

**FINAL SPECIES ACCOUNT
FOR WILLIAMSON'S SAPSUCKER SPECIES-HABITAT MODEL
WEST OF OKANAGAN LAKE**

This account was based on the template developed first for the Okanagan-Shuswap Forest District in the 1990's for Ministry of Environment, Penticton, which was adapted for the Merritt TSA (2006) and then expanded and updated for the entire area west of Okanagan Lake (2010) but applies primarily to the Merritt-Princeton Area of Occupancy.

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 Okanagan 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) on the west side of Okanagan Lake within the Cascade Forest District. The WISA AO west of Okanagan Lake as of 2008 was 743 km² in extent.

Ecoprovince: Southern Interior

Ecoregions: Thompson-Okanagan Plateau, Northern Cascade Ranges

Ecosections: Guichon Upland (GUU), Hozameen Ranges (HOR), Nicola Basin (NIB), Southern Thompson Upland (STU), and Thompson Basin (THB).

Biogeoclimatic Variants: IDFxh1, IDFxh2, IDFdk1, IDFdk2, PPxh2.

Project Map Scale: 1:20,000

Map Products Used: Predictive Ecosystem Mapping covering the Merritt TSA was available from the Nicola-Similkameen Innovative Forestry Society (PEM BAPID 4024; 2003). VRI (forest cover rollover-2007/2008), Forest Cover (1999) and DEM layers were also available. Digital orthophotos (1-m pixel) were available for 1990-1995 (Black and white) and for 2004-2005 (colour). Stereo aerial photo interpretation was done from 2004 colour aerial photos (nominal scale 1:30,000) and 2000 colour aerial photos (nominal scale 1:15,000).

Distribution

Provincial Range

- breeds; uncommon summer resident (Cannings *et al.* 1987, COSEWIC 2005);
- primary area of abundance is east of Okanagan Valley to Greenwood (COSEWIC 2005, Gyug *et al.* 2007)
- 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 Spences Bridge) and Manning Park (Cooper 1995, Gyug *et al.* 2007, Gyug 2007); occasional breeding records near Kamloops as far north as Skull Mt (Barriere) (Gyug *et al.* 2007).
- Kelowna area (Chute Lake) is the northern limit of their range on the east side of Okanagan Lake with some reported west of Okanagan Lake from the border: Mount Kobau, Trout Creek, Terrace Mountain (Gyug *et al.* 2007), Salmon River (Gyug 2007)

Elevational Range:

- breeds between 800 and 1550 m with the majority between 975 and 1475 m (Gyug *et al.* 2007);
- west of Okanagan Lake, 107 nests in 78 trees were found between 1994 and 2009 with all nests between 700 and 1270 m, and the majority (95%) of nests found between 800 and 1200 m (Tables 1 and 2, Gyug unpublished data).
- Figure 1 shows the location of all CPB points and WISA detections west of Okanagan Lake.

Table 1. Relative density of Williamson's Sapsucker by elevation west of Okanagan Lake, 1996-2009.

	CPB Points	WISA detected	WISA detected/100 CPB points
Elevation (m)	n	n	
200-599	197	0	0.0
600-699	145	4	2.8
700-799	239	2	0.8
800-899	437	22	5.0
900-999	671	21	3.1
1000-1099	1063	29	2.7
1100-1199	978	20	2.0
1200-1299	665	6	0.9
1300-1399	275	2	0.7
1400-1499	94	1	1.1
1500-1699	<u>17</u>	<u>0</u>	0.0
Total	4781	107	

