habitats as provided by eco-sites 16, 22, 30, 33 and 34. Eco-site 30 (hemlock/yellow birch) is particularly important for moose in winter.

Late winter habitat that provides relief from heat stress may be more important to moose in APP than it is further north, particularly in light of the trend to warmer winter temperatures. Murray et al. (2006) found evidence that suggested increasing temperatures and resultant thermal stress on moose had contributed to declining populations in Minnesota.

The most recent aerial surveys of APP suggest that the moose population of the park is in the vicinity of 0.3 moose/km^2 animals (OMNR, unpubl. data). This represents about 2500 animals, or about the estimated MVP used in this report. In the mid 1990s, APP supported moose at densities of 0.4 to 0.6 moose/km^2. The decrease in moose population in the park is not believed to have been due to loss of habitat but rather to other factors. Forest management guidelines for provision of moose habitat (OMNR 1988) must be implemented during forest management planning and are designed to ensure that sufficient habitat in an appropriate configuration is available to support high densities of moose. Because of this, no specific quantity of habitat is designated for moose in this report.

General Conclusions

For at least 10 of the indicator species proposed by Algonquin Eco Watch (n.d.), it is possible to estimate the area of preferred habitat required to support 2500 adults. Based on review of recent literature, 2500 adults seems a reasonable minimum population size for long term persistence of species (MVP – minimum viable population). The estimated amount of habitat required varies form 50 to 2500 km^2 (in the specific eco-types and age-classes preferred by the species in question). Without information on the current amount of habitat for each of these species, it is not possible to comment on the feasibility of Algonquin Eco Watch's proposal that twice the amount of habitat for MVP should be provided by the end of Term 3 of the APP FMP.

Because each species has different requirements, it is also not possible to suggest spatial arrangements of preferred habitat patches. Nevertheless, as noted above, habitat patches should be large enough to support more than one home range/territory for any given species and should be distributed across the landscape such that dispersal from occupied to unoccupied patches can readily occur.

Two of the proposed indicator species are nomadic bird species that may travel long distances in search of appropriate breeding conditions, which are provided by heavy seed crops of certain conifers. Pine siskins are both more abundant and less selective in the conifers they prefer than are red crossbills. It is likely that adequate pine siskin habitat will be provided by planning for other species that require mature and old conifers (boreal chickadee, black-backed woodpecker). Red crossbills depend primarily on mature and old white pine. There is no information on which to estimate how much habitat would be required to support a MVP either within APP or on a wider scale.

Moose and white-tailed deer both prefer (slightly different) older age classes of conifer interspersed with younger forest as winter habitat. Because of the requirement for habitat interspersion (and because summer habitat is not considered), it does not seem sensible to provide an estimate of area of habitat for MVP for these species. In addition, the application of existing guidelines for habitat provision for these species should provide adequate winter habitat.

Table 2. Attributes of candidate forest indicator species in Algonquin Provincial Park. Species that prefer old forest over other age classes are shown in bold type.

Species (bold indicates preference for old forest over mature)	No. of Eco-sites Preferred	Forest Habitat Feature Needed	Life History Strategy	Home Range/ Territory Size ('w' indicates winter)	Typical Density [breeding pairs (birds) or no. (mammals)/ km^2]	Estimated Median Dispersal Distance (km)	Estimated Maximum Dispersal Distance (km)	Estimated breeding habitat needed for MVP* (km^2) based on typical density
Blue-spotted Salamander	10	CWD, litter depth(?), microclimate(?)	Resident	$250m^2$	?	?	?	See text
Broad-winged Hawk	10	Closed canopy, high canopy volume(?)	Migratory (breeds)	50-250 ha?	0.5	150?	?	2500
Barred Owl	7	Snags, closed deciduous canopy, high canopy volume(?)	Resident	150- 270 ha, up to 1200 ha(w)	1	200	?	1250
Black-backed Woodpecker	5	Snags, CWD, coniferous canopy	Resident	60-500 ha	1.25	75	?	1000
Pileated Woodpecker	15	Snags, CWD	Resident	40-260 ha	2.5	100	?	500
Boreal Chickadee	6	Snags, dense conifer canopy	Resident	>5 ha	4	30	?	312
Ruby-crowned Kinglet	11	Dense conifer canopy	Migratory (breeds)	1.1-5 ha	25	19	?	50
Bay-breasted Warbler	10		Migratory (breeds)	1.5	25	14	?	50
Canada Warbler	13	Moist forest, well-developed understory	Migratory (breeds)	0.2-1.2 ha	15	8	?	80
Red Crossbill	2	Mature conifers (seeds)	Resident	Nomadic	N/A	N/A	?	See text
Pine Siskin	9	Mature conifers (seeds)	Resident	Nomadic	N/A	N/A	?	See text
Red Squirrel	13	snags, conifer canopy	Resident	0.2-2.15 ha	See text	7	56	50
White-tailed Deer	4	Dense conifer canopy with some openings (browse)	Resident	See text	20 (w)	8	12	See text
Moose	5	Dense conifer canopy with some openings (browse)	Resident	$10 km^2$	0.2-0.3	22	125	See text

*Minimum Viable Population (see text)

Table 3. Use of Great Lakes-St. Lawrence Region Eco-sites by Conservative Species[1].Does not include nomadic species (red crossbill, pine siskin) or species that require interspersion of habitat types (white-tailed deer, moose).

