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Emulating natural disturbance through harvest: responses of upland and riparian cavity-users in the boreal plains mixedwood forest

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Emulating natural disturbance through harvest: responses of upland and riparian cavity-users in the boreal plains mixedwood forest

SFMN Project: Keystones and functional indicators for sustainable forest management with special emphasis on the cavity-using community

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ABSTRACT

We characterized the cavity-using community in landscapes and riparian buffer strips in mixedwood boreal forest and determined effects of harvesting designed to emulate patterns left after fire. We focused on cavity users because most are resident species and may be sensitive to forestry activities. The dominant cavity excavator was the Yellow-bellied Sapsucker and keystone cavity producers were Hairy Woodpeckers, Northern Flickers and Pileated Woodpeckers. Cavities were reused by a variety of species including squirrels, ducks and owls. In harvested landscapes, abundance of flickers increased and sapsuckers decreased, but cavity reuse rates were similar. Buffer strips with more forest had more Brown Creepers and those with lower retention had more Tree Swallows, otherwise communities were similar. Aspen was used most often as a cavity tree. Characteristics of trees and surrounding patches used for cavities varied by excavator species, but decay class, tree diameter and height, presence of fungal conks and tree density were important predictors. Most species selected older (>125 yr) aspen stands for their territories, except for Three-toed Woodpeckers that used white and black spruce. Sapsuckers selected territories in areas with large patches of residual forest, whereas Flickers chose areas with less retention. We make recommendations for planners and operators to retain features required by cavity users.

Keywords: Nest web, keystone species, dominant species, cavity users, partial harvest, aggregated harvest, single-pass harvest, riparian buffers, natural disturbance paradigm, residual structure

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RESEARCH QUESTIONS AND OBJECTIVES

The functional relationships among species creating and using cavities was termed a nest web by Martin and Eadie (1999). Most cavities are produced by strong primary cavity excavators (woodpeckers) and used by secondary cavity users (other birds and mammals). Weak cavity excavators (chickadees and nuthatches) excavate cavities in softer wood or use those produced by primary excavators. Keystone cavity excavators are species that create the majority of cavities used by other species and thus are a critical component of this community. In the Boreal Plains ecozone, up to 25 breeding bird species (including woodpeckers, songbirds, ducks and owls) and several mammal species (including squirrels and bats) use cavities in trees or snags for nesting and roosting but a nest web for this region has not been described. We focused on members of the nest web because cavity excavators are primarily resident species that are affected by changes to habitat throughout the year. Cavity-using wildlife are one of the most sensitive groups to intensified management of boreal forest (Angelstam & Mikusinski 1994, Imbeau et al. 2001).

Changes to the structure, age and composition of boreal forests by timber harvest may affect the structure of nest webs. In general, cavity availability is lower in intensively managed forests where harvesting truncates stand ages, reducing the availability of older, decaying trees and trees large enough to provide suitable cavities (Newton 1994). Many forest companies tasked with maintaining forest biodiversity are investigating new types of forest harvesting, including those that emulate the patterns and structures of natural disturbances (Hunter 1993). Under this approach, patches of forest structure are retained within harvested areas with the intent to emulate unburnt patches remaining after fire. These patches may act as refugia if the amount, configuration, and type of forest structure retained are sufficient to meet nesting and foraging needs of excavators and secondary users. Effects of forest management on primary excavators will have cascading effects throughout a nest web and thus secondary cavity users may be affected not only by changes in habitat structure due to forest harvest, but also by changes in cavity availability. In our study we examined the effects of alternative harvest practices that attempted to emulate fire patterns at local (riparian buffer strips) and landscape levels on the nest web.

Objectives from original proposal

1. Determine the structure of cavity nest webs and identify keystone cavity producers (functional indicators) in post-fire and old seral stages in different habitat types (aspen-dominated mixedwood, conifer) in the boreal plains ecoregion.

2. Characterize key features of cavities, cavity trees, and stands used by primary excavators and secondary users.

3. Evaluate repeatability of sampling methods and detectability of cavity users in order to develop appropriate monitoring techniques.

4. Integrate our results with other research on cavity nesting communities in Canadian forests, in particular with SFMN research conducted on nests webs in British Columbia.

5. Determine the influence on cavity-using communities of new harvesting practices that attempt to approximate structures and patterns left following fire.

