FINAL REPORT

Bird Conservation and Forest Management:

Synthesizing Science and Management Recommendations

Prepared for

Forest Resource Improvement Association of Alberta

Final Report
fRI Research Bird Conservation and Forest Management Project

June 27, 2018

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About the Authors

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Any opinions expressed in this report are those of the authors, and do not necessarily reflect those of the organizations for which they work, or fRI Research.

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Report Summary: Welcome to the fRI Research Bird Conservation Toolkit

Why this toolkit?

Forest managers are responsible for balancing many different values on the landscape—not only timber values and sustained yield, but also the environmental and social values and benefits provided by healthy, functioning forests. Forest birds are often highlighted to forest managers due to their obligations and commitments under the federal *Migratory Birds Conservation Act* and *Species at Risk Act*, provincial requirements, and voluntary corporate commitments and forest certification programs.

A Bird Conservation Workshop hosted by fRI Research in 2016 brought together representatives from industry, research, and government to discuss research and communication needs for more effective conservation of forest birds on managed landscapes. One key take-away of this workshop was that there are large volumes of information on forest birds, but that these are often too spread out, inaccessible, and extensive for time-constrained forest managers and planners to synthesize and apply them.

The objective of this toolkit is to compile, synthesize, and identify forest management applications for bird conservation at multiple scales: single species, broad habitats, and the overall landscape.

What this toolkit is

This document is intended to be used as a reference document, allowing forest managers and planners to access the information they need, at the level they need, when they need it. This toolkit is the result of an extensive review of published literature, species-at-risk documents, and government guidance documents. The extensive results were filtered for forest management opportunities and applications and summarized within short, plain-language accounts. The landscape-level and habitat-level syntheses are several pages long and single-species accounts were limited to one to two pages.

This toolkit is intended as a starting point for managers and planners looking to better understand how their management actions may be affecting species of interest at multiple scales, and to provide concrete options to include in their toolbox that will benefit a wide range of species. Potential applications include but are not limited to:

- A quick reference for species of management interest including species-at-risk.
- A training tool for forest planners, operators, and other staff.
- An extensive bibliography of additional references for deeper review when needed.
- Guidance for habitat and landscape level management that balances the needs of species that occupy forests of different ages and conditions.

- Identification of knowledge gaps encountered in the literature, including but not limited to under-studied species and important forest management questions.

Geographic scope

This toolkit encompasses species of management interest that live in forests in Saskatchewan, Alberta, and interior British Columbia. The geographic scope coincides with Bird Conservation Regions 4, 6, 9, and 10 (Fig. 1).

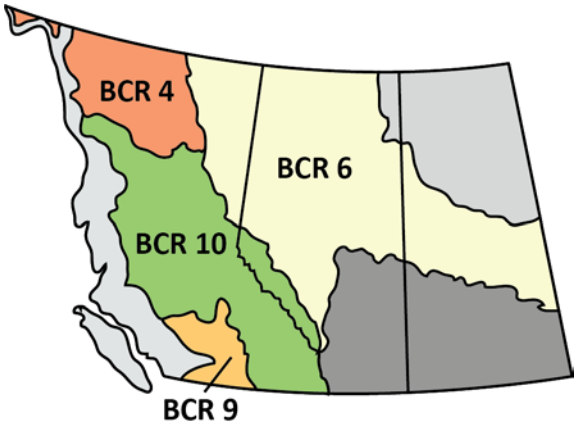

Figure 1. Geographic scope of the fRI Research Bird Conservation Toolkit.

What this toolkit is not

This toolkit is not prescriptive, nor is it aimed at single-species management approaches. Management recommendations should not be considered as "one-size-fits-all" solutions for either single species or entire forest types.

Numerical values have been provided where available (e.g., patch size, retention level) with the intention of providing concrete starting points for a *range* of approaches, and they are not intended to suggest that repeating a single harvest design will be effective from a bird conservation perspective.

The importance of effectiveness monitoring

The habitat management recommendations compiled within this toolkit are based on best available information, but they have been inconsistently tested across the wide range of management areas and landscapes of Canada's western interior (non-coastal) forests. See the Knowledge Gaps section for a more in-depth discussion of the need for effectiveness monitoring.

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Landscape-level Synthesis

Achieving sustainable forest management and bird conservation objectives within managed forests requires a consideration of landscape-level, stand-level and species-level considerations. Here we start by summarizing key considerations for forest managers at the landscape level to achieve forest management and bird conservation objectives.

Many of the principles below draw on the concept of natural range of variation (NRV), which is widely used in the management of forests in western Canada. Within the context of applying NRV strategies, it is important for managers to note that managing for variability within the entire range of forest conditions (or as close to the full range that is possible on a managed landscape), not just the average NRV conditions, is essential for realizing the potential of this management approach.[1] Specific areas where this can be achieved are emphasized throughout this section.

To aid in clarity of application, this section has been summarized into five key principles that can be applied at the landscape scale.

- Use NRV analyses to inform targets
    a. Manage for large forest patches while recognizing the limits of NRV on some landscapes
    b. Use NRV analyses to drive within-block retention levels and retention patch sizes and shapes
- Manage riparian areas for a diversity of conservation outcomes
- Manage for a range of stand types including mixedwoods and mixed-conifer types
- Manage for the full range of age classes that occur within an NRV analysis
- Respect the importance of naturally disturbed forests and manage salvage logging accordingly

Use NRV analyses to inform targets

Landscapes have historically been shaped by natural disturbances including wildfire, insect outbreaks, and smaller-scale processes including windthrow. Differences in disturbance size, severity, and frequency have shaped the composition, age, and distribution of forests, while intensive forest management (e.g., uniform two-pass clearcutting) have significantly changed the patterns of these forests.

Natural range of variation (NRV) analyses can be used to estimate the forest patterns that were found on the landscape before they were substantially altered through forestry, fire suppression, and other human impacts. Throughout this section, NRV is recommended for setting targets for forest stands of different age classes, composition, and for setting targets for the sizes of these stands.

Note: NRV analyses typically identify a range of patch sizes from very small to very large. The benefits of small patches (single trees to <1 ha patches, for example) to forest birds include but are not limited to song posts, perches, nest trees, roosting sites, cover from predators, and vantage points for hunting. However, the benefits of these small

patches are primarily discussed at smaller scales, and they are examined in greater detail within habitat-level syntheses and species-level accounts.

Manage for large forest patches and recognize the limits of NRV on some landscapes

Large forest patches are common on naturally disturbed landscapes[2] and are often characterized by uneven-aged patches caused by fire skips and natural openings. However, traditional forest harvesting approaches that focus on many small, even-aged disturbances as opposed to a few large, complex disturbances can change these patch size dynamics over time. This shift in disturbance sizes, combined with cumulative impacts of multiple industrial footprints, has shifted the fragmentation levels on managed landscapes. Small forest patches may be over-represented relative to the natural range of variation, for example on heavily fragmented landscapes where patches of old forest are smaller than expected, or landscapes with many dispersed harvest events that are smaller than the majority of natural disturbance events.[2] On other landscapes, patches of approximately the same size may be very common, with very small and very large forest patches under-represented,[3] reducing landscape-level habitat complexity.

Fragmentation can impact the species that occupy these landscapes, including forest birds. Large-scale, multi-species studies have generally concluded that it is the *amount* of habitat which is most important, and that birds as a whole (and biodiversity in general) respond more strongly to habitat loss than they do to habitat fragmentation.[4,5] However, many species have been identified as having strong habitat associations with large areas of continuous forest. On heavily fragmented landscapes, these species are negatively affected by shrinking habitat patches, increased edge effects, and increased density of large gaps which they may be reluctant to cross.[6–8] These species are also very often considered to be at-risk or of management concern, and they are expected to be sensitive to landscapes which are heavily fragmented by overlapping developments including agriculture, oil and gas, urban development, and forest management.

Large, complex forest patches are, therefore, important to a range of bird species now and in the future, and they are a key tool for reducing the overall fragmentation effects on sensitive bird species.[9,10] Large forest patches are expected to be consistent with NRV analyses in most western forests, however these large forest areas are most likely to be overlooked by NRV analyses that consider only a subset of NRV conditions rather than the full range. Mid- to large- sized fires (i.e., 10,000 to >100,000 ha) result in concentrated disturbances with a large number of unburned skips in a range of sizes; these large-scale dynamics are important for a wide range of bird species and help reduce fragmentation effects on species that depend on large, “intact” forests.[1]

In this sense, using NRV analyses to derive patch sizes at the landscape scale and to ensure that large patches of unfragmented forest are maintained now and in the future is an important step toward the conservation of some of the most sensitive bird species groups. It may be possible to maintain these stands through a planned time series of temporary or “floating” reserves under extended rotation management in addition to permanent set-asides and protected areas.[11] Edge reduction is recommended within these patches to the extent possible where conservation of old-forest associated species is desired. Long, narrow stands with high amounts of edge will support edge- and open-forest associated bird species that may outcompete old-forest associates, and birds near edges may be more

vulnerable to nest predation,[6,12] however nest predation is not generally considered the strongest effect in the boreal forest.[13]

> *(It is important to note that the majority of studies on edge effects were largely conducted in the first few years following harvest. Longer-term studies to assess whether the value of these features for species of older forest increases as the neighbouring forest regenerates is recommended (see Knowledge Gaps).)*

These large-scale patterns can be difficult to achieve in managed landscapes where there is a legacy of smaller harvest blocks or where multiple industrial footprints overlap (e.g., oil and gas). There are also physical limits on the amount of timber that can be harvested in a single year, and this amount may represent a small fraction of the area that may be disturbed by a very large fire event. These realities constrain management opportunities using an NRV approach and highlight the importance of considering cumulative effects. These cumulative effects both increase the importance of large, continuous forest areas as they become highly limiting on some landscapes, but they also limit the amount of control forest managers have over maintaining large, unfragmented forest stands. Recognizing the limits of NRV approaches on these busy landscapes will help guide management choices to balance the needs of forest management and bird conservation.

Use NRV analyses to drive within-block retention levels and retention patch size

NRV analyses can be used to assign a range of retention levels across forested landscapes to increase diversity. These same analyses can also help inform retention patch sizes, both within harvest blocks and making up the unharvested areas between blocks and on the passive landbase. One key consideration is that NRV analyses have shown that small unburned islands are more common within small (<100 ha) wildfire events but the frequency of large islands (>10 ha) increases as wildfire event size increases.[14,15] Forest planners may wish to increase the frequency of larger within-block retention patches (i.e., apply a few large patches rather than many small patches), particularly in harvest events that are 100–1,000 ha or larger.[14] Larger retention patches (generally exceeding 5–10 ha) may particularly benefit some bird species that are associated with interior forests, particularly as refugia within large aggregated harvests where a wider range of very large retention patches are possible.[16–19]

WHY RETENTION?

Retention harvesting is recognized as a key stand-level tool that can introduce complexity into the harvested matrix[20] and provide habitat features that are important to a wide range of bird species.[17,19] Individual trees can serve as song posts[21] or as perches for avian predators hunting in recently harvested areas.[22,23] Retention patches can help maintain or create nesting habitat/substrates, snags, and other important biophysical habitat features. Retention patches and stands containing dispersed retention have been shown to support many species of unharvested forest,[24] although it is important to note that the bird communities using these stands and/or patches retain slight differences from retention found in wildfire disturbances for many decades.[16]

Specific studies have provided inconsistent guidance on within-block retention patch sizes. Recommended sizes are fairly clear for some well-studied species groups (e.g., small clumps of trees plus patches >5 ha or larger for cavity nesters [see Cooke et al. 2010, page 20]),[19] while other studies have had limited sample sizes or studied a limited range of patch sizes.[16,17] Additionally, studies of retention patch sizes have most often used unharvested forest as a point of comparison rather than comparable natural disturbances. This remains, however, a useful comparison for intensively managed areas where old forest is limiting, and retention patches may play an important role as habitat islands for species of old forest. The value of comparisons with unharvested forest may depend on whether forest managers are more interested in providing habitat to maximize diversity or maintain typical post-fire bird communities.

More targeted study of within-block retention patch size thresholds may be necessary to provide guidance relative to specific conservation objectives: for example, are target species or groups successfully reproducing in retention patches in the short and medium term?

Figure 2. Small retention patch within a DMI harvest block. Photo by Jim Witiw (DMI).

Manage riparian areas for a diversity of conservation outcomes

Riparian areas represent important habitat for a wide range of bird species. They typically support higher bird abundances and more species than interior forests,[25] and they may support unique bird assemblages.[26] Many bird species feed on insects that congregate over and near open water, while adjacent forests provide important habitat for nesting and foraging for a wide range of species associated with riparian vegetation, open water, or both.[26,27] While many riparian areas must be protected according to regulatory requirements in Canada and in North America more broadly, others do not formally require buffers unless mandated by internal operating procedures. However, wet areas, draws, springs, vernal pools, and ephemeral streams are often used as anchor points for retention patches during block design.

It is important to note that the following information on edge effects within wide and narrow riparian buffers has relied largely on studies that were conducted in the first few years following harvest. Longer-term studies to assess

whether the value of these features for species of older forest increases as the neighbouring forest regenerates are recommended.

The value of narrow riparian buffers

Narrow (e.g., < 30 m) riparian buffers provide habitats for edge-associated, shrub-nesting, and generalist species. Provided streamside vegetation and habitat features (e.g., sandy banks) are left intact, these buffers have also been shown to effectively conserve species that nest, forage, and otherwise occupy the habitats immediately next to the stream, river, or lake's edge.[26] In many forest types, riparian zones are often characterized by deciduous trees (e.g., black cottonwood), which provide additional value to primary and secondary cavity nesters.

Among riparian-associated bird species, the importance of riparian buffers and minimum recommended widths varies. Some species, like Bank Swallows, nest directly in the stream bank and forage over open areas, and wide riparian buffers are not expected to benefit them except by protecting the banks from erosion or physical damage.[28]

The value of wide riparian buffers

Several studies comparing a range of buffer widths have found that the widest buffers—100 m or larger—provide habitat for many bird species that are typically found in upland (non-riparian) unharvested forests.[25,26,29,30] Additionally, studies and guidance documents consistently highlight the importance of wide buffers for some riparian species including the Canada Warbler and Pacific Wren, which are not only associated with older forests but are also typically found near streams.[27,31,32]

Increasing buffer widths using attached retention areas would be expected to improve the effectiveness of these buffers for conserving species of upland interior forest; however, this is may not be permitted in some jurisdictions. Note that this is recommended as only one of many options and not as a replacement for large unharvested upland areas intended as refugia for old-forest bird species on harvested landscapes.[29,33]

Beyond the legal mandate

Many studies of the associations between birds and riparian buffers have focused on the range of legally-required riparian buffer areas; however, some studies have recommended management strategies that do not fall cleanly within the legal framework, including voluntary buffering and (approved) partial harvesting of riparian buffers.

Voluntary buffers: the Canada Warbler, a nationally Threatened species, was found to be most common in Alberta in old (>80 years) deciduous forest, particularly near small, incised streams.[32] These streams may not be automatically protected by riparian buffers, and both voluntary buffers and voluntarily exceeding minimum buffer widths are recommended in areas of high habitat value to Canada Warbler (e.g., areas with known high densities of breeding pairs).

Partial harvest of buffers: there has been significant debate both operationally and scientifically about the role of riparian buffers and inconsistencies between fixed-width buffers and natural disturbance patterns (e.g., wildfire). Generally, studies have shown that partially-harvested buffer areas are positively associated with early-seral, shrub-nesting, and/or habitat generalist species (e.g., Least Flycatcher) and negatively

associated with "forest interior" species (e.g., Ovenbird) as harvest intensities increase.[30,34] Riparian areas with low harvest intensities (i.e., 20–33% basal area removal) continued to function as movement corridors after the breeding season.[34]

The question of variable vs. fixed-width buffers remains in early stages of research, and studies continue to stress the importance of the landscape context. On the one hand, increased variability of riparian buffers may provide a greater diversity of habitats for riparian species that live in early-seral, shrubby, post-disturbance riparian areas.[35] On the other hand, wide riparian buffers may represent the majority of continuous unharvested old forest within an intensively managed landscape.[34,35] Studies of harvest within buffers typically suggest off-setting this harvest by leaving an equal volume of merchantable timber as large upland retention patches for maximum benefit.[34,35] While emerging research suggests that a more diverse approach to riparian management has promise, further studies are needed to provide specific guidance that includes the landscape context and does not compromise the primary objectives of riparian buffers (e.g., water quality).

Manage for a range of stand types including mixedwoods and mixed-conifer types

Habitat diversity at a landscape scale is a key contributor to bird diversity in forested areas.[36,37] Mixedwood and mixed-conifer stands are typically more species-rich and contain higher abundances of birds than pure stands, and they provide habitat for birds that require multiple tree species to meet their foraging, nesting, and cover needs.[38,39]

In western Canada, several mixed forest types occur. Mixed coniferous-deciduous forests in Alberta, northern BC, and Saskatchewan are most often composed of white spruce and aspen/poplar, but pine/aspen and spruce/birch mixed stands are also common. Mixed-conifer forests include jack pine/black spruce in Saskatchewan, and several conifer species mixes occur along moisture and elevational gradients in BC.

Maintaining the diversity of mixed forests at the landscape scale therefore appears to be important for bird species, contributing to a diversity of habitats and areas with high bird abundance. Managing the amount of mixed forest at the landscape scale to be consistent with NRV is seen as a key first step. In the case of coniferous-deciduous mixedwood forests, silvicultural techniques may also be used to encourage the development of mixedwood forests over time. This may include thinning, underplanting with conifers, or retention harvesting.

In the case of moist to wet mixed-conifer forests (e.g., western hemlock/western redcedar), some of these forests are characterized by very few stand-replacing fires (e.g., fire-return interval of up to 1,200 years in some very wet sites).[40] As a result, the natural range of variation for these forests is expected to include larger areas of forest much older than the harvest rotation age, in some cases by centuries. Identifying opportunities at the landscape scale to maintain these mixed forests beyond rotation age will provide key benefits to bird species that regularly use them. This may occur within protected areas and the passive landbase, however managers should be careful to ensure that these habitats are not all small, fragmented patches. In cases where harvesting does occur, harvest and regeneration strategies that favour species mixes representing the full range of preharvest overstory tree species are strongly recommended.

MANAGE FOR THE FULL RANGE OF AGE CLASSES THAT OCCUR WITHIN AN NRV ANALYSIS

Forests across a wide range of successional stages provide different habitat features at multiple scales for many bird species. As these forests age, are disturbed, and regenerate, the amount of these habitats and habitat features changes over time and space, as do the kinds of birds that reside in them. In any given year, the amounts of young, intermediate, mature, and old forest may change on the landscape, but their relative amounts typically fall within a given range determined by the natural range of variation.

Many species require early successional forests: young, open forests provide foraging opportunities for many raptors and open- and edge-associated species (e.g., sparrows and flycatchers), while dense regenerating shrubs, saplings, and seedlings provide valuable nesting and foraging habitat for a wide range of species including many warblers and vireos. However, mature and old forests are also important for many forest birds.[8] Structural diversity, understory diversity, and the presence of snags and cavity trees within these very old forests are important for a wide range of bird species.

Figure 3. A Black-capped Chickadee flies through a 15-year regenerating harvest block at the EMEND Project in northwestern Alberta. Photo by S. Odsen

WHY ARE VERY OLD FORESTS IMPORTANT?

Many of the species that are most abundant in very old forests require habitat features which are typically rare or absent from stands that are at or near rotation age. The very features that reduce a stand's overall economic value provide essential features for many birds (and other wildlife), including but not limited to:

- Large-diameter dead or dying trees: excavated by cavity nesters and reused by secondary cavity nesters.
- Snags, stumps, and downed wood: insect infestations provide food for woodpeckers, and downed wood provides cover for some ground-nesting species. Fallen or leaning logs often help young owlets move around the forest.
- Gap dynamics: small gaps are created as single trees or small clumps die, allowing sunlight to penetrate and understory vegetation to grow within the gap. Many birds associated with older forests hunt in small gaps,

nest and forage in understory vegetation, or benefit from the increased complexity and layering that results as new trees regenerate within the gap.

NRV analyses are a key opportunity for representing a diversity of stand ages within managed landscapes. Standard even-aged management produces a landscape that heavily represents stands up to and including the rotation age on the active landbase, but may not provide for older upland forest habitats outside of the passive landbase and the important features they provide for bird species—many of which are considered old forest specialists.[41] In order to fully represent NRV conditions, it will be important to consider the full range of forest ages and conditions that occur within the NRV, including stands that exceed the rotation age. Careful attention to modelling assumptions related to average disturbance return interval will also be important to ensure that modelling reflects the conditions relevant to local landscapes. Planning for floating reserves or areas where stands will grow beyond the rotation age in the future is also a key opportunity for landscape-level planning.

Respect the importance of naturally disturbed forests and manage salvage logging accordingly

Fire is an important process in many forests in western Canada, and several bird species either benefit from, or specialize on, the set of conditions found during the first 5–10 postfire years within burned stands. Recently burned forests contain high densities of snags which immediately attract large numbers of bark beetles and other fire-associated, deadwood-associated insects, which in turn attract insectivorous birds. These burned forests also provide open areas for hunting and nesting, and standing dead and live trees for perching. Some forests (e.g., ponderosa pine) were historically kept open by frequent low-intensity fires, which burn away the understory and often prevent encroachment of shade-tolerant tree species. Black-backed Woodpeckers, Lewis's Woodpeckers, and Common Nighthawk are all species of management concern that specialize on the habitat conditions created by fire. Many other species, including Olive-sided Flycatcher, Northern Hawk Owl, and Bank Swallow include burned-over areas among their preferred habitats.

Figure 4. Juvenile Northern Hawk Owl in a burned stand within the Hinton Wood Products (West Fraser) FMA. Photo by S. Goward (West Fraser).

The combined effects of fire suppression and salvage logging have resulted in important changes to burned forests and the species that specialize on these habitats.[42] For example, in areas with naturally frequent, low-intensity fire regimes, fire suppression has shifted open forests with large-diameter veteran trees to thick stands containing high densities of younger trees (e.g., Douglas-fir).[43] Similarly, species and assemblages that rely on very high snag densities for foraging and nesting (e.g., Black-backed Woodpecker) have a negative response to salvage logging.[44–46] Of importance to landscape-level management is the finding that bird species most strongly associated with burned forests are less well-represented within harvest blocks containing retention, compared with shrub-associated and open-habitat bird species typical of burned-over areas.[16,18,41]

Recently burned forests are, therefore, still an important component of the landscape, providing important habitat to many bird species including specialist species of management concern. Maintaining burned stands on the landscape and avoiding salvage logging in at least some burned stands is an important consideration for forest planners.

High snag retention is strongly recommended where salvage logging cannot be avoided.[a] Retained snags should include high densities of smaller-diameter trees for foraging, large-diameter trees for nesting, and very tall, isolated trees for perching. Small, fully-cleared areas will likely benefit species that hunt and forage in openings, however these should be balanced against high snag retention and large patches elsewhere within the salvage logged stands. Finally, managers are encouraged to focus efforts on salvaging the largest burned areas first, leaving smaller burns to provide habitat across a larger total area, and to delay salvaging for ≥1 years if possible to provide important habitat for one or more breeding seasons for specialist species. As the merchantable value of burned timber declines sharply over time since the fire, the limitations of this approach are recognized. Nevertheless, careful delays within the salvage harvest sequence, combined with strategic retention of snags within harvests, are expected to yield benefits for fire-associated species which are otherwise not well-represented within harvested, unburned stands.

Figure 5. Some species like this Black-backed Woodpecker specialize on recently-burned forest habitats. Photo by G. Romanchuk.

[a] Operators, planners and managers face safety and regulatory limitations that may disallow intentional retention of snags. Recommendations for snag retention during salvaging are not to be applied where they contravene regulatory requirements or may endanger workers. Rather, recommendations are provided to allow managers to identify opportunities to retain snags while remaining in compliance, and to capture the benefits of areas left unsalvaged due to accessibility constraints. Using patches may be an opportunity to achieve both ecological and safety objectives.

REFERENCES: LANDSCAPE-LEVEL SYNTHESIS

1. Andison, D. W., Belisle, A. C., Bergeron, Y. & MacLean, D. 2016. *Towards a Natural Range of Variation (NRV) Strategy for the CBFA*. Prepared for the Canadian Boreal Forest Agreement, Vancouver, BC. 65 pp. Available online: http://cbfa-efbc.ca/wp-content/uploads/2016/11/NRVTechnicalReport_July2016COMPRESSED_FINAL.pdf
2. Andison, D. W. 2002. *What's the Deal with "Fragmentation"?* FMF Natural Disturbance Program Research Quicknote #14, Foothills Model Forest, Hinton, AB. 1p. Available online: https://friresearch.ca/sites/default/files/null/HLP_2002_05_Qknte14_WhatstheDealwithFragmentation.pdf
3. Bonar, R. 2018. Personal communication. April 6, 2018
4. Schmiegelow, F. K. A. & Mönkkönen, M. 2002. Habitat loss and fragmentation in dynamic landscapes: Avian perspectives from the boreal forest. *Ecological Applications* **12:** 375–389. Available online: http://www.jstor.org/stable/3060949
5. Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. *Annual Review of Ecology, Evolution, and Systematics* **34:** 487–515. Available online: http://www.jstor.org/stable/30033784
6. Faaborg, J., Brittingham, M., Donovan, T. & Blake, J. 1995. Habitat fragmentation in the temperate zone: a perspective for managers. Pages 357–380 in *Ecology and Management of Neotropical Migratory Birds* (Martin, T. E. & Finch, D. M., eds.) 357–380. Oxford University Press, New York, NY. Available online: https://www.fs.fed.us/rm/pubs_rm/rm_gtr229/rm_gtr229_331_338.pdf
7. Rail, J.-F., Darveau, M., Desrochers, A. & Huot, J. 1997. Territorial responses of boreal forest birds to habitat gaps. *The Condor* **99:** 976–980. Available online: http://www.jstor.org/stable/1370150
8. Rempel, R. S. 2007. Selecting Focal Songbird Species for Biodiversity Conservation Assessment: Response to Forest Cover Amount and Configuration. *Avian Conservation and Ecology* **2:** 6. Available online: http://www.forestco-op.ca/files/birds_workshop/ACE-ECO-2007-2.pdf
9. Alberta Environment and Sustainable Resource Development. 2014. *Black-Throated Green Warbler, Bay-Breasted Warbler and Cape May Warbler Conservation Management Plan 2014-2019*. Alberta Environment and Sustainable Resource Development. Species at Risk Conservation Management Plan No. 10, Edmonton, AB. 33 pp.
10. Alberta Sustainable Resource Development. 2003. *Status of the Brown Creeper (Certhia americana) in Alberta*. Alberta Sustainable Resource Development, Fish and Wildlife Division, and Alberta Conservation Association, Wildlife Status Report No. 49, Edmonton, AB. 30 pp.
11. Environment Canada. 2013. *Bird Conservation Strategy for Bird Conservation Region 6: Boreal Taiga Plains*. Canadian Wildlife Service, Environment Canada, Edmonton, Alberta. 288 pp.
12. Batáry, P. & Báldi, A. 2004. Evidence of an edge effect on avian nest success. *Conservation Biology* **18:** 389–400. Available online: http://www.jstor.org/stable/3589218
13. Bayne, E. 2018. Personal communication. May 15, 2018
14. Andison, D. W. 2004. *Island Details : Relevant Patterns or Trivial Pursuits ?* Natural Disturbance Program Quicknote #29. Foothills Model Forest, Hinton, AB. 1p. Available online: https://friresearch.ca/resource/healthy-landscapes-program-quicknote-29-island-details-relevant-patterns-trivial-pursuits
15. Eberhart, K. E. & Woodard, P. M. 1987. Distribution of residual vegetation associated with large fires in Alberta. *Canada Journal of Forest Research* **17:** 1207–1212. Available online: http://www.nrcresearchpress.com/doi/pdf/10.1139/x87-186
16. Schieck, J. & Hobson, K. A. 2000. Bird communities associated with live residual tree patches within cut blocks and burned habitat in mixedwood boreal forests. *Canadian Journal of Forest Research* **30:** 1281–1295. Available online: http://www.scopus.com/inward/record.url?eid=2-s2.0-0033780243&partnerID=40&md5=8fd79c66f64c3a4d61853a11c7f5da7f
17. Venier, L. A. *et al.* 2015. Benefits of aggregate green tree retention to boreal forest birds. *Forest Ecology and Management* **343:** 80–87. Available online: http://dx.doi.org/10.1016/j.foreco.2015.01.024
18. Van Wilgenburg, S. L. & Hobson, K. A. 2008. Landscape-scale disturbance and boreal forest birds: Can large single-pass harvest approximate fires? *Forest Ecology and Management* **256:** 136–146. Available online: https://doi.org/10.1016/j.foreco.2008.04.017
19. Cooke, H. A., Hannon, S. J. & Song, S. J. 2010. *Conserving Old Forest Cavity Users in Aggregated Harvests with Structural Retention*. Sustainable Forest Management Network, Edmonton, AB. 36 pp. Available online: https://doi.org/10.7939/R3JQ0SW3P
20. Lindenmayer, D. B. & Franklin, J. F. 2002. *Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach*. Island Press, Washington, DC. 342 pp.
21. Beck, M. J. & George, T. L. 2000. Song post and foraging site characteristics of breeding Varied Thrushes in northwestern California. *The Condor* **102:** 93. Available online: https://doi.org/10.1650/0010-5422(2000)102[0093:SPAFSC]2.0.CO;2
22. Piorecky, M., Beck, B., Beck, J. & Bonar, R. 1999. Great Gray Owl year-round habitat: Habitat suitability index model (version 3). *USDA Forest Service General Technical Report* Available online: https://friresearch.ca/sites/default/files/null/HSP_1999_10_Rpt_GreatGrayOwlYearRoundHabitat.pdf
23. BC Ministry of Forests Lands and Natural Resource Operations. 2013. *Guidelines for Raptor Conservation during Urban and Rural Land Development in British Columbia (2013)*. Victoria, BC. 151 pp. Available online: http://www.env.gov.bc.ca/wld/documents/bmp/raptor_conservation_guidelines_2013.pdf
24. Odsen, S. G. 2015. *Conserving Boreal Songbirds Using Variable Retention Forest Management*. Master of Science. Dept. Renewable Resources, University of Alberta, Edmonton, AB. 84 pp.
25. Marczak, L. B. *et al.* 2010. Are forested buffers an effective conservation strategy for riparian fauna? An assessment using meta-analysis. *Ecological Applications* **20:** 126–134. Available online: http://onlinelibrary.wiley.com/doi/10.1890/08-2064.1/abstract
26. Lehmkuhl, J. F. *et al.* 2007. Breeding birds in riparian and upland dry forests of the Cascade Range. *Journal of Wildlife Management* **71:** 2632–2643. Available online: http://www.jstor.org/stable/4496384
27. Waterhouse, F. L., Harestad, A. S. & Ott, P. K. 2002. Use of small streams and forest gaps for breeding habitats by winter wrens in coastal British Columbia. *Northwest Science* **76:** 335–346. Available online: https://research.wsulibs.wsu.edu/xmlui/bitstream/handle/2376/924/v76 p335 Waterhouse et al.PDF?sequence=1&isAllowed=y
28. Falconer, M. 2018. Personal Communication. March 22, 2018.
29. Hannon, S. J. *et al.* 2002. Abundance and species composition of amphibians, small mammals, and songbirds in riparian forest buffer strips of varying widths in the boreal mixedwood of Alberta. *Canadian Journal of Forest Research* **32:** 1784–1800. Available online: https://doi.org/10.1139/x02-092

30. Kardynal, K. J., Morissette, J. L., Van Wilgenburg, S. L., Bayne, E. M. & Hobson, K. A. 2011. Avian responses to experimental harvest in southern boreal mixedwood shoreline forests: implications for riparian buffer management. *Canadian Journal of Forest Research* **41:** 2375–2388. Available online: http://www.nrcresearchpress.com/doi/abs/10.1139/x11-145
31. Pearson, S. F., Giovanini, J., Jones, J. E. & Kroll, A. J. 2015. Breeding bird community continues to colonize riparian buffers ten years after harvest. *PLoS ONE* **10:** e0143241. Available online: https://doi.org/10.1371/journal.pone.0143241
32. Ball, J. R. *et al.* 2016. Regional habitat needs of a nationally listed species, Canada Warbler (Cardellina canadensis), in Alberta. *Avian Conservation and Ecology* **11:** 10. Available online: http://www.ace-eco.org/vol11/iss2/art10/
33. Morissette, J. & Donnelly, M. 2010. *Riparian Areas: Challenges and opportunities for Conservation and Sustainable Forest Management*. Sustainable Forest Management Network, Edmonton, AB. 56 pp. Available online: https://era.library.ualberta.ca/files/kh04dq598/SR_2010_Morrissette-Donnelly_RiparianAreas_En.pdf
34. Holmes, S. B., McIlwrick, K. A., Kreutzweiser, D. P. & Venier, L. A. 2017. Riparian partial harvesting and upland clear cutting alter bird communities in a boreal mixedwood forest. *Forests* **8:** 10–13.
35. Kardynal, K. J., Hobson, K. A., Van Wilgenburg, S. L. & Morissette, J. L. 2009. Moving riparian management guidelines towards a natural disturbance model: An example using boreal riparian and shoreline forest bird communities. *Forest Ecology and Management* **257:** 54–65.
36. Roth, R. R. 1976. Spatial heterogeneity and bird species diversity. *Ecology* **57:** 773–782. Available online: http://www.jstor.org/stable/1936190
37. Freemark, K. E. & Merriam, H. G. 1986. Importance of area and habitat heterogeneity to bird assemblages in temperate forest fragments. *Biological Conservation* **36:** 115–141. Available online: https://doi.org/10.1016/0006-3207(86)90002-9
38. Hobson, K. A. & Bayne, E. M. 2000. Breeding bird communities in boreal forest of western Canada: Consequences of 'unmixing' the mixedwoods. *The Condor* **102:** 759–769. Available online: http://www.jstor.org/stable/1370303
39. Cavard, X., Macdonald, S. E., Bergeron, Y. & Chen, H. Y. H. 2011. Importance of mixedwoods for biodiversity conservation: Evidence for understory plants, songbirds, soil fauna, and ectomycorrhizae in northern forests. *Environmental Reviews* **19:** 142–161. Available online: https://doi.org/10.1139/a11-004
40. Forest Practices Board. 2008. *Biodiversity in the Interior Cedar-Hemlock Forests Near Dome Creek*. Complaint Investigation 070762. Available online: https://www.bcfpb.ca/wp-content/uploads/2016/04/IRC137-Biodiversity-in-Interior-Cedar-Hemlock-Forests.pdf
41. Schieck, J. & Song, S. J. 2006. Changes in bird communities throughout succession following fire and harvest in boreal forests of western North America: literature review and meta-analyses. *Canadian Journal of Forest Research* **36:** 1299–1318. Available online: https://doi.org/10.1139/x06-017
42. Thorn, S. *et al.* 2017. Impacts of salvage logging on biodiversity: A meta-analysis. *Journal of Applied Ecology* **55:** 279–289. Available online: https://doi.org/10.1111/1365-2664.12945
43. COSEWIC. 2010. *COSEWIC assessment and status report on the Lewis's Woodpecker Melanerpes lewis in Canada*. Committee on the Status of Endangered Wildlife in Canada, Ottawa. x + 23 pp.
44. Saab, V. A. & Dudley, J. G. 1998. *Responses of cavity-nesting birds to stand-replacement fire and salvage logging in ponderosa pine/Douglas-fir forests of southwestern Idaho*. Research Paper RMRS-RP-11, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogen, UT. 17 pp. Available online: https://www.fs.usda.gov/treesearch/pubs/23853
45. Koivula, M. J. & Schmiegelow, F. K. A. 2007. Boreal woodpecker assemblages in recently burned forested landscapes in Alberta, Canada: Effects of post-fire harvesting and burn severity. *Forest Ecology and Management* **242:** 606–618. Available online: https://doi.org/10.1016/j.foreco.2007.01.075
46. Morissette, J. L., Cobb, T. P., Brigham, R. M. & James, P. C. 2002. The response of boreal forest songbird communities to fire and post-fire harvesting. *Canadian Journal of Forest Research* **32:** 2169–2183. Available online: http://www.nrcresearchpress.com/doi/10.1139/x02-134

Habitat Synthesis: Deciduous-dominated Forest

The main merchantable deciduous species of western Canada are trembling aspen, balsam poplar, and black cottonwood, all of which are relatively short-lived compared with most conifer species. Other common deciduous species include birch, alder, willow, and other tall shrubs. Western deciduous forests are known for containing high diversities of bird species across many successional stages,[1–4] with the greatest number of species typically in old stands (e.g., 80–110 years).[5]

Many of the species found in deciduous-dominated forests are also found in deciduous-coniferous mixedwood forests (see *Coniferous-Deciduous Mixedwood Habitat Synthesis* for more information).

Habitat Ecology

- The main natural disturbance events affecting western deciduous forests include fire, insect outbreaks, and floods. Aspen and poplar quickly overtake many disturbed sites where they were present prior to disturbance.[2,3]
- Fire size and the amount, distribution, and species of trees left as fire skips vary by region and depend on the area's natural range of variation (NRV). Deciduous stands may act as natural firebreaks, particularly in the late spring and summer seasons when leaves are out.[2]
- Forest tent caterpillar outbreaks can lead to defoliation of large areas, which may affect stand composition.[6]
- Deciduous forests have declined in some areas due to drought,[7] fire suppression,[8] insect and pathogen outbreaks,[9] climate change,[9] and interactions among these factors.

Forest tent caterpillars

Forest tent caterpillar outbreaks are an important natural disturbance agent in deciduous-dominated forests, where they can defoliate massive areas during outbreak years. Birds are an important predator, however few species specialize on them (although two spruce budworm specialists, the Cape May Warbler and Bay-breasted Warbler, are considered major predators of forest tent caterpillars during outbreak years[10,11]).

The main effects of forest tent caterpillar outbreaks on bird populations are 1) increased population densities in response to increased food resources[12,13] and 2) increased proportions of early-seral or mixedwood-associated bird species in areas of high mortality or altered stand composition caused by defoliation.[6]

Bird Responses to Forest Management/Disturbance in Deciduous Stands

Many of the bird species associated with deciduous forests take advantage of the various nesting and foraging opportunities provided by well-developed understory and shrub layers.[14]

Another important species group is the cavity nesters, many of which specialize on deciduous trees as heart rot (which is less common in conifers) can make these trees species easier to excavate than others. Many species nest in old cavity nests, including owls, ducks, songbirds, and even mammals.

- **Even-aged management and short-rotation clearcutting** push intensively-managed deciduous forests outside of their natural range of variation (NRV) at the stand level. They do this by limiting the amount of large-diameter snags and senescent trees, which are of low or no merchantable value but high value as wildlife habitats.[15]
- **Fragmentation** of large forests into smaller, isolated patches has had mixed effects on bird species. While some species have been negatively affected by fragmentation (e.g., Connecticut Warbler[16] and Ovenbird[17]), other species of concern appear to be somewhat resilient to fragmentation (e.g., Canada Warbler[18,19]). However, habitat management recommendations for these species have consistently identified the importance of large, unharvested areas for providing high quality habitat for breeding pairs.
    - The **cumulative fragmentation** effects of harvesting and linear features (e.g., seismic lines, roads) are expected to have significant negative effects on forest birds, particularly in areas of high densities of both footprints and where linear features cross through old forests at high densities.[20]

Stand-level Management Recommendations

Retention harvesting supports a greater diversity of bird species (including parkland species, species of old forests, and species associated with a well-developed understory) and faster recovery of species associated with mid- and late-seral deciduous habitat features.[14,24] To maximize the value of retention, the following features should be captured in retention patches when and where feasible (see Table 1 for species-specific examples).

- **Large-diameter, live deciduous trees** provide important nesting and foraging habitat for woodpeckers and the species that reuse their old cavity nests.
    - Trembling aspen is an important nest tree species for cavity nesters. **Live**[b] **aspen >35 cm dbh with several (e.g., ≥10) false tinder conks and/or other signs of disease and damage** should be prioritized as retention patch anchors, as these are highly likely to be excavated by primary cavity nesters (e.g., Northern Flicker, Pileated Woodpecker, and Yellow-bellied Sapsucker), providing long-term value to both primary and secondary cavity nesters.[25–27]
    - **Riparian black cottonwood (>60 cm dbh)** is an important species for cavity nesters, including the Threatened Lewis's Woodpecker,[28] and secondary cavity nesters including the Western Screech-Owl,[22] Common Merganser and Barred Owl.[29]
- **Large-diameter snags, stumps, and downed wood** are typically infested with insects, providing valuable food resources to woodpeckers in particular (e.g., carpenter ants).[30]
    - Features with **broken tops and large cavities** (natural or excavated) provide valuable nesting habitat to larger nesters including Barred Owls.[31]

[b] The importance of retaining live deciduous trees with heart rot is emphasized, as these will remain standing for longer than most deciduous snags containing cavities. They will also provide nesting habitat to a wide range of species as the internal cavity becomes larger over time.[27]

- **Patches of coniferous trees** provide stand-level complexity and may increase bird diversity by providing habitat for species associated with mixedwood forests.[32]
- Many deciduous-associated bird species require a **well-developed shrub layer** for nesting, foraging, and cover. These typically only develop on richer ecosites in fairly open stand conditions, so managers are encouraged to identify these situations and develop prescriptions accordingly.[29] Target species include but are not limited to beaked hazelnut, alder, willow, birch, and fruiting shrubs at a range of heights.
    - Likewise, post-harvest silviculture that **avoids shrub suppression** in deciduous stands will benefit shrub-associated species.[33,34]
- Retention of **young, vigorous deciduous trees** (e.g., aspen >12 cm dbh or paper birch poles) provides foraging habitat for sapsuckers[26] and other species that feed off sap wells.[35]

ROLE OF THE PASSIVE LANDBASE

Riparian and lowland deciduous forests (e.g., riparian black cottonwood) are primarily represented on the passive landbase within required riparian buffers[21] and in otherwise inaccessible, protected, or non-merchantable stands (e.g., steep slopes).

Merchantable, upland deciduous stands within the passive landbase are expected to contribute to the habitat needs of bird species associated with older upland forests. Their value to species that specialize on old forest features increases with stand age and size, and it decreases with increasing fragmentation.

Riparian buffers contribute habitat for both riparian and upland species, however their value to each may vary according to their width. Buffers ≥100 m wide are generally considered necessary to provide habitat for upland species associated with mature and old forests, and buffers are generally not considered substitutes for upland unharvested areas. See the *Landscape-level Synthesis* for a discussion of riparian buffers and NRV.

