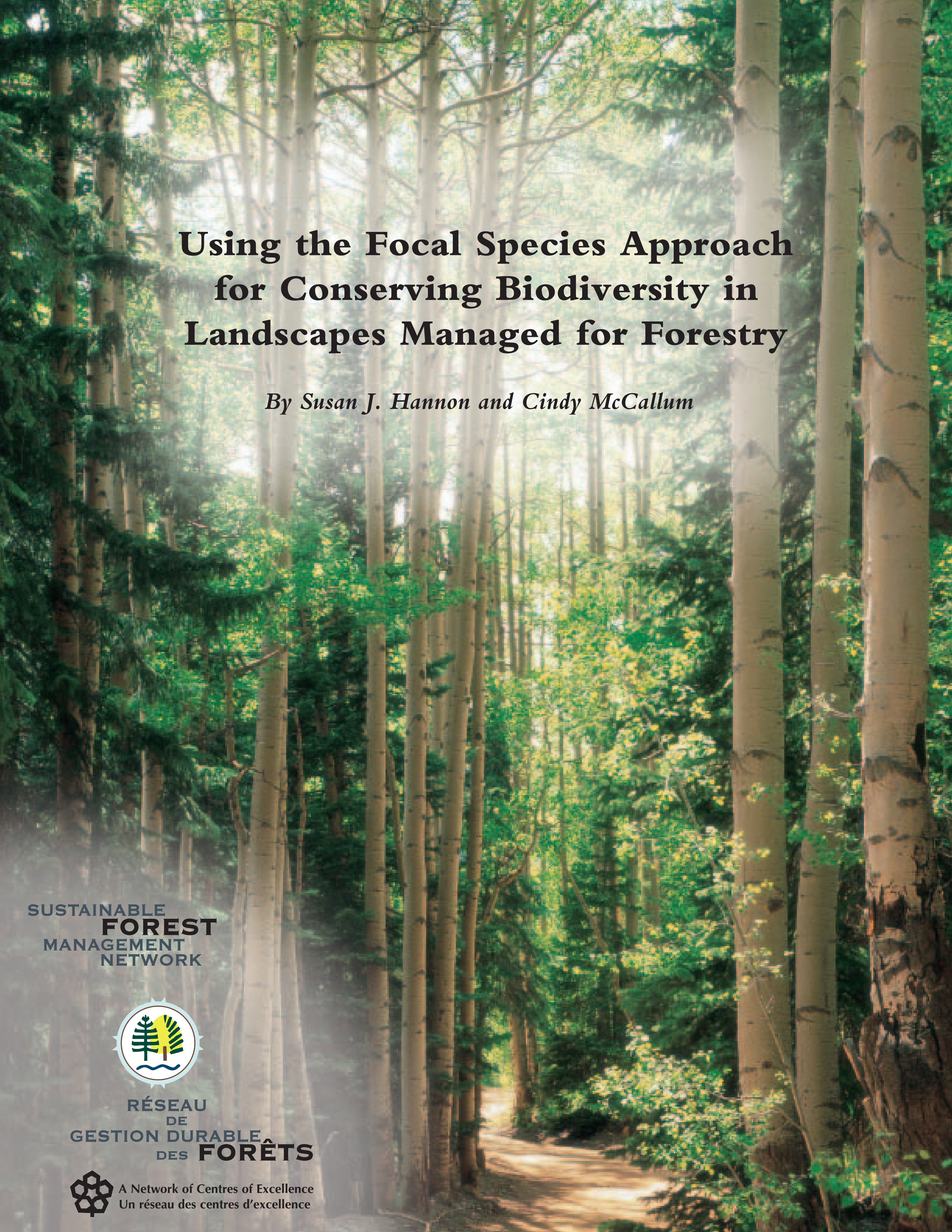

Using the Focal Species Approach for Conserving Biodiversity in Landscapes Managed for Forestry

By Susan J. Hannon and Cindy McCallum

SUSTAINABLE FOREST MANAGEMENT NETWORK

RÉSEAU DE GESTION DURABLE DES FORÊTS

A Network of Centres of Excellence
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THE SUSTAINABLE FOREST MANAGEMENT NETWORK

Established in 1995, the Sustainable Forest Management Network (SFM Network) is an incorporated, non-profit research organization based at the University of Alberta in Edmonton, Alberta, Canada.

The SFM Network's mission is to:
- Deliver an internationally-recognized, interdisciplinary program that undertakes relevant university-based research;
- Develop networks of researchers, industry, government, Aboriginal, and non-government organization partners;
- Offer innovative approaches to knowledge transfer; and
- Train scientists and advanced practitioners to meet the challenges of natural resource management.

The SFM Network receives about 60% of its $7 million annual budget from the Networks of Centres of Excellence (NCE) Program, a Canadian initiative sponsored by the NSERC, SSHRC, and CIHR research granting councils. Other funding partners include the University of Alberta, governments, forest industries, Aboriginal groups, non-governmental organizations, and the BIOCAP Canada Foundation (through the Sustainable Forest Management Network/BIOCAP Canada Foundation Joint Venture Agreement).

KNOWLEDGE EXCHANGE AND TECHNOLOGY EXTENSION PROGRAM

The SFM Network completed approximately 270 research projects from 1995 – 2003. These projects enhanced the knowledge and understanding of many aspects of the boreal forest ecosystem, provided unique training opportunities for both graduate and undergraduate students and established a network of partnerships across Canada between researchers, government, forest companies and Aboriginal communities.

The SFM Network's research program was designed to contribute to the transition of the forestry sector from sustained yield forestry to sustainable forest management. Two key elements in this transition include:
- Development of strategies and tools to promote ecological, economic and social sustainability, and
- Transfer of knowledge and technology to inform policy makers and affect forest management practices.

In order to accomplish this transfer of knowledge, the research completed by the Network must be provided to the Network Partners in a variety of forms. The KETE Program is developing a series of tools to facilitate knowledge transfer to their Partners. The Partners' needs are highly variable, ranging from differences in institutional arrangements or corporate philosophies to the capacity to interpret and implement highly technical information. An assortment of strategies and tools is required to facilitate the exchange of information across scales and to a variety of audiences.

The preliminary KETE documents represent one element of the knowledge transfer process, and attempt to synthesize research results, from research conducted by the Network and elsewhere in Canada, into a SFM systems approach to assist foresters, planners and biologists with the development of alternative approaches to forest management planning and operational practices.

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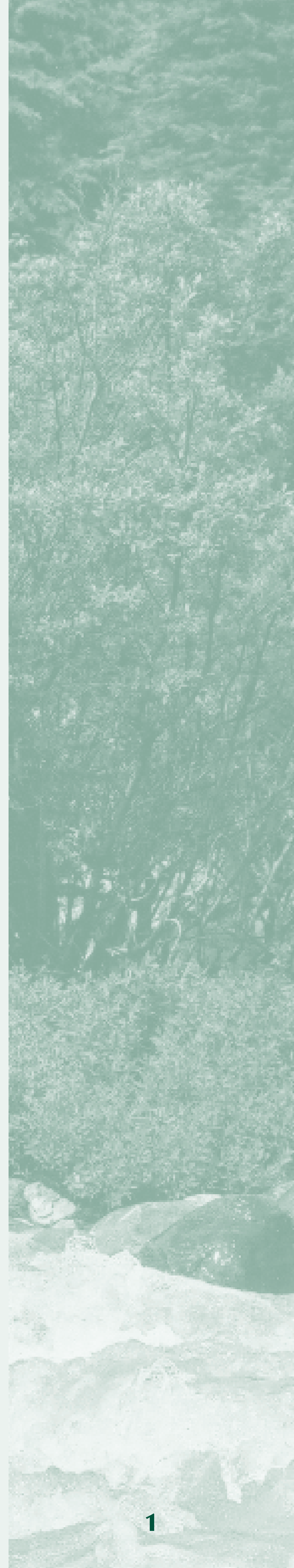
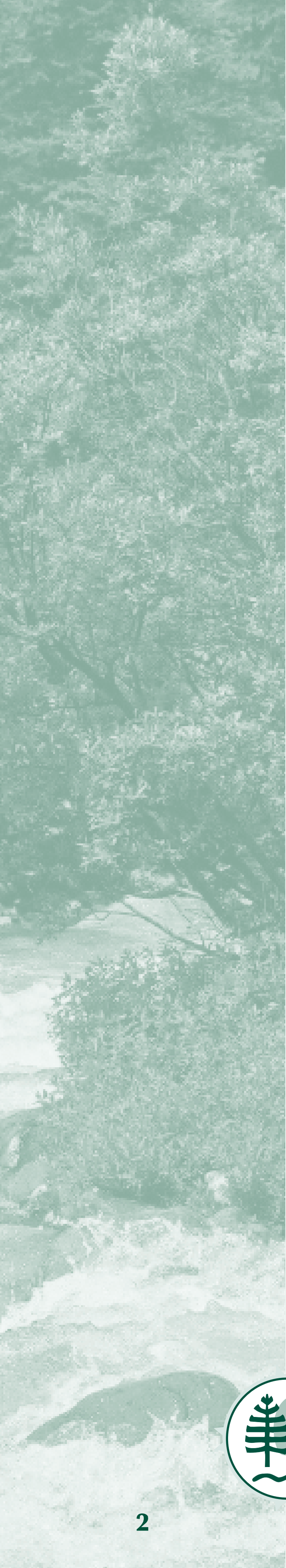
March 2004





1. Objectives

To synthesize research that has used a focal species approach to conserve biodiversity in managed landscapes. In particular the objectives were:

a) Summarize and evaluate research that has used the focal species approach and construct criteria for using this approach. SFMN research will be highlighted, but a broader synthesis will be undertaken.

b) Critique the use of focal or indicator species approaches by the forest industry in Alberta relative to the criteria outlined in point #1 above.

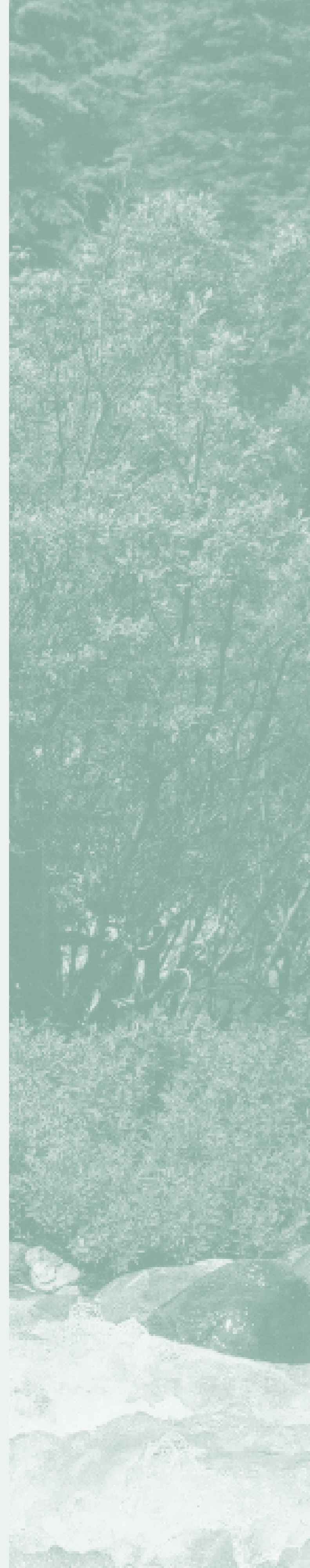
c) Apply the focal species approach to the mixedwood forest of the western boreal plain forest and come up with a multi-taxal/multi-species list based on ecological criteria.

