Biodiversity sustainability analysis for high priority species strongly associated with hardwoods in the Fort Nelson TSA[1]

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Executive Summary

British Columbia recently adapted a Conservation Framework intended to make the allocation of resources to conservation activities more effective. This report summarizes the ability of coarse filter analyses to assess the likelihood that current forest planning and practice will sustain vertebrates that rank high in the provincial Conservation Framework and are strongly associated with hardwoods. Species on Environment Canada's draft list for Bird Conservation Region 6 also are included. The evaluation exploits biodiversity sustainability analysis which combines features of the Species Accounting System and coarse filter analyses of the consequences of forest planning and practice. Non-vertebrates are noted, but data for them are much more limiting.

The recently adapted provincial Conservation Framework is summarized in §2. The Species Accounting System is reviewed in §3. The Species Accounting System recognizes species strongly associated with hardwoods (e.g., Group 2:H) and species relying on hardwood trees for cavity sites (Group 3c) or strongly associated with understory in hardwood stands (Group 3u). Species are considered high priority if they rank 1 or 2 in any of the three goals of the Conservation Framework or are federal candidate species for Bird Conservation Region 6 (Boreal Taiga Plains). In total, 29 bird species and 3 mammal species within the Fort Nelson TSA rank highly and are strongly associated with hardwoods (Tables 1 and 2).

Practices that can have a deleterious effect on amounts and kinds of hardwoods within a Defined Forest Area (DFA) are those that:

1) reduce the amount of older age classes of hardwood or mixed wood types,
2) reduce the proportion of hardwoods in mixed wood types below the level at which the mixed wood contribution to species richness is sustained,
3) reduce the amount of hardwoods through vegetation management,
4) convert significant amounts of hardwood or mixed wood types to conifer-leading types, or
5) inadequately protect riparian areas that are predominantly hardwoods.

Analyses address each of these potential effects to the extent possible (§6). The review and analyses suggest five improvements to current practice.

1. For single trees or retention patches <2 ha, guidelines for retained wildlife trees should be tree sizes >23 cm dbh with densities of $\geq$3 per ha. Greater densities of small snags should be retained where possible.
2. Anchor points for retention should acknowledge potential limitations (e.g., older mixed wood, hardwoods >23 cm dbh; conifer trees >30 cm dbh).
3. Waste management guidelines should ensure that a few larger conifer pieces ($\geq$17.5 cm random diameter) are retained where stand conditions permit; pieces $\geq$2 m long.
4. Pieces of down wood >17.5 cm diameter (random, not top-end) should not all be piled; some should be left scattered on site.
5. S4 streams in candidate bull trout areas should receive a 10 m buffer (see §7.3).

Findings are summarized for each of the 32 high priority bird and mammal species in §7.1. Given current planning and practice, no species is a candidate for monitoring focused specifically on that species. One bat species, however, merits inventory – the presence of bats is more often inferred than documented.

Monitoring should focus on areas where direct or cumulative effects currently are unknown and potentially negative (Table 3), and on areas where potential problems are evident but existing data are inadequate to assess them. Monitoring should be directly linked to practices that offer opportunity for improvement.

Topics for implementation monitoring are ranked: habitat elements in the Riparian Management Zone (very high), nature of retention (very high), trends in tree species composition (very high), trends in amounts of late seral (high), pre-harvest stratification to assist assessment of vegetation management (high), nature and distribution of coarse woody debris left on site (high) and late-seral patch size

distribution (medium). Topics for effectiveness monitoring also are ranked: contributions of NHLB (very high), contributions of retention (high), mixed wood boundaries (very high), evaluation of applicability of findings from TFL 48 on vegetation management (very high), contributions of wildlife tree patches (high), organism response (very high to low, dependent on group), effectiveness of practices in Riparian Management Zone (potentially high, dependent on outcome of implementation monitoring), late-seral boundaries (medium) and suitability of retained coarse woody debris (medium). See §7.3 for details.

There are two major limitations to the coarse-filter evaluation of effectiveness of forest planning and practice at sustaining high-priority species associated with hardwood stands or trees:

1) The survey method employed (Breeding Bird Surveys) does not adequately assess most cavity users. Despite 2,274 station-year combinations, very few observations were attained from which to derive preferred forest types (Table 1). Some other groups within the Species Accounting System (e.g., understory associates) are much better sampled by Breeding Bird Surveys. More broadly, the major approach to monitoring, BBS surveys, does not adequately account for other vertebrate and non-vertebrate groups and exposes potential weaknesses only generally.
2) Coarse-filter analyses are necessarily map-based and riparian habitats are incompletely represented using current monitoring techniques. Three vertebrate species (Barrow's Goldeneye, Common Goldeneye and fisher) cannot be adequately assessed by the coarse filter approach without better information on practices within the Riparian Management Zone.

The first limitation can be addressed by other monitoring methods; the second by specific, targeted implementation or effectiveness monitoring (see §7.3). Despite these limitations, the coarse filter analyses are useful. Briefly, they:

1) Expose which species are most in need of specific monitoring (in this case, three species that seek riparian habitat). The analyses also indicate how relatively simple implementation monitoring can clarify the need for more expensive effectiveness monitoring before the latter is undertaken.
2) Expose which species are most in need of inventory. In this case, bats are. Even their presence within the DFA is ambiguous.
3) Suggest key areas of implementation and effectiveness monitoring to ensure that current planning and practice do not negatively affect the species.
4) Illustrate and focus credible and cost-effective measures for monitoring preferred habitat of most species.

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1 Introduction

Biodiversity sustainability analysis combines features of the Species Accounting System and coarse filter analyses of consequences of forest planning and practice. This report summarizes the ability of coarse filter analyses to assess the likelihood that current forest planning and practice will sustain vertebrates that rank high in the provincial Conservation Framework and are strongly associated with hardwoods. Non-vertebrates also are addressed, but data for them are much more limiting. Species' ranges are rarely so narrowly defined that they are restricted to a single Designated Forest Area (DFA). The high priority species addressed here (provincial and federal) are expected to occur in most or all of Canfor's northeastern tenure. Features of coarse filter analyses, however, specifically address conditions on the Fort Nelson TSA. We briefly review the nature of the provincial Conservation Framework, the Species Accounting System and coarse filter analyses of the impacts of forest planning and practice. We then summarize the high priority species occurring in the region and present findings of the application of coarse filter analyses to those species as they occur on the Fort Nelson TSA. We close with a brief summary of the limitations and utility of the approach.

2 Conservation Framework

In 2008 the province adapted a conservation framework intended to make the allocation of conservation effort more cost-effective in terms of allocation of resources and more effective in achieving desired outcomes. That framework is described in detail by Bunnell et al. (2009a). One feature of the framework is a ranking of each species by priority in three different goals that broadly recognize the conservation adage – think globally act locally. These goals are:

1 = To contribute to global efforts for species conservation. Goal 1 recognizes that some widespread species may occur only sparsely in British Columbia but are under threat throughout their range. It is intended to ensure that some provincial resources are assigned to conserving species globally at risk, even when these are widely distributed.

2 = To prevent species from becoming at risk. Goal 2 is intended to be proactive and provide early detection of threats, thereby reducing the need for costly recovery actions. It is facilitated by including all native species in assessments of priority, rather than focusing solely on those already 'at risk'.

3 = To maintain the richness of native species. Goal 3 represents efforts to sustain all native species, even when only jurisdictionally rare and abundant elsewhere. It ensures that challenging, jurisdictionally rare species will not be ignored in pursuit of Goal 2.

There are 6 potential ranks with 1 = highest and 6 = lowest. The province reports rankings[2] for each species evaluated within each of the three broad goals for conservation. We considered high ranking species to be those ranking 1 or 2 in any of the three goals. The subject of this report are species that ranked 1 or 2 and also show strong dependencies on hardwood stands or trees, plus candidate species for Bird Conservation Region 6 (BCR 6; Boreal Taiga Plains) having similar associations. These latter are draft and may change.

3 Species Accounting System

The Species Accounting System (SAS) acknowledges the complexity and the high costs of monitoring by creating a self-correcting system that allows detail to be added as it appears required. As presented here, the system treats terrestrial vertebrates. Examination of the species groups below indicates that these are applicable to many species other than vertebrates.

The system itself is intended to:

[2] Available at www.env.gov.bc.ca/conservationframework/

1) estimate approximate amounts and location within the DFA of suitable habitat for all[3] forest-dwelling vertebrates;
2) permit 'scaling up' of monitoring findings over the entire DFA, providing estimates of the amount of suitable habitat, including where and when, over the entire area;
3) provide credence to indicators assessing ecosystem representation and habitat by evaluating species' associations with those measures;
4) provide trend estimates for species (as data are accumulated);
5) focus potentially expensive effectiveness monitoring on areas of greatest uncertainty; and
6) be self-correcting,[4] thereby increasing the credibility of the system as data are acquired.

The approach assigns species to the least costly form of monitoring appropriate to the species' natural history. The accounting system incorporates five groups of species determined by their response to forest practice and their accessibility to monitoring. The five monitoring groups are:

Group 1 – generalists, species that inhabit many habitat types or respond positively to forest practices;
Group 2 – species that can be statistically assigned broad habitat types as defined within VRI (e.g., young hardwoods, old conifers);
Group 3 – species with strong dependencies on specific habitat elements (e.g., snags or understory), so may be useful in effectiveness monitoring;
Group 4 – species restricted to specialized and highly localized habitats; and
Group 5 – species for which patch size and connectivity are considered important.

Group 6 is included for completeness. It contains species known or expected to occur in the DFA, but that are not dependent upon forested environments and are not monitored.

Developing credible assignments of species to these groups has the compelling advantages of including all forest-dwelling species and associating species with the least costly form of monitoring. Once there is confidence in the assignment of species to groups, focal species can be selected that are most informative for particular questions about the impacts of forest practices. Boundaries between groups or classes are necessarily arbitrary and influenced by: natural history features (primary) and the approach to monitoring (secondary). Membership is based on available local data and assessment by experts. All vertebrates believed present within the DFA are included, with emphasis on those that are forest dwelling. The monitoring design must include the ability to continually inform assignment to groups (i.e., improve the efficiency of monitoring) while evaluating success in meeting the criterion of sustaining native species richness. By including BEC variant in the monitoring design, it is easier to inform planning and to evaluate which species are accommodated within the non-harvestable land base (NHLB).

Species ranks are determined by the provincial Conservation Framework. The form of coarse filter analysis that is applicable is determined by the Species Accounting System. Species treated here are hardwood associates. Some are members of Group 2 (forest type sufficient for monitoring); some are assigned to Group 3 (dependent on specific habitat elements, such as cavity trees). All rank 1 or 2 for any goal within the provincial Conservation Framework, with the exception of some that currently are included on the Canadian Wildlife Service's draft list of candidate species for BCR 6; all may be influential in assessment of incidental take.[5]

[3] Group 4 species are an exception because their habitat is too finely discriminated to be included in GIS layers. For these species, specifically designed guidelines have been created so appropriate action can be undertaken when that habitat is encountered in the field. See Kremsater et al. (2009).
[4] This is not self-correcting like a self-cleaning oven; effort is required to update the system on the basis of new data as it is acquired. The format of the system, however, encourages and permits correction. Data presented here are updated through the 2009 field season.
[5] 'Incidental take' is the inadvertent destruction of nests and eggs in violation of the Migratory Bird Regulations (Section 6a) of the Migratory Birds Convention Act. It has received renewed emphasis by Environment Canada which is seeking credible ways of assessing whether measures that promote healthy bird populations can compensate for limited amounts of incidental take during forest harvest.