Bird species associated with riparian and otherwise wet deciduous habitats include the federally listed Canada Warbler and Western Screech-Owl.[18,22] These and other riparian species may be found near smaller and/or non-fish-bearing streams, meaning they are not protected by the same buffers as larger, fish-bearing streams. Voluntary buffering of these smaller streams, and voluntarily increasing with widths of required buffers, is recommended in areas that are predicted or known to provide significant benefit to identified species of concern.[18,23]

LANDSCAPE-LEVEL MANAGEMENT RECOMMENDATIONS

Uneven-aged management improves the complexity of deciduous forests at multiple scales, including the landscape scale. Unharvested retention patches, set-asides, and passive areas (e.g., riparian buffers, wet areas, or inaccessible stands) contribute to this complexity and provide present or future old forest habitat features for species that depend on older forests.

- **Patches of deciduous forest** within conifer-dominated landscapes are associated with high bird abundances, particularly species that forage for insects in the leafy canopy.[36] Retention of deciduous forest patches increases overall landscape diversity and may be a strategy that maximizes conservation gains.

- **Large, mature/old unharvested deciduous forests**, whether part of the passive landbase, extended rotation stands, or areas set aside to contribute to NRV targets, will provide greater habitat value to these species associated with old forests than stand-level retention or small unharvested remnants alone.
    - The most area-sensitive species include the Western Screech-Owl, Ovenbird, and Canada Warbler, for whom minimum recommended stand sizes are >10 ha (late-seral riparian), >28 ha (mature with thick leaf litter), and >100 ha (wet/riparian forest >80 years), respectively. Please note these are **minimum recommended sizes** and would typically only support a few breeding pairs. **Large tracts of deciduous forest as would occur within an NRV scenario are also critically important**.
        - Evidence of edge effects for some species (e.g., Ovenbird) suggests that long, linear stands (e.g., riparian buffers) are not a replacement for rounder upland stands containing more core habitat.
    - For some species, retention appears to provide habitat value mainly on landscapes with low human footprint (e.g., Barred Owl),[37] while others do not benefit from retention unless at levels which are generally operationally unrealistic (e.g., 30–50% retention for Canada Warbler).[24,33,38]
- Landscapes managed within the natural range of variation, including naturally-disturbed and older-than-rotation stands of various sizes, are expected to provide higher habitat value for a greater number of species than even-aged management. See *Landscape-Level Synthesis* for a more in-depth description of NRV.
    - Recently burned forests are considered an important component of NRV which cannot be fully emulated by harvesting.[14,39,40] Delayed, reduced-intensity, or avoided salvaging of burned stands is generally recommended wherever operationally feasible and/or in compliance with provincial regulations.[13,41–43]

Figure 6. A Pileated Woodpecker nest in an aspen tree. Photo by G. Romanchuk.

YOUNG AND MID-SERAL FORESTS

Openings created by harvest and fire support many bird species of open, parkland, and edge habitats (e.g., Chipping Sparrow) as well as habitat generalists (e.g., White-throated Sparrow).[14]

Disturbed openings containing large, live residual trees (whether retained during harvest or left by fire) have higher abundances of many woodpeckers and species that require structurally complex habitats (e.g., Blue-headed Vireo).[14,44] Some species are more closely associated with recently harvested stands (e.g., Lincoln's Sparrow, Le Conte's Sparrow)[1,14] while others are characteristic of burned stands (e.g., cavity nesters).[45]

Shrub-nesting species become common over the first 30 years as the shrub layer develops and deciduous trees regenerate. As deciduous stands regenerate and the canopy closes, differences between stands of fire and harvest origin decrease, and many different species of thrushes, vireos, warblers, and some flycatchers become more common as stands approach maturity.[14]

Figure 7. Old deciduous trees provide important nesting habitat to woodpeckers and secondary cavity nesters like this Northern Hawk Owl. Photo by G. Romanchuk.

TABLE 1. RECOMMENDED PRACTICES: WHO BENEFITS IN DECIDUOUS-DOMINATED FORESTS?

This list of species that benefit from recommended practices is limited to species of management interest that are included in this toolkit, and thus do not reflect the full range of species that will likely benefit from each practice. Note: these practices are only expected to benefit species that occur in the same area (e.g., within their geographic range).

Habitat Recommendation	Species expected to benefit
Large-diameter deciduous trees with signs of damage, disease, or cavities	• Barred Owl (broken tops, natural cavities) • Northern Flicker (>35 cm dbh aspen) • Northern Pygmy-owl (cavities) • Pileated Woodpecker (>35 cm dbh aspen) • Western Screech-owl (cavities) • Yellow-bellied Sapsucker (>35 cm dbh aspen)
Large-diameter coniferous trees	• See *Mixedwood Habitat Synthesis* (Table 2)
Snags, stumps, and downed wood, with or without existing cavities	• Barred Owl (broken tops/cavities/leaning logs) • Northern Flicker • Northern Pygmy-owl (cavities) • Pileated Woodpecker • Western Screech-owl (cavities)
Coniferous trees	• Barred Owl • See *Mixedwood Habitat Synthesis* (Table 2)
Deciduous shrubs/reduced herbicide use	• Connecticut Warbler (fruiting shrubs, hazelnut, alder, willow) • Canada Warbler
Poles, young trees, and unmerchantable trees and/or off-target species	• Yellow-bellied Sapsucker (young or pole aspen, birch clumps)
Riparian buffers	• Bank Swallow (sandy, eroded banks) • Canada Warbler (includes intermittent streams)
Large areas of late-seral forest	• Barred Owl • Canada Warbler • Connecticut Warbler (note: this species has highly variable habitat preferences across its range) • Northern Flicker • Ovenbird • Pileated Woodpecker

REFERENCES: DECIDUOUS-DOMINATED FOREST

1. Kirk, D. A., Diamond, A. W., Hobson, K. A. & Smith, A. R. 1996. Breeding bird communities of the western and northern Canadian boreal forest: Relationship to forest type. *Canadian Journal of Zoology* **74:** 1749–1770. Available online: https://doi.org/10.1139/z96-193
2. Howard, J. L. 1996. Populus tremuloides. in *Fire Effects Information System, [Online]* U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available online: http://www.fs.fed.us/database/feis/plants/tree/poptre/all.html
3. Harris, H. T. 1990. Populus balsamifera subsp. balsamifera. in *Fire Effects Information System [Online]* U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available online: https://www.fs.fed.us/database/feis/plants/tree/popbalb/all.html
4. Steinberg, P. D. 2001. Populus balsamifera subsp. trichocarpa. in *Fire Effects Information System [Online]* U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available online: https://www.fs.fed.us/database/feis/plants/tree/popbalt/all.html
5. Hobson, K. A. & Bayne, E. M. 2000. The effects of stand age on avian communities in aspen- dominated forests of central Saskatchewan, Canada. *Forest Ecology and Management* **136:** 121–134. Available online: https://doi.org/10.1016/S0378-1127(99)00287-X
6. Bergeron, Y., Chen, H. Y. H., Kenkel, N. C., Leduc, A. L. & Macdonald, S. E. 2014. Boreal mixedwood stand dynamics: Ecological processes underlying multiple pathways. *Forestry Chronicle* **90:** 202–213. Available online: https://doi.org/10.5558/tfc2014-039
7. Hogg, E. H., Brandt, J. P. & Michaelian, M. 2008. Impacts of a regional drought on the productivity, dieback, and biomass of western Canadian aspen forests. *Canadian Journal of Forest Research* **38:** 1373–1384. Available online: http://www.nrcresearchpress.com/doi/abs/10.1139/X08-001
8. Gallant, A. L., Hansen, A. J., Councilman, J. S., Monte, D. K. & Betz, D. W. 2003. Vegetation dynamics under fire exclusion and logging in a Rocky Mountain watershed, 1856-1996. *Ecological Applications* **13:** 385–403. Available online: http://www.jstor.org/stable/3099906
9. Worrall, J. J. *et al.* 2013. Recent declines of Populus tremuloides in North America linked to climate. *Forest Ecology and Management* **299:** 35–51. Available online: http://dx.doi.org/10.1016/j.foreco.2012.12.033
10. Norton, M. R. 2001. *Status of the Cape May Warbler (Dendroica tigrina) in Alberta*. Alberta Environment, Fisheries and Wildlife Management Division, and Alberta Conservation Association, Wildlife Status Report No. 33, Edmonton, AB. 20 pp.
11. Norton, M. R. 2001. *Status of the Bay-breasted Warbler (Dendroica castanea) in Alberta*. Alberta Environment, Fisheries and Wildlife Management Division, and Alberta Conservation Association, Wildlife Status Report No. 32, Edmonton, AB. 21 pp.
12. Sealy, S. 1980. Reproductive responses of northern orioles to a changing food supply. *Canadian Journal of Zoology* **58:** 221–227. Available online: http://www.nrcresearchpress.com/doi/abs/10.1139/z80-025
13. Environment Canada. 2013. *Bird Conservation Strategy for Bird Conservation Region 6: Boreal Taiga Plains*. Canadian Wildlife Service, Environment Canada, Edmonton, Alberta. 288 pp.
14. Schieck, J. & Song, S. J. 2006. Changes in bird communities throughout succession following fire and harvest in boreal forests of western North America: literature review and meta-analyses. *Canadian Journal of Forest Research* **36:** 1299–1318. Available online: https://doi.org/10.1139/x06-017
15. Andison, D. W., Belisle, A. C., Bergeron, Y. & MacLean, D. 2016. *Towards a Natural Range of Variation (NRV) Strategy for the CBFA*. Prepared for the Canadian Boreal Forest Agreement, Vancouver, BC. 65 pp. Available online: http://cbfa-efbc.ca/wp-content/uploads/2016/11/NRVTechnicalReport_July2016COMPRESSED_FINAL.pdf
16. Cooper, J. M. & Beauchesne, S. 2004. Connecticut Warbler. in *Accounts and Measures for Managing Identified Wildlife (Version 2004)* Biodiversity Branch, Identified Wildlife Management Strategy, Victoria, BC.
17. Flaspohler, D. J., Temple, S. A. & Rosenfield, R. N. 2001. Effects of forest edges on ovenbird demography in a managed forest landscape. *Conservation Biology* **15:** 173–183. Available online: https://doi.org/10.1111/j.1523-1739.2001.99397.x
18. Ball, J. R. *et al.* 2016. Regional habitat needs of a nationally listed species, Canada Warbler (Cardellina canadensis), in Alberta. *Avian Conservation and Ecology* **11:** 10. Available online: http://www.ace-eco.org/vol11/iss2/art10/
19. COSEWIC. 2008. *COSEWIC assessment and status report on the Canada Warbler Wilsonia canadensis in Canada*. Committee on the Status of Endangered Wildlife in Canada, Ottawa. vi + 35 pp. Available online: www.sararegistry.gc.ca/status/status_e.cfm)
20. Bayne, E. M., Van Wilgenburg, S. L., Boutin, S. & Hobson, K. A. 2005. Modeling and field-testing of Ovenbird (Seiurus aurocapillus) responses to boreal forest dissection by energy sector development at multiple spatial scales. *Landscape Ecology* **20:** 203–216.
21. Alberta Sustainable Resource Development. 2006. *Alberta Forest Management Planning Standard (version 4.1)*. Alberta Sustainable Resource Development, Public Lands and Forests Division, Forest Management Branch, Edmonton, AB. Available online: https://wildfire.alberta.ca/firesmart/firesmart-landscapes/documents/ABForestMgmtPlanStandard-2006.pdf
22. COSEWIC. 2012. *COSEWIC assessment and status report on the Western Screech-Owl kennicottii subspecies (Megascops kennicottii kennicottii) and the Western Screech-Owl macfarlanei subspecies (Megascops kennicottii macfarlanei) in Canada*. Committee on the Status of Endangered Wildlife in Canada, Ottawa. xii + 30 pp.
23. Cannings, R. J. 2015. Western Screech-Owl. in *The Atlas of the Breeding Birds of British Columbia, 2008-2012* (Davidson, P. J. A., Cannings, R. J., Couturier, A. R., Lepage, D. & Corrado, C. M. Di, eds.) Bird Studies Canada, Delta, B.C. Available online: http://www.birdatlas.bc.ca/accounts/speciesaccount.jsp?sp=WSOW&lang=en
24. Odsen, S. G. 2015. *Conserving Boreal Songbirds Using Variable Retention Forest Management*. Master of Science. Dept. Renewable Resources, University of Alberta, Edmonton, AB. 84 pp.
25. Cooke, H. A. & Hannon, S. J. 2012. Nest-site selection by old boreal forest cavity excavators as a basis for structural retention guidelines in spatially-aggregated harvests. *Forest Ecology and Management* **269:** 37–51. Available online: http://dx.doi.org/10.1016/j.foreco.2011.12.042
26. Cooke, H. A., Hannon, S. J. & Song, S. J. 2010. *Conserving Old Forest Cavity Users in Aggregated Harvests with Structural Retention*. Sustainable Forest Management Network, Edmonton, AB. 36 pp. Available online: https://doi.org/10.7939/R3JQ0SW3P
27. Edworthy, A. B. & Martin, K. 2014. Long-term dynamics of the characteristics of tree cavities used for nesting by vertebrates. *Forest Ecology and Management* **334:** 122–128. Available online: http://dx.doi.org/10.1016/j.foreco.2014.09.001

28. Environment Canada. 2014. *Management Plan for the Lewis's Woodpecker (Melanerpes lewis) in Canada*. Species at Risk Act Management Plan Series, Environment Canada, Ottawa. iii + 23 pp.
29. Bonar, R. 2018. Personal communication. April 6, 2018
30. Bonar, R. L. 2001. *Pileated Woodpecker Habitat Ecology in the Alberta Foothills*. Ph.D. Thesis. Dept. Renewable Resources, University of Alberta, Edmonton, AB. 75 pp.
31. Mazur, K. M. & James, P. C. 2000. Barred Owl (Strix varia), version 2.0. in *The Birds of North America* (Rodewald, P. G., ed.) Cornell Lab of Ornithology, Ithaca, New York, USA. Available online: https://doi.org/10.2173/bna.508
32. Alberta Sustainable Resource Development. 2005. *Status of the barred owl (Strix varia) in Alberta*. Alberta Sustainable Resource Development, Fish and Wildlife Division, and Alberta Conservation Association, Wildlife Status Report No. 56, Edmonton, AB. 15 pp.
33. Environment Canada. 2015. *Recovery Strategy for Canada Warbler (Cardellina canadensis) in Canada*. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. vi + 55 pp.
34. Pitocchelli, J., Jones, J., Jones, D. & Bouchie, J. 2012. Connecticut Warbler (Oporornis agilis), version 2.0. in *The Birds of North America* (Rodewald, P. G., ed.) Cornell Lab of Ornithology, Ithaca, New York, USA. Available online: https://doi.org/10.2173/bna.320
35. Healy, S. & Calder, W. A. 2006. Rufous Hummingbird (Selasphorus rufus). in *The Birds of North America* (Rodewald, P. G., ed.) Cornell Lab of Ornithology, Ithaca, New York, USA. Available online: https://birdsna.org./Species-Account/bna/species/rufhum
36. Ellis, T. M. & Betts, M. G. 2011. Bird abundance and diversity across a hardwood gradient within early seral plantation forest. *Forest Ecology and Management* **261:** 1372–1381. Available online: http://dx.doi.org/10.1016/j.foreco.2011.01.018
37. Olsen, B. T., Hannon, S. J. & Court, G. S. 2006. Short-term response of breeding barred owls to forestry in a boreal mixedwood forest landscape. *Avian Conservation and Ecology* **1:** 1. Available online: http://www.ace-eco.org/vol1/iss3/art1/
38. Norton, M. R. & Hannon, S. J. 1997. Songbird response to partial-cut logging in the boreal mixedwood forest of Alberta. *Canadian Journal of Forest Research* **27:** 44–53. Available online: http://www.nrcresearchpress.com/doi/abs/10.1139/x96-149
39. Schieck, J. & Hobson, K. A. 2000. Bird communities associated with live residual tree patches within cut blocks and burned habitat in mixedwood boreal forests. *Canadian Journal of Forest Research* **30:** 1281–1295. Available online: http://www.scopus.com/inward/record.url?eid=2-s2.0-0033780243&partnerID=40&md5=8fd79c66f64c3a4d61853a11c7f5da7f
40. Huggard, D. J., Grover, B. E., Dzus, E., Smith, M. & Schieck, J. 2015. Effectiveness monitoring for biodiversity: comparing 15 year old structural retention harvest areas to fires in boreal aspen. *Canadian Journal of Forest Research* **45:** 153–161. Available online: http://www.nrcresearchpress.com/doi/abs/10.1139/cjfr-2014-0091
41. Environment Canada. 2013. *Bird Conservation Strategy for Bird Conservation Region 4 in Canada: Northwestern Interior Forest*. Canadian Wildlife Service, Environment Canada, Whitehorse, Yukon. 138 pp. + appendices.
42. Environment Canada. 2013. *Bird Conservation Strategy for Bird Conservation Region 9 Pacific and Yukon Region: Great Basin*. Canadian Wildlife Service, Environment Canada, Delta, British Columbia. 105 pages + appendices.
43. Environment Canada. 2013. *Bird Conservation Strategy for Bird Conservation Region 10 in Pacific and Yukon Region - Northern Rockies*. Canadian Wildlife Service, Environment Canada, Delta, British Columbia. 109 pages + appendices.
44. Morton, E. S. & James, R. D. 2014. Blue-headed Vireo (Vireo solitarius), version 2.0. in *The Birds of North America* (Rodewald, P. G., ed.) Cornell Lab of Ornithology, Ithaca, New York, USA. Available online: https://doi.org/10.2173/bna.379
45. Van Wilgenburg, S. L. & Hobson, K. A. 2008. Landscape-scale disturbance and boreal forest birds: Can large single-pass harvest approximate fires? *Forest Ecology and Management* **256:** 136–146. Available online: https://doi.org/10.1016/j.foreco.2008.04.017

Habitat Synthesis: Mixedwood Forest (Coniferous-Deciduous)

Mixed coniferous-deciduous forests are common in the upland boreal forest, where trembling aspen, balsam poplar, white spruce, black spruce, and balsam fir often co-dominate.

This account refers primarily to boreal mixedwood forests of aspen/poplar mixed with spruce/fir. Mixed deciduous-pine stands (e.g., aspen/lodgepole pine) will be addressed in a separate section within this account.

Habitat Ecology

- Western boreal mixedwood forests are often dominated by trembling aspen, balsam poplar, paper birch, and white spruce. This account refers to mixedwoods where at least one deciduous species and one coniferous species co-dominate in the canopy (i.e., stand-level mixedwoods). For a discussion of landscape-level forest heterogeneity, see the *Landscape-level Synthesis*.
- In western forests, mixed stands often result several decades following a stand-replacing disturbance as deciduous trees in the canopy age and die, releasing shade-tolerant conifers growing in the understory. Other stands may be mixed throughout succession.[1]
    - Disturbance processes including insect defoliation (e.g., forest tent caterpillar and spruce budworm) and gap dynamics (e.g., blowdown) may produce or maintain mixed stands.[1]
- Mixed stands are generally more species-rich and typically contain more birds than pure stands. This may be due to the presence of both deciduous- and coniferous-associated bird species, the structural complexity of the canopy and subcanopy, and the diversity of foraging opportunities.[2,3]
- **Spruce budworm outbreaks** in mixedwood forests cause spruce budworm specialist species (e.g., Bay-breasted Warbler and Cape May Warbler) to increase substantially. Specialist species will nest in habitats outside of their usual preferences (e.g., in young forests) because there is so much food.[4]
    - Insect outbreaks including spruce budworm, forest tent caterpillar, and mountain pine beetle can change stand composition by creating early-seral openings or releasing codominant trees. These habitat changes can cause bird communities to shift.[1,5]

Bird Responses to Forest Management/Disturbance in Mixedwood (Coniferous-Deciduous) Stands

- Recently burned mixedwood forests provide habitat to conifer-associated woodpeckers (Black-backed and Three-toed Woodpeckers), deciduous-associated woodpeckers (e.g., Hairy Woodpecker), secondary cavity nesters (e.g., American Kestrel), and other birds associated with burned forest and snags (e.g., Brown Creeper) and open habitats (e.g., Olive-sided Flycatcher).[9,10]

- Forest management that converts mixedwoods to **single-species stands**, often with a simplified understory structure, is identified as a threat not only to bird species that are more abundant in mixedwoods but also to landscape-level bird diversity.[2,11]
    - For example, Barred Owls often nest in broken-topped aspen or poplar while understory white spruce and balsam fir provide cover for owlets.[12,13]
- **Understory protection** is a more recent strategy that aims to improve conifer yield by protecting understory conifers rather than destroying them during harvest of the deciduous overstory.
    - Understory protection has been shown to support bird communities that are in-between those found in retention harvests and unharvested forests. It also provides habitat for more species typical of mature or old forests, particularly species that nest and forage in coniferous trees.[14]
- **Retention harvesting** of mixed stands maintains higher densities of large-diameter trees, snags, and overall structural complexity than clearcutting. While retention harvest blocks support fewer cavity nesters and more open-habitat species than burned stands in the short term, differences between the two disturbances decrease as the regenerating stand reaches maturity.[9]
    - Larger retention patches may support bird communities similar to those found after fire,[10] while higher levels of dispersed retention (e.g., 20%) more quickly support species associated with older forests (e.g., after 15 years).[15]
- **Riparian buffers** in mixedwood forests play dual roles by protecting riparian habitats for riparian bird species, while potentially providing habitat for species associated with older forests displaced by adjacent harvesting. Generally, wider buffers (e.g., ≥100 m) are needed to support species associated with older forests and could be used as retention achors,[16–18] while narrower or partially harvested buffers contain more species that nest and forage in shrubby, edge, or open habitats.[18,19]
    - Riparian bird species are generally less sensitive to riparian buffer width provided the shoreline riparian habitat is left intact. Riparian approaches using natural range of variation may have a lower risk of negatively affecting these species, provided other values (e.g., water quality) are protected.[19]

ROLE OF THE PASSIVE LANDBASE

Riparian and lowland mixedwood forests are primarily represented on the passive landbase within required riparian buffers[20] and in otherwise inaccessible, protected, or non-merchantable stands (e.g., steep slopes).

Merchantable, upland mixedwood stands within the passive landbase are expected to contribute to the habitat needs of bird species associated with older upland forests. Their value to species that specialize on old forest features increases with stand age and size, and it decreases with increasing fragmentation.

Riparian buffers contribute habitat for both riparian and upland species, however their value to each may vary according to their width. Buffers ≥100 m wide are generally considered necessary to provide habitat for upland species associated with mature and old forests, and buffers are generally not considered substitutes for upland unharvested areas. See the *Landscape-level Synthesis* for a discussion of riparian buffers and NRV.

Stand-level Management Recommendations

Retention practices increase the stand complexity and deadwood volumes within a site, and this in turn supports overall biodiversity and mitigates the effects of harvesting for some bird species. To maximize the value of retention, the following features should be captured in retention patches when and where feasible (see Table 2 for species-specific examples).

- **Large-diameter live trees** provide important nesting and foraging habitat for many species. In mixedwood forests, bird species may rely on coniferous or deciduous tree species, or both. To that end, leaving >1 overstory species within retention is recommended.
    - **Deciduous trees** provide habitat for many cavity nesting species, particularly aspen >35 cm dbh with several (e.g., ≥10) false tinder conks or other signs of damage/decay (e.g., broken tops, dead branches, frost cracks, etc.).[21]
    - **Conifer trees** provide foraging and nesting habitat for many species. Large patches containing spruce may contain more species of older spruce forests over time as residual deciduous trees die and blow down (providing important sources of dead wood).[10]
- **Large snags, stumps, and downed wood** provide foraging habitat for woodpeckers, nesting habitat for cavity nesters and many raptors (e.g., the Barred Owl often nests in the hollow formed by a snag's broken top or a broken branch), cover for ground-nesters and foragers, and old-growth habitat features for species associated with older forests. Snags with features including broken tops and natural or excavated cavities should be used as anchors where possible.[22–24]
- **Unmerchantable spruce/fir and leaning logs** provide cover within retention patches, including protection and climbable surfaces for young owls.[12] Within patches anchored around stick nests or snags with large cavities or broken tops, operators may consider creating more structural diversity by knocking over trees to create leaning structures.
- Many deciduous-associated bird species that also occupy mixedwood forests require a **well-developed shrub layer** for nesting, foraging, and cover. Target species include but are not limited to beaked hazelnut, alder, willow, and fruiting shrubs at a range of heights.
    - Likewise, post-harvest silviculture that **avoids shrub suppression** will benefit shrub-associated species.[25,26]
- **Young, vigorous trees of all species types** should be represented in retention as they will provide future sources of large-diameter canopy trees and snags as the harvest block regenerates, and may provide foraging opportunities for sapsuckers.[21]

Understory protection of a well-developed understory conifer layer (e.g., spruce) will accelerate recovery of species associated with older conifer forests, yet the long-term effects of this strategy is unknown and may depend on how quickly aspen regenerates under the retained conifers. It may have value as a complementary strategy to retention harvesting but more research is needed to determine its effects on species assemblages over time (but see Landscape-level Management Recommendations).[14]

Landscape-level Management Recommendations

Mixedwood management has become increasingly relevant as the importance of mixedwoods for forest biodiversity has become more apparent at multiple scales.[2,11] While many bird species that are common in mixedwood forests are also common in pure stands, the value of mixedwood stands for supporting species that require a wide range of habitat features cannot be understated.

- **Representation of mixedwood forests** following an area's natural range of variation will help ensure that mixedwood forest habitats are available to the bird species that are common in, or reach their highest densities in, these stand types.
    - **Large, mature/old unharvested mixedwood forests**, whether part of the passive landbase, extended rotation stands, or areas set aside to contribute to NRV targets, will provide greater habitat value to species associated with old forests than stand-level retention or small unharvested remnants alone.
- **Large- and small-scale natural disturbance dynamics**, ranging from stand-replacing fires to gap dynamics, affect the availability of mixedwood forests on the landscape. Maintaining natural disturbances, where possible, is recommended. Where this is not possible, silvicultural practices that may help promote the development of mixedwood stands include:[1]
    - Thinning, gap creation or site preparation to encourage the release or regeneration of sub-dominant tree species.
    - Underplanting conifers or understory protection
    - Retention harvesting
    - Extended rotations
- On landscapes where older coniferous (spruce) forests are under-represented relative to the natural range of variation, understory protection has the potential to increase habitat for the species that inhabit these older forests in the short- to medium-term.[14]

Figure 8. Boreal mixedwood forest. Photo by J. Witiw (DMI).

MIXED ASPEN-PINE STANDS

Mixed stands containing deciduous species (often aspen or paper birch) and pine species (often jack or lodgepole pine) occur on upland sites across western Canada. Black cottonwood also occurs as part of habitat mosaics with ponderosa pine, Douglas fir, and other mixed-conifer stands (see *Dry Mixed-Conifer Forest Habitat Synthesis* for this habitat type).

Mixed aspen-pine forests are often more species-rich than pure pine forests, which generally have a limited shrub layer.[6] Aspen is also heavily preferred by primary cavity nesters and stands with aspen co-dominating will be much more attractive to primary and secondary cavity nesters than pure pine stands.[7]

The following recommendations are provided for retention in mixedwood forests containing aspen and pine, particularly within beetle-killed stands:[8]

- Retain live, dying, and dead aspen and deciduous trees (preferably in patches containing conifers).
- Patches should be at least 1 ha, and some very large patches (>10–50 ha) should be included within very large harvest or salvage blocks.
- On landscapes with low amounts of old forest, retention patches should be larger.
- Following severe bark beetle outbreaks, areas of old forest including riparian areas and non-beetle-killed forest will be important habitat for species of older forests and may serve as retention anchors.

YOUNG AND MID-SERAL FOREST

- Recently burned mixedwood forests provide habitat to conifer-associated woodpeckers, deciduous-associated woodpeckers, secondary cavity nesters, and species associated with burned forest and snags and open habitats.[9,10]
- Recently (e.g., 1 year post-disturbance) harvested stands with some retention have more species than burned mixedwoods. Harvested stands support fewer (or no) fire-associated bird species; rather, they provide habitat for species that forage and nest in open grass or shrubs (e.g., Clay-colored Sparrow).[9]
- Young harvested and burned mixedwoods (e.g., 14–30 years) have fewer differences in bird communities. Regenerating habitats become less suitable for open-habitat and fire-associated bird species. Meanwhile, shrub-nesting and -foraging species (e.g., many warbler species) become more common.
- Differences remain between young burned and harvested mixedwoods: species associated with large snags (e.g., Northern Flicker) are more abundant in burned stands, while more species that nest and forage in mature/old forests (particularly deciduous-dominated forests) may be more common in harvested stands with retention (e.g., Pileated Woodpecker, Canada Warbler).[9]
- Mature harvested and burned mixedwoods (e.g., 60 years post-disturbance) contain very similar bird communities, including many species found in a range of forest types (including Ovenbirds). Residual patches in harvest blocks also contain many (but not all) bird species commonly associated with old forests, albeit at lower densities.[10]

TABLE 2. RECOMMENDED PRACTICES: WHO BENEFITS IN CONIFEROUS-DECIDUOUS MIXEDWOOD FORESTS?

This list of species that benefit from recommended practices is limited to species of management interest that are included in this toolkit, and thus do not reflect the full range of species that will likely benefit from each practice. Note: these practices are only expected to benefit species that occur in the same area (e.g., within their geographic range).

Habitat Recommendation	Species expected to benefit
Large-diameter deciduous trees with signs of damage, disease, or cavities	• Barred Owl (broken tops, natural cavities) • Black-backed Woodpecker (occasional) • Northern Flicker (>35 cm dbh aspen) • Northern Hawk Owl • Northern Pygmy-owl (cavities) • Pileated Woodpecker (>35 cm dbh aspen) • Western Screech-owl (cavities) • Yellow-bellied Sapsucker (>35 cm dbh aspen)
Large-diameter coniferous trees	• Bay-breasted Warbler • Black-backed Woodpecker (>23 cm dbh conifers) • Black-throated Green Warbler • Connecticut Warbler • Golden-crowned Kinglet • Western Tanager
Snags, stumps, and downed wood, with or without existing cavities	• Barred Owl (broken tops/cavities/leaning logs) • Northern Flicker • Northern Hawk Owl • Northern Pygmy-owl (cavities) • Northern Saw-whet Owl • Pileated Woodpecker
Understory protection	• Connecticut Warbler
Poles, young trees, and unmerchantable trees and/or off-target species	• Barred Owl (young spruce/fir) • Northern Saw-whet Owl
Recent burns/Recent harvests	• Northern Hawk Owl
Landscape-level mixedwood management	• Barred Owl • Black-throated Green Warbler • Golden-crowned Kinglet • Western Tanager

REFERENCES: CONIFEROUS-DECIDUOUS MIXEDWOOD FOREST

1. Bergeron, Y., Chen, H. Y. H., Kenkel, N. C., Leduc, A. L. & Macdonald, S. E. 2014. Boreal mixedwood stand dynamics: Ecological processes underlying multiple pathways. *Forestry Chronicle* **90:** 202–213. Available online: https://doi.org/10.5558/tfc2014-039
2. Hobson, K. A. & Bayne, E. M. 2000. Breeding bird communities in boreal forest of western Canada: Consequences of 'unmixing' the mixedwoods. *The Condor* **102:** 759–769. Available online: http://www.jstor.org/stable/1370303
3. Schieck, J. & Song, S. J. 2006. Changes in bird communities throughout succession following fire and harvest in boreal forests of western North America: literature review and meta-analyses. *Canadian Journal of Forest Research* **36:** 1299–1318. Available online: https://doi.org/10.1139/x06-017
4. Venier, L. A., Pearce, J. L., Fillman, D. R., McNicol, D. K. & Welsh, D. A. 2009. Effects of Spruce budworm (Choristoneura fumiferana (Clem.)) outbreaks on boreal mixed-wood bird communities. *Avian Conservation and Ecology* **4:** 3.
5. Matsuoka, S. M. & Handel, C. M. 2007. Nesting ecology of boreal forest birds following a massive outbreak of spruce beetles. *Journal of Wildlife Management* **71:** 51–63. Available online: http://www.bioone.org/doi/abs/10.2193/2005-460
6. Kirk, D. A. & Hobson, K. A. 2001. Bird–habitat relationships in jack pine boreal forests. *Forest Ecology and Management* **147:** 217–243. Available online: http://www.sciencedirect.com/science/article/pii/S0378112700004655
7. Drever, M. C., Aitken, K. E. H., Norris, A. R. & Martin, K. 2008. Woodpeckers as reliable indicators of bird richness, forest health and harvest. *Biological Conservation* **141:** 624–634.
8. Martin, K., Norris, A. & Drever, M. C. 2006. Effects of bark beetle outbreaks on avian biodiversity in the British Columbia interior: Implications for critical habitat management. *BC Journal of Ecosystems and Management* **7:** 10–24.
9. Hobson, K. A. & Schieck, J. 1999. Changes in bird communities in boreal mixedwood forest: Harvest and wildfire effects over 30 years. *Ecological Applications* **9:** 849–863.
10. Schieck, J. & Hobson, K. A. 2000. Bird communities associated with live residual tree patches within cut blocks and burned habitat in mixedwood boreal forests. *Canadian Journal of Forest Research* **30:** 1281–1295. Available online: http://www.scopus.com/inward/record.url?eid=2-s2.0-0033780243&partnerID=40&md5=8fd79c66f64c3a4d61853a11c7f5da7f
11. Cavard, X., Macdonald, S. E., Bergeron, Y. & Chen, H. Y. H. 2011. Importance of mixedwoods for biodiversity conservation: Evidence for understory plants, songbirds, soil fauna, and ectomycorrhizae in northern forests. *Environmental Reviews* **19:** 142–161. Available online: https://doi.org/10.1139/a11-004
12. Alberta Sustainable Resource Development. 2005. *Status of the barred owl (Strix varia) in Alberta*. Alberta Sustainable Resource Development, Fish and Wildlife Division, and Alberta Conservation Association, Wildlife Status Report No. 56, Edmonton, AB. 15 pp.
13. Mazur, K. M. & James, P. C. 2000. Barred Owl (Strix varia), version 2.0. in *The Birds of North America* (Rodewald, P. G., ed.) Cornell Lab of Ornithology, Ithaca, New York, USA. Available online: https://doi.org/10.2173/bna.508
14. Charchuk, C. & Bayne, E. M. 2018. Avian community response to understory protection harvesting in the boreal forest of Alberta, Canada. *Forest Ecology and Management* **407:** 9–15. Available online: https://doi.org/10.1016/j.foreco.2017.10.033
15. Odsen, S. G. 2015. *Conserving Boreal Songbirds Using Variable Retention Forest Management*. Master of Science. Dept. Renewable Resources, University of Alberta, Edmonton, AB. 84 pp.
16. Hagar, J. C. 1999. Influence of riparian buffer width on bird assemblages in western Oregon. *The Journal of Wildlife Management* **63:** 484–496. Available online: http://www.jstor.org/stable/3802633
17. Hannon, S. J. *et al.* 2002. Abundance and species composition of amphibians, small mammals, and songbirds in riparian forest buffer strips of varying widths in the boreal mixedwood of Alberta. *Canadian Journal of Forest Research* **32:** 1784–1800. Available online: https://doi.org/10.1139/x02-092
18. Marczak, L. B. *et al.* 2010. Are forested buffers an effective conservation strategy for riparian fauna? An assessment using meta-analysis. *Ecological Applications* **20:** 126–134. Available online: http://onlinelibrary.wiley.com/doi/10.1890/08-2064.1/abstract
19. Kardynal, K. J., Morissette, J. L., Van Wilgenburg, S. L., Bayne, E. M. & Hobson, K. A. 2011. Avian responses to experimental harvest in southern boreal mixedwood shoreline forests: implications for riparian buffer management. *Canadian Journal of Forest Research* **41:** 2375–2388. Available online: http://www.nrcresearchpress.com/doi/abs/10.1139/x11-145
20. Alberta Sustainable Resource Development. 2006. *Alberta Forest Management Planning Standard (version 4.1)*. Alberta Sustainable Resource Development, Public Lands and Forests Division, Forest Management Branch, Edmonton, AB. Available online: https://wildfire.alberta.ca/firesmart/firesmart-landscapes/documents/ABForestMgmtPlanStandard-2006.pdf
21. Cooke, H. A., Hannon, S. J. & Song, S. J. 2010. *Conserving Old Forest Cavity Users in Aggregated Harvests with Structural Retention*. Sustainable Forest Management Network, Edmonton, AB. 36 pp. Available online: https://doi.org/10.7939/R3JQ0SW3P
22. Olsen, B. T., Hannon, S. J. & Court, G. S. 2006. Short-term response of breeding barred owls to forestry in a boreal mixedwood forest landscape. *Avian Conservation and Ecology* **1:** 1. Available online: http://www.ace-eco.org/vol1/iss3/art1/
23. Mitchell, G. W., Taylor, P. D. & Warkentin, I. G. 2010. Multiscale Postfledging Habitat Associations of Juvenile Songbirds in a Managed Landscape. *The Auk* **127:** 354–363.
24. Cooke, H. A. & Hannon, S. J. 2011. Do aggregated harvests with structural retention conserve the cavity web of old upland forest in the boreal plains? *Forest Ecology and Management* **261:** 662–674. Available online: http://dx.doi.org/10.1016/j.foreco.2010.11.023
25. Environment Canada. 2015. *Recovery Strategy for Canada Warbler (Cardellina canadensis) in Canada*. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. vi + 55 pp.
26. Pitocchelli, J., Jones, J., Jones, D. & Bouchie, J. 2012. Connecticut Warbler (Oporornis agilis), version 2.0. in *The Birds of North America* (Rodewald, P. G., ed.) Cornell Lab of Ornithology, Ithaca, New York, USA. Available online: https://doi.org/10.2173/bna.320

HABITAT SYNTHESIS: SPRUCE-DOMINATED FOREST

Spruce-dominated forests represent important merchantable timber on the landscape, as well as important habitat for many bird species that live and feed in, on, and around them. On many landscapes, spruce characteristically dominates older forests, and thus many species of concern associated with spruce are often found in older forests. Many other species are also associated with recently burned forest and natural openings, for example in wet areas.

MAIN SPRUCE FOREST TYPES

This habitat-level account focuses primarily on upland spruce-dominated forests (including white spruce, Engelmann spruce, and upland black spruce) unless otherwise indicated. Habitat management for poorly-drained lowland spruce stands will in most cases refer to the passive landbase as these stands are often too wet, unproductive, and/or inaccessible to merit forestry operations in western Canada.

Spruce forests are often associated with true fir (*Abies*), which grows in the shady understory to form spruce/fir species mixes, and occasionally (although rarely in western forests) pure stands. The recommendations within this Habitat-level Synthesis generally apply to mixed stands containing fir, and recommendations specific to fir will be indicated.

HABITAT ECOLOGY

- Typically, spruce-dominated forests are characterized by many small- to medium-sized fires and a small number of very large fires that account for most of the area burned in a year.[1–3]
- These disturbance patterns create patchy, uneven-aged stands characterised by fire skips of varying size, shape, and composition.[4]
- Natural disturbance patterns often produce stands of old (i.e., older than rotation age, in some stands by many decades) forests of varying sizes, and these stands provide important habitat for many bird species.
- Within these older forests, small gaps are formed as older, more vulnerable overstory trees die singly and in small patches due to disease, insects, pathogens, and windthrow. These gap dynamics produce important old forest features including:[5]
    a. Vegetation layering and high structural complexity due to growth of young shrubs and trees in gaps.
    b. Increased plant species diversity.
    c. High volumes of coarse woody debris including snags and downed logs of various sizes and degrees of decay.

BIRD RESPONSES TO FOREST MANAGEMENT/DISTURBANCE IN SPRUCE STANDS

Many bird species of management concern within spruce forests are associated with late-seral forest, and they are very sensitive to harvest with even high levels of retention. Ensuring sufficient quantities of late-seral forest over time at the landscape scale is critical for these species. This section summarizes how birds respond to both forest

management and natural disturbance in spruce forests (see Management Recommendations for recommendations to mitigate these effects):

- **Post-harvest silviculture**: Stands that naturally regenerate as deciduous or mixedwood stands may be artificially regenerated to merchantable spruce species using postharvest silviculture (e.g., planting, seeding, herbicide application, etc.).
    a. In the short-term, post-harvest silviculture benefits some conifer-nesting and ground-foraging species (e.g., Song Sparrow, Western Tanager, and Hermit Thrush), but negatively affects deciduous-associated species (e.g., Warbling Vireo, Swainson's Thrush) and open-cup nesting species (increased predation).[6]
    b. In the longer term (20–50 years), some species apparently benefit from the more rapid regeneration of spruce (e.g., Bay-breasted Warbler and Golden-crowned Kinglet) while others appear to be negatively affected by the loss of tree species diversity (e.g., Black-throated Green Warbler).[7]
- **Species associated with recent (<10 years) burns are negatively affected by salvage logging, which removes potential nest sites, food resources, and perches** (see Stand-Level Implications below). In spruce forests, these species include the Black-backed Woodpecker, Olive-sided Flycatcher, and Northern Hawk Owl.
- Spruce budworm specialists (Bay-breasted Warbler, Tennessee Warbler, Cape May Warbler) may be negatively affected by **pest suppression efforts and salvaging**.[8]
- **Edges** between mature forest and cutblocks, grassland, and human footprint (e.g., roads) attract nest predators (e.g., crows, jays, and red squirrels).[9,10]
    a. Cutblock edges are, however, quickly softened as harvest blocks regenerate, and are not considered permanent features.[11]
    b. It is important to note that forest edges and fragmented forests are used by many habitat generalist and open-habitat associated bird species (e.g., Least Flycatcher, Philadelphia Vireo, House Wren, American Robin, Cedar Waxwing, many sparrows, and more[12])—however, these species are generally of lower conservation concern.

THE ROLE OF YOUNG AND MID-SERAL FOREST

- **Recently burned or insect-killed spruce forest** is important habitat for many species that exploit the high densities of deadwood-eating insects and snags used for nesting (e.g., Black-backed Woodpecker)[28,35] or spruce budworm specialists (Bay-breasted Warbler, Tennessee Warbler, Cape May Warbler).[8]
- Spruce-associated bird species that forage on the flowers, insects, and mammals (e.g., rodents) in **recently burned and cutover areas** include the Rufous Hummingbird, Olive-sided Flycatcher, Western Tanager, and Great Gray Owl.
- Absent silvicultural interventions, openings created by harvest and fire on many lower-elevation upland spruce sites may regenerate to shade-intolerant deciduous species and remain deciduous-dominated until the overstory trees senesce and release the conifer understory (See *Deciduous-dominated Habitat Synthesis* for more details).

Stand-level Management Recommendations

Retention practices increase the stand complexity and deadwood volumes within a site, and this in turn supports overall biodiversity and mitigates the effects of harvesting for some bird species. To maximize the value of retention, the following features should be captured in retention patches when and where feasible (see Table 3 for species-specific examples).

