FINAL SPECIES ACCOUNT FOR SPECIES-HABITAT MODEL FOR WILLIAMSON'S SAPSUCKER IN THE BOUNDARY

This account has been based on the template developed first for the Okanagan-Shuswap Forest District in the 1990's for Ministry of Environment, Penticton, then adapted for Merritt TSA (2006) for the Nicola-Similkameen Innovative Forestry Society. However, there is substantial new information presented here, and the modeling was done from first principles for this project.

Common Name: Williamson's Sapsucker

Scientific Name: *Sphyrapicus thyroideus*

Species Code: B-WISA

Status: Provincial Listing: Red (B.C. Conservation Data Centre 2006).

Global G5; Provincial S3B for species, but Boundary subspecies *thyroideus* is S2B; COSEWIC Assessment: Endangered (2005); SARA: Schedule 1

Identified Wildlife under FRPA in B.C. as of 2004.

Project Area:

Williamson's Sapsucker (WISA) Area of Occupancy (AO) within the Boundary Timber Supply Area of the Arrow-Boundary Forest District. The latest revision of the WISA AO in the Boundary as of 2008 was 409 km^2 in extent.

Ecoprovince: Southern Interior, minor inclusion of Southern Interior Mountains.

Ecoregions: Thompson-Okanagan Plateau,
Okanogan Highland,
Selkirk Bitterroot Foothills

Ecosections: Northern Okanagan Highland (NOH), Southern Okanogan Highland (SOH), Selkirk Foothills (SFH)

Biogeoclimatic Variants: ICHmk1, IDFdm1, IDFxh4, MSdm1

Project Map Scale: 1:20,000

Map Products Used: Predictive Ecosystem Mapping covering the entire project area was available for the Boundary TSA (PEM BAPID 4019)and Terrestrial Ecosystem Mapping for Tree Farm Licence 8 (TEM BAPID 235). VRI (forest cover rollover-2007/2008), Forest Cover (1999) and DEM layers were also available. Digital orthophotos (1-m pixel) were available for 1995 (Black and white) and 2005 (colour). Colour aerial photos were available from 1992 (30BCC92087, 92088, 92089). Landsat 5 was available for various dates up to 2007, but July 2005 with deciduous enhancement (RGB = Bands 543) was primarily used.

Distribution

Provincial Range

- breeds; uncommon summer resident (Cannings *et al.* 1987, COSEWIC 2005);
- uncommon migrant and summer visitant to the Thompson-Okanagan Plateau and Kootenay Trench (Campbell *et al.* 1990);
- breeds as far north as Scottie Creek (NE of Cache Creek), and west to Hat Creek (W of Cache Creek), Botanie Valley (W of Spence's Bridge) and Manning Park (Cooper 1995, Gyug et al. 2007); occasional breeding records near Kamloops as far north as Skull Mt (Barriere).
- Kelowna area is the extreme northern limit of their range in the Okanagan with some reported west to Mount Kobau and Terrace Mountain (Gyug et al. 2007)
- primary area of abundance is east of Okanagan Valley to Greenwood (COSEWIC 2005, Gyug et al. 2007)

Elevational Range:

- breeds between 800 and 1550 m with the majority between 975 and 1075 m (Gyug et al. 2007);
- in the Boundary TSA, 144 nests in 92 trees were found between 1995 and 2008 with the majority (84%) of nests found between 1000 and 1400 m (Tables 1 and 2, Gyug unpublished data).

Table 1. Elevations of Williamson's Sapsucker nests in Boundary TSA, 1995-2008.

	Nest Trees		Nests	
Elevation (m)	**n**	**%**	**n**	**%**
850-899	3	3.3	3	2.1
900-999	5	5.4	7	4.9
1000-1099	26	28.3	43	29.9
1100-1199	27	29.3	42	29.2
1200-1299	7	7.6	20	13.9
1300-1399	14	15	16	11.1
1400-1499	7	7.6	10	6.9
1500-1560	3	3.3	3	2.1
Total	**92**	**100**	**144**	**100**

Table 2. Elevations of Williamson's Sapsucker breeding territories and other observations that could not be directly associated with breeding territories in Boundary TSA, 1995-2008.

	Territories with Nests or Breeding Pairs		Territories with Males present for >2 weeks		Other WISA observations	
Elevation (m)	**n**	**%**	**n**	**%**	**n**	**%**
850-899	1	1.3	0	0.0	0	0.0
900-999	4	5.0	0	0.0	1	1.8
1000-1099	22	27.5	1	16.7	10	17.9
1100-1199	22	27.5	3	50.0	16	28.6
1200-1299	11	13.8	0	0.0	15	26.8
1300-1399	13	16.3	2	33.3	13	23.2
1400-1499	6	7.5	0	0.0	1	1.8
1500-1550	1	1.3	0	0.0	0	0.0
Total Territories	**80**		**6**		**NA**	
Total Observations	**369**		**22**		**56**	

Ecosections:

- the Okanagan-Boundary population is found mainly in the Southern Okanagan Basin (49 nests; Gyug, unpublished data), Southern Okanogan Highlands (37 nests) and Northern Okanagan Highlands (187 nests), with two nest records from the Selkirk Foothills;
- other multiple breeding records from the East Kootenays in the East Kootenay Trench (9 nests) and the McGillivray Range (22 nests), and the Eastern Purcell Mountains (1 nest)
- multiple breeding records from west of the Okanagan in the Nicola Basin (22 nests), and Southern Thompson Upland (72 nests)
- scarce breeding records west of the Okanagan from the Guichon Upland (3 nests) Hozameen Range (3 nests), Pavilion Ranges (4 nests), Thompson Basin (3 nests), and Tranquille Upland (nests at 1 site).

BEC Zones:

- highest relative breeding densities (9-10 detected per 100 call playback points, and 8-9 nest territories found per 100 call playback points) in B.C. were in the Okanagan-Boundary in the IDFdm1 and IDFxh1/xh4 (Gyug et al. 2007, updated to 2007 by Table 8 of Gyug 2007)
- moderate relative breeding densities (50% of highest observed) were in the IDFxh1 west of the Okanagan, and the MSdm1 in the Okanagan-Boundary (Gyug, unpublished data)
- relative breeding densities <25% of the maximum were in the MSdk, PPxh2, IDFdm2, IDFdk1, IDFxh2, ICHmk1 and IDFdk2
- in the Boundary TSA alone, relative densities were highest in the IDFdm1, followed by the MSdm1 (Table 3, Gyug, unpublished data)

Table 3. Williamson's Sapsucker relative density, and numbers of territories and nests found by BEC variant in the Boundary TSA based on call playback surveys.

BEC Variant	CPB Survey Points	WISA detected	WISA detected /100 CPBs	Territories (Nests) found	Random Pts within WISA AO (2008)	% Random Pts with WISA detected
IDFdm1	602	46	7.6	49 (135)	31	25.8
MSdm1	574	34	5.9	31 (50)	27	29.6
IDFxh4	72	2	2.8	3 (5)	5	0.0
ICHmk1	258	6	2.3	3 (2)	5	40.0
ICHdw2	13	0	0.0	0	0	NA
PPdh1	2	0	0.0	0	0	NA
Totals	**1521**	**88**	**5.8**	**86 (192)**	**68**	**26.5**

Based on the call playback survey results and the follow-up nest searches, the Area of Occupancy (AO) was defined (COSEWIC 2005). The AO is considered to be the area where breeding is known to occur, or suspected to occur based on habitat similarities to known breeding locations and is recommended to be mapped at a coarse-scale (minimum cell size of 1-km blocks) (see COSEWIC 2005). In the Boundary, about 42% of the call playback points were within what was eventually mapped as the AO, and about 58% were outside the AO. The remainder of this habitat modeling project only deals with the portion of the Boundary TSA contained within the WISA AO as it was mapped in 2004 (COSEWIC 2005), with minor modifications since up to 2008 to make it consistent with any further information, and with the remapped BEC variant boundaries (BEC Version 6).

Provincial Context

Williamson's Sapsuckers do not breed in Canada except in British Columbia, although they have been occasionally seen in Alberta and Saskatchewan (COSEWIC 2005). The remainder of the species breeding range is to the south in the United States.

Ecology and Key Habitat Requirements

Williamson's Sapsucker is the least numerous and most ecologically and genetically specialized species in its genus (Crockett and Hadow 1975, Johnson and Zink 1983). Williamson's Sapsucker require suitable trees or snags with internal decay for nesting, live trees for sap wells, ants upon which the adults forage extensively in the breeding period, and which are the primary nestling food, and standing live trees from which they glean the ants mainly from the trunks as the ants tend aphids in the trees.

Their general habitat descriptions prior to the research initiated by B.C. Environment in 1996 were:

- Found in montane forests in B.C. (Campbell *et al.* 1990);
- pure coniferous and mixed coniferous/deciduous forests, including western larch, interior Douglas-fir, ponderosa pine; most abundant in mature coniferous forests dominated by western larch (Cooper 1995);
- observed occasionally in orchards in the Okanagan valley but not breeding there (Bryan and Mulholland 1992)

Habitat use may be very traditional with 3 of 6 tagged nestlings returning to nest within 3 km of the nest within 2 years (Crockett 1975). However, the only other study that tagged nestlings found none of the 100 tagged nestlings in later years (unpublished data cited in Dobbs et al. 1997 from Arizona).

Habitat Use (Life Requisites and Seasons)

Temporal Pattern of Life Requisites:

- Breeding - eggs found from late April to mid-June; incubation begins in May and young fledge in second half of June and early July (Gyug et al. 2007); egg laying occurs between late April and late May (Dobbs et al 1997); broods range from early May to mid-July (Campbell et al. 1990)
- Foraging – mid-March to late September
- Migration - arrive mid to late-March (Gyug, unpublished data) and most leave by mid-September and occasionally found up to mid-October (Campbell *et al.* 1990; Cannings et al. 1987, COSEWIC 2005);

Habitat Use and Ecosystem Attributes

BREEDING

Habitat Type

In B.C., and throughout most of their breeding range, there are two basic habitat types:

1. Those dominated almost entirely by conifers where nesting trees are large conifers - mainly live Lw, or other dead standing conifers where larch does not occur,
2. Those where trembling aspen occurs within a coniferous forest matrix, and where trembling aspen is the primary nest tree.

In the Boundary TSA, most occupied nest territories are in coniferous forest where western larch and Douglas-fir are present. Aspen stands are only occasionally used in the Boundary (12% of nests).