4 Coarse filter analyses

Detailed treatment of methods of coarse filter analysis are provided in Bunnell et al. (2009b,c,d). Provincial data are most reliable and complete for vertebrates. Those reports also include literature reviews that modify appropriate metrics of analyses derived primarily from vertebrate data to accommodate the different responses of other groups of organisms – fungi, lichens, bryophytes, vascular plants and invertebrates. High priority species strongly associated with hardwoods belong to 3 major groups:

- Group 2 – species that can be monitored by forest type alone,
- Group 3c – species using cavities, so practices affecting cavity sites must be assessed, prior to reliance on forest type alone, and
- Group 3u – species strongly associated with understory, so practices potentially affecting understory must be assessed, prior to reliance on forest type alone.

Practices that can have a deleterious effect on amounts and kinds on hardwoods within the DFA are those that:

1) reduce the amount of older age classes of hardwood or mixed wood types,
2) reduce the proportion of hardwoods in mixed wood types below the level at which the mixed wood contribution to species richness is sustained,
3) reduce the amount of hardwoods through vegetation management,
4) convert significant amounts of hardwood or mixed wood types to conifer-leading types, or
5) inadequately protect riparian areas that are predominantly hardwoods.

More specific questions are asked of Group 3 species. For example, practices that can have a deleterious effect on amounts and kinds of cavity sites within a DFA are those that:

1) fail to provide sufficient dead wood of adequate size,
2) fail to provide the full range of decay classes on a *sustained* basis, and
3) fail to distribute dead wood in ways that meet organisms' requirements.

A detailed rationale for questions relating to Group 3 species is found in Bunnell et al. (2009b,c,d). Analyses of impacts of current practices on dying and dead wood in the Fort Nelson TSA are found in Bunnell and Kremsater (2010) and for hardwoods more broadly (i.e., including more than the high priority species addressed here) in Bunnell et al. (2010a). Here we summarize findings of appropriate analyses (§6) and their implications to high priority species (§7.1).

Because coarse filter analyses of effects of forest practice are intended to be applied broadly, they are map-based to the extent possible – exploiting BEC and VRI (Vegetation Resource Inventory) classifications. In some instances, practices themselves must be evaluated. That evaluation follows the existing SFM plan for the Fort Nelson TSA. Descriptions of practices within the SFM plan were not confirmed on the ground. If they appear to have significant influence, they are noted as candidates for implementation monitoring (§7.3).

5 High priority species

Species' ranges are rarely so narrowly defined that they are restricted to a single DFA. The high priority species listed in Table 1 are expected to occur in most or all of Canfor tenures in northeastern British Columbia. Two largely separate groups of species are included. One recognizes federal concerns. It is derived from the draft candidate species list of priority species for considering incidental take[5] in Bird Conservation Region 6 (BCR 6) which includes northeastern BC. These species are designated by **blue** in tables following. The second group is provincially derived and includes any species strongly associated with hardwoods and ranking 1 or 2 within the provincial Conservation Framework. In tables following, these are designated by SMALL CAPS. A few species occur on both lists so are designated **BLUE.** Three species are listed by CoSEWIC (Committee on the Status of Endangered Wildlife in Canada). The Short-eared Owl and Peregrine Falcon are both designated of special concern; neither are hardwood associates. The former has been observed in the Fort St John TSA several times, mostly in agricultural

lands north of Fort St John, but once in a clearcut along a BBS route. We have no observations from BBS routes in the Fort Nelson TSA. The Canada Warbler is listed as threatened and is a hardwood associate.

In Table 1 species are grouped by the Group to which they are assigned within the Species Accounting System. Groups are the six described above (§3). Analyses to test assignments of species to particular SAS groups or to classes within groups rely on VRI data using classes following the BC Land Cover Classification System (BC MoSRM 2002). Statistical tests could be applied only to habitat types derived from VRI. These are summarized below:

Group	Group Modifier	Description
2 Habitat type; most often forested	NV	**N**on-**V**egetated upland: less than 5% vegetation cover; includes roadsides, oil and gas developments (excludes lakes, rivers and ponds)
	NT	**N**on-**T**reed upland or wetland: less than 10% tree cover; includes tundra, wetland, and other sparsely treed sites such as non-commercial brush (NCBR)
	RD	**R**ecent **D**isturbance: 0 to 30 yrs old; too early in succession to classify as either hardwood- or conifer-leading
	H1	Young **H**ardwoods: 31 to 90 yrs old; at least 75% hardwood
	H2	Old **H**ardwoods: >90 yrs old; at least 75% hardwood
	MW1	Young **M**ixed **W**ood: 31 to 90 years old; neither hardwoods nor conifers attain 75%
	MW2	Old **M**ixed **W**ood: >90 yrs old; neither hardwoods nor conifers attain 75%
	C1	Young **C**onifers: 31 to 140 yrs old; at least 75% conifer
	C2	Old **C**onifers: >140 yrs old; at least 75% conifer

Tests are based on observed versus expected values for individual types using the Bonferroni correction. Water was classified, then removed from reporting because it was not sampled directly. In the Fort St John TSA, we evaluated statistically significant discrimination between conifer- and hardwood-leading mixed wood types, as discriminated within the SFM plan. Nine species showed discrimination; only one of these (Black-throated Green Warbler) is designated as high priority. That warbler has not been reported from the Fort Nelson TSA, so species discrimination among the 9 major VRI classes is reported.

Tests are possible only for bird species, because only birds were sampled by a design permitting testing. Observations for other groups are based on opportunistic sampling and the literature. To ensure the greatest accuracy in location and testing, analyses were restricted to the three years of data (2007-2009) in which birds were located on orthophotos (2,274 station-years).

High priority species strongly associated with hardwoods are summarized in Table 1. Among high priority species, 6 bird species occurring within the DFA that use cavities as nest sites appear to seek hardwood trees preferentially (Table 2). Cavity users are poorly sampled by Breeding Bird Surveys, so unlike other monitoring groups in the Species Accounting System, there are few observations even over 2,274 station-years, and fewer still that are significant (Table 1). Affinity of some cavity users for particular broad forest types was based on review of tree species used for denning and roosting (Table 2). For marten and fisher, it is based on studies in northeastern British Columbia (Poole et al. 2004; Porter et al. 2005; Weir 2008).

Table 1. High priority bird species known or believed to occur in the Fort Nelson TSA and strongly associated with hardwoods.

Species	Records	Habitat affinity: 1st Choice		2nd Choice		Avoid		Territory Size (ha)	Trend[a]
Group 2									
Hardwood-leading									
BAY-BREASTED WARBLER	43	**22/6**	**H2**	10/4	MW2	**4/14 C1**	**/ 0/7 H1**	0.7-0.75[b]	11.4
Broad-winged Hawk	3	1/0	H1	1/0	MW1			1.5 km[c]	nd
Least Flycatcher	360	**50/25**	**NV**	**102/55**	**H1**	**2/12 C2**	**/ 30/114 C1**	0.1-0.2	**-4.9**
PHILADELPHIA VIREO	60	8/3	MW1	22/9	H1	**8/19**	**C1**	0.3-4.0	0.2
Rose-breasted Grosbeak	253	**36/16**	**RD**	**64/33**	**H2**	**26/81**	**C1**	0.3-1.3	2.1
RUFFED GROUSE	12	3/1	RD	2/1	NT	0/4	C1	2.1-2.3	-1.2
WESTERN WOOD-PEWEE	36	**13/2**	**NV**	6/3	MW2	**3/12**	**C1**	0.2-1.7	**-10.6**
Mixed wood									
CAPE MAY WARBLER	21	3/1	MW1	4/3	H1	**0/2**	**NT**	0.2-1.0	6.7
Magnolia Warbler	782	**116/50**	**RD**	**115/71**	**MW2**	**7/26**	**C2**	0.6-0.7	1.9
Merlin	9	**8/1**	**H1**					0.16-4.6 km[c]	-4.3
PACIFIC-SLOPE FLYCATCHER	2	1/0	H2	1/1	C1			1-3.5	[-3.1]
Sharp-shinned Hawk	1	1/0	NT					1.1-6 km[c]	nd
Riparian									
BALTIMORE ORIOLE[R]	0	[riparian]						0.6-1.7	**-9.5**
Bohemian Waxwing[R]	5	1/0	MW1	4/2	C1			nt[d]	nd
Group 3c - cavities									
Upland birds									
AMERICAN KESTREL	17	5/1	NV	6/5	C1	**0/3**	**MW**	0.1-1.75 pr/km^2	**-3.9**
Boreal Owl	0	[H2,MW2]						0.1-0.5 km[c]	19.5
Northern Hawk Owl	6	1/0	NV					2-8 km[c]	nd
NORTHERN PYGMY-OWL	0	[MW2,C2]						1.25-1.6 km[d]	2.5
TREE SWALLOW	31	8/3	NT	11/10	C1	**0/1**	**C2**	0.1-0.2	nd
Riparian									
BARROW'S GOLDENEYE	0	[riparian]						0.05-1.85	[-5.3]
COMMON GOLDENEYE	0	[riparian]						0.1	-3.4
Group 3u – understory									
Alder Flycatcher	1169	**291/81**	**NV**	**173/74**	**RD**	**7/38**	**C2**	0.2-3.0	**-4.1**
CANADA WARBLER	210	**62/28**	**H2**	23/15	NV	**4/11**	**MW1**	0.2-1.2	-2.5
CONNECTICUT WARBLER	11	4/1	H1	4/1	MW1	0/4	C1	0.25-0.5	-4.6
MOURNING WARBLER	223	54/15	NV	30/14	RC	**1/7**	**C2**	0.6-1.0	4.1
RED-EYED VIREO	755	**101/48**	**RD**	**103/52**	**NT**	**2/25**	**C2**	0.9-3.7	0.7
SWAINSON'S THRUSH	1778	**259/161**	**MW2**	**300/235**	**H2**	**94/156**	**NT**	0.9-2.1	-0.4
Tennessee Warbler	1780	**164/133**	**RD**	**129/93**	**MW1**	**36/58**	**C2**	nt	3.7
YELLOW WARBLER[R]	51	16/4	H1	11/4	H2	**2/13**	**C1**	0.05-0.8	**-4.2**

[R] = frequently riparian; [a] Trend in Boreal Taiga Plains BBS routes (1998-2008) as analyzed by CWS; %/yr; significant trends in bold (negative in **red**); sample sizes usually are too small to yield significant estimates; [ ] trends for BC. [b] Territoriality breaks down during insect outbreaks. [c] Mean distance between nests. [d] No territory; does not defend a territory, likely because of patchy distribution of food.

Several species listed by Environment Canada as potential high priority candidates for CFR 6 are not hardwood associates. Some of these are conifer associates (e.g., Black-backed Woodpecker, Northern Goshawk, American Three-toed Woodpecker). Others are associated with wetlands, highly localized or non-forested habitats: Marsh Wren, Le Conte's Sparrow, Clay-colored Sparrow, Eastern Phoebe, Northern Harrier, Northern Shrike, Peregrine Falcon and Short-eared Owl. For three of these latter (Le

Conte's Sparrow, Peregrine Falcon, and Short-eared Owl) the Fort Nelson TSA has adopted specific practices that will be implemented if the species are encountered.[6] We address none of those species here.

