Area-Sensitive Forest Birds in Urban Areas

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Canadian Wildlife Service publications are available on-line at the following URL: www.on.ec.gc.ca/wildlife. All publications

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1. Introduction

Environment Canada recently published

The goal of this report, *Area-Sensitive Forest Birds in Urban Areas*, is specifically to provide information to guide expectations for the use of urban forests[1] by area-sensitive forest breeding bird species.

The primary objectives are to:

a) Identify the primary characteristics of forest patches that would provide habitat for area-sensitive forest breeding birds within a matrix of large urban centres.

b) Identify the types of mitigation and habitat compensation that would be required to offset urban impacts on these birds and how practical this mitigation might be, and provide some guidance on possible restoration activities for other forest species.

c) Identify which area-sensitive forest birds have been lost from Toronto.

d) Discuss the utility of *A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern* (the *Framework*) forest habitat guidelines within an urban matrix.

The integrity of forest patches for other wildlife groups and the social and economic benefits that humans may receive from forested lands in the urban matrix are not the focus of this report.

2. Potential Urban Stressors on Area-Sensitive Forest Birds

In considering the primary objectives, it was determined that an appropriate first step in these investigations would be to consider what types of stressors on area-sensitive forest birds might be anticipated within an urban matrix[2]. Table 1 presents a list of potential stressors, based on relevant literature and scientific deduction within the urban environment.

Table 1. Potential Stressors for Area-Sensitive Forest Associated Breeding Birds in an Urban Environment

1. Barriers to Connectivity	**8. Nest Parasitism**
2. Contaminants	**9. Noise**
3. Direct Disturbance and Trails	**10. Predation by Urban-sponsored Native Predators**
4. Disruption of Ecosystem Process	**11. Predation by Urban-sponsored Non-native Predators**
5. Food Supply Changes	**12. Psychological and Social Behaviour**
6. Habitat Alteration	**13. Removal of Top Predators**
7. Artificial Light	

A review of the literature was undertaken. It was not an exhaustive review; the objective was to highlight key stressors and to gain some understanding (if possible) of the relative importance of these stressors, or to identify knowledge gaps. The following subsections discuss each of these potential stressors.

Marzluff and Ewing (2001) provide an insightful review of urban effects, as they are expressed through anthropogenic habitat fragmentation, and consider two primary attributes of the landscape that influence the effects. The first is the frequency and spatial extent of natural disturbance regimes. These are low in southern Ontario such that many native species are not adapted to rapid change. The second factor is the similarity of the land cover created by humans to natural cover. The change in land use from forest to row crop and pasture, or to urban, results in a loss of regional bird-community diversity. As is characteristic of biotic homogenization, urban fragmentation can increase local diversity (e.g., by adding species associated with humans or edge specialists), but decrease regional avifaunal diversity (Case 1996 *in* Crooks *eattttttttttttttttttttttttttttttttttttttttttttttttts.(*tttttttttttttt98 ref 0 092)Tj11600.98 ref18.7m.0012 Tc.09 Tc0698 0 0

particularly relevant as almost one-third of the earth's land surface is planted in row crops or pastures and in southern Ontario, like many parts of the world, agricultural practices have intensified. Agriculture often converts land to a matrix that is as different (or even more different) from the natural matrix, as is the urban matrix. While an agricultural matrix may provide some

In summary, barrier effects occur in urban environments, but the extent to which they are ecologically limiting is largely unknown. Furthermore, the function of corridors to mitigate the effects of isolation is poorly established and there is increasing evidence that some species at least (e.g., area-sensitive forest birds) can travel among habitat patches without the aid of habitat corridors, at least across an agricultural matrix. Whether connectivity is a limiting factor during the breeding season or also during periods of dispersal, is less clear and is likely species-specific. The role of connectivity in facilitating social interaction is just beginning to be explored. It is likely that connectivity (and patch size) becomes more important when forest cover falls below 30 per cent.