2. Rationale

Major criticisms of ecosystem management approach

Although the goals of the ecosystem management (natural disturbance or coarse filter) approach and the focal species approach are the same (in the forestry context, to identify harvest patterns that minimize the risk of biodiversity loss), the approaches will likely result in very different spatial patterns of harvesting on the landscape. Results of recent research comparing effects of logging versus fire on biota has indicated that we should be cautious in the whole-scale application of logging patterns based solely on natural disturbance patterns (e.g., Hobson and Schieck 1999, Imbeau et al. 1999, Buddle *et al.* 2000; Song 2002).

There have been a number of criticisms recently of the use of the coarse filter approach to the exclusion of fine-filter species-oriented management for the conservation of biodiversity. 1) Concepts of ecosystem management, ecosystem health and sustainability are vague and hence it is difficult to set achievable or workable goals (Tracy & Brussard 1994, Simberloff 1998). For example, how do we define the ecosystem processes that we wish to conserve? What are the boundaries of the system in which the processes function? 2) Maintaining "processes" does not necessarily result in maintaining all of the species (Simberloff 1998). For example, if the goal is to manage for high primary productivity, then the landscape could become dominated by second growth stands which have higher productivity than old growth stands. However, many old growth species will be missing. In addition, there appears to be ecological redundancy in the roles of some species, hence processes could continue without all species. For example, top carnivores that are not keystone species could be lost and have little detectable effect on ecosystem processes (e.g., Florida panther) (Simberloff 1998). 3) Many practitioners of ecosystem management ignore the fact that managing



systems by emulating natural disturbances is an **experiment** that has to be tested by implementing active adaptive management. Many agencies and/or industries promote adaptive management without implementing it in the correct way: i.e., no reference areas or benchmarks used, no replication etc. (Simberloff 1998). 4) Implementation of the natural disturbance paradigm is often planned at the landscape and stand level at scales relevant to vertebrates. Hence, micro-site level habitat may not be maintained for smaller organisms such as invertebrates (Spence *et al.* 1999).

3. Literature review on focal species

Definitions of focal species

The literature on focal species is confusing because of the inconsistent use of terms. In Table 1 (page 4) we have summarized the terminology, provided synonyms and defined each term with examples. In general population indicators, guild indicators, and condition indicators are used to evaluate conservation and management actions, whereas biodiversity and composition indicators are used to determine areas or priorities for conservation using protected areas.

Ecological criteria for choosing focal species

The types of focal species that are chosen on ecological grounds are indicators, species-at-risk, umbrella species and keystone species. Many authors stressed that single indicators are not sufficient and that suites of indicator species should be chosen (Landres *et al.* 1988, McLaren *et al.* 1998).

Indicators

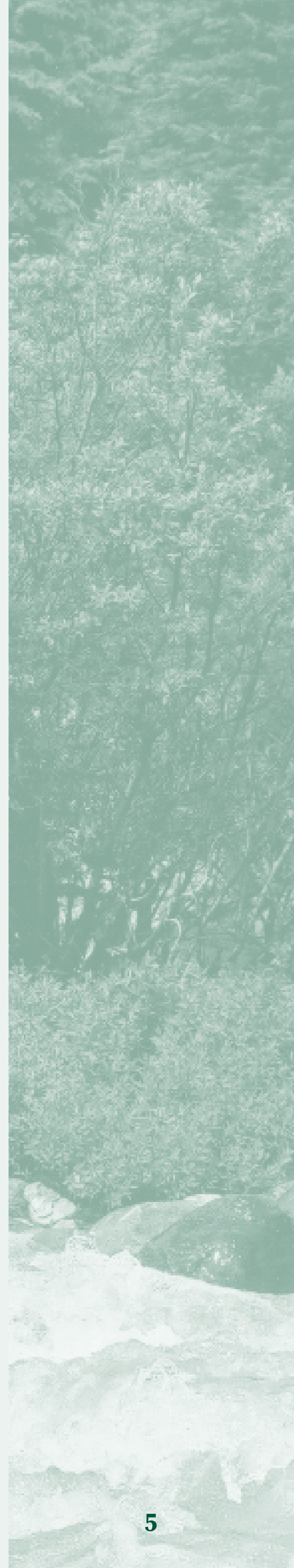
Population/guild indicators: These species have to show similar responses to anthropogenic change as other species in the habitat or to other species within the same guild (Landres *et al.* 1988). Variations in their abundances must be correlated with changes in abundance of other species. This is a fairly coarse indicator as it uses abundance only and does not capture changes in reproductive behaviour or other demographic changes (e.g. sex or age ratio).

Condition indicators: Condition indicators must be sensitive to and respond quickly and strongly to anthropogenic changes in the ecosystem. There must be a demonstrated cause and effect relationship between anthropogenic change and population change of the condition indicator (Landres *et al.* 1988). In many cases condition indicators are specialists and by choosing a set of specialists as indicators, this will conserve habitat for generalists as well. McLaren *et al.* (1998) recommended choosing a number of specialists that represent different habitats, seral stages, different types of structure within forest (e.g., upper, middle, lower canopy, snags).

Table 1. Focal Species Definitions [1]

Type	Synonyms	Definition
Focal	Surrogate	- small number of species whose distributions and abundances are well known; used in conservation planning; assumed to reflect the distribution and abundance of the regional biota; subsumes indicators and umbrella species
Indicators	Management indicators (MIS)	- groups of species or species habitat elements that focus management attention on resource production, population recovery, population viability or ecosystem diversity
a) Population indicators		- species that reflect the dynamics or presence/absence of other species (e.g., species x is always associated with species y and z and population dynamics of species x is the same as in y and z)
b) Guild indicators	Biological, taxon-based	- species that represent other species in the guild (e.g., downy woodpecker chosen to represent all primary cavity nesters)
c) Condition indicators	Health indicators, bio-indicators, sensitive species, sentinel species	- species that are sensitive to stressors in the environment or that have habitat requirements that might be threatened by management activities - sometimes invasive species are used as indicators of anthropogenic stress (e.g., exotic plant species)
d) biodiversity indicators		- species or taxal groups that represent areas of high species richness of other taxal groups (e.g., hot spots of bird species richness overlapping centers of butterfly species richness)
e) composition indicators	Ecological, environmental, structure-based	- species that represent particular habitat types or elements (e.g., Spotted owl representing old growth forest)
Species-at-risk	Recovery species	- species that are threatened, endangered or rare (e.g., Woodland caribou)
Featured species	Special management species	- species with social or economic value (e.g., moose)
Umbrella species	Coarse-filter species	- species with large area requirements. Conservation of these species should automatically conserve a host of other species - e.g., grizzly bear
Keystone species		- species that have an effect on many other species in an ecosystem disproportionate to their abundance or biomass - can be predators, prey, plants, mutualists and habitat modifiers (e.g., beaver)
Flagship species		- charismatic species, usually threatened, used to rally public support for conservation (e.g., Peregrine falcon, Woodland caribou)

1 Compiled from: Landres et al. (1988), Mills et al. (1993), Simberloff (1998), Caro and O'Doherty (1999), Andelman & Fagan (2000) Zacharias & Roff (2001), and Lindenmayer et al. (2000).



Some authors (Landres *et al.* 1988) suggested that large species make better indicators because they have slower turnover and are more stable and their population changes are directly related to environmental change (as opposed to over and undershooting carrying capacity like some r-selected species). However, others (e.g., Caro & O'Doherty 1999) argue that indicators should be small species as they can respond faster to environmental change. Given that large and small species operate on different spatial and temporal scales, both should probably be included (McLaren *et al.* 1998). They also suggested that sets of indicators should include species representing all trophic levels.

Resident species are likely to be more sensitive as they are in the habitat year round. Good indicators should be abundant and widespread within specific habitats and exhibit low temporal and spatial variability to enable ease of census (Dufrene & Legendre 1997). In addition, species that show low variation over individuals within a population are useful so one can extrapolate from a few individuals to the population. Finally, species that are mobile and hence can integrate disturbance over larger areas should make good indictors of processes that occur over larger spatial scales (Landres *et al.* 1988, Caro & O'Doherty 1999).

Biodiversity indicators: The presence of biodiversity indicators must indicate areas of high species richness either within the same taxon or across taxa. They should have well known taxonomy and biology and have a wide geographic range (Pearson 1994).

Species-at-risk

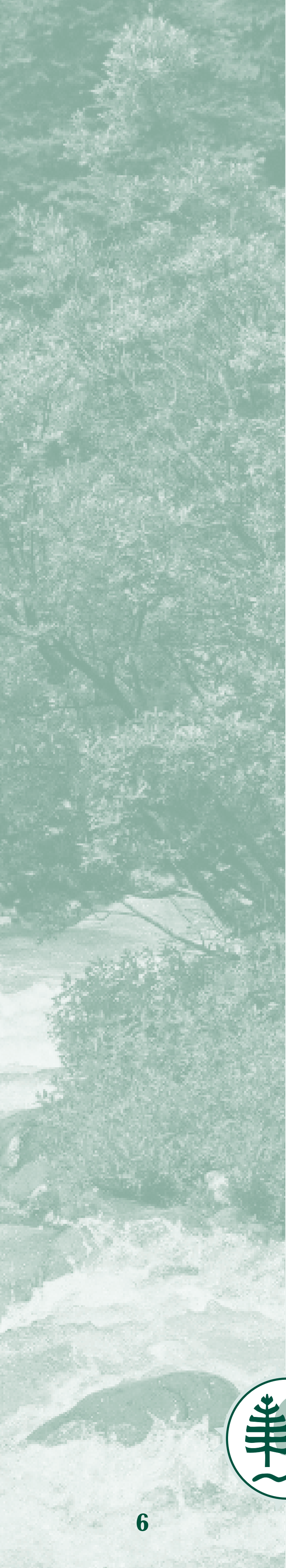
Species-at-risk are those species listed as threatened or endangered by federal and provincial wildlife agencies.

Umbrella species

The following criteria for umbrella species were compiled from Lambeck (1997), Noss (1999), Caro & O'Doherty (1999), and Fleishman *et al.* (2000). Umbrella species are generally large species, with large home ranges whose minimum area requirements encompass those of the rest of the community (area-limited). Similar to indicators, they should be non-migratory, exhibit low temporal variation and be relatively abundant (i.e., not so rare that you can't monitor them) with a large geographic distribution (for ease of monitoring, generality of use). Lambeck (1997) suggested that umbrellas should be process-limited species (e.g., fire-dependent, insect outbreaks, flooding) or species that are dispersal-limited or resource-limited (e.g., cavities) since supplying the habitats for these species should then supply habitat for species with less specialized habitat requirements.

Keystone species

Keystone species are those whose presence or activities support a large number of other species in the community (e.g., primary cavity nesters, herbivorous insects that outbreak). Hence keystone species may also be good umbrella species.



Other general criteria for selection of focal species

Other criteria mentioned by authors include species that are easy and cost-effective to census, are distributed so that statistically valid tests can be made of changes in abundance/distribution, have potential economic importance (to ensure buy-in from the public, decision makers), are species for which the management area has high responsibility and, in the forestry context, have the potential to be used at an operational or planning scales by foresters and focus on environmental conditions that can be controlled by foresters (Pearson 1994, Noss 1999, Caro & O'Doherty 1999, Kneeshaw *et al.* 2000a).