Stands used for nesting can vary from densely forested stands to very open stands with only occasional scattered trees. Descriptions of WISA nesting habitat types in conifer forests (i.e. not in areas where they

primarily nest in aspen) have included:

- Multi-storied grand fir and Douglas-fir forests in northeastern Oregon with mix of species including prominent Py and Lw (Nielsen-Pincus and Garton 2007, Bull et al. 1986),
- Mean tree densities of 57/ha (>22-cm dbh, Neilsen-Pincus and Garton 2007) to 220 trees/ha (>14-cm dbh, Bull et al. 1986),
- Fd forested stands in Montana with a major component of old growth, particularly Lw, and a mean basal area of 35 m^2/ha (McClelland et al. 1979)
- Tree species composition (live trees >23 cm DBH) in Montana was Fd 52%, Bl, 22%, Se 12%, Lw 11%, others 3% (McClelland and McClelland 2000).

In Colorado, where WISA nest most often in aspen, theyfavoured nest sites adjacent to open Py forest (Crockett and Hadow 1975; Smith 1982). Nest stands were typically dominated by At, 0.34 ha in size (range 0.024-1.17 ha) with mean density of 772 trees/ha (range 182-1312 trees/ha; Crockett 1975) [note that size range of trees included in the density was not given]. Conway and Martin (1993) found much lower live aspen (>17-cm dbh) densities in nesting stands (mean 9.2/ha) probably because conifers made up the majority (87.5%) of the canopy cover in the nesting stands (which would imply a mean density of 74 trees/ha). Crockett and Hadow (1975) and Smith (1982) found WISAs nesting in aspens to be foraging in nearby Py stands, rather than in the aspen stands where they nested.

Nest Attributes

- They will often reuse the same tree and may use the same nest hole or excavate a new nest hole each year.
- WISA are relatively weak excavators. They can penetrate very hard wood on the outside of the tree, up to one bill length, only if there are extant heart rots underneath the sound and shallow sapwood. Age of stand may be a good stand-in for presence of suitable nest trees including older Lw or At with heart rots, or standing dead Fd or Py.
- Up to 109 nest holes have been found in one Lw in Boundary (although not all those nest holes were WISA holes, and some may have been blind holes where excavations were started and not finished).
- The most commonly used nest trees in the Boundary were (n = 144 nests; Gyug unpublished data):
    - very large live Lw (mean DBH 88 cm) 66%
    - large dead Lw (mean DBH 69 cm) 11%
    - large dead At (mean DBH 41 cm) 8%
    - large live At (mean DBH 47 cm) 4%
    - dead Ew (water birch) (mean DBH 29 cm) 3%
    - live Ew (mean DBH 39 cm) 2%
    - 1% each of large Ac (96 cm DBH), live Fd (60 dm DBH), dead Fd (42 cm DBH), dead Py (70 cm DBH), live Sx (hybrid white spruce) (63 dm DBH), and dead Sx (45 cm DBH).

<u>*FORAGING*</u>

Diet (as summarized by Dobbs et al. 1997) consists of conifer sap and phloem during prenestling period, shifting to mainly ants gleaned from tree trunks after hatching of young. The ants are normally either carpenter ants (*Camponotus* spp.) or wood ants (*Formica* spp.). This predominance of ants in the nestling diet has been confirmed in B.C., and in the Boundary TSA, based on collections of nestling fecal sacs from below active WISA nests from 2006-2008. These collections have yet to be quantitatively analyzed (a FIA project to analyze them is underway, and results should be complete by 2010), initial inspections showed them to be dominated by ants, and by carpenter ants in particular. Some metallic wood-boring beetle (*Buprestis aureus*) elytra (wing covers) were also found in some fecal sacs in western larch forests.

Conifers used for sapwells are small to medium (10-50 cm dbh) Fd, Lw, Py or other conifers. Unhealthy medium-sized Douglas-fir appear to be the primary sap trees in the Okanagan-Boundary portion of the WISA range in B.C. (Gyug, unpublished data). Pairs maintain 4-5 sap trees that they visit several times daily throughout the breeding season to keep sap wells open (Crockett 1975).

Foraging Habitat Type
Both young and mature trees with flowing sap are required for sapwells. Also required are woody structures for carpenter ants as well as other wood ants to nest in, which may include logs, stumps, trees with decay, and standing snags. These ants require standing live trees for aphids which they milk for honeydew (tree sap). These ants become accessible to foraging WISA as they crawl up and down the trunks from their nests to the aphid-tending sites. Age of stand may be a good stand-in for presence of large snags and standing trees with heart rots that are infected with carpenter ants.

TERRITORY SIZES AND DENSITIES

Territory sizes: Home ranges of WISA in Western Larch habitats in British Columbia appear (54 ha) appear to be larger than in Py/At habitats in Colorado and Arizona (4-11 ha) (see COSEWIC 2005). Methodologies of determining territory size have been quite variable, and are difficult to compare. In Lw forests, average inter-nest spacing in benchmark habitat was about 450 m (Gyug et al. 2007).

Only considering census areas of 100 ha or greater, densities reported in Canada range from 0 to 3.1 breeding pairs per 100 ha (Gyug, unpublished data). Data is similar for the U.S. but with only one density higher than this at 4.8 nests/100 ha in San Juan National Forest (Py forest with nests in At patches). Intensive call playback surveys, nest searches and census areas have given us enough information to assign a density based on the 4-class scale (High, Moderate or Low) to all WISA observations made during the inventories conducted from 1996-2008.

Ratings

This model employs the 6-Class rating scheme (Table 4) recommended in the RISC standards manual (RISC 1998). For the purposes of this Williamson's Sapsucker modeling, the Moderately High and the Moderate have been grouped.

Table 4. Habitat capability and suitability using a 5-Class Rating Scheme based on the 6-class rating schemes of RISC (1998), and density equivalents for Williamson's Sapsucker based on census areas >100 ha in size (Gyug, unpublished data).

Percent of Provincial Benchmark	Rating	Numerical Code	Letter Code	Density (Nests or Breeding Pairs/km^2)
76-100%	High	1	H	2.3 - 3.1
51-75%	Moderately High	2	MH	0.8 - 2.3
26-50%	Moderate	3	M	
6-25%	Low	4	L	0.2 - 0.8
1-5%	Very Low	5	VL	0.03 - 0.2
0-1%	Nil	6	N	0 – 0.03

The WISA model profiles breeding (B) and foraging (F) habitats. WISA is a central-place forager, i.e., the nest site, so breeding and foraging habitats must occur within close proximity. These have been modeled together as the living (LI) life requisite for the first two models, and separated in the third model. Breeding (nesting) occurs during the spring and foraging can extend from April to September, therefore living is modeled for the growing season.

Three models were developed and validated using available data:

1. PEM/TEM using traditional wildlife ratings tables applied to polygons,
2. Forest Cover/VRI attributes at the polygon level (with adjustments for slope) using characteristics determined to be important based on ANOVA analyses of different known nest densities, and on random unoccupied points,
3. After analysis of the classification errors of the preliminary FC/VRI model, the model was adjusted using Forest Cover/VRI attributes and from colour stereo aerial photo interpretation.

Another separate set of models were developed using multivariate analyses based on Classification and Regression Tree (CART) techniques with inputs of plot data, and then of Forest Cover/VRI and DEM attributes at the point (nest) and territory level (using GIS grid techniques). However, none of these techniques were found to produce better models than the other models based on polygon techniques from PEM/TEM, FC/VRI and DEM inputs, therefore these were not presented here. Results of these analyses are available from the author.

Provincial Benchmark Rationale

Provincial Benchmark density is at Schoonover Mt, east of Okanagan Falls, near the junction of 201, 200, Dutton and Browning FSRs on TFL 15 (Gyug et al. 2007). One other site with similar densities has been found at Lehman Springs property owned by The Land Conservancy. These are the only two sites known with nesting at these densities in Canada. Two other similar (but smaller and less extensive) stands were found east of Naramata, but were too small and fragmented to support similar nest densities. High densities have not been found in any other types of stands in Canada.

Provincial Benchmark

Density of 3.1 active nests/breeding pairs per km^2 east of Okanagan Falls (Gyug et al. 2007).

Ecosection: South Okanogan Basin/North Okanagan Highlands (SOB/NOH)

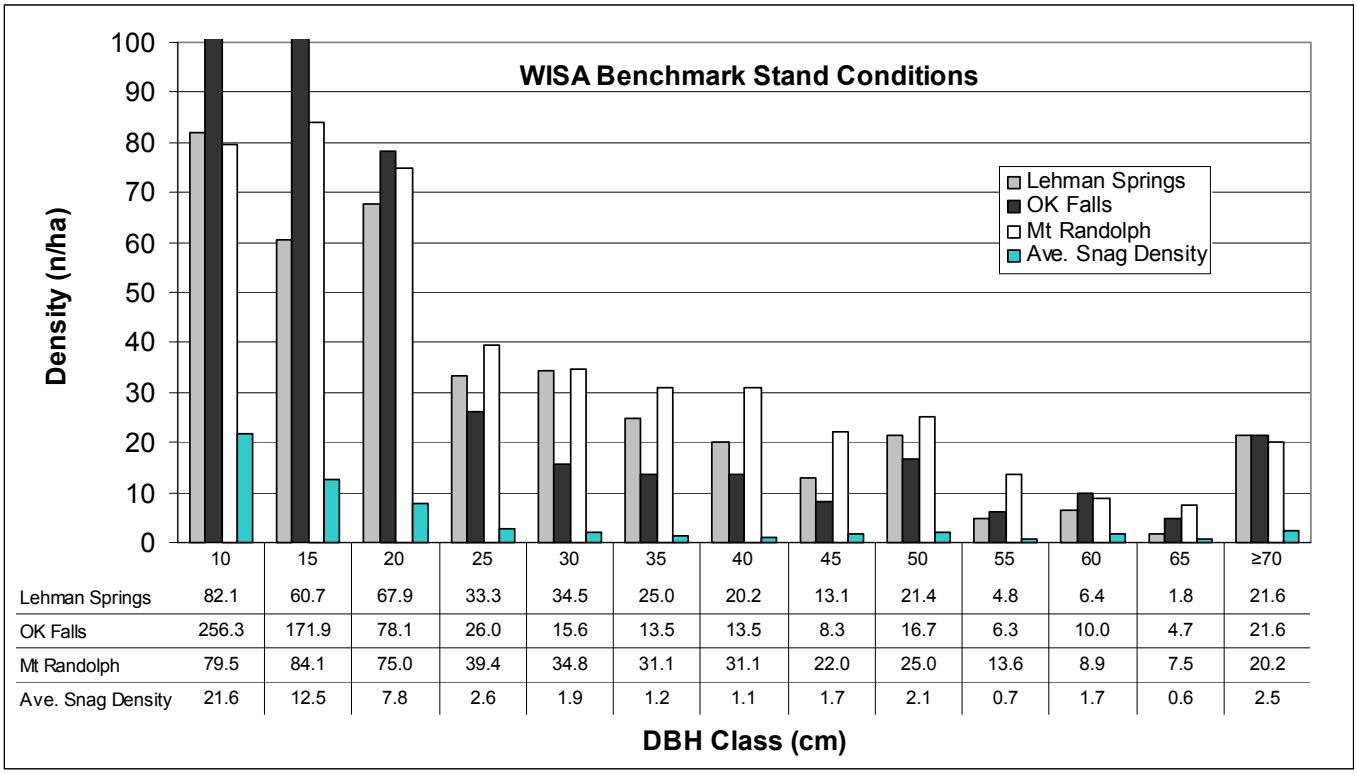
Biogeoclimatic Zone: IDFdm1 bordering on the IDFxh1 at Schoonover Mt.,
IDFdm1 at Lehman Springs,
IDFdm1 bordering on MSdm1 at Naramata.