2.2 Contaminants

Contaminants are usually measured in top predators due to the fact that metals and other contaminants bio-magnify as they move up the food chain. Consequently, contaminants such as metals are usually in low levels and have short residence in birds such as passerines, which are low in the food chain. They can accumulate through drinking and geophagy (Hui and Beyer 1998). Metals and pesticides are only a few of the contaminants that can become common stressors for birds in human-influenced urban landscapes. Bioaccumulation of metals in birds can negatively influence reproductive success or ultimately the survival of species.

A study by Burger *et al*. (2004), reported local exposure to contaminants by analyzing concentrations of metals and metalloids in the eggs of Florida Scrub Jays (*Aphelocoma coerulescens)* from a residential subdivision. The influence of housing density on contaminant levels was analyzed and contaminants found in suburban-area birds versus birds in a biological reserve were compared. Unexpected results indicated that housing density showed no significant differences between contaminant levels except for mercury. Surprisingly, mercury levels were lower in high housing densities and higher in intermediate housing densities. It was also discovered that levels of cadmium, lead, manganese and selenium were significantly lower in the eggs collected in the suburban study area compared to those at the reserve (Burger *et al*. 2004). Nest success did not differ between the two areas. However, hatching failure in nests in the suburbs was twice that of the reserve. Overall, contaminant-level studies are difficult to interpret since one must take many considerations into account including food-chain susceptibility, contaminants in the eggs versus the feathers, surrounding natural features and the specific metals or metalloids being measured.

Lead is another known contaminant in urban environments, which poses a health risk to wildlife, including birds. In disturbed (urban/altered) habitat, lead concentrations in the atmosphere and soil are higher than in non-urban habitats. A study was conducted by Chandler *et al.* (2004), to determine the threat of lead exposure to the Sharp-shinned Hawk (*Accipter striatus)*. Lead blood concentrations of the House Sparrow (*Passer domesticus)*, the preferred prey of the hawk, were measured to determine if hawks were at risk. Lead blood concentrations of the House Sparrow were 4.5 fold higher in urban areas than in the exurban (in this case agricultural) control group. Therefore, Sharp-shinned Hawks may have been at risk of exposure to lead. Although results of

the study signify that the hawks are potentially exposed to high lead levels, the degree to which the exposure became an actual threat remained unclear for the urban dwelling raptors.

Assessing the risk to wildlife of contaminant exposure remains relatively uncertain because empirical data are lacking and the science of ecological risk assessment is relatively new.

2.3 Direct Disturbance and Trails

It is reasonable to assume that more people use wooded areas within an urban matrix than forested areas within non-urban matrices. The presence of people, whether along the edges of wooded areas, on-trail, or off-trail within wooded areas, can result in disturbance to forest birds. Almost all forest-bird species will move away (flush) from a human if he/she approaches too close, as the human is presumably seen as a threat or potential predator. Increased disturbance results in less time for crucial activities such as feeding, territory maintenance and care of young. Trails may also create habitat edges which can increase nest predation, result in trampling and soil compaction or erosion. Also, human activities (e.g., bird feeding) can attract resident wildlife species that become predators during the breeding season.

In wooded parks in Madrid, Spain, Fernández-Juricic (2000) found that increased numbers of people led to lower species richness of forest birds and lower overall abundance of the common species within a forest fragment. After taking into account fragment size, it was also found that between forest fragments, larger numbers of pedestrians resulted in lower species richness. Sixteen of 17 species were negatively affected by an increasing pedestrian rate.

The distance which a perched bird flies upon disturbance is called flight-initiation distance or flush distance. Flush distance varies significantly between species, with larger species tending to be less tolerant of disturbance (Blumstein *et al.* 2003; Wang *et al.* 2004; Fernández-Juricic *et al.* 2001, 2004).

