PEACE/WILLISTON FISH & WILDLIFE COMPENSATION PROGRAM

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BRITISH COLUMBIA

Donna Creek Forestry/ Biodiversity Project (Phase II): Cavity-nesting Bird Monitoring 2006-2007

Final Report

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EXECUTIVE SUMMARY

The Donna Creek Forestry/Biodiversity Project was initiated by the Peace/Williston Fish and Wildlife Compensation Program (PWFWCP) in 1990. Its objective was to experimentally test the long-term effects of alternative stand-level forest harvesting practices on breeding bird communities and cavity-dependent wildlife (birds and furbearers).

The Donna Creek study area is located in north-central British Columbia approximately 240 km north of Prince George and 80 km northwest of Mackenzie. The study area included 6 cutblocks and 3 old-growth stands (Old-growth Controls; OG) within Engelmann Spruce-Subalpine Fir forests of the Donna Creek drainage. The cutblocks were harvested between 1988 and 1992. Three cutblocks were harvested using traditional clearcut harvesting methods (Clearcut Controls; CC). The remaining 3 cutblocks were partitioned into 4 units characterized by either 1) 3-m high stumps (stubs) retained at 5 to 10 stubs/ha (Stub Treatment; SB); 2) tree islands (~0.25-ha leave-patches) retained at about 1 island per 8 ha (Tree Island treatment; TI); 3) stubs and tree islands (Stubs-and-Islands Treatment; SI); or 4) neither stubs nor islands (Clearcut Treatment; CT). Stubs were both spread throughout the treatment (dispersed stubs) and clustered around the perimeter of tree-island patches (perimeter stubs).

Point-count breeding bird surveys and cavity-nest searches were first undertaken in 1995 and 1996 (early seral; Phase I). Follow-up point-count surveys and cavity-nest searches were conducted in 2006 and 2007 (shrub seral; Phase II). Surveys in 2006 and 2007 aimed to replicate the previous surveys and to determine if and how the cavity-nesting bird community has changed as forest succession has progressed, and to re-assess the effectiveness of the treatments.

A total of 11 cavity-using species were detected in the 2000s, comprising 6 primary cavity excavators and 5 secondary cavity users. In both decades a total of 15 cavity-using species were recorded (7 primary excavators and 8 secondary users). Primary cavity excavators were recorded at 3.5% and 4.3% of point-counts in 2006 and 2007 respectively, and secondary cavity users were found at 1.3 and 2.6% of point-counts. Primary excavators were recorded at a quarter of the stations that they were in the 1990s, and secondary cavity users were found at only 16% of the number of stations that they were located at during the 1990s. Six species of cavity-user were only detected during point-counts in the 1990s, and 2 were only found in the 2000s. Of the species that were detected in both decades, most were

more abundant in the 1990s, and none were found more often in the 2000s. No differences in site or treatment use were found between primary excavators and secondary users, or between the decades, though there were species specific preferences of habitat use.

Both Black-backed and American Three-toed woodpeckers were fairly common in the 1990s, but uncommonly detected during the 2000s. Post-harvest effects (e.g., increased abundance immediately post-harvest followed by declining abundances [crowding effects]), reduced canopy covers and increased shrub covers in tree islands and OG controls, or increased habitat suitability elsewhere (e.g., mountain pine beetle infested regions outside study area), may have reduced the abundance of many cavity-nesting species at Donna Creek. Pileated and Hairy woodpeckers and Northern Flicker were also scarce, but elevation and range constraints may have played more of a factor for these species. Red-breasted Nuthatch, Boreal and Mountain Chickadees were the most frequently detected cavity-nesting species in the 2000s. Habitat suitability for Mountain Chickadees may have increased post-harvest, whereas, habitat suitability has likely declined for Tree Swallows and Mountain Bluebirds. The latter was not detected in the 2000s. Habitat succession will continue to alter the suitability of habitat for many of these species.

Active nests of cavity-using birds were relatively scarce in the study area in the 2000s. Only 3 cavity nests were discovered: a Tree Swallow nest in a stub in 2006, an American Three-toed Woodpecker nest in a mature pine tree within an OG control in 2007, and a Mountain Chickadee nest in a snag along the edge of Block 5547 in 2007. Nearly 2,000 stubs were present in the experimental cutblocks in 2007, and only 2.2% of these had a cavity nest present. Overall, 34% of stubs containing cavities had a nesting-cavity (i.e., entrance ≥2 cm by 2 cm and a internal platform sufficient to house a chickadee) that may have been useful to a cavity-nesting species. Most of these cavities pre-dated the 2000s surveys.

Stubs and tree islands of the type found in this study do not provide significant valuable habitat components for birds of the ESSF forests of north-central British Columbia. Stubs may have provided a few nesting opportunities to birds in the early-seral stage (Phase I), but based on monitoring data at the shrub-seral stage (Phase II), the retention of stubs at a density of 5-10/ha does not constitute a meaningful return on the operational investment. Similarly, the size (~0.25 ha) of tree islands retained in this study is too small to be used as nesting habitat for a number of species that may otherwise utilize tree islands for nesting. Future stubbing creation exercises should focus on trees that have pre-existing rot, noticeable scarring, or cavities. Tree islands should be created that are of larger size, and that capture as much canopy and structural diversity as possible within the site.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

Forest ecosystems are crucial to the survival of many organisms. In British Columbia, dead and dying trees, as well as live trees with certain characteristics, known as "wildlife trees", provide essential nesting, roosting, and foraging habitat for a broad range of species (Harmon et al. 1986; Harestad and Keisker 1989; Gyug 2002; Martin et al. 2004; Fenger et al. 2006). Nearly 100 animal species in British Columbia have been identified as wildlife-tree users (Backhouse 1993). Of all forest-dwelling vertebrate species in the province, almost 30% have been identified as users of tree cavities (Bunnell et al. 1999; Drever and Martin 2007). Suitable cavities are created either naturally (e.g., from branches breaking off) or by primary cavity excavators such as woodpeckers. Cavities are often re-used for nesting in successive years or as roosts from season to season, and one cavity may host a wide variety of species during its existence (Fenger et al. 2006). Consequently, primary cavity excavators provide habitat for many other wildlife species and thus play a critical role in maintaining forest biodiversity.

Modern forestry practices that rely mainly on clearcut harvesting do not emulate natural disturbances. In higher elevation forests in central British Columbia (e.g., forests in the Engelmann Spruce – Subalpine Fir biogeoclimatic zone), natural disturbances are rare, small (usually much less than 250 ha), and mainly the result of wind-throw, insects, and disease (B.C. Ministry of Forests 1995). Forest harvesting can clear large portions of land, removing most, if not all, standing structure, thereby reducing the structural diversity of the landscape (Cody 1985; Wiens 1989; Lance and Phinney 2001; Thompson et al. 2003). These cleared areas essentially preclude occupation by some forest-dwelling species, especially cavity users, until these areas regenerate to a more mature seral stage. In an effort to retain biodiversity on the landscape, a number of habitat retention methods have been proposed and conducted in attempts to make forest harvesting more closely approach natural disturbance patterns (e.g., Hunter 1993, Swanson et al. 1993, Attiwill 1994, Bennett 1994, Morgan et al. 1994, BC Ministry of Forests 1995, Bunnell 1995, Fule et al. 1997, Angelstam 1998, Bergeron et al. 1999, Cissel et al. 1999, Bergeron et al. 2002, Harvey et al. 2002).

Trees cut at heights of 3 m were recommended as a method to retain wildlife trees while complying with Worker's Compensation Board regulations (Dawson et al. 1992). Another method recommended for retaining structure that is important for wildlife was the creation of wildlife tree patches. The creation of these wildlife tree patches is now recommended in provincial forestry practices by the Biodiversity Guidebook of the Forest Practices Code (BC Ministry of Forests and BC Environment 1995).

In an attempt to understand how "new" forestry practices affect bird populations, the Peace/Williston Fish and Wildlife Compensation Program (PWFWCP) initiated the Donna Creek Forestry/Biodiversity Project in 1990. The aim of the project was to test the effects of alternative stand-level forest harvesting practices on cavity-dependent birds (Dawson et al. 1992). Preliminary bird surveys were conducted in 1993 (Gyug and Summers 1995). Baseline point-count breeding bird surveys and cavity-nest searches were first undertaken in 1995 and 1996 during the early seral stage after harvest (Phase I; Gyug 1997, Gyug 2002). Follow-up point-count surveys and cavity-nest searches were conducted in 2006 and 2007 to describe the bird communities during the shrub seral stage (Phase II). Surveys in 2006 and 2007 were intended to replicate the 1995 and 1996 surveys as closely as possible. The objectives of Phase II of the project were to: 1) compare changes in bird communities over time; and 2) compare treatment areas to control areas. Hypotheses going into the study were: 1) there will be no habitat differences between primary and secondary cavity users, 2) there will be a reduction in the density of breeding cavity-nesting birds between decades, and 3) there will be no difference in species richness between decades.

This report details the Phase II (2006 and 2007) findings from the breeding-bird point-count and nest-search surveys related to cavity-nesting birds, and compares them to those attained during Phase I (1995 and 1996) of the project (Gyug 2002). A separate report, Hentze and Cooper (2009), details the findings of the Phase II point-count surveys for all breeding bird species observed in the Donna Creek study area.

2.0 STUDY AREA

The Donna Creek study area is located in north-central British Columbia approximately 240 km north of Prince George and 80 km northwest of Mackenzie (Fig. 1). It is west of Williston Lake, south of the Wolverine Range of the Omineca Mountains, and is in the Sub-boreal Interior Ecoprovince (Gyug 1997).

Donna Creek is within the moist very-cold Engelmann Spruce-Subalpine Fir Biogeoclimatic subzone (ESSFmv3) and is characterized by coniferous forests with understories of dense moss, sparse herbs, and ericaceous shrubs (MacKinnon et al. 1990). Lodgepole pine (*Pinus contorta*) is the dominant regenerating tree species within harvested areas, whereas Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) are the dominant mature trees found in the Old-growth Controls and tree-island patches.

The study area ranges from 996 m to 1,341 m elevation above sea level. More detailed physical characteristics and detailed maps of study sites are found in Gyug and Corbould (2002). Study sites (3 experimental cutblocks, 3 clearcut-control cutblocks, and 3 old-growth areas) were aligned in a linear spatial orientation on the northeast side of Solomon Creek (Fig. 2). Detailed maps of the study sites are in Appendix A.

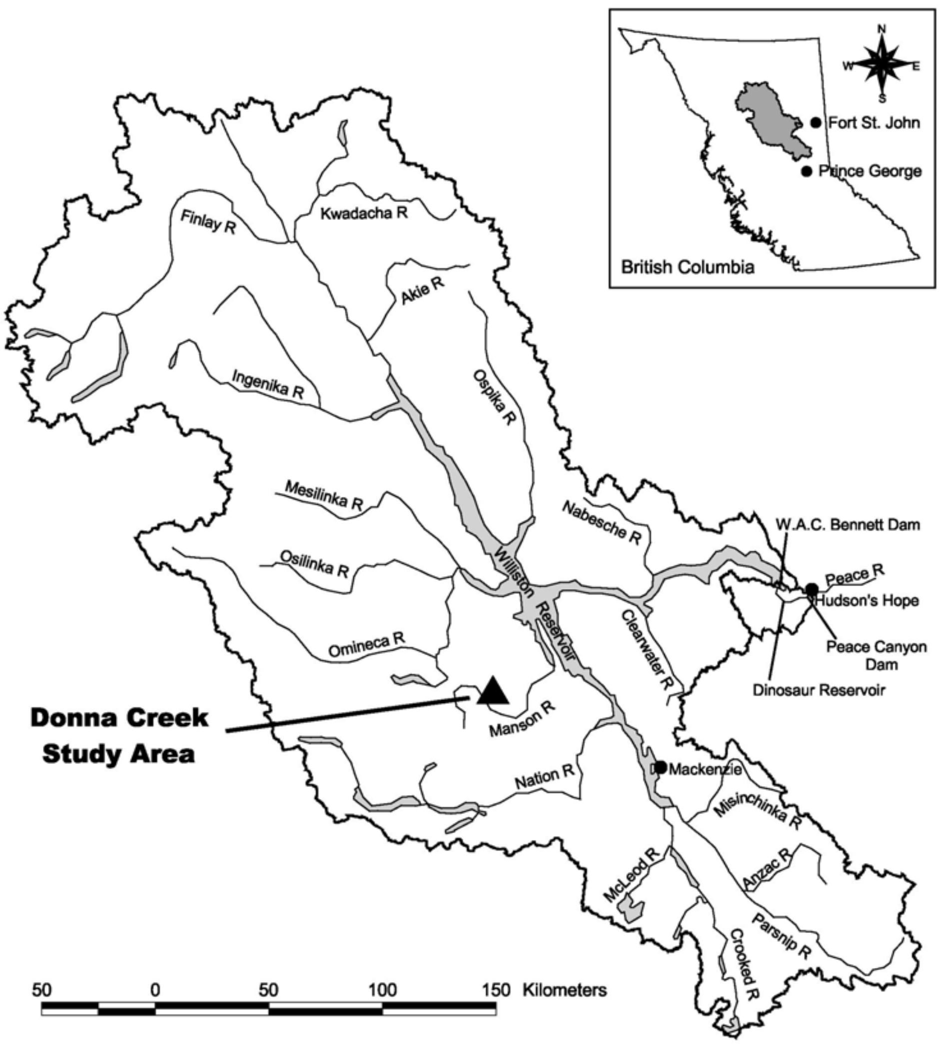


Figure 1. Location of the Donna Creek study area in the Williston Reservoir watershed in north-central British Columbia.