Habitat:

In 2003-2005, the Okanagan Falls site was predominantly (77%) forested interspersed with seedtree/partial cuts (23%). Additional timber harvesting at Okanagan Falls in 2006-2007 has lowered the forested portion to only 57% of the area, and density appeared to have fallen to Moderate levels by 2008 as several former nesting territories appear to have been permanently abandoned. Lehman Springs site was a forest remnant of about 34 ha isolated by hayfields. The site at Naramata was <20 ha in size, and within other types of forests.

The forest stands at all three sites contained 20-40 very large (≥60 cm dbh) western larch and Douglas-fir/ha within stands of 200-300 trees >17.5-cm dbh/ha, or 130-250 trees >22.5-cm dbh (Figure 1). The relatively high density of very large trees was the most characteristic property of these stands. Densities

of smaller trees were more variable depending on local conditions and extent of Douglas-fir ingrowth since the most recent fire events. Total densities of trees >7.5-cm dbh varied from 390-645 with a mean of 503. Western larch made up 30-55% of the trees >22.5-cm dbh in these stands, and 35-80% of the trees >57.5-cm dbh. The benchmark stands at OK Falls and Lehman Springs had estimated Layer 1 ages of >200 years in the FC attribute database and of 192 years at Naramata, and estimated Layer 1 tree heights of 30-44 m. Site indices for Layer 1 were all >15.8. Slopes at each of these sites were gentle to moderate (<25%).



	10	15	20	25	30	35	40	45	50	55	60	65	≥70
Lehman Springs	82.1	60.7	67.9	33.3	34.5	25.0	20.2	13.1	21.4	4.8	6.4	1.8	21.6
OK Falls	256.3	171.9	78.1	26.0	15.6	13.5	13.5	8.3	16.7	6.3	10.0	4.7	21.6
Mt Randolph	79.5	84.1	75.0	39.4	34.8	31.1	31.1	22.0	25.0	13.6	8.9	7.5	20.2
Ave. Snag Density	21.6	12.5	7.8	2.6	1.9	1.2	1.1	1.7	2.1	0.7	1.7	0.6	2.5

Figure 1. Live tree and snag densities by 5-cm dbh classes in Williamson's Sapsucker benchmark high density and high suitability habitat in B.C. Values for densities in the histogram are provided in the table below the histogram.

HABITAT MODELING using PEM/TEM

Regional Habitat values

Ecosections in the project area will be rated against the Provincial Benchmark Ecosections as follows for Williamson's Sapsuckers using the 4-class rating scale:

NOH, SOB, SOH = H (Provincial Benchmarks)
SFH = L
Other Ecosections where Williamson's Sapsucker occurs in B.C. will be rated as:
EKT, MCR, STU, NIB = M
OKR, NOB, HOR, GUU, THB, SHB = L

Ratings Assumptions for Ratings Tables to be applied to TEM/PEM

1. Williamson's Sapsuckers utilize pure coniferous and mixed coniferous/deciduous forests, with a preference for western larch. They are most abundant in mature coniferous forests dominated by western larch. Best habitat overall will include nest sites (veteran western larch with heart rots), young and mature trees for feeding on sap, and veteran or dead trees for catching ants to feed to nestlings. Breeding habitat is only useful when adjacent to foraging habitat so that both must occur in the same spot or beside each other. Therefore only one habitat value layer, living, is modeled.

2. Ecosection values will be applied as listed above.

3. BEC variant values will be applied as listed in Table 3. Maximum rating possible in IDFdm1 and MSdm1 will be H. Maximum possible rating possible in ICHmk1 and IDFxh4 will be M. All others will be Nil.

4. Good growing sites on level to rolling terrain will be the highest rated sites in each BEC variant and ecosection combination. These include sub-mesic, mesic and sub-hygric forested sites in the IDFa nd ICH, and mesic and sub-hygric sites in the MS. Sub-mesic sites in the MS and other wetter subhygric to hygric sites will be rated one level lower. Of 86 nests in the Boundary, 65% were in Mesic sites, 17% in Submesic sites, 7% in subhygric sites, and the remainder (12%) in either drier or wetter sites.

5. Highest rated structural stage will be 7, the oldest forests. Structural stage 6 will be 1 level lower, and structural stage 5, 2 levels lower. Structural stages 2-4 will be rated Very Low, and 0-1 will be rated Nil. Non-treed ecosites (e.g. cultivated fields, open water, marshes, talus) will be rated Nil, except if they were given a structural stage >3.

6. Sites with steep aspect modifiers (k, w) will be rated 1-2 levels lower. Sites with gully (g) modifiers will be rated 1-2 levels lower, but only as low as Very Low (i.e., not to Nil).

Ratings Adjustments:

No model ratings adjustments were applied to these PEM/TEM models. Adjustments that could be applied would be:

1. Adjustments may be made based on percentage tree species composition (see Figure), e.g., excluding sites with >60% Pl.

2. More precise estimates of stand structure than provided for by the 7 class TEM structural stages would also be possible. In the IDF, stand age for structural stage 7 was >250 years, and for structural stage 6 was 140-250 years. 190 years was found to be a better dividing point for WISA High from other habitats. Including stages 6 and 7 in High habitat greatly overestimated the amount of High habitat, and only including stage 7 underestimated the amount of High habitat. However, this will not be required if High suitability habitat is only modeled using FC/VRI, and this layer merged with the PEM/TEM layer.

3. The TFL 8 TEM is out-of-date for the project area since there has been considerable timber harvesting since the mapping was completed (based on layers from the mid-1990's). Large areas of apparently moderate suitability habitat (Figure 7) are no longer moderately suitable in the Ingram Creek area, and are currently Low to Very Low. However, it was found that this cannot just be remapped using current FC/VRI stand attributes because many of these partial-harvest sites in the current VRI have simply been assigned NSR and lack any stand attributes, even though many of these stands are forested with >100 merchantable-sized trees/ha.

4. Adjustments may be made for actual site suitability with the field key provided separately.

Ratings Table

The PEM/TEM wildlife ratings table was provided in csv format for both the TFL 8 TEM, and for the Boundary TSA PEM for use with the Ecosystem-based Resource Mapping (ERM) tools as ArcView 3.2 extensions. These ratings files were too long to include here (tfl8_eco_rat.csv was 906 lines long, and the pem4019_eco_rat.csv was 3226 lines long). The ratings table was applied to the PEM and TEM, and the resultant coverage is presented in Fig. 2.

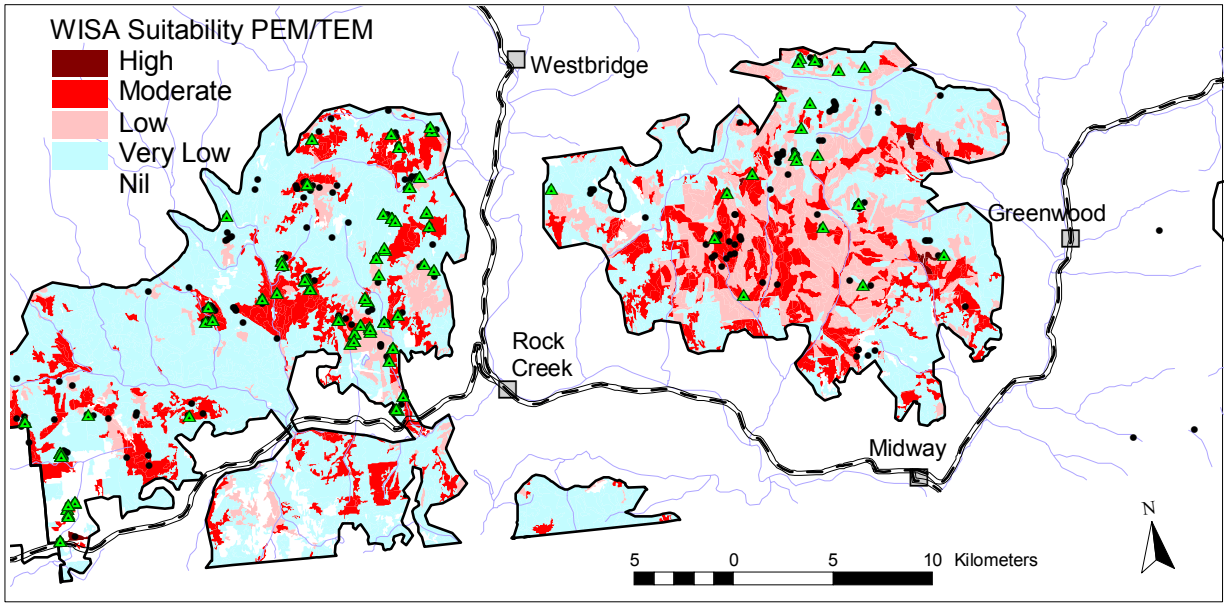


Figure 2. Williamson's Sapsucker nests (green triangles), other observations (black dots), and PEM/TEM suitability ratings in the Boundary TSA.

HABITAT MODELING using FC/VRI and Plot Data

Introduction and Methods

Based on very intensive research efforts conducted from 2006-2008, the habitat in B.C. can be much better described than it could be prior to 1996. This data has yet to be published, and some of it has been analyzed and reported here for the first time. Habitat plots measuring tree (>7.5-cm dbh) densities, species, size (dbh) and condition (wildlife tree class), and cavity presence and ant nest presence were conducted in the 16-ha area (225-m radius) around most of the nests occupied in 2006 and 2007 in B.C., and some in 2008. Stumps >22.5 cm dsh and logs >22.5-cm large end diameter were also measured.