- **Tall, windfirm,**[c] **large-diameter spruce trees** provide important nesting and foraging habitat for many species including canopy and cavity nesters. Young, healthy, merchantable spruce are likewise of value as they increase stand-level complexity and provide future large-diameter trees.[17,18] In stands containing aspen, residual aspen may help increase the windfirmness of residual spruce.
- **Patches of deciduous trees** (particularly trembling aspen and white birch) increase stand complexity, insect prey densities, and potential nesting habitats including cavities.[19]
- **Large-diameter live aspen (>35 cm dbh) with several (e.g., ≥10) false tinder conks or other signs of damage** are most likely to be excavated by many cavity nesters.[20]
    a. **Cavity trees:** live trees with cavities will last the longest, however a range of cavity tree conditions (e.g., more heavily decayed snags containing cavities) will provide the greatest diversity of resources for different species.[21]
    b. **Fir trees containing heartrot** may provide nesting opportunities for some conifer-associated cavity nesters (e.g., Black-backed Woodpecker), however records of cavity nests within firs are extremely limited.[22]
- **Other wildlife trees** including trees with large mistletoe brooms, large forks, large natural cavities, abandoned stick or platform nests, and signs of decay provide nesting opportunities for many species including many raptors. These trees provide ideal anchors for retention patches.[23,24]
- **Non-merchantable trees and shrubs** (e.g., mountain ash, alder, willow, etc.) increase habitat for shrub-nesters and -foragers and provide cover for young birds leaving the nest.[25,26] These can be protected using understory protection and/or by targeting dense areas containing these features for retention patches.
- **Large-diameter snags** provide foraging, nesting, and perching opportunities. Mechanical creation of broken-topped snags is an option where these features are uncommon.[21]
- **Fallen and leaning trees and multiple tree layers** (e.g., young and/or unmerchantable spruce) may benefit some owl species by providing cover and climbable structures for their young.[26]

Landscape-level Management Recommendations

In western Canadian forests, the species facing the strongest conservation challenges are generally understood to be the species associated with older-than-rotation forests and with early post-fire forests.[27,28] This is evident for the

[c] Windfirm spruce are usually those that are emergent above the main canopy, often including veterans that survived earlier disturbances. Spruce and fir are particularly susceptible to windthrow. Recommendations to increase windfirmness include retaining trees in patches, on lee slopes, and/or downwind (sheltered by) adjacent standing timber (R. Bonar, pers. comm.).

spruce-associated bird species included in this tool, which include the fire-associated Black-backed Woodpecker, Northern Hawk Owl, and Olive-sided Flycatcher, as well as several species associated with large areas of late-seral upland or riparian spruce or spruce/fir forest (e.g., Bay-breasted Warbler, Black-throated Green Warbler, Brown Creeper, etc.). Many of these species have exhibited declines in response to even low-intensity retention harvesting and sensitivity to patch size.

Large patches of late-seral forest, consistent with a managed area's NRV and containing old-growth features, contribute to intact spruce forest targets and are the most effective tool for conserving many of the species that are most sensitive to harvesting in spruce stands. These patches of late-seral forests **are of greatest importance on landscapes that are highly modified** by human activity and management.

- In landscapes subject to less intensive forest management and low levels of human footprint (e.g., less accessible northern forests), harvests that are consistent with the area's natural range of variation will likely be effective in supporting birds associated with a range of habitats, including late-seral forests.[29]
- In landscapes subject to intensive forest management and cumulative effects from other sectors (e.g., agriculture, oil and gas, mining, and urban development), late-seral upland spruce forest patches are of high conservation priority.
    a. Within a managed area's NRV targets for late-seral upland forest patches, larger remnants (>5 ha to >100 ha) are most likely to support these area-sensitive species associated with older upland spruce forests (see Table 3). Please note these are **minimum recommended sizes** and would typically only support a few breeding pairs. **Large tracts of coniferous forest as would occur within an NRV scenario are also critically important**.
    b. In heavily fragmented landscapes, larger undisturbed stands play an important role for species which are most sensitive to habitat edges or naturally occur at low densities (e.g., Bay-breasted Warbler).[30]
- **Large, single-pass aggregated harvests containing retention** may be more consistent with the NRV of many western forests than small, multi-pass harvests. These harvests have been shown to support many bird species associated with old forests as well as communities more consistent with NRV [31,32].
    a. Additional benefits include potential reductions in road footprints, and the eventual regeneration of large areas of uneven-aged core habitat when harvested areas reach maturity.
- **Unsalvaged postfire and post-outbreak reserves** are recommended where salvage logging can be avoided (but see Stand-Level Implications). These reserves should be prioritized on landscapes where these habitats are poorly represented relative to the landscape's NRV [14,17,18]. Specific options for planners include:
    a. Salvage log larger burned areas (e.g., >2,000 ha) first, as these will take longer to harvest and will allow smaller burns (<2,000 ha) to act as "stepping stones" between burned areas [18].
        i. Delayed salvage logging of >1 year is expected to provide disproportionately high benefits to woodpecker species including Black-backed and Three-toed Woodpeckers, whose abundances are reported to peak from 2–8 years postfire.[18,33,34]

b. During salvage logging of large burns, attempt to maintain some large, intact core areas centrally within the burn (e.g., patches far from unburned forest edges help Black-backed Woodpeckers avoid nest predators like Red Squirrels).[33]

ROLE OF THE PASSIVE LANDBASE

- Many species that are associated with spruce forests (e.g., Bay-breasted Warbler, Great Gray Owl, Olive-sided Flycatcher, and Rusty Blackbird) are associated with riparian habitats, including white spruce riparian areas and black spruce bogs.[13–16] Areas left unharvested on the landscape due to wet conditions, poor timber quality/quantity, and/or legally mandated riparian buffers all contribute to representation of these habitats on the landscape. The value of these sites to most species increases with their size and connectivity.
- The amount and distribution of the passive landbase should be considered in the context of the area's NRV. In some cases, high representation of both upland and lowland spruce forests on the passive landbase may reduce the need for extended rotations and/or set-asides elsewhere.
- However, it is important to note that for many species, a poorly-drained and unproductive black spruce stand will not provide the habitat features available in upland, productive spruce forest. Neither do narrow riparian buffers provide equivalent habitat to larger stands with less edge and more interior forest.

Figure 9. A male Golden-crowned Kinglet perches on a spruce branch. Photo by G. Romanchuk.

TABLE 3. RECOMMENDED PRACTICES: WHO BENEFITS IN SPRUCE-DOMINATED FORESTS?

This list of species that benefit from recommended practices is limited to species of management interest that are included in this toolkit, and thus do not reflect the full range of species that will likely benefit from each practice. Note: these practices are only expected to benefit species that occur in the same area (e.g., within their geographic range).

Habitat Recommendation	Species expected to benefit
Large-diameter coniferous trees	• Bay-breasted Warbler • Black-backed Woodpecker (conifers >23 cm dbh) • Black-throated Green Warbler • Boreal Chickadee • Brown Creeper (sloughing bark) • Cape May Warbler (>10 m tall conifers) • Golden-crowned Kinglet • Great Gray Owl (>6 ha patch for nest, single trees for perches) • Townsend's Warbler • Western Tanager
Snags, stumps, and downed wood, with or without existing cavities	• Black-backed Woodpecker (mainly conifers >23 cm dbh) • Brown Creeper (conifers) • Great Gray Owl (broken tops, leaning logs) • Northern Flicker • Northern Hawk Owl • Northern Pygmy-owl (cavities) • Olive-sided Flycatcher (>5 m tall, widely spaced within openings) • Western Tanager (downed woody material >20 cm diameter)
Poles, young trees, and unmerchantable trees and/or off-target species	• Bay-breasted Warbler (shrub understory) • Black-throated Green Warbler (paper birch) • Brown Creeper (paper birch) • Pine Grosbeak (mountain ash and fruiting shrubs; black spruce/tamarack) • Rusty Blackbird (<4 cm dbh black spruce/tamarack wetland)
Recent burns/Recent harvests	• Black-backed Woodpecker (<8 years postfire) • Northern Hawk Owl
Large areas of late-seral forest	• Bay-breasted Warbler (>100 ha) • Black-backed Woodpecker (>110 years) • Black-throated Green Warbler (>100 ha) • Boreal Chickadee • Brown Creeper • Cape May Warbler (>100 years white spruce) • Golden-crowned Kinglet • Great Gray Owl (>6 ha) • Varied Thrush

REFERENCES: SPRUCE-DOMINATED FOREST

1. Parisien, M. A., Hirsch, K. G., Lavoie, S. G., Todd, J. B. & Kafka, V. G. 2004. *Saskatchewan Fire Regime Analysis*. NRCAN, CFS, Northern Forestry Centre, Edmonton, AB. Inf. Rep. NOR-X-394.
2. Abrahamson, I. 2015. Picea glauca, white spruce. in *Fire Effects Information System, [Online]* U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available online: http://www.fs.fed.us/database/feis/plants/tree/picgla/all.html
3. Fryer, J. L. 2014. Picea mariana. in *Fire Effects Information System, [Online]* U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available online: http://www.fs.fed.us/database/feis/plants/tree/picmar/all.html
4. Eberhart, K. E. & Woodard, P. M. 1987. Distribution of residual vegetation associated with large fires in Alberta. *Canada Journal of Forest Research* **17:** 1207–1212. Available online: http://www.nrcresearchpress.com/doi/pdf/10.1139/x87-186
5. Canadian Council of Forest Ministers (CCFM). Always Changing: Canada's Boreal Forest. *SFM Canada* Available online: https://www.sfmcanada.org/images/Publications/EN/Boreal_Forests_EN.pdf
6. Easton, W. E. & Martin, K. 1998. The effect of vegetation management on breeding bird communities in British Columbia. *Ecological Applications* **8:** 1092–1103. Available online: http://www.jstor.org/stable/2640964
7. Thompson, I. D., Kirk, D. A. & Jastrebski, C. 2013. Does postharvest silviculture improve convergence of avian communities in managed and old-growth boreal forests? *Canada Journal of Forest Research* **43:** 1050–1062. Available online: https://doi.org/10.1139/cjfr-2013-0104
8. Venier, L. A., Pearce, J. L., Fillman, D. R., McNicol, D. K. & Welsh, D. A. 2009. Effects of Spruce budworm (Choristoneura fumiferana (Clem.)) outbreaks on boreal mixed-wood bird communities. *Avian Conservation and Ecology* **4:** 3.
9. Batáry, P. & Báldi, A. 2004. Evidence of an edge effect on avian nest success. *Conservation Biology* **18:** 389–400. Available online: http://www.jstor.org/stable/3589218
10. Thompson, R. G., Warkentin, I. G. & Flemming, S. P. 2008. Response to logging by a limited but variable nest predator guild in the boreal forest. *Canadian Journal of Forest Research* **38:** 1974–1982. Available online: www.nrcresearchpress.com/doi/pdf/10.1139/X08-049
11. McGarigal, K. & McComb, W. C. 1995. Relationships between landscape structure and breeding birds in the Oregon Coast Range. *Ecological Monographs* **65:** 235–260. Available online: http://www.jstor.org/stable/2937059
12. Hobson, K. A. & Bayne, E. 2000. Effects of forest fragmentation by agriculture on avian communities in the southern boreal mixedwoods of Western Canada. *The Wilson Bulletin* **112:** 373–387. Available online: ttp://www.jstor.org/stable/4164237
13. Bull, E. L. & Duncan, J. R. 1993. Great Gray Owl (Strix nebulosa). in *The Birds of North America* (Rodewald, P. G., ed.) Cornell Lab of Ornithology, Ithaca, New York, USA. Available online: https://birdsna.org/Species-Account/bna/species/grgowl
14. Cooper, J. M. & Beauchesne, S. M. 2004. Bay-breasted Warbler. in *Accounts and Measures for Managing Identified Wildlife (Version 2004)* Biodiversity Branch, Identified Wildlife Management Strategy, Victoria, BC. Available online: http://www.env.gov.bc.ca/wld/frpa/iwms/documents/Birds/b_baybreastedwarbler.pdf
15. Altman, B. & Sallabanks, R. 2012. Olive-sided Flycatcher (Contopus cooperi), version 2.0. in *The Birds of North America* (Rodewald, P. G., ed.) Cornell Lab of Ornithology, Ithaca, New York, USA. Available online: https://doi.org/10.2173/bna.502
16. Avery, M. L. 2013. Rusty Blackbird (Euphagus carolinus), version 2.0. in *The Birds of North America* (Rodewald, P. G., ed.) Cornell Lab of Ornithology, Ithaca, New York, USA. Available online: https://doi.org/10.2173/bna.200
17. Matsuoka, S. M. & Handel, C. M. 2007. Nesting ecology of boreal forest birds following a massive outbreak of spruce beetles. *Journal of Wildlife Management* **71:** 51–63. Available online: http://www.bioone.org/doi/abs/10.2193/2005-460
18. Hoyt, J. S. & Hannon, S. J. 2002. Habitat associations of black-backed and three-toed woodpeckers in the boreal forest of Alberta. *Canadian Journal of Forest Research* **32:** 1881–1888.
19. Stuart-Smith, A. K., Hayes, J. P. & Schieck, J. 2006. The influence of wildfire, logging and residual tree density on bird communities in the northern Rocky Mountains. *Forest Ecology and Management* **231:** 1–17.
20. Cooke, H. A. & Hannon, S. J. 2012. Nest-site selection by old boreal forest cavity excavators as a basis for structural retention guidelines in spatially-aggregated harvests. *Forest Ecology and Management* **269:** 37–51. Available online: http://dx.doi.org/10.1016/j.foreco.2011.12.042
21. Edworthy, A. B. & Martin, K. 2014. Long-term dynamics of the characteristics of tree cavities used for nesting by vertebrates. *Forest Ecology and Management* **334:** 122–128. Available online: http://dx.doi.org/10.1016/j.foreco.2014.09.001
22. Scott, V. E., Evans, K. E., Patton, D. R. & Stone, C. P. 1977. *Cavity-Nesting Birds of North American Forests*. Agriculture Handbook 511. Forest Service, U.S. Department of Agriculture, Washington, DC. 111 pp. Available online: https://www.gutenberg.org/files/49172/49172-h/49172-h.htm
23. Environment Canada. 2013. *Bird Conservation Strategy for Bird Conservation Region 6: Boreal Taiga Plains*. Canadian Wildlife Service, Environment Canada, Edmonton, Alberta. 288 pp.
24. BC Ministry of Forests Lands and Natural Resource Operations. 2013. *Guidelines for Raptor Conservation during Urban and Rural Land Development in British Columbia (2013)*. Victoria, BC. 151 pp. Available online: http://www.env.gov.bc.ca/wld/documents/bmp/raptor_conservation_guidelines_2013.pdf
25. Matsuoka, S. M., Handel, C. M. & Ruthrauff, D. R. 2001. Densities of breeding birds and changes in vegetation in an Alaskan boreal forest following a massive disturbance by spruce beetles. *Canadian Journal of Zoology* **79:** 1678–1690. Available online: http://www.nrc.ca/cgi-bin/cisti/journals/rp/rp2_abst_e?cjz_z01-130_79_ns_nf_cjz79-01
26. Alberta Environment and Parks. 2016. *Barred Owl Conservation Management Plan 2016-2021*. Alberta Environment and Parks. Species at Risk Conservation Management Plan No. 14, Edmonton, AB. 10 pp. Available online: http://aep.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-web-resources/birds/documents/SAR-BarredOwl-ManagementPlan-Mar-2016.pdf
27. Hobson, K. A. & Schieck, J. 1999. Changes in bird communities in boreal mixedwood forest: Harvest and wildfire effects over 30 years. *Ecological Applications* **9:** 849–863.
28. Hannon, S. J. & Drapeau, P. 2005. Bird responses to burning and logging in the boreal forest of Canada. *Studies in Avian Biology* 97–115. Available online: https://sora.unm.edu/sites/default/files/SAB_030_2005 P97-115_Bird Responses to Burning and Logging in the Boreal Forest of Canada_Susan

J. Hannon%2C Pierre Drapeau.pdf
29. Drapeau, P., Villard, M. A., Leduc, A. & Hannon, S. J. 2016. Natural disturbance regimes as templates for the response of bird species assemblages to contemporary forest management. *Diversity and Distributions* **22:** 385–399.
30. Alberta Environment and Sustainable Resource Development. 2014. *Black-Throated Green Warbler, Bay-Breasted Warbler and Cape May Warbler Conservation Management Plan 2014-2019*. Alberta Environment and Sustainable Resource Development. Species at Risk Conservation Management Plan No. 10, Edmonton, AB. 33 pp.
31. Cooke, H. A., Hannon, S. J. & Song, S. J. 2010. *Conserving Old Forest Cavity Users in Aggregated Harvests with Structural Retention*. Sustainable Forest Management Network, Edmonton, AB. 36 pp. Available online: https://doi.org/10.7939/R3JQ0SW3P
32. Van Wilgenburg, S. L. & Hobson, K. A. 2008. Landscape-scale disturbance and boreal forest birds: Can large single-pass harvest approximate fires? *Forest Ecology and Management* **256:** 136–146. Available online: https://doi.org/10.1016/j.foreco.2008.04.017
33. Saab, V. A., Russell, R. E., Rotella, J. & Dudley, J. G. 2011. Modeling nest survival of cavity-nesting birds in relation to postfire salvage logging. *Journal of Wildlife Management* **75:** 794–804.
34. Murphy, E. C. & Lenhausen, W. A. 1998. Density and foraging ecology of woodpeckers following a stand-replacement fire. *The Journal of Wildlife Management* **62:** 1359–1372. Available online: http://www.jstor.org/stable/3802002
35. Schieck, J. & Song, S. J. 2006. Changes in bird communities throughout succession following fire and harvest in boreal forests of western North America: literature review and meta-analyses. *Canadian Journal of Forest Research* **36:** 1299–1318. Available online: https://doi.org/10.1139/x06-017

HABITAT SYNTHESIS: PINE FOREST

The dominant pine species of western upland forests include jack pine, lodgepole pine, ponderosa pine, and longleaf pine species including limber pine and whitebark pine. This habitat account mainly discusses jack pine and lodgepole pine forests unless otherwise indicated (whitebark pine is addressed in a separate section below). Ponderosa pine commonly occurs in mixed conifer forests with Douglas fir, and is addressed in the *Dry Mixed-Conifer Habitat Synthesis*.

HABITAT ECOLOGY

- Jack pine and lodgepole pine both have serotinous cones and often grow to form pure stands following stand-replacing fires. Dense regenerating stands often out-compete understory vegetation, resulting in forests with low structural complexity and high fuel loads.[1,2]
- Pine also often forms mixed stands, and these mixtures depend on the region:
    - Jack pine often co-dominates forests with trembling aspen, paper birch, black spruce, and balsam fir.[2,3]
    - Lodgepole pine is widely distributed and often forms mixed stands other species including trembling aspen, spruce, subalpine fir, Douglas fir, western larch, and more.[1]
- The main natural disturbances affecting pine forests include wildfire, which is often stand-replacing and may maintain pine dominance over other tree species, and mountain pine beetle. Dwarf mistletoe is also an important pathogen, which creates nesting habitat for many birds but also increases the probability of a crown fire.[1]
- Western pure pine forests typically contain fewer bird species and abundances than other stand types. This is especially true of mid-seral pine, which is typically extremely dense and prevents the growth of shrubs, understory plants, and other tree species for birds to forage and nest on.[3,4]

ROLE OF THE PASSIVE LANDBASE

Many species associated with pine forests nest and forage in open habitats created by recent burns, harvest, or in many cases, wet areas including wetlands and wet meadows.

Riparian buffers containing large-diameter deciduous and coniferous trees, large-diameter snags with cavities or broken tops, and shrubby deciduous vegetation will provide important nesting and foraging habitat to many of the species found in pine and mixed-conifer forests. Osprey and Olive-sided Flycatcher will specifically benefit from riparian buffers and nearby patches containing tall snags and very tall conifers to be used as perches or for platform nests.

Steep slopes that are left unharvested will provide valuable habitat to some species including the Norther Pygmy-Owl and Northern Saw-whet Owl, however other species (e.g., Northern Goshawk) prefer gentle slopes and are unlikely to benefit from this component of the passive landbase.

Bird Responses to Forest Management/Disturbance in Pine Stands

- **Thinning** of mature (e.g., 60 years) pine does not drastically affect bird assemblages in most cases, but may cause an increase in the abundance of many species normally found in pine stands including canopy foragers, aerial insectivores, and potentially ground-nesters.[4]
- **Silviculture** that reduces competing deciduous vegetation (especially **herbicide application**) also reduces the amount of habitat for many forest bird species. Many birds, particularly shrub nesters and early- to mid-seral forest species, select deciduous regeneration for nesting, and heavily-treated stands can cause some species to have much lower nest success.[10]
- **Irregular group shelterwood and group selection systems** that were recommended for northern caribou habitat management in BC caused some species to increase but did not negatively affect bird communities of mature and old pine forests.[11]
- Regenerating pine provides fewer nesting opportunities **than residual overstory and understory conifer trees** (e.g., spruce or fir) within retention harvest blocks.[12]

Mountain Pine Beetle

Pine forests of British Columbia and Alberta have been hit with a mountain pine beetle outbreak that is unprecedented in its scale, duration, severity, and spread.[1,5,6] Large, homogeneous areas of lodgepole pine are considered most vulnerable to high-mortality outbreaks.[7]

Bark beetle outbreaks produce a pulse of food resources for breeding birds and provide important winter food sources for resident woodpeckers. High-mortality outbreaks may be followed by increases in woodpeckers, small cavity nesters (e.g., nuthatches and some chickadees), and some songbirds that forage and nest in old and/or decaying conifers,[8,9] and eventually by shrub-nesters as the outbreak area regenerates.[7] However, outbreaks may also negatively affect some groups, including species that forage and nest in canopy foliage.[7]

However, bird populations that have increased (particularly cavity nesters) during bark beetle outbreaks are expected to decline over time, however their responses >5–6 years following peak outbreak are not well-studied.[7,9] Long-term effects of outbreaks may be severe if beetle mortality and salvage-logging push the amount of mature and old conifer forests below the natural range of variability within high-mortality outbreak areas.[5]

Recommendations for salvage-logging of beetle-killed forests may vary depending on the extent and severity of the outbreak. In areas with high post-outbreak mortality and extensive salvage logging, for example, it is recommended that managers identify remaining old forest remnants (particularly those containing deciduous trees) and retain them in patches >1 ha, including some larger patches (e.g., >10–50 ha).[5]

Stand-level Management Recommendations

Retention practices increase the stand complexity and deadwood volumes within a site, and this in turn supports overall biodiversity and mitigates the effects of harvesting for some bird species.

- **Thinning** of dense, mature pine stands has the potential to improve habitat conditions for some breeding bird species, provided thinning operations increase structural complexity by leaving slash, snags, and deciduous trees.[4]
- **Reduced/avoided herbicide application** where possible will help improve the diversity of post-treatment bird communities and avoid impacting the nest success of some deciduous nesters.[10,13]
- During **post-harvest or salvage operations**, operators should be watchful for ground-nesting species like the Common Nighthawk, which is often found in recently cleared pine forest. See the Common Nighthawk account for specific guidance on nest buffers.
- To maximize the value of retention, the following features should be captured in **retention patches** when and where feasible (see Table 4 for species-specific examples). These retention recommendations apply to regular harvests and, where possible, salvage logging operations.
    - **Live, large-diameter aspen** (>35 cm dbh, false tinder conks, signs of damage/decay) are strongly preferred by many cavity nester species.[14] **Other deciduous tree species** including paper birch, willow, and alder provide nesting and foraging habitat for a wide range of species.[10,12,15]
    - **Live overstory trees representative of the stand's original composition** (e.g., mixed-conifer) including large-diameter trees and snags containing cavities.
    - Large trees with **large mistletoe brooms, broken tops, old stick nests, and cavities** provide valuable nesting habitat for many species including raptors.[16,17]
        - **Trees left singly** across harvest blocks and patches closer to unharvested forest are used as perches by raptors and other species that hunt from perches (e.g., flycatchers). Perches positively affect these species by making more of the harvested area available for hunting.
    - **Snags, stumps, fallen and leaning logs, and other woody debris** provide foraging and nesting habitat for many species (including cavity nesters) and ground cover for nests and young.
    - **Retention patches within burned, salvage-logged stands** should include some large patches located toward the center of the burn. These patches provide valuable nesting habitat for species like the Black-backed Woodpecker, which are easy targets for forest predators in patches closer to unburned forest.[18]

Landscape-level Management Recommendations

- Several species associated with pine forests rely on the habitat conditions created by wildfire including high snag abundances and open or partly open habitat. **Management within the natural range of variation**—including strategic application of prescribed burning, salvaging, and free-to-burn scenarios—can be used to help ensure these open habitats are represented on the landscape.
    - **Beetle-killed pine forest** provides similar habitat to burned forest for species like the Black-backed Woodpecker. Recently beetle-killed stands that have not yet been salvaged may be considered as roughly equivalent to recent burns.[19]

- **Salvaging of beetle-killed and burned forests** should be managed to help maintain species associated with old forests and cavity nesters, an important group that creates habitat for many other species.[5]
    - Old forest remnants will be important for providing habitat for species of old forest on landscapes with high current or expected tree mortality.
    - Salvaging operations should be staggered over the landscape where possible to help maintain remnants as a network rather than concentrating them in a single area yet to be salvaged.
- **Heterogeneous landscapes** containing a mosaic of old forest, mixed stands, recently disturbed/open stands, and regenerating forest are expected to provide more diverse habitats for, and support a wider range of birds than, even-aged pine forests managed as single-species plantations. Managing within an area's **natural range of variation** is a strategy that in many cases will naturally promote improved bird diversity, as long as stand diversity is maintained as part of this strategy.[3,20]
    - **Limiting habitats** on some heavily-managed landscapes include recently burned forests and larger areas of forest exceeding the rotation age. Careful attention toward ensuring representation of these features within the area's NRV is recommended.[20]
    - **Mature and old forests** remain an important component of forest landscapes containing pine and mixed-conifer stands. Many of the species with strong habitat preferences are most abundant in these older forests and have shown some sensitivity to habitat fragmentation.[21]

YOUNG AND MID-SERAL FORESTS

Recently burned pine forests provide important habitat to several specialist species including Black-backed Woodpeckers, who forage on a pulse of deadwood-associated insects, and Common Nighthawks, who nest on—and hunt insects over—the exposed ground. Olive-sided Flycatchers are likewise often found nesting and hunting in recently-burned stands.

Young pine forests that have not yet reached their highest densities support many species associated with open and early-seral habitats, including Orange-crowned Warbler, Cedar Waxwing, Dark-eyed Junco, Chipping Sparrow, etc.[3,21] Ground nesters and ground foragers are likewise more common in younger pine forests (e.g., <15 years).

WHITEBARK PINE

The subalpine whitebark pine is an endangered tree species that is well-known for its tight association with the Clark's Nutcracker. Clark's Nutcrackers hide ("cache") pine seeds to get them through the winter, but many of these seeds are never recovered—and some of them go on to germinate in the spring. The whitebark pine relies on the Clark's Nutcracker to disperse its seeds large distances across the landscape.

Fire suppression, white pine blister rust, bark beetles, and other pathogens cause whitebark pine to produce fewer cones, with negative effects on their populations. Conservation efforts for whitebark pine and Clark's Nutcracker go hand in hand, as efforts to conserve one are necessary for the conservation of the other. For more information on whitebark pine, see the Clark's Nutcracker Species Account.

TABLE 4. RECOMMENDED PRACTICES: WHO BENEFITS IN PINE-DOMINATED FORESTS?

This list of species that benefit from recommended practices is limited to species of management interest that are included in this toolkit, and thus do not reflect the full range of species that will likely benefit from each practice. Note: these practices are only expected to benefit species that occur in the same area (e.g., within their geographic range).

Habitat Recommendation	Species expected to benefit
Large-diameter deciduous trees with signs of damage, disease, or cavities	• Brown Creeper (paper birch) • Northern Flicker (>35 cm dbh aspen) • Northern Pygmy-owl (cavities) • Northern Saw-whet Owl (cavities) • Pileated Woodpecker (>35 cm dbh aspen)
Large-diameter coniferous trees [with priority to large mistletoe brooms, large forks, broken tops, stick nests, etc.]	• Black-backed Woodpecker (conifers >23 cm dbh) • Brown Creeper (sloughing bark) • Clark's Nutcracker (whitebark pine, limber pine) • Golden-crowned Kinglet • Great Gray Owl (>6 ha patch for nest, single trees for perches) • Varied Thrush (tall, low foliage density near top) • Williamson's Sapsucker
Snags, stumps, and downed wood, with or without existing cavities	• Black-backed Woodpecker (mainly conifers >23 cm dbh) • Northern Flicker • Northern Pygmy-owl (cavities) • Northern Saw-whet Owl • Olive-sided Flycatcher (>5 m tall)
Deciduous shrubs/reduced herbicide use	• Rufous Hummingbird
Riparian buffers	• Northern Goshawk • Northern Pygmy-owl • Olive-sided flycatcher (perch trees) • Osprey (nest trees and/or tree taller than canopy, within 1-2 km of fish-bearing waterbody)
Recent burns/Recent harvests	• Common Nighthawk (locate and buffer ground nests) • Olive-sided flycatcher (retain some perch trees)
Large areas of late-seral forest	• Black-backed Woodpecker (>110 years) • Boreal Chickadee • Brown Creeper • Northern Goshawk • Northern Pygmy-owl • Northern Saw-whet Owl

REFERENCES: PINE-DOMINATED FOREST

1. Anderson, M. D. 2003. Pinus contorta var. latifolia. in *Fire Effects Information System [Online]* U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available online: https://www.fs.fed.us/database/feis/plants/tree/pinconl/all.html
2. Carey, J. H. 1993. Pinus banksiana. in *Fire Effects Information System [Online]* U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available online: https://www.fs.fed.us/database/feis/plants/tree/pinban/all.html
3. Kirk, D. A. & Hobson, K. A. 2001. Bird–habitat relationships in jack pine boreal forests. *Forest Ecology and Management* **147:** 217–243. Available online: http://www.sciencedirect.com/science/article/pii/S0378112700004655
4. Bayne, E. M. & Nielsen, B. 2011. Temporal trends in bird abundance in response to thinning of lodgepole pine (Pinus contorta). *Canadian Journal of Forest Research* **41:** 1917–1927. Available online: http://www.nrcresearchpress.com/doi/10.1139/x11-113#.Wftr0NCnFzB
5. Martin, K., Norris, A. & Drever, M. C. 2006. Effects of bark beetle outbreaks on avian biodiversity in the British Columbia interior: Implications for critical habitat management. *BC Journal of Ecosystems and Management* **7:** 10–24.
6. Dhar, A., Parrott, L. & Heckbert, S. 2016. Consequences of mountain pine beetle outbreak on forest ecosystem services in western Canada. *Canadian Journal of Forest Research* **46:** 987–999. Available online: http://www.nrcresearchpress.com/doi/10.1139/cjfr-2016-0137
7. Saab, V. A. *et al.* 2014. Ecological consequences of mountain pine beetle outbreaks for wildlife in Western North American forests. *Forest Science* **60:** 539–559. Available online: https://doi.org/10.5849/forsci.13-022
8. Swanson, D. L., Ingold, J. L. & Galati, R. 2012. Golden-crowned Kinglet (Regulus satrapa), version 2.0. in *The Birds of North America* (Rodewald, P. G., ed.) Cornell Lab of Ornithology, Ithaca, New York, USA. Available online: https://doi.org/10.2173/bna.301
9. Edworthy, A. B., Drever, M. C. & Martin, K. 2011. Woodpeckers increase in abundance but maintain fecundity in response to an outbreak of mountain pine bark beetles. *Forest Ecology and Management* **261:** 203–210.
10. Easton, W. E. & Martin, K. 2002. Effects of thinning and herbicide treatments on nestsite selection by songbirds in young managed forests. *The Auk* **119:** 685–694. Available online: http://www.jstor.org/stable/4089967
11. Waterhouse, M. J. & Armleder, H. M. 2007. Forest bird response to partial cutting on caribou winter range in west-central British Columbia. *BC Journal of Ecosystems and Management* **8:** 75–90. Available online: http://www.forrex.org/publications/jem/ISS39/vol8_no1_art6.pdf
12. Stuart-Smith, A. K., Hayes, J. P. & Schieck, J. 2006. The influence of wildfire, logging and residual tree density on bird communities in the northern Rocky Mountains. *Forest Ecology and Management* **231:** 1–17.
13. Easton, W. E. & Martin, K. 1998. The effect of vegetation management on breeding bird communities in British Columbia. *Ecological Applications* **8:** 1092–1103. Available online: http://www.jstor.org/stable/2640964
14. Edworthy, A. B. & Martin, K. 2014. Long-term dynamics of the characteristics of tree cavities used for nesting by vertebrates. *Forest Ecology and Management* **334:** 122–128. Available online: http://dx.doi.org/10.1016/j.foreco.2014.09.001
15. Alberta Sustainable Resource Development. 2003. *Status of the Brown Creeper (Certhia americana) in Alberta*. Alberta Sustainable Resource Development, Fish and Wildlife Division, and Alberta Conservation Association, Wildlife Status Report No. 49, Edmonton, AB. 30 pp.
16. BC Ministry of Forests Lands and Natural Resource Operations. 2013. *Guidelines for Raptor Conservation during Urban and Rural Land Development in British Columbia (2013)*. Victoria, BC. 151 pp. Available online: http://www.env.gov.bc.ca/wld/documents/bmp/raptor_conservation_guidelines_2013.pdf
17. Piorecky, M., Beck, B., Beck, J. & Bonar, R. 1999. Great Gray Owl year-round habitat: Habitat suitability index model (version 3). *USDA Forest Service General Technical Report* Available online: https://friresearch.ca/sites/default/files/null/HSP_1999_10_Rpt_GreatGrayOwlYearRoundHabitat.pdf
18. Saab, V. A., Russell, R. E., Rotella, J. & Dudley, J. G. 2011. Modeling nest survival of cavity-nesting birds in relation to postfire salvage logging. *Journal of Wildlife Management* **75:** 794–804.
19. Bonnot, T. W., Rumble, M. A. & Millspaugh, J. J. 2008. Nest success of Black-backed Woodpeckers in forests with mountain pine beetle outbreaks in the Black Hills, South Dakota. *The Condor* **110:** 450–457. Available online: http://www.jstor.org/stable/10.1525/cond.2008.8460
20. Hejl, S. J., Mack, D. E., Young, J. S., Bednarz, J. C. & Hutto, R. L. 2002. Birds and changing landscape patterns in conifer forests of the north-central Rocky Mountains. *Studies in Avian Biology* **25:** 113–129. Available online: https://www.researchgate.net/profile/Richard_Hutto/publication/267211708_Birds_and_changing_landscape_patterns_in_conifer_forests_of_the_north-central_Rocky_Mountains/links/5447e7370cf2d62c305295ad/Birds-and-changing-landscape-patterns-in-conifer-forests-
21. Venier, L. A. & Pearce, J. L. 2005. Boreal bird community response to jack pine forest succession. *Forest Ecology and Management* **217:** 19–36.

Habitat Synthesis: Dry Mixed-Conifer Forest (Interior Douglas Fir/Ponderosa Pine)

Dry mixed-conifer forests in southern interior BC and the Rocky Mountains are typically dominated by Douglas fir, mixed stands of Douglas fir and lodgepole pine, and ponderosa pine on very dry sites. Mixed stands often form at transition zones and may contain white spruce, western redcedar, grand fir, western larch, and paper birch. Patches of trembling aspen are also common within these forests. Fire is an important process that historically affected forest composition and structure, and this is reflected in the habitat associations of forest birds that nest and forage in dry mixed-conifer forests.[1]

Habitat Ecology

- Ponderosa pine is a fire-resistant tree species that has historically dominated dry valley bottoms and south-facing slopes. Frequent, low-severity fires prevent shade-tolerant understory trees from becoming co-dominant in the overstory, and have typically maintained open or partially open stands.[2]
- Douglas fir dominates many forest stands on more mesic sites and on northerly slopes. It often forms mixed stands with lodgepole pine, ponderosa pine, grand fir, western larch, western redcedar, white spruce, and trembling aspen (in patches).[2–4]
- Douglas fir encroachment within formerly open ponderosa pine stands is common due to fire suppression and harvesting.[5] This encroachment reduces the openness of stands, negatively affecting many bird species that rely on these more open habitats. True fir or spruce may likewise grow up in the understory of a ponderosa pine stand that has not burned in several decades.

Bird Responses to Forest Management in Dry Mixed-Conifer Stands

- Many of the bird species of concern within dry mixed conifer forests rely on frequent, low-severity fires to maintain high-quality foraging and nesting habitats. **Fire suppression negatively affects many species** by reducing the amount of open habitat (dense regenerating understory left unchecked). Lewis's Woodpecker and Williamson's Sapsucker are among the species-at-risk that are negatively affected by fire suppression.
- **Even-aged management reduces the structural complexity and layering** typical of stands that are either very old or have been subject to mixed-severity fire regimes. The Northern Spotted Owl is among the species-at-risk that are negatively affected by widespread even-aged management.
- **Thinning of Douglas fir,** while not equivalent to a low-intensity fire, benefits species associated with more open habitats and open forests (e.g., Common Nighthawk and Rufous Hummingbird).[6,7]
    - However, some species are negatively affected by thinning, including Brown Creeper, Varied Thrush, and other species associated with older forests.[6]

ROLE OF THE PASSIVE LANDBASE

Dry mixed conifer forests form extensive forest mosaics with other forest types across the landscape, including aspen stands and riparian areas typically containing black cottonwood.

Several species rely on both dry mixed-conifer stands and riparian cottonwood areas, including several species that are federally listed as Endangered or Threatened (e.g., Lewis's Woodpecker and Western Screech-Owl). In light of these close associations with both habitat types by many species of interest, these deciduous riparian areas are being considered as part of the habitat mosaic inherent to dry mixed-conifer landscapes.

Riparian areas also support other species including the Rufous Hummingbird and Pacific Wren. While riparian forests provide important habitat, narrow buffers are not considered substitutes for upland forests. However, there is some evidence that >30 m up to 100-m buffers, which contain a large area of upland forest, may provide suitable refuge for bird species of upland forest and provide connectivity in areas affected by clearcutting.[3] Note that riparian buffers near agricultural areas may be more vulnerable to predation and be less suitable as refuges.[8]

Open forests may not be targeted for harvesting due to low timber volumes, however active management is needed to maintain these habitat types. Thinning of dense understory trees, potentially followed by prescribed burning, is a restoration treatment that increases overall bird diversity in the short term.[9]

STAND-LEVEL MANAGEMENT RECOMMENDATIONS

Retention practices increase the stand complexity and deadwood volumes within a site, and this in turn supports overall biodiversity and mitigates the effects of harvesting for some bird species. To maximize the value of retention, the following features should be captured in retention patches or as single residual trees when and where feasible (see Table 5 for species-specific examples). These retention recommendations apply to regular harvests and, where possible, salvage logging operations:

- **Mixed-species patches containing coniferous species (e.g., Douglas-fir) and aspen** will support the greatest diversity of woodpeckers. Large-diameter aspen (>35 cm dbh) with conks, damage, or signs of disease are ideal anchors for mixed-species retention patches containing conifers.[10] By maintaining a variety of tree species and sizes, many different nesting and foraging opportunities are made available.[11]
- **Snags created by topping large-diameter conifers** (e.g., cutting the tops of Douglas-fir >53 cm dbh at heights of ~17 m) may be excavated by cavity nesters after >5 years.[12] Machine stubbing at heights of 3 m provides a safer alternative, and this practice has been shown to benefit cavity-nesting species depending on the stub densities employed.[13,d]
    - This technique will likely be most appropriate in harvest areas where large-diameter aspen and well-decayed veteran conifers—the trees preferred by woodpeckers for their soft heartwood—are rare.[12]

[d] Stub densities of 5–10 stubs/ha, in addition to 0.25 ha live tree islands every 8 ha, clearly mitigated the effects of clear-cutting by providing nesting habitat for Black-backed Woodpeckers, however these experimental densities were too low for Three-toed Woodpeckers unless within 50 m of unharvested forest.[13]

- **Large-diameter western larch, ponderosa pine, and other conifers (veteran trees)** (>45 cm dbh or largest available) provide valuable nesting habitat for woodpeckers (including the endangered Williamson's Sapsucker) and secondary cavity nesters.[14]
- **Small-diameter conifer trees** provide structural complexity within patches and sources of sap for sapsucking species (e.g., Williamson's Sapsucker) and the species that feed off saps (e.g., Rufous Hummingbird).[14]
- During salvage logging of burned stands, **clumps of residual trees and snags** are more likely to be selected by cavity nesters than evenly-dispersed retention. Patches containing large-diameter and well-decayed snags with broken tops are more likely to be selected by cavity nesters and will likely remain standing for longer.[15]
- **Snags, stumps, fallen logs, and other downed wood** provide foraging habitat, nesting habitat, and ground cover for a variety of species including cavity nesters.

Stand thinning is recommended in some stands where fire suppression and/or historical harvesting have caused formerly open forests to become young and dense, moving outside their natural range of variation.

- Ponderosa pine restoration treatments include **thinning** (20–30% retention) that retains the largest-diameter trees, **followed by prescribed burning**. These treatments increase overall bird diversity and some focal species including the White-headed Woodpecker.[9]

WHITEBARK PINE RESTORATION

Douglas fir is an alternate food source for Clark's Nutcracker, and may attract this species during the breeding season. Restoration treatments for whitebark pine are recommended where this at-risk tree species grows near Douglas fir. See the Clark's Nutcracker account for more information.

LANDSCAPE-LEVEL MANAGEMENT RECOMMENDATIONS

- Fire suppression and historical even-aged management have caused many open dry mixed-conifer forests to become dense, closed, and even-aged over time. **Partial harvesting (e.g., thinning, group and patch selection, retention harvesting, etc.) and prescribed burning** to return these forests to conditions closer to their natural range of variation will likely have many positive effects for the species that nest and forage in frequently disturbed, open forests, and for species that rely on mixed-composition overstory trees.[8,9,11]
- Many dry mixed-conifer landscapes are heavily altered not only by harvesting, but by extensive land conversion for agriculture, ranching, and urban development. Landscape-level management should consider not only **maintaining forest heterogeneity at multiple scales**, but carefully consider the kinds of habitats that are most severely limited on the landscape.
    - **Region-level targets for old forest amount** should be carefully applied with consideration for **size and connectivity to reduce fragmentation** wherever possible.[16] Species including the Williamson's Sapsucker require these older forests for nesting and/or foraging, particularly the large-diameter veteran trees they contain.