Major criticisms of the focal species approach

Criticisms of focal species' choice

Many indicator species are chosen based on socioeconomic criteria (charismatic, high public interest, high economic value; Landres *et al.* 1988, Simberloff 1998). For example, large carnivores (e.g., Noss *et al.* 1996) or raptors (Thiollay 1996) are often chosen as umbrellas, but many of these species are quite adaptable and can live in human-modified habitats if they are not persecuted (e.g., bears in managed forests of Scandinavia; Linnell *et al.* 2000; raptors in developed areas in Baja; Rodriguez-Estrella *et al.* 1998). These species may not be an umbrella or an indicator of any other species and are often very expensive to manage (Simberloff 1998).

The majority of indicators are vertebrates and several studies have shown that they are not good umbrellas or indicators for invertebrates or plants (e.g., Oliver *et al.* 1998, Lawton *et al.* 1998, Fleishman *et al.* 2000; but see Pearson & Cassola 1992). Murphy *et al.* (1990) criticized the use of vertebrates as indicators because they are long-lived, have low rates of population increase, long generation times, and low habitat specificity when compared with invertebrates and hence are unlikely to represent population changes in this group.

A number of studies criticized the use of a single focal species, however it is not clear how many indicators are "enough" to represent the whole community. Hutto (1998) suggested using "indicator species survey groups". These are groups of species that can be easily censused using a single survey technique, for example terrestrial birds using point counts. In addition, combining multiple focal species into an index, such as the approach by Karr and Chu (1997), should be used with caution since the same absolute values of an index for two different systems could represent very different attributes of community structure (Simberloff 1998).

Criticism of using keystone species

Simberloff (1998) presented a critique on the focal species approach and advocated that use of keystones species was preferable since they interacted with a large number of other community members. However, others have questioned the efficacy of using keystones. First, it is not clear if all ecosystems have keystone species and the experiments required to identify keystones are difficult (Mills *et al.* 1993). Secondly, once a keystone has been identified in one place, it may not be a keystone in another area (Power *et al.* 1996). Third, the operational definition of a keystone is not clear (i.e., how many species does the removal of species x cause to decline in order to qualify species x to be a keystone?). It may be more important to document the strengths of interactions among species in communities and identify "strong interactors" (Mills *et al.* 1993) rather than defining a species as a keystone or not. Power *et al.* (1996) suggested a measure called "community importance", but again, this would be difficult to quantify without performing experiments. Another difficulty is that it is impossible to use species life history traits to identify keystones a *priori* (Power *et al.* 1996). However, Paine (1995) argued that using the keystone approach was important because it emphasizes ecological interactions and uses a multi-species approach.

Lack of research

One of the major criticisms of using focal species in conservation and management has been that practitioners have not tested the assumptions of the indicator species approach. There is a lack of research into whether the habitat quality for an indicator indicates habitat quality for other taxa. This assumption seems unlikely, due to the complexity of ecological systems (Simberloff 1998). Another complicating factor is that density of a species may not necessarily be a good index of habitat quality (van Horne 1983) and most approaches using indicators only examine their abundance.

Indicators often don't work

Of the studies that have examined the efficacy of indicators, most have found either that randomly selected species are just as good as "indicators" in representing population trends and biodiversity hotspots of other species as those chosen by other criteria or that indicators and umbrellas did not protect other species or taxal groups (e.g., Niemi et al 1997, Oliver *et al.* 1998, Lawton *et al.* 1998, Hutto 1998, Ricketts *et al.* 1999, Andelman and Fagan 2000, Fleishman *et al.* 2000, Fleishman *et al.* 2001; but see Pearson and Cassola 1992, Noss *et al.* 1996, Mikusinski *et al.* 2001, Watson *et al.* 2001 for exceptions).

Foresters cannot control all land use activities

Choosing focal species that have the potential to be used at an operational scale and that focus on conditions that can be controlled by foresters (Kneeshaw *et al.* 2000a) is problematic. Often foresters cannot control all the land use activities on their forestry management area, such as hunting and oil and gas activities, which may negatively affect the focal species. For example, **Rempel** *et al.* (1997) noted that the application of "Moose Habitat Guidelines" for forest harvesting in Ontario did not increase moose populations as expected because of ingress of hunters on logging roads.

Repercussions of choosing the wrong focal species

A major problem of choosing the wrong focal species is that managing the habitat for the focal species may result in the loss or decline of other species in the area that require different habitat elements (Simberloff 1998). For example, harvest planning that uses focal species is usually highly prescriptive in terms of habitat elements to be left on cutblocks (e.g., see Watt *et al.* 1996 for Ontario). Essentially, this will reduce the variation in habitat and could cause declines in other species.

In addition, many of the forest management guidelines for focal species management have been derived from Habitat Suitability Index (HSI) models. These models are often derived from data from other geographical areas from where they will be applied and most HSI models have not been tested in the field.

4. Summary of SFMN projects dealing with focal species

One of our objectives was to review completed SFMN projects that focused on compositional elements of biodiversity (single species, species groups) to determine which species or groups were chosen, why they were chosen and what the results of the research were with respect to management recommendations for industry. In other words, could any of this research be used to plan harvest patterns or silvicultural treatments using a focal species approach.

Methods:
We searched the SFMN database using available keywords (Table 2) for research on single species or species groups. We then used the search results to find other related projects and publications within the database. We examined project reports, final project reports, published papers, theses and abstracts from SFMN conference proceedings. Searching the SFMN database was difficult and inefficient because only preset keywords could be used. For example, we could not search for highly appropriate keywords such as "focal", "keystone", or "fine-filter". Hence, it is likely that some projects may have been missed. In addition, various reports, theses and publications may have been part of one project, but because the project number was not given, it was quite confusing and hence there may be some double-listing of projects. Some investigators listed publications as funded by SFMN in their project reports, but in these publications SFMN was not acknowledged as a funder. This again led to confusion as what exactly SFMN funded.

Table 2. Keywords used to search the SFMN database

indicator	fish
bear	frog
beetle	insect
bird	mammal
bison	moose
budworm	rodent
butterfly	spruce budworm
caribou	tent caterpillar
caterpillar	weasel
deer	woodpecker
elk	

Results:
We reviewed 40 projects that dealt in some way with focal species or groups, fine-filter or single species (Appendix 1). The majority of the projects assessed whether a particular species or group of species was sensitive to forest change due to logging (*condition indicators*). In most cases, some rationale was given as to why the focal species was chosen (see Table 3, page 10) and in general these rationales were based on ecological criteria. However, few gave rationales as to why the taxal group they chose was important (for example, why should small mammals be better indicators than spiders?). In addition, no studies examined whether the species or group chosen indicated other groups (*population indicators or biodiversity indicators*). Four studies focused on development of indicators for sustainable forestry and six conducted modeling exercises (to determine habitat supply for vertebrates under various harvest scenarios; habitat models, and biomonitoring design).

Fourteen of the field projects focused on birds, 5 on small mammals (squirrels, murid rodents), 2 on mustelids (short-tailed weasel, marten), one on moose, 4 on invertebrates (forest tent caterpillars, spiders, carabids, bark beetles, arthropod assemblages), one on plants, and one on fish and benthic communities (Appendix 1). Only 3 projects used multiple taxal groups. This breakdown of studies by taxal group is indicative of the amount of funding provided by the SFMN in years 1-7 of the program (Fig. 1, B. McNab, personal communication). While noteworthy in departing from a sole emphasis on vertebrate focal species, there is still a major discrepancy between funding allocated by taxal group and the actual taxal diversity in Alberta forests (Fig. 1). Clearly more studies on plants and invertebrates should be undertaken.

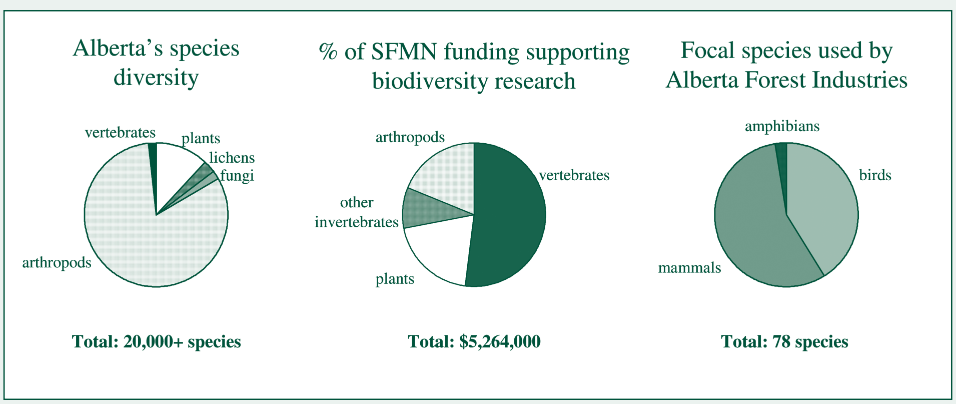


Fig. 1. Representation of different terrestrial taxal groups in Alberta species' diversity (http://www3.gov.ab.ca/env/resedu/biodiversity/biodiversityreport.pdf), research funded by SFMN over the first seven years and focal species chosen by Alberta industry.

Table 3. Summary of rationales given for choice of focal species in SFMN projects

Species or group	Rationale for choice
Forest birds	Compose 70% of vertebrates in forest, react to changes in stand and landscape due to forestry, easy to monitor, insectivorous so important in food chain, biology well known, may regulate insect populations, have diverse habitat requirements hence can reflect forest change at different scales and of different types, short generation time so fast response to disturbance, public likes them, reproductive success may be impacted due to fragmentation and influx of predators.
Cavity nesting birds	Sensitive to changes in availability of snags, primary cavity nesters keystone species in providing cavities for other cavity nesters,
Pileated woodpecker	Needs older forest and large diameter snags for nesting
Barred owl	Old-forest interior obligate, sensitive to fragmentation
Black-backed/Three-toed woodpecker	Old-growth and burn-dependent, habitat modifiers, insect control, sensitive to salvage logging, and forestry that reduces fires and old growth
Ovenbird	Requires open understory with leaf litter under closed canopy forest, sensitive to fragmentation, common, sensitive to opening canopy
Black-throated blue warbler	Possibly sensitive to fragmentation, common, easy to find nests and hence determine reproductive success, respond to selection cuts
Small mammals (voles, mice)	Small, easily trapped, operate on scale relevant to forestry, residents, common, important ecological roles (prey, eat inverts, disperse seeds and micro fungi, aerate soil) esp red-backed vole, require CWD
Red squirrel	Conifer specialist, spatial scale relevant to forestry
Marten	Indicator of old growth, umbrella species
Black bear	Economic importance, susceptible to increased access provided by forestry roads
Caribou	Rare/threatened species
Scolytid bark beetles	Dispersal limited, Sensitive to low impact harvesting such as thinning
Caribidae and Staphylinidae	Relatively stable taxonomically, easily captured, sensitive environmental change, have a range of trophic roles, range of dispersal capabilities, sensitive to removal of CWD
Forest tent caterpillar	Outbreaks occur at similar scales to forest mgt, outbreaks sensitive to changes in forest and landscape structure, most abundant animal in boreal forest during outbreak, affect growth of aspen trees
Spiders	Inverts comprise 80% of global biodiversity, vital to ecosystem function, important as predators, sensitive to changes in habitat, life history well known, abundant, widely distributed
Invasive plant species	Can alter the natural character of ecosystems, indicators of human disturbance
Boreal forest plants	Important in structure and function of boreal forest

The majority of the final reports, publications and/or theses gave management recommendations or implications of their studies (see Table 4, pages 12 – 14). These varied greatly in detail, but in most cases the recommendations were vague and although suggesting what elements or seral stages to leave or manipulate (e.g., downed woody material, old growth forest) they did not specify how much should be left, where it should be left and what the spatial configuration should be. In addition, recommendations for management actions for some groups contradicted those of other groups. For example, Buddle *et al.* (2000) and Lisgo (1999) recommended leaving coarse woody material on blocks to retain spiders and weasels respectively, whereas Hindmarch and Reid (1999) advocated removing coarse woody debris to prevent bark beetle outbreaks. Overall, it would be very difficult for forest managers to implement these recommendations for forest harvest planning because of their vague or contradictory nature.