An investigation by Miller *et al*. (1998), studied the influence of recreational trails on breeding-bird communities in North America. Species composition, nest predation and brood parasitism by the Brown-headed Cowbird (*Molothrus ater)* were considered. It was discovered that control transects housed significantly more birds than were along trails. However, some generalist species such as American Robins (*Turdus migratorius)* were found to be much more abundant along trails than in the forest. Results from that study also indicated that there was a significant positive correlation between distance from trails and nest survival. The zone of influence from trails into the forest was estimated at approximately 75 m and elevated rates of nest predation were evident. In a similar study, findings indicated that a single pedestrian moving through the territory of a specific bird may have a negative effect, such that it could reduce the occurrence and consistency of its primary song (Gutzwiller *et al.* 1994 *In* Miller *et al.* 1998).

The literature suggests that the larger area-sensitive forest species (such as hawks and owls) might be disturbed frequently enough by humans that they do not occur or that it is not possible

for them to successfully reproduce in certain human visited woodlots. Furthermore, more disturbance-sensitive smaller species could also have lower rates of productivity. The effects of faster-moving disturbance (e.g., all-terrain bicycles) might be different, although no specific studies were noted.

Of interest is research that shows that at least some species can habituate to human disturbance (Miller *et al.* 2001; Fernández-Juricic *et al.* 2002) This includes habitat generalists and urban associated species such as Blackbirds (*Turdus merula)* (an ecological equivalent of

unmanaged (save perhaps for snag removal). This could affect a wide range of species (e.g., Wood Thrush (*Hylocichla mustelina)* that require a well-developed understorey including saplings or thickets).

2.6.2 Invasive Species and Exotic Plants

Non-native (exotic) plant species, especially invasive ones, are likely to be found in urban forest fragments, due to the proximity of nearby gardens and the physical introduction of plants along trail systems. These species may also be encouraged where soil conditions, including nutrient levels, are affected by human use.

In general, there is a much higher abundance of non-native plants in urban versus rural areas. For example, in California, urbanized coastal plant communities are 40 per cent exotic, in contrast with 5 per cent exotic in interior mountain regions (Mooney *et al.* 1986 *In* Smallwood 1994).

Studies have shown differing results regarding the effects of exotic plants on bird communities, often negative but sometimes neutral. Most relevant is Schmidt and Whelan's (1999) study of the effect of a non-native Honeysuckle (*Lonicera maackii)* and Common Buckthorn (*Rhamnus cathartica)*, both shrub species present in southern Ontario, on nest predation rates. They found that predation of American Robin and Wood Thrush nests was greater when the nests were in the non-native shrubs versus the native species. They theorized that the exotic species either lacked the protection afforded by the thorns of the native hawthorns (*Crataegus* sp.*)* or that they had a different plant structure that made it easier for the predators to reach the nests.

In a study that examined a gradient of urban through rural areas in the Seattle, Washington region, native forest-bird species decreased with increasing amounts of exotic ground and shrub cover. Although the effect associated with landscape was explained by exotic ground and shrub cover it was unclear whether some correlated urban factor(s) was the cause (Donnelly and Marzluff 2004). In suburban Australia, native nectar producing plants produced more nectar and were the preferred foraging sites of nectarivorous birds in contrast with non-native nectar producing plants (French *et al.* 2004). Although this study is of less relevance for southern Ontario, as the ecosystem is very different in Australia and there are few nectarivorous species in Ontario, it is another example of non-native plants being less suitable for native birds. In contrast, in the different riparian habitats in the Mojave desert, the presence of an invasive plant did not affect the species richness of native birds (Fleishman *et al.* 2003).

In southern Ontario, studies that examine the influence of common invasive species (such as Garlic Mustard (*Alliaria petiolata)* and Common Buckthorn) on species such as the Wood Thrush and the Ovenbird would be a useful contribution.

2.6.3 Snags and Cavity Nesting Competitors

The majority of cavity nesting birds (e.g., nuthatches, woodpeckers) require snags within which to situate their nests. Cavity nesting birds might face steeper competition for cavities in urban

It is well-established that cowbirds can reduce host productivity in some species and in certain landscape contexts. In the context of other urban-related stressors, this could be an important additive effect. There is also evidence that, in some regions at least, the effect of cowbirds may be enhanced when urban development is present.