Natural history features of species guide the coarse filter analyses of effectiveness of practices. For example, the diameter of cavity sites used determines the appropriate age classes that can provide suitable habitat. Diameters are summarized in Table 2, which summarizes two data sets. One is the sparse data from the region available in the BC Nest Records Scheme and sampling of Yellow-breasted Sapsucker by K.A. Squires. Whether the nest site was conifer or hardwood was inconsistently recorded and the percent use of hardwoods as nest trees can rarely be extracted. Sample sizes also are small, and where <10 the range of diameters is given. The designation 'live' or 'dead' also was inconsistently recorded, so is as indicated 'both'. The second form of data is a compilation of >150 studies from more southern forest types (data base of Bunnell 2009b augmented for this project). Data are restricted to inland sites; coastal studies show use of larger nest trees, often predominantly conifers. In these data from southern forest types, the kestrel shows a preference for conifer nest sites. We believe that in the boreal forest, where hardwoods are more common, the kestrel more often seeks hardwood trees.

Table 2. Attributes of trees sought as nesting, denning and roosting sites by high priority species known or likely to occur on the Fort Nelson TSA and strongly associated with hardwoods.

	Northeastern BC			More southern forest types					
		%	%	Diameter (cm)		% Hardwoods		% Dead[b]	
Species	**mean**	**HW**	**Dead[a]**	**Con**	**Hdwd**	**%**	**n**	**%**	**n**
Birds									
AMERICAN KESTREL	24-42		both	40.9	40.7	38.5	144	55.2	114
BARROW'S GOLDENEYE	26-38		both	nd	48.2	72.0	41	59.5	42
Boreal Owl				56.5	43.7	69.3	75	57.1	21
COMMON GOLDENEYE	28-40		both	nd	nd	100.0	16	6.3	16
NORTHERN PYGMY-OWL	20		stub	54	nd	58.3	12	100.0	7
TREE SWALLOW	20		both	31.8	29.3	53.8	234	89.0	245
Mammals									
AMERICAN MARTEN				72.8		0	906	28.9	906
FISHER					54.7	100	27	0	27
NORTHERN MYOTIS				65.0	47.1	48.9	182	62.6	182

[a] Separate samples in which conifers and hardwoods were not distinguished.
[b] Note that studies reporting proportion of dead and proportion of hardwood sometimes are independent and drawing from different pools of data.

Two and possibly three mammal species also prefer hardwoods as cavity sites in the boreal forests (Table 2). Only the fisher shows a pronounced affinity for hardwood denning sites in the boreal forest. All den sites of fisher reported from the boreal (n=27) were large *Populus* (Weir 2008). We believe that selection of slightly <50% hardwoods by the northern myotis reflects the fact that studies were concentrated on sites where hardwoods were sparse. Where hardwoods are more common, the northern myotis locates 100% of its roosts in hardwoods (Menzell et al. 2002). Findings of Poole et al. (2004) and Porter et al. (2005) suggest that, in northeastern BC, marten also are seeking large hardwoods as denning sites, but there are no data to confirm this suggestion.

No liverworts or carabids have been assessed within the provincial Conservation Framework (Kremsater and Bunnell 2010) and no high priority lichens are known to occur in northeastern BC. Although none of the 144 mosses that are priority 1 or 2 in the NE are noted as requiring hardwoods, 9 high priority mosses use down wood (which may include hardwoods) and 36 high priority moss species are associated with riparian areas that often are associated with hardwoods. As well, large hardwood patches may be

[6] Kremsater, L., Bunnell, F.L. and Houde, I. 2009. Sustaining species using localized habitats in Canadian Forest Products northeastern Divisions. Bound booklet. 32 pp.

beneficial to high priority mosses because many bryophytes respond poorly to desiccation and would benefit from patches that provide protection from environmental extremes. One high priority butterfly is associated with forests, but not with hardwoods in particular – the Eastern Pine Elfin (*Incisalia niphon clarki)* is a forest-dwelling generalist. Of the 42 vascular plants of the northeast that ranked 1 or 2 within one of the three goals of the Conservation Framework, one uses hardwoods (western rattlesnake-root; *Prenanthes alata*), and 8 have some association with riparian areas, so may be peripherally associated with hardwoods. Several Odonates are high priority but none are directly associated with hardwoods.

6 Findings

The natural history of species strongly associated with hardwoods determines the relevant questions that need to be addressed to assess the degree to which forest practices are compensating for incidental take and sustaining the presence of hardwood associates. Here we review findings of key issues raised in §4 and evaluated in Bunnell and Kremsater (2010) and Bunnell et al. (2010a).

6.1 Provision of suitable dying and dead wood

Diameters sought by high priority species of cavity users are generally higher than those sought by species ranking less high (compare Table 2 of this report to Table 3 of Bunnell et al. 2009b). The means of Table 2 will be higher than both the minimum and median diameters used by cavity users (Bunnell et al. 2002a). Actions undertaken within the Fort Nelson SFM plan to sustain these species and compensate for incidental take include:

- Applying single-tree and patch-wise retention. The density for cutover areas (at least 7 snags or live trees per ha) appears adequate and exceeds the value intended to maintain 50% of the full complement of cavity nesters as derived from small areas (about 2 to 10 ha; patch-wise retention; Bunnell et al. 2002b).
- Increasing the area of the non-harvestable land base (NHLB) by ecosystem representation intended to reserve rarer ecosystems from harvest. Ignoring recently disturbed areas, the proportion of NHLB that is 'old' for major forest types is 24.2% hardwood-leading, and 33.8% conifer-leading mixed wood and 35.5% hardwood-leading mixed wood (when hardwood- and conifer-leading mixed wood are distinguished).
- Leaving large diameter *Populus* in Riparian Reserves. Within its SFM plan, the Fort Nelson TSA follows regulatory widths for Riparian reserves and for Riparian Management Zones by appropriate stream, lake or wetland classification within cutblocks. In the Riparian Management Zone, it is common practice to retain large hardwoods. It is these larger trees that best meet the requirements of fisher and the two high priority cavity-nesting ducks.
- Applying a target of >4 logs (2 m or greater length; 7.5 cm or greater top diameter) per ha after harvesting. Specification of retention of logs of a given size is an improvement over volume (see Bunnell et al. 2009b). However, the current target is potentially inadequate for vertebrates and likely inadequate for some non-vertebrates. The SFM plan notes the need for a more credible target than FRPA standards. For many species groups, richness increases with log diameter. There is no minimum diameter because some non-vertebrates exploit fine debris. Because of the way in which coarse woody debris surveys were conducted, the target (>7.5 cm) is based on top end. Appropriate targets are unclear. The two high priority mammal species typically associated with larger logs in southern forest types do not appear to den within logs in northeastern BC (e.g., Poole et al. 2004; Porter et al. 2005; Weir 2008). Our review of non-vertebrate responses to dying and dead wood (Bunnell et al. 2009b) reveals that dispersed logs are favourable to far more organisms than are piled logs, so some estimate of the portion of volume left dispersed would facilitate assessment of likely effectiveness.

In addition to these practices, we also evaluated stand age distribution and physical distribution of dead wood. Stand age distribution reflects the ability to sustain a range of all decay classes. There is clear potential for amounts of older hardwoods and mixed woods to decline (Bunnell et al. 2010a: Figure 5). Consideration of physical distribution immediately confronts the scale problem. Current literature permits only the broadest generalizations. Data guiding recommendations (e.g., a local density of 3 trees >23 cm

per ha) are derived from small areas and apply best to small areas, such as retention patches. At a larger scale, however, the large amounts of NHLB provide a useful buffer against the lack of detailed knowledge. The dispersed distribution of cavity sites and subsequent down wood provided by 'stubbing' or 'high topping' has been a significant part of forest practice in the Fort Nelson TSA. Though it is known that cavity nesters use stubs, the contribution of stubbing is poorly documented. Present data suggest that the major potential problem in terms of distribution is with down wood. Again, specific guidelines cannot be drawn from current literature (review of Bunnell et al. 2009b), but three generalities are apparent. First, simply burning down wood ignores and eliminates its contribution to sustaining biodiversity. Second, dispersed distribution of down wood is of much greater value to most non-vertebrates than are piles. Third, piles of down wood rapidly lose their value over about 1 m in height. These issues reflect practice and are not readily accessible to coarse filter analysis. We make specific recommendations under monitoring (§7.3).

6.2 Amounts of suitable older age classes

The simplest measure of potential effectiveness at providing dying and dead wood is amount of forest in older age classes with some consideration for patch size. Age must be old enough to permit trees of the required size (above). For hardwoods and mixed wood, Bunnell et al. (2009b) found this to be 90 years, provided large hardwood trees were retained in Riparian Management Zones (hardwoods attain greater sizes at younger ages in riparian areas). Both NHLB (Non-harvestable land base) and THLB (Harvestable land base) can contribute to older forests; the former will not be scheduled for harvest. Several high priority species show a statistically significant preference for older hardwood and mixed wood stands (Table 1). Actions undertaken within the Fort Nelson TSA to sustain these species and compensate for incidental take include:

- Sustaining areas of limited habitat and increasing the area of the non-harvestable land base (NHLB) by applying ecosystem representation analysis to reserve rarer ecosystems from harvest.
- When locating Wildlife Tree Patches, giving priority to areas of operational concern which can contribute significantly to the provision of key habitat elements (riparian habitats, large live trees, snags or declining trees, broadleaf (hardwood) trees, CWD, or shrubs). Fort Nelson takes its targets for WTPs from the Land Use Planning Guide which sets targets for each Landscape Unit. These are based on disturbance regimes that no longer occur (Flannigan et al. 2005; Stocks et al. 1998; Xiao & Zhuang 2007). Targets range from 1 to 11%, but most targets are below 3%. Actual amounts in WTPs appear to be somewhat above targets and range from 3 to 19% (with most in the 5 to 9% range).
- Leaving on average 7 snags per hectare (with no guidance on diameter or height, although that guidance is intended to be added),
- Leaving large diameter *Populus* in Riparian Management Zones (see above).

Evaluation of current conditions and projected harvest (Bunnell et al. 2010a) reveals other key points influencing the sustained provision of older hardwoods and mixed woods:

- About 637,000 ha of hardwood-leading stands and 207,000 ha of hardwood-leading mixed wood stands >30 years old occur in the NHLB and are excluded from harvest, representing 58.6% and 66.5%, respectively, of all hardwood-leading and hardwood-leading mixed wood forest. Within the NHLB, proportions older than 90 years are 24.2% and 35.5%, respectively. The NHLB will not be harvested; all the THLB cannot be harvested quickly.
- Examination of current age structure (Bunnell et al. 2010a: Figure 5) indicates no near term decline in amounts of hardwoods or mixed wood, but the potential exists for longer term declines, particularly among older age classes.
- Because hardwood and mixed wood types are the least extensive in the DFA, they are the most likely to become limiting. Trends in amounts of older hardwoods thus merit monitoring.
- Patches of hardwoods and mixed woods are naturally smaller than patches of conifers in the DFA. Under a 20 year projection, the area in larger patch sizes tends to increase in conifer-leading stands; the area in larger patches of mixed wood and hardwood-leading stands tends to decrease or remain stable (Bunnell et al. 2010a: Figure 3). That is particularly true of the

BWBSmw2 where most of the hardwood and mixed wood occurs. Few hardwood associates show negative edge effects. Given the diversity of response among species dependent on older forest, there is no specific 'target' array for distribution, but it is important to avoid a long-term trend towards homogeneity in patch size – either all large or all small.