- Larger unharvested areas of old forest are particularly important where forests occur <10 km from agriculture and ranching, as small/fragmented forests within this distance will be more vulnerable to Brown-headed Cowbird invasions. Similarly, thinning is not recommended in these areas as it will make it easier for Cowbirds to travel farther into the forest.[7]

YOUNG AND MID-SERAL FORESTS

Many of the bird species associated with dry mixed-conifer forests are associated with the conditions found in recently burned stands. Black-backed Woodpecker, Common Nighthawk, and Lewis's Woodpecker are among the species that are common in, or rely on, these burned habitats.

Young, shrubby habitats that have not yet reached crown closure provide habitat for species that feed and nest in shrubs, for example the Rufous Hummingbird, that feeds on the nectar of flowering plants. Recently harvested stands, including clearcuts, partial cuts, patch cuts, etc., contain many species associated with open or shrubby habitats including Chipping Sparrow, Orange-crowned Warbler, and MacGillivray's Warbler.[17]

Vireos, some flycatchers, Western Tanagers, and more common species (e.g., Ruby-crowned Kinglet and Yellow-rumped Warbler) occupy young forests that have reached the point of canopy closure.[17]

TABLE 5. RECOMMENDED PRACTICES: WHO BENEFITS IN DRY MIXED-CONIFER FORESTS?

This list of species that benefit from recommended practices is limited to species of management interest that are included in this toolkit, and thus do not reflect the full range of species that will likely benefit from each practice. Note: these practices are only expected to benefit species that occur in the same area (e.g., within their geographic range).

Habitat Recommendation	Species expected to benefit
Large-diameter deciduous trees with signs of damage, disease, or cavities	• Brown Creeper (paper birch) • Dusky Grouse (clumps of aspen) • Lewis's Woodpecker • Northern Flicker (>35 cm dbh aspen) • Pileated Woodpecker (>35 cm dbh aspen) • Western Tanager • Williamson's Sapsucker
Large-diameter coniferous trees [with priority to large mistletoe brooms, large forks, broken tops, stick nests, etc.]	• Black-backed Woodpecker (conifers >23 cm dbh) • Brown Creeper (sloughing bark) • Clark's Nutcracker (whitebark pine, limber pine) • Dusky Grouse (patches >1 ha, pref. >4 ha, old Douglas fir, Engelmann spruce, and subalpine fir) • Golden-crowned Kinglet • Lewis's Woodpecker • Rufous Hummingbird (Douglas fir, western red cedar: nest trees) • Townsend's Warbler (high retention levels needed) • Western Tanager

Habitat Recommendation	Species expected to benefit
	• Williamson's Sapsucker (veteran western larch, ponderosa pine plus small-diameter Douglas fir, patches >3 ha)
Snags, stumps, and downed wood, with or without existing cavities	• Dusky Grouse • Lewis's Woodpecker (avg. 6 snags/ha in >1 ha patches during salvage) • Western Tanager (downed woody material >20 cm diameter)
Deciduous shrubs/reduced herbicide use	• Dusky Grouse • Lewis's Woodpecker (fruit-bearing shrubs) • Rufous Hummingbird
Poles, young trees, and unmerchantable trees and/or off-target species	• Rufous Hummingbird (young or pole aspen, birch clumps) • Western Tanager (non-merchantable timber) • Yellow-bellied Sapsucker (young or pole aspen, birch clumps)
Riparian buffers	• Brown Creeper (>30 m minimum, >80 m preferred) • Lewis's Woodpecker (black cottonwood >60 cm preferred)
Recent burns/Recent harvests	• Black-backed Woodpecker (<8 years postfire) • Common Nighthawk (locate and buffer ground nests) • Lewis's Woodpecker (burned, esp. ponderosa pine) • Rufous Hummingbird (shrubby regeneration)
Prescribed burning and/or thinning	• Clark's Nutcracker (see species-level account; thin + burn) • Gray Jay (thinning)
Large areas of late-seral forest	• Black-backed Woodpecker (old DF/PP stands, some >380 ha)* • Brown Creeper (>80 years Douglas fir, >10 to >54 ha) • Clark's Nutcracker (>10 ha patches with high cone density) • Dusky Grouse (>200 years Douglas fir with openings) • Townsend's Warbler (Grand fir/Douglas fir)

*Note: Old (> rotation age) forest is important secondary habitat for Black-backed Woodpeckers, as recently burned forest may be uncommon on the landscape in any given year. See the species account.

REFERENCES: DRY MIXED-CONIFER FOREST

1. Hope, G. D. *et al.* 1991. Interior Douglas-fir Zone. Pages 154–166 in *Ecosystems of British Columbia* 154–166. Research Branch, BC Ministry of Forests, Victoria, BC. Available online: https://www.for.gov.bc.ca/hfd/pubs/docs/srs/Srs06/chap10.pdf
2. Hejl, S. J., Mack, D. E., Young, J. S., Bednarz, J. C. & Hutto, R. L. 2002. Birds and changing landscape patterns in conifer forests of the north-central Rocky Mountains. *Studies in Avian Biology* **25:** 113–129. Available online: https://www.researchgate.net/profile/Richard_Hutto/publication/267211708_Birds_and_changing_landscape_patterns_in_conifer_forests_of_the_north-central_Rocky_Mountains/links/5447e7370cf2d62c305295ad/Birds-and-changing-landscape-patterns-in-conifer-forests-
3. Lehmkuhl, J. F. *et al.* 2007. Breeding birds in riparian and upland dry forests of the Cascade Range. *Journal of Wildlife Management* **71:** 2632–2643. Available online: http://www.jstor.org/stable/4496384
4. Stuart-Smith, A. K., Hayes, J. P. & Schieck, J. 2006. The influence of wildfire, logging and residual tree density on bird communities in the northern Rocky Mountains. *Forest Ecology and Management* **231:** 1–17.
5. George, T. L. & Zack, S. 2008. Bird occupancy and richness in ponderosa pine forests with contrasting forest structure and fire history. *Canadian Journal of Forest Research* **38:** 936–942. Available online: http://www.nrcresearchpress.com/doi/full/10.1139/X07-238#.Wj1_8d-nFzB
6. Hayes, J. P., Weikel, J. M. & Huso, M. M. P. 2003. Response of birds to thinning young Douglas-fir forests. *Ecological Applications* **13:** 1222–1232. Available online: http://dx.doi.org/10.1890/02-5068
7. Hagar, J. C., Howlin, S. & Ganio, L. 2004. Short-term response of songbirds to experimental thinning of young Douglas-fir forests in the Oregon Cascades. *Forest Ecology and Management* **199:** 333–347.
8. Saab, V. A. & Vierling, K. T. 2001. Reproductive success of Lewis's woodpecker in burned pine and cottonwood riparian forests. *The Condor* **103:** 491–501. Available online: http://www.jstor.org/stable/1369820
9. Gaines, W. L., Haggard, M., Lehmkuhl, J. F., Lyons, A. L. & Harrod, R. J. 2007. Short-term response of land birds to Ponderosa pine restoration. *Restoration Ecology* **15:** 670–678.
10. Drever, M. C. & Martin, K. 2010. Response of woodpeckers to changes in forest health and harvest: Implications for conservation of avian biodiversity. *Forest Ecology and Management* **259:** 958–966.
11. Mahon, C. L., Steventon, J. D. & Martin, K. 2008. Cavity and bark nesting bird response to partial cutting in northern conifer forests. *Forest Ecology and Management* **256:** 2145–2153. Available online: https://doi.org/10.1016/j.foreco.2008.08.005
12. Walter, S. T. & Maguire, C. C. 2005. Snags, cavity-nesting birds, and silvicultural treatments in western Oregon. *Journal of Wildlife Management* **69:** 1578–1591.
13. Gyug, L. W. 2002. Donna Creek Forestry/Biodiversity Project : Cavity Nests 1995 and 1996. Peace/Williston Fish and Wildlife Compensation Program, Report No. 253. 52pp plus appendices. Available online: http://www.env.gov.bc.ca/wildlife/wsi/reports/4795_WSI_4795_RPT_1995-1996_CAVITYNEST.PDF
14. Drever, M. C. *et al.* 2015. Using field data and GIS-derived variables to model occurrence of Williamson's Sapsucker nesting habitat at multiple spatial scales. *PLoS ONE* **10:** e0130849.
15. Saab, V. A. & Dudley, J. G. 1998. *Responses of cavity-nesting birds to stand-replacement fire and salvage logging in ponderosa pine/Douglas-fir forests of southwestern Idaho*. Research Paper RMRS-RP-11, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogen, UT. 17 pp. Available online: https://www.fs.usda.gov/treesearch/pubs/23853
16. B.C. Ministry of Forests Lands and Natural Resource Operations. 2014. *Best Management Practices for Timber Harvesting, Roads, and Silviculture for Williamson's Sapsucker in British Columbia: Western Area of Occupancy*. B.C. Ministry of Forests Lands and Natural Resource Operations, Nelson, BC. 15 pp. Available online: http://a100.gov.bc.ca/pub/eirs/viewDocumentDetail.do?fromStatic=true&repository=BDP&documentId=11941
17. Hutto, R. L. & Young, J. S. 1999. *Habitat relationships of landbirds in the Northern Region, USDA Forest Service*. Gen. Tech. Rep. RMRS-GTR-32. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT. 72 pp. Available online: https://www.fs.fed.us/rm/pubs/rmrs_gtr032.pdf

Habitat Synthesis: Moist to Wet Mixed-Conifer Forest (Interior Cedar/Hemlock)

Many areas in southeastern and west-central British Columbia are dominated by wet, diverse, productive forests that are often dominated by western redcedar and western hemlock. Mixed-conifer stands often contain lodgepole pine, trembling aspen, and paper birch; grand fir, white spruce, Engelmann spruce, and subalpine fir are also common in many forests. At transition areas with drier sites, mixed-conifer stands contain western larch, Douglas fir, and western white pine.[1]

This habitat-level account addresses primarily mesic to wet forests dominated by western hemlock and/or western redcedar. For habitat information on dry Douglas-fir dominated forests within the Interior Cedar-Hemlock (ICH) zone, see the *Dry Mixed-Conifer Forest Habitat Synthesis*.

Habitat Ecology

- Western hemlock and western redcedar are considered climax species due to their high shade tolerance; however, they may be found at all successional stages. They have low resistance to fire and burned stands generally have very high mortality, although large western redcedar typically survive fires if they are not girdled.[2,3]
    - Growing mainly in moist, riparian, and/or bottomland areas, these forests normally have a long fire return interval (>200 years). As a result, extensive late-seral forests are more common than in other western forests.[1–4]
- Young forests may be dominated by trembling aspen, paper birch, Douglas-fir or lodgepole pine until western hemlock or western redcedar become codominant and eventually, if the forest is not burned, dominant.[4,5]
- While some bird species are closely associated with recently burned stands (or harvests containing high densities of snags), many are found in mature to old forests.[1]
    - Many of the bird species found in these forests require large, old, veteran trees which can be easily excavated, providing nesting opportunities for both cavity nesters and the many owls and other species that reuse cavities. Other species of concern forage and nest in large conifers, while some (e.g., Varied Thrush) require the shady, moist understory conditions of these old forests.
    - Additionally, mixed forests containing a deciduous component in the overstory provide important habitat to cavity nesters (e.g., Yellow-bellied Sapsucker) and other species including Pine Grosbeaks and Veery.[1]

Bird Responses to Forest Management in Moist to Wet Mixed-Conifer Stands

- The majority of species of concern found in moist to wet mixed-conifer forests have negative responses to even-aged management (clearcutting). Clearcutting removes important habitat features including snags and large-diameter trees, and it causes understory vegetation to become dense with regenerating shrubs.
- Alternative harvesting systems have the potential to reduce the harmful impacts of harvesting for many of these sensitive species. These include **retention harvesting, shelterwood harvesting, group selection, and light thinning**. However, most of the studies testing the effects of these methods have been concentrated in other forest types, including boreal or sub-boreal forests (e.g., Barred Owl),[6] coastal forests (e.g., Pacific Wren),[7,8] and dry interior mixed-conifer forests (e.g., Varied Thrush).[9]
    - Within old interior cedar-hemlock forests, small-scale partial harvests (e.g., 30–60% volume removal in openings <0.5 ha) supported most cavity- and bark-nesting species of unharvested forest.[10,11]

Role of the Passive Landbase

Old, conifer-dominated riparian areas (e.g., along small mountain streams) contain high abundances of birds associated with older forests, likely due to the diverse foraging and nesting opportunities available in complex, layered forests. Brown Creeper, Varied Thrush, and Golden-crowned Kinglets have high abundances in these stands. However, younger riparian stands with high stem densities and low understory complexity may provide important habitat to overwintering birds.[12]

Riparian buffers <18 m support many species that nest and forage in early-seral habitats (e.g., Rufous Hummingbird, MacGillivray's Warbler and Orange-crowned Warbler), while buffers 40–70 m are not sufficient to support all species found in unharvested forest. Varied Thrush and Golden-Crowned Kinglet are among the species that are uncommon in riparian buffer strips <70 m.[13] However, species associated with riparian habitats may be effectively conserved by buffers as narrow as 13 m over the first postharvest decade.[14]

Species associated with steep slopes include Northern Pygmy-owl, Northern Saw-whet Owl, and Varied Thrush. These species may benefit from the passive landbase on steep slopes, however their success in these unharvested areas remains to be tested within intensively managed interior landscapes.

Stand-Level Management Recommendations

- Retention practices increase the stand complexity and deadwood volumes within a site, and this in turn supports overall biodiversity and mitigates the effects of harvesting for some bird species. To maximize the value of retention, the following features should be captured in retention patches or as single residual trees when and where feasible (see Table 6 for species-specific examples). These retention recommendations apply to regular harvests and, where possible, salvage logging operations:
    - **Mixed-species patches containing coniferous species (e.g., western hemlock, true fir, or spruce) and aspen** will support the greatest diversity of woodpeckers. Large-diameter aspen (>35 cm dbh) with conks, damage, or signs of disease are ideal anchors for mixed-species retention patches containing

conifers.[15] By maintaining a variety of tree species and sizes, many different nesting and foraging opportunities are made available.[10]

- **Large-diameter, veteran conifer trees** (e.g., western larch) provide important nesting and foraging habitats for many species of older forests.
- **Tall conifers** provide perches and potential nesting habitat for species including Varied Thrushes and Osprey, particularly near water.

- **Small-diameter conifer trees** provide structural complexity within patches and sources of sap for sapsucking species (e.g., Williamson's Sapsucker) and the species that feed off sap (e.g., Rufous Hummingbird).[16]
  - **Complex, layered vegetation** is an important characteristic of Northern Spotted Owl habitat. While retention is unlikely to provide habitat in a recently harvested stand for the Northern Spotted Owl, retention will contribute to habitat complexity at multiple successional stages.[17]
- **Snags, stumps, fallen logs, and other downed wood** provide foraging habitat, nesting habitat, and ground cover for a variety of species including cavity nesters.

- **Careful management of coarse woody debris and large-diameter trees** is strongly encouraged, as these features are expected to be increasingly limiting on even-aged and/or intensively-managed landscapes.[18]
  - Recommendations to **reduce damage to CWD** (larger, intact pieces have higher overall habitat value) include logging on settled snowpacks in the winter, using designated skid trails, and protecting fallen trees with large root wads.[18]
  - **Partial harvest systems** are recommended to ensure that large-diameter trees and CWD at different levels of decay, representing different overstory species, are available in the long-term. Retained patches or cohorts of trees will need to be managed beyond standard rotations of 80–100 years to ensure that habitat features of very old forests are formed and maintained over time.[18]

Landscape-level Management Recommendations

- Unlike dry mixed-conifer forests, moist to wet mixed-conifer forests (e.g., western hemlock/western redcedar) are characterized by very few stand-replacing fires (e.g., fire-return interval of up to 1,200 years in some very wet sites).[19] As a result, the natural range of variation for these forests is expected to include larger areas of forest much older than the rotation age, in some cases by centuries.[1]
  - Many of the species of management concern in these wetter forests are associated with the features of old forests—very large-diameter trees, snags, and coarse woody debris;[18] small gaps and openings;[6] and high structural complexity.[17]
  - Harvest systems that preserve these features, namely group selection, shelterwoods, patch cuts, and high overstory retention, have been shown to affect many species associated with older forests less severely than clearcutting.[10,11]
  - Stands containing very old trees (e.g., >250 years up to 600 years old, particularly western redcedar) provide unique habitat features and are often uneven-aged, putting them at risk for age class

misclassification in forest inventories. While research in these stands is limited for birds, these moist to wet mixed-conifer forests should be carefully managed and their protection considered within old growth management areas (OGMAs) until the potential habitat value for birds is better understood.[19]

- Many of the species associated with moist to wet mixed-conifer forests are known to nest, forage, and perch on a range of tree species that co-occur with western hemlock and western redcedar along moisture, temperature, and elevational gradients (e.g., Douglas-fir, subalpine fir, Engelmann spruce, trembling aspen, etc.). Harvest/regeneration strategies that favour species mixes representing the full range of preharvest overstory tree species are strongly recommended.
    - Deciduous patches may have disproportionate benefits at the stand and landscape scales. These patches have been associated with increased bird abundances, particularly species that forage for insects in the leafy canopy.[20]

YOUNG AND MID-SERAL FORESTS

Recently burned or harvested sites may contain Black-back Woodpeckers, Three-toed Woodpeckers, Olive-sided Flycatchers, Western Bluebirds, and/or Townsend's Solitaire. Burned stands are of particular importance to Lewis's Woodpecker (see *Dry Mixed-Conifer Forest Habitat Synthesis* for more information).

"Representative" species of young seral mesic to wet mixed-conifer forests include Ruffed Grouse, Downy Woodpeckers, Steller's Jays, American Robins, and Dusky Flycatchers.[1]

Figure 10. Northern Spotted Owl. Photo by the US Fish & Wildlife Service.

TABLE 6. RECOMMENDED PRACTICES: WHO BENEFITS IN MOIST TO WET MIXED-CONIFER FORESTS?

This list of species that benefit from recommended practices is limited to species of management interest that are included in this toolkit, and thus do not reflect the full range of species that will likely benefit from each practice. Note: these practices are only expected to benefit species that occur in the same area (e.g., within their geographic range).

Habitat Recommendation	Species expected to benefit
Large-diameter deciduous trees with signs of damage, disease, or cavities	• Northern Spotted Owl
Large-diameter coniferous trees [with priority to large mistletoe brooms, large forks, broken tops, stick nests, etc.]	• Northern Spotted Owl (plus unmerchantable trees for layering) • Pacific Wren (10% dispersed in cutblocks <10 ha near mature/old forest) • Townsend's Warbler (grand fir or white spruce) • Varied Thrush (tall, with low foliage density at top) • Williamson's Sapsucker (veteran western larch plus small-diameter Douglas fir; patches >3 ha)
Snags, stumps, and downed wood, with or without existing cavities	• Northern Spotted Owl • Pacific Wren (especially in riparian buffers of streams <10 m wide)
Riparian buffers	• Pacific Wren (buffers >40 m by streams <10 m wide) • Varied Thrush (buffers >35 m)
Understory protection	• Varied Thrush
Large areas of late-seral forest	• Northern Spotted Owl • Pacific Wren (>80 years forest; >30 ha unfragmented) • Townsend's Warbler (Grand fir/Douglas fir) • Varied Thrush • Williamson's Sapsucker (region-specific targets; see species account)

REFERENCES: MOIST TO WET MIXED-CONIFER FOREST

1. Ketcheson, M. V *et al.* 1991. Interior Cedar — Hemlock Zone. Pages 168–181 in *Ecosystems of British Columbia* 168–181. Research Branch, BC Ministry of Forests, Victoria, BC. Available online: https://www.for.gov.bc.ca/hfd/pubs/docs/srs/Srs06/chap11.pdf
2. Tesky, J. L. 1992. Thuja plicata. in *Fire Effects Information System [Online]* U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available online: https://www.fs.fed.us/database/feis/plants/tree/thupli/all.html
3. Tesky, J. L. 1992. Tsuga heterophylla. in *Fire Effects Information System [Online]* U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available online: https://www.fs.fed.us/database/feis/plants/tree/tsuhet/all.html
4. Steinberg, P. D. 2002. Pseudotsuga menziesii var. glauca. in *Fire Effects Information System [Online]* U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available online: https://www.fs.fed.us/database/feis/plants/tree/psemeng/all.html
5. BC Forest Practices Branch. 1996. Are British Columbia's New Forests Natural? Available online: https://www.for.gov.bc.ca/hfp/publications/00218/natur.htm
6. Piorecky, M. D. & Prescott, D. R. C. 2004. *Distribution, abundance and habitat selection of northern pygmy and barred owls along the eastern slopes of the Alberta Rocky Mountains*. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 91, Edmonton, AB. 26 pp.
7. Waterhouse, F. L. & Harestad, A. S. 2002. *Habitat use of a dispersed retention area by breeding Winter Wrens*. Technical Report TR-020. Research Section, Vancouver Forest Region, BC Ministry of Forests, Nanaimo, BC. 16 pp. Available online: https://www.for.gov.bc.ca/rco/research/wildlifereports/tr020.pdf
8. Beck, M. J. & George, T. L. 2000. Song post and foraging site characteristics of breeding Varied Thrushes in northwestern California. *The Condor* **102:** 93. Available online: https://doi.org/10.1650/0010-5422(2000)102[0093:SPAFSC]2.0.CO;2
9. Hayes, J. P., Weikel, J. M. & Huso, M. M. P. 2003. Response of birds to thinning young Douglas-fir forests. *Ecological Applications* **13:** 1222–1232. Available online: http://dx.doi.org/10.1890/02-5068
10. Mahon, C. L., Steventon, J. D. & Martin, K. 2008. Cavity and bark nesting bird response to partial cutting in northern conifer forests. *Forest Ecology and Management* **256:** 2145–2153. Available online: https://doi.org/10.1016/j.foreco.2008.08.005
11. Steventon, J. D., MacKenzie, K. L. & Mahon, T. E. 1998. Response of small mammal and birds to partial cutting and clearcutting in northwest British Columbia. *Forestry Chronicle* **74:** 703–713. Available online: http://pubs.cif-ifc.org/doi/pdf/10.5558/tfc74703-5
12. Anthony, R. G., Green, G. A., Forsman, E. D. & Nelson, S. K. 1996. Avian abundance in riparian zones of three forest types in the Cascade Mountains, Oregon. *Wilson Bulletin* **108:** 280–291. Available online: http://www.science.fau.edu/biology/gawliklab/papers/AnthonyRG-etal1996.pdf
13. Hagar, J. C. 1999. Influence of riparian buffer width on bird assemblages in western Oregon. *The Journal of Wildlife Management* **63:** 484–496. Available online: http://www.jstor.org/stable/3802633
14. Pearson, S. F., Giovanini, J., Jones, J. E. & Kroll, A. J. 2015. Breeding bird community continues to colonize riparian buffers ten years after harvest. *PLoS ONE* **10:** e0143241. Available online: https://doi.org/10.1371/journal.pone.0143241
15. Drever, M. C. & Martin, K. 2010. Response of woodpeckers to changes in forest health and harvest: Implications for conservation of avian biodiversity. *Forest Ecology and Management* **259:** 958–966.
16. Drever, M. C. *et al.* 2015. Using field data and GIS-derived variables to model occurrence of Williamson's Sapsucker nesting habitat at multiple spatial scales. *PLoS ONE* **10:** e0130849.
17. Blackburn, I. & Godwin, S. 2004. *Status of the Northern Spotted Owl (Strix occidentalis caurina) in British Columbia*. B.C. Minist. Water, Land and Air Protection, Biodiversity Branch, Victoria, BC. Wildl. Bull. No. B-118.
18. Stevenson, S. K., Jull, M. J. & Rogers, B. J. 2006. Abundance and attributes of wildlife trees and coarse woody debris at three silvicultural systems study areas in the Interior Cedar-Hemlock Zone, British Columbia. *Forest Ecology and Management* **233:** 176–191. Available online: https://doi.org/10.1016/j.foreco.2006.06.023
19. Forest Practices Board. 2008. *Biodiversity in the Interior Cedar-Hemlock Forests Near Dome Creek*. Complaint Investigation 070762. Available online: https://www.bcfpb.ca/wp-content/uploads/2016/04/IRC137-Biodiversity-in-Interior-Cedar-Hemlock-Forests.pdf
20. Ellis, T. M. & Betts, M. G. 2011. Bird abundance and diversity across a hardwood gradient within early seral plantation forest. *Forest Ecology and Management* **261:** 1372–1381. Available online: http://dx.doi.org/10.1016/j.foreco.2011.01.018

KNOWLEDGE GAPS

One of the objectives of this toolkit has been to evaluate important knowledge gaps in the literature. Rather than summarize individual gaps on a species-by-species basis, this section provides a summary of broad gaps that have received limited research, or for which research has been conducted at a limited scale. In many cases, these are questions that are difficult to research at broad scales, for example because of resource- and time-intensive data collection methods. In other cases, these are knowledge gaps around the effectiveness of specific silvicultural practices or BMPs in achieving specific goals.

Many of the knowledge gaps identified during the course of developing this toolkit overlap substantially with the questions of interest identified during the fRI Research Bird Conservation Workshop held in December, 2016:

1. How effective are Beneficial Management Practices at achieving bird conservation at multiple spatial and temporal scales?
2. What is the best way to establish population targets?
3. What are the key human dimensions that help engage practitioners and the public in bird conservation?
4. What is occurring at wintering grounds?
5. What influence do management techniques/practices have on population drivers?

Of these questions, knowledge gaps outlined in this section overlap most strongly with 1) BMP effectiveness at multiple scales and 5) management influence on population drivers. Questions regarding human dimensions and wintering grounds were out of scope for this toolkit, however they remain critical questions in the larger context of bird conservation in forest ecosystems and beyond.

A key take-away of this work has been the recommendation for increased communication and collaboration between industry practitioners, government policy makers, and researchers to identify questions of interest and well-suited study areas. This collaboration can benefit both parties by having more applied research questions addressed and in turn having more relevant and directly applicable results and recommendations from scientific studies. These studies, when guided by a common goal and a scientifically robust study design, represent an important opportunity to advance the understanding of bird conservation and forest management.

ECOLOGICAL TRAPS/REPRODUCTIVE SUCCESS

Large-scale studies of birds, like many wildlife studies, most often rely on abundance data—they obtain counts of birds, and then look for relationships between these counts and habitat features including vegetation type and structure, harvest history, and landscape context.

One of the main concerns or criticisms of this approach is the major assumption it makes: that sites with high numbers of birds represent high-quality habitat for them. For some time, it has been recognized that this assumption may be incorrect under certain conditions, for example:[1]

- If a small number of males with mates monopolize the best habitats, causing large numbers of unpaired males to crowd into lower-quality habitats; or,
- If human habitat alteration has affected a species' ability to correctly judge habitat quality (see Ecological Traps below).

Studies comparing abundance against reproduction mostly find that the two are positively related. However, a disconnect between the two is more likely to occur when studying habitats that have been disturbed by human activity.[1] This means that the habitats of most interest in this synthesis—habitats affected by forestry, for example—may be more likely to lead to misleading conclusions if only count data are used. The Olive-sided Flycatcher and Rusty Blackbird are two species of concern that have been found to have high numbers yet decreased reproductive success in harvested stands in some studies.[2,3] It is important to note, however, that not all studies testing for the presence of ecological traps have found them. In hardwood forests in New Brunswick, for example, two sensitive species (Brown Creeper and Ovenbird) showed no preference for low-intensity selection cuts over unharvested sites, nor was there evidence of significantly lower reproductive success in treated sites.[4]

Population Sink: Species that are spread across large areas are often distributed across a range of habitats. Population sinks occur when the local population is declining. This is a concern in fragmented habitats where old forest-associated birds breeding in increasingly smaller forest patches may have low success, causing the overall population to decline over time.[5]

Ecological Trap: When environments are altered by humans, the signs that birds use to find quality habitats may no longer be reliable. In these cases, a habitat may appear to be of high quality, attracting birds there to build nests and breed. But if appearances are deceiving and human impacts have lowered the habitat's quality—for example, by reducing prey densities or increasing predator densities—the birds breeding in them will experience lower survival, lower nest success, higher stress, or other negative impacts. When studying birds purely based on their abundances, it is likewise easy to incorrectly assume that an altered habitat is high quality when in fact the birds nesting there are struggling to survive and raise young.[6]

Recommendations for Research

Ultimately, reproductive studies are too labour- and cost-intensive to be undertaken at a large scale, meaning they should be prioritized mainly when there is reason to suspect that management practices may be creating an ecological trap. In these cases, targeted studies are needed that identify habitats of interest (e.g., naturally disturbed habitats, unharvested habitats, and habitats harvested under different harvest systems or BMPs) and collect data on both abundance and reproductive success.

While the Olive-sided Flycatcher and Rusty Blackbird have been identified as experiencing possible ecological traps, these studies had low sample sizes and were conducted in the northern Rocky Mountains (USA) and New England, respectively.[2,3] Within forest areas where these species are expected to overlap with managed landscapes, local

studies to test for ecological traps are encouraged. Until their local reproductive success is better understood, it will remain difficult to develop appropriate habitat management recommendations for either species in western Canada. A question of interest is whether the passive landbase (e.g., wet, stunted conifer stands) provides optimal habitat, and whether nearby retention harvests draw these species away and into ecological traps.

Federally- and provincially-listed bird species that have shown some positive response to harvest or other silvicultural treatments (e.g., prescribed burn or harvested areas) may also be high priority candidates for reproductive research. These species include the Common Nighthawk (Threatened) and Lewis's Woodpecker (Threatened).

Reproductive research, and research during sensitive life stages (e.g., juvenile dispersal, moulting, etc.) is also considered an important component of effectiveness monitoring.

Effectiveness Monitoring of BMPs/Habitat Management

Research has been ongoing to determine threshold retention levels, patch sizes, landscape conditions, etc. that support different bird conservation goals. Meanwhile, forest managers have been applying BMPs and a range of harvest systems on their active landbases, including but not limited to nest buffers, riparian buffers, retention, and set-asides or extended rotation stands to meet old forest targets.

An important gap in this process is research that explicitly follows up on recommended practices and BMPs to determine whether they are achieving their desired outcomes. Adaptive management requires that these strategies be tested and evaluated, and that they be adjusted if they are not achieving their objectives.

Practices including nest buffers, retention, block design and placement, and forest targets according to an area's natural range of variation (NRV) are all examples of practices that lack information on whether they are achieving conservation objectives, whether these are single-species, multi-species, or biodiversity objectives. This is due, in part, to the fact that these practices often vary among jurisdictions and companies, and it is difficult to evaluate the effectiveness of the full range of practices being applied. This contrasts with riparian buffers: since buffer widths are federally mandated, studies testing the range of buffer widths being applied in western Canada are more common and easily found (see *Landscape-level Synthesis*).

Long-term Monitoring

While some studies have taken place over longer time periods, most studies in the published literature have assessed bird responses to harvest treatments in the first few years after harvest (or natural disturbance, depending on the study). There are several reasons for this, including but not limited to the fact that monitoring requires a long-term commitment by researchers and funders to re-visit harvested sites over time periods that outlast most research projects. A consequence of this is that the majority of our understanding of harvest effects, edge effects, and population responses comes from studies that lack the context of stand regeneration over one to several decades.

Many long-term studies use data collected from stands that were harvested, burned, or otherwise disturbed at different times within the same harvested landscape, which makes it difficult to assess specific treatments (e.g.,

specific retention levels or patterns), but allows researchers to collect pseudo-time series data over a small number of years.[7,8] Others have used computer simulations where long-term data were unavailable.[9]

Periodic songbird monitoring at the EMEND project in northwestern Alberta provides some longer-term perspectives up to 15 years postharvest (see *Landscape-level Synthesis*), but is limited to results from stands with 10%, 20%, 50%, and 75% combined dispersed and patch retention.[10] While this information is highly valuable for testing specific project-level hypotheses, it nevertheless is not equivalent to monitoring of operational patterns and levels of retention in use by most operators in western Canada.

Long-term monitoring is expensive and logistically difficult to undertake. In some cases, the existence of a long-term project (e.g., EMEND and the Calling Lake Fragmentation Project, both in Alberta) helps ensure that data, methods, and field access are available to allow new researchers to continue this work. The benefits of these long-running projects are self-evident: recent research from the Calling Lake Fragmentation Project, for example, tracks the recovery of individual bird species over 23–33 years postharvest. They found that most old forest-associated bird species, particularly those that require large snags, tall trees, and/or large conifers were uncommon or absent in even 33-year regenerating clearcuts.[11]

In other cases, the long-term bird data collected by forestry companies may be a valuable source of information for long-term monitoring, particularly if there are efforts to pool and robustly analyze these data among companies. An additional opportunity exists for companies, with the help of researchers, to design future monitoring points to more effectively monitor the long-term outcomes of management practices of interest.

As long-term monitoring will not be possible in all cases, priority is recommended for monitoring of sites that meet one or more of the following conditions:

- Sites where specific management practices or BMPs were followed for the conservation of species-at-risk,
- Sites where widely-used or legally-required BMPs (e.g., riparian buffers) are in place (i.e., a better understanding of their long-term effectiveness will have the greatest impact), or
- Sites where novel harvest systems have been employed (e.g., pilot sites) and are under consideration for wider application.

While long-term monitoring is of greatest interest in sites that meet the above conditions, it is important to note that monitoring is likewise important in stands that represent business-as-usual, and potentially unharvested and/or naturally disturbed stands, to provide a point of comparison.

Examples of Candidate Practices for Effectiveness Monitoring

The following list provides examples of practices or questions which may be suitable candidates for direct effectiveness monitoring, including long-term monitoring. Partnerships between forest companies or organizations and the research community are recommended to help ensure that research designs are both scientifically robust and have direct applications within an adaptive management framework.

1. Identify an internal or legally-mandated BMP that has been consistently applied for >10 years. Options include analyzing internal biodiversity data, if they are available for stands in which this BMP has been applied, or collecting new data in these stands to construct a pseudo-time series.
2. Collect before-after data in summer harvests to evaluate the degree of incidental take and evaluate rates of nest abandonment and failure within retention areas following harvest.
3. Pilot new BMPs under consideration and design a before-after control-impact experiment. This type of monitoring will be most effective if two or more years of data are collected prior to harvest.
4. Monitor nests that have been buffered using internal or legally-mandated BMPs to determine whether these nests are re-used, either by the original species or by secondary nesters.
5. Monitor retention patches of a range of sizes to assess whether target species (e.g., cavity nesters) are foraging and/or successfully breeding in them, and timelines for this use (e.g., the first two postharvest years vs 10–30 years postharvest). Likewise, patches of a range of shapes (from linear to round) should be monitored to evaluate the strength of edge effects as the harvested area regenerates.
6. Revisit the oldest stands available that contain retention patches and evaluate whether they contain bird assemblages that more closely resemble those in similar aged clearcuts, burns, or unharvested forest. (i.e., test the long-term effectiveness of retention for improving stand structure and complexity.)

The Role of Maps and Models

An important question remains the use and effectiveness of models for predicting population densities and responses to disturbance, including harvest, within management units. Major initiatives to produce maps and models include the Boreal Avian Modelling project, Bird Studies Canada (provincial atlases), the Alberta Biodiversity Monitoring Institute, and more. These include partnerships that collate data from various studies, for example by data contributed by individual researchers working in the boreal forest (Boreal Avian Modelling Project). The strength of these models—massive datasets—is also, however, an important challenge, as studies record information on forestry practices at sampling locations differently, if at all. Not all forestry practices have been incorporated yet into the models, and this is an important step if these maps and models are to be effective tools for forest managers.

Recommended steps for improving maps and models include:

- Conducting model validation studies across a range of forest types, harvest types, forest ages, and landscape configurations.
- Collaborating with researchers producing maps and models to identify important gaps in their datasets (e.g., certain forest practices or regions), as well as data collection and documentation methods to ensure these data can be used in their models.
- Contributing company bird datasets to organizations producing maps and models to improve their data and, in turn, model accuracy.

Post-harvest Silviculture

Postharvest regeneration often, but not always, includes some combination of site preparation, seeding, planting, spraying, thinning, or otherwise tending stands to ensure they meet required regeneration standards. In western Canada, low-growing, shade-tolerant conifers (e.g., spruce) are often managed to ensure they are not replaced by fast-growing shade-intolerant species like trembling aspen—in essence, accelerating or "skipping" mid-seral stages to produce pure or nearly-pure conifer stands.

To our knowledge, there are few studies that have looked at the effects of postharvest silviculture—specifically, the effects of herbicide spraying—on forest bird communities. Examples include one study from Ontario (20–52 year clearcuts),[12] one study from Nova Scotia (4 year clearcuts),[13] and one study from south-central British Columbia (11–22 year conifer plantations).[14,15] Additional studies in western Canada, across a range of harvest systems subject to postharvest silviculture, are recommended to address this gap.

Comparisons between stands subject to postharvest silviculture and stands permitted to regenerate naturally may be useful in answering the following questions:

- How does postharvest silviculture affect the forest birds that nest and forage in stands compared with naturally regenerating harvested or burned stands? Are there species at risk of declining on landscapes where intensive postharvest silviculture (e.g., herbicide followed by planting) is applied on a large scale?
- Does postharvest silviculture improve habitat quality for birds associated with late-seral or pure stands (e.g., spruce) faster than natural regeneration?
- Does postharvest silviculture negatively affect species that require a well-developed shrub layer, mixed tree species composition, or other habitat features which are being suppressed on an intensively managed landscape?

Value of the Passive Landbase

There are many reasons that a patch, stand, or large forest area may belong to the passive landbase. In many cases, the passive landbase makes up a large proportion of a company's FMA or operating area. However, the large majority of studies compare harvested upland forests with unharvested (or burned) merchantable upland forest.

There are certainly some species of management concern with known habitat associations with habitats characteristic of the passive landbase, for example wet, unproductive, sparse, or stunted (mostly coniferous) stands (e.g., Rusty Blackbird, Olive-sided Flycatcher, Great Gray Owl, Northern Hawk Owl, and Connecticut Warbler). However, many other species of concern are instead associated with late-seral upland forests: while the value of legally-mandated riparian buffers for these upland old forest-associated species has been well-studied, other components of the passive landbase (wet areas, unproductive/unmerchantable areas, steep slopes, etc.) are not well-represented in the literature.

The value of stands left unharvested on steep slopes is an interesting question that is not well-understood. Most mentions of steep slopes encountered in the published literature were from studies that did not explicitly study slope, but simply included slope as a variable in their models. For example, Lewis's Woodpecker had a negative relationship with slope in one study,[16] while the Northern Pygmy-owl was associated with high slope and terrain variability in another.[17] Studies that directly assessed which birds occupy high-slope retention areas were not encountered over the course of the literature review for this toolkit.

The value of wet, steep, inaccessible, riparian, or protected areas depends not only on which species are successful in them, but also depends on their size, degree of fragmentation, and connectivity. As with upland unharvested or extended-rotation areas, the passive landbase provides different benefits to different species depending whether it is a large, continuous area or broken into small, isolated patches embedded in an intensively managed landscape. For these reasons, studies of the passive landbase are strongly encouraged.

Under-studied Species of Concern

Research on birds in forest ecosystems relies heavily on auditory cues to help researchers count birds and, in some studies, locate their territories and potentially nests for closer observation. Identifying and counting birds by their songs, calls, and other sounds (e.g., drumming) has the benefit of efficiency and increases sample sizes compared with practices like mist-netting or nest-peeping.

There are, however, several downsides to reliance on bird songs and calls for research. Early morning bird counts do not capture nocturnal species like owls, and some species are very quiet while others occur at very low densities and are rarely encountered. Recent technologies (automated recording units - ARUs) and statistical methods (detectability models) have made progress in addressing some of these challenges. However, the issue remains that the bulk of the literature for the last several decades have focused on birds that are common or which have loud calls. Rare species are frequently omitted from analyses because of low sample sizes.

The following list includes species that have little to no direct information on their responses to forestry (based on our review in this toolkit). Many of these are species that are difficult to detect, while others are species for which there were very few North American studies.

- Bay-breasted Warbler: this species occurs at low densities and is difficult to detect. As a spruce budworm specialist, there are also concerns that the Bay-breasted Warbler may experience chronic negative effects of insecticide spraying.[18]
- Blackpoll Warbler: most targeted studies of this species have been conducted in Newfoundland and northeastern USA. In western Canadian studies, this species is most often observed incidentally, and the habitat associations found by the Alberta Biodiversity Monitoring Institute and Boreal Avian Modelling project are not entirely consistent with expected habitat associations from the literature, suggesting possible differences in habitat associations across their range (which require further testing).
- Boreal Owl: most North American management recommendations have been based on either known

habitat ecology or a small number of forestry-specific studies conducted in Finland. A recent study in Alberta used provincial-scale data to determine habitat associations for this species, however analysis of responses to forestry using a nest-box experiment was hindered by extremely low sample sizes.[19]

- Cape May Warbler: this species has low natural densities and a subtle song. Responses to specific forestry treatments are particularly poorly understood (however, their avoidance of early-seral stands is well-established). As a spruce budworm specialist, there are also concerns that the Cape May Warbler may experience chronic negative effects of insecticide spraying targeting this pest.[20]
- Clark's Nutcracker: This species is well-studied compared with the other species listed here. However, published studies for this species have focused primarily on their responses to restoration treatments for whitebark pine, while there was little to no information found regarding their responses to conventional forest harvest.
- Common Nighthawk: This species is nocturnal and easily missed unless it is calling while flying overhead during the day. They are rarely observed except by targeted studies, and information on their responses to clearcut and retention harvests is extremely limited as a result.
- Great Gray Owl: Forest management recommendations are almost entirely inferred from known habitat ecology of this species.
- Pine Grosbeak: This species occurs at very low densities except during winter irruptions, and mostly occupies remote habitats (particularly during the breeding season). There is little to no information on the Pine Grosbeak's responses to forestry apart from a small number of studies from Finland.

Recommended Practices for Research

Research undertaken to fill the knowledge gaps listed here will help evaluate existing forest management practices and help ensure that forest birds are not being pushed outside their natural range of variation or put at risk by forest management. It is strongly recommended that forest companies collaborate with researchers to identify research questions of interest with strong potential applications, and to develop harvest designs that meet industry needs and facilitate future research (e.g., by replicating harvest patterns, controlling for variables like cutblock size or shape, or configuring harvest designs to test larger-scale questions).

Additionally, synthesis or meta-analysis of research findings will be most straightforward and accurate if detailed information on the harvest system(s) or pattern(s) under investigation are more consistently reported. This will facilitate replication of these approaches in future studies or enable more direct comparison with various company operations to assess the relevance of the conclusions at a local scale:

- Retention amount (e.g., percent volume or stems), retention patch/residual tree composition (e.g., merchantable timber vs off-target species or wet areas), retention pattern (dispersed, patches, or both), and size (patch size or distribution of sizes).
- Extent of overlapping human footprints (e.g., seismic lines, roads, oil and gas wells, etc.).
- Landscape context (intensively managed, relatively undisturbed, agriculture, etc.).