5. Summary of Forest Management Plans of Alberta industries

Our goal was review forest management plans of Alberta industries to determine what their approach was to biodiversity retention on their management areas, whether they used a focal species approach and if so, whether they used focal species for planning or for monitoring.

Methods

We examined the current forest management plans of 14 Alberta forestry companies (Appendix 2). If we had questions about the plans, we followed up with phone calls to the companies.

Results

Ten companies included a focal species approach along with a coarse filter management strategy, however the focal species chosen and the rationale for choosing them differed widely among companies (Appendix 3). Most companies did not provide an ecological rationale for choice of focal species and none of the companies tested the assumptions of using indicator and/or umbrella species. The most detailed rationales and ecological criteria for choice of focal species were given by Weldwood and Millar Western.

Most companies chose only one or two species for fine-filter management, usually species of concern such as caribou or those of economic/social significance such as moose, elk or marten. Only Millar Western, Alpac and Weldwood chose a suite of species. Few companies used amphibians as indicators, despite their known sensitivity to environmental change and no companies used indicators other than vertebrates despite the low representation of vertebrates in Alberta's biodiversity (Fig. 1). Millar Western indicated that the use of invertebrates as indicators would be investigated for the future. Only a few keystone species were chosen (primary cavity nesters, beavers).

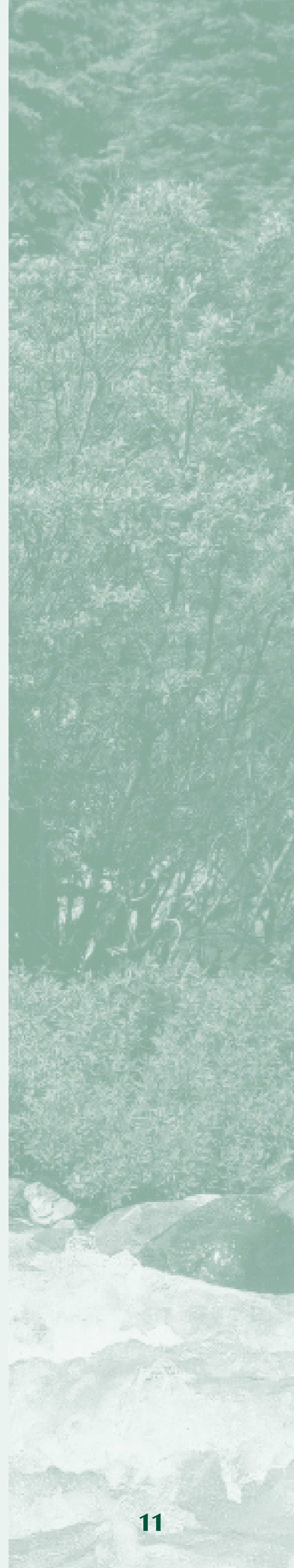


Table 4. Management recommendations provided in project reports, theses and publications from SFMN funded research on biodiversity.

Focal species/group	Management recommendations	Authors
Cavity nesting birds		
Black-backed and Three-toed woodpeckers, conifer, AB	Prescriptive at stand level; during salvage logging leave trees with large dbh; density of trees, burn level; Unknown at landscape level	Hoyt 2000
Three-toed woodpeckers, conifer, QC	Leave old growth coniferous forests, but amount unknown	Imbeau & Desrochers 2002
Primary cavity nesting woodpeckers, BC	Retain large (size not given) wildlife tree patches in both riparian and upland habitats, within patches retain range of tree diameters, gives minimum dbh's for each tree species, include as many snags as possible, retain stand level tree diversity, retain trees with endemic insect damage	Zimmerman 1998
Barred Owls, boreal mixedwood, AB	Leave patches of old growth *Populus* trees, leave patches of younger trees for future snag recruitment, Size and spatial arrangement of patches unknown; leave large areas of uncut old growth forest or have extended rotations (100yr) on some stands (size unknown)	Olsen 1999
Songbird communities		
Edge effects/stand structure, boreal mixedwood, AB	Don't need to worry about creating edge, but more study is needed; retain current range of stand age and stand composition on landscape (including conifer in mixedwood)	Song 1998
Stand vs landscape structure, boreal mixedwood, AB	Landscape composition should be taken into account during forest planning (details not given), old growth forest should be maintained, some burned areas should be maintained without salvage logging (sizes not given)	Hannon 1999
Landscape disturbances, boreal mixedwood, QC	Stand- use silvicultural treatments to mimic natural successional pathways of forest; Landscape- retain proportion of deciduous, mixed and coniferous stands similar to natural patterns; retain large (size not given) tracts of unharvested forest	Drapeau & Giroux 1999; Drapeau et al. 2000
Stand structure, black spruce, QC	Stand- maintain structures from all age classes of forests within natural range of variability	Drapeau et al. 1999

Focal species/group	Management recommendations	Authors
Moderate vs intense timber harvest, hardwoods, NB	Maintain relatively large (size not given) blocks of mature closed canopy forest, reduce areas planted to conifer and allow natural regeneration to take place, increase distance or time between selection cuts (distance and times not given), protect large diameter trees (especially sugar maple) for Pileated woodpeckers, maintain minimum of 60% mature forest in FMU (dispersion not given)	Villard 2000 Bourque and Villard 2001
Effects of clearcutting in black spruce, QC	Lateral visual obstruction is higher in riparian than non-riparian strips, so put leave strips between clearcuts in riparian zone. Riparian and non-riparian strips as well as 20-ha blocks of forest in landscapes dominated by clearcuts cannot maintain some forest bird species, (e.g., bay-breasted warbler). Need to maintain large forest tracts (>1 km^2) in forest management units. At the stand scale, variable retention harvesting should be encouraged. Bay-breasted warbler and golden-crowned kinglet would be good indicators of mature or old growth stages.	Darveau et al 1999, 2000; Boulet et al. 2000
Bird habitat models, boreal mixedwood, AB	Harvest models project reduction in amount and size of old growth forest; leave large contiguous reserves of old forest (size not given)	Schmiegelow & Beck 2001
Small mammals		
Red squirrels, effects of landscape structure, boreal mixedwood, AB	Harvest planning should occur on the landscape level, but no details given on how this should be done	Fisher 1999
Red-back voles, deer mice, effects of landscape structure, boreal mixedwood, AB	Harvesting not problematic for these species, at least at the levels in this study (9%)	Corkum 1999
Red-backed voles, deer mice, short-tailed shrews, woodland jumping mice; hardwoods, NB	Most species robust to forest management activities, in intensively harvested areas red-backed vole abundance related to amount of highly decayed logs; retain coarse woody debris (no amounts given); reduce softwood plantations (no area given)	Bowman 2000 Bowman et al. 2000 Bowman et al. 2001
Red-backed voles, other forest floor small mammals, stand-thinning, lodgepole pine, BC	Thinning accelerates development of old growth characteristics, maintain variety of stand treatments, seral stages, species and structures across landscape.	Sullivan et al. 2001
Logging effects on Short-tailed weasel, boreal mixedwood, AB	Retain slash and standing trees in cutblocks, 6% of cutblock should have slash retained in a linear pattern on haul roads and spurs, cutblocks should not exceed 1000m in width, retain conifer stands	Lisgo 1999

Table 4. (Cont'd)

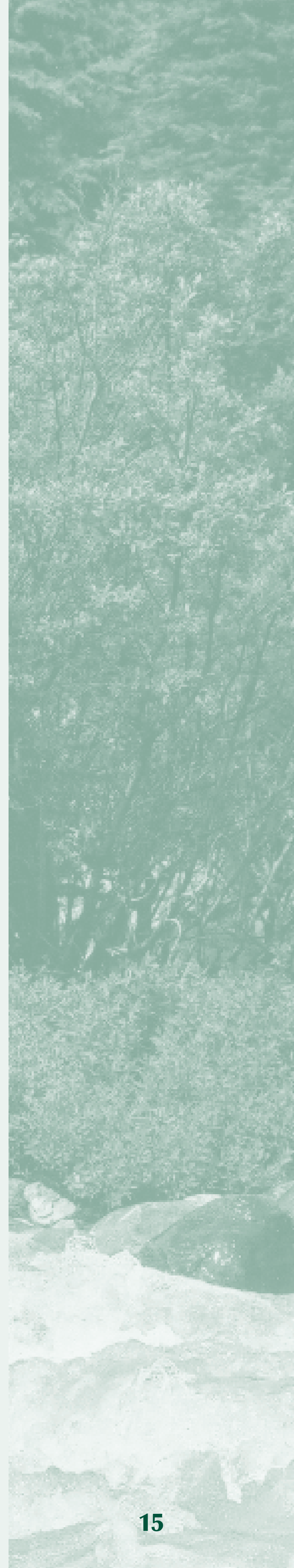
Focal species/group	Management recommendations	Authors
	of at least 35ha less than 1250 m apart	
Ungulates		
Moose, evaluate Ont. Moose habitat guidelines for timber harvest	Don't use moose guidelines, emulate natural disturbances; details not given	Rempel et al. 1997
Invertebrates		
Forest tent caterpillar, forest fragmentation effects, aspen, AB	Forest fragmentation increases duration and amplitude of outbreaks, leave areas should be at least 850m on a side, remove small forest blocks adjacent to large ones, make edge to area ratios of leave areas as small as possible	Roland 2000
Effect of commercial thinning on bark beetles, lodgepole pine, AB	Remove downed woody debris, control amount of large woody debris, reduce number of trees removed during thinning	Hindmarch & Reid 1999
Forest management and spiders, boreal mixedwood, AB	Leave downed woody debris following harvest with varying amounts of bark, elevated and at ground level (amount and state not given); spider communities converge in post-fire and post-logged forests after 30yrs, fire origin stands more diverse spider assemblages and some species only found after fires,	Buddle et al. 2000; Buddle 2001a,b
Fire residuals as habitat for Coleoptera, conifer, AB	Leave a range of different sized forest patches; location, size, structure, ages similar to fire skips	Gandhi 1999 Gandhi et al. 2001

Most companies do not use focal species to plan timber harvest over their whole forest management areas (FMA's). Rather they use them for monitoring the impacts of coarse filter ecosystem management (e.g., Alpac, Diashowa-Marubeni). Millar Western and Weldwood chose a suite of focal species and then ran simulations of different landscape harvesting patterns over time within the constraints of the AAC to determine whether timber supply forecasts also supplied habitat for the focal species (habitat supply models based on HSI). Some "best practices" were derived for focal species at the stand scale, such as leaving coarse woody material or residual trees on cutblocks (Millar Western). Some forest planning is done in special management areas for species of concern such as mountain goats, trumpeter swans and caribou (e.g., Weyerhaeuser, Weldwood) or for species of economic or social significance (e.g., moose, Slave Lake Pulp) (see details in Appendix 3). These latter plans are quite prescriptive and are targeted at single species.