- The fisher is often assumed a "forest interior" species associated with conifer forest, but in northeastern BC is dependent on hardwood trees as den sites and data are equivocal on its requirement for "forest interior". Large areas in patches >100 ha for both favoured habitat types occur in the NHLB within the Fort Nelson TSA. When analyses are restricted to what is believed to be the most favourable BEC subzone, the area of conifer-leading in patches >100 ha in NHLB of the BWBSmw2 decreased modestly over 20 years (Bunnell et al. 2010a: Figure 4). Natural disturbance was not projected. The decline likely reflects failure to incorporate the most recent TSR updates into the NHLB layer.
- Few members of the high priority non-vertebrate groups evaluated show strong relations with hardwoods (§5).

We believe that trends in suitable habitat for most high priority bird species can be adequately monitored by trends in particular forest type x age class combinations. Such trends also are the best currently available measure for assessing suitable habitat for forest-dwelling bats. Bats have been poorly inventoried. Their presence in the DFA is inferred from studies in northern Alberta and environmental impact work by Jacques Whitford on wind turbines in northeastern BC.

6.3 Conversion of hardwoods and mixed woods to conifer-leading types

Older hardwood trees make two major contributions to sustaining biodiversity: they provide substrate for a number of epiphyte species when living and dying and are preferred cavity sites for many species when rotten or dead. There are two major issues. One is shifting the proportion of the forest comprised of hardwoods downward; the second is 'unmixing' the mixed wood. The latter cannot be evaluated well because the relative proportions of conifers and hardwoods that provide the apparent mixed wood advantage is not clear. To avoid these potential problems, thereby compensating for incidental take of species preferring hardwood and mixed types (no species is restricted to mixed wood types), the Fort Nelson SFM plan has undertaken the following actions:

- Recognized the degree of interspersion of hardwoods with conifers by using four broad forest types of the SFM plan: conifer-leading, hardwood-leading, hardwood-leading mixed woods, and conifer-leading mixed woods.
- Sustained significant amounts of natural stands of hardwood-leading (~367,000 ha), hardwood-leading mixed wood (~207,000 ha) and conifer-leading mixed wood (~355,000 ha) in the NHLB.
- Adopted the principle, within its SFM plan, to keep the existing proportion of hardwoods by sustaining 43% ($\pm$5%) of the stands as pure or hardwood-leading in the THLB while tracking the trend in the NHLB (using updated inventory information).
- Monitored stand composition at each update of the SFM plan by best available inventory.
- Funded study attempting to discern the proportions of hardwoods and conifers that confer the apparent increase in species richness within mixed woods (Preston 2008, 2009a).

Empirical evaluation of habitat preference on the Fort St John DFA found that only one high priority species distinguished between hardwood-leading and conifer-leading mixed woods; it has not been observed in the Fort Nelson TSA. Hardwood and mixed wood types are less abundant than conifer-leading types on the Fort Nelson TSA, so have the greatest potential to become limiting. Crude 20-year projections show very little change in the proportion of conifer, mixed wood and hardwood over the 20-year period of projection (Bunnell and Kremsater 2010: Table 6). However, existing age structure indicates the potential for longer-term declines in both hardwoods and hardwood-leading mixed woods (Bunnell et al. 2010a: Figure 5). Trends in amounts of hardwoods and mixed woods should be monitored; currently there is no evidence of conversion of hardwoods and mixed woods to conifer.

6.4 Reduction of amounts of understory, including hardwoods, through vegetation management

Within the Fort Nelson TSA, Canfor employs vegetation management on cutblocks to reduce competition with future crop trees. Shrubs, forbs and grasses are the primary target, but hardwoods are equally susceptible. Currently, most conifer cut blocks receive some form of vegetation management, primarily chemical administered aerially. Over the past 5 years, most hardwood blocks have received no vegetation management. The trend in area treated is erratic but not increasing over the past 10 years. Over an 11-year period (1999-2009), the area treated averaged about 2695 ha per year. From the perspective of biodiversity, the duration of effect can be estimated only in terms of species' response. The reduction of understory will impact understory associates, but the duration of the effect is undocumented and is likely to be temporary. That is particularly true of hardwood tree species, because of their capacity to reproduce vegetatively and produce abundant seeds. Study of the response of bird species and shrubs after vegetation management has been initiated, but documenting the response pattern requires time.

Actions undertaken by the Fort Nelson TSA to minimize negative effects on understory associations and future hardwood production include:

- Funding study of the duration of effects of vegetation management on understory and future hardwood tree species (Preston 2009b).
- Incorporating principles in its SFMP to sustain forest composition and stand structure that approximate natural baseline information.
- Reducing treatment of hardwood types, which helps ensure maintenance of hardwoods.
- Monitoring that composition at each update of the SFM plan by best available inventory.

Evaluation of empirical habitat associations (Table 1) reveals other key points relevant to the sustained production of understory and high priority species. Specifically, in some instances the most preferred habitat types are NT and NV; neither of these are in the commercial land base. Non-commercial types are as likely to be selected as are recently disturbed habitat ($\leq$30 years post-disturbance by fire or harvesting). As well, understory associates often show preference for shrubs under canopy, rather than more open areas.

6.5 Protection of riparian areas

The SFM plan for the Fort Nelson TSA follows regulatory guidelines for stream width. Hardwoods in riparian areas are particularly important to some high priority hardwood associates, including cavity nesters (e.g., Barrow's Goldeneye, Common Goldeneye, fisher) and some species closely associated with shrubby understory (e.g., Bohemian Waxwing, Yellow Warbler). Beyond following regulatory riparian guidelines, to minimize effects of harvesting and compensate for incidental take, the actions on the Fort Nelson DFA attempt to reduce harvesting effects in "machine free" zones along an RMZ by:

- "Reaching in" with the intention of protecting understory shrubs and retained trees.
- Increasing the retention of hardwood trees.
- Leaving large diameter *Populus* in Riparian Management Zones.

Regulatory guidelines provide no protection to S4 streams or to wetlands and lakes <5 ha. Map-based, coarse-filter analyses are inadequate to assess consequences of harvest practices in riparian areas. Specific recommendations for practices and monitoring are made in §7.2 and 7.3.

7 Summary

We summarize major findings, recommendations regarding practice and monitoring derived from these findings and limitations to the approach.

7.1 Major findings

Analyses reported above are intended to evaluate effectiveness of planning and practices intended to sustain biodiversity. In several instances (e.g., appropriate patch size, targets for late-seral forest), effectiveness cannot be evaluated against data collected on site, but must be assessed on the basis of literature or natural baselines. The evaluation is thus a combination of specific findings that can be supported from data collected on site, interpretation of the SFM Plan and relevant literature. Of the monitoring groups derived from the Species Accounting System, 3w and 3r (wetland and riparian) are least well evaluated by the coarse filter approach. Findings are summarized by species in Table 3, with more detail for individual species following.

Table 3. Findings of coarse filter evaluation of the effects of forest planning and practices for species of high conservation priority in the Fort Nelson TSA. Where they exist, potential trends in primary habitat attributes are noted; the most potentially influential uncertainties are flagged red. Blank indicates no troubling trends are apparent.

Common Name	Cons. Prio.[a]	Size		Amount		Patch Size	Decay Range	Riparian	Trend[b]
		Tree	Log	Cur	Trend				
Alder Flycatcher	**6**								**-4.1**
American Kestrel	**2(G2)**	↓							**-3.9**
Baltimore Oriole	**2(G2)**							?	**-9.5**
Barrow's Goldeneye	**1(G2)**	?		?	?		?	?	[-5.3]
Bay-breasted Warbler	**2(G3)**				?				11.4
Bohemian Waxwing	6							?	nd
Boreal Owl	6	↓			↓				nd
Broad-winged Hawk	4				↓				nd
Canada Warbler	**2(G2)**				↓				-1.5
Cape May Warbler	**2(G3)**								-2.5
Common Goldeneye	**1(G2)**	?		?	?		?	?	-3.4
Connecticut Warbler	**2(G3)**								-4.6
Least Flycatcher	6								**-4.9**
Magnolia Warbler	6								1.0
Merlin	6								-4.3
Mourning Warbler	**2(G2)**								4.1
Northern Hawk Owl	5	?							[0.4]
Northern Pygmy-owl	**1*(G2)***								nd
Pacific-slope Flycatcher	**2(G2)**								[-3.1]
Philadelphia Vireo	**2(G2)**								0.2
Red-eyed Vireo	**2(G2)**								0.7
Rose-breasted Grosbeak	5			↔	↓				2.1
Ruffed Grouse	**2(G2)**		?	↔	↓		?		-1.2
Sharp-shinned Hawk	6								nd
Swainson's Thrush	**(G2)**								0.7
Tennessee Warbler	5								3.7
Tree Swallow	**2(G2)**						?	?	0.2
Western Wood-pewee	**2(G2)**								**-10.6**
Yellow Warbler	**2(G2)**							?	**-4.2**
American Marten	**2(G2)**	↓	?						nd
Fisher	**2(G3)**	?	?	↔	↓	↓	?	?	nd
Northern Myotis	**2(G2)**	↓	↔	↔	↓	↔	↔	↔	nd

[a] Conservation Priority under the provincial system (1 = highest; 6 = lowest). Highest rank is given. Number in brackets indicates the highest ranked Goal (see text, p. 1).

[b] Trend in Boreal Taiga Plains BBS routes (1998-2008) as analyzed by CWS; %/yr; most sample sizes are too small to yield significant estimates. Where no trend data are available for the Boreal Taiga Plains, data are provided for BC in [ ]. nd = no data

Of the 29 high priority bird species, 10 appear only on the candidate federal list, 11 rank highly within the provincial Conservation Framework and 8 rank highly on both lists. In the following comments for specific species, 'directed monitoring' refers to monitoring focused on or directed specifically to that species. Even when not candidates for directed monitoring, these species should be included in more general monitoring, such as Breeding Bird Surveys (even though these surveys do not adequately sample most cavity users).

Broad forest types do not adequately express the needs of three of the high priority species using cavities – Barrow's Goldeneye, Common Goldeneye and fisher – which seek cavities in riparian areas. It is only in these more productive sites that trees (all hardwoods) attain the diameters sought. Within its SFM plan, Canfor follows regulatory widths for Riparian reserves and for Riparian Management Zones by appropriate stream, lake or wetland classification within cutblocks. This protection represents 'potential' hardwoods because riparian areas commonly contain hardwoods. Riparian areas, still less hardwoods within riparian areas, do not lend themselves well to coarse-filter analyses. The actual classification of riparian areas within VRI and GIS is not consistent. Along rivers and around lakes, riparian areas often are large enough to be typed as hardwood-leading where appropriate. Along many smaller streams, they are too narrow to be mapped separately so appear as part of a larger polygon, which may or may not be hardwood-leading. The degree to which current planning and practice are likely to sustain riparian associates cannot be adequately assessed by coarse filter analysis. At a minimum, some form of implementation monitoring is required (§7.3).