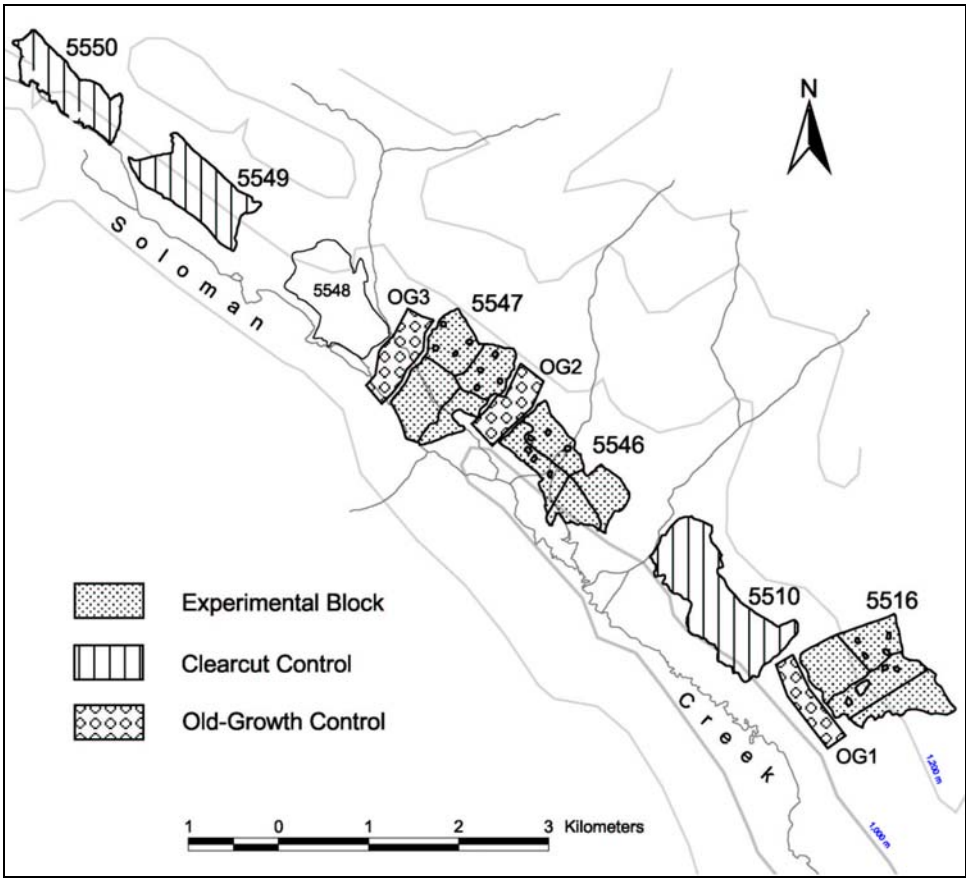


Figure 2. Locations and arrangement of experimental cutblocks (Blocks 5516, 5546 and 5547), clearcut control cutblocks (Blocks 5510, 5549 and 5550) and old-growth control areas (OG1, OG2 and OG3) within the Donna Creek study area.

3.0 METHODOLOGY

3.1 Study Design

The study was designed following a randomized block two-factor ANOVA method using 2 levels of each between-subjects factor (Gyug 1997). The 2 factors were 1) the retention of stubs and 2) the retention of mature-forest patches (tree islands). The study design was to have stubs either absent or present at densities of 8-10 stems/ha. Actual stub densities ranged from 0 to 0.3 stems/ha in “absent” areas and 4.7 to 9.5 stems/ha in “present” areas (Gyug and Corbould 2002). The stub factor refers to dispersed stubs (i.e., those distributed evenly over the harvested area), though a ring of “perimeter stubs” was also present at the outer edge of all but 1 tree island. Tree islands ranged from 0.18-0.41 ha in size, with the exception of a 1.4-ha island in Block 5516 that was retained due to slope stability concerns. Excluding this lone large island, the average tree island size was 0.26 ha (for tree island areas see Table 3 in Gyug and Corbould 2002).

The combination of 2 factors and 2 levels of each resulted in 4 treatment combinations. These treatments were 1) Clearcut (**CT**) - no dispersed stubs and no tree islands; 2) Stub (**SB**) - dispersed stubs present but no tree islands; 3) Tree Island (**TI**) - tree islands present but no dispersed stubs; and 4) Stub-and-Island (**SI**) - dispersed stubs and tree islands present. Each treatment combination of about 25 ha was randomly assigned in each of 3 experimental cutblocks (Blocks 5516, 5546, and 5547; Table 1, Figure 2, Appendix A). Thus, there were 3 replicates of each treatment. In addition to the treatments, control areas were established . Clearcut Controls (**CC**) were established in 3 conventional cutblocks (Blocks 5510, 5549 and 5550; Table 1, Figure 2 and Appendix A) to discount the possibility of any "neighbour effects" of adjacent treatments on the CT treatment. Old-growth Controls (**OG**) were located in the forest areas adjacent to Blocks 5516, 5546 and 5547 (Figure 2, Appendix A) where "neighbour effects" were also minimized. The OG controls permitted comparisons of bird communities within experimental cutblocks to those of intact old coniferous forest.

Table 1. Total areas, number of point count stations, and total surveyed area for controls and treatments within all study sites, Donna Creek 1995, 1996, 2006 and 2007. Total area data from Tables 1 and 2 of Gyug and Corbould (2002).

	Site 5516			Site 5546			Site 5547		
Treatment/ Control type	Total area (ha)	No. of PCs	Area surveyed (ha)	Total area (ha)	No. of PCs	Area surveyed (ha)	Total area (ha)	No. of PCs	Area surveyed (ha)
CT	29.4	7	5.5	23.4	7	5.5	18.2	7	5.5
SB	32.1	7	5.5	17.6	7	5.5	39.3	7	5.5
TI	32.8	12	9.4	26.5	10	7.9	28.9	11	8.6
SI	25.5	11	8.6	23.2	10	7.9	26	11	8.6
CC[1,2]	120.1	7	5.5	74.8	7	5.5	59.9	7	5.5
OG[3]	N/A	7	5.5	N/A	7	5.5	N/A	7	5.5
Total (excluding CC)	119.8	44	34.5	90.7	41	32.3	112.3	43	33.7

[1] CC is greater than other individual treatment types, but point count stations were clustered into an area of similar proportion to the CT area.

[2] CC point-count stations were in 3 separate cutblocks. From left to right, the numbers refer to Blocks 5510, 5549, and 5550 respectively.

[3] OG total area cannot be defined, as this control was part of continuous uncut forest.

3.2 Cavity-nesting Bird Surveys

In 2006 and 2007, cavity-nesting birds and their nest sites were formally and informally surveyed within the study area using 3 methods: point-count surveys, stub assessments, and incidental observations. Unlike the 1990s surveys (Gyug 2002), however, call playback, systematic (*sensu stricto* Gyug 2002), and intensive local searches were not conducted. Omitting these detection methods was not expected to have an influence on the 2006-2007 dataset. All stubs and tree islands were surveyed intensively during point-counts and stub assessments, so nesting birds in this area would have been detected by their vocalizations. Many cavity-nesting birds are vocal and conspicuous, especially nestlings during rearing periods, and are relatively easy to detect if present (e.g., Ruge 1971 in Cramp 1985, Dixon and Saab 2000).

3.2.1 Point-count Stations

Permanent breeding-bird survey stations (n = 149) were established in 1995 at all treatment and control sites. Each control replicate (OG and CC areas) and CT and SB treatments were assigned 7 survey stations each. Between 10 and 12 stations were placed in each TI and SI treatment, with 7 stations in the harvested portion and a station in each of the tree islands, except for the large island in Block 5516 which had 2 stations. Stations were placed to give relatively even coverage of each unit (Joy and van den Dreissche 1995), for an average of 1 station per 3 hectares (range of 1 station per 2.3 ha to 1 station per 5.6 ha). For stations not within a tree island, they were placed at least 100 m apart and at least 50 m from any tree island. A single station was placed near the centre of each tree island, except for the large island in Block 5516 which had 2 stations spaced >100 m apart.

The center point of each station was geo-referenced using a Global Positioning System (GPS) in 1996 and marked with angle iron stakes, spray paint and flagging tape. Routes between stations and the perimeter around stations (50 m radius) were also flagged.

3.2.2 Survey Method

Point-count surveys in the 2000s mainly followed methodologies used in the 1990s (Gyug 1997) and followed current standards for forest and grassland songbirds (RISC 1999). A survey was defined as an individual point count at an individual station. All birds detected (song, call or visual observation) within a 50 m radius were recorded. Data were also collected for distances beyond 50 m (in intervals of 50-75 m, and >75 m) at point-count stations, but these distances >50 m were not analysed. Sampling took place within a 4-hr period starting at dawn and ending around 0930 hours. Surveys were not conducted during periods of rain (>drizzle) or high wind (>3 on the Beaufort Scale). For all point-count surveys, the observer recorded environmental conditions (ceiling, cloud cover, wind speed, precipitation, and temperature) at the station for the survey period.

Three differences in point count methodology occurred between the 2 study periods. In the 1990s, all birds detected within a 10 minute interval were recorded. Surveys of 5 to 8 minutes have proven to be adequate and comparable to 10-minute surveys (RISC 1999); therefore, all 2006 and 2007 surveys were 8 minutes in duration, with intervals recorded for 0-3, 3-5, and 5-8 minutes. This increased survey efficiency without compromising on data quality. The second difference involved non-OG and non-tree island (SI and TI islands) stations. The 1990s surveys began upon reaching the edge of non-OG and non-tree island point-count stations (i.e., beginning at 50 m from station centre) to include any birds that flushed during the observer's approach, but allowing a 1-minute settling period for all other stations (van den Driessche and Joy 1998). Understory vegetation and tree growth often obscured visibility at all point count stations in 2006 and 2007, so fleeing birds could not easily be observed. In addition, the 1990s methodology created an inconsistency in the way that data was collected between point counts. Current RISC (1999) standards require a 1-minute waiting period after arrival at a survey point to allow birds to resettle after the observer arrived at a station. This procedure was followed in 2006 and 2007 for all stations. Lastly, although each of the 149 stations was surveyed once per replicate during both survey periods, 7 replicates were conducted in the 1990s and 5 replicates were conducted in the 2000s. We did not feel that the difference in the number of replicates was a concern because bird detection densities were pooled and averaged across replicates. Some rarer species may have had slightly more detections with 7 replicates, but any reduction in point-count detections were compensated for by targeted cavity-nester searches. Furthermore, 7 replicates would not be possible to complete without extending further into July (when bird activity is much reduced), or without significant increases in observer effort. Replicates for both periods were spaced between late May and early July each year to ensure representative sampling of birds during the breeding season. This spacing was important as the first replicates may have captured migrating individuals. Migrating birds may sing on their way to breeding grounds and there was no way to differentiate migrants from breeding birds early in the season, though most cavity-nesting species are likely resident.

In tree islands (SI and TI treatments), the 50 m radius of the survey area often extended beyond the island boundary. At these stations, birds were recorded as being either “in” or “out” of the island.

Survey teams were comprised of 2 to 3 skilled bird surveyors, with a single observer conducting individual point counts. Unless logistically infeasible, observers alternated stations between replicates. Station survey chronology was reversed whenever possible, such that a station surveyed at dawn for one replication was subsequently surveyed at the end of the station order on the next replication. Prior to initiating the annual surveys, surveyors conducted quality-control training in the study area for bird identification and distance estimations.

3.2.3 2006-2007 Sampling Chronology

Point-count surveys were conducted from 26 May to 1 July, 2006, and 30 May to 3 July, 2007 (Table 2). Each point-count station was surveyed 5 times in both years. With 2 observers, an early dawn, and closely spaced stations, an average of 30 point counts were completed per morning, with a maximum of 36. Due to stand regeneration in the cutblocks and blow-down in tree islands and old-growth areas, surveying was likely not as expedient as the 1990 surveys.

In 2006, surveys were conducted on consecutive days except for a break of 7 days between the second and third replicates, and 4 days between the fourth and fifth replications while cavity-nest searches were conducted. Weather was not a significant problem in 2006, although surveys were abandoned during the second replicate on 2 days due to high winds. Higher than preferred winds were often present at Block 5516 stations and fog delayed point counts at stations in Blocks 5549 and 5550 on 1 morning.

In 2007, there was a break in continuous surveys of 4 days each between 8 and 11 June and 21 and 24 June. When possible, all points within a replicate were completed as close to each other as possible. Due to weather events and scheduled crew shifts, this was not always possible. For example, all points in replicate 2 were completed between 3 June and 7 June except for Block 5510, which was completed on 12 June. Unlike 2006, weather posed a greater challenge to point-count completion during 2007. On 5 June heavy rains caused road washouts within the region, which prevented access to the study area until 7 June. Poor weather conditions prevented surveys on 27 June, and delayed or forced abandonment of counts on 5 other dates between 15 June and 1 July.

Table 2. Timing of breeding-bird point-count surveys conducted in the Donna Creek study area, 2006 and 2007.

	2006		2007	
Replicate	Start date	End date	Start date	End date
1	26 May	31 May	30 May	3 Jun
2	29 May	7 Jun	3 Jun	12 Jun
3	15 Jun	18 Jun	12 Jun	17 Jun
4	19 Jun	22 Jun	18 Jun	28 Jun
5	27 Jun	1 Jul	28 Jun	3 Jul

3.2.4 Stub Assessments

Stub assessments followed procedures conducted during the 1996 sampling period (Gyug 2002). Every standing stub in the experimental cutblocks (Blocks 5516, 5546 and 5547; n = 1,949 in 2007 [Juelfs and Corbould in prep.]), and the lone stub in Block 5549, was assessed for the presence of cavities; a cavity was any hole in the wood portion of the stem (i.e., did not include hollows under the trunk or root system). Stubs were located using 1:2,500 maps and a Global Positioning System (GPS) unit.

For any cavity that was identified, the tree species and diameter-at-breast height (DBH) of the stub were noted based on 1996 assessment data. For each cavity, several characteristics of the cavity entrance were recorded: height above ground; opening size (width and height); shape (e.g., round, rectangular); horizontal depth; orientation (direction the cavity opening was facing); and age (new [since winter] or old [prior to winter]) (Juelfs and Corbould in prep.). If possible, the agent (e.g., broken limb, woodpecker) that created the cavity entrance was also recorded.

In 2006, stub assessments were conducted on 7 days (24 Jun to 1 Jul, excluding 29 Jun) following the morning point-count surveys. In 2007, PWFWCP personnel conducted stub assessments from 13 June to 2 July while conducting their more detailed stub-decay assessments. If evidence of a potential cavity nest was found, the location was relayed to the bird survey crew, and the site was investigated for cavity-nesting birds.

3.2.5 Incidental Observations

In addition to the formal surveys, observers were keenly attentive to any sign from cavity-nesting birds while they conducted their activities in the study area (e.g., observations during point-count surveys but beyond 50-m radius, and travelling between point-count stations and study sites) between 26 May and 1 July 2006, and 30 May and 3 July 2007. Any cavity-nesting birds were observed and evaluated for nesting behaviour. If nesting behaviour was observed, the area was investigated for the presence of a cavity after the point-count surveys had ended for the day.

3.3 Nest-site Characterization

In 2006 and 2007, for any active cavity nest identified in the study area, characteristics were recorded for the nest-tree surroundings, nest-tree structure, and nest cavity. The stem that housed a cavity nest was termed the “nest-tree”, even though it may be a stub or snag and not an actual live tree (sensu Gyug 2002). Nest-site and nest-tree characteristics were assessed in accordance with methods used in 1996 (van den Driessche and Joy 1998).