6. Evaluation of the use of focal species for forest harvest planning

Kneeshaw *et al.* (2000a) defined two types of indicators used in forest management: 1) prescriptive indicators used in harvest planning and 2) evaluative or environmental indicators used for monitoring and adaptive management, to verify whether the targets determined in planning have been achieved. Their prescriptive indicators were not focal species based and related to maintaining patterns of natural variability at the stand and landscape levels. Only the evaluative indicators were focal species. For example, a planning indicator might be to maintain forest age class distribution similar to that produced by natural disturbance and the evaluative indicator would use species presence/absence to verify that all species have been maintained.

Harvest planning should include the following elements: tree species composition, seral stage distribution, structural elements left within cutblocks, silvicultural treatments, cutblock size distribution, unharvested or protected area size distribution, connectedness of unharvested forest, and adjacency and configuration of harvested and unharvested blocks. Lambeck (1997) suggested that the use of focal species as prescriptive indicators in landscape planning required identifying the species that were most limited (e.g., dispersal limited, element limited, area-limited, seral stage limited) and then planning for these species. For example, the species with the largest area requirements would define the minimum patch size, the species that was the poorest disperser would define the isolation of patches or the level of connectedness, species that were resource-limited would define stand level retention of those resources (e.g., snags, large diameter trees) and species that were the most process-limited would define silvicultural treatments (e.g., burn dependent species might require prescribed burns). Population viability analysis (PVA) would have to be conducted to ensure that enough suitable habitat is maintained over the long-term. However, we are limited by a lack of data on habitat requirements and habitat threshold levels for most species and on demographic data for constructing PVA's (e.g., reproductive



rates in different habitats, dispersal distances and habitats, mortality rates in different habitats etc.). Lindenmeyer *et al.* (2002) criticized Lambeck's approach as being non-operational in a planning sense.

As outlined earlier in the report, the use of focal species in both planning and monitoring has been criticized. However, we conclude that the use of focal species in harvest planning is particularly problematic. If our goal is to maintain the full biodiversity in managed landscapes, then planning for a restricted set of focal species will be unlikely to achieve this. Timber harvesting plans that use a focal species approach tend to be very prescriptive (e.g., Watt *et al.* 1996; Naylor *et al.* 1996). Hence fairly rigid rules about canopy cover, coarse woody debris etc are given. This will reduce variability in those attributes and the forest will be managed for marten or pileated woodpeckers, not necessarily any other species. Most of these efforts are based on HSI models, many of which are not verified for the area of interest, hence the prescriptions may not be relevant to the planning area.

Because of the limitations in using the focal species approach for harvest planning, we do not recommend that it be used in a strictly prescriptive sense, with the possible exception of managing for species-at-risk. Hence, we have not completed Objective c (above). However, because we know that logging does not completely emulate natural disturbances, we do advocate that suites of focal species could be used to determine lower thresholds for critical stand and landscape features. These thresholds would have to be determined using species that are most sensitive to stand or landscape change (i.e. as per Lambeck 1997), that operate on various spatial scales (microsite to landscape) and that represent different trophic levels and guilds in the ecosystem.

7. Alternatives and Future Research

The shortcomings in the focal species approach for harvest planning has lead to the popularity of ecosystem management based on a natural disturbance paradigm (e.g., Hunter 1993). Lindenmeyer *et al.* (2000) proposed the use of structural indicators such as stand complexity and plant species composition, level of connectivity, and landscape heterogeneity patterned after natural disturbances. Lindenmayer and Franklin (1997) advocated a variety of approaches, implemented at different spatial scales, in order to spread the risk of species loss. They emphasized the need for protected areas and, within the managed landscape, the protection of sensitive (i.e. those that are not resilient to anthropogenic change) habitats. At the stand scale they advocated leaving elements such as snags, logs, large live trees, and understory plants. However, as outlined at the beginning of this document, logging does not fully emulate natural disturbances and hence a coarse-filter approach alone is not sufficient.

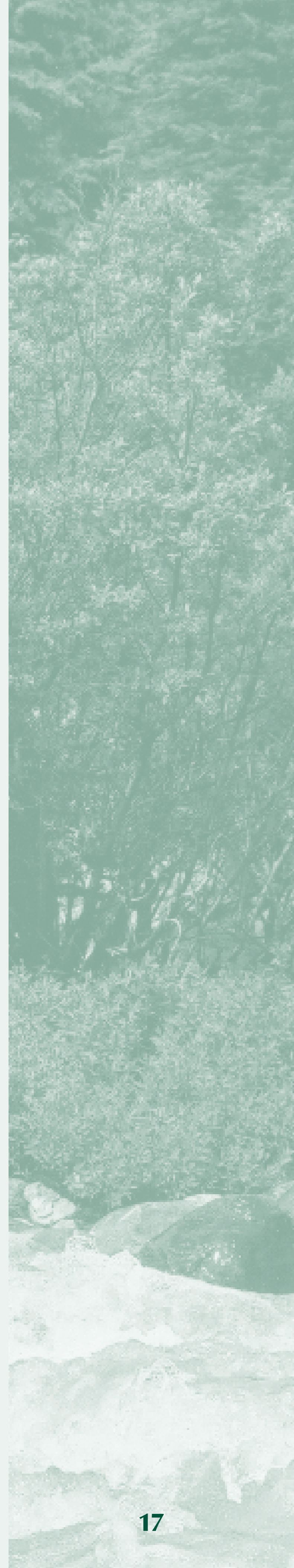
Despite the huge amount of funding provided by the SFMN for research on biodiversity and single species, few of these studies provide concrete prescriptions for habitat needs for the species, nor do any determine threshold responses by focal species (although current research in the Biodiversity group is addressing this for birds and mammals). Similar to much of the forestry/wildlife research (e.g., see Sallabanks *et al.* 2000, Marzluff *et al.* 2000), SFMN studies have focused on examining the impacts of current forestry practices on wildlife. Generally, studies have focused on impacts on abundance and not on population processes and have been short-term. Hence, the conclusions are either that timber harvest is beneficial, detrimental or neutral in its effect on wildlife, without providing insight to the mechanisms of how harvest has impacted populations. A preferable approach is to experimentally vary the element of interest (e.g., amount of conifer, number of snags etc) over a biologically relevant range and then measure wildlife response in terms of abundance, reproductive success and mortality. Current SFMN research, such as EMEND (Spence *et al.* 1999), uses this approach.

Given the limitations of both ecosystem management and the use of indicator species, we suggest a blended approach as follows:

1. Compare landscapes that have undergone natural disturbance with those that have been logged. Identify which seral stages, habitats and elements are likely to be missing or reduced in managed landscapes. Retrospective studies will be necessary (e.g., Hobson and Schieck 1999). SFMN research and other research in the boreal forest have already identified some of these seral stages and elements (Cumming et al 1994, Lee *et al.* 1997, Schieck *et al.* 1995, Spence *et al.* 1996, Hobson and Schieck 1999, Imbeau *et al.* 1999, Schmiegelow and Beck 2001): old growth forest, non-salvage logged burns, mixedwood, and snags and downed woody material.

2. In the habitats/elements identified above, document relationships between structural elements in the stands, tree species composition and wildlife species abundances across a range of conditions and over a wide range of species, including invertebrates, in habitats where logging will occur. We recommend using indicator species survey groups (Hutto 1998; defined above under "Criticisms of focal species' choice"). Identify thresholds in habitat supply for species associated with these habitats/elements. This will allow managers to predict the outcomes of logging operations. If logging that attempts to emulate natural disturbances does not produce sufficient habitat, then provision of protected areas must be made. In order to determine how large protected areas should be, population modeling must be done on the species with high associations to the threatened habitat/element, hence information on their demography should be collected.

3. Do large-scale surveys across all habitat types in boreal forests and identify important habitat classes (covers) that have species restricted to them or are most abundant in them



(e.g., early post-fire stands). These surveys should be of species groups across a range of taxa. Ensure that forest management practices will not reduce the abundance, configuration or integrity of these habitats. For example, although an old aspen stand may not be logged, adjacent logging could impact the ability of organisms to colonize or persist in it (e.g. Hannon 1999). See Hutto and Young (1999) for an example of this approach.

4. In any use of indicator or focal species approaches, statistical tests must be made to determine whether those species indicate particular habitat types and whether they indicate changes in other taxa (see Niemi *et al.* 1997 for an example).

5. As emphasized above, much of the funded SFMN research and all of the focal species chosen by industry has been based on vertebrates. This is not reflective of the taxal diversity in the boreal forest. More studies on plants and invertebrates should be undertaken.

6. Research should be collaborative between industry and academics and be conducted by research teams on the same landscapes. Instead of funding individual researchers, which has lead to the taxal bias and piecemeal nature of the current research, research groups that tackle a set of high priority questions should be funded. Again, EMEND is an example of this approach.

7. If forest industries wish to continue using focal species they should attempt to adopt similar sets of indicators based on ecological criteria and monitor these focal species in the same way. This would allow for analysis of change in focal species at larger spatial scales.

8. The SFMN should adopt a better system (i.e., ProCite) for searching their data base which allows free use of keywords to search titles and abstracts of reports. In addition, it was difficult to assign some reports to a particular project, resulting in confusion. Each project should have a number that is listed in all reports, theses and publications. Graduate student publications should be listed under the supervisor's project number.