2.9 Noise

Jays and American Crows. These two species may be key avian nest predators in urban forests.

Shochat's (2004) discussion of urban nest predation states that it is difficult to assess whether urban predator abundance is lower or higher than in wild lands. It is likely that the species richness of predators will be lower in urban areas as some raptorial birds, snakes and mammals (such as weasels) might be absent or nearly so. However, the density of highly efficient nest predators that *prefer* urban and suburban environments may limit birds attempting to breed within forests in the urban matrix. To be productive, birds within urban forests such as High Park in the GTA, with its high populations of key predators (e.g., squirrels, Raccoons, Blue Jays, American Crows and Common Grackles), must be able to withstand potentially very high predation rates.

2.11 Predation by Urban-sponsored Non-native Predators

In southern Ontario, predation by urban-sponsored non-native predators is primarily the purview of pet cats that are permitted to range outdoors and perhaps rats. Various non-native pathogens that can affect survivorship and fitness of birds could also be included in this category.

While outdoor pet cats are clearly more abundant in urban areas than in rural areas (Lepczyk *et al.* 2003), their role as an important predator of forest birds is uncertain. Birds are generally cats' second-most-favoured prey group after mammals. Studies have found that birds constituted 24 per cent of prey items retrieved from cats (Woods *et al.* 2003; Gillies and Clout 2003). Most cats feed on at least some birds (47 per cent of cats caught birds according to Lepczyk *et al.* 2003 and up to 71 per cent caught birds according to Gillies and Clout 2003). The House Sparrow (a non-native, non-forest bird) is often the most frequent prey in urban areas (Gillies and Clout 2003). However, numerous other species have been recorded as being taken by cats (Gillies and Clout 2003; Lepczyk *et al.* 2003). In the latter study 23 bird species were taken in urban through rural Michigan. While most species identified were not forest area-sensitive species, a few were or might have been (e.g., nuthatch, Purple Finch (*Carpodacus purpureus)*). Also, Lepczyk *et al.* (2003) estimated that a minimum of about one bird/km/day (along a linear route) was killed by cats. Intuitively, one might suppose that juvenile birds are more susceptible to predation by cats that do venture into urban forests. However, the relative importance of juvenile birds to the overall population is much less, as mortality rates for young birds is known to be very high.

Outdoor cats generally range a maximum of 100 m to 200 m from their home base. Overall,

of raised nests, and may not even be major predators of other nests compared to other species such as Raccoons and Striped Skunks.

The role of rats in the urban environment is even less clear. There are many examples of the dramatic influence of rats on oceanic island bird communities. In a study of urban forest birds in Seattle, (Donnelly 2002), it was postulated that rats were the main cause of high predation rates of shrub-nesting birds.

2.12 Psychological and Social Behaviour

In a discussion of potential factors that led to a sharp decline in forest birds in plots that included residential dwellings, Friesen *et al*. (1995) noted the possibility that "A species psychological need for maintaining distance from houses (Whitcomb *et al.* 1981)…" may affect the presence of breeding birds. This was also postulated in a study of nesting worm-eating warblers in small woodlots, where the birds appeared to avoid buildings, although nesting success was not affected (Gale *et al*. 1997 *In* Mancke and Gavin 2000).

Morton (1992) also noted that there is evidence that neotropical migrants may be looking not just for habitat, but for a population with which to interact reproductively and that such social behaviour might require the presence of conspecifics.

Stressor	Likely Relative Importance	Notes

4. Setting Area-Sensitive Forest Breeding Bird Expectations for Urban Forest Reserves

In tackling the question *How Much Habitat is Enough?* for area-sensitive forest breeding birds it is necessary to understand the current community of area-sensitive forest breeding birds within urban areas. In the following chapter a selection of this evidence is presented.

4.1 Profiles of Area-Sensitive Forest Breeding Birds in Urban and Suburban Forests

To see what empirical evidence there is for area-sensitive forest breeding birds in forests within the urban matrix, a number of recent studies of forests within the urban matrix of the Greater Toronto Area were examined. Summaries of these are presented in the following sections.