Alder Flycatcher: This species is commonly sampled on BBS in northeastern BC; records across the 3 DFAs total 2239. Environment Canada considers the Alder Flycatcher a riparian associate. Analyses reveal the following preferences (in order of preference): TFL 48 – RD (significant), NV(non-significant); Fort St John TSA – NT(significant), RD(significant), NV(non- significant); Fort Nelson TSA – NV, RD, NT (all significant). In all DFAs, preferences were for RD, NV, and NT – all upland sites. Riparian is not adequately sampled by BBS, but the Alder Flycatcher is clearly common on upland sites. The large majority of nest sites reported are <1 m in shrubs (review in Lowther 1999). We believe our designation of this species as an understory associate in the region is more fitting than is riparian associate. NT and NV frequently represent moist to wet or boggy areas, particularly in the northeast. Because it seeks out clearcuts and non-commercial types not subject to harvesting, the species is a poor indicator of incidental take. It is well represented throughout the northeast and we do not recommend it be monitored directly.

AMERICAN KESTREL: **2(G2)** We assume the kestrel uses primarily hardwood nest trees in the region. Data from more southern forest types (Table 2) indicate a majority of conifer nest trees, but this is unlikely to apply where hardwoods are more common. Nest tree diameters in the region range from 24 to 42 cm dbh. The kestrel uses a wide variety of open to semi-open habitats. Breeding territories are characterized by patches of short ground cover, with taller woody vegetation either sparsely distributed or almost completely lacking (Bird and Palmer 1988), though suitable nest trees and perches are required. BBS were established to sample forested habitats. In the Fort St John TSA, for example, 3 sightings of the kestrel were reported from BBS routes, but >200 incidental sightings were reported off routes in more open habitat. In the Fort Nelson TSA, 17 records are distributed across 7 of the 9 habitat types with modest preference for more open types (NV and NT). Provided some trees > 24 cm dbh are retained, the species is unlikely to be negatively affected by forest practices and we do not recommend it be monitored directly.

BALTIMORE ORIOLE: **2(G2)** Environment Canada designates the Baltimore Oriole a mixed wood species. It is often found in deciduous and mixed wood forests near edges, particularly riparian. The species has not been reported from the Fort St John or Fort Nelson TSAs, but could be moving north with climate change. It is not known whether the species is more common in riparian areas, so the assignment to riparian is tentative. Retention of hardwoods in the Riparian Management Zone of the Fort Nelson TSA has been increasing, and should favour the species if it moves north. The species is too rare in the area to serve as an indicator of forest practice in any forest type. It does illustrate the importance of estimating impacts on hardwoods in riparian areas. We do not recommend it be directly monitored.

BARROW'S GOLDENEYE: **1(G2)** This species requires relatively large hardwoods (72%; Table 2) in riparian areas. In the region, nest tree diameters range from 26 to 38 cm dbh; most are in riparian areas. Larger streams receive regulatory buffers, but smaller streams and wetlands do not. Moreover, the species may nest much farther from water than the common 10- to 30-m Riparian Reserve width. Such behaviour means that conditions within the Riparian Management Zone also are important, particular the degree of retention of hardwoods. Current age structure suggests a likely decline in amounts of upland, older hardwoods (Bunnell et al. 2010a: Figure 5). The inability to evaluate riparian areas leads to uncertainties. In Table 3, these are flagged for tree size, trends in amount and decay range (assessed by age distribution as an index of sustained provision). All are affected by riparian practices. Intended riparian practices are presented in the SFM Plan. Even if these are implemented as intended, it is unclear to what degree they sustain habitat. Coarse-filter analyses cannot assess consequences of practices in and around riparian areas. Those consequences cannot be evaluated without, at the least, implementation monitoring. The degree to which practices retain hardwoods, particularly in Riparian Management Zones, should be assessed. That assessment should occur before more costly directed monitoring of the species is done.

BAY-BREASTED WARBLER: **2(G3)** Environment Canada's designation of this species as a conifer associate appears based on eastern data where it occurs predominantly in spruce-fir forests. In 7,748 station-years, 50 observations were obtained across the 3 northeastern DFAs – 24 in hardwood-leading, 16 in mixed wood, and 6 in conifer-leading stands (others in RD or non-commercial types). In the Fort Nelson TSA where there were sufficient records to test preference (43), the species significantly avoided conifer stands. We designated it a hardwood associate. It reaches the western edge of its range in the Fort St John TSA (only 6 observations from BBS routes). Given the significant efforts undertaken in the SFM Plan of the Fort Nelson TSA to mitigate incidental take in hardwood types (§6), we do not recommend directed monitoring.

Bohemian Waxwing: The Bohemian Waxwing is resident, but uncommon, in much of northeastern British Columbia. In 7,748 station-years across the 3 northeastern SFAs, only 2 observations were reported from BBS routes, both from the Fort St John TSA (1 in mixed wood, 1 in young conifers). Given its preference for fleshy fruits and hawking insects over water, we suspect it is primarily a riparian associate in the area, but do not have data to confirm that (riparian areas are poorly sampled by the BBS). It may also exploit NT in the region. Because it is typically clumped in distribution (review of Witmer 2002), it is not readily sampled by BBS. The species appears too uncommon to inform incidental take. We do not recommend it be directly monitored.

Boreal Owl: Environment Canada has designated this as a conifer associate. Of 75 reported nests, about 70% are in hardwoods, usually trembling aspen (Table 2). No nest tree diameters are reported from the region, but elsewhere hardwood nest trees averaged 43.7 cm dbh over several studies (Table 2). There were no observations of Boreal Owl across the 3 northeastern DFAs; we designated it a hardwood associate based on nest site selection elsewhere. The required size of nest tree is attained only in older hardwood stands, somewhat younger in riparian areas. Measures taken within the DFA to sustain older hardwood stands, thereby compensating for incidental take, were noted (§6 above). Lack of a minimum target diameter for retained hardwoods could lead to a gradual degradation of habitat. The species breeds well before BBS are conducted and requires specialized surveys. It is not a candidate for directed monitoring or useful for assessing incidental take.

Broad-winged Hawk: The Broad-winged Hawk is considered secretive other than during migration. The 3 northeastern DFAs have yielded only 4 observations: 2 in H1,1 in MW1 and 1 from C1. The 3 records from the Fort Nelson TSA were in H1, MW1, and C1. Goodrich et al. (1996) described its breeding habitat as continuous deciduous or mixed-deciduous forests, with openings and water nearby. The species has been moving northwest and has only recently entered British Columbia. It is too secretive and infrequent to be informative in assessing incidental take. Practices noted above compensate for any potential take. We do not recommend directed monitoring.

CANADA WARBLER: **2(G2)** Canada Warbler significantly prefers young hardwoods in TFL 48 and old hardwoods in the Fort Nelson TSA (Table 1) and the Fort St John TSA (also significant). In a separate

study focused on the species, aspen was the dominant tree species in 99% of sites occupied in northeastern BC, but the warbler was present *only* when a well-developed shrub layer also was present (Campbell et al. 2007). The Canada Warbler is relatively common when appropriate habitat is sampled. We consider this species less an indicator of hardwoods, than of shrubs under hardwoods. That means that assessment of compensation for incidental take must consider how forest practices affect the understory, which is not possible from the air or simple map-based data. Because it is relatively common in appropriate habitat, we do not recommend directed monitoring of the species. We do recommend that the study initiated as part of effectiveness monitoring (Preston 2008, 2009a) be continued and analyzed to quantify the role of understory.

CAPE MAY WARBLER: **2(G3)** Environment Canada's designation of this species as a conifer associate appears based on eastern data where it occurs predominantly in spruce forests. In 7,748 station-years, only 50 observations were obtained across the 3 northeastern DFAs – 25 in hardwood-leading and mixed wood stands, 19 in conifer-leading stands. Hardwoods and mixed wood woods were evenly split – 13 hardwood-leading and 12 mixed wood. The 3 reported nests are from types that would be designated NT, older mixed wood and older conifer (Campbell et al. 2001; Preston and Pomeroy 2009). For the Fort Nelson TSA, we have designated it a mixed wood associate, pending further data (Table 1). On the DFA, the species is near the western edge of its range, with 21 records in 2,274 station-years. The species is of limited utility in assessing incidental take – it is reported from all major forest types and NT (non-commercial) in northeastern BC. Measures to compensate for incidental take in both hardwood and conifer types are in place (§6). We do not recommend directed monitoring; although still uncommon in the region, further range expansion west is likely detectable by BBS.

COMMON GOLDENEYE: **1(G2)** All reported nests are from hardwoods; mean diameter of nest trees in the region range from 28 to 40 cm dbh (Table 2). Nests are primarily in riparian areas, but, like the Barrow's Goldeneye, it may nest 1 km or more from water (Eadie et al. 1995), so is equally susceptible to application of regulatory measures in riparian areas. Inability to evaluate riparian areas leads to uncertainties. In Table 3, potential weaknesses or uncertainties are flagged for riparian practices, trends in tree size, amount and decay range (assessed by age distribution as an index of sustained provision). The latter three are affected by riparian practices. Intended riparian practices are presented in the SFM Plan. Even if these are implemented as intended, it is unclear to what degree they sustain habitat. Coarse-filter analyses cannot assess consequences of practices in and around riparian areas. Those consequences cannot be evaluated without, at the least, implementation monitoring. The degree to which practices retain hardwoods, particularly in Riparian Management Zones, should be assessed. Because monitoring the species requires specialized approaches, we recommend implementation monitoring of practices to determine the degree to which hardwoods are maintained in the Riparian Management Zones before direct monitoring is done.

CONNECTICUT WARBLER: **2(G2)** Although it is relatively common, the Connecticut Warbler is not well represented in data from BBS routes. Across the 3 northeastern DFAs, it has been reported 45 times: 11 times from the Fort Nelson TSA over the past 3 years. In the Fort St John TSA, it significantly prefers H1, followed by H2 (not significant) and significantly avoids both C1 and C2; on the Fort Nelson TSA the pattern is similar with H2 and MW2 ranking equally in preference. The species' nests are hidden on or near ground, in thick undergrowth of saplings, among thickets or at the base of a shrub, in a sunken clump or mound of moss, or in dry grasses sometimes covered by overhanging vegetation (Harrison 1978; Salt 1973). We designated the species an understory associate and the same constraints as for Canada Warbler apply to its utility in assessment of incidental take. The introductory comments on compensatory measures for understory associates also apply. Incidental sightings (off BBS routes) suggest the species is relatively common in suitable habitat (pole to mature aspen with sparse shrub understory, but abundant herbs) and that targeted sampling, as for Canada Warbler, could be employed. Such sampling currently does not appear needed.

Least Flycatcher: Within the Fort Nelson TSA, the species has been recorded 360 times from BBS routes in the past 3 years. It shows strong preference for both young hardwoods and open sites (NV) and significantly avoids conifers (Table 1). The species is strongly enough associated with hardwoods that it is a potentially useful indicator of incidental take within that forest type. Measures taken within the DFA to

compensate for incidental take are noted above. The species has a role in effectiveness monitoring because it is a useful indicator of the presence of suitable hardwood forest.

Magnolia Warbler: Environment Canada designates the Magnolia Warbler a conifer associate; this likely reflects reliance on eastern data. Within the Fort Nelson TSA, the species shows statistically significant preference for RD (116/50), NV(88/54), MW2 (115/71) and H2 (146/103 (Table 1). On TFL 48, it shows statistically significant preference for MW2 and H2; on the Fort St John TSA, it exhibits preference for H2 and MW2. It consistently uses conifers less than are available in all 3 DFAs and significantly avoids conifers in the Fort St. John and Fort Nelson TSAs. Because it is relatively abundant, we consider it a good indicator of incidental take in hardwood and mixed wood types. Practices noted above compensate for any potential take on the DFA. We do not recommend directed monitoring.