Random sites were sampled for Williamson's Sapsucker presence/absence in 2008. Habitat data at unoccupied random sites within the AO were contrasted with the known nest sites from 2006-2008 which were ordered by estimated local nest densities relative to the benchmark density. Habitat modeling was based on both the habitat plot results and available GIS layers. Variables available from the habitat plots included densities by size classes and species of live trees, snags, stumps and logs, volume of logs, densities of trees with nest cavities, and densities of ant nests (either tallied, or assumed based on sign). Variables available from the GIS layers included elevation, slope and aspect from the TRIM Digital Elevation Model, and Forest Cover (FC) attributes (now termed Vegetation Resource Inventory (VRI), even though almost all the data consisted of simple rollovers from the older FC layers). Variables derived from FC attributes included stand age of Layer 1, maximum stand age of any layer, site index, crown closure for any layers >15-m ht., species composition, and maximum or mean of these attributes within 225-m or 500-m of the nest or random point. DEM and FC attributes were attached to points by converting the layers to grids, and then attaching the cell grid or neighbourhood mean or maximum to the point).

Analyses for Habitat Modeling

Data sets available for habitat modeling and/or model validation included:

1. Using GIS variables only, all randomly sampled points in 2008, including those where WISA were found (occupied points, n = 55), and where WISA were not found (unoccupied points n = 143), and including those for which habitat plots had not been completed,
2. Using GIS variables only, the same data set as #1, but substituting actual WISA locations, or nest locations if known, for "occupied points" to strengthen the contrast with unoccupied points,
3. Using habitat plot and GIS variables, the main data set for these analyses—2006 and/or 2007 nest territories where habitat plots were completed (n = 108) (based on single trees, or average of two trees if nest was shifted >50-m to another tree within the territory in the second year) contrasted with unoccupied random points (2008; n = 97)) including the Boundary TSA, and each of the other project areas (West, Okanagan TSA and East Kootenay),
4. Using habitat plot and GIS variables, other nest territories from 2004-2005 and 2008 (n = 24) where there were habitat plots, but the nests were not part of the 2006-2007 data set,
5. Using GIS variables only,
    a. all other nest territories known from 1996-2008 (n = 111) that were not part of the 2006-2007 nest data set (#3), or
    b. other observations from territories where breeding was not confirmed or no nest found, using the most central observation for each territory (n = 66), or
    c. other single WISA observations where breeding occupancy was either not considered probable or confirmed (n = 213).

d. all call playback points from 1997-2008 within the WISA AO that could be considered unoccupied, i.e. WISA were never found within 600 m, random points of 2008 were not included, and points were at least 300-m from nearest neighbour point (n = 1589; East Kootenay 565, West 517; Okanagan 179; Boundary 328). This set could be contrasted with data sets 5a, b and/or c which were considered to be occupied points.

The first step in analyses of the first three datasets consisted of one-way ANOVA contrasts for each variable by density (High, Moderate, Low or Nil, where Nil was the unoccupied random sites). ANOVA techniques were not entirely suitable for all variables. For example, the majority of nest sites were found in sites with 50-300 live trees/ha (Figure 2) which was a subsample of the random sites where the majority of live tree >17.5-cm dbh densities were between 0-400 live trees/ha (Fig. 3). Therefore the relationship of live tree density to nesting was not a regularly increasing or decreasing one, and was more complex, i.e. within a subset of occurring live tree densities. Small tree (7.5-17.5-cm dbh) densities were an example of a variable that would fit well into ANOVA analyses because the means were very different, and nesting use decreased regularly with increasing density (Figure 2). All possible variables were examined for differences in distributions that may not have been apparent if means were similar.

Some unoccupied random points that would have been selected for plots were not sampled because they had >70% composition of lodgepole pine in the FC attribute layer, or because there were no standing live trees at all on the site. No WISA nests had been found where lodgepole pine composed >70% of the stand, or where there were no trees at all, so these points would not have contributed any new information to the model, i.e. these points were going to be excluded from the final model at any rate. Therefore the basis of the habitat models already excluded areas where lodgepole pine dominated, and where there were no standing trees.

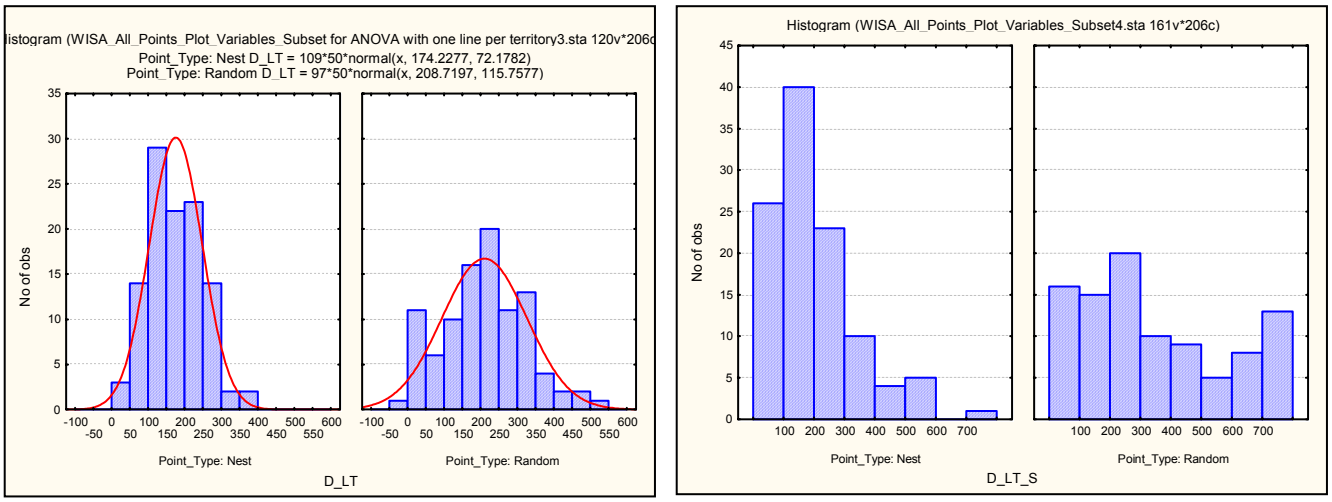


Figure 3. Distribution of live trees >17.5-cm dbh (D_LT, left), and live trees 7.5-17.5-cm dbh (D_LT_S, right) occurring in the 16-ha areas (225-m radius) around Williamson's Sapsucker nest trees occupied in 2006 and/or 2007 and unoccupied random points. Densities >800 have been lumped with the 700-800 group (for nests, n = 1; for random, n = 8).

Table 5. Tree species composition of the 16-ha Williamson's Sapsucker nest territories in the Okanagan-Boundary (n = 66) within each class of woody structure.

	Tree Species Composition within Category (%)					
	Small Live Trees	**Large Live Trees**	**Very Large Live Trees**	**Large Snags**	**Logs**	**Cut Stumps**
Size Range (DBH)	*8-22 cm*	*23-57 cm*	*≥58 cm*	*≥23 cm*	*≥23 cm*	*≥23 cm*
(n)	**(3546)**	**(4135)**	**(624)**	**(802)**	**(1897)**	**(2454)**
Tree Species						
Western larch	20.3	25.2	57.0	18.7	29.6	24.4
Douglas-fir	48.9	56.3	36.9	53.5	38.2	52.5
Hybrid white spruce	9.1	11.7	2.7	7.1	7.8	10.2
Lodgepole pine	18.6	2.7	0.0	9.5	19.0	11.9
Trembling aspen	0.9	1.2	0.3	4.6	1.5	0.0
Ponderosa pine	0.3	1.1	2.3	1.0	0.6	0.3
Other species	1.9	1.8	0.8	5.7	3.0	0.6

Not every breeding territory is occupied every year, so that a certain percentage of breeding territories may have been misclassified based on presence/absence within 225-m of a random point in 2008. Occupancy rates of breeding territories have been shown to be 50% on the long term (Gyug et al. 2007) and about 70% on a year-to-year basis (Gyug, unpublished data based on 2006-2007). Therefore any habitat model is not likely to be more than 50-70% efficient at classifying random sites as truly unoccupied, or as possible nest sites. Depending on project area, 20-33% of the randomly selected sites were found to be occupied in 2008, so that model efficiency (nest vs. unoccupied) has probably been significantly improved by deleting these sites from the random sample alone, but still may only be 50-70% efficient at best.

Tree species composition around nests was also examined graphically for trends. Based on this examination in early 2008 of the nest plot data from 2006-2007 (Fig. 4), sites where lodgepole pine made up >60% of the crown closure were not considered to be WISA nesting habitat. No habitat plots were completed around random unoccupied sites where Pl made up >60% of the forest cover layers. Table 5 gives a complete breakdown of tree species composition at WISA nest plots.

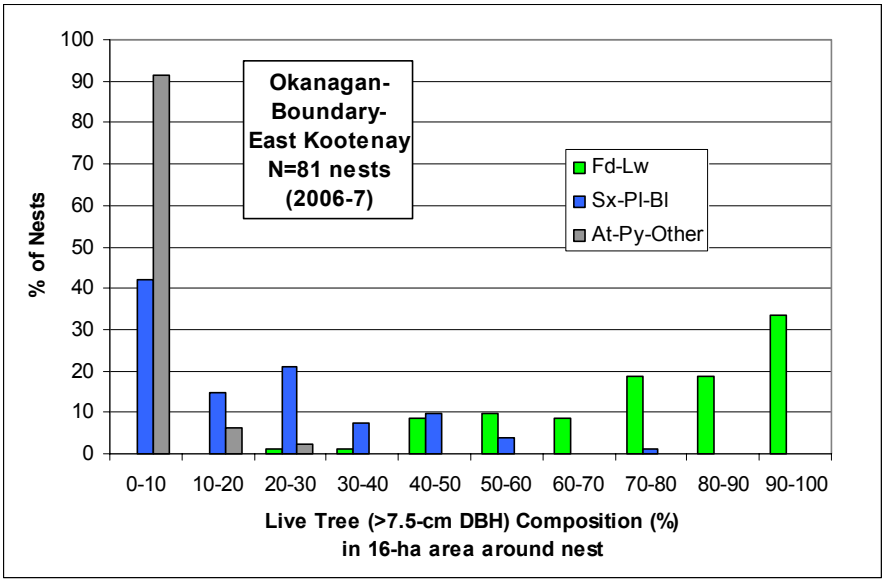


Figure 4. Tree species composition within 225 m of Williamson's Sapsucker nest trees, 2006-7.