4.1.1 Altona Forest, City of Pickering

Detailed territory mapping of breeding birds has been conducted in this forest for 1949/50, 1994/95, 1997 and 2000/01 (Henshaw 2001). The forest area is presently about 45 ha; it was somewhat larger prior to 1994, when portions of it were developed. Forest cover in the City of Pickering is approximately 18 per cent, most of which is located north of Altona Forest.

After normalizing data for area surveyed (now about a 9.9 ha core portion of the forest), the species residing in the area (including forest associated) have remained relatively constant over the period of record. This was in sharp contrast to a 70 per cent decline in the number of territories of neotropical forest-associated migrants. The number of neotropical bird species also declined from between seven and nine in 1949/50 to three to four in 2000/01. With only one exception (the Red-eyed Vireo (*Vireo olivaceous*)), species recorded were below the lowest densities generally reported in the literature. It is thought that if conditions do not change the only two neotropical migrants to persist in Altona Forest in the future would be the Red-eyed Vireo and the Great Crested Flycatcher (*Myiarchus crinitus)*.

The following area-sensitive forest birds are likely to persist at Altona Forest:

- Red-breasted Nuthatch (*Sitta canadensis)* (one pair)
- White-breasted Nuthatch (*Sitta carolinensis)* (one to three pairs)
- Wood Thrush (one to two pairs)

Resident forest-associated breeding species that dominated the avifauna of the forest were:

4.1.2 High Park, City of Toronto

High Park is approximately 150 ha of which, approximately 47 ha is forested (one 30 ha block, one 13 ha block and smaller blocks throughout). Large mature deciduous trees (largely oak) are also present in many areas around the park. A review of current and historical breeding birds

The following area-sensitive forest birds are usually present in multiple pairs at the Block 12 forest:

- Hairy Woodpecker (one to two pairs)
- White-breasted Nuthatch (several pairs)
- Brown Creeper (*Certhia americana)* (one to two pairs)
- Wood Thrush (several pairs)
- Black-throated Green Warbler (*Dendroica virens)*

Another study examined the species richness of forest breeding birds within TRCA jurisdiction using presence-absence data (Zajc and Murphy 2005). Only 12 area-sensitive forest species were found in the entire data set and among 485 forest patches that were identified, 80 per cent had no area-sensitive species. That study found that both patch and landscape variables may influence certain bird species and that urbanization was an important variable. However, the definition of urbanization and the scale of investigations (i.e., 800 m around patches defined "landscape area") may have influenced the outcome.

4.2 Potential and Actual Area-Sensitive Breeding Birds in the City of Toronto

Using the breeding bird data in the preceding subchapters, other published data on breeding birds in the GTA, monthly newsletters from the Toronto Ornithological Club and comments from Paul Prior of the Toronto and Region Conservation Authority, a palette of area-sensitive forest breeding birds for the Toronto area was prepared (Table 4). The purpose of this palette is to provide additional empirical evidence on which area-sensitive forest species can be expected to occur in forests within the urban matrix.

Only species that currently nest in south-central Ontario were included as potential area-sensitive forest breeding birds. Species were determined to be area-sensitive if they have been designated by the Ontario Ministry of Natural Resources in the *Significant Wildlife Habitat Technical Guide* (2000). To this group, a number of additional species were added. These were either thought to be area-sensitive in this region by Henshaw (pers. obs.) (i.e., Ruffed Grouse [*Bonasa umbellus*], Golden-crowned Kinglet [*Regulus satrapa*], White-throated Sparrow [*Zonotrichia albicollis*] and Purple Finch); and/or were so designated by other sources such as Freemark and Collins (1992) (Red-bellied Woodpecker [*Melanerpes carolinus*], Wood Thrush, Chestnut-sided Warbler [*Dendroica pensylvanica*], Northern Waterthrush [*Seiurus noveboracensis*], Louisiana Waterthrush [*Seiurus motacilla*], Mourning Warbler [*Oporornis philadelphia*] and Hooded Warbler).