6. Using previously collected data on songbirds, owls and grouse identify a multi-taxal set of avian species that are sensitive to decreases in forest cover caused by harvesting (conditional indicators).

7. Test whether these conditional indicators are indicators of other bird species (population indicators) and at what spatial scale these indicators should be measured for use in monitoring.

8. Field test these species as indicators of change in forest structure using sites in #5 (validation).

Change in research objectives

Objective 1 was modified to only look at aspen-dominated mixedwood stands (intact and harvested) due to lack of funding.

Objective 3 was not done in a rigorous fashion due to lack of funding.

Objectives 6-8 were dropped from the project as we did not receive enough funding to hire a postdoctoral fellow, who was slated to do this.

KEY FINDINGS

1. *Determine the structure of cavity nest webs and identify keystone cavity producers in aspen-dominated mixedwood.*

A cavity nest web is a diagram showing the production of cavities by each excavating species (woodpeckers, chickadees, nuthatches) and their reuse by others in the community. The cavity nest web for aspen-dominated boreal mixedwood was determined by finding cavities and observing them for subsequent reuse by other excavators or secondary cavity users for 1-3 years (Fig. 1). Cavity reuse was organized by excavator body size, with larger-bodied excavators (Pileated Woodpecker, Northern Flicker) providing cavities for larger-bodied secondary cavity users (Common Goldeneye, Bufflehead, Northern Saw-whet Owl). Cavities of smaller-bodied excavators (Yellow-bellied Sapsucker, American Three-toed Woodpecker, Hairy Woodpecker) were used by smaller-bodied secondary cavity users (Northern Flying Squirrel, Red Squirrel, Tree Swallow), however these secondary species also utilized cavities of the larger excavators. We modeled cavity reuse by secondary species to determine the relative importance of four cavity excavators and to identify keystone cavity producers. Three species were identified as keystones – Hairy Woodpeckers, Northern Flickers, and Pileated Woodpeckers. Cavities of these three species were five (Hairy Woodpecker), 19 (Pileated Woodpeckers), and 25 (Northern Flicker) times more likely to be reused than cavities of Yellow-bellied Sapsuckers, a dominant excavator that produced over 60 percent of the cavities in these landscapes.