HIGH Suitability Habitat

The provincial benchmark habitat was the only type of site where High densities occurred, and was considered to be the only High suitability habitat. Final habitat model used for High suitability habitat based on GIS layers is in Table 8. With the slope adjustment, and eliminating isolated polygons <1 ha in size, there were only 428 ha of Highly suitable habitat, or about 1% of the gross area of 41000 ha (Fig. 5, Table 9).

Even though a polygon may be mapped as High suitability, it would still need to be field assessed for actual high suitability based on:

1. 125-250 live trees >22.5-cm dbh/ha,
2. <650 live trees >7.5-cm dbh/ha,
3. >20 very large live trees >57.5-cm dbh/ha, which include some western larch
4. 30% western larch composition of live trees >17.5-cm dbh
5. standing very large snags averaging 10% or more of the very large live tree density.

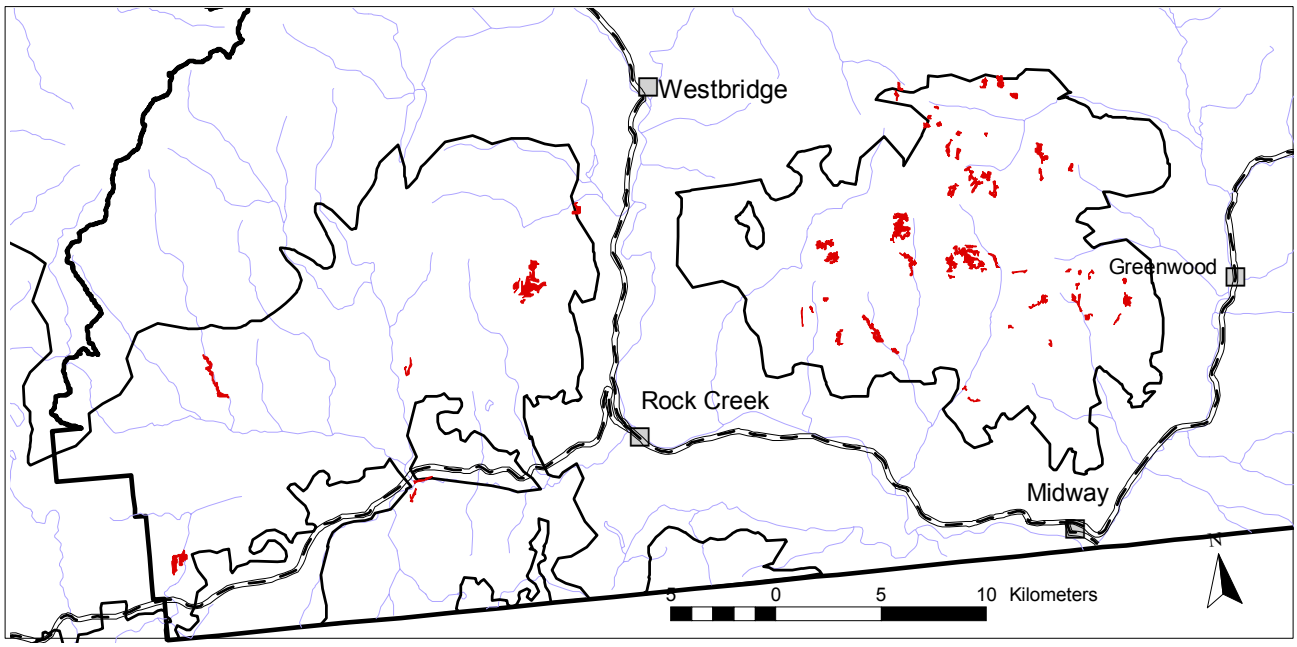


Figure 5. Williamson's Sapsucker Area of Occupancy (2008) within the Boundary TSA showing the High Suitability modeled (red) habitat based on Forest Cover attribute GIS layers, and excluding areas with slopes >30%.

Characterization of Habitat Suitability (Data Set 3; ANOVA Results)

High density nest sites were characterized by moderate large tree densities (Table 6; D_LT_L) compared to low density sites where large trees were less dense, and unoccupied sites where trees were more dense. High density sites were characterized by higher densites of very large trees, very large snags and very large woody structures in general (D_VL). Stand tables (Fig. 6) clearly show the "top-heavy" stand structure of High density and High suitability sites with relatively high densities of trees >57.5-cm dbh, and higher densities in the 40-50-cm dbh classes for High and Moderate sites. Other classes of sites had progressively greater densities of small trees (7.5-17.5-cm dbh) as the nest density and habitat suitability declined (Figure 6).

Nest sites had lower densities of lodgepole pine than random sites (Table 6), even though the random sites with the highest lodgepole pine densities had already been excluded from the study by design. However the differences in these densities were relatively low (10 trees/ha compared to 25 trees/ha) and would therefore not likely form good variable for use in GIS FC layer modeling where percentage composition of tree layers is rarely that precise. Nest sites had higher percentages of very large western larch than random sites, and while densities were low all around, the percentages were relatively large. Percent tree composition of spruce and balsam (mostly spruce) was higher at nest sites than at unoccupied sites, probably because nest sites tended to be better growing sites including creek bottoms where there were more spruce trees.

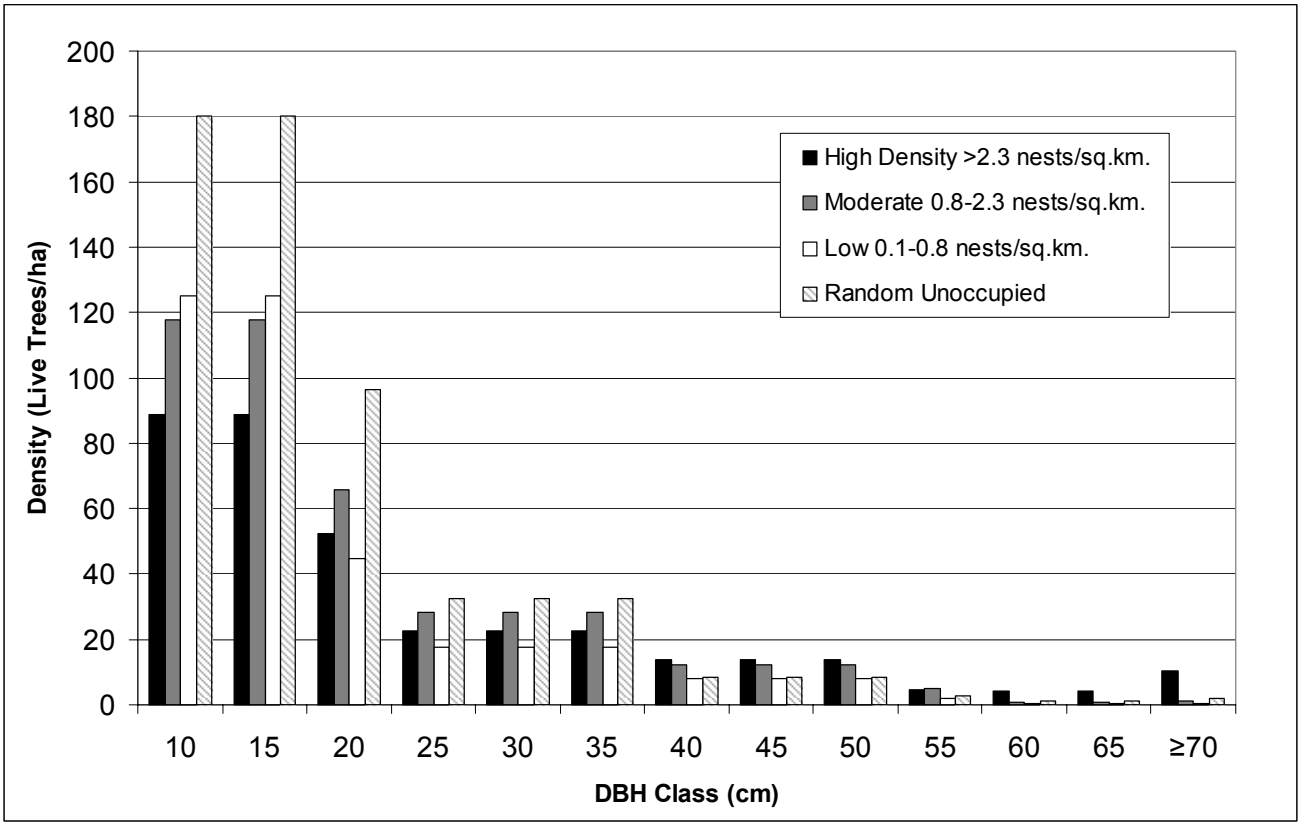


Figure 6. Mean stand structure of live standing trees within 225-m of Williamson's Sapsucker nest sites by nest density class and for random unoccupied sites within the Area of Occupancy in the Okanagan-Boundary.

Table 6. Means for plot and forest cover attribute variables for different densities of Williamson's Sapsucker nests where densities were significantly different at p = 0.05. Means followed by like letters were not significantly different at p = 0.05 using Scheffe's post-hoc test. If no letters present, then there were no significant post-hoc differences among means. Moderate or Low Density sites (n = 5) where there were High Suitability stands (based on high density of veteran western larch trees) present, but these were too fragmented or small to support high nest densities in a wide area have been included with the High for this contrast.