Habitat surrounding nest-trees were described within macroplots centred at the nest-tree. Slope, aspect, elevation, macrosite position, and number of stubs were recorded within 50 m of the nest-tree. Site series type, moisture regime and nutrient regime were also identified based on the macroplot. Within an 11.3-m radius plot, percent cover of vegetative species in 6 strata was recorded: mosses and lichens, herbs, low shrubs (<2 m), tall shrubs (2-10 m), sub-canopy trees, and canopy trees (Habitat Monitoring Committee 1990). Percent cover by surface substrate (wood, bedrock, cobble, mineral, organic, and water) was visually estimated (Habitat Monitoring Committee 1990). The number of stumps (not including stubs), root wads, snags (<15 cm and ≥15 cm DBH), and stubs were also recorded. Stumps were classed by their diameter, and root wads were classed by 1-m height intervals. The species, DBH, wildlife tree code (Wildlife Tree Committee 2001) and heights of snags ≥15 cm DBH were recorded. To measure coarse woody debris (pieces >7.5 cm in diameter) at the site, two 24 m transects were positioned at right angles with the origin at the nest-tree. The diameter, length, line-intercept distance, decay class, and percent sound wood of all coarse woody debris was measured (B.C. Ministry of Forests 1996).

For each nest-tree, species, DBH, height, signs of decay, percent remaining bark, location (latitude/longitude), and distance to nearest cutblock boundary were recorded. Nest-tree height was measured with a tape measure up to about 4-5 m; otherwise, a clinometer and 50-m tape were used. Signs of decay, percent remaining bark, and proximity to cutblock boundary were visually estimated.

Orientation, height, and position (top, middle, or bottom third of stem) of entrances to cavity nests were recorded as per the 1990s assessments (Gyug 2002). However, not all the same cavity data was collected during the recent study period because nests were still active at the end of the field season and cavities were difficult to access (i.e., >10 m in height). The cavity-entrance dimensions, cavity depth, and diameter of the stem at cavity height were not measured, though cavity-entrance dimensions were estimated in 2007.

3.4 Statistical Analysis

Differences in cavity-nesting bird abundances were tested using a Generalized Linear Model with Poisson probability distribution. A non-parametric Kruskal-Wallis test was used to determine if there was a difference between treatment and controls. The location of differences was determined by pair-wise comparisons of each treatment and control type using individual Mann-Whitney U-tests.

Differences in treatment and control and site were compared between primary cavity excavators and secondary cavity users using an Independent Samples T-test. Where Levene's test for equality of variances was significant (i.e., unequal variances), a non-parametric Mann-Whitney U-test was conducted. All p-values for all tests were considered significant at $\propto > 0.05$.

No meaningful statistical comparisons could be conducted for nest data in the 2000s as the sample size was very small and each nest represented a different bird species, location and stem type (details in Appendix B).

4.0 RESULTS

In 2006 and 2007, 11 species of cavity-nesting birds were observed in the study area. Most detections occurred during point-count surveys (Table 3, Appendix C). Six species were primary cavity excavators and 5 species were secondary cavity users. Primary cavity excavators (e.g., woodpeckers, some chickadees, nuthatches) were relatively uncommon in the area, with Red-breasted Nuthatches having the greatest number of detections (n = 37).

Table 3. Detections of all cavity-nesting bird species recorded, by control and treatment type[a], observed during 50-m radius point-count surveys in the 1990s (1995-1996) and 2000s (2006-2007), Donna Creek study area.

		Controls		Treatments				
Species	Decade	CC	OG	CT	SB	SI	TI	Total
Primary Cavity Excavators								
American Three-toed Woodpecker	1990s		18			6	9	33
	2000s		7				1	8
Black-backed Woodpecker	1990s		8	1	14	38	35	96
	2000s					1	2*	3
Hairy Woodpecker	1990s	1	5			2	8	16
	2000s							0
Northern Flicker	1990s					3		3
	2000s				1			1
Pileated Woodpecker	1990s							0
	2000s				1			1
Red-breasted Nuthatch	1990s		53	1		13	16	83
	2000s		25			3	9	37
Boreal Chickadee	1990s		18					18
	2000s		9			2	5	16
Total Primary		1	143	2	16	68	83	315
Secondary Cavity Users								
American Kestrel	1990s			2	1	10	5	18
	2000s							0
Boreal Owl	1990s		1					1
	2000s							0
Brown Creeper	1990s		16					16
	2000s		6					6
Mountain Bluebird	1990s	6		21	25	50	16	118
	2000s							0
Mountain Chickadee	1990s							0
	2000s		9			2	15	26
Northern Hawk Owl	1990s					1		1
	2000s							0
Northern Pygmy-Owl	1990s		1					1
	2000s							0
Tree Swallow	1990s	25	2		19	15	20	81
	2000s				2			2
Total Secondary		31	35	23	47	78	56	270
Total Primary and Secondary		32	178	25	63	146	139	585

[a] Habitats include controls: Clearcut Control (CC), Old-growth Control (OG); and treatments: Clearcut Treatment (CT), Stub Treatment (SB), Stub-and-Island Treatment (SI), and the Tree-island Treatment (TI).

* This observation is of a bird seen flying through a tree island, but never observed perched.

Woodpeckers were sampled mainly by hearing their drumming activity, while smaller species (e.g., chickadees, nuthatches) were usually detected by their vocalizations. Primary cavity excavators were recorded during 3.5% and 4.3% of the 745 point-count surveys conducted each year in 2006 and 2007, respectively. Woodpeckers alone were recorded at <1% and 1.2% of point-count surveys in these 2 years.

Secondary cavity users (e.g., owls, creepers, some chickadees) were also uncommonly detected in 2006 and 2007 (Table 3). Mountain Chickadees were the most frequently detected secondary cavity user (n = 26). These species were detected either visually or by their vocalizations, as none have distinct drumming behaviour as do the woodpeckers. Secondary cavity users were recorded during 1.3% and 2.6% of point-count surveys in 2006 and 2007 respectively.

For both survey decades combined, 15 cavity-nesting species were observed during point-count surveys: 7 species of primary cavity excavators and 8 species of secondary cavity users (Table 3). Primary cavity excavators in the 2000s were recorded at 25% of the number of point-counts as in the 1990s. Secondary cavity users were detected at 16% of the number of stations in the 2000s compared with the 1990s (Table 4). Six species of cavity user were only detected during the 1990s, while Pileated Woodpecker and Mountain Chickadees were only detected in the 2000s. Almost all of the species that were detected in both decades were more common in the 1990s, and none were detected more frequently in the 2000s.

Table 4. Number of point-count surveys that cavity-users were recorded at in the 1990s (1995-1996) and 2000s (2006-2007), Donna Creek study area. Data from 1990s modified from raw point-count data on file with PWFWCP. In 1995 and 1996, n = 1,043 point-count surveys (7 replicates of 149 stations). In 2006 and 2007, n = 745 point-count surveys (5 replicates of 149 stations).

Year	Primary cavity excavators	Secondary cavity users
1995	143	110
1996	82	70
2006	26	10
2007	32	19
Total	283	209

There was a significant difference in the number of detections of cavity-nesting birds between the 1990s and 2000s (P-value < 0.001), with more bird detections during the 1990s. Treatments and controls were also significantly different (P-value < 0.001), and further tests showed that the differences occurred between OG and CC, and between OG and CT, with

OG having significantly more bird detections than either clearcut type (both P-values < 0.001). There were no differences in site or treatment preferences between primary and secondary cavity users in either decade, with the exception of OG. OG had more primary cavity excavators than secondary cavity users (Mann-Whitney U test, Z = -2.65; P-value = 0.004). Both groups had species specific habitat associations. Black-backed Woodpeckers were most often found in tree islands, whereas American Three-toed Woodpeckers, Brown Creepers, and Boreal Chickadees were usually located in the continuous mature forest (including OG) within the study area. Brown Creepers had no detections outside of OG controls in either decade. Red-breasted Nuthatches and Mountain Chickadees were found in both the continuous mature forest and tree islands.

American Three-toed Woodpeckers were commonly detected in both tree islands and OG, but not in stubs or clearings within any treatment (Gyug 2002; Gyug 1997; Joy and van den Driessche 1995). Seven of 8 observations in the 2000s were in OG, with only 1 sighting from a tree island.

Black-backed Woodpeckers, though common in the 1990s, were observed only 3 times in 2006 and 2007: one of these sightings involved a bird flying through a tree island within the TI treatment of Block 5516.

The other woodpecker species (Hairy Woodpecker, Pileated Woodpecker, and Northern Flicker) all were seldom recorded in either decade. Gyug (1997) lists 16 observations of Hairy Woodpeckers from tree islands, old growth, and clearcuts within the 1990s, though none were observed in the 2000s.

Boreal Chickadees and Red-breasted Nuthatches were among the most common primary cavity excavators recorded during the 2000s. The chickadee was detected in all OG sites during both survey decades, and once in a cutblock during the 2000s. The nuthatch was found mostly in OG forest, with a few detections from tree islands and harvested sections of some treatments.

Mountain Chickadees were detected in 1993 in Block 5516, but not detected again in subsequent surveys during the 1990s (Gyug and Summers 1995; Gyug 2002). In contrast to surveys in the 1990s when Mountain Chickadee appeared rare, there were 26 detections of this species in 2006 and 2007. These observations were again mostly from old growth areas, with many observations from tree islands as well, and a few from clearcut portions of treatments.

A number of other cavity-nesting species also occurred in the study area. Many secondary cavity-using species were only recorded in the 1990s. The Brown Creeper was rare, but occurred in every OG control with 6 observations in all from the 2000s. All of the owls were scarce, though a Northern Pygmy-Owl was detected on a number of occasions in 1995 from one locality (Joy and van den Driessche 1995), and once incidentally in 2006. The Boreal Owl was detected only in 1995, and a Northern Hawk Owl was seen twice: once in 1996 and once in 2006, though the latter was not during a point-count survey.

4.1 Active Cavity Nests

In 2006 and 2007, only 3 active cavity nests (i.e., occupied by birds egg-laying, incubating, or feeding nestlings) were discovered in the study area: a Tree Swallow nest in stub #1917 within Block 5516 in 2006, an American Three-toed Woodpecker nest in a mature pine within the OG of site 5547 in 2007, and a Mountain Chickadee nest in a natural wildlife tree along the cutblock-forest interface of Block 5547 in 2007.

The stub nest was located by observing a pair of Tree Swallows flying around the area until one was observed entering the nest cavity. The following year a single Tree Swallow was again witnessed in the same vicinity on one occasion, though no evidence of nesting was found. The American Three-toed Woodpecker nest was found incidentally when a surveyor was walking back from a station after completing the morning's point-count surveys. Begging calls of young alerted the surveyor, and constant feeding forays of the adults led to the cavity location. The Mountain Chickadee nest was found by the stub-assessment crew. Although the wildlife tree was not being assessed, the nest was found when one of the adults was observed exiting its cavity from the edge of the cutblock.

In the 1990s, 47 active cavity nests of 7 species were found in 34 nest-trees (stubs, dead trees, and live trees) in the study area (Table 5; Gyug 2002). Thirty-one active cavity nests were found in 10 stubs (8 dispersed and 2 perimeter) and 9 tree-island stems (dead or live trees) in the experimental cutblocks. Some cavities were used in consecutive years and by more than 1 species, and others were located in control areas and continuous forest in the study area, thus accounting for the differences between number of cavity nests and nest-trees.

Boreal Chickadees were suspected of breeding, although no evidence for this was found (Gyug 2002), and Brown Creepers probably bred as well. No nests of these 2 species were found in the 2000s, though potential nesting cavities and a pair of Boreal Chickadees were observed outside of experimental areas near a wetland between Blocks 5547 and 5549 during 2006. Mountain Chickadees were not suspected as a breeding bird during the 1990s (Gyug 2002).

Table 5. Total number of nests and nest-trees by decade (1990s and 2000s) for experimental units, controls, and continuous forest, Donna Creek study area. Data for 1990s from Gyug (2002).

		Experimental cutblocks				Control areas						
		Outside tree islands		Inside tree islands		OG		CC		Continous forest		
Species	Decade	Nests	Nest-trees	Nests	Nest-trees	Nests	Nest-trees	Nests	Nest-trees	Nests	Nest-trees	Total nests
Primary cavity excavators												
Black-backed Woodpecker	1990s	4	2	4	3							8
	2000s											0
American Three-toed Woodpecker	1990s	1	1	4	3					11	11	16
	2000s					1	1					1
Hairy Woodpecker	1990s			1	1							1
	2000s											0
Northern Flicker	1990s			1	1							1
	2000s											0
Red-breasted Nuthatch	1990s			1	1	1	1			1	1	3
	2000s											0
Secondary cavity users												
Tree Swallow	1990s	4	2	2	2			1	1			7
	2000s	1	1									1
Mountain Bluebird	1990s	6	4	3	3			2	2			11
	2000s											0
Mountain Chickadee	1990s											0
	2000s	1	1									1
All cavity-nesting species		17	11	16	14	2	2	3	3	12	12	50
Total nest-trees			10		11		2		3		12	

4.2 Cavities in Stubs

In 2007, assessments of standing stubs in the 3 experimental blocks found 125 cavities in 98 stubs (Juelfs and Corbould in prep). A cavity was defined as any hole (≥2 cm x 2 cm) that had a platform capable of housing the smallest potential cavity-using bird (i.e., a chickadee). A nesting (or nest) cavity was any cavity that had evidence of current or former bird nesting activity. Forty-three of these cavities (34%) were created by a primary cavity excavator for nesting purposes and 38 cavities (30%) were created by Pileated Woodpeckers to feed on carpenter ants (Table 6; data modified from Juelfs and Corbould in prep). Most

Pileated Woodpecker feeding cavities were in spruce stubs (n = 29); 8 feeding cavities were in fir stubs and 1 feeding cavity was in a pine stub.

Nest cavities were found throughout the entire study area. Preliminary analyses by Juelfs and Corbould (in prep) indicated that spruce and subalpine fir stubs are more likely to contain nesting cavities than lodgepole pine stubs. In addition, Block 5516 appears to be more likely to contain a nesting cavity than other blocks, though treatment type had no effect. In 1995 and 1996, all of the nest-trees used had decayed heartwood, and variable sapwood decay condition (Gyug 2002). It was estimated that only 7.6% of stubs were suitable for cavity nest excavation (i.e., had decay) in the 1990s, corresponding to about 162 stubs (Gyug and Corbould 2002, Gyug 2002). Therefore, all the nesting habitat provided by stubs has likely not been realized as nest cavities were found in only 35 stubs during surveys in 2007 (Juelfs and Corbould in prep.).

Nest cavities were found primarily in spruce and fir (17 and 23 cavities respectively) based on surveys of all stubs in 2007, though most stubs were cut from those species. The average diameter of stubs with nest cavities was 39 cm (range = 19-66 cm, n = 42). Preliminary analysis indicates that the average diameter of stubs with cavities is larger than those without, though there is no difference in dbh between stubs with nesting and/or bird-created cavities than non-nesting and non-bird cavities.

Table 6. Number of active and inactive nesting cavities in stubs within the 3 experimental blocks of the Donna Creek study area, 1995-1996 and 2006-2007. Data modified from Juelfs and Corbould (in prep).