2. Characterize key features of cavities, cavity trees, and stands used by primary excavators and secondary users.

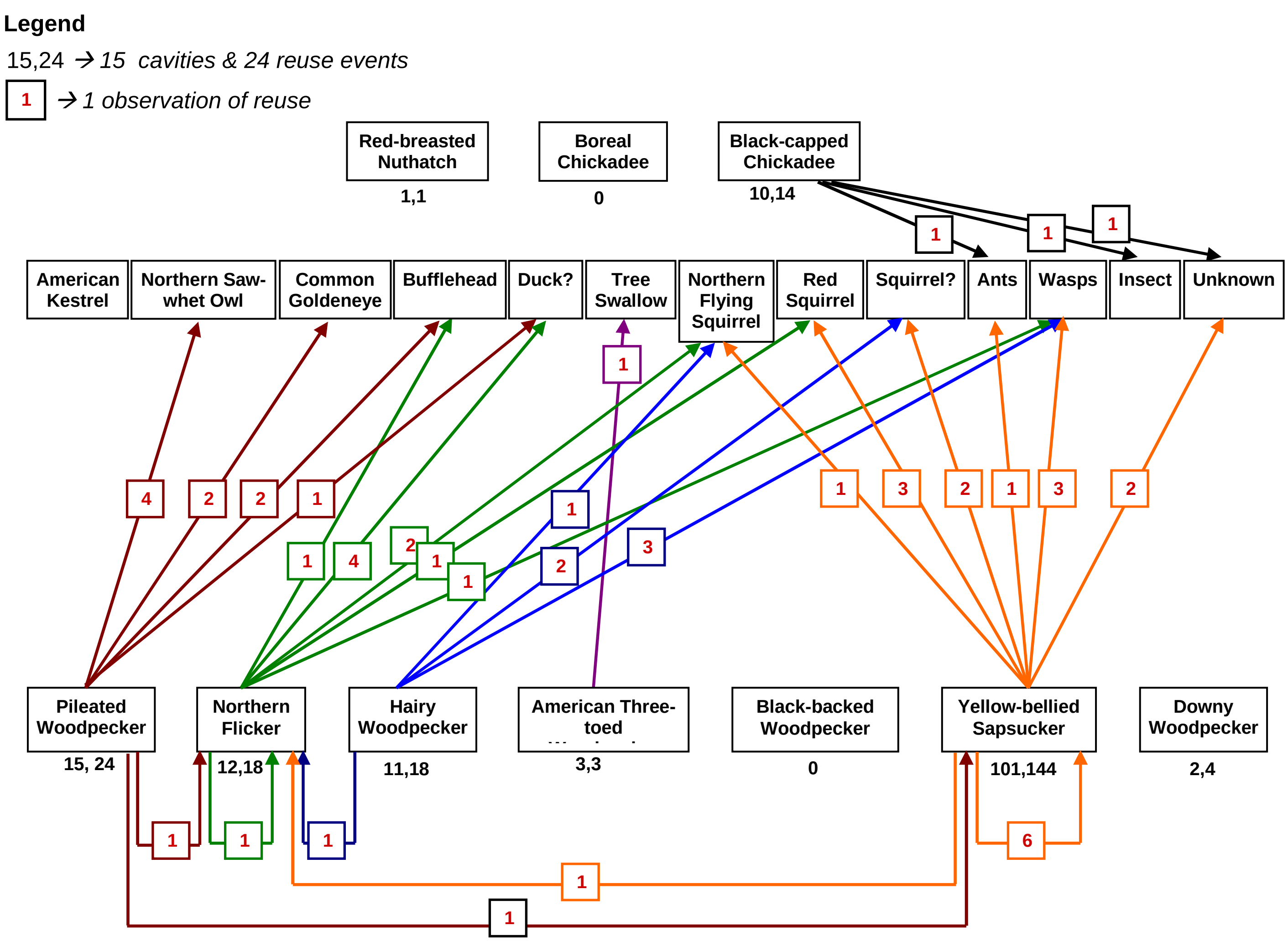
Cavity trees and surrounding trees

Aspen was the most frequently used tree species for cavity excavation. Yellow-bellied Sapsucker, Hairy Woodpecker and Pileated Woodpecker primarily used live trees with no decay and early decay (<50% of the canopy dead). Northern Flickers, Black-capped Chickadees, Red-breasted Nuthatches, and Three-toed Woodpeckers used snags in later stages of decay (softer wood and usually had broken-tops). Nest trees used by excavators ranged in size from 12 cm in diameter for the smallest excavators (Red-breasted Nuthatches, Black-capped Chickadees) to over 60 cm for Northern Flickers. Median nest tree diameters ranged from 20 cm for Black-capped Chickadees to 47 cm for Pileated Woodpeckers. Height of nest trees varied among species from 2 m to over 35 m. Black-capped Chickadees, Red-breasted Nuthatches and Three-toed Woodpeckers used the shortest trees of all excavators (median height 10 m). In contrast, Hairy Woodpeckers, Pileated Woodpeckers, and Sapsuckers used trees of median heights near 25 m. The number of conks of the heartrot fungus Phellinus tremulae varied from zero to >70 on nest trees. Cavities of species using live aspen had medians ranging from 14 to 19 conks whereas nest trees of species that used snags had very few conks. We measured characteristics of trees in a 11m radius plot centred on the nest tree. Again, features varied depending on woodpecker species, but two main types of surroundings were found: either a high density of aspen trees with conks (~ 30 trees/0.04 ha plot) or a low density of aspen trees (~ 10 trees/0.04 ha plot).

Stand use in unharvested landscape

We categorized stand types where cavities were found (all excavator species combined) into four groups: aspen (old: >125 yr), aspen (young: 25-75 yrs; mature: 75-125 yrs), white spruce (all ages), and other (remaining deciduous and coniferous dominated and non-forested stands). Most woodpecker cavities (in particular Sapsuckers) were found in old aspen-dominated stands at a significantly higher rate than expected based on availability (used: 58%; available: 33%). American Three-toed Woodpeckers used white and black spruce-dominated stands exclusively, whereas Black-capped Chickadees used aspen-dominated stands exclusively. Hairy and Pileated Woodpeckers both used aspen and balsam poplar stands, however six of 10 cavity trees used by

Figure 1. Cavity nest web for intact aspen-dominated mixedwood boreal forest observed over 4 breeding seasons.



Pileated Woodpeckers were in old aspen stands. Flickers used old and mature aspen stands and two non-forest areas associated with riparian areas (beaver ponds and streams).