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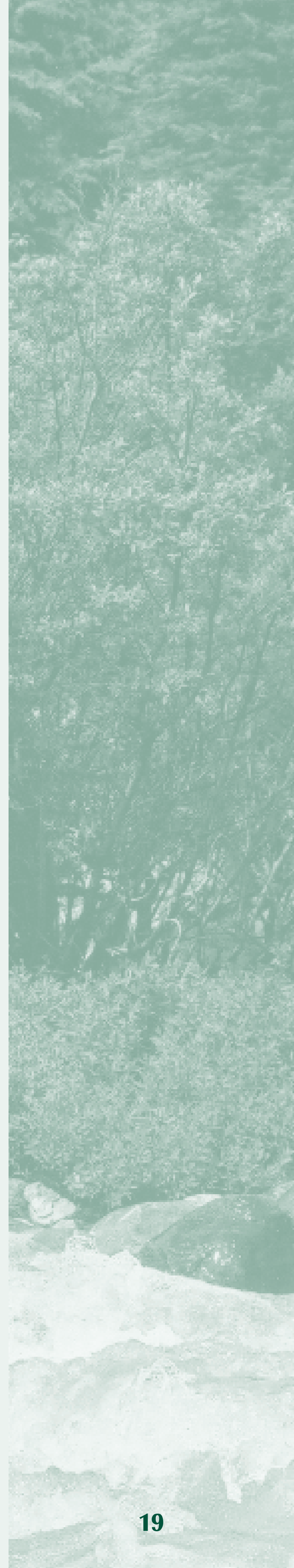

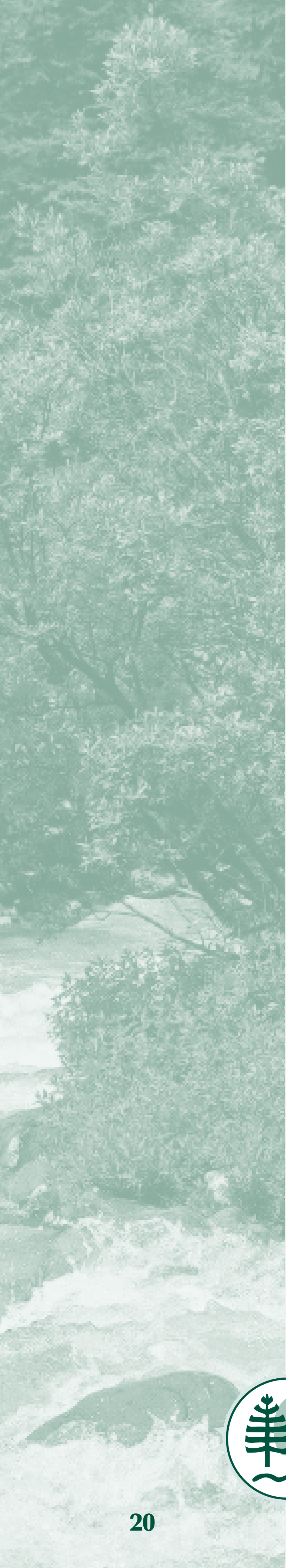

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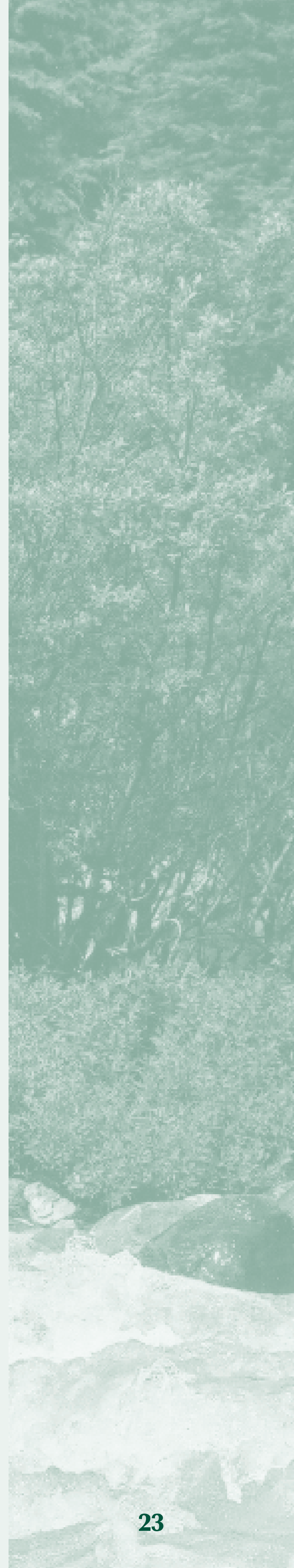

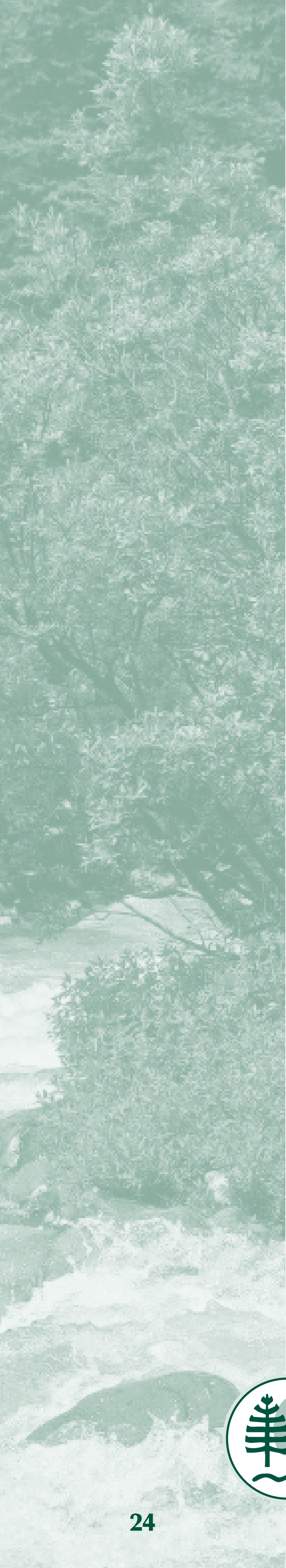

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Appendix 1. Summary of SFMN Projects on focal, single species or species groups.

Focal Species	**Kind of focal species**	Reference
Field research		
Bird communities	Condition indicators (effects of logging at stand and landscape levels)	Drapeau and Giroux 1999; Drapeau et al. 2000
Forest passerines, with data for 14 species	Condition indicators (effects of logging at stand and landscape levels)	Hannon 1999.
Forest passerines	Condition indicators (effect of edges)	Song 1998.
Black-throated Blue Warbler, Ovenbird	Condition indicators (logging intensity)	Bourque and Villard. 2001.
Bird communities, specifically the Bay-breasted Warbler	Condition indicators (clear cutting, provision of buffer strips)	Darveau et al. 1999. Darveau et al. 2000.
Nesting songbirds	Condition indicators (clear cutting, provision of buffer strips)	Boulet et al. 2000
Barred owl	Condition indicator (snags, old growth forest)	Olsen 1999.
Black-backed and Three-toed woodpeckers	Condition indicators (burns, old growth forest)	Hoyt 2000.
Pileated Woodpecker, Ovenbird	Condition indicators (logging intensity); population indicators (representative of forest birds in general- not tested) Looking for threshold responses in bird presence/abundance relative to silvicultural intensity	Villard, 2000; and Currently funded project (apr 2000)
Primary cavity nesters: Hairy Woodpecker, Three-toed Woodpecker, Black-backed Woodpecker, Pileated Woodpecker, Northern Flicker, Red-bellied Sapsucker, Red-breasted Nuthatch, Black-capped Chickadee, Boreal Chickadee	Keystone	Zimmerman 1998
Cavity nesting birds	Indicators sensitive to habitat change	Nappi et al. 1999.
Three-toed Woodpecker	Sensitive to habitat change	Imbeau and Desrochers 2002
Bird assemblages in general,	Sensitive to change in forest structure	Imbeau et al. 1999.

Focal Species	**Kind of focal species**	Reference
Black-backed Woodpecker, Three-toed woodpecker and Brown Creeper		
Cavity nesting birds	Condition indicators (logging, salvage logging)	Stepnisky and Schmiegelow 2001.
Mammals		
Moose	Condition indicator (moose management guidelines, clearcutting).	Rempel et al. 1997
Small mammal populations	Condition (forest management and spatial structure of small-mammal populations)	Bowman 2000 Bowman et al. 2000
Red-backed voles Deer Mouse	Condition (effects of logging at stand and landscape levels)	Corkum 1999
Forest floor small mammal communities, Red-backed Vole	Communities: indicators of change in forest structure Red-backed Vole: indicator of old growth forest conditions	Sullivan et al. 2001.
Red Squirrel	Condition indicators (effects of logging at stand and landscape levels)	Fisher 1999
Short-tailed Weasel	Condition (logging, amount of residual material in cutblocks)	Lisgo 1999
Marten	Indicator of old growth forest and umbrella species for all other taxonomic groups- testing this.	Sleep et al. 2001
Invertebrates		
Forest Tent Caterpillar	Condition indicators (forest integrity, fragmentation)	Roland, 2000.
Spiders	Sensitive to changes in habitat	Buddle 2001a
Epigaeic beetles – Carabidae and Staphylinidae	Potential “indicator taxa” sensitive to alteration of physical and chemical properties of forest soil and litter by wildfire and harvesting	Ghandi et al. 2001.
Scolytid Bark Beetles	Sensitive to changes in environment	Hindmarch and Reid 1999
Plants		
Various	Condition indicators (fragmentation) and population/biodiversity indicators	Gignac and Dale (in progress)
Multiple taxal groups		
1.vascular plants 2.non-vascular plants 3.invertebrates (carabid beetles)	Effects of logging on biodiversity that requires old growth forest and habitat elements such as coarse woody debris.	Drapeau et al. 1999.

Focal Species	**Kind of focal species**	Reference
4. vertebrates (songbirds)		
Arthropods Forest birds Bats plants	Condition indicators (residual material left after fire and logging)	EMEND –project spr98-mar01; Various projects
Moose Pitcher's thistle (cirsium pitcheri) Woodland Caribou Invasive plant species	Moose: indicator of small, upland conifer and mixedwood shrub at the landscape level Pitcher's thistle: threatened Caribou: vulnerable Invasive species: indicators of human disturbance	Promaine 1999
Development of indicators		
Landscape patterns, Forest bird communities	Development of indicators for sustainable forest management	Kneeshaw et al. 2000a. Kneeshaw et al. 2000b.
Various	Plan to develop and integrate indicators of sustainability at an operational level	Yamasaki et al (2001)
Vegetation patterns, traditional indicators	Indicators of biodiversity- combination of natural disturbance patterns and traditional indicators (abstract only)	Dye and Andison 2001
Fish and Benthic communities	Sensitivity to anthropogenic change (effluent in streams)	Kilgour et al. 2001
Modelling		
Terrestrial vertebrates	Harvest scenario modeling to support all terrestrial vertebrates (abstract only)	Higdon et al. 2001
Forest birds	Scenario modeling fire and logging and habitat supply for birds	Cumming et al. 2001
Vertebrates	Harvest scenario modeling with indicators (Biodiversity Assessment Project	Doyon and Duinker. project aug96-mar00; Doyon 2001
Various taxa including caribou	Habitat modeling, developing multi metric indices of ecological integrity, biomonitoring simulation model, land zonation issues and wildlife habitat	Schmiegelow, Beck and Adamowicz. project apr2000-present
Various forest passerines	Power analysis, biomonitoring design	Carlson 2000
Black-throated Green Warbler, Red-breasted Nuthatch, White-throated Sparrow, Yellow Warbler	Develop habitat models for birds at local and neighborhood scales, use of AVI data for modeling bird abundance	Schmiegelow and Beck. 2001, Vernier et al. 2000 (draft).

Appendix 2. Forest Management Plans reviewed

Alberta-Pacific's Detailed Forest Management Plan. Jan 1 2000.

Millar Western Whitecourt 2001-2006; phone call to Jonathan Russell May 8, 2002.

Weyerhaeuser Canada Slave Lake Forest Management Plan May 1, 1998.

Slave Lake Pulp Corp Detailed Forest Management Plan September 1998. Also conversation with Richard Briand at Alberta Plywood (where they have the woodlands division of Slave Lake Pulp) regarding their new plan. April 17, 2002.

Sundance Forest Industries Ltd. Detailed Forest Management Plan June 1999.

Weyerhaeuser Edson Detailed Forest Management Plan June 2001-2007.

Weyerhaeuser Grande Prairie/Grande Cache Detailed Forest Management Plan March 1999.

Alberta Newsprint Company Detailed Forest Management Plan October 2001.

Weldwood of Canada Ltd. 1999 Forest Management Plan. Management Strategy 1999-2008.