	Active nests	Inactive nests	Total
Number of cavity nests in stubs			
1995-1996	12	16	28
2006-2007	1	42	43 [a]
Number of stubs with cavity nests			
1995-1996	10	9	19
2006-2007	1	35	36 [b]

[a] Does not include 8 cavities that were present in 1996. Stubs had fallen or cavities were no longer present in stubs in 2007.
[b] Does not include 4 stubs that had a cavity present in 1996. Stubs had fallen or cavities were no longer present in stubs in 2007.

5.0 DISCUSSION

Most cavity-nesting species were less abundant during the 2000s compared with the 1990s. There were notably fewer detections (100 vs. 485) and fewer active cavity nests (3 vs. 47) in the 2000s. Despite this decline in abundance, most species were observed in both decades and were distributed across the study area. Thus, the decline was driven by fewer individuals rather than fewer species or a decline in a particular area. All cavity-nesting birds expected within the study areas were found, except for sapsuckers (*Sphyrapicus* spp.). Red-breasted Sapsuckers (*Sphyrapicus ruber*) were observed in forested habitats in the surrounding region, such as near the community of Germansen Landing (N. Hentze pers. obs.). Their absence from the Donna Creek study area may be due to a lack of deciduous trees within those sites, as deciduous trees are most often used for nesting by this group of birds (Campbell et al. 1990, Martin et al. 2006).

There was no apparent habitat preference between primary cavity excavators and secondary cavity users as a group, except in relation to OG. No difference was expected due to the secondary users depending on the primary users for the creation of nest sites. The greater number of primary cavity users in OG may have been due to a greater number of detections of this group within this habitat.

The sharp decline in active nests in the 2000s compared to the 1990s was not predicted at the extent to which it occurred, but not entirely unexpected. While it was expected for a few species which have strong preferences for early seral habitat or clearings (e.g., Mountain Bluebird, Tree Swallow), it was less predictable for most primary cavity excavators. This reduction is probably the result of a number of factors, such as post-harvesting effects and large-scale beetle infestations in adjacent areas. Surveys in the 1990s may have detected higher than normal cavity-nester densities due to overcrowding effects post-harvest. Several studies show a pattern of increased density of birds immediately post-fragmentation, followed by a reduction in bird density in subsequent years (Bierregaard and Lovejoy 1989, Darveau et al. 1995, Schmiegelow et al. 1997). This is due in part to pre-fragmentation bird populations competing for less overall area. After a period of time, either through dispersal or mortality, the crowding effects are reduced.

Dispersal of individuals to areas of higher habitat suitability or higher food availability may further reduce the population densities observed at Donna Creek. Black-backed Woodpeckers, for example, have a strong dispersal ability, often leaving previously occupied areas to rapidly colonize new sites of favourable habitat (Dixon and Saab 2000).

Within the north-central interior of British Columbia, vast areas have been infested by the Mountain Pine Beetle (*Dendroctonus ponderosae* Hopkins). The Mountain Pine Beetle adults and/or larvae may constitute a significant source of food for many cavity-nesting species, and insect epidemics are known to significantly increase the densities of many cavity-nesting species in some areas (Martin et al. 2006). Although Mountain Pine Beetle is responsible for some attack of trees near the Donna Creek study area (N. Hentze pers. obs.), the region has been infested more recently than areas to the south (e.g., Prince George Forest District). Thus, some individuals may have withdrawn from Donna Creek to areas of higher beetle densities in the surrounding region. If Mountain Pine Beetle infestations intensify at or near the Donna Creek study areas, a resultant increase in woodpecker densities may again be observed.

A suitable site for excavating a nest cavity requires trees that have heart-rot decay present at the time of stubbing, or other obvious defects (e.g., scars, or pre-existing cavities) (Harris 2001; Fenger et al. 2006; T. Manning, Manning, Cooper and Associates, personal communication). Harris found that stubs that were sound when cut were still sound after a decade, though sap-rot was forming in some (2001). Only about 11% of the decay-assessed stubs in this study had characteristics considered good for primary cavity excavators (i.e., hard sapwood and soft heartwood). This factor could limit nesting opportunities in the study area. While the number of cavities may have limited the nesting densities of some species in the early-seral stage, the lack of nesting evidence in the 2000s indicates that cavities are not limited in the 2000s. The number of cavity-nests in 2006 and 2007 may not be unusually low in this system. Stub assessments in 2007 found 43 nesting cavities in the experimental treatment blocks, which includes all cavities deemed to be used and/or have been used for nesting. If averaged out over the past decade since the 1990 surveys, this averages only 4.3 new nests/year. Considering the greater number of nests found during 1990s surveys, nesting attempts may not be linear, and the rate of decline may have been greater in earlier years. A study in south-central British Columbia found birds continuing to nest in stubs 10 years after stub creation (Harris 2001); however, it also noted that no new excavations took place as all nesting attempts were in previous cavities.

Declines in active nests within the continuous forest are harder to interpret. Vegetation data presented in the companion report "Donna Creek Forestry/Biodiversity Project: Phase II (2006-2007) Breeding-Bird Monitoring" indicates that there are concurrent increases in ground cover variables and decreases in tree-canopy covers. Changes in these habitat variables in combination with general declines in cavity-user abundance may help explain this trend, though more detailed study is needed. Despite these changes, the only primary cavity excavator found nesting in the 2000s did occur within the continuous forest, and it belonged to the same species that had the greatest nesting-association with continuous mature forest in the 1990s.

Behavioural constraints, such as nest site territoriality and foraging range, may also limit the amount of use possible at any given time. Gyug found a minimum spacing of 200 m between woodpecker nests in this study area in the 1990s (2002). As home range size and territorial behaviour varies per species, the effects of breeding density will be species-specific. Nonetheless, nesting of one species in the stub treatment or tree island in a given block may preclude other conspecifics from inhabiting the same area at the same time. Again though, this effect does not appear to have affected cavity-nesting bird populations in the study area during the shrub-seral survey period.

It is not known why American Three-toed Woodpeckers were not observed within tree islands more frequently in the 2000s. It may be due to the species preference for mature, continuous forest (Leonard 2001), but several nests were found at Donna Creek in tree islands in the 1990s. Nonetheless, tree islands, such as those found in Donna Creek, do not meet the size and area requirements (>5 ha over 5-10% of the area) deemed necessary to benefit this species (Fenger et al. 2006). The quiet and reclusive nature of this species makes detection difficult at times, but the extreme disproportion in detections by habitat suggests that its association with mature continuous forest is not an effect of observer bias, as any present in tree islands should be as easily detectable as those in continuous forest. American Three-toed Woodpeckers have been noted to colonize sites following disturbances such as fire, and some movements into and out of stands following changes in insect abundance certainly occur (Murphy and Lehnhausen 1998, Kreisel and Stein 1999, Leonard 2001). The scarcity of nests in the 2000s compared to the 1990s suggests that current conditions in the study area provide poor habitat for breeding American Three-toed Woodpeckers.

Gyug and Corbould (2002) reported recent foraging sign on 50% of the dispersed stubs (from the period up to 1996), and Gyug (2002) further speculates that much of this was due to Black-backed Woodpecker. In addition to foraging evidence, Black-backed Woodpeckers spent 89% of their daily activity-budget on stubs (Joy and van den Driessche 1995). Based on available habitat within the study area, and published woodpecker home ranges, Gyug (2002) states that insect-infested stubs can support much of the food requirements of this species. No Black-backed Woodpeckers were observed utilizing stubs in either 2006 or 2007. There are a number of factors that may help explain this observation. The Black-backed Woodpecker is perhaps the most fire-dependent bird species in boreal and sub-boreal forests. The irregular timing and distribution of wild-fires dictates a strong dispersal mechanism in this species. Black-backed Woodpeckers are widely known for their ability to rapidly colonize newly created favourable habitat, and to disperse away at the end of an insect outbreak (Dixon and Saab 2000). It is often the most abundant woodpecker immediately following a stand-destroying fire-event (Fenger et al. 2006). The lack of recent foraging sign on stubs may support the hypothesis that suitable insect prey no longer occupies standing wood within the experimental cutblocks. Because tree islands consisted of live trees, snags and perimeter stubs, localized aggregations of insect larvae in these patches likely accounted for Black-backed Woodpecker use of this habitat. More suitable nesting and foraging conditions may exist elsewhere on the landscape, thereby drawing birds away, as tree islands within the study area do not meet the characteristics needed to benefit this species (>5 ha over 5-10% of the area; Fenger et a. 2006). The absence of nests within the study area in the 2000s implies that current conditions, 16-17 years post-harvest, provide poor breeding habitat for breeding Black-backed Woodpeckers. The low number of detections of Black-backed Woodpecker, the locations of sightings, and the lack of apparent association with stubs in this time period, suggests that this species has not benefited noticeably by having stubs present to this stage of the study.

No Hairy Woodpeckers were detected on point-counts in the 2000s. It appears that Hairy Woodpeckers do not currently inhabit the Donna Creek project area. No regular seasonal movements or irruptive behaviour due to insect outbreaks are known (Jackson et al. 2002), and it is not known why they are absent from the study area.

Pileated Woodpeckers in the study area are approaching their northernmost distribution west of the Rockies (Campbell et al. 1990, Bull and Jackson 1995). The breeding habitat of this species includes mature forest and younger forest where large, dead trees remain (Bull and Jackson 1995). Home ranges for this species can be quite large, and may exceed 1,000 ha (Mellen et al. 1992, Fenger et al. 2006). The combination of large home range, low population density, and distributional limit indicate that this species may be able to breed in the Donna Creek study area but few pairs likely occur.

Northern Flicker preys predominantly on ants, and spends considerably more time foraging on the ground than other woodpeckers (Moore 1995). Their absence as a breeding species in the area during the 2000s survey period is perplexing as this woodpecker typically occupies harvested forest areas where it nests in remnant dead or decayed trees, stubs, or even low stumps (Campbell et al. 1990). Some stubs with extensive ant-infestations were seen, and the presence of old cavities excavated by Northern Flickers suggests that habitat was suitable at some point. The near absence of this species from the study area may be related to elevation effects as Northern Flickers are much less numerous at high elevations, such as the ESSF zone, compared to low-elevation areas (Campbell et al. 1990, Moore 1995).

Chickadees and nuthatches were the most common cavity-using species in the 2000s, and may be the cavity-nesting species that could benefit the greatest from tree islands. In general, it appears that Boreal Chickadees were as common in the 1990s as they were in the 2000s. Tree islands and mature continuous forest appear to be providing suitable habitat as harvested areas continue to regenerate. Chickadees can be benefited by small wildlife tree patches, but those in Donna Creek are still much smaller than the 5 ha patch-size recommended for these species (Fenger et al. 2006). The Mountain Chickadee was much more common in the 2000s than during the 1990s. Data are lacking, but this change may be due to effects of harvesting in the surrounding area, providing suitable breeding habitat for this chickadee, or a general population increase in the broader region. Red-breasted Nuthatches likely breed within the continuous forest in and around the study area. Tree islands may be utilized, and likely provide foraging potential, and could be incorporated as part of a larger territory, though are much smaller than the 1.5 ha recommended by other researchers to benefit Red-breasted Nuthatch (Gyug and Bennett 1995)

A few cavity-nesting species that were relatively common in the 1990s have mostly disappeared from the study area all together. Mountain Bluebirds breed in open areas such as grassland, subalpine meadow, farmland, burns, and clearcuts (Power and Lombardo 1996, Campbell et al. 1997). General avoidance of nesting near continuous forest has been observed (Holt and Martin 1997, Gyug 2002). This species is probably absent from the Donna Creek study area due to increased forest and shrub cover in the experimental cutblocks. Increased ground cover may reduce nesting-habitat suitability for this species, related to either foraging ability or predator avoidance. As forest succession continues within the experimental treatments, Mountain Bluebirds are unlikely to occur again as anything other than migrants unless new openings are created. Tree Swallows were uncommon in the project area. In remote forest-dominated areas, breeding sites of this species are usually found near water (Robertson et al. 1992). The recently-harvested landscape of the 1990s likely provided new breeding habitat for Tree Swallows as large areas with much edge habitat was created. In later years, conditions seem to have declined for this species and, as forest succession continues, Tree Swallows will likely not breed in the study area. Similarly with the American Kestrel, forest regeneration will likely exclude this species from the study area until another disturbance event occurs.

None of the owls detected are likely to nest in stubs within the experimental treatments. Furthermore, tree islands are too small to encompass owl territories, though may be incorporated into territories, and are used as foraging areas. Some species, such as the Northern Hawk Owl and Northern Pygmy-Owl, may choose breeding sites near to clearings due to their affinity for foraging in more open areas (e.g. Duncan and Duncan 1998). Point-counts are not a good method for inventorying owl species, and dedicated owl surveys would be needed to properly assess habitat use and abundance within the study area.

The Brown Creeper is strongly associated with late-successional forests as it requires large trees for breeding and foraging microsites (Hejl et al. 2002). The continuous forest (including OG) of Donna Creek is solely where this species was detected, and it probably breeds within those areas.

6.0 MANAGEMENT IMPLICATIONS

Small tree islands (<0.4 ha), such as those retained in this study, do not appear to be providing valuable breeding habitat for many cavity-nesting species. While some species, such as Black-backed Woodpecker, do utilize them, the limited breeding evidence to date (~15 years post-harvest) of cavity-nesters suggests that these tree islands were probably too small to support breeding pairs for many species. This is further enforced by published cavity-user territory sizes, which are generally larger than the tree island size used in this study (Fenger et al. 2006) This supports Gyug's (1997) statement that tree islands of 0.2-0.4 ha are of little breeding value to many of the forest bird species present. Where they are spatially close to mature continuous forest, tree islands may be incorporated into breeding territories, but alone, appear to provide only foraging and perching habitat. In addition to their small size, almost all tree islands experienced high wind-throw, reducing the effective size of the patch and the availability of standing stems. Though tree islands may have future ecological benefits, such as adding to coarse woody debris levels, they are currently of minimal use for birds in the ESSF zone of north-central BC. Increasing the size of tree islands would likely increase their ecological value.

Stubs also appear to have very limited value to cavity-nesting birds in the mid-term in the ESSF zone of British Columbia, although in the short-term stubs had a much higher rate of use by cavity-nesters (Gyug 2002). The rate of use of high cut stubs in the mid-term is lower than that seen in another study of high-cut stub use in British Columbia (Harris 2001), despite a similar number of cavity-nesters between studies. The study by Harris, however, is in a different Biogeoclimatic Zone (Interior Douglas-Fir), and so results are not directly comparable. It should be noted that stubs at a density of 5-10/ha may provide different results at lower elevations and different regions of the province. The low rate of use of stubs likely does not warrant the operational investment required to establish them utilizing their current creation methods. Stubs should be much taller and selected based on the presence of pre-existing decay, scarring, or cavities, to be of value. Without such provisions, stubbing does not appear to be a worthwhile component to the bird community within ESSF stands.

7.0 LITERATURE CITED

Angelstam, P., 1998. Maintaining and restoring biodiversity in European boreal forests by developing natural disturbance regimes. J. Veg. Sci. 9, 593–602.