3. *Integrate our results with other research on cavity nesting communities in Canadian forests, in particular with SFMN research conducted on nests webs in British Columbia*

This has not been completed yet. We plan to do this in fall of 2008 in collaboration with Dr. Kathy Martin, University of British Columbia. Towards this end, initial discussions have occurred, results shared and Dr. Martin participated in our partner workshop in 2006.

4. *Determine the influence on cavity-using communities of new harvesting practices that attempt to approximate structures and patterns left following fire*

We contrasted community structure, cavity reuse, and nest site selection in harvested and unharvested mixedwood boreal landscapes. We evaluated two harvesting approaches based on the Natural Disturbance Model: single-pass harvesting with structure retention (in Alberta and Saskatchewan) and riparian buffers (in Manitoba) with structure retention. Single-pass harvesting is done on larger landscapes (>1500 ha) and leaves trees singly or in patches up to several hundred hectares. In Manitoba, riparian buffers were either left intact (50m wide buffer), were partially harvested (10m wide intact and 30m wide strip with 25% timber left) or were harvested to the high water mark with some residual trees (5-12% retention). We divided these into 3 groups based on amount of forest retained: 12 low retention (0-33%), 14 medium retention (33.1-66%), and 20 high retention (>66%) sites. We have organized the results for this objective under three questions:

A. Is the structure of the excavating guild similar in the intact and harvested landscapes and how does amount of residual structure affect occurrence of excavators (AB, SK, MB)?

Single-pass harvest
We surveyed the cavity-using community using 15 700-m line transects in two harvested and two intact landscapes. All excavators observed within the intact landscapes were also observed in the harvested landscapes, however differences in abundance and frequency of occurrence resulted in significant differences in overall guild structure. Consistent with our nest web analysis, Northern Flickers were significant indicators of the harvested landscapes whereas Yellow-bellied Sapsuckers were significant indicators of the intact landscapes. To determine whether the abundance of species differed between harvested and intact landscapes when corrected for the actual amount of forest on each landscape, we repeated the analysis. Abundance per ha of forest of sapsuckers did not differ between harvest and intact landscapes, but flicker abundance/ha forest was still higher in the harvest area. There was very high variability in the abundance of Sapsuckers across harvest transects suggesting abundance is related to other

residual characteristics, such as configuration and stand composition, in addition to total forest area. Overall, we conclude that 1) harvested landscapes support fewer Sapsuckers and more Flickers than intact landscapes, 2) harvested landscapes support similar abundances of Sapsuckers/ha of structure retained in harvested and intact landscapes. Further analysis will evaluate the effect of residual patch type and configuration on variability in Sapsucker abundance.

Riparian buffers
Members of the cavity community were surveyed on 400m long transects through riparian buffer strips. All species were present in all treatment groups. In MB, medium and high retention buffers supported similar bird communities, while low retention buffers differed from both. Along a gradient from high to low retention, communities shifted from being Brown Creeper-dominated to Tree Swallow-dominated. Amount of retention per se, did not influence abundance of other species, but Northern Flicker abundance increased and Yellow-bellied Sapsucker abundance decreased with increasing mean deciduous tree diameter (measured at breast height). Abundance of Flickers decreased and Sapsuckers increased with increasing density of large live aspen trees with conks. Boreal Chickadee abundance was positively related to conifer tree density. Although less important, large snag density was negatively related to Northern Flicker, and positively related to Boreal Chickadee abundance. Amount of downed woody material and the density of live birch stems were positively related to Northern Flicker and Yellow-bellied Sapsucker, respectively. In areas surrounding the buffers, the amount of harvest negatively impacted the abundance of Boreal Chickadees but not other species. We note that these landscapes retain a high amount of forest (mean 69% ±0.02; range 37-95%).

B. Are rates of cavity reuse, the structure of cavity nest webs, and the role of keystone cavity producers similar in the intact and single-pass harvested landscapes (AB and SK)?

Cavity reuse
For the four most common excavators, rates of cavity reuse by secondary cavity users ranged from 6 to 60 percent in the intact landscapes and 4 to 30 percent in the harvested landscapes. There were no significant differences in rates of cavity reuse by secondary cavity users between the intact and harvested landscapes for the cavities of Yellow-bellied Sapsuckers, Hairy Woodpeckers, or Pileated Woodpeckers. However, Northern Flicker cavities in the harvested landscape were reused significantly less frequently by secondary cavity users than in the intact landscapes.