Diashowa-Marubeni International Ltd. Peace River Pulp Division Detailed Forest Management Plan 1999-2000.

Blue Ridge Lumber (1981) Ltd. Detailed Forest Management Plan September 1999.

Sunpine Forest Products Detailed Forest Management Plan November 1996.

Vanderwell Contractors (1971) Ltd. Preliminary Forest Management Plan DRAFT July 1998. NOTE (75% of their FMA was burnt in the Chisholm Burn, so they are currently putting together a new plan. This draft plan is from before the burn). Spoke to Darryl MacKay April 15, 2002 for update.

Tolko Industries Ltd. Phone call with Bob Boyce, April 11, 2002.

Canadian Forest Products Ltd (CANFOR). Phone call with Dwight Weeks, April 2002. FMP is in the pending approval process, so they don't want it referenced yet.

Appendix 3. Rationale for use of indicator species or groups by Alberta Forest Industries in their Forest Management plans (page numbers in brackets refer to page numbers in Forest Management plans).

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
Alpac	Ecosystem management in adaptive management framework • coarse filter (natural disturbance paradigm) • plus fine-filter and monitor indicator species	Yes, condition indicator species	Forest birds	Sensitive to forest fragmentation, some species declining (neotropical migrants), many species depend on boreal mixedwood for breeding habitat. 3 habitat elements: food type and abundance, nest site quality and availability, habitat area sensitivity (p41)
		Featured species	Furbearers- especially Fisher, Marten, Wolverine	Economic/social value for trappers, close association with old stands, susceptible to over harvest by trappers (increased forestry may increase access by trappers)
		Featured species Species-at-risk	Ungulates- especially Moose Woodland caribou	Value for viewing, hunting (subsistence and recreation); indicators of habitat fragmentation at large scales (e.g., caribou), relatively easy to monitor
Millar Western	Coarse filter via bioindicators of ecosystem diversity analyses and landscape configuration analyses. Fine filter via species-based	Yes, population and condition indicators, keystone	Habitat Supply Models on: Barred Owl Brown	Used 9 criteria to rank 76 vertebrate species that might be found on the FMA. Criteria (and weight for ranking): 1. Sensitivity to disturbance (4) 2. Species status (are they rare, vulnerable,

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
	Habitat Supply Models (HSMs) Sustainable forest management using adaptive management. Maintain biological diversity by maintaining ecosystem and species diversity, genetic diversity, and protection of rare and endangered species (maintain the range of natural variation).	species, species-at-risk, Featured species	Creeper Least Flycatcher Northern Goshawk Pileated Woodpecker Ruffed Grouse Spruce Grouse Three-toed Woodpecker Varied Thrush American Marten Canada Lynx Elk Moose Northern Flying Squirrel Snowshoe Hare Southern Red-backed Vole Woodland Caribou	threatened or endangered) (3) 3. Are they easily monitored (i.e., relatively common with entire home range contained in FMA area) (3) 4. Do they have specific requirements for particular habitats (2) 5. Do they use special habitat elements like snags, downed woody debris, arboreal lichens (2) 6. Are they functionally essential (i.e., do they have a substantial influence on the ecosystem, like top predators or large browsers) (2) 7. Are they expected to be sensitive to landscape composition and structure (2) 8. Are they hunted, trapped, viewed or photographed by local people (2) 9. Have they been studied extensively (so there is information available on them) (1) They then took into account taxonomic class, home range size, and information available for modelling and came up with 17 species to do Habitat Supply Models (HSM). Use the HSM to predict the suitability of the forest as habitat for each of the species while running simulations over time. Use Biodiversity Assessment Project (BAP) to continuously monitor success of the bioindicators
			Future: invertebrate	Can act as excellent biodiversity indicators – diverse and abundant, many are microhabitat

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
			communities	specialists and are sensitive to subtle changes; play critical roles in ecosystems; only a small number have been subjected to forest management activity in the past
			Future: amphibians	Have to assess presence/distribution of aquatic biota in the next 10 years
Weyerhaeuser Slave Lake	Integrated resource management guided by the framework provided by Integrated Resource Plans, which have been or will be developed for the region. Multiple use management (integrated resource management) including recreation, fisheries, wildlife, gas and oil exploration, grazing. Mgmt rights are "to establish, grow and harvest deciduous timber on the forest management area". P28 Will use FMA ground rules as the primary vehicle for addressing wildlife habitat protection. P32. They have some integrated resource plans for various areas that they will follow if they are consistent with the FMA management objectives.	No	Caribou (they don't say they are using it as an indicator, but rather that they are managing for it's presence.)	Portions of the FMA lie within areas identified by F&W as caribou range and so a site specific management strategy has been adopted in consultation with F&W. General development plan and Annual operating plan will detail. Most current caribou management info and strategies will be utilized. P32 Shoreline of Lesser Slave Lake may receive special management considerations and so harvest operations have been temporarily excluded within 400m of lakeshore.

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
	Will take into acct TROLS recommendations during future planning and operations.			
Slave Lake Pulp Corp	An adaptive approach to forest management planning is being adopted. p2 Protect biological diversity within an objective natural range of variability. "Strategies will be developed during the term of this plan to provide for forest sustainability through management of vegetation associations" Develop a deciduous growth and yield program which will predict and evaluate stand performance, regeneration and will monitor harvesting effects on other resources such as wildlife and watershed, on an ecoregion basis. p17 Develop a process to ensure that wildlife habitat diversity on the FMA is maintained and is adequate to support the range of existing species. p 19 Use special criteria or techniques	Not explicitly, but do mention big game, especially moose	Moose (again, they don't say they are using it as an indicator, but rather that they are managing for its presence)	Big game hunting is a popular and important public use of the landbase p61. Their objective in the general moose zone is to maintain or increase the diversity of vegetation and to maintain cover (hiding/thermal) in proximity to the abundant food supply created by harvesting. They will use the usual cutblock designs (line of sight, access management, 3-pass system, follow stand boundaries for cutblock edges), etc to manage for moose in certain areas. p65 Concentrating harvest operations in decadent, overmature aspen stands will create opportunities to improve habitat diversity and food production for many species, notably moose and deer. In their new plan they are not planning any single species management because they don't want to have "blinders" on and manage for one species at the expense of others (Richard Briand, pers comm.).

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
	found in the operating ground rules to maintain or enhance important species in areas that have key wildlife concerns. They recognize that habitat management zones and associated wildlife management guidelines are narrow in scope as they are intended for management of big game species (e.g., moose zone p 62), and they intend to revise as objectives and strategies are developed and implemented which plan for the maintenance of biodiversity. Until that time existing guidelines and ground rules will be used for the basis of management. Mention that old age class timber will be maintained an average of 10ha per sq mile for wildlife that depends on old age forest In their new plan, they will use coarse filter, maintaining successional stages over time, maintaining structure in cutblocks. Will have a monitoring/feedback plan in place to re-evaluate and adapt if			

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
	necessary (Richard Braind, pers comm.)			
Sundance Forest Industries Ltd	Pp56-58 Maintain natural range of variability in the forest landscape (maintain current distribution of ecosites by natural subregion; maintain appropriate % and area of age classes) Maintain a range of habitat types for forest-dependent species (protect rare and sensitive habitat types; maintain some structural attributes of the harvested forest within cutover areas – snag retention, unmerchantable patches) Coarse filter based on measuring forest landscapes and stands. Fine filter when an individual species has been shown to be at risk or representative of an important process. Used Habitat Suitability Indices models developed by Foothills Model Forest for Weldwood (adjacent to Sundance FMA).	Yes, condition indicator species (species that are representative of a habitat type) An ungulate, a fur-bearer and a bird selected in consultation with NRS, Sundance public advisory committee and Sundance technical committee.	Elk	Recreational importance of elk and it's need for a variety of ecosites
		Featured species	Marten	Economic importance, role as a predator, and it's need for a coniferous forest habitat
		Umbrella	Great Gray	Preference for wetlands and deciduous nesting

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
		species	Owl	sites, and it's role as a predator, dependent on the existence of prey species
Weyerhaeuser Grande Prairie/Grande Cache	Ecologically based forest management. Adaptive forest management – including monitoring to ensure that management objectives are met. Coarse filter at landscape and stand level combined with fine filter. Patch harvest with stand level retention. Mixedwood management – in conjunction with Ainsworth, they will maintain mixedwood forests. New idea for both companies and so will take some time to study and understand the processes. They chose 1946 as a reference date – predates effective fire suppression and significant logging. Hence the relative amounts of late stage (80+ 120+ and 140+) forest occurring on the landscape in 1946 can be used as initial targets in forest	Species-at-risk They say they are in the process of establishing what could serve as indicators (interim results available end of 1999) p. 3-A-18 Right now, specifically Woodland Caribou (there are 7 winter ranges on their FMA)	Woodland Caribou	Listed as endangered under Alberta wildlife act. Policy is to manage FMA to maintain a winter habitat configuration for caribou by integrating such configuration into both wood fibre planning and actual operations to harvest and deliver the fibre (p 3-B-5) This will be done by managing caribou habitat at the landscape level using a set of long-term management principles that will ensure and adequate flow of habitat thru time while providing a sustainable flow of wood from the entire range. They have 6 long-term habitat management principles, including large contiguous patches, adequate food, cover and travel corridors, soil disturbance and water quality, access, and adaptive management: 1. To maintain large contiguous patches, they will • Concentrate harvesting in one area at a time (100-1000ha) rather than the 2-3 pass system. • No harvesting in new contiguous areas until it has been finished in the previous areas. • In areas that have been previously

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
	management to address the habitat needs of old growth dependent species and to ensure the maintenance of forest ecosystem processes. P 3-A-4			fragmented by removal of first pass in traditional pattern, remaining passes should be harvested as quickly as possible without compromising other important values (i.e., water quality, fisheries, soils, aesthetics) • These new contiguous areas will regenerate as even-aged stands and will be spatially arranged so the remaining parts of the range are not isolate. 2. They consider good quality habitat to be stands older than 80-140yrs. They are using the 1946 age class structure as a reference and over their planning period of 240 yrs are retaining an adequate amt of such stands in each caribou range. 3. To maintain effective habitat (habitat used primarily for escape cover and travel corridors) across each caribou range they are assuming that effective habitat are stands that are >= 30 years of age. Their goal is to ensure that at least 80% of the range remains as effective habitat thru time. Based on professional judgment of Weyerhaeuser foresters after numerous seasons of observing caribou usage patterns. 4. Ensure all operating ground rules that pertain to soil disturbance, water quality, and utilization standards are followed

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
				5. Manage access – follow west central Alberta caribou standing committee access guidelines 6. Adaptive management – make changes as new info warrants; continuous monitoring to assess strategies against goals For caribou ranges that cross jurisdictional boundaries (2 of them cross boundaries between FMA holders), Weyerhaeuser will continue to work with these land managers and the LFS and NRS to develop joint plans for these ranges. They say that this approach will also be beneficial to other wildlife (i.e., marten, fisher, grizzly bears) that don't do well in fragmented landscapes and which also require large contiguous areas of forest p 3-B-12
Alberta Newsprint Company Timber Ltd	Adaptive Management Alberta Sustainable Resource development has developed 8 wildlife habitat types they will try to maintain. E.g., deciduous, young burnt, post rotation, riparian, caribou, grizzly, etc Emulation of natural disturbance patterns. Identify 8 habitat types and	Yes Species-at-risk	Woodland Caribou	They consider patches > =10ha and >80years of age to be caribou habitat (p4-42). Alberta sustainable resource development established a targeted minimum amount of caribou habitat within the caribou zone of the FMA. They can see maintaining this amount until year 180. But over time the larges patches become more fragmented, so there will be a greater number of smaller patches comprising more of the total habitat area at 100 and 180 years.