Table 4. Potential GTA Area-sensitive Forest Breeding Birds and their Current Breeding Status in the City of Toronto *(and contiguous urban areas)*

Common Name	Scientific Name	Current Breeding Status in the City of Toronto
Sharp-shinned Hawk	*Accipiter striatus*	**V**, irregular, rare
Cooper's Hawk	*Accipiter cooperi*	**V**, irregular, rare
Northern Goshawk	*Accipiter gentilis*	**X**, generally absent
Red-shouldered Hawk	*Buteo lineatus*	**X**, generally absent
Broad-winged Hawk	*Buteo platypterus*	**X**, generally absent
Ruffed Grouse	*Bonasa umbellus*	**X**, generally absent
Barred Owl	*Strix varia*	**X**, generally absent
Yellow-bellied Sapsucker	*Sphyrapicus varius*	**X**, generally absent (occasionally on territory)

Of the 43 potential area-sensitive forest breeding birds only 14 occur as breeding birds with any regularity in the urban environment, and 29 species have been lost or have not expanded into the urban forests. Of the 14, nine are regular breeders, and five are considered to be “uncommon” or “fairly common”.

By way of example, a smaller less-urbanized area (about 2,000 ha) that is forested on the Oak Ridges Moraine (also within the GTA), supports about 33 species from this list, 30 of which are regular breeders, and about 24 of which are at least “fairly common” in abundance (not including the low density raptors) (B. Henshaw, unpub. data).

5. Maintaining Area-sensitive Forest Breeding Birds in the Urban Matrix – Is it Possible?

This report is primarily concerned with the maintenance of area-sensitive forest breeding bird populations. The *Framework* has presented an argument for maintaining at least 30 per cent of

Even if it were possible to determine a forest area that might preserve viable populations of these birds in the urban matrix, it would still be necessary to manage some of the stressors that a large human population will inevitably bring to bear on an attractive natural area. One has only to visit the popular Rouge River Park in Scarborough, or various conservation areas within the GTA to realize that human disturbance could be a very real factor in areas close to or within large populated areas.

Rather than trying to establish, whether a 1,000 ha forest or a 3,000 ha forest might be sufficiently robust using species-specific habitat quantity and quality thresholds, it is worth considering that forest areas of this size are not going to be realistically restorable within the existing urban matrix.

Based on this review an alternative approach that seeks to identify and protect existing forest cover well above the minimum 30 per cent threshold, before significant pressures of urbanization arrive, is the most practical and appropriate means to provide habitat for area-sensitive forest birds. To this objective could be added other forest cover metrics such as the big woods and aggregation of forest (clumping); native forest species, particularly long-distance migrants, were present and more abundant where forest was aggregated greater than 64 per cent (Donnelly 2002). This does not completely preclude restoring and enhancing existing urban forest patches to maintain other forest-associated bird species that are urban-tolerant or restoring urban forests for other ecological services they provide.

There is a tendency to rate woodlands in areas with the lowest forest cover as the most significant, over those in areas where forest cover is still at relatively high levels. In terms of area-sensitive forest birds at least, the opposite appears to be true. High forest cover and the big woods are likely to be more important for the conservation of forest birds in southern Ontario, not connected fragments.

In recent years, there has been a movement to use legislative tools (e.g., the *Oak Ridges Moraine Conservation Act*) to endeavour to protect natural areas/countryside from conversion to urban-land uses. This has led to increased planning controls over large areas of the Oak Ridges Moraine, and in 2005, to a *Green Belt Protection Act* and a larger growth plan for the greater Golden Horseshoe that extends beyond the Moraine. While there is very limited scope within existing built-up urban areas to provide viable habitat for area-sensitive forest birds, there is still opportunity to do so within the undeveloped portions of many ‘urban’ watersheds (i.e., outside of the existing urban limits). In many cases there are sufficient non-urban lands in the undeveloped portions of these watersheds that the 30 per cent threshold would be attainable. These areas could, in some way, help to begin to compensate for the lack of such habitat within the urban portion of the watershed; forest habitat could be maintained or restored to partially offset permanent loss in urban areas.