Cavity nest web
In the single-pass harvested landscapes the nest web changed: there was a higher availability of Northern Flicker cavities, an additional species (American Kestrel) was present, which predominantly used Flicker cavities, and there was a higher rate of reuse of Flicker cavities by other Flickers (Figure 2). Flickers and Pileated Woodpeckers persisted as keystone excavators, but in contrast to the intact landscapes, their cavities were only nine times (vs. 19 and 25, respectively) as likely to be reused as cavities of Sapsuckers, which persisted as dominant excavators.

C. What is the influence of the type and amount of structure retained in single-pass landscapes on nest site selection by excavators?

Residual structure in the harvested landscapes can be classified as either planned structure (delineated for retention at the planning stage) or operator structure (retention within cutblocks chosen by operators). Planned structure includes larger residual patches of merchantable and non-merchantable material whereas operator structure includes single trees and small patches. The two single-pass harvested landscapes in this study (AB, SK) varied in characteristics of planned and operator structure retained (Table 1). The AB harvest had more but smaller patches of operator structure and the SK harvest had fewer but larger patches of planned structure.

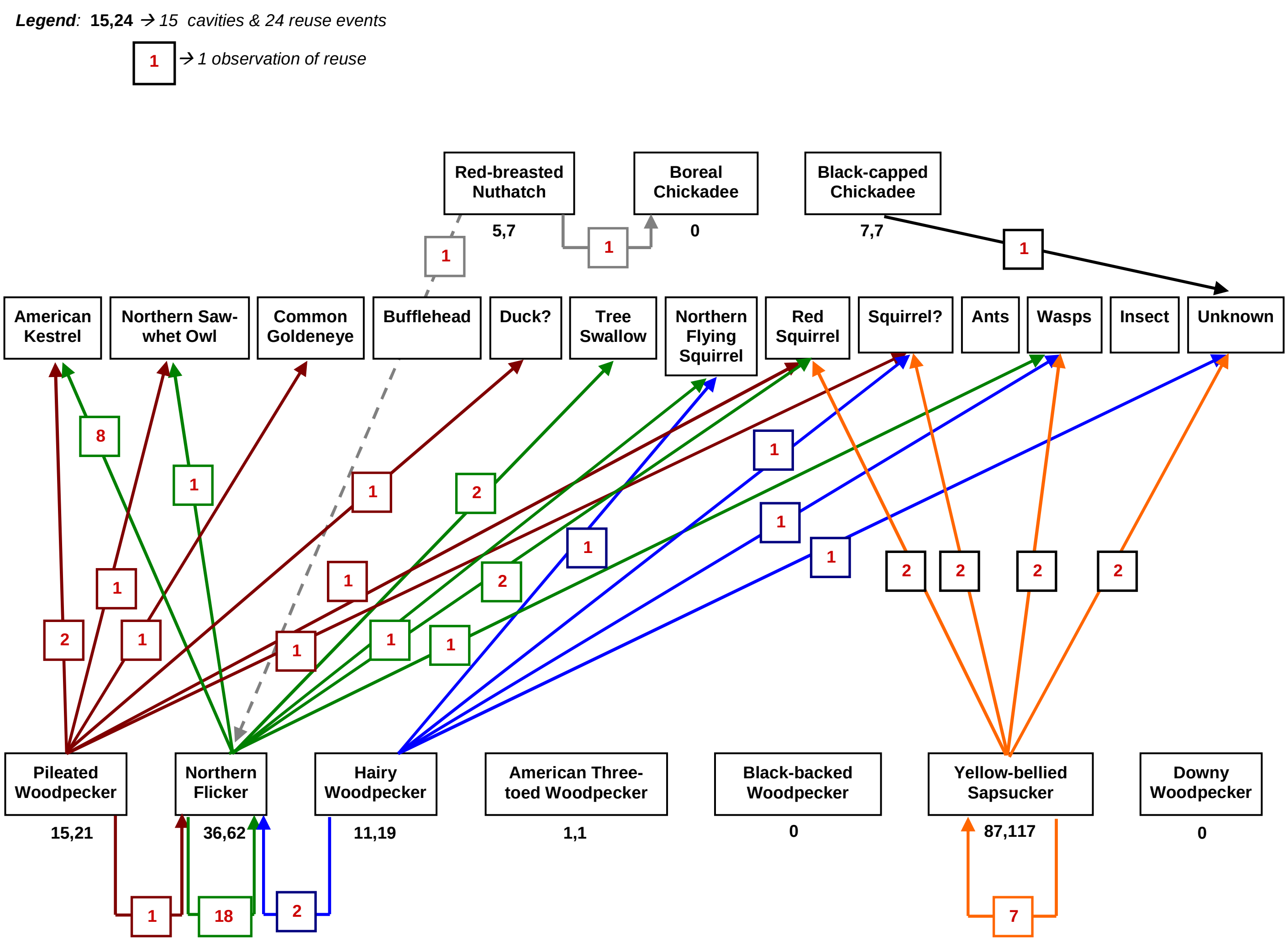
For all excavators, nest tree characteristics were similar in the harvested landscapes to those selected in the intact landscapes: Sapsuckers, Hairy Woodpeckers, and Pileated Woodpeckers all selected large diameter, diseased aspen with multiple fungal conks; Flickers selected large diameter aspen and balsam poplar snags with fungal conks; and Black-capped Chickadees selected small diameter aspen snags. Thus, structural elements retained in the harvested landscape provided similar types of trees as selected by these excavators in the intact landscapes.