		High	Moderate	Low	Unoccupied	p
Variable Name	**n**	12	39	13	51	
D_LT_S		175	235	250	360	0.028
D_LT_L		166 ab	192 ab	123 a	222 b	0.002
D_LT_VL		18.4 a	3.0 b	1.1 b	3.9 b	<0.001
D_LT		184 ab	194 ab	125 b	226 a	0.003
D_LT_GT8		361	430	374	591	0.006
D_SN_VL		2.5 a	1.2 b	0.6 b	1.0 b	0.001
D_VL_UP		30.7 a	15.5 b	11.8 b	15.6 b	<0.001
D_VL		32.5 a	19.0 b	13.2 b	19.9 b	0.002
P_LT_SB		20 a	12 ab	14 ab	6 b	0.005
D_LT_FD		82	117	64	113	0.048
D_LT_PL		9.9 a	8.1 ab	7.1 ab	23.6 b	0.041
D_LT_VL_FD		7.2 a	1.6 b	0.6 b	2.1 b	<0.001
D_LT_VL_LW		10.5 a	1.0 b	0.4 b	1.3 b	<0.001
P_LT_VL_LW		57.4 a	32.2 ab	43.4 ab	22.9 b	0.02
D_E_NEST		(0.91)0.76 a	0.18 b	0.10 b	0.20 b	<0.001
D_E_ANT		34.2	27.1	23.9	33.7	0.042
V_LG_L_MN		28.6 ab	22.7 a	11.6 a	34.7 b	0.001
V_LG_VL_MN		9.6	6.3	3.2	11.9	0.018
V_LG_MN		39.5 ab	29.2 a	14.7 a	46.5 b	<0.001
DEMSLOPEP		13.5	16.7	14.2	21.9	0.026
MAXAGE		220 a	125 b	106 b	109 b	<0.001
MAXAGE225		238 a	181 b	195 ab	174 b	0.001
MAXAGE500		244	214	224	207	0.041
CROWNGT15		52.1 a	41.0 b	19.2 c	33.5 abc	0.002
MNCRN15225		37.9 a	34.9 a	18.8 b	33.7 a	0.006
L1_AGE		219 a	114 b	78 b	98 b	<0.001
MNL1AGE225		148 a	105 b	77 b	95 b	0.001
MXL1AGE225		238 a	176 b	176 ab	156 b	0.001
FCP_VLT_LW		24.8	12.8	25.4	5.6	0.023
FCP_LT_FD		46.8 a	43.7 a	11.8 b	29.6 ab	0.003

For variable names: D = Density, P = Percentage, LT = Live Trees, SN = Snags, ST = Stumps, S = Small (7.5-17.5-cm dbh), L = Large (17.5-57.5-cm dbh), VL = Very Large (>57.5-cm dbh), UP = trees, snags and stumps, D_VL includes trees, snags, stumps and logs >57.5-cm dbh. D_E_Nest and D_E_Ant are estimated nest tree and ant nest densities based on densities of suitabilt woody structures.
DEMSLOPEP indicates Percentage slope derived from Digital Elevation Model.
The lower 10 variables were derived from the Forest Cover attribute layer: .L1 = Forest Cover Layer 1, MN = Mean within 225-m radius, MAX = Age of oldest stand layer, MX = Maximum within 225-m radius, Crowngt15 is crown closure sum for all layers ≥15-m ht, FC indicates percentage derived from Forest Cover attributes,

Log densities were higher at unoccupied sites than at other sites (Table 6), partially because this was correlated with slope position (densely forested north aspects) and with stand age, where young stands still had a high volume of CWD from the stand-initiating fire that may have been 60-100 years previous, and these trees had decayed beyond tallying in the older sites where WISA were found. The exception was for very large log volume which was lower at moderate and low density sites than at high density sites, or at unoccupied sites.

Age of oldest stand layer (MAXAGE; Table 6) at the high density nest sites were significantly higher than at any other sites, but this difference was not as high when considering the oldest layer within 225 and 550-m radii. Age of layer 1 was significantly higher at high density nest sites compared to moderate and low nest sites, and unoccupied sites, and this difference persisted even when considering the oldest layer 1 found within 225 m (MXL1AGE225) and the mean layer 1 stand age within 225 m (MNL1AGE225). The proportion of very large larch in the stand was much higher at high nest density sites than at other sites, and very low at unoccupied sites. This was partly because there was no very large tree layer at all at many unoccupied sites, so these had been assigned a zero value for this variable. The percentage of Douglas-fir among live trees >15-m ht from the FC attributes (FCP_LT_FD) was much higher at high nest sites than at unoccupied or low density nest sites.

Slopes were lower at nest sites than random sites (Table 6). However, this may have been because nests found in 2006-2007 were simply easier to search for and find on level ground than nests in broken or steep terrain. Nest searches in very difficult conditions may have been abandoned much more easily and before nests were found than searches in easier terrain. To test whether this effect may therefore have been spurious, and would therefore not be a good predictor variable, the 2008 random site data was analyzed alone where this bias would not have been evident since the results were based only on WISA detections, and not necessarily on finding an active nest. Two-factor ANOVA was used to contrast the slopes at random sites found to be occupied by WISA (where we had no habitat plot data) to the slopes at unoccupied sites. The result was found to be significant ($F_{1,135} = 3.85$, $p = 0.05$). However, the differences were more pronounced in the Boundary (22.4% slope vs 16.1%) and East Kootenay (19.4% vs 12.1%) than in the Okanagan (18.1% vs 17.3%).

Possible differences in aspect were examined using Chi-squared contingency tables for any sites with slopes >10%. There were significant differences in aspect for nests and random sites (Chi-squared = 13.88, $p < 0.05$). Fewer nest sites were on north aspects (315-045 degrees) than random sites (5 vs 24). On non-north aspects (046-314 degrees) there were slightly more nest sites than random sites (69 vs 55).

Nest Tree Densities

While sampling random points in the spring for WISA presence, and later for habitat plots, it appeared that most of the unoccupied sites lacked any suitable nesting trees or snags for WISA (see Gyug et al. manuscript on nest papers for definitions of suitable nest trees or snags). There did not appear to be any other consistent and obvious defining characteristics that separated most of the unoccupied plots from plots where we detected WISAs. The lack of nest trees at some sites may make any analyses difficult to interpret. If, indeed, that is a controlling factor, then sites may be suitable for any aspect of foraging and meet all suitable characteristics, but will be unoccupied if there are no suitable nest trees.

Suitable nest trees occurred at very low densities that were below the resolving power of our sampling method, which was 0.625/ha in a 10% sample of a 16-ha area for veteran trees and large snags. At nests, mean density of suitable nest trees was 0.24/ha. Mean suitable nest tree density was only 0.06/ha at random sites, which was far below the resolving power of our methods at the individual site level. In addition, there was a significant interaction effect, i.e., the mean (not including known nest trees that were in the sites by design) at nest sites varied greatly between regions (0.044-0.379/ha), but the mean at

random sites (0.054-0.074/ha) did not vary as much between regions. Because of this significant interaction effect, and because the density levels of suitable nest trees were so far below the resolving power of our plot coverage, this variable does not make a good criterion for classifying nest vs. random sites with this data set. However, since nesting cannot occur without some suitable nest trees present, this is still a good criterion for quick field estimation of nesting potential as long as entire sites can be quickly viewed, even if it is not a statistically reliable method for classifying habitat potential within this particular data set.

Derivation of a Suitability Model based on FC/VRI and DEM attributes from the Plot Data

Using habitat plot data and the estimated nest tree density to search for correlates in the FC attribute layer, the highest correlations ($r > 0.25$) were with the following FC attributes: age of oldest layer (at the point and the mean and maximum within 225-m), and age of layer 1 (at the point, and mean and maximum within 225 m). It was not significantly correlated with percentage composition of any tree species, although the strongest correlation ($r = 0.15$) was with percentage of very large western larch in a stand. Since nests, and the unoccupied sites where we conducted plots, were limited to Douglas-fir/western larch stands, clearly, estimated nest tree densities were best correlated with stand age.

The most significant differences were between High density sites and all the other sites (Table 6). It was more difficult to characterize the differences between Moderate, Low and Unoccupied sites consistently on any single variable, or set of variables. The differences between High, Moderate and Low were consistent for crown closure, very large log volume, age, very large snag density and Douglas-fir percentage in that the means decreased from High to Moderate and then from Moderate to Low. However, there was not another consistent drop to the unoccupied sites, and the means for the unoccupied sites were often in the mid of the other means. Sometimes the mean dropped from High to another level, and then was similar for Moderate, Low and unoccupied (e.g., age of oldest stand layer). One conclusion might be that many of the unoccupied sites may be suitable as Low or Moderate habitat, but just lack that crucial nest tree as the most suitable nest trees have already been cut down during the last century of logging and high-grading throughout most of the AO.

The other problem with analyzing this data just by differences in means, is that even though a mean may be significantly different, there was so much overlap between the individual observations that one cannot reliably separate one class from another on an individual basis, except maybe for the High Suitability stands (Table 7). There were also a number of different types of unoccupied stands that contribute noise, i.e., variation, to the data set. Some of the unoccupied sites lacked almost any trees, some had too many small trees, some were otherwise suitable but lacked any potential nest trees, and some may have had fragments of suitable habitat that were within very large matrices of unsuitable habitat. Therefore using any of the means for unoccupied sites as potential characteristics for distinguishing them from occupied sites, without first identifying the reason it may have been unoccupied, would not be fruitful.

A preliminary habitat suitability model (Table 8) based only on FC/VRI attributes was developed from the mean values for each variable based on nest densities, using the standard deviations as a guide to the limits of the criteria to separate densities/suitability (Table 7). This model was applied spatially to the Boundary FC/VRI (Fig. 7).

Table 7. Ranges of stand conditions used to define Williamson's Sapsucker habitat suitability based on observed means and standard deviations. In a normally distributed variable, 68% of observations will be within one SD above and below the mean. See Table 6 for explanations of variable names.