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
	maintain them. There is a section p2-58 to p2-67 that gives natural history info on at risk or sensitive species found in their area, but no info on what they plan to do about it. Same for rare plants (2-24 to 2-27)			
		Species-at-risk Flagship	Grizzly bear	Used models from Foothills model forest. They see a steady increase in the most suitable habitat areas over their planning horizon.
Weldwood	Intend to use a coarse filter approach based on emulating natural disturbance, with concurrent fine filter analysis to demonstrate that it works for individual species of interest. Look at fire disturbance patterns at meso scale as well as island remnants and disturbance in riparian corridors They assume coarse filter strategy will conserve most species, and they also use habitat supply analysis and specific "actions" designed to conserve site-specific habitats or species as fine filter components (p 6-17) Chose 30 species and ran H.S.I. models. Used these for habitat	Yes, Featured species, Flagship spp, Condition indictors, guild indicators, population indicators, Species-at-risk, Keystone species	30 species for Habitat Suitability Indices (from Foothills Model Forest). Specific conservation strategies developed for and agreed upon by IRMSC: • Woodland Caribou • Mountain Goat • Grizzly Bear	Criteria for species selection for H.S.I. models: 1. Economic importance (high social interest or economic value) • Species-at-risk • Important species for consumptive use (hunting, trapping) • Important species for non-consumptive use (wildlife viewing) 2. Ecological Importance • Species associated with particular stages of ecological succession • Species associated with special habitat elements such as snags, downed wood, etc. • Species that represent groups of species which utilize a common resource (eg cavity-users) • Species with strong associations with specific forest ecosystems and successional stages

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
	supply analysis on the Weldwood two/three pass system for all 30 species. Showed "relatively stable habitat supply at the FMA scale for all species over the 180 year forecast period….Overall the assessment indicated that there are no habitat supply bottlenecks at the FMA scale for any of the modeled species' habitats." pg 6-17 online A Biodiversity Conservation Strategy is proposed to be developed through the Integrated Resource Management Steering Committee (IRMSC) (govt and industry cooperating). This will be done for the FMA over the period of the FHP. pg 6-8 online		• Trumpeter Swan • Northern Long-eared Bat • Columbia Spotted Frog • Black-throated Green Warbler • Fish species	• Species whose responses to habitat changes reflect responses of other species • Species with a narrow range of ecological tolerance • Species with anticipated sensitivities to proposed land use and timber mgmt activities • Species with a wide geographic distribution in the project area • Important prey species whose numbers influence predator populations • Species with an important community role in nutrient cycling, energy flows, habitat modification, etc. 3. Management Importance • Species from each taxonomic class in approximate proportional occurrence • Species with are comparatively easy to inventory and monitor • Species which are suitable for habitat modelling
		Species-at-risk	Woodland Caribou	Threatened. Will reduce harvest rate in caribou planning area and will concentrate harvest ops to reduce area impacted. Will set up harvesting in the first decade as a deliberate experiment and will monitor caribou/habitat response through monitoring/research programs. Experimental harvesting will limit reduction of mature/old

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
				habitat, fragmentation of caribou habitat and reduction of range effectiveness (all 3 to be defined by IRMSC) while at the same time be designed to minimize risks to caribou. Will continue to participate in the development of a caribou conservation strategy for the A la Peche caribou herd. When a strategy is developed, Weldwood will review it and adjust it as appropriate to support caribou conservation goals p.6-18, 6-19, online
		Species-at-risk	Pinto Creek Mountain Goat Herd (< 30 goats)	Only known canyon-dwelling mountain goat herd in Alberta. Unique character of the herd, small population size and isolation from other goat populations. Have created a reserve area (unharvested) surrounded by a special management area where they will do experimental harvesting and monitor goat/habitat response.
		Species-at-risk, Condition indicator	Grizzly Bear	Sensitive to disturbance and increased human presence assoc with road development can offset habitat benefits. "Ongoing discussions have centered on developing a cooperative, integrated approach to grizzly bear conservation in a 20,000km2 area that includes the FMA. When measures are identified and agreed to by Weldwood they will incorporate them into their planning framework at appropriate scales and times.
		Species-at-risk, Condition indicator	Trumpeter Swan	Sensitive to disturbance during nest season. Nesting lakes are excluded from forest management plan landbase allocation, and management will be carefully times in area

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
				with pairs of trumpeters.
			Northern Long-eared Bat	Roost individually under peeling bark or in tree cavities. Plan to provide a supply of suitable roost trees through coarse filter.
			Columbia Spotted Frog	Breeds in ponds with cool, permanent water and generally remains close to permanent water. Efforts to protect all aquatic ecosystems should take care of this one
			BTGW	Needs open, multi-stories, mature conifer, mixedwood, and deciduous forests. Plan to conserve by providing suitable nesting habitat with coarse filter. ID known breeding locations and implement appropriate planning.
			Fish species	Will limit or modify harvest activities in riparian special management areas
Weyerhaeuser Edson	Ecologically based forest management: 1. 1.maintain landscape diversity and stand structure within the range of natural variability. 2. conserve habitat for threatened and endangered plant and wildlife spp. 3. allow for integration of societal needs and expectations (p2-5) **they seem to suggest that this applies to all their FMAs in AB or, on p 5-6, the same points 1 and 2, with	P8-13: "work will continue to gather baseline and update info relating to all species upon the FMA. This work should help identify rare endangered or threatened species on the FMA. Management practices will then be put	Moose (plus Elk and Deer)	Involved in a plan with buck for wildlife to limit fragmentation of an area that is significantly important regionally and provincially for its moose habitat as well as elk and deer. Using access control zones.

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
	3. Minimize the potential impact of forest harvesting on other values (e.g., watershed, wildlife, water, etc.) Adaptive management. Coarse filter complemented by fine filter to address the habitat needs of feature species p 8-2. Will try to achieve a forest age distribution similar to what would occur under more natural conditions (fire). They list the species-at-risk from Fish and Wildlife found in their area, but don't say which species they will use.	into place to insure the preservation of these species….”		
Tolko all info via Bob Boyce, pers comm. 11Apr02	Their FMP will be done at end of May. They are planning adaptive mgt, with coarse filter on the landscape scale and fine filter on specific species.	So far have finalized Caribou and Bison but are in the process of choosing others (they plan to have a number of species)	Caribou	Species-at-risk Large reserves and large cuts, with access restrictions (but access restrictions not useful if gas/oil companies don't cooperate. For every 1km of Tolko road, the oil and gas companies put in 50km)
			Bison	
Diashowa-Marubini International	State-dependant approach, coupled with a monitoring program.	No		

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
Ltd. Peace River Pulp Division	Coarse filter – allows view of forest mgmt as an experiment and can develop monitoring and research to periodically test assumptions. However, they say themselves that all the objectives relate to trees. Involved with EMEND – a range of harvest intensities over a range of communities Replanning and adaptive management – will adjust immediately when new info is available rather than wait for the 10 year resubmission required date			
Blue Ridge Lumber	Adaptive management (forest management plan is a “living flexible document” open to changes as new info is obtained) Design harvesting to emulate natural disturbances. They list all the mammals in their FMA with natural history info but without specifics as to how they will manage for them	No, but they say they will have a plan for choosing indicators and doing up a H.S.I. for moose		

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
	(except the ungulate cutblock methods)			
Sunpine forest products	Approximating natural processes, maintain diversity of habitats, spp, and genetic resources. Adaptive ecological management practices, using inventory, monitoring and research programs not yet developed.	No, not yet Multi stakeholder team will ID species on fma that are of “high interest”. Approx 10-12 species may be identified. Plan to use habitat suitability modeling, and cumulative effects assessment.		
Vanderwell Contractors (1971) Ltd.	“wildlife management objectives will be included in normal operations which will take into consideration the slave lake caribou plan” p 4. 75% of their wood burned in the 1998 Mitsue and 2001 Chisholm burns. They went from 40,000m of timber to 10,000m of timber. They are just finishing salvage	No		

Company	Approach to biodiversity retention	Focal species approach used in Forest Management Plan?	Indicator(s)	Rationale
	logging and will refly the FMA and redo their timber supply info, then get to work on the plan. They will use adaptive mgmt and coarse filter, as required by gov't, but they don't intend to go into much depth in the plan, given the small amount of timber left. Darryl MacKay pers comm. 15Apr02			

OUR PARTNERS AND AFFILIATES MARCH 2004

GRANTING COUNCILS

- Networks of Centres of Excellence (NCE) Program
    - Natural Sciences and Engineering Research Council of Canada (NSERC)
    - Social Sciences and Humanities Research Council of Canada (SSHRC)

SPECIAL FUNDING AGREEMENTS

- Sustainable Forest Management Network/BIOCAP Canada Foundation Joint Venture Agreement

FUNDING PARTNERS

GOVERNMENTS

- Environment Canada
- Parks Canada
  Ecological Integrity Branch
- Government of Alberta
  Alberta Sustainable Resource Development
- Government of British Columbia
  Ministry of Forests
- Government of Manitoba
  Manitoba Conservation
- Government of Newfoundland and Labrador
  Department of Forest Resources and Agrifoods
- Government of Ontario
  Ministry of Natural Resources
- Gouvernement du Québec
  Ministère des Ressources naturelles, de la Faune et des Parcs
- Government of Yukon Territory
  Energy, Mines and Resources

INDUSTRIES

- Abitibi-Consolidated Inc.
- Alberta-Pacific Forest Industries Inc.
- Bowater Inc.
- Canadian Forest Products Ltd.
- Daishowa-Marubeni International Ltd.
- J.D. Irving, Limited
- Louisiana-Pacific Canada Ltd.
- Riverside Forest Products Limited
- Slocan Forest Products Ltd.
- Tembec Inc.
- Tolko Industries Ltd.
- Weyerhaeuser Company

ABORIGINAL GROUPS

- Gwich'in Renewable Resource Board
- Heart Lake First Nation
- Kaska Tribal Council
- Little Red River/Tall Cree Nation
- Moose Cree First Nation

NON-GOVERNMENTAL ORGANIZATIONS (NGOs)

- Ducks Unlimited

INSTITUTION PARTNERS

- University of Alberta
  (Host Institution; also a Funding Partner)
- Concordia University
- Dalhousie University
- Lakehead University
- McGill University
- Memorial University of Newfoundland
- Ryerson University
- Trent University
- Université de Moncton
- Université de Montréal
- Université de Sherbrooke
- Université du Québec à Chicoutimi
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- University of Lethbridge
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- University of New Brunswick
- University of Northern British Columbia
- University of Ottawa
- University of Regina
- University of Saskatchewan
- University of Toronto
- University of Victoria
- University of Waterloo
- University of Western Ontario
- University of Winnipeg

AFFILIATES

- Canadian Forest Service
- Canadian Institute of Forestry
- Forest Ecosystem Science Cooperative
- Forest Engineering Research Institute of Canada
- Lake Abitibi Model Forest
- Manitoba Model Forest
- National Aboriginal Forestry Association

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