6. Restoring and Enhancing Urban Forests

It is very important to note that the provision of forest within the urban matrix produces a wide range of benefits for many, non-forest birds, migrant birds, some forest-associated breeding birds, a host of ecological and environmental services and many social benefits to the urban

Realize that Habitat Fragments May Not Support All Target Species

Many urban forest fragments will not support area-

7. Applicability of the *How Much Habitat is Enough?* Forest Guidelines in Urban Areas

How Much Habitat is Enough? A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern (2nd edition) (Environment Canada 2004) provides forest guidelines designed with Areas of Concern as the primary target, although the principles within them are applicable to many parts of Ontario. The forest guidelines are presented in Table 5.

Table 5. Summary of Forest-Habitat Guidelines from Environment Canada (2004)

Parameter	Guideline
Per cent forest cover	At least 30 per cent of the AOC watershed should be in forest cover.
Size of largest forest patch	A watershed or other land unit should have at least one 200 ha forest patch

corridors. In this instance guidelines pertaining to forest configuration and linkages, will assume greater importance when other conditions, such as total forest cover, decline. In particular, stressing the importance of percent forest cover will make the *Framework* more applicable in guiding restoration and conservation of forest habitat.

On a watershed basis, most *Framework* forest guidelines can currently still be met in the remaining non-urbanized portions of AOC watersheds through forest habitat protection and restoration. However, this opportunity will very likely be lost with continued conversion of watersheds to urban land use. Enhanced protection and restoration efforts in the non-urbanized portions of watersheds may even serve to mitigate and compensate for the loss of forest-bird habitat in urban portions of the watershed, although such efforts will not fully represent the range of bioregions within a watershed (e.g. the Carolinian life zone within the Toronto AOC).

In terms of urban forests directly, their inadequacy to support the original palette of area-sensitive forest birds, even after on-site mitigation and restoration, does not preclude their importance for other ecological values and functions. As noted in the *Framework*: "*new baselines for habitat and ecosystem functions may have to be established, and innovative systems devised to compensate for the effects of lost habitat and to mitigate the impact of urban centres on the surrounding landscape".* Urban forests must be assessed in terms of realistic expectations and ecological goals within the context of urban 'ecosystems'.

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10. Appendix 1: Suggested Research Questions

During the preparation of this report several key questions were recurrent themes either in the literature (e.g., Marzluff and Ewing 2001), or because of a lack of available information. Answers to the following suggested questions may benefit the study and conservation of forest breeding birds in the urban matrix.

Corridors

- How important are corridors to forest birds at different levels of forest cover levels; what is the use of corridors by detrimental fauna and flora; and what is the net benefit to breeding birds?

Predators

- Which are the key predators of nests in urban forests; are the predation rates elevated; and how are they supported in the urban matrix? What is the role of bird feeders or other supplemental food sources in this regard?
- Are Brown-headed Cowbirds more abundant in urban settings; if so, why? Do they impact forest birds in a significant way?
- Are urban forests 'sinks' for forest birds due to elevated predation rates?

Food Resources

- What is the effect of urban environment on insect assemblages in urban woodlots?
- To what extent are urban contaminants (including airborne contaminants) directly or indirectly limiting the productivity of forest birds?
- What is the effect of invasive plant species on forest habitats and breeding bird fecundity?

Ecological Planning

- What is the effect of increased 'urban greening' (i.e., more urban trees, natural areas within the urban matrix) on forest birds in southern Ontario?
- What is the difference in forest-bird viability in fragments adjacent to dispersed housing *versus* higher density subdivisions?
- Among forest birds, why are neotropical migrants particularly sensitive to residential housing? What is the role of psychological and/or social behaviour?
- What design guidelines can be applied to Protection Zones around forest fragments to maximize bird fitness without hindering inter-patch movements?
- Does urban light pollution negatively impact forest breeding birds?
- What are the effects of traffic noise of differing intensities on breeding birds in southern Ontario landscapes?