Attiwill, P.M., 1994. The disturbance of forest ecosystems: the ecological basis for conservation management. For. Ecol. Manage. 63, 247–300.

Backhouse, F. 1993. Wildlife Tree Management in British Columbia. Co-published by Workers' Compensation Board, B.C. Silviculture Branch and Canada-B.C. Partnership Agreement on Forest Resource Development: FRDA II.

B.C. Ministry of Forests. 1995. Biodiversity Guidelines. Forest Practices Code of British Columbia, Victoria, BC, Canada.

______. 1996. Vegetation Resources Inventory: Ground Sampling Procedures (Chapter 5, Coarse Woody Debris). Ministry of Forests, Resource Inventory Branch, for the Terrestrial Ecosystems Task Force, Resources Inventory Committee.

Bennett, S.N. 1994. Initiatives in wildlife tree management: an evaluation of the high-cut stumping technique. Master's Thesis. Report No. 152, School of Resource and Environmental Management, Simon Fraser Univ., Burnaby, B.C.

Bergeron, Y., Harvey, B., Leduc, A., Gauthier, S., 1999. Forest management guidelines based on natural disturbance dynamics: stand and forest-level considerations. For. Chron. 75, 49–54.

Bergeron, Y., Leduc, A., Harvey, B.D., Gauthier, S., 2002. Natural fire regime: a guide for sustainable management of the Canadian boreal forest. Silva Fennica 36, 81–95.

Bierregaard, R.O., and T.E. Lovejoy. 1989. Effects of forest fragmentation on Amazonian understory bird communities. Acta Amazonica 19: 215-241.

Bull, Evelyn L., and Jerome A. Jackson. 1995. Pileated Woodpecker (*Dryocopus pileatus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/148

Bunnell, F.L. 1995. Forest-dwelling vertebrate faunas and natural fire regimes in British Columbia: patterns and implications for conservation. Cons. Biol. 9: 636-644.

Bunnell, F.L., L.L. Kremsater, and E. Wind. 1999. Managing to sustain vertebrate diversity in forests of the Pacific Northwest: Relationships within stands. Environmental Reviews 7:97–146.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, M.C.E. McNall, and G.E.J. Smith. 1997. The birds of British Columbia – Volume 3: Passerines (Flycatchers through vireos). UBC Press, Vancouver. 693 pp.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, and M.C.E. McNall. 1990. The Birds of British Columbia, Volume 2, Non-passerines, Diurnal Birds of Prey through Woodpeckers. UBC Press, Vancouver. 662 pp.

Cissel, J.H., Swanson, F.J.,Weisberg, P.J., 1999. Landscape management using historical fire regimes: Blue River, Oregon. Ecol. Appl. 9, 1217–1231. Bender, D.J., T.A. Contreras, and L. Fahrig. 1998. Habitat loss and population decline: a meta-analysis of the patch size effect. Ecology 79: 517-533.

Cody, M.L. (Ed.) 1985. Habitat selection in birds. Academic Press, London.

Cramp, S. 1985. The birds of the Western Palearctic. Vol. 4: terns to woodpeckers. Oxford Univ. Press, Oxford, U.K.

Darveau, M., P. Beauchesne, L. Belanger, J. Huot, and P. Larue. 1995. Riparian forest strips as habitat for breeding birds in the boreal forest. Journal of Wildlife Management 59: 67–78.

Dawson, R., L.J. Murray, and M.D. Wood. 1992. Wildlife tree maintenance and creation in managed ESSF forests in the Mackenzie District. Working Plan. Peace/Williston Fish and Wildlife Compensation Program, Report No. 16. Prince George, B.C. 13 pp plus appendices.

Dixon, Rita D., and Victoria A. Saab. 2000. Black-backed Woodpecker (*Picoides arcticus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/509

Drever, M.C. and K.M. Martin. [2007]. Spending time in the forest: Responses of cavity-nesters to temporal changes in forest health and environmental conditions in interior British Columbia. In Temporal explicitness in landscape ecology: Understanding wildlife responses to changes in time. J.A. Bissonette and I. Storch (editors). Springer, New York, N.Y. pp. 236–251. In press.

Duncan, J.R. and P.A. Duncan. 1998. Northern Hawk Owl (*Surnia ulula*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/356

Fenger, M., T. Manning, J. Cooper, S. Guy, and P. Bradford. 2006. Wildlife and trees in British Columbia. Lone Pine Publishing, Vancouver, B.C.

Fule, P.Z., Covington, W.W., Moore, M.M., 1997. Determining reference conditions for ecosystem management of southwestern Ponderosa Pine forests. Ecol. Appl. 7, 895–908.

Gyug, L.W. 1997. Donna Creek Forestry/Biodiversity Project: Breeding bird point counts 1995 and 1996. Peace/Williston Fish and Wildlife Compensation Program Report No. 129. 40 pp plus appendices.

_______. 2002. Donna Creek Forestry/Biodiversity Project: Cavity nests 1995-1996. Peace/Williston Fish and Wildlife Compensation Program Report No. 253. 52 pp plus appendices.

_______ and S.N. Bennett. 1995. Bird use of wildlife tree patches 25 years after clearcutting. Report for B.C. Ministry of Environment, Penticton, B.C. 30pp.

_______ and F.B. Corbould. 2002. Donna Creek Forestry/Biodiversity Project: Stubs, residual islands and other habitat characteristics. Peace/Williston Fish and Wildlife Compensation Program Report No. 252. 58 pp plus appendices.

_______, and K. Summers. 1995. Donna Creek Biodiversity Project: Preliminary Breeding bird surveys 1993. Peace/Williston Fish and Wildlife Compensation Program Report No. 41. 45 pp plus appendices.

Habitat Monitoring Committee. 1990. Procedures for environmental monitoring in range and wildlife habitat management. British Columbia Ministry of Environment, Lands and Parks and British Columbia Ministry of Forests, Victoria, B.C.

Harestead, A.S., and D.G. Kiesker. 1989. Nest tree use by primary cavity-nesting birds in south-central British Columbia. Can. J. Zool. 67: 1067-1073.

Harmon, M.E., J.F. Franklin, F.J. Swanson, P. Sollins, S.V. Gregory, J.D. Lattin, N.H. Anderson, S.P. Cline, N.G. Aumen, J.R. Sedell, G.W. Lienkaemper, K. Cromack, Jr., and K.W. Cummins. 1986. Ecology of coarse woody debris in temperate ecosystems. Adv. In Ecol. Res. 15: 133-302.

Harris, B. 2001. Observations on the use of stubs by wild birds: a 10-year update. B.C. J. of Ecosystems and Management. Accessed online 05 Aug., 2007: http://www.siferp.org/jem/2001/vol1/no1/art3.pdf

Harvey, B.D., Leduc, A., Gauthier, S., Bergeron, Y., 2002. Stand-landscape integration in natural disturbance-based management of the southern boreal forest. For. Ecol. Manage. 155, 369–385.

Hejl, S. J., K. R. Newlon, M. E. Mcfadzen, J. S. Young and C. K. Ghalambor. 2002. Brown Creeper (*Certhia americana*), The Birds of North America Online (A. Poole, Ed.).

Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/669

Hentze, N.T., and J.M. Cooper. 2009. Donna Creek Forestry/Biodiversity Project (Phase II): Breeding bird monitoring 2006-2007, Final Report. Peace/Williston Fish and Wildlife Compensation Program Report No. 327. 51pp plus appendices.

Holt, R.F., and K. Martin. 1997. Landscape modification and patch selection: the demography of two secondary cavity nesters colonizing clearcuts. Auk 114: 443-455.

Hunter Jr., M.L., 1993. Natural fire regimes as spatial models for managing boreal forests. Biol. Conserv. 32, 115–120.

Jackson, Jerome A., Henri R. Ouellet, and Bette J. Jackson. 2002. Hairy Woodpecker (*Picoides villosus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/702

Joy, J., and R. van den Driessche. 1995. Donna Creek Biodiversity Project: Habitat use of cavity nesting birds in the Donna Creek Study Area, 1995. Peace/Williston Fish and Wildlife Compensation Program Report No. 54. Prince George, B.C. 26pp. plus appendices.

Juelfs, F.K., and F.B. Corbould. in prep. Donna Creek Forestry/Biodiversity Project (Phase II): Status of retained stubs and tree islands, 1996-2007. Peace/Williston Fish and Wildlife Compensation Program, Prince George, B.C.

Kreisel, K. J. and S. J. Stein. 1999. Bird use of burned and unburned coniferous forests during winter. Wilson Bull. 111: 243–250.

Lance, A.N., and M. Phinney. 2001. Bird responses to partial retention timber harvesting in central interior British Columbia. Forest Ecol. Manage. 142: 267-280.

Leonard, Jr., David L. 2001. American Three-toed Woodpecker (*Picoides dorsalis*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/588

MacKinnon, A., C. DeLong, and D. Meidinger. 1990. A field guide for identification and interpretation of ecosystems of the northwest portion of the Prince George Forest Region. Land Management Handbook No. 21. BC Ministry of Forests, Victoria, BC. 116 pp.

Martin, K., A. Norris, and M. Drever. 2006. Effects of bark beetle outbreaks on avian biodiversity in the British Columbia interior: implications for critical habitat management. BC Journal of Ecological Management 7: 10-24.

______, K.E.H. Aitken, and K.L. Wiebe. 2004. Nest sites and nest webs for cavity-nesting communities in interior British Columbia, Canada: Nest characteristics and niche partitioning. Condor 106: 5-19.

Mellen, T. K., E. C. Meslow and R. W. Mannan. 1992. Summertime home range and habitat use of Pileated Woodpeckers in western Oregon. J. Wildl. Manage. 56: 96–103.

Moore, William S. 1995. Northern Flicker (*Colaptes auratus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/166a

Morgan, P., Alpet, G.H., Haufler, J.B., Humphries, H.C., Moore, M.M.,Wilson, W.D., 1994. Historical range of variability; a useful tool for evaluating ecosystem change. J. Sust. For. 2, 87–111.

Murphy, E. C. and W. A. Lehnhausen. 1998. Density and foraging ecology of woodpeckers following a stand-replacement fire. J. Wildl. Manage. 62: 1359–1372

Power, Harry W., and Michael P. Lombardo. 1996. Mountain Bluebird (*Sialia currucoides*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/222

Resources Information Standards Committee (RISC). 1999. Inventory Methods for Forest and Grassland Songbirds. Standards for Components of BC's Biodiversity No. 15. Version 2.0. Min. Environ., Lands and Parks, Resources Inventory Branch, Victoria, BC. 37pp.

Robertson, R. J., B. J. Stutchbury, and R. R. Cohen. 1992. Tree Swallow (*Tachycineta bicolor*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/011

Ruge, K. 1971. Zur Biologie des Dreizehenspechtes *Picoides tridactylus* L. 3. Beobachtungen während de Brutzeit. Ornithol. Beobachter 68: 256–271 (with English summary).

Schmiegelow, F.K.A., C.S. Machtans, and S.J. Hannon. 1997. Are boreal birds resilient to forest fragmentation? An experimental study of short-term community responses. Ecology 78: 1914-1932.

Swanson, F.J., Jones, J.A., Wallin, D.O., Cissel, J.H., 1993. Natural variability—implications for ecosystem management. In: Jensen, M.E., Bourgeron, P.S. (Eds.), Ecosystem Management: Principles and Applications, vol. II. Eastside Forest Ecosystem Health

Assessment, USDA Forest Service, Pacific Northwest Research Station, Wenatchee, WA, pp. 85–98.

Thompson, I.D., J.A. Baker, and M. Ter-Mikaelian. 2003. A review of the long-term effects of post-harvest silviculture on vertebrate wildlife, and predictive models, with an emphasis on boreal forests in Ontario, Canada. Forest Ecol. Manage. 177: 441-469.

van den Driessche, R. and J. Joy. 1998. Donna Creek Forestry/Biodiversity Project: Methods of 1996 breeding bird investigations: point count surveys, cavity nest searches, and cavity nest habitat characterization. Peace/Williston Fish and Wildlife Compensation Program, Report No. 247. 12pp plus appendices.

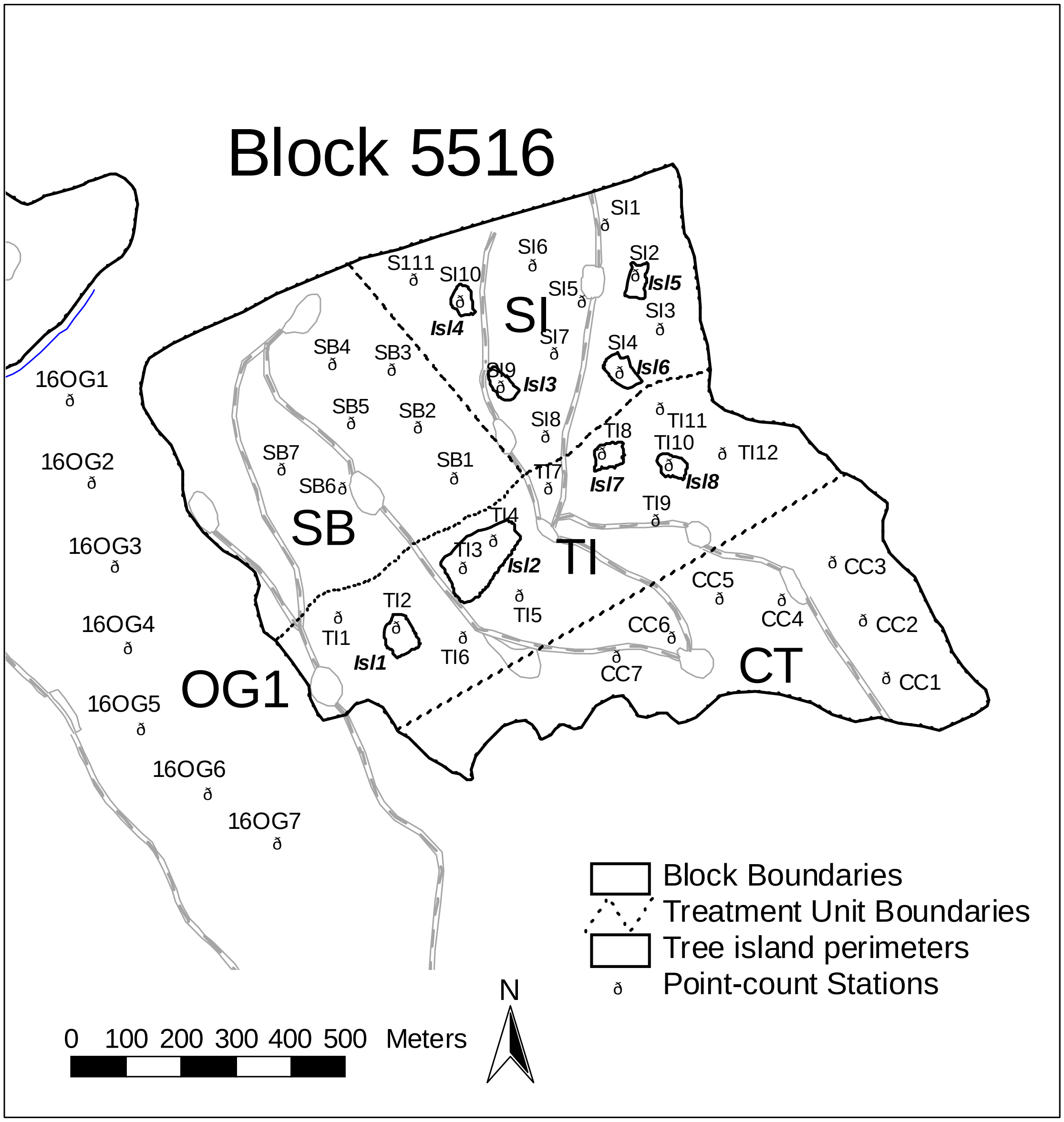
Wiens, J.A. 1989. The ecology of bird communities. Cambridge Univ. Press, Cambridge, UK.