Collaboration among forestry companies and researchers may create further opportunities for large-scale research projects designed to test landscape-scale questions or to replicate the same study across a large area, providing greater confidence in findings which are consistent across large management areas.

Figure 11. A Barred owl looks out over an ATV trail at the EMEND Project in northwestern Alberta. Photo by S. Odsen.

REFERENCES: KNOWLEDGE GAPS

1. Bock, C. E. & Jones, Z. F. 2004. Avian habitat evaluation: should counting birds count? *Frontiers in Ecology and the Environment* **2:** 403–410. Available online: http://www.jstor.org/stable/3868428
2. Powell, L. L., Hodgman, T. P., Glanz, W. E., Osenton, J. D. & Fisher, C. M. 2010. Nest-site selection and nest survival of the rusty blackbird: Does timber management adjacent to wetlands create ecological traps? *The Condor* **112:** 800–809. Available online: http://www.bioone.org/doi/full/10.1525/cond.2010.100152
3. Robertson, B. A. & Hutto, R. L. 2007. Is Selectively Harvested Forest an Ecological Trap for Olive-Sided Flycatchers? *American Ornithological Society* **109:** 109–121. Available online: http://dx.doi.org/10.1650/0010-5422(2007)109[109:ISHFAE]2.0.CO;2
4. Villard, M.-A., D'Astous, É., Haché, S., Poulin, J.-F. & Thériault, S. 2012. Do we create ecological traps when trying to emulate natural disturbances? A test on songbirds of the northern hardwood forest. *Canadian Journal of Forest Research* **42:** 1213–1219. Available online: https://doi.org/10.1139/x2012-047
5. Pulliam, H. R. 1988. Sources, sinks, and population regulation. *The American Naturalist* **132:** 652–661. Available online: http://www.jstor.org/stable/2461927
6. Schlaepfer, M. A., Runge, M. C. & Sherman, P. W. 2002. Ecological and evolutionary traps. *Trends in Ecology and Evolution* **17:** 474–480.
7. Schieck, J. & Hobson, K. A. 2000. Bird communities associated with live residual tree patches within cut blocks and burned habitat in mixedwood boreal forests. *Canadian Journal of Forest Research* **30:** 1281–1295. Available online: http://www.scopus.com/inward/record.url?eid=2-s2.0-0033780243&partnerID=40&md5=8fd79c66f64c3a4d61853a11c7f5da7f
8. Hobson, K. A. & Schieck, J. 1999. Changes in bird communities in boreal mixedwood forest: Harvest and wildfire effects over 30 years. *Ecological Applications* **9:** 849–863.
9. Millington, J. D. A. *et al.* 2011. Combined long-term effects of variable tree regeneration and timber management on forest songbirds and timber production. *Forest Ecology and Management* **262:** 718–729. Available online: https://doi.org/10.1016/j.foreco.2011.05.002
10. Odsen, S. G. 2015. *Conserving Boreal Songbirds Using Variable Retention Forest Management*. Master of Science. Dept. Renewable Resources, University of Alberta, Edmonton, AB. 84 pp.
11. Leston, L., Bayne, E. & Schmiegelow, F. 2018. Long-term changes in boreal forest occupancy within regenerating harvest units. *Forest Ecology and Management* **421:** 40–53. Available online: https://doi.org/10.1016/j.foreco.2018.02.029
12. Thompson, I. D., Kirk, D. A. & Jastrebski, C. 2013. Does postharvest silviculture improve convergence of avian communities in managed and old-growth boreal forests? *Canada Journal of Forest Research* **43:** 1050–1062. Available online: https://doi.org/10.1139/cjfr-2013-0104
13. MacKinnon, D. S. & Freedman, B. 1993. Effects of silvicultural use of the herbicide glyphosate on breeding birds of regenerating clearcuts in Nova Scotia, Canada. *Journal of Applied Ecology* **30:** 395–406. Available online: http://www.jstor.org/stable/2404181
14. Easton, W. E. & Martin, K. 2002. Effects of thinning and herbicide treatments on nestsite selection by songbirds in young managed forests. *The Auk* **119:** 685–694. Available online: http://www.jstor.org/stable/4089967
15. Easton, W. E. & Martin, K. 1998. The effect of vegetation management on breeding bird communities in British Columbia. *Ecological Applications* **8:** 1092–1103. Available online: http://www.jstor.org/stable/2640964
16. Vogeler, J. C., Yang, Z. & Cohen, W. B. 2016. Mapping suitable Lewis's woodpecker nesting habitat in a post-fire landscape. *Northwest Science* **90:** 421–432. Available online: http://www.bioone.org/doi/pdf/10.3955/046.090.0404
17. Piorecky, M. D. & Prescott, D. R. C. 2006. Multiple spatial scale logistic and autologistic habitat selection models for northern pygmy owls, along the eastern slopes of Alberta's Rocky Mountains. *Biological Conservation* **129:** 360–371. Available online: https://doi.org/10.1016/j.biocon.2005.11.003
18. Environment Canada. 2013. *Bird Conservation Strategy for Bird Conservation Region 6: Boreal Taiga Plains*. Canadian Wildlife Service, Environment Canada, Edmonton, Alberta. 288 pp.
19. Domahidi, Z. 2018. *Distribution and breeding ecology of boreal and northern saw-whet owls in the Boreal forests of Alberta, Canada*. M.Sc. Thesis. Department of Renewable Resources, University of Alberta, Edmonton, AB. 81 pp.
20. Baltz, M. E. & Latta, S. C. 1998. Cape May Warbler (Setophaga tigrina), version 2.0. in *The Birds of North America* (Rodewald, P. G., ed.) Cornell Lab of Ornithology, Ithaca, New York, USA. Available online: https://doi.org/10.2173/bna.332

Species Scoping Process

A prioritization process was conducted to narrow down the priority species for Bird Conservation Regions 4, 6, 9, and 10 for inclusion in this report. The objective of this process was to develop a final list containing up to 40 species that met the following criteria:

- Associated with habitats subject to forest management within the provinces of Alberta, British Columbia, and Saskatchewan (both early, mid and late successional habitats)
- Known or suspected to be sensitive to forest management
- Conservation priority (e.g., population objective is to increase and/or listed)

Where possible, this process used data contained within the Bird Conservation Strategies developed for each Bird Conservation Region. These data include population trends, population objectives, and primary habitat associations. Provincial and federal species statuses were reviewed and updated if the status listed in the BCR strategy was out-of-date.

Additional data were collected for candidate species to determine whether they are considered sensitive to forestry. The process is described below and was cross-validated using the Alberta Biodiversity Monitoring Institute Human Footprint dataset.

Species prioritization process

The full species list was initially filtered to include only landbirds. While many waterfowl and shorebird species may be sensitive to forestry, this was an important first step to limit the scope to species whose primary habitat associations include values that are directly affected by forestry at the stand and landscape levels. Sensitive waterfowl and shorebirds may be considered for future additions to this tool.

Species were subsequently filtered to include only species with primary habitat associations (as defined within the BCR strategies) with at least one of the following habitat values: coniferous, deciduous, mixed, shrub/early successional, lichens/mosses, and riparian.

Many of the species included in the BCR priority species list are known to have wide ranges and large, stable populations. Species were filtered to include only species that are listed federally on Schedule 1 of the *Species at Risk Act*, considered sensitive or at-risk in Alberta, British Columbia, or Saskatchewan, assigned a population objective of increase or decrease[e] within at least one of the four Bird Conservation Strategies, or were added based on expert opinion to the BCR Priority Species list.

The remaining species were then assigned a value indicating relative sensitivity to forest management. Sensitivity was assigned using a coarse-filter review of the available literature. If a species was listed under the *Species at Risk Act*,

[e] Species with a Population Decrease objective were not explicitly filtered out, as harmful species (e.g., brood parasites or non-native species) may have implications for forest management.

the Threats section was reviewed for terms relating to forest management. When available, Recovery Strategies were reviewed. For unlisted species, species accounts on the Birds of North America (Conservation and Management) were reviewed for evidence of responses to forest management or habitat degradation through tree removal or landscape alteration by forestry. If sensitivity was unclear, other online accounts or reports were used (e.g., allaboutbirds.org, Boreal Avian Modeling project, etc.). In cases where sensitivity to forest management was uncertain, whether due to lack of information or conflicting accounts, sensitivity was conservatively assigned the higher value under consideration.

Cross-validation step: species responses to human footprint, as modeled by the Alberta Biodiversity Monitoring Institute,[f] were compared against forest sensitivity values assigned in the step above. Where values disagreed, they were reviewed and adjusted if appropriate.

Species considered to have "low" sensitivity to forest management were filtered out at this stage.

Expert opinion and a finer-filter literature review were then used in the final stage of species scoping. Closer examination revealed that some species were unsuitable for inclusion due to marginal associations with forest management or with the geographic scope of the project. Other species were identified by industry members and experts as species of management concern and were included in the final list.

Prioritization Exercise

Following these steps, the final list contained 61 species. A prioritization exercise was undertaken by which species were ranked by members of the Forest Management Advisory Group (FMAG), a group composed of forest ecologists currently or formerly involved in forest management. Advisory Group members were likewise invited to add species which had been overlooked or removed from the priority species list if there were industry-specific information needs. Species were prioritized according to the following steps:

Priority rank	Designation	Rule
1	Must include	At least one FMAG member identified as top priority (rank = 1)
2	High priority	All FMAG members identified as medium priority OR at least two FMAG members added to the list as medium priority.
3	Medium priority	Majority of ranks assigned as medium priority with at least one rank as low priority.
4	Low priority	Majority of ranks assigned as low priority.
5	Remove	Species ranked entirely as low priority.

[f] http://abmi.ca/home/data-analytics/da-top/da-product-overview/Species-level-Data-Sets/Species-level-effects-of-Human-Footprint.html

Following these steps, the first two priority ranks (Must Include and High Priority) made up the 40 species reviewed in this initial version of the toolkit. The remaining list will be useful for identifying candidate species for future expansions of the toolkit.

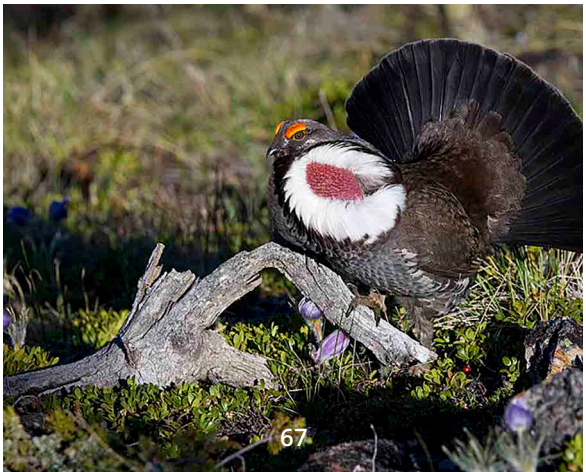
Species Accounts





Species Accounts

fRI Research Bird Conservation Toolkit


These fast-flying acrobats hunt for insects mid-air over open areas, and nest in burrows they dig in the sandy sides of stream banks (and sand piles, if available).

Bank Swallow

(Riparia riparia)

STATUS

SARA		British Columbia	YELLOW
Alberta	THREATENED SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Riparian

TERRITORY SIZE
~200 ha

NEST TYPE
Burrow

NEST REUSE
Frequent

STAND LEVEL
Inspect crossings for nests and sandy stream banks for colonies.

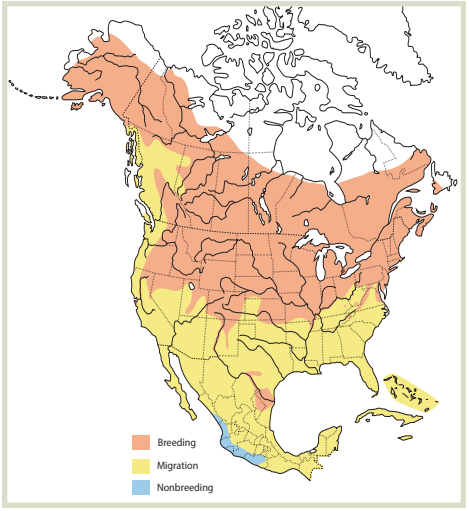
LANDSCAPE LEVEL
Colonies more likely in areas with open water, meadows, and sandy/silty/loamy soils.

BREEDING WINDOW

HABITAT ECOLOGY

- The Bank Swallow is a fast-flying bird that breeds in colonies of 10 to 2,000 nests.[1]
- They excavate nesting burrows in sandy, eroded riparian banks, large sand piles and road cuts.[1]
    - Features with vertical/nearly vertical faces and firm substrate (i.e., can be tunnelled without collapsing) are most suitable for excavation. See Stand-level Recommendations.
- Bank Swallows forage in open areas, including above riparian (and sometimes upland) woodlands.[1] They typically avoid dense forests and are expected to forage over recent burns and harvest blocks.[2]
- In forested landscapes, Bank Swallows are mostly likely to occur in riparian areas where sandy soils occur (e.g., glacial outwash), which may be indicated by the presence of pine.[3,4] They forage in nearby open habitats, however the presence of sandy, eroded banks for nesting is the most important factor in determining their presence.[2]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Nesting Bank Swallows are vulnerable to mortality from riparian banks collapsing, flooding, or being otherwise damaged (e.g., by road-building).[1]
- Erosion control measures used during road construction can cause nesting habitat loss or direct mortality when materials (e.g., rock walls) are placed in front of nest sites.[5]
- Insecticide use is a concern due to effects on food supply, which may affect the Bank Swallow's reproductive success or survival.[6,7]

STAND-LEVEL RECOMMENDATIONS

- Planned stream crossings should be inspected for nest entrances on stream banks prior to road construction. Where large colonies (>10 pairs) are located, a 50-m buffer should be established within which high-intensity activities (road-building, landings, stream crossings) should be avoided.[2,8]
- Monitoring should be frequent in the spring (May-June) as swallows may establish a colony over several days.[9]
- Riparian buffers should be maintained, and streams not requiring buffers should be checked for eroded, sandy banks which could be potentially used by nesting Bank Swallows. Where these features are found, voluntary buffers are recommended to avoid damaging current or future nesting sites.
- Bank Swallows may excavate nests in sand piles or road cuts, risking mortality if disturbance is planned during the breeding season. The following steps are recommended for operators to manage this risk:[9,10]
    - Evaluate suitability for excavation: If you insert a 4–5" pipe and dig out the sand inside, does the cavity collapse when the pipe is removed? If no, Bank Swallows may excavate burrows on vertical faces of this feature.
    - If vertical faces are present (e.g., on a sand pile), collapse them using equipment during the breeding season.
    - If the feature is firm enough to be excavated, and vertical faces cannot be collapsed, it should be tightly covered with tarps if

left exposed for >48 hours during the breeding season.[11]

- Note that mist nets and other thin netting should not be used as swallows may become tangled in them. Operators should instead use canvas or other textiles (e.g., silage tarps).[2,9]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Areas with streams/rivers and open areas (meadows, bogs, open woodland, cutover areas, and recent burns) have a higher likelihood of containing Bank Swallow colonies, particularly in areas characterized by sandy soils. Surveying planned road right of ways and avoiding creek crossings in areas with open, sandy banks is an important planning step.
- In operating areas known or expected to contain Bank Swallows, careful attention during road-building and stream-crossing is encouraged to avoid impacting stream flow and natural hydrologic processes.[2]

The Barn Swallow is a common bird of agricultural areas where it predominately nests in colonies in open barns. In more forested regions the Barn Swallow nests in smaller colonies (sometimes single nests) on bridges, inside culverts, and on other structures within or near forestry operations.[1]

Barn Swallow

(Hirundo rustica)

STATUS

SARA		British Columbia	BLUE
Alberta	THREATENED SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Structure/Crossing

TERRITORY SIZE
0.01 ha

NEST TYPE
Buildings, banks, culverts, bridges

NEST REUSE
Frequent

STAND LEVEL
Inspect bridges and buildings for nests; prevention using textiles (not netting).

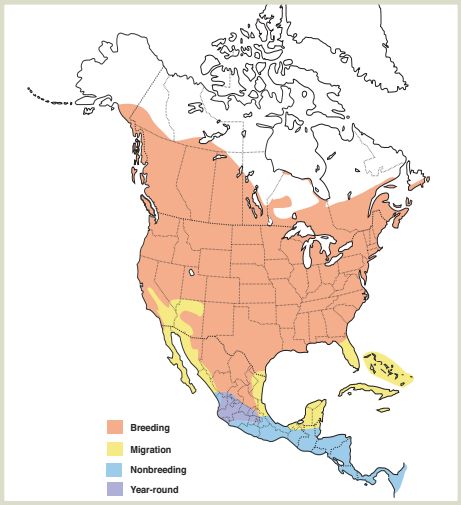
LANDSCAPE LEVEL
Awareness important near meadows, waterbodies and other open areas.

BREEDING WINDOW

HABITAT ECOLOGY

- Barn Swallow breeding habitat usually contains three important features.[2]
  - Open areas for foraging (e.g., meadow)
  - Nearby source of mud for use in nest-building.[1]
  - Nest site is usually in or on a building (e.g., rafters, eaves, ledges, etc.), bridge, or culvert. Natural sites such as cliff faces and caves are also used but less frequently than human-made sites.[1]
- These birds mainly use agricultural areas for foraging, but may also use wetlands, lakes, and sometimes shrubby riparian areas.[3] Large cutover areas and wet meadows may provide adequate foraging sites assuming available nesting sites are nearby.[1,4]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Threats to the Barn Swallow include direct prey reduction associated with insecticide use, indirect prey reduction associated with herbicide-caused vegetation changes, and loss of nesting sites due to building modification or intentional nest removal by people. While these threats are most severe within agricultural areas, they have **implications in recent forest clearings where they may build nests on outbuildings, water crossings, or equipment.**[5,6]

STAND-LEVEL RECOMMENDATIONS

- Operators should be trained to recognize Barn Swallow nests (active and inactive). Bridges, outbuildings, and large (~1 m) culverts are attractive nest sites, and operators should note and record nests they observe on these structures.
- Prevention: Old nests reflect sites which may attract future nesting pairs. If these sites will be disturbed during the breeding season (May 1 to Aug 31), operators can prevent nest-building by blocking sites (e.g., eaves) using geotextiles, tarping, or canvas.[7]
- Do not use mist nets or other thin netting, which may entangle swallows.[8]
- Covering of empty nests and/or potential nest sites should be completed before April 1.[9]
- Nesting may be encouraged on structures that will not be disturbed during the breeding season, including by installing ledges or platforms that Barn Swallows and other species may nest on.[10]
- Avoidance: Operators should stay at least 1.5 m away from active nests (~May 1 to Aug. 31)[9] and remain particularly watchful when young fledge (leave the nest but cannot fly).

LANDSCAPE-LEVEL RECOMMENDATIONS

- Awareness of potential nest locations is important where all operations occur, but is especially important for operations near large open areas including wetlands, waterbodies, agricultural fields, and cutovers (e.g., during silviculture).
- Temporary crossing removal only before or after the breeding season, and protection of active nests until the breeding season is complete, are the main strategies for protecting Barn Swallows. Nest platform placement is a potential form of habitat enhancement on sites that will not be disturbed.[10]

Note: Operations within Spotted Owl range may be recommended to discourage Barred Owl occupancy, rather than promoting it. See Spotted Owl.

Barred Owl

(Strix varia)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Old deciduous, mixedwood

TERRITORY SIZE
300–1,000 ha

NEST TYPE
Cavity (natural)

NEST REUSE
Frequent

STAND LEVEL
Old, large deciduous snags in large patches (>10 ha).

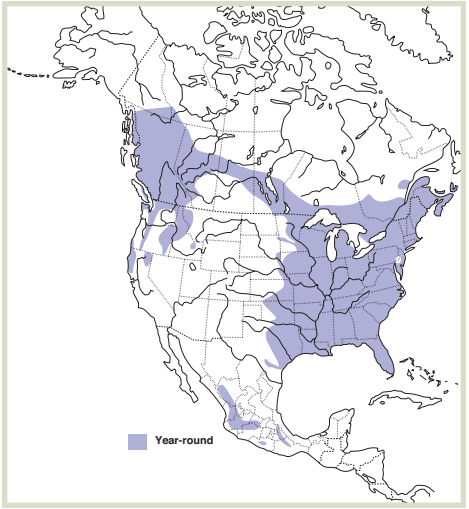
LANDSCAPE LEVEL
Old, large mixedwood forest stands and upland forests.

BREEDING WINDOW

HABITAT ECOLOGY

- Barred owls are associated with large trees and snags in old (>80 years) mixedwood forests and, in BC, upland mature and old conifer forests.[1]
  - Aspen and poplars provide nest trees, while white spruce and balsam fir provide cover for owlets.[2]
  - Structural diversity, including partially fallen trees, is important near nest trees.[3]
  - They also use Douglas fir, western hemlock, western larch, and black cottonwood forests (coniferous or mixed), often near water.[4]
- Barred Owls mainly nest in large-diameter deciduous trees in natural cavities formed by disease, broken branches, or broken tops. Woodpecker cavities are too small for this large-bodied species. They will readily use nest boxes.[1]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Barred Owls require large, contiguous mature forest habitat and have been negatively impacted by severe fragmentation and habitat loss in parts of their range.[2]
- Where the Barred Owl's range overlaps with that of the Great Horned Owl, fragmentation negatively affects Barred Owls by creating habitat for this aggressive predator and competitor.[2]
- Clear-cutting without retention is considered an important threat due to loss of cavity trees and snags for nesting.[1]
- Barred owls have been observed nesting in retention patches and within 50 m of cutblock edges in landscapes with a low amount of harvested area (7%).[5]

STAND-LEVEL RECOMMENDATIONS

- Managers should prioritize old (>100 years), large-diameter (>36 cm) deciduous trees and snags as anchor points for retention patches, particularly those with large existing cavities, and/or broken tops.[6] If these are scarce or unavailable, some large deciduous trees may be retained to provide future nest trees. Unmerchantable timber should be retained near large retention trees, including spruce or fir if available, to provide cover for owlets.[2,3]
- Patch retention more effectively provides nesting habitats within harvest sites for this species, while dispersed retention trees provide hunting perches for Barred Owl and other species while the harvest block regenerates.[7]
- Patches should be 10–20 ha or larger if possible, and contain high densities of large-diameter aspen and poplar trees/snags for nesting.[5]
- Recommended activity buffers around known, active nests range from 50 m (low-impact activities) to 200 m (high-impact activities, e.g., road building). An unharvested forest patch of at least 20 m radius is recommended around the nest tree.[8]

LANDSCAPE-LEVEL RECOMMENDATIONS

- The most benefit for Barred Owls will likely be derived from large stands of mixedwood forest >100 years.[2] The size, amount, and composition of these stands should be determined within the context of the natural range of variation for the region.[9]
- Retention harvesting (patches) may be effective on landscapes with low disturbance intensity, but patches may have less value on intensely-managed landscapes. In these cases, large stands of unharvested forest are likely more effective. Patches offer value by potentially providing nesting structures as the harvested stand regenerates and improving landscape-level complexity,[5] and are expected to more quickly produce habitats suitable for Barred Owl than severe fires or clearcuts.[10]

This beautiful warbler has a high-pitched, inconspicuous song, making it a difficult species to study. A spruce budworm specialist, its population booms during budworm outbreaks.

Bay-breasted Warbler

(Setophaga castanea)

STATUS

SARA	NO STATUS	British Columbia	RED
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Old Spruce/Mixedwood

TERRITORY SIZE
>1 ha

NEST TYPE
Canopy (spruce, fir)

NEST REUSE
Unknown

STAND LEVEL
Patches >5 ha of spruce >80 years old with shrubby understory

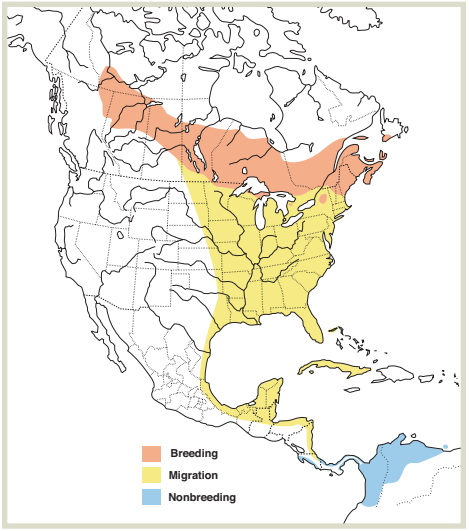
LANDSCAPE LEVEL
Reserves >100 ha of spruce >140 years old

BREEDING WINDOW

HABITAT ECOLOGY

- Bay-breasted Warblers breed in old white spruce, balsam fir and mixedwood stands.[1,2] In Saskatchewan, they are most abundant in very old (>140 years) forest.[3]
- They are often found near water[4] and will use riparian corridors.[5]
- This species is a spruce budworm specialist: populations will increase greatly during outbreaks, and they may spill over into younger-than-usual habitats due to the abundance of food.[4]
- Bay-breasted Warblers nest mainly in the canopy of spruce or fir trees. Nest height varies widely (1–20 m recorded), but average nest height values range from 4.5–7.5 m.[4]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Bay-breasted Warblers depend almost exclusively on old, unharvested forests during the breeding season.[6]
- They were unlikely to be present in clearcut (i.e. no planned retention) stands up to 33 years postharvest.[7]
- They are sensitive to removal or fragmentation of old forests. They were absent from 100-ha landscapes with <55% forest cover in Quebec,[8] and even wide riparian buffers are not considered quality breeding habitat.[4]
- However, mid-seral (30–50-year) harvest-origin (i.e., planted) conifer stands may be suitable habitat.[9]

STAND-LEVEL RECOMMENDATIONS

- Retention areas (e.g., Wildlife Tree Areas and Wildlife Habitat Areas in BC) are recommended in areas of high habitat quality where larger-scale deferments are not feasible. While they are expected to provide important habitat features as the forest regenerates, they are not expected to match the habitat quality of larger unharvested areas, and their value to breeding pairs needs further research.[5]
    - Retention areas (e.g., Wildlife Tree Areas in BC) >5 ha, containing >80 year-old white spruce with dead lower branches and shrubby understory, are recommended within managed areas.[5]
    - Larger unharvested areas of at least 10–30 ha are recommended within areas of very high habitat quality (e.g., white spruce >100–140 years with signs of declining health).[5]
- While direct observations are low due to low population densities, this species is considered unlikely to benefit from dispersed retention levels <40%, based on responses of other forest specialist species.[6]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Large white spruce forests past the rotation age are considered the most important tool for forest managers.[8]
- Bay-breasted Warblers are most likely to occur in areas with a high proportion of older forest within 50 ha,[6] and old forest areas >100 ha are considered optimal habitat for this species.[10] Natural range of variation analyses can be used to plan for supply of these large, unfragmented habitats on the landscape.[11]
- These large, old forests and/or set-asides are also likely to benefit Cape May Warbler, and should preferentially include sites containing spruce >140 years old to maximize these co-benefits.[5]

A striking bird with a striking song. Listen for "see-see-see-see-see-SooZIE" in pure or mixed white spruce stands.

Black-throated Green Warbler

(Setophaga virens)

STATUS

SARA	NO STATUS	British Columbia	BLUE
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Old Coniferous/Mixedwood

TERRITORY SIZE
0.12–1 ha

NEST TYPE
Canopy (conifer)

NEST REUSE
No

STAND LEVEL
High dispersed retention or >0.5 ha patches of large-diameter Sw, Bw

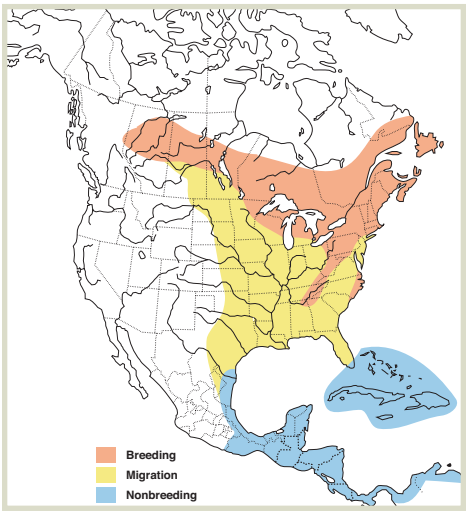
LANDSCAPE LEVEL
Old (100–130 years) riparian Sw or mixedwood, >100 ha if possible

BREEDING WINDOW

HABITAT ECOLOGY

- Black-throated Green Warblers are found in a wide range of forests containing large white spruce (including mixedwoods and deciduous-leading forests), with their highest densities in 100–130 year stands where they often use small-scale canopy gaps.[1,2] They are also known to occupy young to mature forests.[3,4]
  - In BC, mature riparian white spruce or mixedwood forests are considered their most important habitat, while mature or old deciduous forests containing mature spruce may attract them.[3]
- These warblers forage and nest on large-diameter (>50 cm dbh) white spruce.[1]
- Black-throated Green Warblers usually nest in conifers[5] but have shown some preference for paper birch with ~20 cm dbh in Alberta.[1]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- This species is most abundant on unlogged landscapes[6] with a strong preference for forests exceeding the rotation age.[7]
- In deciduous-dominated forests in Alberta, they disappeared from stands with 2–6% retention but were present at low levels in harvests with 40% retention.[8] They were unlikely to be present in clearcut (i.e. no planned retention) stands up to 33 years postharvest.[9]
- They may be sensitive to fragmentation: in New England, they were absent from forests <100 ha,[5] and there is evidence that they avoid cutblock edges and crossing openings ≥25–40 m wide.[2,10]

STAND-LEVEL RECOMMENDATIONS

- High retention (>40%) may be needed to reduce short-term harvest effects on this species, however these recommendations are based on studies from aspen-leading boreal mixedwood forests and may not be applicable to spruce-leading or-dominated forests.[11,12]
  - Retention patches placed ≤40 m apart may make it easier for these warblers to travel across large harvest areas, however this strategy has not been tested for efficacy.
- Mixed-species retention patches (0.5 ha) containing large-diameter spruce may provide suitable nesting habitat in 30–60 years within a harvest block.[2]
- Riparian buffers >20 m may support pairs, but larger (>60 m) buffers will likely be more effective.[13]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Mixedwood management to maintain coniferous-deciduous mixed stands on the landscape, as is present under NRV scenarios, will benefit this species.
- Old (100–130 year-old) mixed and spruce-leading stands >100 ha will provide important habitat on intensively-managed landscapes, as retention patches are expected to take several decades to provide suitable breeding habitat.[2]
  - The role of older-than-rotation stands will likely be most important in BC, where its range is extremely limited and riparian spruce or mixed forests are highly valuable.[3]

This soot-coloured woodpecker hunts for bark and wood-boring beetles in burned and very old coniferous forests. The subtle sound of it flicking bark off trees, or drilling for beetle grubs, announces its presence.

Black-backed Woodpecker

(Picoides arcticus)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Burned Coniferous

TERRITORY SIZE
20–825 ha

NEST TYPE
Cavity (conifer snag)

NEST REUSE
Rare

STAND LEVEL
Retention patches of conifer snags >23–40 cm dbh during salvage

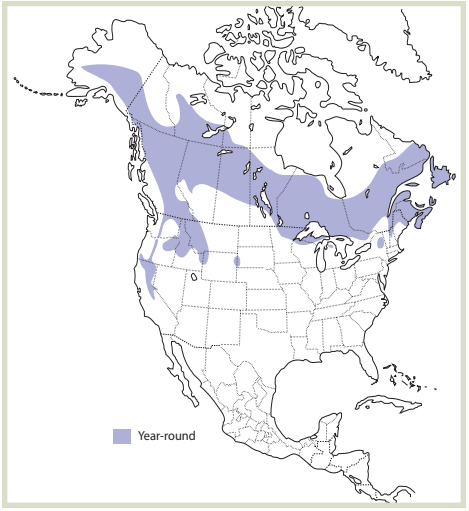
LANDSCAPE LEVEL
Young (<8-year-old) burns and coniferous forest stands >110 years old

BREEDING WINDOW

HABITAT ECOLOGY

- Black-backed Woodpeckers are most common in 2–8 years post-fire conifer-dominated forests that have not been logged or salvaged.[1–3]
  - Forest types include spruce, tamarack, Douglas fir, ponderosa pine, lodgepole pine, and jack pine.[4]
  - They are negatively associated with high densities of deciduous trees.[2]
  - They are most abundant in stands with high densities of smaller-diameter burned conifers (e.g., ≥23 cm dbh in Douglas fir/ponderosa pine[5] or 14–19 cm dbh in boreal jack pine/spruce[3]).
  - They excavate nests in large-diameter trees and snags with low decay.[1]
- Conifer forests >110 years old likely provide important habitat when recently burned forest is not available.[3]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Black-backed woodpeckers are strongly negatively affected by postfire salvage logging, which removes both foraging and nesting habitat.[4]
  - Salvage logging of Mountain Pine Beetle-killed stands may also have a negative effect.[6]
  - Within salvage-logged stands, woodpeckers nested in retention patches even when dispersed trees were available.[5]
- Summer wildfires in coniferous forests create higher-quality foraging habitat than fall/winter prescribed burns or MPB infestations.[7]

STAND-LEVEL RECOMMENDATIONS

- Patch retention during salvage logging of burned forests is strongly recommended:
  - Retention patches containing both small-diameter trees for foraging and larger-diameter trees for nesting are recommended. Average recommended densities across the salvaged area are >104–123 trees or snags/ha (>23 cm dbh).[5]
  - Retention recommendations range from trees or snags >23 cm dbh for Black-backed Woodpeckers[5], to >40 cm dbh to provide habitat for a range of primary and secondary cavity nesters including Black-backed Woodpeckers.[8]
- Given the high densities of burned trees/snags preferred by this species, clearcut areas exceeding 2.5 ha are discouraged within salvage areas.[4]
- Planners should include patches located far from the edges of unburned forest, as unburned forest is a source of nest predators.[9] Black spruce-dominated forest is the exception to this recommendation.[10]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Recent postfire coniferous forest is the most valuable habitat for Black-backed Woodpeckers. Old coniferous forests (>110 years) at levels derived from NRV analyses should be represented on the landscape to support this species where and when postfire stands <8 years old are unavailable.[3]
  - Old coniferous forests >100 up to >380 ha should be conserved if possible given reported home range sizes in unburned forest.[4]

This species occurs in low densities and has a quiet song, making it difficult to study. Most studies are from the eastern boreal forest and should be interpreted with caution.

Blackpoll Warbler

(Setophaga striata)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Wet Coniferous

TERRITORY SIZE
0.2–1.9 ha

NEST TYPE
Ground

NEST REUSE
No

STAND LEVEL
Unknown

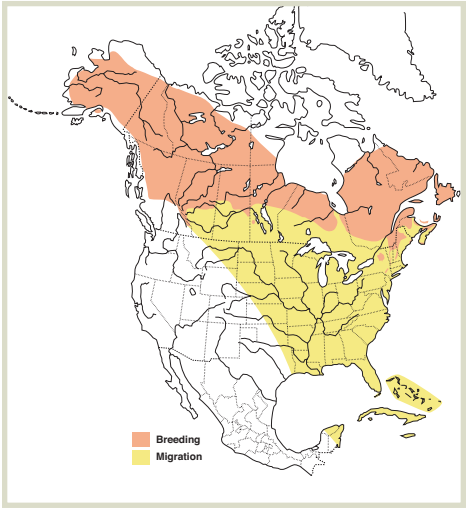
LANDSCAPE LEVEL
Old/riparian coniferous forest

BREEDING WINDOW

HABITAT ECOLOGY

- The Blackpoll Warbler's primary habitat is wet conifer forest (black spruce, tamarack) and riparian spruce/alder/willow thickets. Subalpine habitats include mixed conifer, birch and aspen.[1]
    - Old aspen forest (>125 years old)[2] and young pine and mixedwood[3] may be important habitat in western forests but this is based on only a few studies, making it difficult to draw strong conclusions (See Knowledge Gaps).
- These warblers typically build their nests about a meter off the ground, often against the trunk of a conifer.[1]
- Young Blackpoll Warblers use habitat with high volumes of coarse woody debris.[4]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Clearcuts are generally considered low-quality habitats, but they may recolonize them relatively quickly (e.g., after 10 years).[1]

STAND-LEVEL RECOMMENDATIONS

- Given the small amount of information available on this species, their response to riparian buffers is uncertain.[5,6] Minimum riparian buffer widths of 60 m are conservatively recommended within spruce forests.[5]
- The amount of green-tree retention needed to benefit this species is not known. However, harvest patterns that increase volumes of coarse woody debris may provide some long-term benefits as the block regenerates.

LANDSCAPE-LEVEL RECOMMENDATIONS

- Blackpoll warblers have a strong association with riparian white spruce, low-productivity black spruce/tamarack (including bogs), and other wet, old coniferous forests. This suggests that the passive landbase (riparian zones, wet areas) will likely contribute to habitat for this species on the landscape.[1,7]

KNOWLEDGE GAPS

- This species occurs at low densities and is difficult to detect, and multi-species studies rarely obtain enough observations to analyze Blackpoll Warbler's response to harvest. More targeted research is required to determine best practices for managing this species in western Canadian forests.

With browner plumage than the black-capped chickadee, the boreal chickadee's squawking "TISK-a-day" or "FITZ-brew" song is commonly heard in older spruce forests.

Boreal Chickadee

(Poecile hudsonicus)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Old Coniferous/Mixedwood

TERRITORY SIZE
>5 ha

NEST TYPE
Cavity (secondary)

NEST REUSE
Unknown

STAND LEVEL
Large (>5 ha) patches containing large-diameter cavity trees

LANDSCAPE LEVEL
Old coniferous or mixed forest; black spruce peatlands may also be of value

BREEDING WINDOW

HABITAT ECOLOGY

- Boreal Chickadees are found in conifer forests (mainly spruce and sometimes balsam fir) and mixedwoods. In northern BC, they are found across a range of habitats including open forests.[1]
  - In Alberta, they are found mainly in older (>80 years) forests.[2]
  - In BC spruce-fir forests, they are also found in 31–75 year-old burns containing residual trees.[3]
  - Lowland black spruce or tamarack forest may represent valuable habitat.[4]
- This species excavates nest cavities in snags with very soft heartwood or reuses cavities excavated by small woodpeckers.[1]
- The Boreal Chickadee is a year-round resident that prefers mature stands in the winter.[5]

RANGE MAP

RESPONSE TO FOREST MANAGEMENT

- Boreal Chickadees avoid young and regenerating harvested stands, and they are expected to decline where old conifer forests are reduced (landscape-level) and potential nest trees/snags are removed (stand-level).[6,7]
  - Boreal Chickadees were unlikely to be present in regenerating clearcuts (i.e. no planned retention) up to 33 years postharvest.[8]
  - Some winter use of regenerating stands (4–7 m tall balsam fir/white spruce) has been observed, however chickadees mainly used habitats at edges between cutblocks and mature (>7 m tall) forests.[9]
- They were more than twice as abundant in un-thinned lodgepole pine stands than stands that were thinned seven years earlier.[10]

STAND-LEVEL RECOMMENDATIONS

- Retention at levels of up to 22% and patches up to 5 ha do not appear to benefit this species in the short term.[11,12]
- Longer-term benefits of retention include large-diameter residual trees contributing to potential nest trees as they are excavated by woodpeckers or become soft enough for chickadees to excavate.[13]
  - Large-diameter aspen (>35 cm dbh) with conks or other damage, plus large-diameter spruce, are recommended for inclusion in retention patches.

LANDSCAPE-LEVEL RECOMMENDATIONS

- Boreal Chickadees are not considered sensitive to fragmentation,[9] however their absence from patches ≤5 ha in one study suggests larger blocks of older coniferous or mixedwood forest are valuable.[12]
- Networks of older spruce and/or mixedwood stands will be important for maintaining this species, and near-rotation age spruce and mixed stands may also contribute to habitat on the landscape.
- Old and/or lowland black spruce and tamarack stands may support high densities, suggesting this component of the passive landbase (e.g., wet, unmerchantable, or off-target species) likely contributes to habitat for the Boreal Chickadee.[4,14]

This elusive owl is poorly studied in North America and its response to forest management is not well-understood.

Boreal Owl

(Aegolius funereus)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Old Coniferous/Mixedwood

TERRITORY SIZE
~150–230 ha or larger

NEST TYPE
Cavity (secondary)/broken-top

NEST REUSE
Yes

STAND LEVEL
Unknown beyond retention of trees

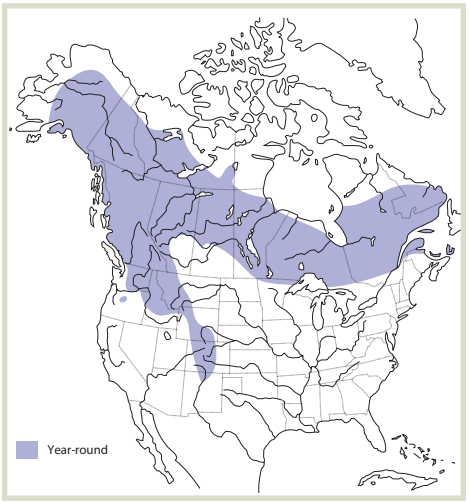
LANDSCAPE LEVEL
Old coniferous or mixed forest

BREEDING WINDOW

HABITAT ECOLOGY

- Boreal Owls occupy a wide range of habitats within the boreal forest,[1] but are mainly associated with old forest features including large downed logs, tall canopies, tall snags, and large-diameter trees for singing and nesting.[2]
  - In Finland, old forests (>80 years) were most important for this species, potentially due to increased prey and/or shelter from predators.[3]
  - Nest boxes in spruce forest and <200 m from agricultural fields had higher breeding success in Finland,[4] while in Alberta Boreal Owls were observed on sites with forest openings, <20% grassland cover within the home range, and low amounts of "soft" (e.g., vegetated) linear disturbance.[5]
- This species is a secondary cavity nester and nests mainly in old Pileated Woodpecker (and occasionally in Northern Flicker) cavities.[6]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Declines of old (i.e., >80–100 years) coniferous forests are considered the main reason for observed Boreal Owl population declines. Reduced old forest cover has been associated with lower winter survival, reproductive success, prey densities, shelter from predators, and nest tree availability.[1,4]
- Boreal Owls have shown some tolerance to landscapes with a high proportion of clearcut areas, possibly due to high abundances of voles within clearcuts.[7]
- In a nest-box study with low sample size (4 nest Boreal Owl pairs) in a 17 years postharvest study area, Boreal Owls nested exclusively in postharvest conifer-dominated (white spruce) stands with at least 50% green-tree retention but predominantly in unharvested forest.[5]

STAND-LEVEL RECOMMENDATIONS

- Retention patches containing veteran trees are expected to contribute to longer-term habitat value by providing a continued supply of old forest habitat features (e.g., large-diameter trees and snags) within regenerating stands.
  - Dispersed retention <50% within coniferous stands is not expected to support breeding Boreal Owls, emphasizing the importance of unharvested old forest areas.[5] However, further research with larger samples is recommended.
  - Nest boxes may be an effective strategy to increase nest availability for this species, however these are likely to provide the greatest benefit in unharvested areas of old coniferous forest.[5]
- Large-diameter (>35 cm dbh) snags and aspen with cavities, conks or other signs of damage within coniferous retention patches may provide future nesting opportunities as the harvest block approaches maturity.