		High		Moderate		Low		Unoccupied	
Variable Name	**Comments**	Mean	SD	Mean	SD	Mean	SD	Mean	SD
D_LT_S	Moderate to Low densities are better.	175	135	235	134	250	316	360	294
D_LT_L	Moderate densities required. Both increases and decreases may decrease habitat value. At low tree densities, nest productivity will also be reduced (Gyug, unpublished data)	166	41	192	61	123	71	222	110
D_LT_VL	Higher values better; VRI polygons with 20-40 VL trees/ha are benchmark habitat.	18.4	6.0	3.0	3.4	1.1	0.9	3.9	5.0
D_LT	(Sum of 2 variables above)	184	44	194	62	125	71	226	111
D_SN_VL	10-15% of VL tree density is best- indicates a healthy old stand, rather than one that is declining rapidly due to pest outbreaks, etc, or a previously harvested stand that has very few nesting opportunities	2.5	1.7	1.2	1.1	0.6	0.7	1.0	1.5
D_VL_UP	Higher better	30.7	9.6	15.5	9.6	11.8	7.6	15.6	12.8
D_LT_PL	Lower better	9.9	11.6	8.1	15.1	7.1	13.1	23.6	39.0
D_LT_VL_FD	Higher better	7.2	21	1.6	35	0.6	42	2.1	33
D_LT_VL_LW	Higher better	10.5	4.1	1.0	1.8	0.4	0.8	1.3	2.9
P_LT_VL_LW	Higher better	57.4	5.4	32.2	1.8	43.4	0.5	22.9	2.8
D_E_NEST	Higher better	0.91	0.36	0.18	0.15	0.10	0.06	0.20	0.22
D_E_ANT	Does not appear to be a controlling factor except in extreme circumstances since many unoccupied sites had high ant densities	34.2	16.5	27.1	13.5	23.9	13.1	33.7	14.2
V_LG_MN	Higher is better within occupied sites, but may be higher in unoccupied sites due to local stand history	39.5	25.0	29.2	18.8	14.7	9.4	46.5	30.7
DEMSLOPEP/ ASPECT10	South steep (>25%) slopes tend to be unforested, and north steep (>10%) slopes too densely forested	13.5	6.7	16.7	13.5	14.2	5.3	21.9	11.9
MAXAGE	Older better- but this is not generally not well mapped as veteran layer	220	64	125	75	106	109	109	70
CROWNGT15	More is better, but there are limits as very high closures are associated with very high tree densities	52.1	15.4	41.0	24.0	19.2	25.5	33.5	25.9
MNCRN15225	"	37.9	7.9	34.9	13.3	18.8	11.9	33.7	18.3
L1_AGE	Older is better (more VL trees)	219	64	114	61	78	90	98	68
MNL1AGE225	"	148	46	105	41	77	58	95	45
FCP_VLT_LW	Higher better (=older stands with more nest and ant nest opportunities)	24.8	22.3	12.8	30.9	25.4	36.0	5.6	18.0
FCP_LT_FD	Moderate better, but not too high, or it will displace Lw	46.8	21.2	43.7	33.7	11.8	15.2	29.6	31.1

Table 8. Preliminary Habitat Suitability Model for the Boundary TSA for Williamson's Sapsucker based on Forest Cover/VRI attribute and DEM layers.

Input Data	High (H) (1)	Moderate (M) (2-3)	Low (L) (4)
Rank 1 Layer Projected Age	>190 years	>120	
Rank 1 Layer Projected Ht	>29.0 m		
Rank 1 Layer Site Index	>15.0		
Rank 1 Layer Crown Closure	>30%		
Crown Closure ≥15.0 m ht		>20%	
Age of oldest layer	>190 years	>125 years	>80 years
Tree Species	Fd or Lw leading, contains Lw	Fd, Lw present	Fd or Lw present
Cw %.	<10%	<10%	<10%
Sum of Pl and Bl % composition	<30%	<30%	<60%
Sum of Fd and Lw % composition			>40%
% Fd of all layers ≥15.0 m ht	10-90	10-90	Fd not = 100%
Upgrade from VL to L if:			Age of oldest Lw layer >125 yr
			Contains Fd or Lw, and At >4% and age of At layer >55 yr
Reduce one level if:	Slope >30%	Slope >30%	Slope >30%

Notes:

1. Non-forest polygons labelled Lake, Meadow, Alpine, Alpine Forest, Clearing, Cultivated field, Glacier, Ice, Gravel Bar, River, Claybank and Urban were assigned Nil (N).
2. Non-forest polygons labelled Open Range, Rock, Non-productive, or Swamp were assigned Very Low (VL) because these may be partially forested.
3. Any polygons not otherwise assigned to H, M or L using the table were assigned VL.
4. To derive slopes from the DEM, only where "slope >30%" polygons were >1 ha in size were used.
5. The last step in this model was to dissolve all polygons <1 ha in size (if split by slope) back into the parent FC polygon.
6. An assumption of this classification is that likely nesting trees (primarily veteran Lw) are more common and abundant in older forests (>80 years old, in particular). Most of these nest Lw trees were veteran trees generally >300 years old, i.e., much older than the other trees in the stand in which they occurred, although the FC database tends to be rather conservative in estimating age of these trees. In the Boundary AO, most older stands will contain these trees as the stands are the product of a mixed fire regime and were therefore not even-aged. In areas where most stands are even-aged, this classification will not correctly classify habitat, because the assumption that veteran Lw occur in most stands >80 years old will not be correct. For example, the extensive even-aged stands generated by the 1931 Camp McKinney fire will not magically transform into WISA habitat when they become >80 years old unless these stands have been noted as containing veteran Lw during the aerial photo correction mapping phase.
7. In this model, Moderately High (2) and Moderate (3) of the 6-class rating scale have been grouped. However, if Moderately High were to be mapped, the criteria would be the same as for High, except Rank 1 height and site index criteria would be removed, and crown closure of Rank 1 would be >20%. This applied to 1422 ha and 9 known WISA nest sites in the Boundary.

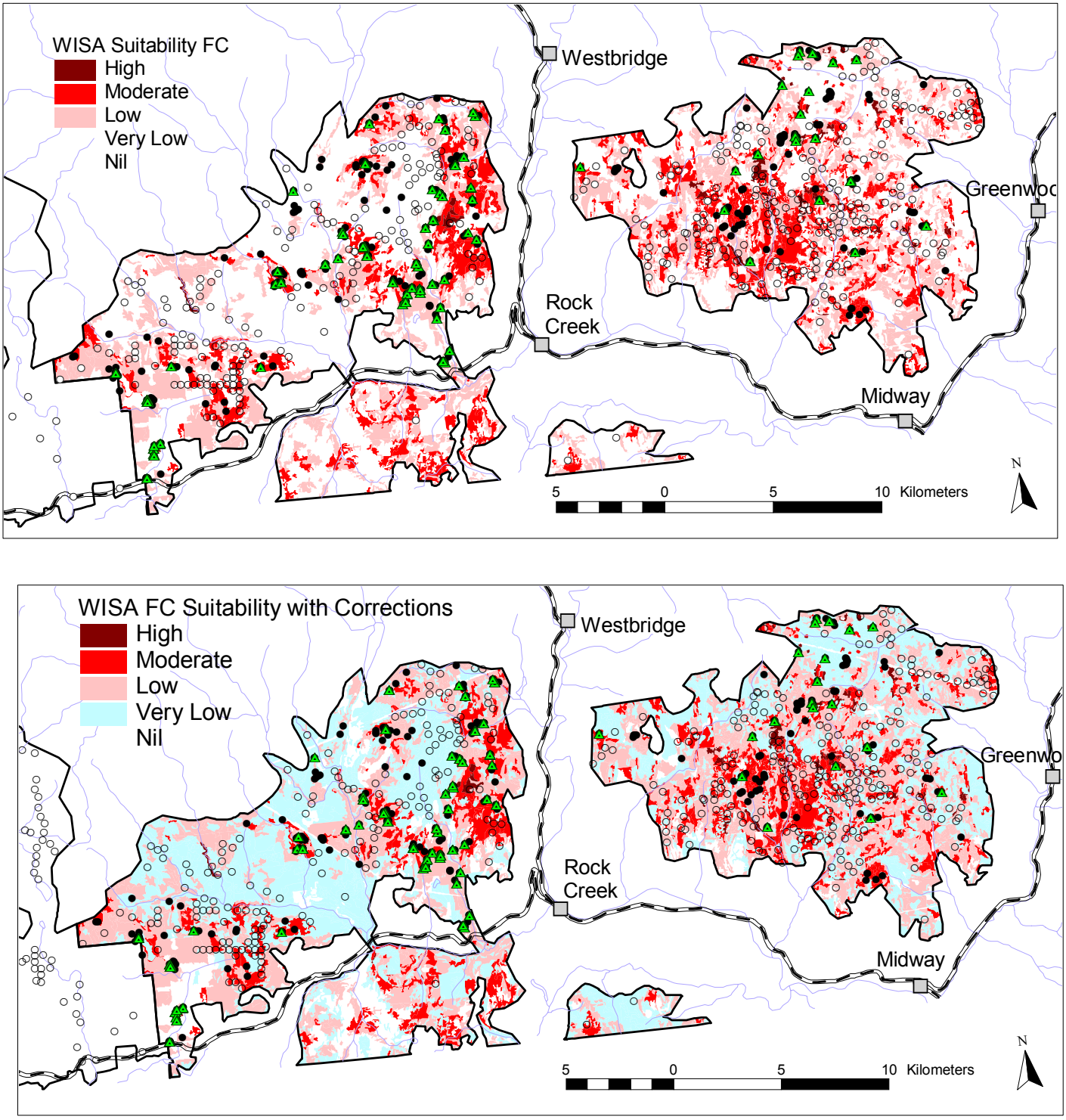


Figure 7. Williamson's Sapsucker Area of Occupancy (2008) within the Boundary TSA showing the initial model of habitat suitability habitat based on Forest Cover attribute GIS layers only (Table 8) with adjustment for slope (reduced by one class if slope >30%). Lower figure shows the habitat suitability after corrections based on aerial photo interpretation. Shown are WISA nests (green triangles), other WISA observations (black dots), and unoccupied CPB and Random points (open circles).

Ratings Adjustments:

After the initial run of the Forest Cover and PEM/TEM models (January 2009), neither model met criteria sufficient to the Williamson's Sapsucker Action Planning Team for spatial definition of Williamson's Sapsucker habitat suitability. With >30% of nests in Very Low or Nil habitat which would not receive enhanced conservation measures, this was not be deemed to provide protection/conservation of habitat as per the Recovery Strategy goal. Therefore, each classification error of a nest in Very Low or Nil habitat was examined to determine the source of the error, and how it might be corrected either by modifying the classification criteria, or by additional stereo aerial photo interpretation of nest trees (veteran Lw and mature At), in particular (Table 9).