Ecosite	General Description	No. proposed indicator species that prefer this type	Species preferring old forest stage	Species with largest home range	Home range size	Species with lowest typical density	Typical density [pairs (birds) or no. /km^2]	Approx. area to support 2500 individuals (km^2)*	Species with smallest dispersal distance	Natal dispersal distance (km)	Maximum dispersal distance (km)
ES11	White pine, red pine	5		Pileated woodpecker	75 ha	Broad-winged Hawk	0.5	2500	Red squirrel	1	6
ES12	Red pine	3		Pileated woodpecker	75 ha	Pileated woodpecker	2.5	500	Red squirrel	1	6
ES13	Jack pine, white pine, red pine	3		Pileated woodpecker	75 ha	Marten	0.6	4000	Red squirrel	1	6
ES14	White pine, largetooth aspen, red oak	4		Pileated woodpecker	75 ha	Broad-winged Hawk	0.5	2500	Red squirrel	1	6
ES15	Jack pine, black spruce	3	Ruby-crowned Kinglet	Red-breasted Nuthatch	10 ha	Ruby-crowned Kinglet	20	62	Red squirrel	1	6
ES16	Black spruce, pine	9	Ruby-crowned Kinglet, Black-backed Woodpecker	Pileated woodpecker	75 ha	Marten	0.6	4000	Red squirrel	1	6
ES17[2]	Poplar, white birch	5		Broad-winged Hawk?	?	Broad-winged Hawk	0.5	2500	Blue-spotted salamander?	250m?	
ES18[2]	Poplar, white birch, white spruce, balsam fir	6		Broad-winged Hawk?	?	Broad-winged Hawk	0.5	2500	Blue-spotted salamander?	250m?	
ES19	Poplar, jack pine, white spruce, black spruce	2		Pileated woodpecker	75 ha	Pileated Woodpecker	2.5	500			
ES20	White pine, red pine, white spruce, white birch	6		Pileated woodpecker	75 ha	Pileated Woodpecker	2.5	500	Red squirrel	1	6
ES21	Eastern white cedar, white pine, white birch, white spruce	6		Pileated woodpecker	75 ha	Pileated Woodpecker	2.5	500	Red squirrel	1	6
ES22	Eastern white cedar, other conifers	10		Pileated woodpecker	75 ha	Black-backed Woopecker	1.25	1000	Red squirrel	1	6
ES23	Red oak, sugar maple	1		Pileated Woodpecker	75 ha	Pileated Woodpecker	2.5	500	Pileated woodpecker	100	?

Table 3 (cont.). Use of Great Lakes-St. Lawrence Region Eco-sites by Conservative Species. See text for explanation.

Ecosite	General Description	No. species that prefer this type	Old forest species	Species with largest home range	Home range size	Species with lowest typical density*	Typical density (no./km^2)	Approx. area to support 2500 individuals (km^2)	Species with smallest dispersal distance	Natal dispersal distance (km)	Maximum dispersal distance (km)
ES24[2]	Sugar maple, red oak, basswood	2		Broad-winged Hawk?	?	Broad-winged Hawk	0.5	2500	Broad-winged hawk	?	/?
ES25[2]	Sugar maple, American beech, red oak	3		Barred owl	150-270 ha	Broad-winged Hawk	0.5	2500	Barred owl	200	?
ES26[2]	Sugar maple basswood	4		Barred owl	150-270 ha	Broad-winged Hawk	0.5	2500	Canada warbler	8	?
ES27[2]	Sugar maple, white birch, poplar	4		Barred owl	150-270 ha	Broad-winged Hawk	0.5	2500	Pileated woodpecker		
ES28[2]	Sugar maple, hemlock, yellow birch	4		Barred owl	150-270 ha	Broad-winged Hawk	0.5	2500	Canada warbler	8	?
ES29[2]	Sugar maple, yellow birch	4		Barred owl	150-270 ha	Broad-winged Hawk	0.5	2500	Canada warbler	8	?
ES30[2]	Eastern hemlock, yellow birch	6		Red squirrel	2 ha	Canada warbler	15	80	Red squirrel	1	6
ES31	Black spruce, tamarack	6		Marten	8 km^2	Black-backed Woodpecker	1.25	1000	Red squirrel	1	6
ES32	Easrern white cedar, black spruce, tamarack	5	Ruby-crowned Kinglet, Black-backed Woodpecker	Marten	8 km^2	Marten	0.6	4000	Red squirrel	1	6
ES33	Eastrern white cedar, other conifers	10	Ruby-crowned Kinglet, Black-backed Woodpecker	Pileated woodpecker	75 ha	Marten	0.6	4000	Red squirrel	1	6
ES34	Eastern white cear, lowland hardwoods	6		Barred owl	150-270 ha	Barred owl	1	1250	Canada warbler	8	?
ES35[2]	Lowland hardwoods	3		Barred owl	150-270 ha	Barred owl	1	1250	Bay-breasted warbler	14	?

[1] See text for explanation.

[2] Most likely blue-spotted salamander has the shortest dispersal distance in these eco-types but there is no published information.

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