Wildlife Tree Committee of British Columbia (WTC). 2001. Wildlife/danger tree assessor's course workbook – forest harvesting and silviculture module. Victoria BC: British Columbia Ministry of Forests, Workers' Compensation Board, Minerals Water, Land and Air Protection, June 2001. 139 pp.

APPENDICES

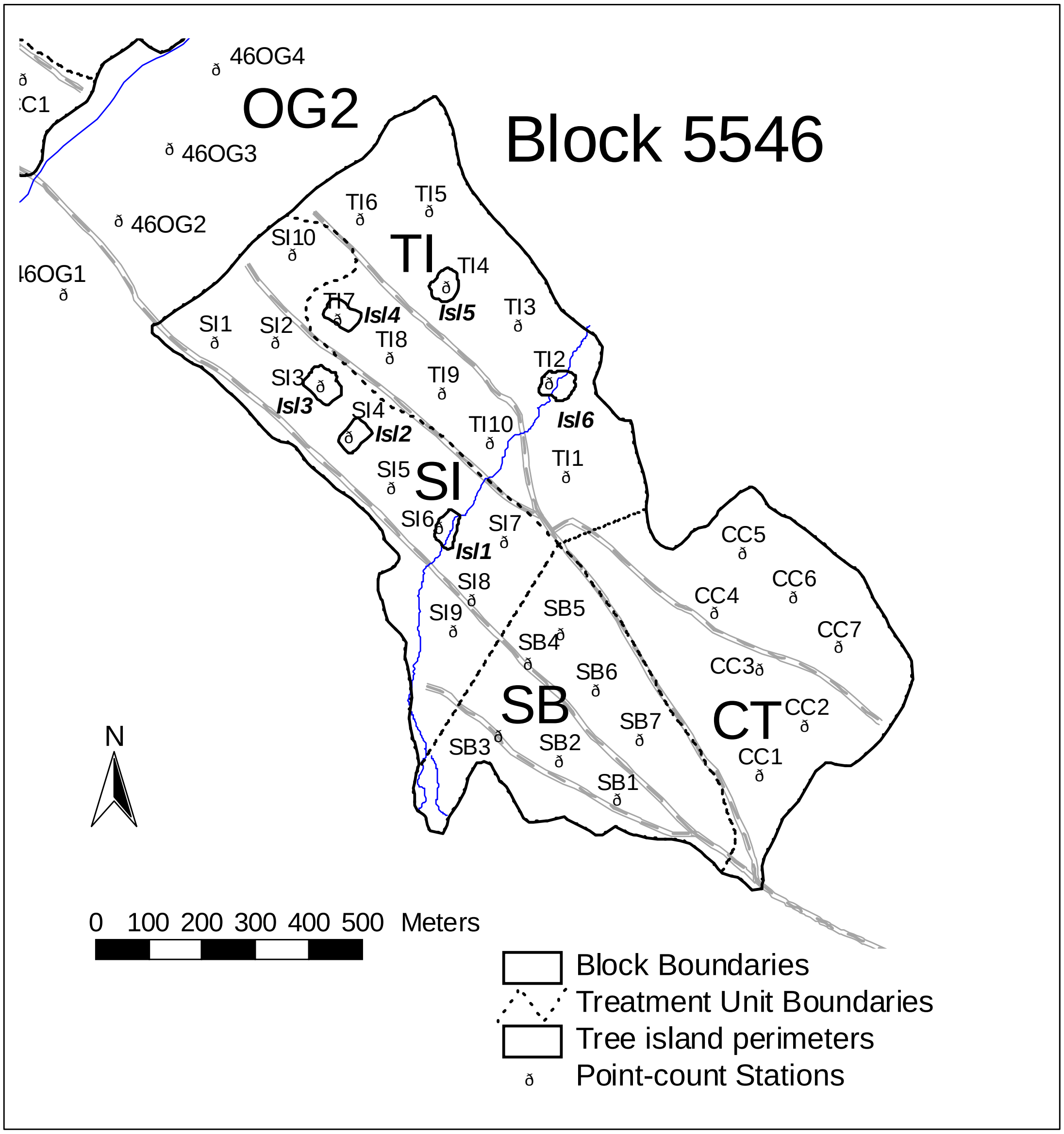
Appendix A. Maps showing the locations of point-count stations in the 3 experimental cutblocks (Blocks 5516, 5546, and 5547), 3 Clearcut Control cutblocks (Blocks 5510, 5549, and 5550), and 3 Old-Growth areas (OG1, OG2, and OG3), Donna Creek Forestry/Biodiversity Project (from Gyug and Corbould 2002).

Experimental cutblock Block 5516 and Old-Growth area OG1



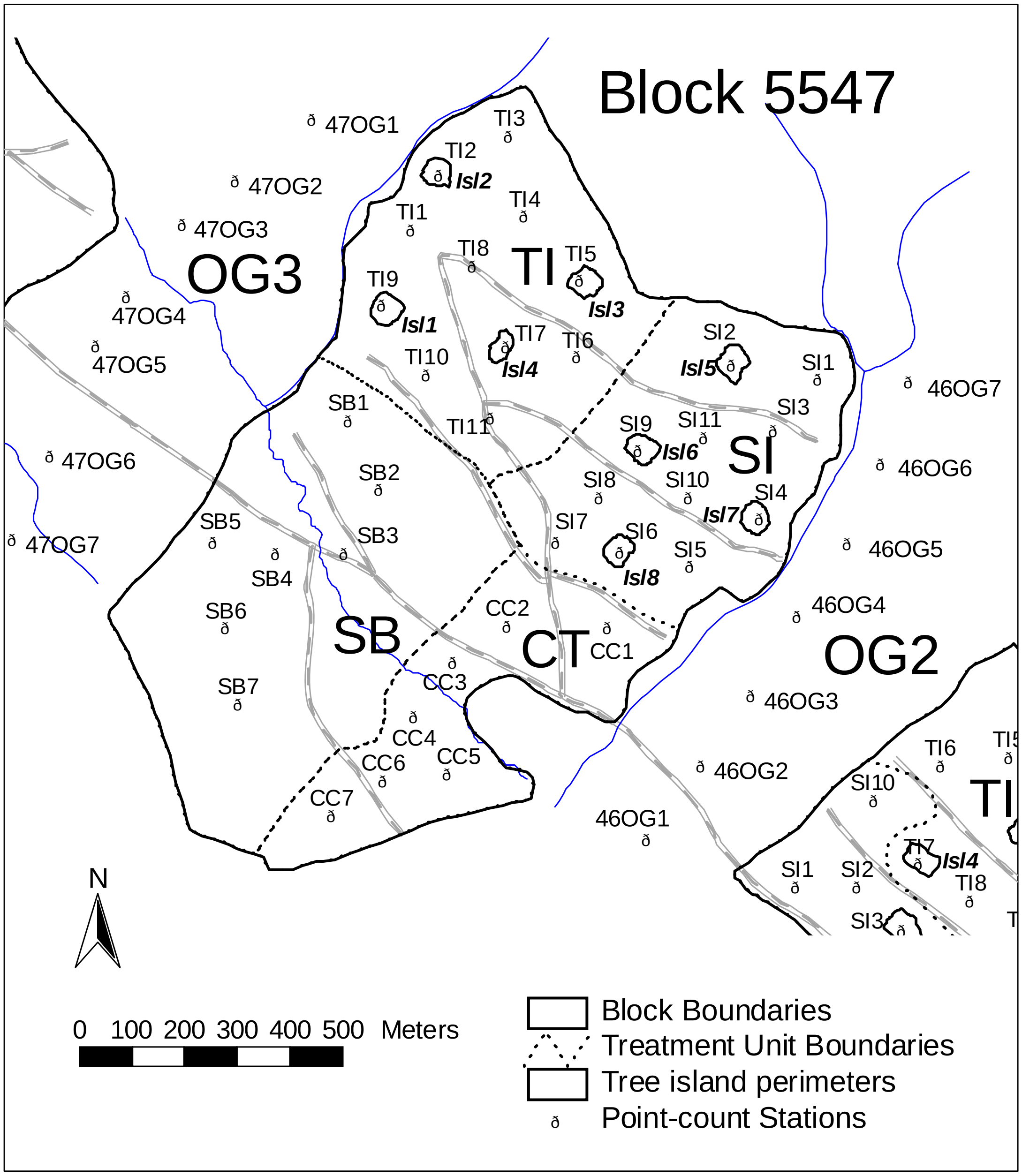
Note: For map legibility, the first 2 numbers referencing the block number have been omitted from each point-count station (e.g., SB6 = 16SB6) and tree-island (e.g., Isl 6 = Isl 16-6) label.

Experimental cutblock Block 5546

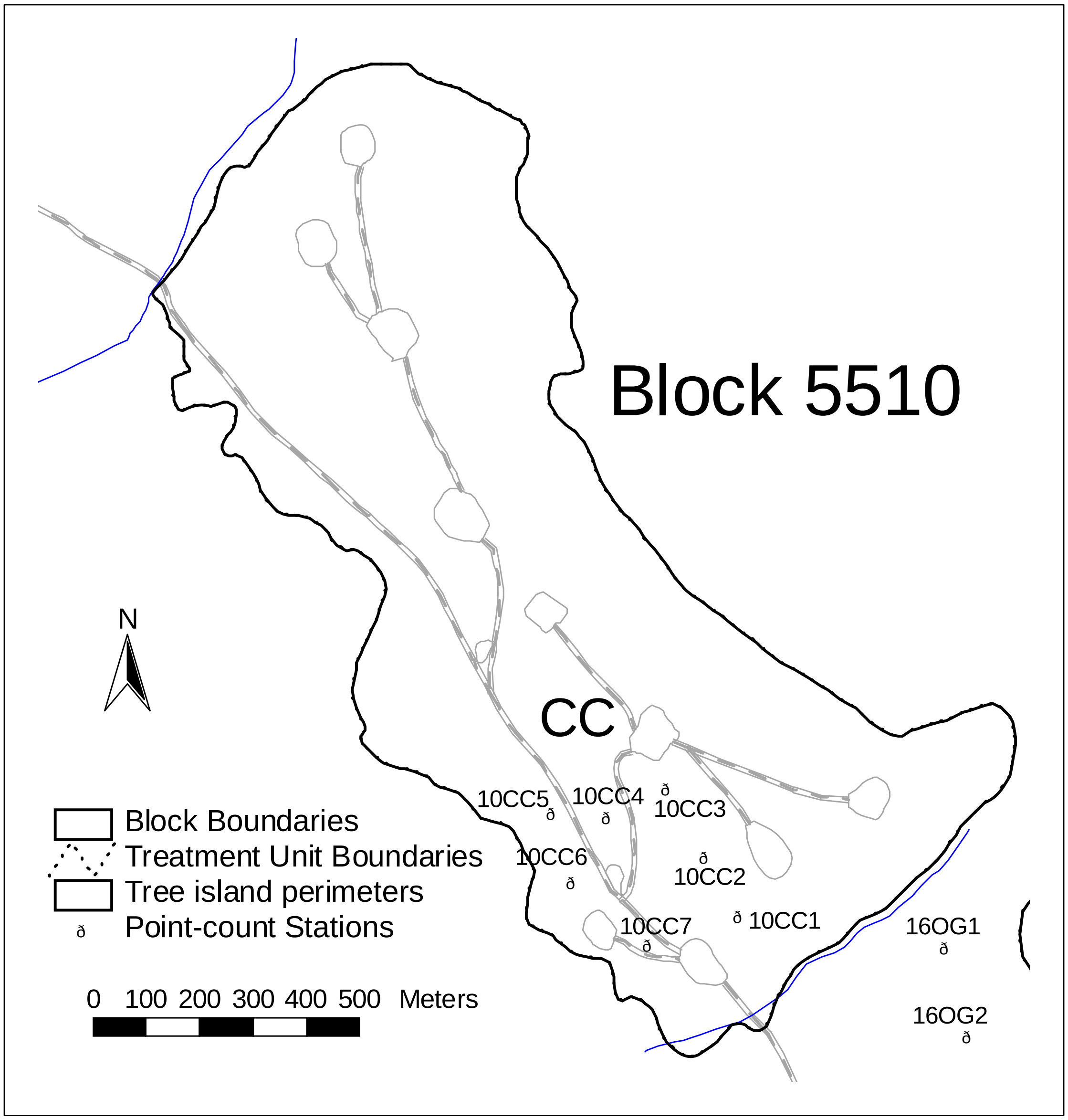


Note: For map legibility, the first 2 numbers referencing the block number have been omitted from each point-count station (e.g., SB6 = 46SB6) and tree-island (e.g., Isl 6 = Isl 46-6) label.