Merlin: The Merlin is sampled infrequently by BBS routes. In 7,748 station-years the total observations were 15; 9 from the DFA, where 8 were in young hardwoods. Overall, there is little marked preference for any specific forest type, though young hardwoods appear favoured: NV(1), NT(2), H1(8), MW2(2) and C1(1), C2(1). Observations in the openings of NV and NT likely represent foraging. Records from the boreal suggest the Merlin commonly nests near forest openings, in fragmented woodlots, and often near rivers, lakes, or bogs; also commonly on islands in larger lakes (Craighead and Craighead 1940; Johnson and Coble 1967; Lawrence 1949). There is nothing in current data from the area to suggest otherwise. Literature indicates use of diverse nesting habitats, including relatively treeless areas where it is a ground nester. It is likely that the large areas of both hardwood and conifer forest in the NHLB, plus areas not in the commercial forest land base, provide nesting and foraging opportunities. Because of its use of many forest types (including non-commercial), the species is unlikely to be a good indicator of incidental take. We do not recommend directed monitoring.

MOURNING WARBLER: 2(G2) Pitocchelli (1993) observed that this is one of the few Neotropical migrants that have benefited from human settlement. That observation is based on its selection of clearings created by fire and clearcutting (Pitocchelli 1993). It is clearly common in the region – 380 observations from BBS. Where it is most common (Fort Nelson TSA, 223 records), it significantly prefers (in order of preference): NV(54/15), RD(30/14), and H2(49/30). On TFL 48, it significantly prefers MW1(13/3) and H2(20/6); it shows no significant preference in the Fort St John TSA, but uses H2 and MW2 disproportionately. We interpret the observations to support Pitocchelli's review that recently disturbed and open areas are important habitat, but so are shrubs under the more open canopies of older hardwood and mixed wood types (it nests in dense vegetation, rarely >1 m above ground). Both these favoured habitat types undermine its utility as an indicator of incidental take – it is encouraged by clearcutting, and shrubs under canopy are poorly sensed remotely or by coarse filter approaches. We do not recommend directed monitoring for the species.

Northern Hawk Owl: The Hawk Owl is a cavity nester, but uses cavities <50% of the time so is not assigned to Group 3c in the Species Accounting System. Duncan and Duncan (1998) reported 19 of 58 nest sites were in cavities. The species has been reported 9 times from BBS routes on the 3 northeastern DFAs. The distribution across habitat types was NC(1), RD(1), H1(1), H2(1), MW1(2), C1(3), indicating a wide range of habitat use. As noted by Austen et al. (1994) and Duncan (1993), the best breeding habitat in North America is likely noncommercial or "forest and barren" area where forests are more open. In the boreal and elsewhere, these areas are often wet – muskeg or swampy – and are netted out of the commercial forest land base. The species is thus not an informative candidate for assessing incidental take. Because forestry is unlikely to have an effect on its preferred habitat, other than by creating openings, we do not recommend it be directly monitored by the company.

NORTHERN PYGMY-OWL: **1(G2)** About 60% of reported nest trees are hardwoods; mean dbh of nest trees in the region is 20 cm (Table 2). Across the 3 DFAs, there are only 2 observations on BBS routes, both from TFL 48 and both from conifer-leading stands. We designated it a hardwood associate on the basis of preferred nest sites. Holt and Petersen (2000) reported that its habitats range from deciduous bottomlands to high-elevation coniferous forests. They also observed that it is rarely seen during the breeding season. No owl is well sampled by BBS routes, largely because breeding is well over by the time routes are implemented. The species is likely little affected by current forest planning and practice –

all forest types are well represented in the NHLB. It uses nest trees of relatively small diameter (Table 2), but likely requires older trees with heart rot. It has been reported from stubs, indicating that patch size is not an issue. So little is known of this species that it merits attention, but specialized sampling is required and current measures appear to maintain its habitat, so directed monitoring is not recommended.

PACIFIC-SLOPE FLYCATCHER: **2(G2)** Pacific-slope and Cordilleran Flycatchers appear to be sympatric in the region (Lowther 2000) and difficult to distinguish in the field. The distribution is ill-defined in northeastern BC. In total, 56 observations were obtained from BBS routes, 50 of these in TFL 48 to the west. In TFL 48, the species significantly prefers older conifers. In the Fort St John and Fort Nelson TSAs, 4 of 6 observations were in hardwood or mixed wood types. Because the species sometimes uses cavities, which are more common in hardwoods, we have tentatively assigned it as a hardwood associate in the Fort Nelson TSA. There are ample hardwoods, including older age classes reserved from harvest (Bunnell et al. 2010a: Figure 1 and Table 4). Because forestry will have little impact on its habitat and the species is casual (possibly tending to uncommon with climate change), we do not recommend it be monitored directly.

PHILADELPHIA VIREO: **2(G2)** The sparse data from the northeast (77 records from BBS) are largely consistent with the notion that this species is "Primarily a bird of early- to mid-successional deciduous woods and woodland edges" (Moskoff and Robinson 1996). Despite sparse numbers across all 3 northeastern DFAs, the species is reported from all habitat types sampled: NV(2), NT(6), RD (11), H1(25), H2(8), MW1(9), MW2(5), C1(10) and C2(1). Although tending to be a generalist, the species favours hardwood types, specifically the younger age classes. The species' ubiquitous, though sparse, distribution undermines any value as an indicator of incidental take – it occurs in clearcuts, burns and non-commercial forest (NV,NT). Among measures to compensate for incidental take, the most prominent is the area of all forest types in the NHLB (Bunnell et al. 2010a: Table 4). We do not recommend the species be monitored directly.

RED-EYED VIREO: **2(G2)** This vireo nests in live midstory to understory trees or shrubs; nests are frequently shaded and concealed by vegetation above (Lawrence 1953; Sutton 1949). The range of mean nest heights reported in 4 studies was 2.5–4.3 m (Cimprich et al. 2000). In short, understory is significant. The species is common in northeastern BC with 994 records from BBS in the 3 DFAs. The preference for understory, often taller, is evident in most preferences documented across the DFAs: TFL 48, significant preference for H2 and NT; Fort St John TSA, significant preference for H1, not significant for NT (26/17); Fort Nelson TSA, significant preferences (in order) for RD, NV, H1, and MW1. Older conifer and mixed wood generally are significantly avoided; only on TFL 48 did the species show preference for older hardwoods. NV and NT are not part of the commercial forest land base; there is unlikely to be a shortage of recently disturbed areas or young hardwoods, particularly given the shortening fire-return interval. We do not recommend this species be directly monitored.

Rose-breasted Grosbeak: This is another of the several species for which the area represents the western edge of their range. It is relatively common: 136 observations on BBS in the Fort St John TSA, 127 in TFL 38 and 253 records in the Fort Nelson TSA. Within the Fort Nelson TSA, the species shows significant selection for RD and H2; in the Fort St John TSA, preferences for H1 and H2 are both highly significant; within TFL 48, H1 and H2 receive disproportionate use (not significant). In all DFAs, it occurs less commonly in mixed wood and significantly avoids conifer. The species is strongly enough associated with hardwoods that it is a potentially useful indicator of incidental take within that forest type – both hardwood-leading and mixed wood. Practices noted above compensate for any potential take on the TSA. We do not recommend directed monitoring.

RUFFED GROUSE: **2(G2)** Across the 3 northeastern DFAs, 118 records were reported from BBS routes in all habitat types and distributed: NV(4), NT(11), RD(33), H1(8), H2(12), MW1(6), MW2(16), C1(17) and C2(8). Because conifers comprise the largest area, conifer types typically tested as significantly avoided. Table 3 indicates three areas of potentially troubling or inadequate information. A limit of 7.5 cm at top end of retained logs could serve to reduce the number of suitable logs available for territorial males. The question about decay range acknowledges the lack of a more suitable target diameter for down wood that would sustain the provision of large logs. The potential downward trend in hardwoods suggests a

potential long term decline in suitable habitat, although the large amounts of hardwoods in both NHLB and THLB will mitigate that. The species itself is not currently a candidate for directed monitoring, but implementation monitoring (to quantify what is actually being left as coarse woody debris) is desirable.

Sharp-shinned Hawk*:* This species uses conifers but is unlikely to be restricted to conifer-leading forest types, as implied by the Environment Canada designation. It does nest in aspen (Joy et al. 1994). Only 1 record is reported from BBS on the TSA (in NT); across all 3 northeastern DFAs there are 6 records: NT(2), MW1(1), MW2(1), C1(1), C2(1). We expect its habitat in the region is more accurately designated C/MW. The species likely hunts in NT, but breeds in productive conifer and mixed wood forests. It is a potentially useful candidate for incidental take, though difficult to monitor. Measures taken in the DFA to compensate for incidental take include the large amounts of conifer forest in the NHLB, retention in cutblocks and a large area of older mixed wood in the NHLB (~562,000 ha, Bunnell et al. 2010a: Table 4). We do not recommend this species be directly monitored.

SWAINSON'S THRUSH**: 2(G2)** This thrush is the most commonly recorded species from BBS in northeastern BC. Across northeastern BC there are 6323 records. The species nests most often in understory, particularly in thickets of deciduous shrubs or conifer saplings; the large majority of nests are <3 m above ground (review of Mack and Yong 2000). Analyses reveal the following statistically significant preferences in order of preference: TFL 48 – MW1, RD, MW2; Fort St John TSA – MW2, C1; Fort Nelson TSA – MW2, H2. Documented selection is consistent with use of understory shrubs or saplings for nesting. Older hardwood and mixed wood types are often open enough to support taller understory below. The species is likely common simply because its nesting habitat occurs in disturbed areas and in all major forest types. It uses, but tends to avoid, non-commercial types (NV and NT), perhaps because while shrub growth may be dense there, it is often low and the Swainson's Thrush typically seeks taller shrubs. Given its common and widespread nature, we do not recommend directed monitoring.

Tennessee Warbler: The Tennessee Warbler is a ground nester, with nests always well concealed and often in a moss hummock or at the base of a shrub or small tree. It is common in the region, with 3444 records from BBS over the 3 DFAs. Analyses reveal the following statistically significant preferences in order of preference: TFL 48 – RD; Fort St John TSA – H2, NT; Fort Nelson TSA – RD, MW1 and NT. It shows avoidance of conifer stands of both age classes, usually significant. Documented selection is consistent with its preferred breeding habitat. NT often includes mossy sites with dense shrubs; RD is <31 years post disturbance (these observations suggest the duration of understory control by vegetation is not long lasting); hardwood and mixed wood stands are often open enough to encourage understory below. Given the species' significant preference for non-commercial sites and areas of recent disturbance, its value as an indicator of incidental take is limited. Because of its common and widespread nature, we do not recommend directed monitoring of the Tennessee Warbler.

TREE SWALLOW: **2(G2)** Data on nesting in the region are sparse: about 54% of nest trees in more southern forest types are hardwoods. Mean dbh of nest trees in the region is 20 cm (Table 2). It is a species of open fields, meadows, marshes, beaver ponds, lakeshores, and other wetland margins, using trees only for nesting and occasional roosting. Like most high priority excavators, where nest boxes are not available it is dependent on primary excavators for its nest sites. Preference for these habitats means it is not well sampled by BBS; 39 observations are reported from the 3 northeastern DFAs. Their distribution across habitat types reflects the eclectic use: NV(1), NT(8), RD(6), H1(9), MW1(2), MW2(1), C1(12), C2(2). Lack of buffers around small wetlands could negatively impact the species. Because it is presently unclear to what degree appropriate wetlands are affected by forest practice, we recommend implementation monitoring precede any direct monitoring of the species.