LANDSCAPE-LEVEL RECOMMENDATIONS

- The most valuable habitat for Boreal Owls are old coniferous (spruce, pine or fir) forests, however minimum stand sizes required are unknown. Their successful reproduction on landscapes fragmented by clearcutting in Finland suggests the amount of old forest may be more important than size of contiguous reserves at the territory scale (~150–230 ha).[4,7]
- Managers are encouraged to maintain at least 15–20% old forest cover containing >150 m3/ha of timber at the territory scale within known or potential Boreal Owl habitats.[7]
- In Alberta, provincial data suggests black spruce, tamarack, and wetlands may be high-value habitats.[8] Boreal Owls were more likely to be observed in forests containing openings.[5]

This tiny songbird is well-camouflaged as it creeps up coniferous trees, probing for insects under the bark scales. Listen for their gentle song:
"see! … see all-the-big-trees!"

Brown Creeper

(Certhia americana)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Old Coniferous/Mixedwood

TERRITORY SIZE
0.01–0.025 ha

NEST TYPE
Behind loose bark

NEST REUSE
May use same nest tree

STAND LEVEL
Patches (>4.5 ha) with large-diameter paper birch, spruce, or Douglas fir trees/snags.

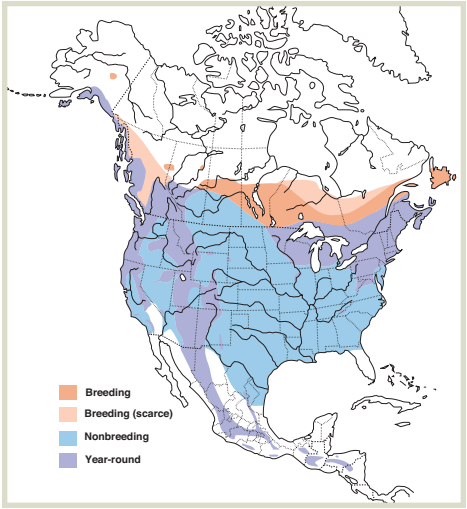
LANDSCAPE LEVEL
Old unharvested conifer forest >10 ha up to >54 ha.

BREEDING WINDOW

HABITAT ECOLOGY

- Brown Creepers occupy a broad range of forests and are most common in mature to old coniferous forests and mixedwoods containing poplar or birch. They are rare in unproductive black spruce and jack pine stands[1].
- Their preferred habitat is older-than-rotation age stands (e.g., >80 years)[2], and they are also found in recently burned forests[3]. In interior BC, they are associated with very large (>100 cm dbh, >80 year-old) Douglas fir[1].
- Brown Creepers build a cup nest of twigs, bark, and other material between sloughing bark and the bole of a tree. Dead and dying trees with papery bark are therefore important habitat features[2]. They will also nest in crevices created by frost cracks and fire scars[4].

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Brown Creepers are highly sensitive to harvesting, including partial retention up to 80%[1,5], moderate to heavy thinning[6], and salvage logging of burned stands with <20% snag retention[2].
- Despite being highly sensitive to harvesting, this species was observed within stands with residual patches containing large-diameter trees—albeit at 10–15% of their abundance in the unharvested forest[7].
- They are sensitive to fragmentation: in a study in eastern Canada, Brown Creepers were reluctant to cross gaps >25 m wide in balsam fir stands[8].

STAND-LEVEL RECOMMENDATIONS

- Large retention patches are recommended, anchored around large-diameter trees/snags with sloughing bark (especially birch and Douglas fir) in coniferous and mixedwood stands[2].
- Patches >4.5 ha or as large as possible are recommended, although smaller patches nevertheless contribute to stand-level complexity and longer-term habitat quality[9].

LANDSCAPE-LEVEL RECOMMENDATIONS

- Contiguous, large forest stands exceeding the rotation age are the most valuable habitat for this species, with minimum stand sizes of 10 ha[10] up to >54 ha[1] recommended.
- Edge reduction within old forest stands is recommended as Brown Creepers are associated with stands with low edge densities (e.g., <18.5 m/ha in Ontario)[11].
- Riparian buffers in Douglas fir/western hemlock forests >30 m wide, and particularly buffers >80 m wide, contribute to habitat on the landscape[12].

This nationally threatened species occupies wet, deciduous-leading forests, where complex understory vegetation and deep leaf litter hide their ground nests.

Canada Warbler

(Cardellina canadensis)

STATUS

SARA	THREATENED	British Columbia	BLUE
Alberta	AT RISK	Saskatchewan	NO STATUS

PRIMARY HABITAT
Old/riparian Deciduous

TERRITORY SIZE
0.2–1 ha

NEST TYPE
Ground

NEST REUSE
Rare

STAND LEVEL
Voluntary, wide riparian buffers in deciduous forest >80 years old and/or dispersed retention ≥30%.

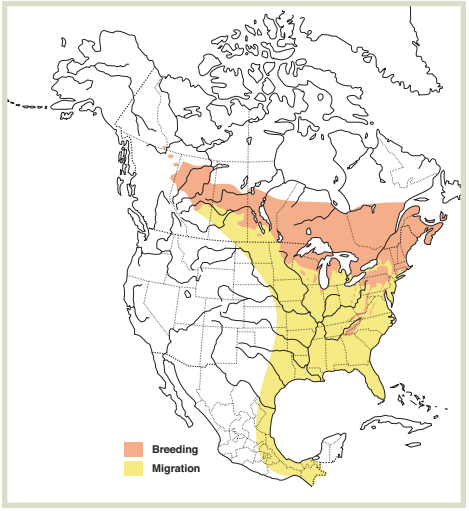
LANDSCAPE LEVEL
Large (>100 ha) reserves of old deciduous and mixed forests, especially wet/riparian.

BREEDING WINDOW

HABITAT ECOLOGY

- Canada Warbler's primary habitat is cool, moist, typically deciduous-leading forest with a dense shrub understory, complex ground cover, and steep slopes and/or open water.[1]
- Forests older than rotation age (e.g., >125 years) are consistently identified as the most valuable habitat for this species, as well as high shrub cover within stands.[2,3]
    - In Alberta, they are strongly associated with deciduous-dominated forest >80 years old and areas near small, incised streams.[4]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Canada Warblers have shown some use of young (11–30 years) clearcuts[5] and postharvest stands containing large residual trees and brushy block edges.[6] However, recent research using province-wide data in Alberta suggests that young forest, regardless of origin, is not suitable habitat for this species.[4]
    - It has been suggested that Canada Warblers are far more likely to use harvest units where there are high densities of Canada Warblers in nearby unharvested forests, and regenerating forest itself may be suboptimal habitat.[5,7]
- Canada Warblers were essentially absent from stands with low retention (2–6%) immediately after harvest in deciduous forests of Alberta.[8]
- Canada Warbler abundances have shown a relationship with spruce budworm abundances, suggesting a possible connection to spruce budworm declines in some provinces. Field testing to establish a causal link is strongly recommended.[9]

STAND-LEVEL RECOMMENDATIONS

- Unharvested areas (e.g., Wildlife Habitat Areas in BC) may be appropriate where several pairs are present. These areas should ≥500 m in diameter. Should pairs be located near a stream, these patches should ideally be placed linearly along the slope above the stream.[10]
- Wide riparian buffers are recommended for at least a portion of a harvested area, including voluntary buffers of ephemeral and intermittent streams. Buffers exceeding the minimum buffer widths required by regulations are recommended within deciduous forests >80 years old with a well-developed shrub layer.[4] This variability in buffer widths should also bring harvests more in line with NRV patterns.
- If possible, high retention levels (e.g., 30–50%) paired with shrub and understory protection are recommended in high-quality occupied habitats where harvesting cannot be avoided.[3,11,12]
- Stand tending that suppresses shrub growth will negatively affect habitat quality.[3] Similarly, selection harvesting within dense old stands with suppressed shrub growth may be beneficial by promoting shrub growth.[1]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Old deciduous-leading forest on the landscape is the most important habitat for this species, and the highest-quality habitat areas (old, wet forest with dense shrub layer) should be prioritized for set-asides or extended rotations. Stands with breeding pairs (e.g., pre-harvest surveys and/or habitat models) should be a very high priority for protection, as Canada Warblers are more likely to establish territories near other members of their species.[4,7,13]
- Minimum old forest stand sizes of 100 ha are recommended,[14] however the amount of habitat is considered more important than continuity based on Canada Warbler's relative tolerance of fragmentation (i.e., reserves not meeting the 100 ha target still have value).[4,15] NRV analyses may also serve as a useful guide for establishing patch sizes on the landscape.
- Deciduous forests 11–30 years old and containing some overstory residual trees may represent secondary or sub-optimal habitat on the landscape, but their value is questionable.[2]

KNOWLEDGE GAPS

- While this species has been observed using stands <80 years old, reproductive studies are necessary to determine whether pairs are successfully reproducing in these habitats.

Populations of this spruce budworm specialist fluctuate with the booms and busts of budworm outbreaks. Its high-pitched song is easily confused with the Bay-breasted Warbler, another budworm specialist.

Cape May Warbler

(Setophaga tigrina)

STATUS

SARA	NO STATUS	British Columbia	BLUE
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Old Coniferous

TERRITORY SIZE
0.25–1 ha

NEST TYPE
Canopy (conifer)

NEST REUSE
Unknown

STAND LEVEL
Large patches containing white spruce >10 m, with some taller than the canopy

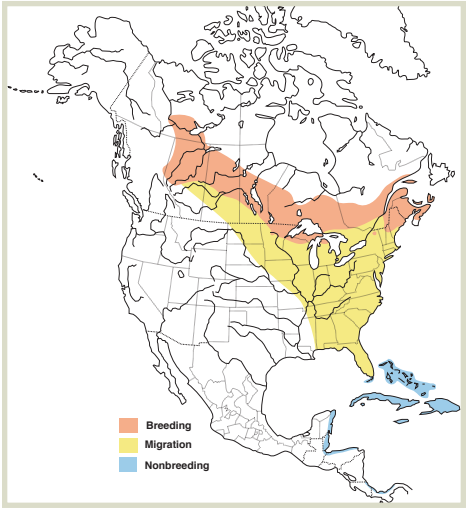
LANDSCAPE LEVEL
Reserves of white spruce or mixed forests >100 years; old black spruce may have value

BREEDING WINDOW

HABITAT ECOLOGY

- Cape May Warblers are found in old coniferous (>76 years) and conifer-leading mixedwood (>125 years) forests containing spruce and/or balsam fir, particularly stands with spruce >10 m tall with some trees extending above the canopy.[1,2]
    - Important habitat features across their range include an open, mossy understory and richer, wetter sites containing white spruce, balsam poplar, and high alder cover (Saskatchewan).[1,3]
- Populations of Cape May Warblers increase sharply in areas infested with spruce budworm.[1] During outbreaks, they are also found in early-seral forests.[4]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Cape May Warblers are very rarely observed in recently disturbed forest stands[5] or mid-seral forests.[2]
- Evidence of use of riparian buffers is mixed for this species. In New England, Cape May Warblers had much lower densities in riparian buffers than unharvested forest.[6] In Saskatchewan, Cape May Warblers and other coniferous-associated species used 10 m buffers plus 30 m partially harvested forest, but their abundance compared with unharvested stands what not tested.[7]
- Cape May Warblers occur at very low densities so there is little information on their responses to different harvest strategies.

STAND-LEVEL RECOMMENDATIONS

- Large retention patches containing >10 m tall white spruce may provide some benefit, however their utility has not been tested for this species.
- Large, old forest stands are likely the most important tool for conserving this species (see Landscape-level Recommendations).[8]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Large, old white spruce or spruce-leading mixedwood forests are considered the most important habitat for this species.[8] Stand sizes >100 ha or larger areas consistent with NRV are recommended. Remnant forest blocks >50 ha are seen as a minimum for this species.[9]
- Cape May Warbler use of old black spruce forest and treed fens is uncertain based on available research but there may be some value of these forests.[5,10]
- Spruce budworm outbreak areas may represent opportunities for increasing populations within infested stands.[9]
- Microbial controls (e.g., Bt) or lepidopteran-specific insecticides (e.g., tebufenozide) are recommended over other chemical insecticides for controlling spruce budworm outbreaks, as chemical insecticides may have unknown toxicity to Cape May Warblers and other budworm-eating species.[11]

Clark's Nutcracker caches pine seeds for eating later, but they don't relocate every last one. The nationally Endangered Whitebark Pine relies on this species' forgotten caches for seed dispersal.

Clark's Nutcracker

(Nucifraga columbiana)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SENSITIVE	Saskatchewan	ABSENT

PRIMARY HABITAT
Semi-open/mountains/conifer

TERRITORY SIZE
100–300 ha or larger

NEST TYPE
Canopy (conifer)

NEST REUSE
Unknown

STAND LEVEL
Selective cutting followed by prescribed burn to promote open whitebark/limber pine stands

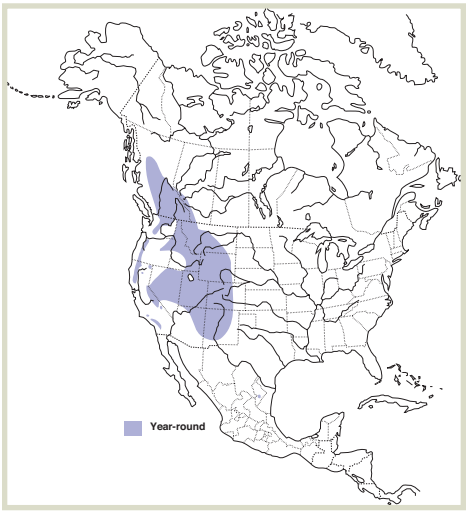
LANDSCAPE LEVEL
Whitebark pine stands >10 ha with >1,000 cones/ha are essential habitat

BREEDING WINDOW

HABITAT ECOLOGY

- Clark's Nutcracker occupies semi-open montane and subalpine coniferous forests dominated by ponderosa pine, Douglas fir, limber pine, and/or whitebark pine.[1]
- It is a resident species that is found mainly in subalpine forests in the spring and summer, moving down to montane forests in the late autumn, although these movements are not consistent among all populations.[1,2]
- Clark's Nutcracker is rarely found at altitudes higher than 2,600 m.[1]
- This species breeds as early as January, with peak breeding from early February to late May. This means that standard avoidance techniques may be ineffective for reducing incidental take.[1]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Clark's Nutcracker is highly threatened by tree mortality and reduced cone production resulting from mountain pine beetle outbreaks and whitebark pine blister rust.[3]
  - Fire suppression in the Rocky Mountains has made whitebark pine more vulnerable to these threats.[1]
- Recent clearcuts may be used for seed caching, as well as recent openings caused by burns.[4]

STAND-LEVEL RECOMMENDATIONS

- This species requires ≥10 ha whitebark pine stands with an average cone density of ≥1,000 cones/ha.[5] The following actions are recommended where these stands, or stands nearly meeting these conditions, are identified:
  - In collaboration with provincial land managers, prescribed burning at a location within 10 km of the stand can create habitat for caching.[5]
  - Planting of rust-resistant whitebark pine seedlings in stands that approach but do not meet this threshold.[5]
- Thinning treatments targeting non-whitebark pine species, followed by prescribed burning, may create caching habitats. The effectiveness of this approach has been mixed and it should be undertaken with caution.[6,7]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Maintenance or restoration of healthy populations of limber pine and whitebark pine are considered essential to maintaining Clark's Nutcracker populations.[8]
- Whitebark pine restoration is recommended for locations adjacent to habitat mosaics that include Douglas fir, an alternative food source which may attract Clark's Nutcracker.[9]

KNOWLEDGE GAPS

- Studies have mainly focused on Clark's Nutcracker responses to whitebark pine restoration treatments, while responses to conventional harvests are unclear.
- Sensitivity to human disturbance is unknown during their winter nesting period.[1] This knowledge gap has implications for avoiding incidental take and the unknown effectiveness of nest buffering.

The Common Nighthawk swoops over open grass or water to catch insects mid-air, hunting mainly at dusk or dawn. Their tendency to build ground nests in recent openings makes them vulnerable to silviculture and salvage logging.

Common Nighthawk

(Chordeiles minor)

STATUS

SARA	THREATENED	British Columbia	YELLOW
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Open/burned pine

TERRITORY SIZE
~28 ha

NEST TYPE
Ground

NEST REUSE
Some

STAND LEVEL
Operator training to avoid disturbing nests during postharvest/postfire activities

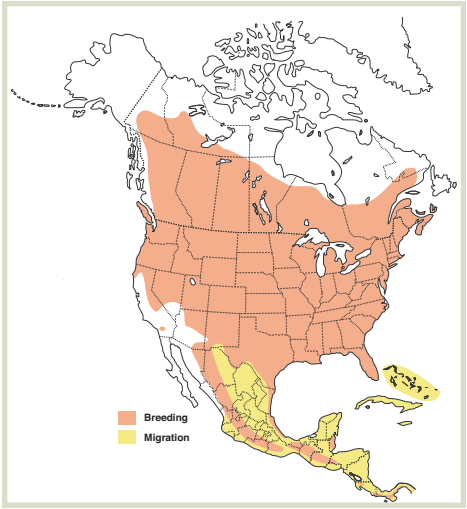
LANDSCAPE LEVEL
Natural disturbance (wildfire) and early-seral habitats within NRV

BREEDING WINDOW

HABITAT ECOLOGY

- Common Nighthawks are mainly found in grassland habitats, but part of the population breeds in open pine or mixedwood forests including lodgepole pine, ponderosa pine, mixed pine/aspen, and young mixedwoods.[1–5]
- This species prefers open habitats including recently burned or logged stands.[6] They hunt by catching insects mid-air over open ground and/or water.[1]
- Common Nighthawks lay two large, spotted eggs on open ground or near logs, boulders, grass clumps or shrubs.[1]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Fire suppression is the main threat to Common Nighthawks as it reduces openings and bare ground within forested habitats needed for foraging and nesting.[6] Afforestation of abandoned agricultural areas and grasslands likewise reduces habitat availability for this species.[7]
- Common Nighthawks have been observed in stands with low (2%) retention, recent clearcuts, and recently thinned Douglas fir stands (30–40% retention), however at numbers too low for statistical analysis.[8–10]

STAND-LEVEL RECOMMENDATIONS

- Recent harvests or burns may attract nesting pairs of Common Nighthawk, and ground nests are highly vulnerable to disruption during silviculture (e.g., site preparation, planting) or salvage logging.[6]
- Operators should be on the lookout for this species from mid-May until the end of August.[1]
- The following recommendations apply to operators working in recently disturbed (mainly pine) stands:
  - Halt operations if a flushing adult is observed and mark off the suspected or known nest area to be avoided.
  - General buffer recommendations for ground-nesting species range from 10–25 m for low-impact activities (e.g., planting) and 50–100 m for high-impact activities (e.g., road-building).[11]
  - If defensive behaviour (e.g., hissing, diving, flushing) is observed, buffer distances should be increased until the behaviour ceases.

LANDSCAPE-LEVEL RECOMMENDATIONS

- Maintenance of natural disturbance regimes (e.g., wildfire) and management within the natural range of variation to maintain distribution of early-seral habitats.[2–5,12]
- Province-wide data indicates that tamarack stands and wetlands may represent important habitat on the landscape,[13] however these passive areas should not be considered as substitutes for open upland forests, whose value is known.

The Connecticut Warbler is less well-studied than other warblers due to its inconspicuous behavior. Alberta, Saskatchewan and BC represent the western edge of its breeding range.

Connecticut Warbler

(Oporornis agilis)

STATUS

SARA	NO STATUS	British Columbia	BLUE
Alberta	SECURE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Aspen/Mixedwood with shrubs

TERRITORY SIZE
0.25–0.48 ha

NEST TYPE
Ground

NEST REUSE
No

STAND LEVEL
Patches >5 ha containing mature aspen (>40 years) and fruiting species in the shrub layer.

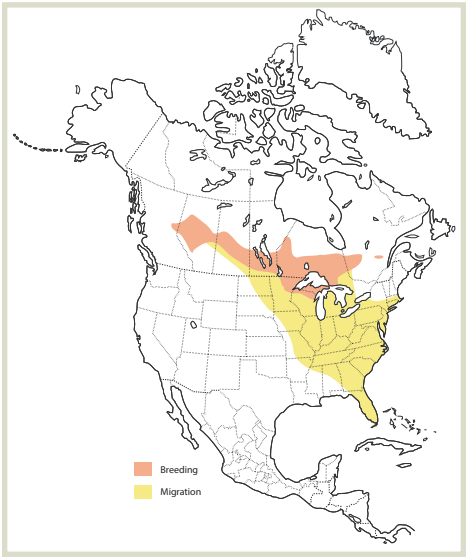
LANDSCAPE LEVEL
Patches within 5 km of larger mature aspen or mixedwood forests.

BREEDING WINDOW

HABITAT ECOLOGY

- Connecticut Warblers are mainly found in deciduous forests and aspen-leading mixedwoods with a well-developed shrub layer (aspen, rose, beaked hazelnut, alder, willow, and fruiting shrubs).[1,2] However, its habitat selection is highly variable across its range:
  - It is also found at the edges of small meadows, wetter stands with high tamarack cover and low shrubs,[1,2] and in eastern North America, muskegs and lowland conifer forests.[3]
- This species occupies a range of stand ages ranging from 0–10 years to mature and old (>76 years) aspen and mixedwood forests.[4,5]
- Its nest is built on or near the ground, often in thickets, clumps of vegetation, or at the base of a shrub.[1]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- This species is more abundant in recently burned than recently harvested forest,6 and is more abundant in burned riparian forest than intact or partially-harvested riparian buffers.[7]
- In BC, the largest threats to Connecticut warbler include 1) herbicide application to reduce understory vegetation and deciduous regeneration and 2) logging of aspen stands.[1]
- Connecticut Warbler has shown mixed responses to retention harvesting. High retention (>20%) appears to have a negative effect, however lower retention levels (e.g., 10%) may benefit this species.[8]
- Regenerating clear-cut stands (i.e., no planned retention) are likely to contain Connecticut Warblers from 15–25 years postharvest.[9]

STAND-LEVEL RECOMMENDATIONS

- Managers should establish large retention patches (>5 ha) where possible, containing mature aspen or poplar and a well-developed shrub and herbaceous layer (particularly fruiting shrubs).[5,10]
- Retention harvesting (e.g., 10% retention in small, evenly distributed clumps) may be beneficial.[8] Avoiding shrub and understory suppression using herbicides is also important for this species.[1]
- Mid-seral regenerating stands (15–25 years postharvest) may provide habitat for this species.[9]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Forest management within the natural range of variation, including clearcuts, blocks containing low overall retention, blocks containing large (>5 ha) retention patches, burned forest, and larger areas of unharvested deciduous forest, is expected to benefit Connecticut Warblers on the landscape.
- Smaller patches and remnants have been shown to have greater benefits to this species when >5 ha and/or located closer to unharvested forest. Patches, remnants, and set-asides (preferably consistent with NRV patch sizes) are recommended with the following additional parameters:
  - Pure aspen or mixedwood forest set-asides should contain old aspen (>40 years) and developed herbaceous and shrub layers.[11]
  - Stands/remnants should be either very large OR smaller and located within 5 km of larger areas of high forest cover.[5]
  - Stands/remnants located on flat sites or gentle south- or west-facing slopes may have additional habitat value.[11]

The Dusky Grouse was considered a subspecies of the Blue Grouse until 2016, when it was recognized as a separate species.

Dusky Grouse

(Dendragapus obscurus)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	ABSENT

PRIMARY HABITAT
Old Coniferous

TERRITORY SIZE
Unknown

NEST TYPE
Ground

NEST REUSE
Some

STAND LEVEL
Patches (1–4 ha) of Douglas fir >150 years old with clumps of mature ESSF or Aw.

LANDSCAPE LEVEL
Old Douglas fir (>200 years old) containing openings; heterogeneous landscapes

BREEDING WINDOW

HABITAT ECOLOGY

- Dusky Grouse occupy a range of habitats including sagebrush and grasslands. They use forest habitats including ponderosa pine, Douglas fir, and true fir. Aspen thickets are important habitat for juveniles and breeding males.[1]
- During the winter, this species migrates to higher elevations (up to >3,600 m) to conifer-dominated stands including Douglas fir, subalpine fir, lodgepole pine, limber pine, Engelmann spruce, and western hemlock.[1,2]
- Conifer needles, particularly Douglas fir needles, are an important winter food source.[1]
- Ground nests are built in well-developed herbaceous and shrub layers within forest openings.[1] Fallen, suspended logs may increase nesting success.[3]

RANGE MAP

RESPONSE TO FOREST MANAGEMENT

- Responses to harvest are not well-studied or well-understood,[1] however the loss of coniferous habitats and structural diversity due to harvesting are considered threats to the Dusky Grouse.[4]
- This species has been observed feeding on planted ponderosa pine seedlings in Idaho.[5]

STAND-LEVEL RECOMMENDATIONS

- Selective logging with retention of old (>150 years if available), large-diameter Douglas fir and clumps of mature subalpine fir and/or Engelmann spruce is recommended within wintering habitats. Recommended retention patch sizes range from 1 ha to >4 ha.[4,6,7]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Heterogeneous landscapes including shrubby grasslands, open ponderosa pine with aspen groves, and Douglas fir with true fir appear to provide a range of high-quality breeding and wintering habitat.[1,6]
- Within Douglas fir forests on intensively managed landscapes (e.g., subject to extensive clearcutting), old (>200 year-old) Douglas fir stands should be represented.[6]
- Uneven-aged management that promotes structural diversity, creates forest openings, and maintains patches and stands exceeding the rotation age, as occurs in an NRV scenario or using ecosystem-based management, are likely to benefit this species throughout its range.[4,7]

This small, round songbird is a familiar sight in many coniferous forests, where its high-pitched song sounds like a tiny car trying (unsuccessfully) to start.

Golden-crowned Kinglet

(Regulus satrapa)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Old Coniferous

TERRITORY SIZE
0.3–1.6 ha

NEST TYPE
Canopy (conifer)

NEST REUSE
No

STAND LEVEL
Riparian buffers >30–35 m wide in old conifer forest; large-diameter spruce, Douglas fir, or hemlock

LANDSCAPE LEVEL
Large, unfragmented stands of old coniferous forest

BREEDING WINDOW

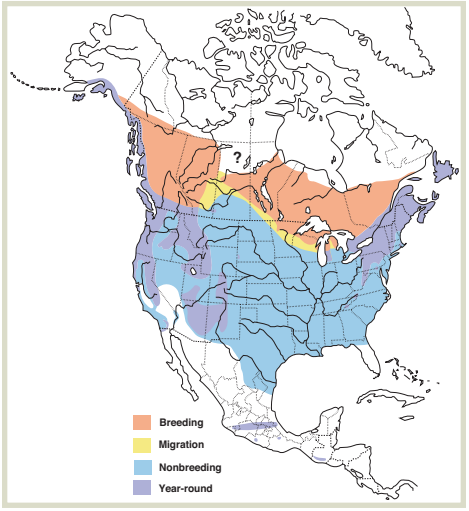
HABITAT ECOLOGY

- The Golden-crowned Kinglet is associated with old, dense conifer forests including Douglas fir, western hemlock, mountain hemlock, and spruce.[1] It is also common in spruce-aspen mixedwood forests from >75 years[2] to >140 years old.[3]

RESPONSE TO FOREST MANAGEMENT

- This species' close association with forests older than rotation age makes it highly sensitive to harvest. It was absent from stands up to 33 years following clearcutting[1,4] and declined following harvests with 20–70% retention,[1,5] small-scale harvests including uniform single-tree removal,[6] and moderate to heavy thinning.[7,8]
- Riparian buffers >30–35 m may support higher occupancy than narrower buffers ≥10 years postharvest.[9–11] Varying buffer widths with wider areas serving as retention anchors may benefit this species.
- Golden-crowned Kinglet abundance increases in areas of mountain pine beetle, spruce beetle, and spruce budworm infestation.[1]

RANGE MAP



STAND-LEVEL RECOMMENDATIONS

- Retention harvest is overall considered less effective than old forest stands or set-asides, given this species' declines even in harvested blocks with very high retention. The retention of features including large-diameter conifers will, however, likely improve the structural complexity and long-term habitat value of regenerating stands.
- Riparian buffers >30–35 m wide may help support this species, however they will likely occur at lower densities than in unharvested forest.[12]

LANDSCAPE-LEVEL RECOMMENDATIONS

- The primary strategy for conserving this species is the maintenance of conifer-dominated forest stands exceeding the rotation age on the landscape.
- Large continuous stands and/or strong connectivity among stands, as would occur under an NRV scenario, will likely be of higher quality than fragmented or isolated forest patches, as this species has shown edge sensitivity[13] and reluctance to cross gaps >25 m wide.[14]

Also known as a Whiskeyjack, the Gray Jay is an iconic Canadian species known for its low fear of humans. It is also an important nest predator in the boreal forest and may pose a threat to at-risk songbirds.

Gray Jay

(Perisoreus canadensis)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Old Coniferous

TERRITORY SIZE
15–65 ha (up to 130 ha)

NEST TYPE
Canopy (conifer)

NEST REUSE
No

STAND LEVEL
Thinning, selection cutting, or large patches (2–5 ha) of dominant conifer species.

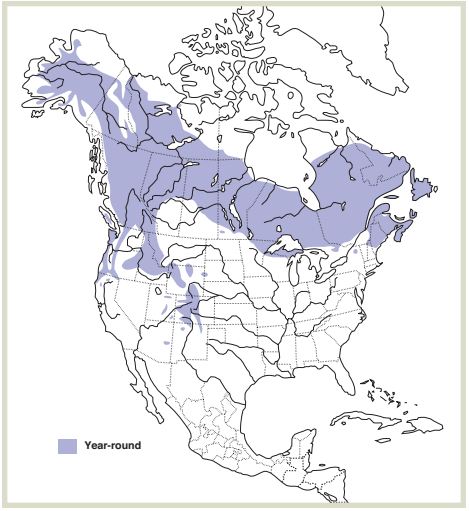
LANDSCAPE LEVEL
Attracted to fragmented landscapes and forest within 30 m of edge.

BREEDING WINDOW

HABITAT ECOLOGY

- Gray Jays are mainly found in coniferous and mixed coniferous-deciduous forests, particularly spruce-leading stands. They are also abundant in black spruce and jack pine stands (Saskatchewan),[1] Douglas fir and Engelmann spruce above 100 m elevation (southern BC),[2] open and semi-open woodlands, and near bogs.[3]
    - There is some evidence of higher Gray Jay abundances at the boundaries between coniferous and deciduous forests.[4]
- This species is widespread across coniferous-leading forests including disturbed and fragmented areas. It is most common in old forests and is also found in burned stands containing snags.[5]
- The Gray Jay nests during late winter (beginning mid-March) and may be vulnerable to incidental take during winter logging.[2]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Gray Jays are rare or absent in large clear-cuts because they need trees for nesting and food caching.[2]
- Retention harvests with up to ~22% forest cover in 2–5 ha patches and riparian buffers supported fewer Gray Jays than unharvested forest, but substantially more than in clear-cuts.[6]
- This species has responded positively to thinning in Douglas-fir forests (~60% stem density removal)[7] and selection cutting with 60–70% retention in lodgepole pine forests.[8]
- In Quebec, responses to forest edge in balsam fir forests suggest that heavily fragmented forest may provide high-value habitat for 20–30 years post-disturbance.[9]

STAND-LEVEL RECOMMENDATIONS

- High-intensity thinning and low-intensity selection cutting appear to benefit this species.[7,9]
- Retention harvesting is recommended over clear-cutting, leaving large retention patches containing coniferous trees for nesting and food caching.[6]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Fragmented landscapes may attract Gray Jays, particularly to forest within 30 m of disturbance edges. This attraction may have unintended negative effects on nesting songbirds in the same area as Gray Jays are an important nest predator.[9]
- While this species will benefit from old coniferous stands (set-asides, remnants, etc.) on the landscape, its tolerance of harvesting other than clear-cutting suggests it is likely to be resilient to many landscapes managed under NRV and using harvest systems including retention, selection cutting, and thinning. It is also highly likely to benefit from old black spruce and tamarack forests, which may be well-represented on the passive land base.[10]

The Great Gray Owl is a large, majestic owl that resides in northern coniferous forests, where it hunts for rodents in openings, meadows, and bogs.

Great Gray Owl

(Strix nebulosa)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT

Old coniferous/wet areas

TERRITORY SIZE

Home range ~4.5 km2 (may overlap)

NEST TYPE

Old stick nest, broken top, mistletoe

NEST REUSE

Common

STAND LEVEL

Residual trees/patches every ~100 m for foraging; patches >6 ha for nesting (see below for anchors).

LANDSCAPE LEVEL

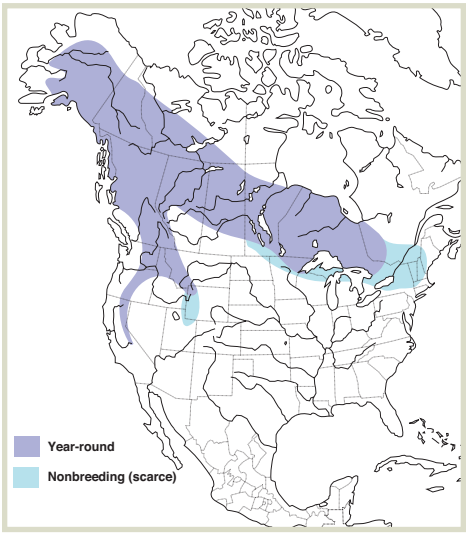
Heterogeneous landscapes containing openings/wet areas and large patches of old forest.

BREEDING WINDOW

HABITAT ECOLOGY

- The Great Gray Owl is a year-round resident found in open and mature coniferous forests, including dry pine stands,[1] treed muskeg and black spruce/tamarack bogs,[1] mature/old lodgepole pine and ponderosa pine forests near meadows,[2] and riparian white spruce forest.[3]
- They often nest in old stick nests, broken-topped snags, or mistletoe brooms. Nests are located in forest patches larger than six hectares with ≥35% (preferably ≥60%) crown closure and leaning trees.[2]
- Great Gray Owls forage in open forests (≤40% closure of trees, saplings and shrubs),[2] where they hunt for mice and voles from perches on trees or snags.[4]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Intensive forest management that removes large-diameter trees and snags, leaning trees, and opens the canopy is expected to negatively affect Great Gray Owls by reducing suitable nesting habitat.[1]
- However, Great Gray Owls are known to hunt in areas harvested using selective harvesting and clear-cutting.[1]
- Pathogen outbreaks, insect outbreaks, fire, and dwarf mistletoe infestations create high-value natural nest sites and patches of important nesting habitat features.[4]

STAND-LEVEL RECOMMENDATIONS

- Nesting habitat: Retention patches >6 ha are recommended within the harvested matrix, anchored around one or more stick nests, large-diameter broken-topped snags, and/or large mistletoe brooms. Patches should have >60% crown closure and contain leaning trees (which can be knocked over if not naturally occurring).[2]
- Great Gray Owl hunting flights are typically within 50 m of their perch. Planners and operators can increase the amount of available foraging habitat in a recent cut by leaving residual trees and patches roughly every 100 m.[2,4]
- Silviculture that reduces shrub cover may improve foraging habitat, but the rapid return of cover by seedlings or saplings will reduce available foraging area as the harvest block regenerates.[2,4]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Burned/harvested areas are expected to provide foraging habitat for up to 20 years, provided there are residual patches and/or hunting perches. Dense shrub cover reduces foraging habitat value.[4]
- Nest sites are more likely to be limiting than foraging habitat, and maintenance of old coniferous stands >6 ha will be an important strategy, particularly within coniferous landscapes containing many wetlands or openings.[5]
- Wet areas containing black spruce and/or tamarack may represent quality habitat within the non-operable/unmerchantable landbase. Its value relative to harvested and old dense forest requires testing.

KNOWLEDGE GAPS

- Management recommendations for Great Gray Owl are inferred almost entirely from its known habitat ecology. Direct tests of this species' responses to forest management are needed to inform more targeted management approaches.

The northern edge of the Lewis's Woodpecker's range extends into southern interior BC and, to a very small extent, western Alberta.

Lewis's Woodpecker

(Melanerpes lewis)

STATUS

SARA	NO STATUS	British Columbia	BLUE
Alberta	SENSITIVE	Saskatchewan	ABSENT

PRIMARY HABITAT
Burned/open Douglas fir/Ponderosa pine

TERRITORY SIZE
1–6 ha

NEST TYPE
Cavity (snag)

NEST REUSE
Common

STAND LEVEL
Severely-burned patches ≥1 ha containing large-diameter snags.

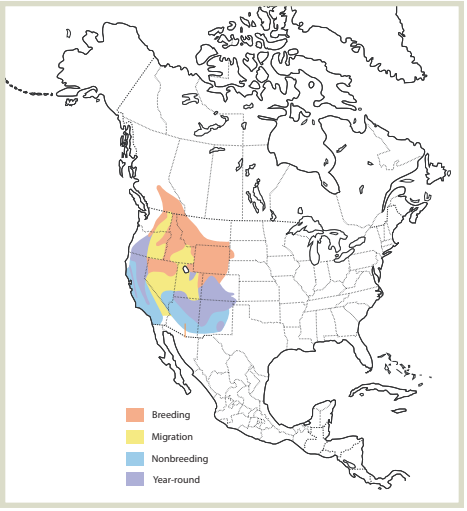
LANDSCAPE LEVEL
Prescribed burns and/or maintenance of open forests containing nest trees.

BREEDING WINDOW

HABITAT ECOLOGY

- The Lewis's Woodpecker, unlike most other woodpeckers, catches insects mid-air during the spring and summer. Thus, this species needs open habitats with dense ground cover over which to hunt.[1]
- This species is mainly found in open ponderosa pine, open riparian cottonwood, and logged or burned pine forests.[1]
  - Their habitat requirements include <30% crown closure and scattered/clumped large-diameter nesting trees.[2]
  - Riparian black cottonwood stands near open areas for foraging are important habitat in the Okanagan and Thompson regions,[2] but these may experience high predation if near intense agricultural development/grazing.[3]
- Burned forests may represent the highest-value habitats for this species, particularly crown-burned ponderosa pine stands and/or 2- to 25-year-old burns.[4]
- This weak cavity nester will either reuse cavities or excavate new nests in heavily-decayed, large-diameter snags (especially broken-topped snags and Douglas fir, ponderosa pine, or cottonwood).[2,5]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- This species' foraging habitat quality is declining due to decades of fire suppression and forestry, which have caused many open ponderosa pine forests to be filled in by dense Douglas fir.[2]
- The main threats to this species include fire suppression and fuel management (understory vegetation removal). Forest harvesting in itself is not considered an important threat because Lewis's Woodpecker's preferred habitat contains tree densities too low for commercial forestry.[6]
- Unlike most woodpeckers, Lewis's Woodpecker appears to benefit from salvage logging (e.g., up to 40% removal of snags >23 cm dbh), provided nest trees are retained (see Stand-level Recommendations).[4,7]

STAND-LEVEL RECOMMENDATIONS

- When salvage logging burned ponderosa pine/Douglas fir forest, the following retention patch characteristics are recommended:
  - Patches should be of variable size but greater than 1 ha[8], and reach an average minimum snag density of 6 snags/ha within the salvaged area.[9]
  - Patches should contained relatively severely burned trees.[10]
  - Patches should contain high densities of large-diameter ponderosa pine, black cottonwood, or Douglas fir snags with evidence of heartrot, broken tops, or broken limbs.[8] Where possible, retain trees >50 cm dbh.[9]
- Large-diameter trees and snags, including high-cut stumps or stubs (e.g., 5 m in height) dispersed across the salvaged area will also likely contribute to habitat quality while maintaining open conditions.[8,11]
- Patches retained on steep slopes are not likely to contribute to high-value nesting habitat.[5]
- Near potential or known nest areas, strategic silviculture may improve foraging habitat by maintaining high understory diversity

including fruiting shrubs (especially chokecherry).[6]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Managers should maintain open (<30–35% canopy closure) forest areas dominated by ponderosa pine, black cottonwood or Douglas fir. These forests should be old enough to contain large (>45 cm dbh) snags of decay classes [2–4] (ponderosa pine) or [4–7] (Douglas fir).[9]
- Mature riparian cottonwood stands with 5–80% canopy closure and large-diameter trees (>60 cm dbh) should also be maintained, particularly stands that are not immediately adjacent to high-intensity agriculture and/or grazing.[3]

IMPORTANT NOTE ON CONSERVING THIS SPECIES

- BC has established Wildlife Habitat Areas and Wildlife Management Areas that include suitable habitat for Lewis's Woodpecker, and the federal Management Plan[9] contains a more extensive list of BMPs for directly managing this species-at-risk. Critical habitat has been defined for the Okanagan-Similkameen, Thompson-Nicola, Boundary, East Kootenay, West Kootenay, and Cariboo-Chilcotin regions; it is the responsibility of the forest operator to review the federal Recovery Strategy for this species and identify critical habitat within the managed area.

This woodpecker is easily identified by the dark polka-dots on its underside, although its call sounds quite similar to that of the Pileated Woodpecker. The Northern Flicker spends a lot of time foraging for insects on the ground.

Northern Flicker

(Colaptes auratus)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Deciduous or Mixed-Conifer

TERRITORY SIZE
~25 ha up to >100 ha

NEST TYPE
Cavity (snag)

NEST REUSE
Common

STAND LEVEL
Aspen >35 cm dbh with signs of disease or damage retained within harvests, singly or in patches.

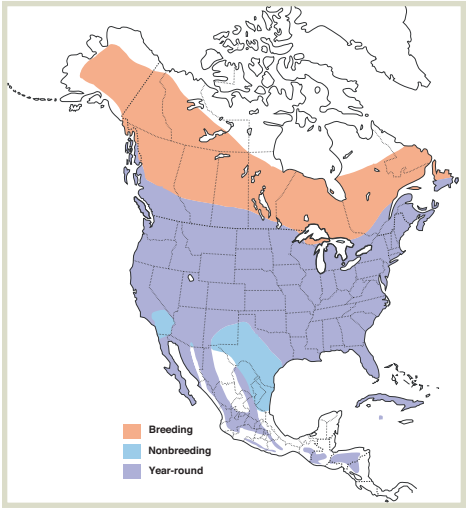
LANDSCAPE LEVEL
Heterogeneous landscapes containing late- and early-seral forests.