For Yellow-bellied Sapsuckers and Northern Flickers (the most abundant species) we evaluated nest site selection based on the amount of residual structure within a core area (75-m radius) and within a home range (200-m radius for Sapsuckers; 500-m radius for Flickers) surrounding nest locations. Within the core area, Sapsuckers and Flickers in SK selected for greater cover of operator structure than available across the landscape. Sapsuckers in both landscapes selected core areas with more planned structure than available across the landscape, whereas Flickers in AB selected for core areas with less planned structure than available. At the home range scale, Flickers in AB displayed selection for greater cover of operator structure and less cover of planned structure. Sapsuckers showed positive selection for planned structure at the home range scale in both landscapes. Thus, at both scales Sapsuckers selected nest locations associated with high cover by large patches of residual structure. In contrast, at both scales Flickers selected nest locations with higher cover from operator patches and less cover by planned patches than expected due to availability across the landscapes.

Table 1. Characteristics of residual structure in two single-pass harvested landscapes in AB and SK

Residual Type	**Operator Structure**		**Planned Structure**	
Site	AB	SK	AB	SK
Number of patches	2752	528	112	50
Total Harvest Area (ha)	1636	3473	1636	3473
Structure Area (ha) - total	150	116	383	1223
Structure Area - percent of total harvest area	9.18	3.33	23.38	35.22
Structure Area (ha) - mean	0.05	0.22	3.42	24.46
Structure Area (ha) - median	0.03	0.14	0.56	2.50
Structure Area (ha) - SD	0.11	0.31	6.59	101.09
Structure Area (ha) - min	0.00	0.00	0.01	0.23
Structure Area (ha) - max	3.26	5.00	36.44	681.69

Figure 2. Cavity nest web for mixedwood boreal landscapes harvested using single-pass with structural retention practices as observed over 4 breeding seasons



KEY DELIVERABLES

Workshops organized

We held three workshops in conjunction with our partners (March 9, 2005, Feb 16 2006, April 24, 2007). These were fruitful in determining research goals, methods, management implications and plans for KETE products.

Conferences/workshops/lectures:

Cooke, H.A. 2004. Ecology of the cavity-using community in old mixedwood boreal forest. Presentation at Ducks Unlimited Canada Western Boreal Program Team Meeting.

Clarke, H.D., S.J. Hannon, and S. Song. 2005. The effects of partial harvesting in riparian buffer strips on cavity-nesting bird communities in boreal mixedwood. Poster presented at SFMN workshop Towards a systems approach for management in terrestrial, riparian, and aquatic ecosystems.

Cooke, H.A., H.D. Clarke, S.J. Hannon, and S. Song. 2006. Effects of harvesting on the cavity-using community in mixedwood forest on the boreal plains. Poster presented at the SFMN conference.

Clarke, H.D., S.J. Hannon, and S. Song. 2007. Effects of riparian partial-harvesting on cavity-nesting birds. Poster at SFM Management of Aquatic Systems in Forested Landscapes: Knowledge Exchange Workshop.

Clarke, H.D., S.J. Hannon, and S. Song. 2007. Effects of riparian partial-harvesting on cavity-nesting birds. Poster presented at 26th Annual Meeting of the Society of Canadian Ornithologists.