WESTERN WOOD-PEWEE: **2(G2)** In their review, Bemis and Rising (1999) considered this species a habitat generalist. That is apparent in the habitats from which it is reported in the 3 northeastern DFAs: NV(19), NT(10), RD(31), H1(4), H2(27), MW1(2), MW2(13), C1(13), C2(14). Because of the differing sample pools, preferences are expressed differently across DFAs, but recent disturbances were most used, followed by non-commercial types (NV & NT), then hardwoods, conifers and mixed wood (generally older age classes favoured). The species' use of non-commercial types and recently disturbed means it is not greatly impacted by forest practices. Although it tends to favour older forest age classes of commercial

forest types, there is abundant area of these types in the NHLB. We do not recommend that this species be directly monitored.

YELLOW WARBLER**: 2(G2)** The Yellow Warbler is expanding its range northward (Bunnell et al. 2010b) and is now relatively common in the region, with 500 observations from BBS routes in the 3 DFAs. Analyses reveal the following statistically significant preferences in order of preference: TFL 48 – H2, MW1 (both significant); Fort St John TSA – H1 (significant), H2 (near significant); Fort Nelson TSA – NV, MW1, and NT (non-significant). The species breeds most commonly in wet, deciduous thickets, especially those dominated by willows, and in disturbed and early successional habitats (Dunn and Garrett 1997). In drier areas, the species' affinity for willows enacts a correlated affinity for riparian areas. The northeast is moist enough that the Yellow Warbler is relatively common on upland sites (where BBS are located). It uses non-commercial NV and NT in all DFAs, but not consistently disproportionate to abundance. The Fort Nelson TSA has taken measures to mitigate impacts of forest practices on hardwood and mixed wood types (§6). Given its common and widespread nature, we do not recommend directed monitoring for the Yellow Warbler.

AMERICAN MARTEN: **2(G2)** Data summarized for this species in Table 2 are from forests well to the south. In southern forests, it has been reported denning and resting only in conifers, about 70% of them live. Diameters used are well above those attained by conifers in boreal forests. Nonetheless, healthy marten populations exist in northeastern BC; the best documented is that on the Rice property within TFL 48 (Poole et al. 2004; Porter et al. 2005). The Rice property is a former agricultural area now covered with regenerating forest that is 90% hardwood-leading; about 65% of the property is <65-years-old and 45% is <25-years-old. Research elsewhere reveals that viable marten populations can be maintained in early seral and second-growth forests where sufficient physical structure is present (Baker 1992; Bowman and Robitaille 1997; Johnson et al. 1995; Payer and Harrison 2003), and when prey populations are high (Baker 1992; Lofroth 1993; Paragi et al. 1996; Potvin et al. 2000; Snyder and Bissonette 1987). The key appears to be adequate down wood and shrub cover to encourage prey, provide resting sites and reduce aerial predation. Neither Poole et al. (2004) nor Porter et al. (2005) measured shrubs or down wood. Porter et al. (2005) reported that marten selected for large, decayed snags as denning sites, but provided no diameters or species for snags selected. It is unclear whether provision of downed wood is appropriate; piled logs appear to be suitable in the boreal (see fisher). Given the flexibility observed for marten, it does not appear to be a candidate for directed monitoring.

FISHER: **2(G2)** This species requires uncommonly large hardwoods in riparian areas. In Table 3, potential weaknesses are flagged for size of denning tree and logs, amounts and patch sizes of habitat (riparian and older mixed wood), riparian practices and decay range (assessed by age distribution as an index of sustained provision). Inability to evaluate riparian prompts questions about sustained provision of appropriate size of tree, appropriate decay class and trends in amounts of habitat. Intended riparian practices are presented in the SFM Plan. Even if these are implemented as intended, it is unclear to what degree they sustain habitat. Coarse-filter analyses cannot assess consequences of practices in and around riparian areas. Those consequences cannot be evaluated without, at the least, implementation monitoring. The degree to which practices retain hardwoods, particularly in Riparian Management Zones, should be assessed. In the northeast, fisher do not den within logs but rest beside logs or in log piles (Weir 2008). We expect the marten to respond similarly.

The fisher is considered a Group 5 species for which at least some studies have concluded that patch size is important. Bunnell et al. (2010a: Figure 4) illustrate patch sizes in what is believed to be favoured fisher habitat. There appears to be ample area of larger patch sizes of both conifer and mixed wood in the NHLB, but a declining trend in patch size for both forest types in the THLB. Current data for fisher in boreal forests do not indicate patch size to be important (Weir 2008). Although the magnitude of potential decline in older mixed wood merits monitoring, the greater issue is the degree to which large hardwoods are being maintained in the riparian (see Weir 2008 for regional data). Currently the species is not a candidate for directed monitoring, but implementation monitoring of practices in riparian areas is needed before a credible assessment of likely trend can be made.

NORTHERN MYOTIS: **2(G2)** Studies in more southerly forests indicate that about 50% of denning or roosting sites are in hardwoods, most dead (Table 2). One large sample size in conifer stands dominates the proportion of hardwoods used and we expect greater use of hardwoods in the northeast. Reported roost tree diameters indicate diameters are attainable by hardwoods in boreal forests, in both upland and riparian areas. Suitable habitat for the species could be monitored by tracking older hardwood stands (H2), which currently cover extensive areas but show negative trends (Bunnell et al. 2010a). Implementation monitoring of practices in riparian areas would benefit from a credible assessment of likely consequences of forest practice. The species is a candidate for basic inventory, not monitoring.

7.2 Recommendations for practice

The review and analyses suggest five improvements to current practice.

1) For single trees or retention patches <2 ha, guidelines for retained wildlife trees should be tree sizes >23 cm dbh with densities of ≥3 per ha. Greater densities of small snags should be retained where possible.
2) Anchor points for retention should acknowledge potential limitations (e.g., older mixed wood, hardwoods >23 cm dbh; conifer trees >30 cm dbh).
3) Waste management guidelines should ensure that a few larger conifer pieces (≥17.5 cm random diameter) are retained where stand conditions permit; pieces ≥2 m long.
4) Pieces of down wood >17.5 cm diameter (random, not top-end) should not all be piled; some should be left scattered on site.
5) S4 streams in candidate bull trout areas should receive a 10 m buffer (see §7.3).

7.3 Recommendations for monitoring

Recommendations are summarized separately for implementation and effectiveness monitoring. These recommendations are based on apparent requirements of high priority species strongly associated with hardwoods.

Implementation monitoring

Implementation monitoring should focus on areas where effects currently appear negative. It should be directly linked to practices that offer opportunity for improvement. Note that in some instances it is important that implementation monitoring be initiated before effectiveness monitoring because implementation monitoring can determine whether effectiveness monitoring is required. We have estimated priorities for specific habitat attributes (**VH** = very high; **H** = high; **M** = moderate); issues following are ordered by priority.

Riparian and wetlands: Uncertainties about riparian areas figure prominently in Table 3. Several high priority, cavity-using species seek large hardwoods in riparian areas. The degree to which larger hardwoods (and shrubs) are retained in the Riparian Reserve Zone and Riparian Management Zone should be assessed (**VH priority**). Environment Canada designates 3 wetland associates as candidates for assessment of incidental take – Le Conte's Sparrow, Marsh Wren and Nelson's Sharp-tailed Sparrow. The latter ranks 2 in Goal 3 of the provincial Conservation Framework; several other wetland associates also rank highly with the provincial Conservation Framework.[7] In total, more than 50 vertebrate species within the DFA are associated with wetlands and lakes <5 ha. Current guidelines do not buffer small lakes and wetlands (<5 ha). The number of small lakes and wetlands encountered within treatment units, and the proportion of those harvested with and without buffers, should be tracked until it is apparent what portion is unaffected by forest activity (**VH priority**). Wetland size distribution should be recorded in 1-ha classes up to 5-ha. NT is frequently used by high-priority species, is non-commercial and often associated with wet areas. The degree to which NT is incorporated into retention anchor points should be evaluated (**M priority**). The degree to which both conifer and hardwood stems are retained around small streams, particularly in areas likely to be inhabited by bull trout, merits monitoring. Bull trout ranks 2 in Goals 2 and 3 of the provincial Conservation Framework and there is circumstantial evidence it has

[7] Wetland associates were not treated explicitly here because most wetlands are not associated with a specific forest type, such as hardwoods.

declined elsewhere in the province due to lack of buffers (Hinch and Mellina 2008). Bull trout are fall spawners that prefer cooler water than do other trout. As a result of recent studies of salvage logging, there is mounting evidence that most S4 streams should be buffered; 10 m is recommended (Maloney 2004; Nordin et al. 2008; Rex et al. 2009). The degree to which S4 streams occur in areas favourable to bull trout, a high priority species, should be assessed (**H priority**).

Retention: Actual diameters of retained trees, including 'high-topped' stubs, should be assessed; the current contribution these snags and trees are making is not documented. A range in diameters is appropriate, but some should be >23 cm; **VH priority**). Within the THLB, the state (size, age, tree and log attributes, species composition, anchor points) of patches should be monitored periodically to assess trend in older blocks or patches across the landscape (**H priority**).

Size: The lower boundary for effective patches should be set at 0.25 ha,[8] until further evaluated.
Age: Recommended targets for age are >90 (hardwoods) and >140 years (conifers). Actual age should be estimated.
Tree and log attributes: Number, dbh, species and height should be measured for a sample of live trees and snags; number, diameter, decay state and length should be measured for logs.
Anchor points: Rationale for patch locations should be recorded. Natural anchor points may be riparian boundaries, wetlands, appropriate wildlife trees, etc. Targets for wildlife trees should ensure that some are at least 23 cm dbh for hardwoods and 30 cm for conifers. The limits are particularly important, when retained patches are small (≤2 ha). Larger retention patches (>10 ha) need not target particular tree sizes, but can use age as a surrogate. In these cases, the age classes should be at least age class 5 for hardwood and mixed wood stands and age class 8 for conifer-leading stands. Minimum densities of wildlife trees should be 3/ha in patches less than 2 ha. Snags naturally are clumped, and cavity-users appear to respond to clumped distributions. Actual conditions should be recorded.

Species composition: There are indications that the relative amounts of hardwood stands could be locally reduced over the long term (Bunnell et al. 2010a: Table 5, Figure 5). 'Natural' targets based on current species composition are unlikely to represent a critical limit. Burn rates are increasing in boreal forests and more frequent fires are likely to encourage hardwood cover (e.g., Bergeron et al. 1998). Hardwoods make a disproportionate contribution to sustaining biodiversity. It is important that the area of hardwood-leading and mixed wood types, particularly late seral classes, be tracked over time to ensure there is no strong, harvest-driven trend away from present proportions. Amounts in both NHLB and THLB should be tracked (**VH priority**).

Late seral targets: Status relative to current targets should be assessed every 5 years for the three broad forest types in both the NHLB and THLB (four if it ultimately proves useful to distinguish hardwood- and conifer-leading mixed wood). Recommended lower boundaries for late seral are >90 years for hardwoods and mixed woods and >140 years for conifers. For many hardwood associates, late seral is more important than early seral. Targets could change if climate change significantly increases the incidence of forest fire. Trends in late seral hardwoods and mixed wood are of most concern (**H priority**).