BREEDING WINDOW

HABITAT ECOLOGY

- The Northern Flicker is a ground-foraging species found in a wide range of forest habitats including deciduous-dominated and mixed-conifer stands. It is typically found along in or near forest edges and open woodlands.[1]
  - This species is most common in <30 year-old burned forests, suggesting the high importance of burned stands.[2]
- Northern Flickers mainly excavate cavities in aspen >35 cm dbh, which they will preferentially select even in conifer-leading stands.[3–5] They prefer recently dead trees with up to 50% of branches and bark missing[4] and/or false tinder conks.[6]
  - Northern Flickers may preferentially select nest trees where many suitable nest trees occur within a 10 m radius.[6]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Retention harvesting appears to benefit Northern Flicker habitat in deciduous or deciduous-coniferous forests. They have responded positively to patch retention and riparian buffers totalling ~20% forest cover[7] and large aggregated harvests containing 29–33% merchantable retention.[3]
- This species was likely to be found in young regenerating clearcuts (1–11 years postharvest), possibly due to increased ground-foraging opportunities.[8] Given the Northern Flicker's large territory size, it seems likely that nearby unharvested forest was an important source of nest trees.
- However, in dry mixed-conifer forests (ponderosa pine/Douglas fir), salvage logging with 40% retention of snags >23 cm dbh caused Northern Flicker to decline relative to burned, unsalvaged forest.[9,10]
- Harvesting and/or fragmentation may make Northern Flicker more vulnerable to nest theft by European Starlings in dry mixed-conifer forests of interior BC.[11]

STAND-LEVEL RECOMMENDATIONS

- Managers should prioritize aspen >35 cm dbh with false tinder conks and/or recently dead aspen for retention. Residual patches <0.5 ha and single trees provide short-term benefits, while larger patches may have greater longevity.[3,6,12]
- During salvage logging of burned stands, large-diameter snags should be prioritized for retention. In western woodlands, an average snag density of 93 snags per 100 ha is predicted to be optimal.[1]

LANDSCAPE-LEVEL RECOMMENDATIONS

- The Northern Flicker is likely to benefit from management strategies that maintain representative amounts of early- and late-seral forests, as observed in an NRV scenario. Burned forests are most important to them. Uneven-aged management (e.g., retention harvesting) will increase nesting opportunities across the harvested landscape in the short and long term.

Northern Goshawk

(Accipiter gentilis) [atricapillus subspecies]

Adult Northern Goshawks are immediately recognizable by their bold plumage and bright red eyes. They live across most of North America and occupy Canadian forests year-round.

STATUS

SARA	NO STATUS	British Columbia	BLUE
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Old Coniferous/Mixedwood

TERRITORY SIZE
>1,000 ha

NEST TYPE
Stick

NEST REUSE
Common

STAND LEVEL
Nest-tree buffers 100–200 m containing mature/old forest with high canopy closure.

LANDSCAPE LEVEL
Maintenance of mature/old forests at multiple scales.

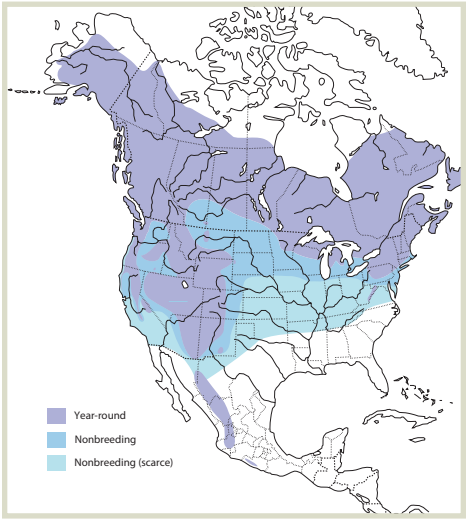
BREEDING WINDOW

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

HABITAT ECOLOGY

- Northern Goshawks live across a wide range of forest types, but are most common in mature and old forests, particularly coniferous stands where they are available.[1]
- This species uses habitat at multiple scales:
  - "Nest site" is the 1-ha area surrounding the nest. It generally contains large-diameter trees (e.g., aspen ~30 cm dbh) and has high canopy closure (>60%).[2]
  - "Nest area" is the 8–20 ha area around the nest. It contains >50% mature/old forest and alternate nest trees.[3]
  - "Post-fledging area" is the 120–240 ha area around the nest. It contains alternate high amounts of mature/old forest, nest stands, snags, downed logs, and a well-developed understory that provides cover for flightless young.[3,4]
  - "Foraging area" is the >1,000 ha area around the nest. It may contain more early- to mid-seral forest, but ideally contains >60% forest area >80 years old.[3,5]
- The Northern Goshawk's breeding period begins in February/March, meaning winter operations have an increased risk of incidental take or disruption of nests and/or fledglings.[6,7]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- The Northern Goshawk's close association with mature/old forest makes it sensitive to forest harvesting, which may reduce habitat quality by removing nest trees, opening the canopy, and promoting understory closure.[1]
- This species' responses to harvesting have been mixed but are generally characterized by lower occupancy of harvested areas. Reproductive success does not appear to be affected by harvesting.[8]

STAND-LEVEL RECOMMENDATIONS

- While there is some evidence that nest-tree buffers may be effective[9], they fail to maintain habitat at larger scales (see Landscape-level Recommendations).[4]
- Where harvesting cannot be avoided near known Northern Goshawk nests, the following precautions are recommended:[6]
  - Operators should place 500–1,000 m no-work zones around active nests from Feb. 15 to Aug. 15.
  - Nests should be buffered by at least 100 m (preferably >200 m), and these patches should be designed to reduce edge.

LANDSCAPE-LEVEL RECOMMENDATIONS

- NRV targets for mature and old forest (closed canopy, >80 years old) are recommended to be concentrated in large, continuous stands within the breeding area where possible. The total amount of old forest should be at least 25 ha but preferably >100 ha or more to provide greatest benefit to this species.[6]
- Steep slope areas left unharvested are not considered to contribute to nesting habitat for this species, as Northern Goshawk typically nests on gentle slopes (<40%).[10]
- Where harvest occurs, the maintenance of several old stands >12 ha within the 120–240 ha area around the nest may be beneficial, provided they have closed canopies and multiple vegetation layers. The effectiveness of this strategy requires testing, and contiguous forest is preferred to isolated patches.[11]

This owl is named for the way its plumage looks like that of a hawk. Active during the day, the Northern Hawk Owl likes to perch on top of the most prominent trees, making it easy to spot (and a favourite of birders).

Northern Hawk Owl

(Surnia ulula)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Coniferous/riparian/early-seral

TERRITORY SIZE
>50 ha to hundreds of ha

NEST TYPE
Cavity

NEST REUSE
Common

STAND LEVEL
Retain cavity trees, aspen >35 cm dbh, and tall trees/snags without foliage, singly or in patches.

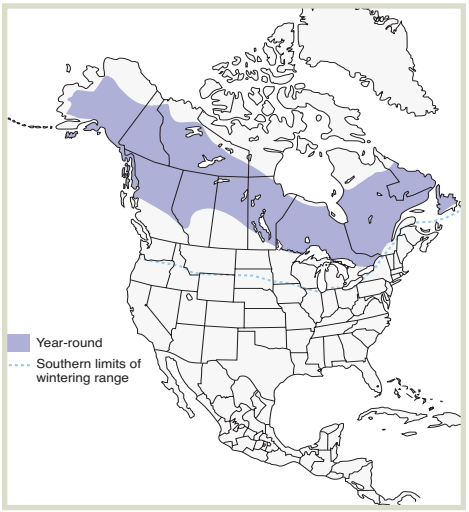
LANDSCAPE LEVEL
Habitat heterogeneity including burned forest, old forest, and wet areas.

BREEDING WINDOW

HABITAT ECOLOGY

- The Northern Hawk Owl lives in the boreal forest year-round, where it is mainly found in moderately dense coniferous or mixedwood forests.[1,2]
  - Key habitat features for this species include forest edges from which they hunt for small mammals,[1] tall hunting perches (including residual trees, snags, or stumps within openings),[2] and nest trees (see below).
  - Northern Hawk Owls are often found near water, including riparian closed conifer forests.[1] They are also found in burned forests, which typically provide hunting, perching, and nesting habitats.[1,3]
- This species nests in old Pileated Woodpecker and natural tree cavities. Hollow stubs,[1] broken-topped snags,[2] and aspen >35 cm dbh with signs of damage or decay[4,5] are all potential nest trees.

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- The Northern Hawk Owl's response to forest management in North America is not well-studied.
- Given this species' habitat ecology, it is generally expected to be negatively impacted by very large (e.g., >100 ha) clearcuts that do not contain any retention.[2]
- In contrast, retention harvesting is expected to benefit Northern Hawk Owls by increasing prey populations, providing open areas for hunting, and maintaining nest trees and perches. These benefits are expected to last ~15 years postharvest.[2]
- Burned coniferous or mixed forests provide high-quality habitats, but rapid regeneration reduces habitat value after ~8 years in some regions.[3]

STAND-LEVEL RECOMMENDATIONS

- If the following features are maintained within harvest blocks, foraging habitat for Northern Hawk Owls is expected to increase:
  - Tall perches (singly or in patches), especially trees without dense foliage and/or snags and in cutblocks >2 ha.[1]
  - Existing or potential nest trees: trees, snags, or stumps with cavities, broken-topped snags, and aspen >35 cm dbh with damage or signs of decay (e.g., false tinder conks). Nest trees can be retained along edges and within patches.[1,4,5]
- Shrub suppression through silviculture in 11–15 year-old cutbocks may maintain foraging habitat value for longer.[1]
- During salvage logging, operators should retain patches containing large-diameter snags and trees/snags with visible cavities to reduce the negative effects of salvaging on nest availability.[1,3]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Recently burned forests (2–8 years) may represent crucial habitat, especially at margins between coniferous and mixed/deciduous forests. These stands provide high-quality foraging habitat as well as nest trees.[3] Retention harvests may provide similar value to this species on managed landscapes, but further research is required in North America to confirm this expectation.
- Unharvested riparian buffers and non-operable wet areas within coniferous or mixed forests, as well as areas containing stunted or scrubby spruce, may contribute to Northern Hawk Owl habitat on the landscape (studies are needed to confirm this).

The Northern Pygmy-Owl is, as its name suggests, one of the smallest owls in North America. It is secretive and hard to detect during the breeding season, making it a hard species to study.

Northern Pygmy-Owl

(Glaucidium gnoma)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SENSITIVE	Saskatchewan	ABSENT

PRIMARY HABITAT
Coniferous

TERRITORY SIZE
>75 ha

NEST TYPE
Cavity

NEST REUSE
Some

STAND LEVEL
Retention of large-diameter deciduous trees/snags when harvesting coniferous/mixed stands.

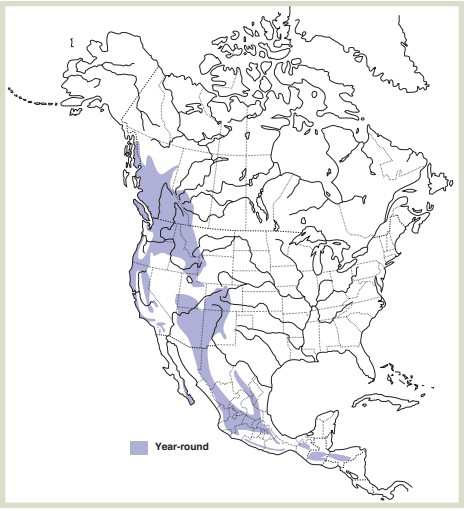
LANDSCAPE LEVEL
Large, old, conifer-leading forest stands with natural gaps and openings.

BREEDING WINDOW

HABITAT ECOLOGY

- The Northern Pygmy-Owl occupies a wide range of habitats, including spruce-fir, cottonwood bottomlands, aspen/poplar, mixed pine, deciduous-coniferous mixedwood, Douglas fir, western hemlock, and western larch.[1,2]
  - Important habitat features for this species include large trees containing cavities. They are mainly known to nest in cavities excavated by Black-backed Woodpeckers, Hairy Woodpeckers, Northern Flickers, and Pileated Woodpeckers.[2]
  - Nests are typically observed within old forest but near openings including waterbodies and clearings.[2]
- This species is associated with older forests (e.g., >80 years in the Alberta Foothills) and high crown closure, tree height, slope, and terrain variability.[3]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Few studies have looked at Northern Pygmy-Owl responses to forest management, but it is expected to be sensitive to even-aged management and clear-cutting (removal of existing and potential cavity trees).[1,2]
- Retention harvesting may benefit this species by retaining nest trees and creating openings for hunting. However, there have been few studies to confirm this and study results have been mixed.[3,4]

STAND-LEVEL RECOMMENDATIONS

- Unharvested forest patches on steep, inoperable slopes may improve foraging habitat value, particularly in conifer-leading forests.[3]
- Managers should include large-diameter live deciduous trees in patches where available, as these will provide suitable hunting perches and future nest cavities while increasing structural diversity.[3] Where deciduous cover is sparse, dispersed retention of trees, snags and stubs may be beneficial,[5] however research to determine minimum and optimal retention level and pattern is needed.

LANDSCAPE-LEVEL RECOMMENDATIONS

- Large, old forest areas with high canopy closure, structural complexity, layering, and natural gaps and openings are considered the most valuable habitat for Northern Pygmy-Owls on the landscape. NRV approaches that maintain these upland habitats are important.
- While retention harvesting may provide foraging habitats, representation of older forest types on the landscape is considered the most valuable action unless further studies provide clear evidence of use and breeding success in harvested areas.[3,4]

The Northern Saw-whet Owl is one of the smallest owls in North America, and also one of the most common in northern forests.

Northern Saw-whet Owl

(Aegolius acadicus)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Coniferous/Mixedwood

TERRITORY SIZE
> 50 ha

NEST TYPE
Cavity (secondary)

NEST REUSE
Common

STAND LEVEL
Retain aspen >35 cm dbh with signs of damage or decay, and trees/snags with visible cavities.

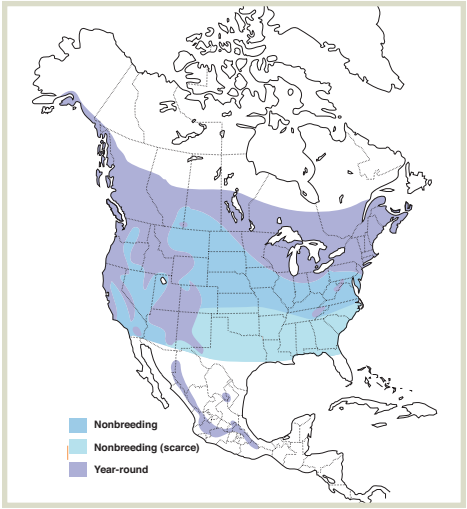
LANDSCAPE LEVEL
Large, contiguous old coniferous or mixedwood forests with natural gap dynamics.

BREEDING WINDOW

HABITAT ECOLOGY

- The Northern Saw-whet Owl is found in a wide range of forest types but is most common in riparian coniferous forests.[1] It is also found in cottonwood, ponderosa pine and Douglas fir forests[2] but it is uncommon in subalpine forests.[1]
    - In Alberta's boreal mixedwood forest, Northern Saw-whet Owls were most common on landscapes with cropland (average = 20%) interspersed with deciduous forest, and were positively associated with soft (vegetated) linear features.[3]
- This species nests in old cavities excavated mainly by Northern Flickers as well as by Pileated Woodpeckers, meaning large-diameter deciduous trees are an important habitat feature, particularly in coniferous-dominated stands.[3,4]
- This species begins laying eggs as early as February or March, meaning it may be at risk of incidental take or nest disruption during winter operations. Nests should be protected from early February (BC) or March (Alberta) to the end of July.[2,5]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Large clear-cuts without retention and even-aged management are considered important threats to this species as they remove potential nest trees.[6]
- Retention harvesting or small entries that maintain high densities of cavity trees and hunting perches may have a neutral or potentially positive effect:
    - This species hunts from forest edges out into openings and clearings, and has shown positive responses to landscapes containing many openings within dry mixed-conifer forests.[7]
    - Low levels of fragmentation and/or forest clearing may increase prey densities and foraging habitat, but these benefits can be easily outweighed by the negative impacts of perch removal, nest tree removal, and increased predation where fragmentation is high.[8]
    - A nest box study with a low sample size (4 Northern Saw-whet Owls) found this species nesting in deciduous and mixedwood harvested stands with between 20% and 75% dispersed and patch retention.[3]

STAND-LEVEL RECOMMENDATIONS

- Managers should retain patches containing large-diameter trees and snags with cavities, multiple vegetation layers, and natural openings.[2]
- In dry mixed-conifer forests (e.g., Douglas fir/ponderosa pine), retention patches located on south-facing aspects may provide greater benefits.[7]
- Nests that are encountered and found to be occupied should be protected using nest buffers of up to 25 m or wider during the critical breeding period (e.g., Feb./Mar. to July).[9]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Wet areas including riparian zones, valley bottoms and wetlands are considered beneficial habitat features for the Northern Saw-whet Owl.[2] These passive areas likely contribute to overall habitat on the landscape.
- Large tracts of mature and old forest are considered the most important habitat for this species due to the Northern Saw-whet Owl's use of cavity nests and the natural gap dynamics that occur in older stands.[2,10] Managing landscapes within the full range of NRV to ensure representation of these old forests will be important.
    - Their positive association with cropland and soft linear features suggests that Northern Saw-whet Owls may be resilient to some habitat fragmentation and will benefit from habitat edges and openings, provided nest trees are available.[3]

Wild Spotted Owl populations in British Columbia have fallen from about 1,000 (historical population estimate) to less than 30 individuals due to extensive habitat loss, fragmentation, and competition with Barred Owls. The province has undertaken several direct actions for their recovery including establishing extensive protected areas and a captive breeding program.

Photo by US Fish & Wildlife Service

Northern Spotted Owl

(Strix occidentalis)

STATUS

SARA	ENDANGERED	British Columbia	RED
Alberta	ABSENT	Saskatchewan	ABSENT

PRIMARY HABITAT
Old Coniferous (Douglas fir)

TERRITORY SIZE
2,000–3,000 ha

NEST TYPE
Cavity/broken top

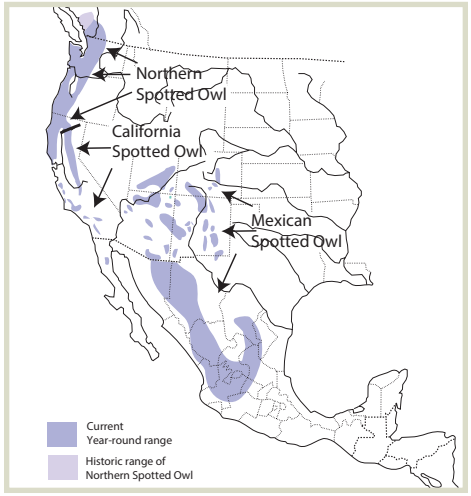
NEST REUSE
Common

STAND LEVEL
Retention of large-diameter trees/ snags with broken-tops, cavities, mistletoe brooms, etc.

LANDSCAPE LEVEL
Establishment of protected areas, particularly on wetter, less fire-prone sites.

BREEDING WINDOW

RANGE MAP



Rather than attempting to synthesize the many region-specific recommendations outlined in recovery and BMP documents, this species account provides a broad overview of recommended practices for improving habitat quality for Spotted Owls. Forest managers are referred to region-specific strategies, detailed species recovery plans/requirements, and/or provincial biologists within their Forest District for targeted guidance (see Resources section at the end of this account).

HABITAT ECOLOGY

- Spotted Owls reside in >100-year-old forests, and forest >140 years old is considered "superior." Superior habitats are also conifer-dominated (preferably Douglas fir), multi-species stands with high stand complexity. Superior habitat is characterised by the following habitat features:[1]
  - Canopy closure >70% provides thermal cover and protection from bad weather.[1]
  - Broken-topped snags, cavities, mistletoe brooms, and in some cases abandoned raptor nests for nesting.[1–3]
  - Vertical and horizontal structural diversity (i.e., 3 or more shrub/canopy layers) and perches at several heights.[1,2,4]
  - Large-diameter trees (>75 cm dbh) and large snags, logs, and other downed woody material.[2]
  - Patchy understory vegetation totalling >40% cover, over a quarter of which is shrubs.[1]
- Barred Owls have been expanding into the Spotted Owl's range. Although closely related, the Barred Owl consistently out-competes Spotted Owls, and is thus considered a significant threat.[2,5]

RESPONSE TO FOREST MANAGEMENT

- Habitat loss, fragmentation, and replacement of old forests with dense, even-aged forests are among the primary threats to the Spotted Owl.[2]
- Fragmentation makes it more difficult for juvenile owls to safely disperse and establish new territories.[2]
- Spotted Owls appear to avoid hard habitat edges but favour diffuse edges created by low-severity fire.[6]
- Spotted Owl responses to stand thinning have been mixed; some studies have found negative effects of intensive thinning, while others have observed Spotted Owls in 10–50 year-old thinned and selectively harvested stands.[5]
- In California and Oregon, Spotted Owls were observed using variable retention harvest units, irregular shelterwoods, and seed-tree harvests. This response was attributed to high woodrat densities within these harvest blocks, but the authors cautioned that a different response was expected in Douglas fir/western hemlock forests where northern flying squirrel is a more important prey item.[7]

STAND-LEVEL RECOMMENDATIONS

- Within-block retention should be employed to promote the long-term structural diversity of harvested stands, including a combination of patches and dispersed retention,[8] with an emphasis on large-diameter trees and snags with broken-tops, large horizontal branches, forks, cavities, mistletoe brooms, and evidence of decay.[1,9]
    - The above features should also be retained during salvage logging following low- and medium-severity fires.[5]
    - Large retention areas should be located in wetter areas and northern aspects, as these are more naturally resistant to fire.[5]
    - See Blackburn and Godwin (2004) for retention targets within management zones for different BEC subzones.[3]
- Variable-density stand thinning may have short-term negative effects on northern flying squirrel abundances, but may provide long-term benefits to habitat quality and prey abundance (the oldest, largest trees and trees with deformities should be retained and snags should be created if not naturally available).[5]

LANDSCAPE-LEVEL RECOMMENDATIONS

- The creation of Wildlife Habitat Areas to protect known Spotted Owl habitat is the main tool recommended for protecting and recovering this highly endangered species. The recommended reserve size is 3,600 ha, of which 2,400 ha should be old forest.[9]
- In dry conifer forests that face a high risk of stand-replacing fires, there is cautious support for forest management that directly or indirectly promotes fire resistance.[5]
- Fuel reduction treatments are discouraged within 125 ha around nesting and roosting habitats.[10]
- Treatments may negatively impact local Spotted Owl habitat and/or nesting pairs in the short term.[5,11]
- Potential treatments include retention of fire- and drought-resistant tree species, reducing stand basal area around these tress, and thinning of dense young stands that result from fire suppression.[5]
- Natural fire refugia (wet areas, valley bottoms, perched water tables, etc.) may represent strategic areas for retention and reserves as they are more likely to resist future high-severity fire events.[5]

RESOURCES

- Chutter, M. J. et al. 2004. Recovery strategy for the northern spotted owl (Strix occidentalis caurina) in British Columbia. Prepared for the BC Ministry of Environment, Victoria, BC. 74 pp. https://www.sararegistry.gc.ca/virtual_sara/files/plans/rs_spotted_owl_caurina_1006_e.pdf
- Blackburn I, Godwin S. 2004. Spotted Owl, Strix occidentalis. Accounts and Measures for Managing Identified Wildlife- V. 2004. Biodiversity Branch, Identified Wildlife Management Strategy, Victoria, BC. https://www2.gov.bc.ca/assets/gov/environment/natural-resource-policy-legislation/accounts-measures-for-managing-identified-wildlife/birds_spotted_owl.pdf
- BMPWG (Spotted Owl Best Management Practices Working Group). 2009. Best Management Practices For Managing Spotted Owl Habitat. Page Spotted Owl Management Plan 2 (Chilliwack Forest District, Squamish Forest District). BC Ministry of Environment and Ministry of Forests and Range. Available from http://bcwildfire.ca/ftp/DCK/external/!publish/SOMP/DOCUMENTS/SPOWBestManagementPractiesJul2009.pdf

"Quick, three beers!" is the distinctive song of the Olive-sided Flycatcher. This nationally Threatened bird hunts by swooping over clearings, meadows, or wetlands and catching insects mid-air.

Olive-sided Flycatcher

(Contopus cooperi)

STATUS

SARA	THREATENED	British Columbia	BLUE
Alberta	MAY BE AT RISK	Saskatchewan	NO STATUS

PRIMARY HABITAT
Open coniferous/wetland, edge

TERRITORY SIZE
10.5–45 ha

NEST TYPE
Canopy (conifer)

NEST REUSE
No

STAND LEVEL
May depend on nest success; see Response to Forest Management.

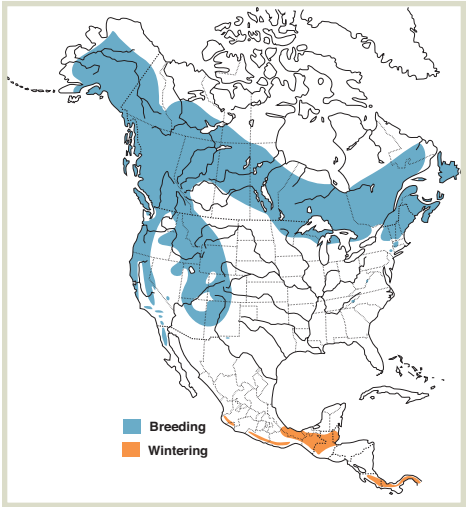
LANDSCAPE LEVEL
Patchy, wet, open, and recently burned coniferous forests on the passive landbase.

BREEDING WINDOW

HABITAT ECOLOGY

- In western Canada, the Olive-sided Flycatcher is found in 0–30 year-old harvested stands and 0–10 year-old burned stands, provided they contain residual trees, and >125 year-old fire-origin mixedwood forests.[1]
- This species' preferred habitat is old, open (<40% cover) coniferous forests or young burned stands, forest openings, and edges containing snags and live trees.[2,3] Important habitat features for this species include:
  - Tall, prominent perches (snags preferred to live trees).[2,4]
  - Riparian areas, water bodies, swamps, bogs, and muskegs containing snags.[2]
  - High-contrast edges between mature forest (used for nesting) and openings (used for hunting).[5]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Clearcutting without residuals, post-fire salvage logging, and herbicide and insecticide use are considered important threats to this species because they reduce forest diversity and structural complexity.[6]
- This species is attracted to young retention harvests, selection harvests, shelterwoods, thinned stands, and landscapes fragmented by clearcutting.[1,2,7–9]
- However, a small-scale study in the northern Rocky Mountains of the USA suggests that Olive-sided Flycatchers may preferentially nest in harvested stands with retention and have much lower nest success than in fire-origin openings due to increased nest predation.[10]
  - Follow-up studies in western Canadian forests are strongly recommended to determine whether retention harvests are acting as ecological traps on these landscapes.

STAND-LEVEL RECOMMENDATIONS

- High densities of Olive-sided Flycatcher within harvest blocks containing residual spruce, fir, larch, and tall snags suggest that these features may be useful for improving habitat quality within harvested stands. The following harvest strategies and/or retention guidelines are expected to attract Olive-sided Flycatcher:[4]
  - Coniferous residual trees of varying heights, singly or in small clumps, for perching (females prefer shorter trees for perching than males).
  - Snags and trees exceeding the canopy height of retention patches and trees with reduced foliage at the top.
  - Selection harvest within spruce, fir, and larch stands.
- However, if these stands are shown to lead to low Olive-sided Flycatcher nest success, alternative strategies will be needed to avoid unintended consequences (see Landscape-level Recommendations and Knowledge Gaps).[4]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Coniferous areas which are patchy, recently burned, and contain wet areas are most likely to contain high densities of Olive-sided Flycatcher.[6]
    - These types of forests can be maintained according to a region's NRV, and may be well-represented within the passive landbase, particularly if salvage logging of burned stands can be deferred or avoided.[11–13]
- If retention harvests and other low-intensity harvests are shown to a) draw Olive-sided Flycatchers away from unharvested habitats and b) lead to reduced nest success, it may be more appropriate to avoid selective or retention harvesting on landscapes adjacent to the high-quality habitats described above for the 10 years following the burn.[4]

KNOWLEDGE GAPS

- Management implications for the Olive-sided Flycatcher are contingent on its reproductive success in harvested stands containing retention. It is critical to study this species' reproductive output in retention harvests in western Canadian forests to determine whether these harvest treatments are having the opposite effect than is intended.

The osprey is a striking raptor that nests near fish-bearing waters. Note that in BC, active and inactive Osprey nests are protected and government authorization is required to destroy them.[1]

Osprey

(Pandion haliaetus)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Riparian/Wetland

TERRITORY SIZE
0.8–3.1 ha

NEST TYPE
Platform

NEST REUSE
High

STAND LEVEL
1.8 ha patches around nests and 300–500 m high-impact activity buffers around active nests.

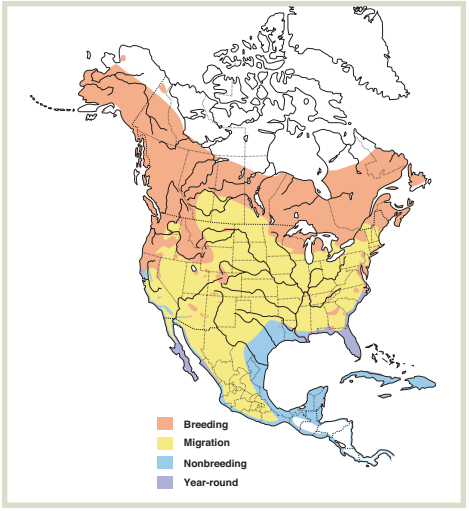
LANDSCAPE LEVEL
Retention patches and riparian buffers containing tall trees within 1–2 km of fish-bearing waters.

BREEDING WINDOW

HABITAT ECOLOGY

- The Osprey is mainly found nesting within 1–2 km of fish-bearing waters, although it may nest up to 20 km away from these waters.[2]
- Platform nests are built on trees that are taller than the surrounding canopy and which often have flat tops (e.g., dead tops, broken tops, etc.). Nests may also be built on very tall snags.[3]
- Osprey nests have a high likelihood of reuse, either by Osprey or by other species.[2,4]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Harvesting that removes existing or potential nest trees (e.g., flat-topped trees taller than the canopy) negatively affects Osprey. This is particularly true of removal of existing nests, as they are very likely to be reused if left.[3]
- Osprey have been observed nesting on isolated residual trees and snags within clearcuts, however these isolated trees may be at higher risk of blowdown than patches.[3]
- Osprey responses to human disturbance are highly variable and appear to depend on whether individuals are habituated to human activity. Some pairs will breed successfully in heavily-developed areas, while pairs nesting in remote areas may be more likely to be disrupted by low amounts of disturbance.[5]

STAND-LEVEL RECOMMENDATIONS

- Platform nests should be protected even when not occupied due to their strong chance of future reuse.[4]
- Patch retention is recommended over single-tree retention to provide nest trees for Osprey.[4]
- Unharvested buffers around nests are recommended and studies generally suggest maintaining 1.8 ha (75 m radius) unharvested patches around platform nests that were occupied at least once within the last five years[5]. During the critical breeding period, high-impact activities (e.g., road-building, logging) should be avoided within 300–500 m of active nests.[5,6]
- Patch retention in harvest blocks near fish-bearing waters is recommended to provide potential future nest opportunities, particularly patches with one or more trees extending above the canopy.

LANDSCAPE-LEVEL RECOMMENDATIONS

- Forested landscapes within 1–2 km of a fish-bearing waterbody contain potential Osprey habitat, even if nests are not observed prior to harvesting. Riparian buffers and patches containing tall, broken-topped trees and snags may provide valuable nesting habitat following harvest.

This ground-dwelling, large-bodied warbler is more often heard than seen thanks to its distinctive and loud "teacher-teacher-teacher-teacher" song.

Ovenbird

(Seiurus aurocapilla)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Deciduous

TERRITORY SIZE
0.6–1.6 ha

NEST TYPE
Ground

NEST REUSE
Same area

STAND LEVEL
High dispersed retention or large deciduous patches with deep leaf litter.

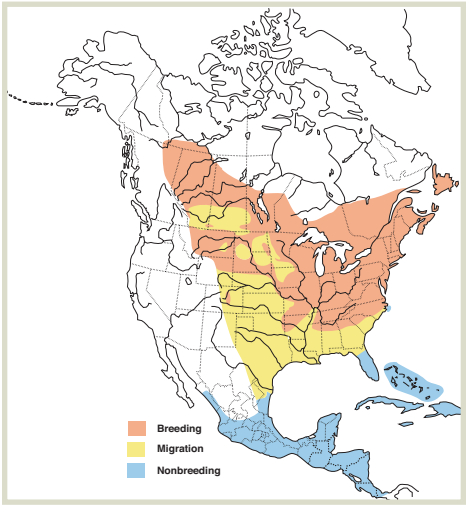
LANDSCAPE LEVEL
Large areas of core habitat; riparian buffers >100 m wide.

BREEDING WINDOW

HABITAT ECOLOGY

- The Ovenbird is most common in large, contiguous deciduous or mixed forest with the following habitat features:[1,2]
  - Closed canopy (60–90%).[1]
  - Lower understory cover but deep leaf litter,[1] which improves cover for nests and increases invertebrate prey.[3]
- The Ovenbird is most strongly associated with mature and older forests, however it has been observed in stands as young as 11–14 years post-disturbance, suggesting some flexibility in its use of forested habitats.[2,4]
- This species shows a slight increase following spruce budworm outbreaks.[5]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Overall, Ovenbird is considered a forest-interior species that is sensitive to even low-intensity harvesting in the short term (e.g., harvest with 30–40% retention).[3,6–8]
- However, this species was observed using clearcut (i.e., no planned retention) harvest stands 15–33 years postharvest, suggesting rapid recovery on harvested sites as leaf litter from regenerating vegetation becomes thick—however, occupancy was consistently higher in unharvested forest.[9]
- In Saskatchewan, Ovenbirds responded positively to large aggregated harvests (250–400 ha and 1,200–2,700 ha) compared with postfire stands and salvage-logged burns.[10]

STAND-LEVEL RECOMMENDATIONS

- High retention levels (e.g., 70 trees/ha with ≥30 cm dbh or >30% retention) may affect this species less negatively than clearcuts in the short term by providing greater canopy closure and leaf litter,[1] however at least one study suggests that 20–50% dispersed retention has a limited positive effect up to 15 years postharvest.[11]
  - The negative effects of clearcutting may be limited to the first 15 postharvest years provided regenerating deciduous vegetation produces deep leaf litter, yet this may represent lesser-quality habitat.[9]
- Patches of closed-canopy, mature deciduous trees with low understory cover and deep leaf litter are recommended within harvested stands. Patch sizes, amount, and distribution should be consistent with the region's natural range of variation (but see Landscape-level Recommendations).[12,13]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Large blocks of young to mature forest (e.g., 30–100 years[14]), represented according to the area's natural range of variation, will likely contribute the most important habitat for Ovenbirds to successfully breed.
  - On heavily fragmented landscapes, protection of very large (>500 ha) forests with >90 ha in "core habitat" is recommended to reduce the risk of local population declines.[15]
- "Core habitat" is defined as habitat >100 m from an edge, because Ovenbirds have been shown to experience negative edge effects within 100–300 m of cutblock edges.[16]
- Riparian buffers ≥100 m are necessary to accommodate an Ovenbird territory,[17] but smaller buffers may provide corridors for dispersal.[18]

Until 2010, the Pacific Wren was considered a sub-species of the Winter Wren. It is small and well-camouflaged but is easily detected by its complex and vibrant song.

Pacific Wren

(Troglodytes pacificus)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	NO STATUS	Saskatchewan	ABSENT

PRIMARY HABITAT
Old coniferous/riparian

TERRITORY SIZE
1.2–3.3 ha

NEST TYPE
Variable (cavities, root masses, soil)

NEST REUSE
Some

STAND LEVEL
Retention of large trees, large downed logs, root masses, and slash piles.

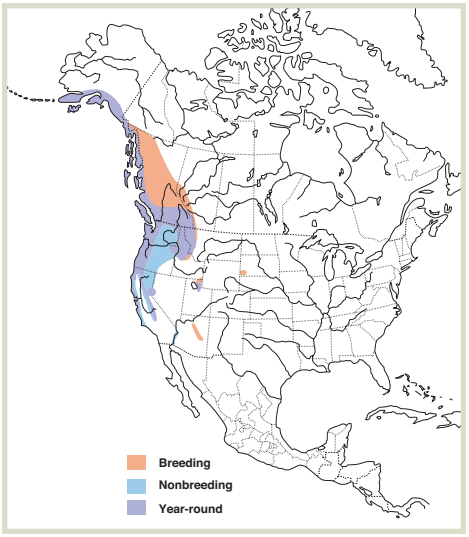
LANDSCAPE LEVEL
Large, old coniferous forests >30 ha (Douglas fir, western hemlock, western red cedar, etc.)

BREEDING WINDOW

HABITAT ECOLOGY

- The Pacific Wren is a year-round resident in parts of its range, including southern interior BC. During the breeding season, its range extends to include central and northern interior BC and the Alberta foothills.[1]
- This species is strongly associated with old coniferous forests that contain old forest features including snags, upturned tree root masses, downed trees, and large-diameter trees.[1]
  - The most suitable habitats for Pacific Wren include old western hemlock forests[2,3] and/or closed conifer forest >200 years old (e.g., Douglas fir, western red cedar, etc.).[4]
- In BC, the Pacific Wren is often found within 5 m of streams <10 m wide, where they nest on stream banks under soil overhangs and upturned root masses.[1,5,6]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Clear-cutting and partial harvest reduce habitat suitability for the Pacific Wren[3] for up to 40 years,[7] however harvesting that retains high snag densities, slash piles, and upturned root masses may improve postharvest habitat quality.[1,8]
- Reduced densities of Pacific Wren near forest edges,[9] forest stands <20 ha.[1] and in narrow riparian buffers (avg. 13 m)[10] suggest that this species is sensitive to fragmentation of late-seral habitats.

STAND-LEVEL RECOMMENDATIONS

- Recommended retention patch anchors include large-diameter downed logs, large-diameter trees, and fallen trees with large rootwads. Slash piles and shrub cover protection (i.e., maintaining >60% shrub cover) are also considered likely to improve habitat quality within harvested stands.[1,11]
- The creation of small canopy gaps using selection cutting may be an appropriate strategy, but would require the targeted retention of important habitat features including snags, downed woody debris, large-diameter trees, and upturned root masses.[6]
  - Cutblocks <10 ha that contain 10% dispersed retention may provide sub-optimal breeding habitat for Pacific Wrens, provided they are near mature or old forest.[12]
- Wide riparian buffers (e.g., >40 m), particularly along streams <10 m wide and including snags and downed trees, may represent suitable breeding habitat.[6,10,11]

LANDSCAPE-LEVEL RECOMMENDATIONS

- On landscapes managed within the area's NRV, unfragmented forest stands larger than 30 ha and >80 years old (preferably >200 years old if available) are considered the most valuable habitats for conserving the Pacific Wren.[1]

KNOWLEDGE GAPS

- The majority of research on the Pacific Wren has been concentrated within coastal forests. Further research is needed to assess Pacific Wren responses to forest management in interior BC and determine whether similar habitat features are of equal importance to breeding pairs in these areas.

One of the largest North American woodpeckers, the Pileated Woodpecker is easily spotted thanks to its bright red crest and loud call that resembles manic laughter. Many species reuse old Pileated Woodpecker cavity nests.

Pileated Woodpecker

(Dryocopus pileatus)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT

Deciduous, mixedwood, dry mixed-conifer

TERRITORY SIZE

~2,500 ha (highly variable)

NEST TYPE

Cavity (mainly deciduous)

NEST REUSE

Same area

STAND LEVEL

Aspen >35 cm dbh with conks or western larch, ponderosa pine, or black cottonwood >75 cm dbh.

LANDSCAPE LEVEL

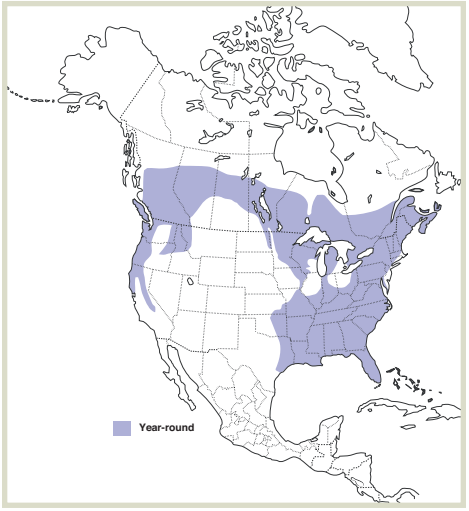
Uneven-aged management and large retention patches within aggregated harvests.

BREEDING WINDOW

HABITAT ECOLOGY

- Pileated Woodpeckers are found in a wide range of forest types, including deciduous forests, mixedwoods, and dry mixed-conifer forests. Their occurrence is mainly driven by their need for large-diameter, decaying trees or snags which can be excavated for nests and roosts, and insect-infested deadwood for foraging.[1]
    - In deciduous and mixed deciduous-coniferous forests, optimal nesting trees are >35 cm dbh, decay class 2 (live and unhealthy), and have 10–25 conks on average.[2]
    - In dry mixed-conifer forests, optimal nesting trees include western larch, riparian black cottonwood, and ponderosa pine, although Douglas-fir is used to a smaller extent.[3,4]
- Due to their need for large, old trees for nesting and foraging, this species is mainly found in older forests, as well as forest stands containing snags and trees for foraging and nesting.[5,6] Unlike some other woodpecker species, the Pileated Woodpecker is not associated with burned forests.[7,8]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- The main impact of intensive harvesting is the removal of the large-diameter live and dead trees that Pileated Woodpeckers need for nesting, foraging, and roosting.[1]
- This species' response to retention harvesting has been mixed.[2,9] Regardless, they are rare or absent in clearcuts without residual trees up to at least 25 years postharvest,[10] indicating that harvest strategies that include retention mitigate harvest effects at the very least and provide some foraging and nesting opportunities.[11]

STAND-LEVEL RECOMMENDATIONS

- Retention recommendations focus on identifying and protecting existing and potential cavity trees and other coarse woody debris for foraging. Retention anchor points include:
    - Aspen trees with existing cavities should be used as retention anchor points, particularly if they are still alive or not heavily decayed as they will last longer.[12] Additional aspen with the following characteristics should also be conserved in patches: >35 cm dbh, >25 m tall, with 10–25 false tinder conks and no live branches for 70% of the tree's height.[2,11]
    - Large-diameter western larch (77–91 cm dbh), ponderosa pine (76–96 cm dbh) within mixed ponderosa pine/Douglas fir groves, and black cottonwood (75–100 cm dbh) are recommended as retention patch anchor points where aspen is unavailable.[4] Unlike aspen, broken-topped snags and trees/snags with existing cavities are a high priority, as these species and are more easily excavated when they have more decay.[4]
    - Standing live and/or dead trees with visible carpenter ant colonization at the base (fine sawdust piles, woodpecker foraging holes, basal scars, etc.).[6]
- While heavily-decayed snags containing cavities may be too rotted for nesting, they may be suitable foraging habitat.[13]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Traditional two-pass clear-cutting removes the old, large-diameter trees needed for nesting and produces even-aged stands where these important features are rare or absent. Harvest patterns more consistent with an area's NRV are recommended. Particularly, harvest areas containing patches of older forest and suitable nest tree species are most likely to benefit this species.
    - In aspen-dominated forests in the boreal mixedwood forest, for example, large aggregated harvests (1,000s of ha) with ~30% overall retention of mature and old aspen cover, and small aggregated harvests (100s of ha) with >30% retention in patches >10 ha) are recommended.[14]
    - In dry coniferous forests, management areas of 300–400 ha are recommended within which ≥60% canopy closure is maintained within at least 50% of the management area.[15]

The Pine Grosbeak is an inconspicuous species that is rarely observed except during years when their populations boom and they spread into new areas during the winter.