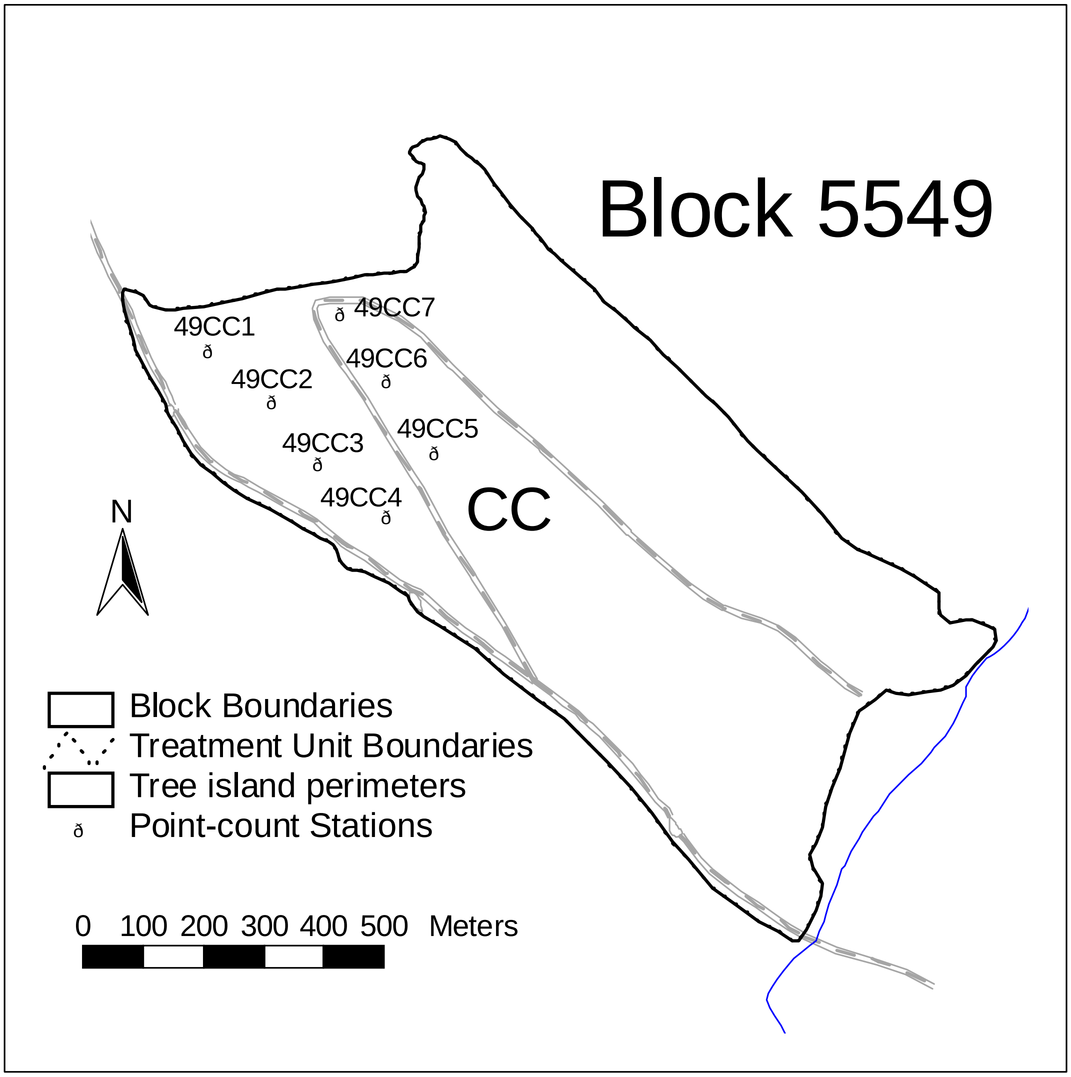
Experimental cutblock Block 5547 and Old-Growth areas OG2 and OG3



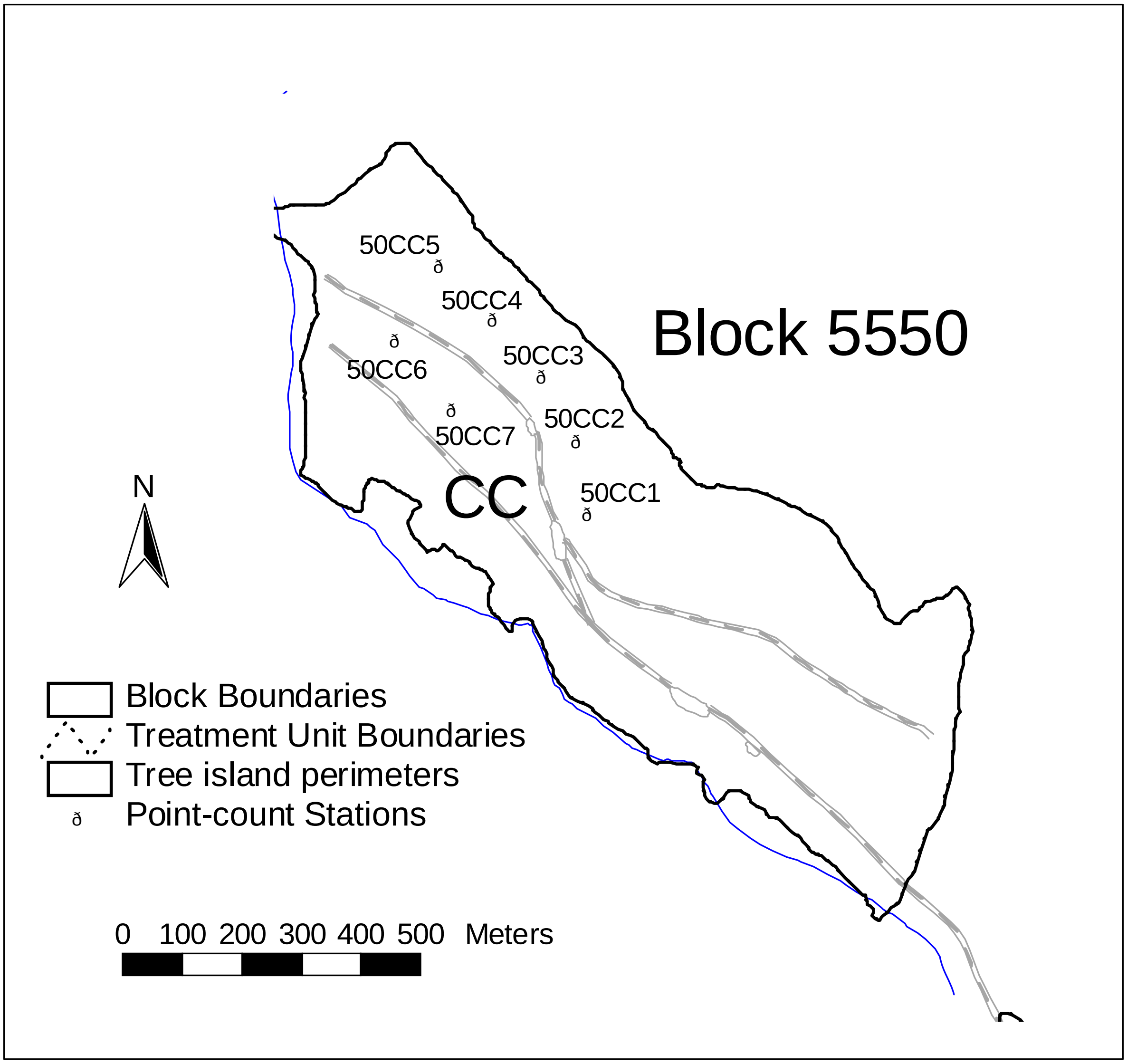
Clearcut Control cutblock Block 5510



Clearcut Control cutblock Block 5549



Clearcut Control cutblock Block 5550



Appendix B. Nest-tree and cavity characteristics for the 3 cavity nests found in the Donna Creek study area in 2006 and 2007.

Nest No.	Bird species	Date found	Block	Treatment	GPS Location Zone	GPS Location Easting	GPS Location Northing	Stub No.
06-16SB-01	Tree Swallow	25 June 2006	5516	SB	10U	422999	6164202	1917
07-47OG-01	American Three-toed Woodpecker	26 June 2007	5547	OG	10U	418102	6167452	NA
07-47SI-02	Mountain Chickadee	~01 July 2007	5547	Edge of SI	10U	419315	6167168	NA

Nest No.	Stem species	No. of cavities in stem	Stem condition	Stem height (m)	DBH (cm)	Canopy cover	Canopy density	Distance to/from edge	Location on stem
06-16SB-01	Sx	1	Stub; 90% bark remaining	3.4	38.5	None	None	-	Top 1/3
07-47OG-01	Pl	2	Live; Dying	18	27.0	Sparse	Sparse	76 m to road edge	Bottom 1/3
07-47SI-02	Pl	3	Advanced Stage of Decay; Broken Top	10.8	27.3	Sparse	None	0 m to continuous forest	Top 1/3

Nest No.	Cavity age	Cavity-entrance height above ground (m)	Cavity-entrance orientation	Cavity-entrance width (cm)	Cavity-entrance height (cm)	Location on stem
06-16SB-01	~1 yr	~2.8	~270	-	-	Top 1/3
07-47OG-01	~1 yr	8	4	3	3	Bottom 1/3
07-47SI-02	2+ yrs	8	86	2.5	3	Top 1/3

Appendix C. Detections of all cavity-nesting bird species recorded, by control and treatment type[a] and site[b], observed during 50-m radius point-count surveys in the 1990s (1995-1996) and 2000s (2006-2007), Donna Creek study area.

		Controls						Treatments												
		CC			OG			CT			SB			SI			TI			
Species	Year	5510	5549	5550	5516	5546	5547	5516	5546	5547	5516	5546	5547	5516	5546	5547	5516	5546	5547	Total
Primary Cavity Excavators																				
American	1995				1	8	4							4				1	5	23
Three-toed	1996				1	2	2									2			3	10
Woodpecker	2006						1													1
	2007				2	3	1										1			7
Black-	1995				1	1		1			6	2		6	5	14	20	4	1	61
backed	1996				1	1	4				6			4	1	8	9		1	35
Woodpecker	2006																1*			1
	2007															1	1			2
Hairy	1995		1		4														8	13
Woodpecker	1996				1									2						3
	2006																			0
	2007																			0
Northern	1995																			0
Flicker	1996													3						3
	2006											1								1
	2007																			0
Pileated	1995																			0
Woodpecker	1996																			0
	2006												1							1
	2007																			0
Red-	1995				11	12	12							9			14			58
breasted	1996				5	9	4		1					1	1	2	1		1	25
Nuthatch	2006				11	8	2													21
	2007				3	1								2		1	9			16

		Controls						Treatments												
		CC			OG			CT			SB			SI			TI			
Species	Year	5510	5549	5550	5516	5546	5547	5516	5546	5547	5516	5546	5547	5516	5546	5547	5516	5546	5547	Total
Boreal	1995				5	1	2													8
Chickadee	1996				4	6														10
	2006				1	1	1								1					4
	2007				4		2									1	4		1	12
Total Primary		0	1	0	55	53	35	1	1	0	12	3	1	31	8	29	59	5	20	315
Secondary Cavity Users																				
American	1995								1				1		3	7		3		15
Kestrel	1996							1										1	1	3
	2006																			0
	2007																			0
Boreal Owl	1995				1															1
	1996																			0
	2006																			0
	2007																			0
Brown	1995				2	4	5													11
Creeper	1996					4	1													5
	2006				1		1													2
	2007					1	3													4
Mountain	1995		2					12	1		12	10		25	1		9			72
Bluebird	1996		4					6	2		2	1		23	1		7			46
	2006																			0
	2007																			0
Mountain	1995																			0
Chickadee	1996																			0
	2006						1										7			8
	2007				4	2	2							2			6	2		18

		Controls						Treatments												
		CC			OG			CT			SB			SI			TI			
Species	Year	5510	5549	5550	5516	5546	5547	5516	5546	5547	5516	5546	5547	5516	5546	5547	5516	5546	5547	Total
Northern	1995																			0
Hawk Owl	1996														1					1
	2006																			0
	2007																			0
Northern	1995																			0
Pygmy-Owl	1996					1														1
	2006																			0
	2007																			0
Tree	1995	7	6	1	1	1					5	8	2	4	4		2	2	2	45
Swallow	1996	11										3	1	3	4		4		10	36
	2006										2									2
	2007																			0
Total Secondary		18	12	1	9	13	13	19	4	0	21	22	4	57	14	7	35	8	13	270
Total Primary and Secondary		18	13	1	64	66	48	20	5	0	33	25	5	88	22	36	94	13	33	585

[a] Control and treatment types include Clearcut Control (CC), Old-growth Control (OG), Clearcut Treatment (CT), Stub Treatment (SB), Stub-and-Island Treatment (SI), and the Tree-island Treatment (TI).

[b] Sites include the CC control sites (5510, 5549 and 5550), and the treatment and control sites of 5516, 5546, and 5547 that include all treatments as well as OG control.

* This observation is of a bird seen flying through a tree island, but never observed perched.

Appendix D. Stem and cavity characteristics for cavities found in stubs in the Donna Creek study area, June and July 2007. Data from Juelfs and Corbould (in prep).

								Cavity entrance information										PIWO drill hole for carp. ants?
								Ht AGL										
Block	Trtmt	Isl. #	**Stub tag #**	Tree sp.	DBH	Cavity type[b]	Cavity no.	Code[c]	Ht (cm)	Wd[d] (cm)	Ht[e] (cm)	Dp[f] (cm)	Shape	Orient.[g]	New cavity?	Agent or sp.		
5547	SB		**5**	Sx	38	bear	1	B	20	7	30	11	elliptical	nd	N	PIWO		Y
5547	SB		**8**	Bl	38	nest	1	T	270	6	8	nd	round	nd	nd	unk		N
5547	SB		**15**	Act	46	nest	1	T	280	5	5	7	round	nd	N	unk		N
5547	SB		**21**	Sx	39	fc	1	B	20	9	21	8	rectangle	nd	N	PIWO		Y
5547	SB		**22**	Sx	40	fc	1	B	10	14	20	6	oval	nd	N	PIWO		Y
5547	SB		**49**	Sx	47	unk	1	B	10	9	18	12	oval	nd	N	PIWO		Y
5547	SB		**87**	Pl	36	nest	1	T	250	5	7	7	round	nd	N	unk		N
5547	SB		**172**	Sx	64	fc	1	B	100	4	10	9	elliptical	nd	N	PIWO		Y
5547	SB		**185**	Sx	49	nest	1	T	250	9	8	12	round	nd	N	unk		N
5547	SB		**192**	Bl	50	fc	1	B	108	8	14	12	elliptical	nd	N	PIWO		Y
5547	SB		**209**	Pl	37	fc	1	B	65	8	11	7	rectangle	nd	N	PIWO		Y
5547	SB		**212**	Sx	53	fc	1	B	100	15	30	10	elliptical	nd	N	PIWO		Y
5547	SB		**231**	Sx	51	fc	1	B	0	12	12	10	round	nd	N	PIWO		Y
5547	SI	47-5	**324**	Sx	50	nest	1	T	270	5	5	15	round	nd	N	unk		N
5547	SI		**375**	Sx	60	unk	1	B	10	16	39	13	elliptical	nd	N	PIWO		Y
5547	SI		**381**	Sx	49	bear	1	B	20	14	28	nd	elliptical	nd	N	PIWO		Y
5547	SI		**389**	Sx	42	unk	1	T	250	7	24	12	elliptical	nd	N	PIWO		Y
5547	SI		**392**	Bl	34	nest	4	T	~350	~5	~5	nd	round	nd	N	unk		N
5547	SI		**392**	Bl	34	nest	3	T	~370	~5	~5	nd	round	nd	N	unk		N
5547	SI		**392**	Bl	34	nest	2	T	~370	~5	~5	nd	round	nd	N	unk		N
5547	SI		**392**	Bl	34	nest	1	T	~395	~5	~5	nd	round	nd	N	unk		N