Vegetation management: Pre-harvest forest cover on sites selected for treatment should be recorded so that potential changes in conifer to hardwood and vice versa can be assessed in the future (**H priority**).

Coarse woody debris: Natural levels of coarse woody debris are rarely helpful in creating targets because they are so variable. Amounts and distribution of pieces left behind and unburned can be informative if either butt-end or a random sample of diameter is measured by an adequate sample. Some sampling of length also is informative. Total area from which all wood >17.5 cm in diameter is removed should be recorded, as should the relative proportion of debris left scattered and piled. Height of unburned piles should be estimated. Little advantage is gained beyond 1 m in height (**H priority**). Knowing what is actually being left and how it is distributed will influence the priority assigned to effectiveness monitoring for woody debris.

[8] This value is consistent with BC MoWLP (2005) for the Omineca Region.

Late seral patch sizes: Status should be assessed every 5 years when polygons are updated for TSR review. Trends in sizes of older forest patches should be tracked by forest type within BEC variant for both the NHLB and THLB. Targets guided by historical disturbance regimes may no longer apply. Two trends are undesirable: 1) a long-term tendency towards homogeneity in patch size, 2) a long-term (>10 year) decline in mean size of patches with appropriate attributes (age, tree size). **M priority**.

Effectiveness monitoring

Effectiveness for biodiversity can only be assessed credibly in terms of organisms themselves. While those data accumulate, effectiveness can be inferred. Note that portions of implementation monitoring inform effectiveness monitoring. Major management 'levers' that can be used to counter unfavourable trends are noted. We have estimated priorities for specific attributes (**VH** = very high; **H** = high; **M** = moderate; **L** = low).

NHLB contributions: Our assessment of the relative suitability of current practices to sustain hardwood associates was influenced by the assumption that old hardwoods in the non-harvestable land base were contributing significantly. Much of the NHLB is lower productivity and Boudreault et al. (2008) noted that site productivity influences the contribution to sustaining some organisms. The assumption that NHLB contributes significantly should be checked. Currently, of the 2,274 orthophoto points sampled in the TSA, 44.2% are in the THLB, 35.2% are in the NHLB, and 20.5% are in land excluded from productive forest (e.g., non-commercial brush classified as NT). NT is actually a productive habitat, particularly for understory associates, but apparently hardwood associates as well (Table 1). Comparisons between NHLB and THLB of relative abundance for selected species would help address the validity of the assumption regarding contributions of the NHLB (**VH priority**). This should first be done with existing sample data of organisms. If NHLB is less productive and a particular forest type in the THLB is potentially limiting, the appropriate management level is retention.

Retention: It is likely that stubbed areas and retention patches will support different groups of cavity nesters as well as other species. For dispersed retention of high-topped stubs, use should be documented (**VH priority**); over the longer term, duration of snags and their continued use should be documented (**M priority**, but requires initial base line data). For patch-wise retention, occurrence of cavity users in patches of different broad forest types should be documented. Relevant variables for assessing retained habitat were noted under implementation monitoring. In the near term, effectiveness can be evaluated in terms of the target diameters and ages recommended (**VH priority**), especially when late-seral relations below are documented. Longer-term, more credible evaluations require assessment of patches for suites of organisms, particularly those responsive to dead and dying wood (**H priority**). See organisms below. Data would be strengthened by the inclusion of nest-tree diameters when found, to challenge the diameter limits currently extracted from sparse regional data. Evaluation could lead to refinement of retention guidelines.

Mixed wood: In sub-boreal and boreal forests, hardwood species play a major role in sustaining biodiversity. Currently, boundaries of amounts of hardwoods or conifers that confer the mixed wood advantage to species richness are unknown. The most cost-effective way of estimating them is to acquire simple measures from existing BBS stations (% hardwoods, simple indices of shrub abundance based on height and % cover classes)[9]. Data elsewhere indicate that richness of cavity nesters is correlated with richness of songbirds. Assessment can be informed by relating the abundance of songbird species closely related to hardwoods, but not ranked highly in the Conservation Framework (e.g., American Redstart, Hammond's flycatcher, Least Flycatcher, Magnolia Warbler, Rose-breasted Grosbeak and Warbling Vireo), to the proportion of hardwoods present. There may be sufficient data (Preston 2008, 2009a) that focused analyses would reveal whether there is an apparent threshold. This is assigned **H priority** because it will help guide the priority with which the potentially declining trend in amounts of older mixed wood should be addressed. Moreover, much of the data are in hand, so it would be cheap to do. The major management 'levers' are retention guidelines and possibly vegetation management.

[9] There is a documented trade-off between percent hardwoods and shrub abundance. The acquisition of data to help define mixed wood boundaries has been initiated in the Fort St John TSA (Preston 2008; 2009).

Organisms: Response of organisms is the most credible, and ultimately a necessary, measure of effectiveness. Candidate organisms for the Fort Nelson TSA are listed with priorities derived from review of current data and the literature (portions are **VH priority**). Different candidate groups are assigned the priorities of the management issues noted. Focus is on a suite of species to attain an aggregate response less susceptible to vagaries of individual species. Note: for the broader assessment of habitat these are not necessarily high priority species. Ideally the monitoring would be periodic with the aggregate number of observations for that group compared to the mean over the initial monitoring period; a 30% decline merits further examination. However, it is unclear that current base line monitoring is sufficient. That is particularly true for cavity nesters, and should be evaluated soon.

- Cavity nesters – these should be divided into two groups: largely hardwood dependent and largely conifer dependent (Tables 1 and 2). For example, American Three-toed Woodpecker, Boreal Chickadee, Brown Creeper, and Winter Wren for conifers;[10] Black-capped Chickadee, Hairy Woodpecker, Northern Flicker, Red-breasted Nuthatch and Yellow-bellied Sapsucker for hardwoods. Although suites are important, the sapsucker merits individual attention because it is the keystone excavator in the region. Initial efforts should focus on retention patches; knowing relations between organisms and larger retention patches will assist scaling up over the entire tenure (**VH priority**). Forest interior plots may be necessary for the American Three-toed and Black-backed Woodpeckers (**M priority**).
- Old hardwood and mixed-wood suite – as well as cavity nesters associated with old hardwood types these include American Redstart, Hammond's Flycatcher, Least Flycatcher, Magnolia Warbler, Rose-breasted Grosbeak and Warbling Vireo, and serve to confirm or reject the utility of the proposed older age class boundary for monitoring. Because this suite of species is surveyed more readily than cavity nesters, they may prove a useful surrogate for older forest types, but will not reveal appropriate diameters. Given that all are migratory and subject to influences well outside the tenure, they should be monitored as a suite (**H priority**).
- Fisher – elsewhere the fisher is believed to be sensitive to the diameter of both standing trees and down wood. Canfor has contributed to a local fisher study and results to date reveal use of old hardwoods for maternal dens and no use of down wood as denning sites. **H priority** for literature review; **L priority** for further field study.
- Marten – data for marten were not collated for boreal forests more generally. That should be done before any study is initiated. This is assigned **M priority** because the marten population on the nearby Rice property (TFL 48) has been studied, but could be anomalous.
- Old riparian suite – these species are not readily monitored by Breeding Bird Surveys (e.g., cavity-nesting ducks). Implementation monitoring of riparian practices would indicate whether they 'should be' there, but that ultimately needs confirmation. We have ranked this **M priority** because no problem is apparent and the surveys are specialized.
- Bryophytes and lichens – those dependent on down wood appear more likely to be threatened. Tree species, diameter and decay state should be recorded during surveys of snags and down wood. Initial efforts should focus on retention patches with adjacent 'natural' controls. We ranked this **M priority**, primarily because of the difficulty in finding qualified personnel.

Riparian areas: Because current guidelines do not buffer small lakes and wetlands (<5 ha), and more than 50 species are associated with wetlands, ponds and small lakes (though not consistently with hardwoods), we do not know whether a significant portion of biodiversity is exposed to habitat degradation. Monitoring should assess species presence in small wetlands with (if such exist) and without adjacent harvesting; these should be stratified by 1-ha size classes up to 5 ha (**H priority**). If the implementation monitoring recommended above discovers that proportionately few small lakes and wetlands receive adjacent harvest, the priority should be lowered. That is, implementation monitoring should be done first.

The effectiveness of riparian management guidelines at maintaining hardwoods in Riparian Management Zones and the species associated with riparian areas around streams and larger lakes has not been

[10] The Pacific-slope Flycatcher could be added; it is an opportunistic cavity user but common and readily surveyed.

assessed. The current approach to monitoring organisms (Breeding Bird Survey routes) assesses riparian areas only poorly. Some preferred NT sites appear to be a product of high moisture levels. A focused evaluation of the effectiveness of practices is needed. Specific questions include: 1) are species expected in wetland/riparian areas actually present, and 2) do practices around areas classified as NT maintain the ability of NT to support understory associates. Measures of shrub abundance attained under implementation monitoring of shrub abundance in the RRZ and RMZ will assist interpretation. We rank this as **M priority** simply because we do not anticipate problems and surveys are specialized; the number of species potentially affected, however, may encourage a higher ranking.

Late seral: Apparent effectiveness of recommended age class boundaries could be evaluated only by diameter of cavity trees sought by vertebrates in the area. Data were sparse and it is not known whether estimated boundaries are effective for other organisms. Forest interior plots should be used to assess projected effectiveness of current age class boundaries for cavity nesting birds (**H priority**) and for bryophytes and lichens (**M priority**). See also organisms above. Significant downward trends in older age classes can be ameliorated by increased retention.

Coarse woody debris: Collate estimates of use of down wood by marten and fisher in boreal forest sites and relate to measures derived from implementation monitoring (**M priority)**. Pursue an analogous approach for bryophytes and lichens relying on down wood (**M priority)**. Major management 'levers' are retention guidelines and waste management practices.

7.4 Limitations and utility of the approach

There are two major limitations to the coarse-filter evaluation of effectiveness of forest planning and practice at sustaining high priority species strongly associated with hardwoods:

1) The survey method employed (Breeding Bird Surveys) does not adequately assess some species. For example, despite 2,274 station-year combinations, very few observations were attained from which to derive preferred forest types for cavity nesters (Table 1). Other groups within the Species Accounting System are much better sampled by Breeding Bird Surveys. More broadly, the major approach to monitoring, BBS surveys, does not adequately account for other vertebrate and non-vertebrate groups and exposes potential weaknesses only generally.

2) Coarse-filter analyses are necessarily map-based and riparian habitats are incompletely represented using current monitoring techniques. At least three high-priority species (Barrow's Goldeneye, Common Goldeneye and fisher) cannot be adequately assessed by the coarse filter approach without better information on practices within the Riparian Management Zone.

The first limitation can be addressed by other monitoring methods: the second by specific, targeted implementation or effectiveness monitoring (see §7.3). Despite these limitations, the coarse filter analyses are useful. Briefly, they:

1) Expose which species are most in need of targeted monitoring. In this case, they are species that seek riparian habitat, particularly Barrow's and Common Goldeneye. The analyses also indicate how relatively simple implementation monitoring can clarify the need for more expensive effectiveness monitoring, before the latter is undertaken.

2) Expose which species are most in need of inventory. In this case, the single bat species. Even its presence within the DFA is ambiguous.

3) Suggest key areas of implementation and effectiveness monitoring directed to ensuring that current planning and practice do not negatively affect the species.

4) Illustrate and focus credible and cost-effective measures for monitoring preferred habitat of most species.

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