Cooke, H.A. and S.J. Hannon. 2007. Keystone excavators and cavity nest webs in intact and harvested mixedwood boreal forest. Presentation at 26th Annual Meeting of the Society of Canadian Ornithologists.

Cooke 2007. Cavity nest webs and keystone species in managed boreal forests. Lecture to Biology of Birds course, Department of Biological Sciences, University of Alberta.

Publications

Most are pending but will include two graduate theses (expected April and Sept 2008), a KETE document outlining best practices and publications in peer-reviewed journals.

Training

The project provided funding for training of two graduate students (PhD Hilary Cooke, MSc Heather Clarke), one technician and 15 undergraduate assistants.

BENEFITS TO PROJECT PARTNERS AND OTHERS

The following groups have or will benefit from our research:

Industrial partners: Alberta Pacific Forest Industries Inc., Weyerhaeuser Canada Ltd, Louisiana Pacific Canada Ltd.
Government partners: Environment Canada, Alberta Sustainable Resource Development.
NGO partners: Ducks Unlimited Canada.

These groups have been involved in the project since its inception and have participated fully in project development and discussion of results and management implications. They will continue to participate as we develop a KETE document with recommendations for best practices at various spatial scales (single tree, patch, landscape) and levels of operation (planning, operator) to ensure maintenance of cavity-using communities.

MANAGEMENT/POLICY IMPLICATIONS

We are currently finishing data analysis and synthesizing results in preparation for a KETE document. To date our data would support the following management implications.

In both buffer strips and single-pass harvest landscapes, the communities appeared to be fairly resilient in the short term to harvest with structural retention. In single-pass harvest landscapes, Sapsuckers became less abundant as expected with the overall loss of forest cover. In contrast, in association with increasing open habitat, Flickers became more abundant and American Kestrels entered the community. All other excavators nesting in the intact landscapes (primary: Downy Woodpecker, Hairy Woodpecker, Three-toed Woodpecker, Pileated Woodpecker; weak: Black-capped Chickadee, Red-breasted Nuthatch) were found nesting in the harvested landscapes but in both landscapes these species were at densities too low to detect any differences. In riparian buffers, old-growth species such as Brown Creepers were absent in low retention sites and more open-country species, such as Tree Swallows, were more abundant in low retention sites. When the effect of the landscape surrounding the buffers was considered, only Boreal Chickadees were negatively affected by the amount of harvest. However, these landscapes still had a fairly high degree of forest retained. Both Brown Creeper and Boreal Chickadee have negative population trends over portions of the Boreal Plains. Protection of intact old forests to provide habitat for these species is a prudent management response given the negative association with harvesting.

Based on use and selection of cavity trees and patches, to meet the current nesting needs of all excavators, operators should leave the following trees and small patches in cutblocks**:**

- Large diameter (>30 cm) live aspen with >10 fungal conks surrounded (11m radius) by a high density of aspen trees with conks (~ 30 trees/0.04 ha plot).
- Large diameter (>35 cm) broken-top aspen and balsam poplar snags. These should be surrounded by a low density of aspen trees (~ 10 trees/0.04 ha plot).

- Small diameter (>20 cm) broken-top aspen snags surrounded by a high density of aspen trees with conks (~ 30 trees/0.04 ha plot).

Based on our analysis of selection of stand types and residual structure in single-pass harvested sites, planners should leave large patches of old (>125 yr) aspen stands to retain the dominant cavity producer, the Yellow-bellied Sapsucker. We are still conducting analyses to determine the size and configuration of these patches, which will be outlined in our KETE document.

SUGGESTIONS FOR FUTURE RESEARCH

Our work focused on distribution and abundance of members of the cavity-using guild during the breeding season and the features of cavity trees and their surroundings. Future research should examine characteristics of trees used for foraging and should determine habitat use of animals in fall and winter. Our study evaluated the short-term response of cavity users and thus may not signal their long-term use of these areas. As well, high reproductive success is critical for ensuring persistence of cavity users in harvested landscapes over the long term but was not evaluated. To provide a supply of trees to ensure recruitment into the selected size and decay classes, managers will need information on the mechanisms and rate of fungal colonization and decay with respect to tree size and landscape context. Little is known about the effect of harvest on fungal dispersal or on the factors that promote heart rot infection in aspen.

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