Block	Trtmt	Isl. #	**Stub tag #**	Tree sp.	DBH	Cavity type[b]	Cavity no.	Cavity entrance information: Ht AGL Code[c]	Ht (cm)	Wd[d] (cm)	Ht[e] (cm)	Dp[f] (cm)	Shape	Orient.[g]	New cavity?	Agent or sp.	PIWO drill hole for carp. ants?
5547	SI		**397**	Sx	54	fc	1	T	120	15	26	24	elliptical	nd	N	PIWO	Y
5547	SI		**399**	Sx	64	nest	1	T	285	7	9	6	oval	nd	N	unk	N
5547	SI		**401**	Sx	53	fc	1	B	120	10	15	11	oval	nd	N	PIWO	Y
5547	SI		**405**	Pl	43	unk	1	B	10	13	50	18	elliptical	nd	N	PIWO	Y
5547	SI		**410**	Sx	46	nest	1	T	280	4	4	4	round	nd	N	unk	N
5547	SI		**720**	Sx	28	fc	1	M	134	7	9	8	oval	180	N	PIWO	Y
5547	SB		**737**	Sx	55	fc	1	B	20	8	16	11	rectangle	nd	N	PIWO	Y
5547	SB		**769**	Bl	48	fc	1	B	60	6	8	24	oval	nd	N	unk	N
5547	SI		**783**	Sx	59	fc	1	M	80	11	20	12	oval	nd	N	PIWO	Y
5547	SI		**785**	Sx	42	bear	2	B	90	7	20	16	elliptical	nd	nd	PIWO	Y
5547	SI		**785**	Sx	42	bear	1	M	125	8	20	16	elliptical	nd	nd	PIWO	Y
5546	SB		**1008**	Bl	32	fc	1	B	20	6	18	4	elliptical	138	N	PIWO	Y
5546	SB		**1023**	Pl	28	nest	1	M	210	4	6	5	oval	10	N	unk	N
5546	SB		**1043**	Sx	28	fc	1	B	60	12	19	11	rectangle	180	N	PIWO	Y
5546	SB		**1064**	Bl	43	unk	1	B	10	6	17	6	rectangle	260	N	PIWO	Y
5546	SI		**1072**	Sx	43	nest	1	B	350	8	8	nd	round	342	N	unk	N
5546	SI		**1073**	Bl	46	natural	3	B	30	7	17	8	oval	200	N	PIWO	Y
5546	SI		**1073**	Bl	46	natural	2	B	37	6	9	12	oval	318	N	natural	N
5546	SI		**1073**	Bl	46	natural	1	B	73	7	11	13	oval	80	N	natural	N
5546	SI		**1075**	Sx	37	fc	1	B	107	8	17	13	elliptical	240	N	PIWO	Y
5546	SI		**1076**	Bl	36	nest	1	T	350	7	7	n/a	round	354	N	unk	N
5546	SI		**1091**	Bl	41	bear	1	B	25	8	40	26	elliptical	16	Y	PIWO	Y
5546	SI	46-1	**1110**	Sx	47	fc	1	B	30	11	16	10	oval	142	N	PIWO	Y

								Cavity entrance information										PIWO drill hole for carp. ants?
								Ht AGL										
Block	Trtmt	Isl. #	**Stub tag #**	Tree sp.	DBH	Cavity type[b]	Cavity no.	Code[c]	Ht (cm)	Wd[d] (cm)	Ht[e] (cm)	Dp[f] (cm)	Shape	Orient.[g]	New cavity?	Agent or sp.		
5546	SI		**1144**	Sx	38	fc	1	B	50	7	20	10	rectangle	nd	N	PIWO	Y	
5546	SI	46-3	**1234**	Sx	33	fc	1	T	210	6	5	2	oval	20	N	PIWO	Y	
5546	SI	46-3	**1238**	Sx	30	fc	1	B	20	7	13	10	oval	197	N	PIWO	Y	
5546	Si		**1299**	Sx	63	fc	1	B	100	10	14	18	elliptical	30	N	PIWO	Y	
5546	SB		**1321**	Sx	43	nest	1	B	48	6	15	10	rectangle	261	N	PIWO	Y	
5546	SB		**1326**	Sx	49	nest	1	B	0.2	7	17	14	oval	64	N	PIWO	Y	
5546	SB		**1333**	Sx	56	fc	1	B	49	8	13	7	oval	202	N	PIWO	Y	
5546	SI		**1354**	Sx	46	unk	1	B	10	7	29	9	elliptical	308	N	PIWO	Y	
5546	SI		**1356**	Sx	37	fc	2	B	75	5	13	11	rectangle	225	N	PIWO	Y	
5546	SI		**1356**	Sx	37	fc	1	B	75	12	15	18	rectangle	225	N	PIWO	Y	
5516	SI	16-6	**1480**	Sx	35	nest	1	T	208	4	6	3	rectangle	360	N	unk	N	
5516	SI	16-3	**1535**	Bl	31	fc	1	B	18	4	12	15	elliptical	245	N	unk	unk	
5516	SI	16-4	**1615**	Sx	43	nest	1	T	330	5	5	11	round	320	N	unk	N	
5516	SI		**1629**	Bl	19	nest	1	T	240	4	5	7	oval	37	N	PIWO	unk	
5516	SI		**1681**	Bl	29	nest	1	T	267	6	4	4	oval	8	N	unk	N	
5516	SI		**1688**	Bl	42	nest	1	T	420	6	7	10	round	340	N	unk	N	
5516	SI		**1702**	Bl	35	nest	1	M	211	9	8	15	oval	297	N	unk	N	
5516	SI		**1730**	Bl	39	unk	1	B	5	4	6	9	oval	172	N	PIWO	Y	
5516	SI		**1731**	Bl	25	nest	2	M	275	4	6	7	round	65	N	unk	N	
5516	SI		**1731**	Bl	25	nest	1	T	370	5	5	9	round	13	N	unk	N	
5516	SI		**1759**	Bl	62	nest	1	T	230	7	9.5	15	oval	350	N	unk	N	
5516	SI		**1759**	Bl	62	unk	2	M	177	9	11	19	pear	340	N	unk	N	
5516	SI		**1759**	Bl	62	unk	3	B	105	9	13	13	oval	330	N	unk	N	

Block	Trtmt	Isl. #	**Stub tag #**	Tree sp.	DBH	Cavity type[b]	Cavity no.	Cavity entrance information: Ht AGL Code[c]	Ht AGL Ht (cm)	Wd[d] (cm)	Ht[e] (cm)	Dp[f] (cm)	Shape	Orient.[g]	New cavity?	Agent or sp.	PIWO drill hole for carp. ants?
5516	SI		**1778**	Bl	21	nest	1	T	355	4.5	5	9.5	round	275	96-cav	unk	N
5516	SI		**1809**	Bl	40	bear	1	B	0	6	14	15	rectangle	39	N	unk	unk
5516	SI		**1821**	Bl	38	fc	1	B	10	8	18	25	oval	325	N	unk	unk
5516	SI		**1839**	Bl	46	nest	1	B	25	10	25	32	elliptical	13	N	PIWO	Y
5516	SI		**1842**	Bl	26	unk	1	B	20	16	26	5	rectangle	104	N	PIWO	Y
5516	SI		**1845**	Bl	36	nest	1	T	340	5	6	15	round	349	N	unk	N
5516	SI		**1847**	Bl	51	unk	1	B	0	15	38	41	elliptical	308	N	PIWO	Y
5516	SI		**1860**	Bl	29	nest	1	T	255	5	6	5	oval	81	N	unk	N
5516	SI		**1883**	Sx	44	nest	1	T	337	5	9	16	oval	47	N	unk	N
5516	SI		**1904**	Bl	47	fc	1	B	15	6	15	9	oval	326	N	unk	N
5516	SI		**1912**	Bl	50	unk	4	B	56	10	100	23	elliptical	78	N	PIWO	Y
5516	SI		**1912**	Bl	50	pce	3	M	210	2	3	6	round	78	N	PIWO	Y
5516	SI		**1912**	Bl	50	pce	2	T	240	3	3	4	round	78	N	PIWO	Y
5516	SI		**1912**	Bl	50	pce	1	T	240	3	4	5	round	78	N	PIWO	Y
5516	SI		**1916**	Sx	27	nest	3	M	140	5	5	7	round	80	N	PIWO	unk
5516	SI		**1916**	Sx	27	nest	1	M	196	5	5	16	round	80	N	unk	N
5516	SI		**1917**	Bl	40	nest	1	T	320	8	8	4	round	260	Y	unk	unk
5516	SI		**1924**	Bl	29	nest	1	M	220	5	5	10	round	180	N	unk	N
5516	SI		**1947**	Bl	43	unk	1	B	10	9	16	18	rectangle	287	N	PIWO	Y
5516	SB		**2020**	Sx	66	nest	2	M	140	5	6	5	oval	28	N	PIWO	unk
5516	SB		**2020**	Sx	66	nest	1	T	324	4	6	10	oval	324	N	unk	N
5516	SB		**2028**	Bl	49	natural	1	M	157	3	5	30	elliptical	30	N	unk	N
5516	SB		**2036**	Bl	25	nest	2	M	205	3	5	4	rectangle	30	N	PIWO	unk

								Cavity entrance information										PIWO drill hole for carp. ants?
								Ht AGL										
Block	Trtmt	Isl. #	**Stub tag #**	Tree sp.	DBH	Cavity type[b]	Cavity no.	Code[c]	Ht (cm)	Wd[d] (cm)	Ht[e] (cm)	Dp[f] (cm)	Shape	Orient.[g]	New cavity?	Agent or sp.		
5516	SB		**2036**	Bl	25	nest	1	M	170	5	5	19	round	248	N	unk		N
5516	SB		**2053**	Bl	51	fc	1	B	80	19	37	17	elliptical	192	N	PIWO		Y
5516	SB		**2061**	Bl	41	unk	1	B	98	14	3	15	elliptical	351	N	PIWO		Y
5516	SB		**2068**	Bl	31	nest	1	M	200	4.5	5	10	round	300	96-cav	unk		N
5516	SB		**2075**	Sx	33	nest	1	T	280	5	5	5	round	75	N	unk		N
5516	SB		**2084**	Sx	30	bear	1	B	60	15	25	16	oval	118	N	PIWO		Y
5516	SB		**2101**	Sx	23	bear	1	B	60	7	15	8	rectangle	295	N	PIWO		Y
5516	SI	16-8	**N002**	Bl	58.8	unk	1	T	350	nd	nd	nd	round	277	N	unk		unk
5516	SI	16-8	**N032A**	Bl	46.8	fc	1	T	213	10	15	13	rectangle	160	N	PIWO		Y
5516	SI	16-7	**N098**	Pl	29.5	unk	1	B	0	9	8	3	oval	282	Y	PIWO		Y
5516	SI	16-1	**N139**	Sx	64.7	natural	1	M	270	3	5	4	round	264	Y	unk		unk
5516	SI	16-2	**N159**	Sx	54.5	fc	7	B	18	16	27	12	elliptical	248	N	PIWO		Y
5516	SI	16-2	**N159**	Sx	54.5	unk	6	B	34	5	10	10	rectangle	47	N	PIWO		Y
5516	SI	16-2	**N159**	Sx	54.5	natural	5	M	174	5	6	11	round	20	N	natural		N
5516	SI	16-2	**N159**	Sx	54.5	natural	4	T	224	6	6	11	round	47	N	natural		N
5516	SI	16-2	**N159**	Sx	54.5	natural	3	T	222	5	5	14	round	62	N	natural		N
5516	SI	16-2	**N159**	Sx	54.5	natural	2	T	257	3	3	7	round	140	N	natural		N
5516	SI	16-2	**N159**	Sx	54.5	natural	1	T	255	5	5	14	round	20	N	natural		N
5516	CT		**N163**	Sx	67.2	fc	2	B	133	12	15	18	rectangle	168	N	PIWO		Y
5516	CT		**N163**	Sx	67.2	fc	1	B	97	11	21	4	rectangle	203	N	PIWO		Y
5547	TI	47-2	**N190**	Sx	53.8	fc	1	T	>200	10	15	17	oval	124	N	unk		N
5547	SI	47-2	**N196**	Sx	24.5	pce	1	T	285	5	5	5	round	nd	N	unk		N
5547	SI	47-3	**N207**	Bl	41.9	unk	1	B	30	11	42	8	elliptical	nd	N	PIWO		Y

								Cavity entrance information									PIWO drill hole for carp. ants?
								Ht AGL									
Block	Trtmt	Isl. #	**Stub tag #**	Tree sp.	DBH	Cavity type[b]	Cavity no.	Code[c]	Ht (cm)	Wd[d] (cm)	Ht[e] (cm)	Dp[f] (cm)	Shape	Orient.[g]	New cavity?	Agent or sp.	
5547	SI	47-3	**N211**	Bl	66	unk	2	M	200	4	17	nd	elliptical	nd	N	unk	N
5547	SI	47-3	**N211**	Bl	66	unk	1	B	50	10	30	nd	elliptical	nd	N	unk	N
5547	TI	47-1	**N256A**	Sx	51	fc	1	M	137	10	23	14	oval	nd	Y	PIWO	Y
5547	TI	47-1	**N272**	Sx	47	unk	3	B	0	10	15	17	round	nd	N	PIWO	Y
5547	TI	47-1	**N272**	Sx	47	nest	2	T	260	5	5	17	round	nd	N	unk	N
5547	TI	47-1	**N272**	Sx	47	nest	1	T	300	5	4	19	round	nd	N	unk	N
5547	TI	47-1	**N278**	Sx	40.5	fc	1	B	100	10	13	15	oval	nd	Y	PIWO	Y
5546	SI	46-5	**N325**	Bl	51.8	nest	1	M	287	3	4	7	round	42	N	unk	N
5546	SI	46-4	**N410**	Sx	34.5	fc	2	B	20	8	36	19	elliptical	256	N	PIWO	Y
5546	SI	46-4	**N410**	Sx	34.5	fc	1	B	40	6	17	13	elliptical	154	N	PIWO	Y
5549	CT		**N471**	Bl	43	nest	2	T	300	4	8	16	oval	105	N	unk	N
5549	CT		**N471**	Bl	43	nest	1	T	310	5	6	8	oval	142	N	unk	N
5546	SI		**N473**	Sx	27	fc	1	B	0.5	11	19	12	oval	225	N	PIWO	Y
5516	SI		**N479**	Bl	47.6	natural	1	M	135	9	15	19	rectangle	116	N	PIWO	Y

[a] Trees species: Act = black cottonwood, Bl = subalpine fir, Pl = lodgepole pine, Sx = spruce.
[b] Cavity types: fh = feeding hole, nest = cavity-nest, peh = primary excavator hole (use unknown), unk = unknown cavity type.
[c] Height code: B = bottom third of stem, M = middle third of stem, T = top third of stem.
[d] Wd = cavity-entrance width at widest point.
[e] Ht = cavity-entrance vertical dimension.
[f] Dp = cavity-entrance distance from opening to back of cavity.
[g] Orient. = cavity-entrance orientation (0-360^0).
nd = not determined.