Pine Grosbeak

(Pinicola enucleator)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Coniferous

TERRITORY SIZE
12 ha (uncertain)

NEST TYPE
Canopy (coniferous/shrubs)

NEST REUSE
Unknown; site fidelity

STAND LEVEL
Retain mountain ash and berry-producing trees and shrubs, where available, in spruce harvests.

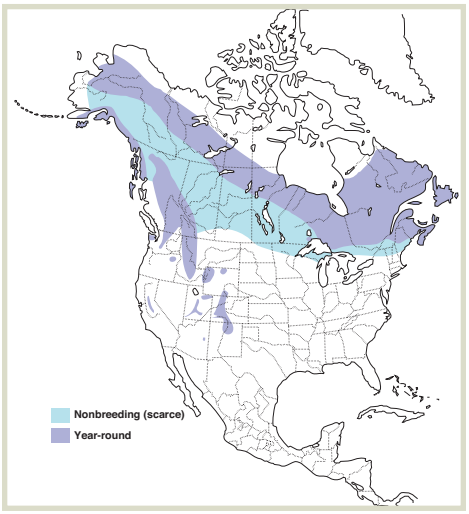
LANDSCAPE LEVEL
Large, old, open unharvested forests. Passive landbase (wet, subalpine, remote) is also important.

BREEDING WINDOW

HABITAT ECOLOGY

- The Pine Grosbeak lives year-round within the Boreal Shield and across most of interior BC. Populations east of the Rockies have periodic "winter irruptions", during which large numbers of birds move outside of their usual range, sometimes as far south as the Canada-US border. These irruptions occur every 5–25 years and are thought to be driven by food availability.[1]
- Pine Grosbeaks are most abundant in open coniferous (spruce, subalpine fir and tamarack) forests near the treeline (northern or montane), drainages and wet valleys.[1]
    - They only breed in subalpine and subarctic open coniferous forests.[1] In the winter, they will occupy a range of habitats including mixed coniferous-deciduous, deciduous, and second-growth forests.[2] Wintering habitats are thought to be driven by availability of mountain ash, ash, and maple.[1]
- In BC, the Pine Grosbeak's breeding range is now understood to be widespread. It is most common in the Northern Boreal Mountains and Sub-Boreal Interior ecoprovinces, particularly above 1,500 m, and in remote forests and parklands dominated by western hemlock, subalpine fir, white spruce, and Engelmann spruce.[3]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Pine Grosbeaks are very rarely observed, making it difficult to draw conclusions about their response to forestry.
- Studies in Finland show that Pine Grosbeaks are mainly observed in very old (>200 years) spruce or pine forests, and very rarely in thinned and/or fragmented forests.[4,5] They are also positively associated with large, unharvested reserves, but negatively associated with the amount of pine forest in the reserves.[6]

STAND-LEVEL RECOMMENDATIONS

- Based on known habitat associations, the following habitat features are recommended for retention within harvested areas:
    - Mountain ash trees and other berry-producing trees or shrubs.
    - Wet areas containing sparse black spruce, tamarack, or other conifers.
- Given the Pine Grosbeak's association with open coniferous stands during the breeding season, silviculture that promotes dense regeneration appears likely to reduce habitat quality. Harvesting is most likely to affect breeding habitats in BC, where they are more widespread, but more research is needed to determine the degree of overlap between breeding populations and harvesting, and the effect of harvest.

LANDSCAPE-LEVEL RECOMMENDATIONS

- While there is very little information available, it is likely that large, unharvested areas of old and/or open coniferous forests within the Pine Grosbeak's breeding range will be of greatest benefit to this species.
- The passive landbase likely provides important high-quality breeding habitat, including wet, unproductive coniferous forests, sparse subalpine parklands, and remote or inaccessible forests. However, more research is required to confirm this assumption.

The Rufous Hummingbird is an incredible species that travels from Mexico and the Gulf States to the Pacific Northwest and as far north as Yukon and Alaska. And yet, it manages to return to the same site to nest each year.

Rufous Hummingbird

(Selasphorus rufus)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	ABSENT

PRIMARY HABITAT
Coniferous

TERRITORY SIZE
Colonial

NEST TYPE
Canopy

NEST REUSE
Common

STAND LEVEL
Retention of preferred nest tree species, flowering plants, and trees with sapsucker wells.

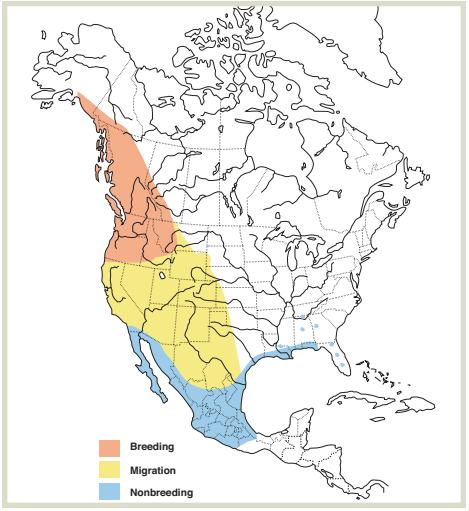
LANDSCAPE LEVEL
Heterogeneous landscapes containing early- and late-seral forests.

BREEDING WINDOW

HABITAT ECOLOGY

- The Rufous Hummingbird feeds mainly on flower nectar, insects, and both the sap flowing from sapsucker wells and the insects that get caught in it.[1,2]
- This bird species is found in a wide range of habitats, and the common factor among them is the presence of flowering plants and shrubs.[2] Habitats include:
  - Dense second-growth and mature coniferous forests (primary breeding habitat).[1]
  - Deciduous stands, riparian thickets, swamps, and meadows.[1]
  - Young postfire and postharvest habitats with abundant shrubs.[3]
  - Mature and old coniferous forests containing tree-fall gaps, natural openings, edges, and/or riparian habitats (i.e., openings where flowers grow) and old forest features including high structural diversity, high midstory cover, and lower canopy cover.[2]
- The Rufous Hummingbird mainly nests in conifers. They mostly nest in western redcedar and Douglas fir, and also nest in spruce, hemlock, pine, and fir trees. About 25% of nests are in deciduous species.[1]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Many studies have found a positive association between Rufous Hummingbird and clearcutting[2,4–6] and narrower riparian buffers,[7,8] and neutral to positive effects of thinning,[4] selection harvesting,[2] and patch retention.[6]
- However, other studies (primarily in the Washington Cascades) have found reduced numbers in old forests fragmented by clearcutting. Low numbers were also observed in young and mature stands, suggesting the above results should be interpreted with caution.[2]

STAND-LEVEL RECOMMENDATIONS

- Relatively young harvest blocks (with or without retention) with a well-developed shrub layer appear to be suitable habitat for this species. Foraging habitat for the Rufous Hummingbird may be improved by protecting and/or not suppressing understory shrubs during and after harvest.
- Retention patches containing preferred nest tree species (e.g., western redcedar and Douglas fir) may benefit Rufous Hummingbirds, however their direct use of retention patches for nesting has not been verified.
- Trees with visible sapsucker wells and high sap-yield species (e.g., paper birch) are recommended as anchor points for retention patches as they may increase food availability for Rufous Hummingbirds.

LANDSCAPE-LEVEL RECOMMENDATIONS

- While this species clearly benefits from early seral habitats containing flowering shrubs, the value of old forest, old forest features, and gap dynamics remains important on the landscape scale. NRV strategies promoting landscape heterogeneity, maintaining a mix of early- and late-successional forests (as well as natural disturbance dynamics including fire) will likely benefit the Rufous Hummingbird.

KNOWLEDGE GAPS

- Rufous Hummingbird populations have continued to decline despite increases in apparently suitable habitat (cutblocks and burned forest). While declines may be due to factors on wintering grounds and/or migration routes, reproductive studies comparing harvested, burned, and old forest habitats are recommended to determine whether harvest blocks are ecological traps for this species.[1]

The Rusty Blackbird breeds up to the northern tree line in Canada, farther north than any other North American Blackbird. Its nest is usually within 12m of water and is often reused by Solitary Sandpipers.

Rusty Blackbird

(Euphagus carolinus)

STATUS

SARA	SPECIAL CONCERN	British Columbia	BLUE
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Coniferous/wetland/early-seral

TERRITORY SIZE
Colonial, ~11–37 ha

NEST TYPE
Trees, shrubs, stumps near water

NEST REUSE
No

STAND LEVEL
Riparian buffers, voluntary buffering of vernal pools, with focus on short, small-diameter conifers.

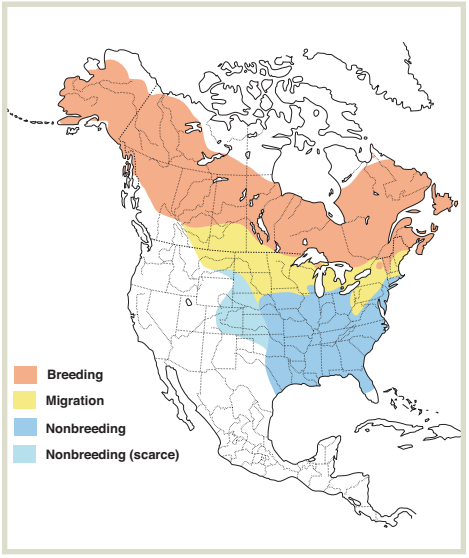
LANDSCAPE LEVEL
Coniferous wetlands with short trees, including burned-over stands, are most valuable.

BREEDING WINDOW

HABITAT ECOLOGY

- The Rusty Blackbird has a northern breeding range, where it is mainly found in wet coniferous forests (mainly black spruce and tamarack) near and along bogs, muskeg swamps, beaver ponds, and streams.[1]
- Nests are usually built in dense thickets of small conifers (e.g., 3–6 m black spruce with <8 cm dbh or 1–3 m balsam fir) or, where coniferous trees are limiting, deciduous shrubs (e.g., willow).[2,3]
  - Nests are typically built within 12 m of water, on average.[3]
  - Important habitat features for nest sites include shallow or vernal pools containing aquatic invertebrates and insects[4] (including recently burned wetlands[5]).
  - Stand age appears to be less important than the presence of short conifers, whether due to recent disturbance (e.g., harvest) or due to stunted growth on wet/low-productivity sites.[6]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Harvest effects in western forests are poorly understood for Rusty Blackbirds. While they have been observed in harvested stands containing residuals up to 30 years postharvest, sample sizes have been too low to conclusively infer a positive response to harvesting.[7–9]
- Some studies of reproductive success in New England suggest that harvested stands near coniferous wetlands may act as ecological traps, however results have been mixed and local studies are needed.
  - In one study, Rusty Blackbirds preferentially nested in <20 year-old regenerating clearcuts than in unharvested stands. However, nests in harvested stands were less than half as likely to successfully fledge young than nests in unharvested areas.[3]
  - In another study in the same region found that harvest history did not affect nest success, but rather that survival increased with increasing densities of trees ≤4 cm dbh around nests.[10]

STAND-LEVEL RECOMMENDATIONS

- Continuous, 75 m buffers are recommended around coniferous bogs, fens, and other wetlands suitable for Rusty Blackbirds. These buffers should provide nesting habitat and increase nest survival.[3,11]
- Voluntary buffering of, or retention patches anchored around, small or vernal pools is recommended, particularly if the surrounding vegetation contains short, small-diameter, dense conifers (black spruce, tamarack, or balsam fir).[1,10]
- Precommercial thinning of small-diameter conifers is discouraged in cutblocks adjacent to coniferous wetlands or streams, as the reduced cover will make Rusty Blackbird nests more vulnerable to predators.[10]

LANDSCAPE-LEVEL RECOMMENDATIONS

- The Rusty Blackbird's primary breeding habitats are likely to be well-represented on the passive landbase, including shallow wetlands, bogs, muskeg, beaver ponds, and low-productivity wet coniferous stands. Areas with high proportions of these features within a 38-ha area (i.e., this species' home range) are considered of highest value and, if possible, road-building and other disturbances should be avoided within them.[10]
- While there is some evidence that Rusty Blackbirds are drawn to harvest-origin early-seral habitats with dense regenerating conifers, research is needed in western forests to determine whether these habitats negatively impact nest success.[3,10]

The Townsend's Warbler is a stunning songbird, yet it has been studied much less than other warblers. Its song is similar to the Black-throated Green Warbler, but with a quicker final note: "see-see-see-see-seePTCHeee".

Photo by F. Veronesi

Townsend's Warbler

(Setophaga townsendii)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	ABSENT

PRIMARY HABITAT
Canopy (spruce)

TERRITORY SIZE
Unknown/unreported

NEST TYPE
Trees, shrubs, stumps near water

NEST REUSE
No

STAND LEVEL
Large-diameter grand fir, Douglas fir, and white spruce in patches and high overstory retention.

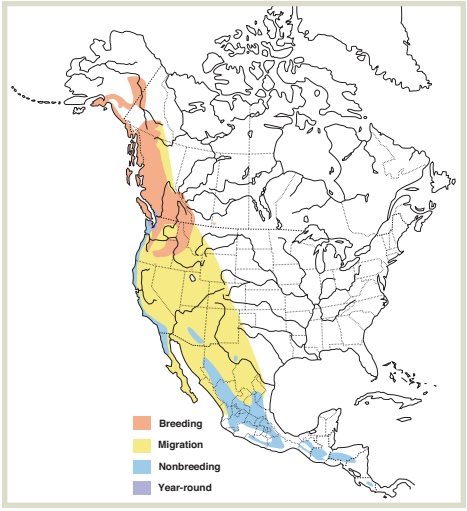
LANDSCAPE LEVEL
Large, old upland conifer forests (extended rotation or set-asides).

BREEDING WINDOW

HABITAT ECOLOGY

- The Townsend's Warbler is found in a range of forests including mature fir in the Pacific Northwest, interior mixed conifer forests, and coniferous and mixed deciduous-coniferous interior, sub-boreal, and boreal forests.[1]
- This species is most strongly associated with unharvested old forests.[1]
  - In interior mixed conifer forests, they prefer to nest where there are high volumes of grand and Douglas fir, and prefer to forage on grand fir and western larch.[2]
  - In boreal and sub-boreal forests, they prefer to nest on large-diameter white spruce in white spruce-dominated forests. Medium-diameter spruce (15–38 cm dbh) were used for foraging and, in Alaska, alder and paper birch.[3]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- While direct studies of the Townsend's Warbler's response to forest management are limited, their habitat associations suggest that reductions of mature and older-than-rotation forests are a threat.[1]
- In northern Rocky Mountain forests of the United States, they were most common in mature and old forests, and declines were attributed to harvesting.[4,5]
- They were, however, more abundant in logged than in burned stands in southeastern BC, with higher abundances in cutblocks with high levels of overstory conifer retention.[6]

STAND-LEVEL RECOMMENDATIONS

- Given the Townsend's Warbler's preferred nesting habitats, large-diameter grand fir, Douglas fir or white spruce are recommended for retention. These trees may provide suitable nesting habitat once surrounding regenerating trees reach a minimum dbh of 15 cm.
  - Of these large diameter trees, trees with thick, dense foliage should be prioritized for retention as they conceal nests from predators.[7]
  - High levels of overstory retention (e.g., up to 320 stems/ha) or high-grading are recommended in at least some harvest blocks in lieu of clearcutting or low-retention treatments.[6]

LANDSCAPE-LEVEL RECOMMENDATIONS

- While more extensive research is necessary to determine best practices at the landscape scale for the Townsend's Warbler, recommendations for this species typically highlight the importance of large, old, conifer-dominated forest. Given the Townsend's Warbler's association with important merchantable species, it seems likely that representation of these stands on the landbase (e.g., extended rotation management and representation of older forests within an NRV scenario) will be an important component for their conservation, particularly if these forest types are not well-represented on the passive landbase.

The Varied Thrush seems like it would be hard to miss, with its bold orange and black plumage and loud, drawn-out song. But it is actually quite shy and lives mainly in dark, wet forests where it forages on the ground for insects.

Varied Thrush

(Ixoreus naevius)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	ABSENT

PRIMARY HABITAT
Old coniferous

TERRITORY SIZE
Unknown, ~7 ha suspected

NEST TYPE
Variable, often understory vegetation

NEST REUSE
Rare but site fidelity

STAND LEVEL
Entries <10 ha, understory protection, and riparian buffers >30–35 m wide.

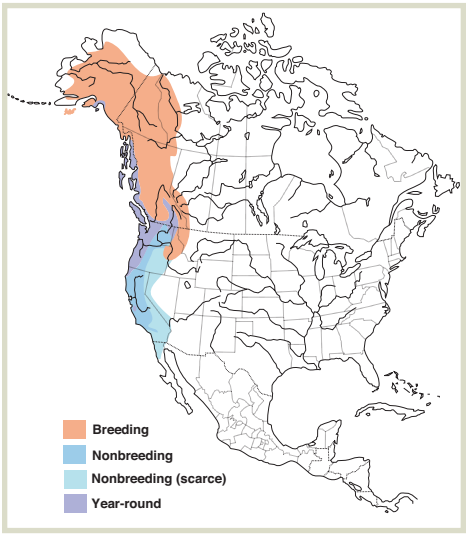
LANDSCAPE LEVEL
Large, old, wet upland coniferous forests, possibly >16 ha (more research needed).

BREEDING WINDOW

HABITAT ECOLOGY

- The Varied Thrush is generally considered a species of mature and old coniferous forests.[1] They are associated with old, unharvested cedar/hemlock and spruce/fir forests,[2] lodgepole pine/white spruce,[3] Douglas fir/western hemlock/western red alder,[4] and black spruce/tamarack.
  - They are associated with wet, upland, old forests[5] and positively associated with herbs, ferns, and berry-producing shrubs in the understory.[6]
  - The Varied Thrush is often described as a species of dark, wet, and mossy forests.[1]
- Nests are usually built in the understory vegetation of mature forests (and sometimes second-growth). They may be built on the lower branches of a small conifer, on the ground, in shrubs, or more.[1]
- While Varied Thrushes do not reuse nests, they tend to build nests near or even on top of old nests.[1]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- This old forest-associated species is rarely observed in young harvested stands, including retention harvests. It was absent from clearcuts and retention harvests[7] and declined in thinned stands.[8–10]
- Two studies of riparian buffers in the Pacific Northwest found conflicting results. Riparian buffers >30 m supported Varied Thrushes, however it is unclear whether these buffers will support numbers comparable to unharvested forest.[11,12]
- Low-intensity harvests (e.g., single-tree up to 10 ha openings totaling 30% volume removal within 30 ha blocks) mitigated harvesting effects, particularly in harvests <10 ha.[13]
- The Varied Thrush showed higher resilience to harvesting in the ESSF dry cool biogeoclimatic zone, where it was common in second-growth stands >7 years (compared with the MS dry cool biogeoclimatic zone, where it was common in second-growth stands >27 years).[14]

STAND-LEVEL RECOMMENDATIONS

- Very small harvesting entries (<10 ha) may reduce negative short-term effects on the Varied Thrush,[13] and understory protection may improve habitat value after >7 years,[14] in Engelmann spruce-subalpine fir forests.
- Riparian buffers >30–35 m are recommended in old conifer habitats, however these may only provide marginal benefits.[11,12]
- Large conifers with low foliage density near the top, near water or drainages and on steep slopes, may represent potential song posts and thus be useful as retention patch anchor points. However, this recommendation is derived from research conducted in coastal redwood forests and local studies are suggested.[15]

LANDSCAPE-LEVEL RECOMMENDATIONS

- The Varied Thrush's high sensitivity to harvest and thinning, particularly in lodgepole pine and Douglas fir forests, suggests this species will have its highest densities in older-than-rotation, wet, upland coniferous forests represented on the landscape.
- Old unfragmented forest patches >16 ha, or larger sizes consistent with NRV approaches, are considered to be of the highest value to this species. However, this threshold was determined for coastal redwood forests and may not apply to forests in interior BC or Alberta.[16]

The Western Screech-Owl (macfarlanei subspecies) is Threatened in Canada. Managers are responsible for ensuring that they meet the requirements of the Species at Risk Act, the provincial Forest and Range Practices Act, and the Identified Wildlife

Photo by Arbyreed

Western Screech-Owl

(Megascops kennicottii macfarlanei)

STATUS

SARA	THREATENED	British Columbia	BLUE
Alberta	ACCIDENTAL/VAGRANT	askatchewan	ABSENT

PRIMARY HABITAT
Riparian/Deciduous

TERRITORY SIZE
~20 ha during breeding season; 65–77

NEST TYPE
Cavity (secondary)

NEST REUSE
Common

STAND LEVEL
Retention patches >2.5 ha containing large-diameter aspen, cottonwood, water birch, or Douglas fir.

LANDSCAPE LEVEL
Riparian habitats around non-fish-bearing waters and landscapes with openings for foraging.

BREEDING WINDOW

HABITAT ECOLOGY

- The Western Screech-Owl has been subdivided into eight populations in BC, each of which has distinct habitat associations.
- This species is mainly found in lowland riparian habitats including black cottonwood, water birch, and trembling aspen.[2] These riparian habitats are usually within a landscape matrix that contains mixed coniferous stands (e.g., Douglas fir or ponderosa pine) where they forage.[3]
- Western Screech-Owls nest in tree cavities, including natural cavities and old Northern Flicker and Pileated Woodpecker nests.[2] Nest trees are >25 cm dbh,[2] decay class [2–6,1] and have cavity openings >7.5 cm in diameter.[4]
    - Nesting habitats include a moderate to dense understory of shrubs >2 m tall, with open ground, high tree cover (>70%), and multiple large-diameter trees for both nesting and roosting.[5]
- Important foraging habitats include fields, pastures, rivers, streams, open woodlands, and other open habitats provided there are perches from which owls may hunt.[4]

RANGE MAP

RESPONSE TO FOREST MANAGEMENT

- The primary causes of Western Screech-Owl declines include habitat conversion for residential and agricultural developments. However, the continued removal of existing or potential habitats through harvest and fuel management (e.g., thinning) have the potential for severe negative effects.[5]
- While Western Screech-Owl territories normally occur within riparian areas, these are often small, non-fish-bearing streams and wetlands, meaning they are not subject to riparian buffers by default.[1]

STAND-LEVEL RECOMMENDATIONS

- Prior to all activities, managers are encouraged to review known Western Screech-Owl occurrences to determine whether planned operations are near or within recorded nesting territories. Targeted surveys (e.g., nocturnal call-playback surveys) are recommended in areas near known locations to improve provincial inventories and better protect nesting habitats.
- Suitable wildlife trees and/or nesting sites (see Habitat Ecology) within known or potential nesting habitats should be prioritized for retention, most likely but not exclusively through voluntary riparian buffers. Wildlife tree areas should be >2.5 ha and prioritize retention of black cottonwood/trembling aspen/water birch trees >35 cm dbh and Douglas-fir >75 cm dbh.[1]
- Minimum 50-m buffers are suggested for low-impact activities near occupied nests. Larger buffers for high-impact activities are advisable, however this species is very tolerant of human disturbance.[5,6]

LANDSCAPE-LEVEL RECOMMENDATIONS

- Riparian habitats have been shown to be essential to the Western Screech-Owl. In the Shuswap River Valley, most owls had home ranges (65–77 ha) containing >10 ha late-seral riparian forest habitats.[7] This proportion may be a suitable landscape target within timber supply areas, mixed with open areas for foraging.
- This species' habitat associations vary by region. In the Trail/Nelson area, coniferous cover (especially western red cedar) plays a more important role than other areas, where black cottonwood and trembling aspen are the most important component of riparian forests.[8]
- Many new Wildlife Habitat Areas have been proposed/defined where this species is known to occur on Crown land.[9] Reserves and large retention patches may be helpful to improve connectivity between protected areas, facilitating dispersal of young and improving the genetic connectivity of populations.[5]

The Western Tanager is a handsome bird with a song that somewhat resembles a robin with a sore throat. Although it is common in open woodlands, it tends to stay in the shade, making it hard to spot.

Western Tanager

(Piranga ludoviciana)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SENSITIVE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Coniferous/mixedwood

TERRITORY SIZE
>2.8 ha (core area ~0.8 ha)

NEST TYPE
Canopy (conifer)

NEST REUSE
No

STAND LEVEL
Retention patches containing snags, deciduous trees, and large-diameter conifers.

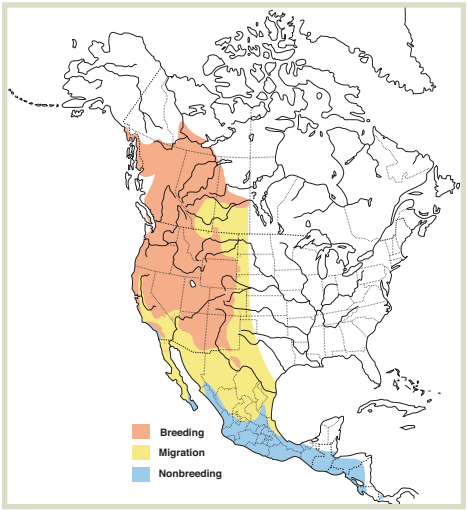
LANDSCAPE LEVEL
Heterogeneous landscapes with late-seral upland forests and early-seral openings.

BREEDING WINDOW

HABITAT ECOLOGY

- The Western Tanager is found in a wide range of forest habitats west of Manitoba, but is mainly found in open coniferous, mixed coniferous, and mixed coniferous-deciduous woodlands.[1]
  - This species is often found at forest edges of natural openings and transitions to aspen patches and second-growth harvest- and fire-origin stands.[1,2]
  - They are associated with a high overstory canopy, large-diameter trees, and a coniferous component.[1]
- Western Tanager nest trees and habitat associations vary according to forest type:
  - In boreal forests, they are associated with late-seral open coniferous or mixed coniferous-deciduous forest,[1] particularly white spruce.[3,4]
  - In ponderosa pine/Douglas fir/grand fir mixed conifer forests, they are associated with late-seral fire-origin forest and mid-seral forests originating from uneven-aged management and selection harvest.[5]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- This species responds well to uneven-aged management including partial retention harvesting,[6,7] but is rare or absent from regenerating clearcuts without residual trees (up to 33 years postharvest and possibly longer).[6–8]
- Thinning of Douglas fir stands increased Western Tanager numbers relative to unharvested stands.[9,10]
- Over 10 years, Western Tanagers had higher occupancy of wide (avg. 30 m) riparian buffers compared with narrow (avg. 13 m) buffers in Douglas fir/western hemlock/western red cedar forests.[11]
- Western Tanagers appear to be more sensitive to harvesting in aspen-dominated forests, where they prefer old unharvested forests over clearcuts and harvests with up to 40% retention.[12,13]

STAND-LEVEL RECOMMENDATIONS

- Within pure and mixed conifer forests, retention harvesting or thinning are recommended in lieu of clearcutting. The following habitat features are recommended for retention to increase within-stand complexity:
  - Snags and large-diameter (e.g., >20 cm diameter) downed woody material[1,5]
  - Deciduous species (e.g., paper birch, trembling aspen, black cottonwood),[14] including large-diameter trees[12]
  - Large-diameter coniferous canopy trees for nesting (e.g., white spruce or Douglas fir)[1]
- It is suggested that Western Tanagers breed in retention patches with preference given to larger patches, however patch size thresholds for successful breeding are not provided.[1]

LANDSCAPE-LEVEL RECOMMENDATIONS

- The Western Tanager's association with high-contrast edges suggests they may be positively associated with landscape fragmentation. At the 300-ha scale in Douglas fir/western hemlock/western red alder forests, they have showed a preference for fragmented landscapes but were positively associated with the amount of late-seral forests.[15]
- Heterogenous landscapes subject to uneven-aged management, and containing high-contrast edges between stand types, late-seral forests containing conifer species (white spruce in boreal forests), and natural and man-made openings will likely benefit this species. However, high proportions of clearcuts with no retention are expected to have a negative effect.[1,4]

Williamson's Sapsucker

(Sphyrapicus thyroideus)

STATUS

SARA	ENDANGERED	British Columbia	BLUE
Alberta	ABSENT	Saskatchewan	ABSENT

PRIMARY HABITAT
Coniferous

TERRITORY SIZE
17–54 ha

NEST TYPE
Cavity

NEST REUSE
Yes (same nest tree)

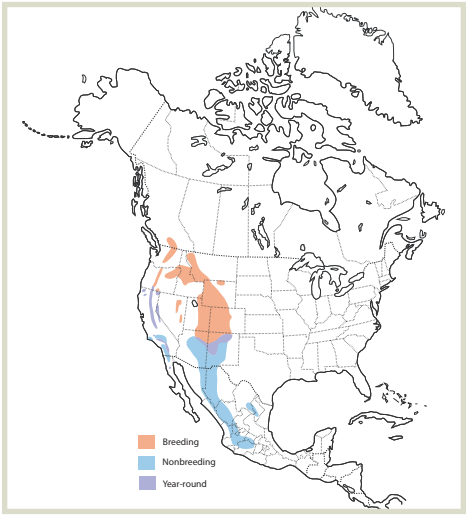
STAND LEVEL
Large-diameter western larch, small-diameter Douglas fir, and coarse woody debris containing ants.

LANDSCAPE LEVEL
Low-intensity fires and uneven-aged forests containing veteran nest trees.

BREEDING WINDOW

The Williamson's Sapsucker is Endangered in Canada, and forest managers are responsible for ensuring their activities conform with federal and provincial regulatory requirements. The following species account provides a broad overview; however, the BC Ministry of Forests, Lands and Natural Resource Operations has produced region-specific habitat suitability models[1] and best management practices within the Area of Occupancy of this species (see a list of documents at the end of this account).

RANGE MAP



HABITAT ECOLOGY

- The Williamson's Sapsucker's breeding range in Canada is limited to a very small area in south-central interior BC, which represents the northernmost tip of its range in North America.[2]
- This species breeds in mid- to high-elevation conifer and mixed conifer-deciduous forests including western larch, Douglas fir, ponderosa pine, and pine/fir forests. In these forests, the Williamson's Sapsucker is positively associated with western larch and ponderosa pine.[2]
- The Williamson's Sapsucker's main habitat needs include nest trees, medium-sized trees for sap wells, and stumps, snags and logs containing ant colonies.[2]
- Nest trees are an important limiting factor for the Williamson's Sapsucker, and preferred nest tree species vary according to forest type:
  - In mixed coniferous-deciduous forests, trembling aspen is an important nest tree species, however aspen patches surrounded by non-forest are not used.[2]
  - In mixed-conifer forests, large veteran western larch trees with heartrot are important nest trees. Suitable nest sites are located in late-seral stands containing 20–40 cm dbh Douglas fir and western larch trees, and containing old trees infested with carpenter ants (an important food source).[3]
  - In sites without western larch, nests may be excavated in large-diameter aspen (avg. 35 cm dbh), ponderosa pine (avg. 72 cm dbh), and to a smaller degree, Douglas fir (avg. 72 cm dbh). Nest trees are located in sites meeting the description of the preceding bullet.[4]
- While this species does not typically reuse cavities, it frequently excavates new nests on trees containing old cavities.[2]
- The Williamson's Sapsucker's association with veteran trees means it is mainly found in old forests. For example, in the Okanagan-Greenwood population, most nests were found in stands >170 years old or containing western larch trees older than 170 years.[3]

RESPONSE TO FOREST MANAGEMENT

- Even-aged management under ~100-year rotations is a primary threat to the Williamson's Sapsucker, as it entails removal of old veteran trees used for nesting and foraging, and removal of old forest stands used for foraging.[3]
- Williamson's Sapsuckers will forage on logs in clearcuts, nest in snags 5–8 year-old burned stands, and use logged forests with 25% retention of trees and snags.[2,4]

- Notably, nests in retention harvests were always adjacent to mature or old stands, which the Williamson's Sapsuckers used for foraging.[4]

STAND-LEVEL RECOMMENDATIONS

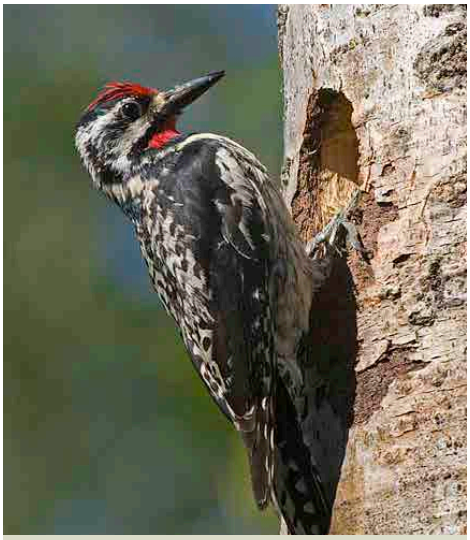
- The following habitat features are recommended for retention to provide future nesting and foraging habitat. Patches should be large enough to buffer nest trees (i.e., 100 m from high-impact activities) and ensure that nest trees will not need to be removed per WorkSafeBC regulations.[5–7]
    - Trees containing cavities with 3–5 cm diameter openings (high probability of future nests on the same tree).[2]
    - Large-diameter coarse woody debris for foraging.
    - Large-diameter western larch located centrally within patches for wind-firmness. Absent western larch, large-diameter trembling aspen and/or ponderosa pine.
    - Small-diameter Douglas fir for sap wells and several large-diameter trees for eventual snag development.
- A 100-m buffer is recommended for high-disturbance activities around confirmed or probable nests during the nesting season (generally from March 15 to July 15).[5]
- Region-specific BMPs (see below) recommend minimum targets for suitable and/or known nest trees, large-diameter live tree retention, sap tree provision, and woody debris that supports ants. These targets should be met, if possible, within a 200–500 m radius of any known nest tree.

LANDSCAPE-LEVEL RECOMMENDATIONS

- The federal Recovery Strategy defines Critical Habitat as a minimum patch size of 16 ha that contains ≥0.35 suitable nest trees/ha, ≥85 live trees/ha with ~17.5 cm dbh (including conifers) to provide sap, and downed wood, stumps, and decaying trees known or suspected to contain ant colonies.[4]
- Low-intensity or patchy fires may increase breeding densities in areas where conifers are the primary nest tree species. Stands subject to low-intensity burns may warrant surveys for breeding pairs and, if detected, subsequent protection from salvage logging.[2]
- BC region-specific BMPs provide a suite of targets that vary according to the modeled habitat suitability of a planned harvest area, and they should be consulted. Links to FTP sites containing nest locations, area of occupancy boundaries, habitat suitability mapping, habitat management areas, and background documents are available within these BMP documents (see Resources).

RESOURCES

- B.C. Ministry of Forests, Lands and Natural Resource Operations. 2014b. Best management practices for timber harvesting, roads, and silviculture for Williamson's Sapsucker in British Columbia: Western area of Occupancy. B.C. Ministry of Forests, Lands and Natural Resource Operations, Nelson, BC. 15 pp. http://a100.gov.bc.ca/pub/eirs/viewDocumentDetail.
- B.C. Ministry of Forests, Lands and Natural Resource Operations. 2014a. Best management practices for timber harvesting, roads, and silviculture for Williamson's Sapsucker in British Columbia: East Kootenay Area of Occupancy. B.C. Ministry of Forests, Lands and Natural Resource Operations, Nelson, BC. 15 pp. http://a100.gov.bc.ca/pub/eirs/viewDocumentDetail.
- B.C. Ministry of Forests, Lands and Natural Resource Operations. 2014c. Best management practices for timber harvesting, roads, and silviculture for Williamson's Sapsucker in British Columbia: Okanagan-Boundary Area of Occupancy. B.C. Ministry of Forests, Lands and Natural Resource Operations, Nelson, BC. 15 pp. http://a100.gov.bc.ca/pub/eirs/viewDocumentDetail.



The Yellow-bellied Sapsucker can be detected by its double “tap-tap” drumming and their distinctive meow-like call.

Yellow-bellied Sapsucker

(Sphyrapicus varius)

STATUS

SARA	NO STATUS	British Columbia	YELLOW
Alberta	SECURE	Saskatchewan	NO STATUS

PRIMARY HABITAT
Deciduous/mixedwood

TERRITORY SIZE
2–3 ha

NEST TYPE
Cavity (deciduous)

NEST REUSE
High (up to 6–7 years)

STAND LEVEL
Aspen trees >35 cm dbh with false tinder conks for nesting and white birch/alder for foraging.

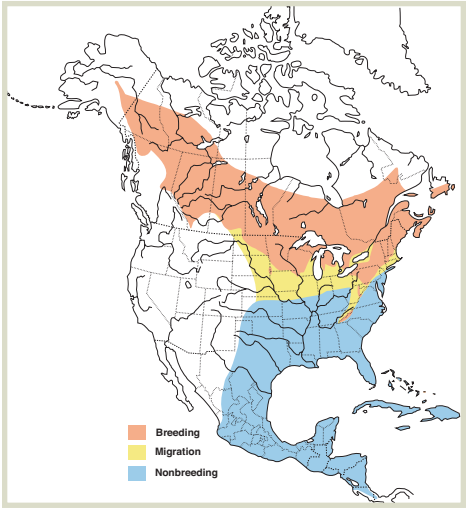
LANDSCAPE LEVEL
Unharvested deciduous or mixed stands and uneven-aged management.

BREEDING WINDOW

HABITAT ECOLOGY

- The Yellow-belled Sapsucker is considered a keystone excavator of forest habitats since a large number of bird and mammal species reuse its old cavities, and many other feed on the sapwells they drill on deciduous trees (including the Rufous Hummingbird).[1]
- Typical nesting and foraging habitat for this species includes trembling aspen and paper birch, including mixed conifer-deciduous forests.[1] It is found in a wide range of forest age classes including early-seral forests that contain large, old trees suitable for nesting.[2]
    - Their preferred nest trees are similar to those of Northern Flickers and Pileated Woodpeckers: large-diameter live deciduous trees with heart rot (mainly aspen >35 cm dbh with 10–25 false tinder conks). Their nests are typically found in clumps of 25–30 trees >12 cm dbh.[3]
    - Foraging habitat includes birch, willow, white spruce and aspen.3 Birch poles are preferred where available and alder is used where there are low birch densities.[4]
    - Nest trees may be reused for 6–7 years, and some reuse of old cavity nests has been observed.[1]
- In northern BC, Yellow-bellied Sapsuckers were observed almost entirely in upland aspen/poplar/white spruce mixedwood and pure deciduous forests older than 60 years (predominantly in forests older than 90 years). This preference for older stands was attributed to higher densities of nest trees and white birch poles.[4]

RANGE MAP



RESPONSE TO FOREST MANAGEMENT

- Yellow-bellied Sapsuckers are resilient to harvests leaving residual structure and/or adjacent unharvested remnants in which they can nest, but they decrease substantially in clearcuts.[2,5,6]
- This species was not, however, likely to occur in regenerating clearcuts up to 33 years postharvest, suggesting potential long-term negative impacts of extensive harvest without residual structure.[7]
- Large, aggregated harvests will support more sapsuckers than recently-burned forests,[8] but fewer sapsuckers than mature and old aspen and mixedwood stands.[3]
- Retention harvests may make nesting sapsuckers more vulnerable to predation by black bears if optimal nest trees (see Habitat Ecology) are selectively removed, leaving sapsuckers to nest in less protected trees (e.g., trees left unharvested due to substantial decay). Note: this study was conducted in American Beech forests in Ontario[9]. Local research is recommended, however unsuccessful black bear nest predation attempts have been observed in Alberta.[10]

STAND-LEVEL RECOMMENDATIONS

- Large aggregated harvests containing retention patches >5 ha, with many patches >15 ha and some patches >100 ha, are recommended as better alternatives to two-pass clearcutting. Larger patches containing both merchantable and non-merchantable trees are desired, and smaller patches should contain mature or old aspen/mixedwood. Smaller patches that provide foraging habitat are also recommended (see below).[3,6]
- Smaller patches containing foraging features (see below) may also improve habitat value provided they are <60 m from unharvested areas larger than 5 ha (e.g., riparian buffers, remnants) that contain high densities of known or potential nest trees.[3,6]
- Retention patch anchor points to provide **nesting habitat** include clumps of potential or known nest trees (see Habitat Ecology) surrounded by clumps of trees >12 cm dbh.[3] If possible, >15 living cavity trees per hectare (on average) are recommended to ensure the highest-quality trees can be selected.[9]
- Retention patch anchor points to provide **foraging habitat** include clumps of pole stage or younger white birch, provided there are nearby patches or unharvested forest containing suitable nesting habitat. Where white birch is absent, alder, willow, and aspen saplings should be retained.[3,10]
    - Careful communication between harvest and reforestation operators is encouraged to ensure that retained clumps of young trees and shrubs are not damaged during mechanical site preparation.[10]
- In harvest areas optimized for Yellow-bellied Sapsucker, post-harvest silviculture that reduces white birch and alder densities should be avoided if possible.[4]

LANDSCAPE-LEVEL RECOMMENDATIONS

- While this species is resilient to retention harvesting, their conservation on heavily-managed landscapes over the long-term will likely require strategic conservation of stands exceeding the rotation age,[11] particularly in northern forests (e.g., northeastern BC) where sapsuckers were rarely observed in stands younger than the rotation age.[4]
- A variety of retention levels is recommended within the planning unit (e.g., according to the area's NRV). Of these, stands with ≥20% retention as planned operator patches (mature and old aspen or mixedwood), and up to 50% retention in some blocks, are expected to contribute the most to Yellow-bellied Sapsucker habitat on the landscape (second to unharvested forest remnants).[3]