Table 9. Number of classification errors of Williamson's Sapsucker observations in preliminary (January 2009) FC/VRI model for the Boundary TSA and TFL 8. Totals were 86 nests, 15 other territories, and 37 other observations (not known to be connected to breeding territories)

Preliminary Rating	Errors (n)	Type of Error	Correctable on complete AO basis using Aerial Photos?
Nests: Very Low	1	Nest in unmapped 0.5-ha WTP previously mapped (prior to recent ST cut) as 91 yrs (scarce vet Lw not mapped)	Yes- ST Cuts upgraded from VL to L, and would include any WTPs
	1	On slopes >30%, and VL ST cut	Yes, upgrade slopes >30% from VL to L if vet Lw
	2	Mapped as L, but reduced to VL by slope >30% adjustment	Yes, upgrade slopes >30% from VL to L if vet Lw present
	2	Scarce unmapped Lw vets or stubs in old partial cuts	No-vets cannot be detected in some ragged multi-storied stands from old HG or old partial cuts
	1	Mapping errors 1)Did not include Fd in "100 yr old" stand even though it is present, and 2)did not map scarce vet Lw (nest was in Ew but near Lw vets)	1)Yes, but only if make some assumptions, e.g., Fd is virtually always present in mixed species stands in the IDFdm, but would ideally be corrected based on field verification of age and sp present. 2)No, scarce Lw vets are very hard to detect in multi-storied older forest "ragged" stand structure when they do not stand above the main stand—only correctable using stand age surrogate.
	2	Ring of At around Swamp polygons	Yes, split SWAMP polygons by 20-m buffer adjacent to H/M/L (181 ha)
	1	Scarce veteran trees at edge of OR polygon	Yes, split OR polygons by 20-m buffer adjacent to H/M/L (1905 hal)
	2	Scarce unmapped Lw vets in old HG (1950's)	Yes, vets visible on photo above younger Fd layer if that layer is even
	2	Scarce unmapped Lw vets in ST cut since 1992	Yes, would add in all ST cuts if >2 ST/ha
	3	Scarce unmapped Lw vets in fire-origin stands (<100 yrs old)	Yes-including splitting polygons to make new polygons including only vet Lw (1-4/ha)
	1	Remnant At in partial cut that was more recently salvaged for Pl as well	No-cannot detect single isolated At on aerial photos
	1	Remnant At in ST cut at edge of gully and edge of ST cut	No-very difficult to detect reliably on aerial photos
	2	Unmapped At remnant in gully in ST cut (1988)	Yes, can see At patch on 1992 aerial photos of ST cut
Nil	1	Unmapped scarce At in gully adjacent to uncut riparian forest-mapped as U (Urban) at Phoenix Mine	Yes, ST/At in cutover areas <100 m from uncut forest, although this was not actually applied
Total Other Territories	**0**		**None needed correcting**
Other Observations (not Territories)	3	Obsn in VL or N stand adjacent (<100 m) to actual habitat stand, but never observed again.	No correction possible since birds not observed in nesting habitat
	1	Slope > 30%, otherwise would be L	Yes, upgrade slopes >30% from VL to L if vet Lw present
	1	Unmapped <0.5-ha At grove	No, almost impossible to correct
	1	Vets and Fd (0% label) not mapped-in error.	Yes, assume Fd present in almost all sites in IDF and correct maps on that basis in the absence of conflicting data.
	2	Partial Cut with very scarce Lw and other vets	No, Uncorrectable because of "ragged" multi-layered stand where vets are very hard to detect
	3	In mapped younger forest (no mapping error)	No correction necessary but birds may not have been in nesting habitat.

Prior to any corrections to be applied by aerial photo interpretation, some errors found in the mapping were corrected. In the most recent version of the VRI mapping, some of the polygons that had been split by timber harvesting had been re-typed incorrectly-in some cases, both the harvested and the unharvested portions. In some cases all attributes had been removed, in other they had been simplified to "Fd 100%". In some cases, the stand age had simply been downgraded, for no apparent reason.

For unharvested stands, mapping errors were corrected by reverting to the 1999 FC mapping (which I felt was actually more accurate than the latest revision) for species presence and for age where these sites had been downgraded with the latest adjustment. For harvested stands, I applied what I felt to be the most accurate age of oldest layer, crown closure and species presence based on personal knowledge of most of the sites. Total amount of area affected by these changes was in the range of 5-7% of the total project area. These changes were only used this to convert VL to L, not to change any L to M.

Based on the analysis presented in Table 9, the following adjustments were made to the FC/VRI habitt suitability model based primarily on interpretation of colour stereo aerial photos, and of Landsat 5 with deciduous enhancement to assist in determining presence of aspen patches:

For slopes <30%:

1. ST cuts (>2 ST/ha) upgraded from VL to L if vets present in ST cut (500 ha)
2. Mature At patches upgraded from VL to L (190 ha)
3. Fire-origin (60-100 year) stands upgraded from VL to L (330 ha) if:
    a. Lw vets scattered throughout if >0.5/ha, or
    b. portions of the polygon split out if vets were clumped
4. Old high-graded (generally prior to mid-1960's) or partially cut stands (generally from late 1960's to 1980's):
    a. upgraded from VL to L if I could detect vets >0.5/ha (40 ha),
    b. **not** upgraded from VL to L if they were too "ragged" and multi-storied to determine if there were actually any vets in the stands (660 ha)
5. Any other stands that contained vets that was for some other reason excluded (e.g. no Fd in VRI label, but actually considered to contain some Fd, as do almost all stands anywhere in the IDFdm1 in the AO) (140 ha)
6. Clearcuts that were not ST cuts were downgraded from M/L to VL (100 ha)

For slopes >30%

7. Upgraded steep (Slope >30%) Lw vet stands (>1/ha) from VL to L if:
    a. Based on FC/VRI attributes: (470 ha)
        i. age of oldest layer >190 years
        ii. contains Lw
        iii. Crown Closure of layers >15-m ht was >25%,
        iv. <60% PL + Bl
        v. <10% Cw, and from VL to L with just this FC correction 0 nests, 0 other observations, 1 CPB unoccupied, 0 of any random points), or
    b. Based on aerial photo interpretation: (620 ha out of 2310 possible ha adjacent to H/M/L)
        i. adjacent to H/M/L,
        ii. polygon size >1 ha, and
        iii. density of vets >1/ha,

For Non-productive polygons

8. OR, R, NP polygons (total 1288 polygons, 5327 ha):
    a. assign as Nil if truly non-treed (1605 ha),
    b. if partly treed, e.g., at the edges or within an arm in an irregularly shaped polygon, then remain VL, or
    c. if NP polygons had been rated M or L, reduce to VL if barely treed (<10%) (177 ha).
9. All Swamps (53 polygons, 181 ha) were either ringed by At or tall shrubs, and remained VL—none were moved to Nil
10. Split inside OR and SWAMP polygons with 20-m buffer adjacent to H, M or L rated polygons (930 ha total buffer area) (5 of 86 nests), and rate these as L.

Reliability/Verification of Models

The areas occupied by each class of suitability for each model are given in Table 10, along with the number of nests in each suitability class.

Reliability of the habitat suitability models were tested with the existing data of WISA and/or random unoccupied data sets (Table 11). Models were validated using all known nests, other breeding territories, other Williamson's Sapsucker observations not known to be associated with breeding territories, the random occupied points (2008), the random unoccupied points (2008) and unoccupied call playback (CPB) points sampled from 1997-2008.

The suitability models were more successfully used as presence (H/M/L) and absence (VL/N) predictors (Table 11) than they were for predicting nest densities. Neither the PEM/TEM nor the final FC/VRI models were very accurate at correctly classifying nests of a known density to the same suitability level, and therefore neither rating system should be relied upon for precise ratings levels. Of 86 nests with known densities (6 H, 41 M and 39 L), the PEM/TEM model classified all of the H nests as M, 33% of the M nests, and 33% of the L nests, and the final FC/VRI model correctly classified all of the H nests, 14% of the M nests, and 53% of the L nests.

Table 10. Areas of suitable Williamson's Sapsucker habitat from PEM/TEM and Forest Cover/VRI habitat models. Areas in the PEM/TEM area based on the highest suitability ecosite within each polygon. Total AO area was 40792 ha, and was 86 nests.

Model		Habitat Suitability				
		High	Moderate	Low	Very Low	Nil
PEM/TEM	Area (ha)	89	7654	7194	23375	2582
	% of AO	0.22	18.7	17.6	57.2	6.3
	Nests (n)	1	33	19	29	4
FC/VRI/DEM Polygon -Preliminary	Area (ha)	424	5580	12343	20208	2238
	% of AO	1.0	13.7	30.3	49.5	5.5
	Nests (n)	10	21	31	23	1
FC Polygon after initial photo corrections on slopes <30%	Area (ha)	424	5544	13719	17452	3653
	% of AO	1.0	13.6	33.6	42.8	9.0
	Nests (n)	10	21	43	11	1
FC Polygon after all corrections	Area (ha)	424	5379	15252	16083	3653
	% of AO	1.0	13.2	37.4	39.4	9.0
	Nests (n)	10	21	50	4	1

Table 11. Percentage of correctly classified locations based on presence/absence levels in the Boundary Area of Occupancy for habitat suitability models. Sample size for each column provided in ellipses. Random Occupied Points were the actual random point, and not the location of the bird, which would have been recorded in one of the three preceding columns (birds were known to travel up to 500 m from nests to be recorded within the 225-m random point radius).

			Presence[1]				Absence[1]	
			Nests	Other Territories	Other Obsn	Random Occupied Point[2]	Random Unoccu-pied Point	Unoccu-pied CPB point
Habitat Model	**Area (ha)**	**% of AO**	**(86)**	**(15)**	**(37)**	**(17)**	**(51)**	**(328)**
PEM/TEM	14937	37	60	67	49	50	66	46
FC/VRI/DEM Preliminary	18347	45	74	100	70	47	53	57
FC/VRI/DEM Final with adjustments	21055	52	94	100	73	71	51	46

[1]Presence was considered correctly classified if observations were in High, Moderate of Low Suitability polygons, and Absence considered correctly classified if unoccupied random or other Call-Playback (CPB) points were in Very Low or Nil polygons.

[2]Random Occupied Points were the actual random point, and not the location of the bird, which would have been recorded in one of the three preceding columns (birds were known to travel up to 500 m from nests to be recorded within the 225-m random point radius).

Clearly, no habitat model will correctly classify 100% of both presence and absence points (Table 10). Up to 50% of the breeding territories may not be used in a given year (Gyug et al. 2007) which would add considerable "noise" to any validation attempt, and therefore 100% correct classification of absence would never be achievable. However, the final FC/DEM model was the most successful at classifying nests and breeding territories, and did so with what might be considered the best possible inclusion of unoccupied points, i.e., about 50%. Random occupied points were generally modeled more poorly than nests or breeding territories, which may be expected since the birds may have wandered >500 m from nest sites to respond to the call playbacks in the random points.

The improvement of the final FC/VRI/DEM models over the initial model and the PEM/TEM model was dramatic, and included almost all nests and breeding territories. Inclusion of 7% more of the AO area improved the inclusion of nests by 20%. For management of an Endangered species, and for designation of critical habitat, preliminary models that only correctly predicted occupancy for 60-70% of nest sites would probably be judged to make an unacceptably large number of errors. However, the final FC/VRI/DEM models that contain 94% of known nests may be much more acceptable.

Field Ratings Adjustments:

Adjustments may be made in the field to ascertain actual site suitability. A draft field key has been developed and provided separately as a guide to site suitability.

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