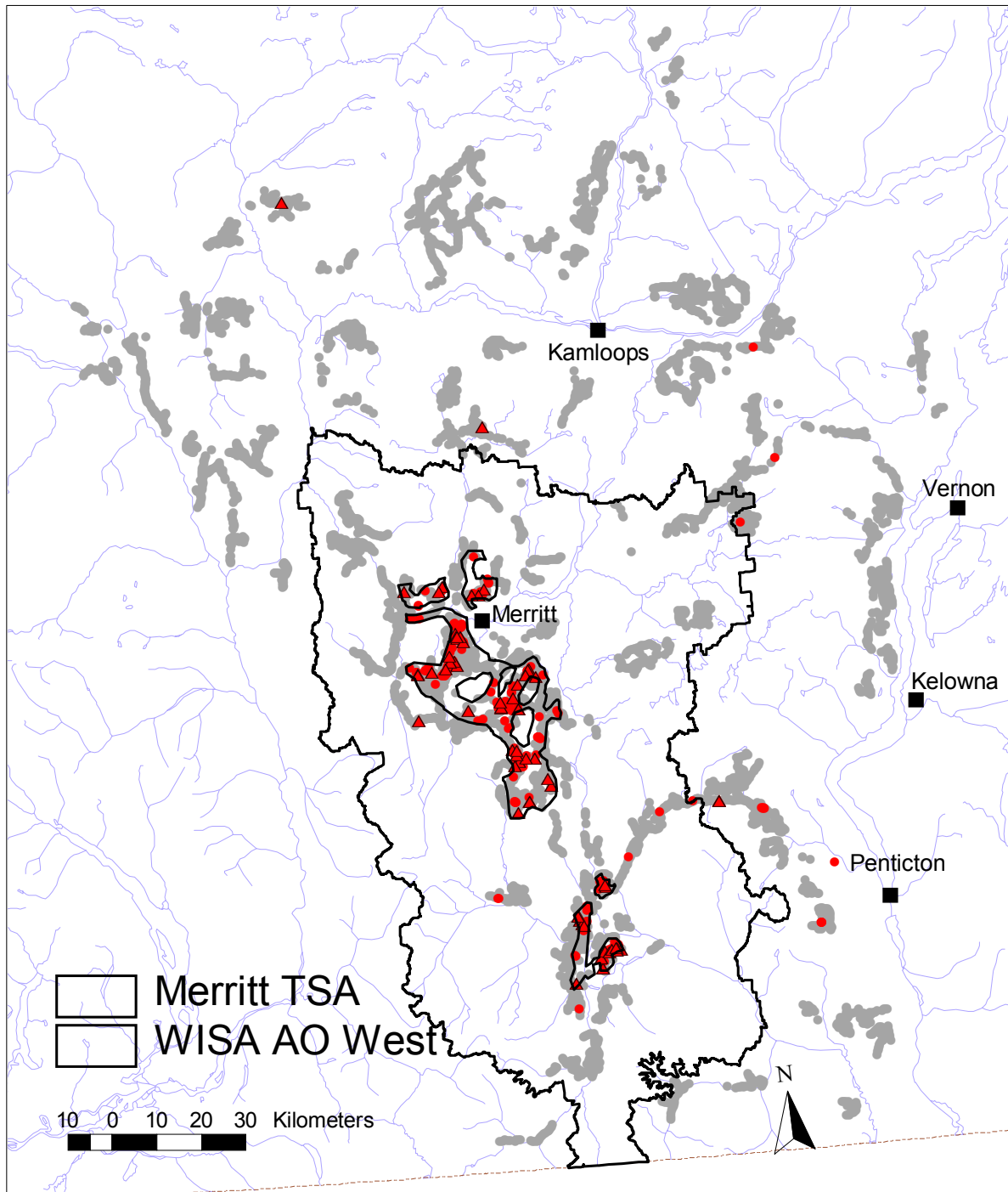


Figure 1. Call playback stations (grey dots) and Williamson's Sapsucker locations (red dots) and nests (red triangles) west of Okanagan Lake, 1994-2009.

Table 2. Average elevations of Williamson's Sapsucker breeding territories and other observations that could not be directly associated with breeding territories west of Okanagan Lake, 1995-2009.

Elevation (m)	Territories with Nests or Breeding Pairs		Territories with Males present for >2 weeks or in >1 year		Other WISA observations		Total
	n	%	n	%	n	%	%
600-699	1	1.4	0	0.0	1	1.2	1.1
700-799	2	2.8	0	0.0	4	4.7	3.2
800-899	14	19.7	6	20.0	13	15.1	17.6
900-999	15	21.1	7	23.3	12	14.0	18.2
1000-1099	21	29.6	10	33.3	32	37.2	33.7
1100-1199	16	22.5	3	10.0	20	23.3	20.9
1200-1299	2	2.8	3	10.0	3	3.5	4.3
1300-1399	0	0.0	0	0.0	1	1.2	0.5
1400-1499*	0	0.0	1	3.3	0	0	0.5
Total Territories	71	100	30	100	NA		
Total Observations	595		118		86	100	100

*The only observation >1350 m was in the Shingle Creek drainage west of Okanagan Lake in the Penticton TSA.

Ecoregions:

WISA were found primarily in the Southern Interior Ecoprovince (268 detected at 6749 call playback stations; 4.0 detected/100 CPB) and in the Southern Interior Mountains Ecoprovince (56 detected at 2342 CPB stations; 2.4 detected/100 CPB). Only CPB points that were not part of intensive area searches, were at least 300 m from other points, >800 m from points with previous detections, and were not repeats of previous year's points were included in the relative density analyses.

At the Ecoregion level, WISA were found primarily in the:

1. Thompson-Okanagan Plateau (4.2 detected/100 CPB; n = 5324 CPB),
2. Okanagan Highland (13.5 detected/100 CPB; n = 312 CPB),
3. Northern Columbia Mountains (3.3 detected/100 CPB; n = 1121 CPB) ,
4. Southern Rocky Mountain Trench (2.1 detected/100 CPB; n = 808 CPB).
5. Other ecoregions where they were detected uncommonly were the
 - a. Northern Cascade Ranges (0.2 detected/100 CPB; n = 440 CPB), and the
 - b. Selkirk-Bitterroot Foothills (1.1 detected/100 CPB; n = 167 CPB).

Overall the bulk of the known breeding population occurred in 7 ecoregions (Table 3): 24% in the Nicola Basin and Southern Thompson Upland west of Okanagan Lake, 57% in the Southern Okanagan Highland, Southern Okanagan Basin and Northern Okanagan Highland in the Okanagan-Boundary, and 16% in the MacGillivray Range and East Kootenay Trench in the East Kootenay. Note that the Northern Okanagan Highland was not occupied throughout its area, as WISA were concentrated in a narrow band of <10 km from the Southern Okanagan Basin and Southern Okanagan Highland. This was the primary location where very large veteran western larches historically occurred at high densities because of a high-frequency low-intensity fire regime. This fire regime was not found throughout the remainder of the range of western larch in B.C except perhaps in the southern Rocky Mountain Trench. This fire behaviour pattern at the landscape level is a possible causal influence on WISA distribution within BC. Of 193 nests in the NOH, 88% occurred within 10 km of the SOB or SOH boundary, with the exception accounting for 11% of the nests above Naramata in the northern most location where high densities of very large veteran larch were found.

Table 3. Relative density of Williamson's Sapsucker by ecosections based on call playback (CPB) responses, and numbers of known nests and nest territories in B.C., 1995-2009.

Ecosection		CPB Points	WISA detected	WISA detected/ 100 CPB	Nests	Known Nest Territories	
		n	n		n	n	%
West of Okanagan Lake							
NIB	Nicola Basin	215	25	11.6	22	13	5.5
STU	Southern Thompson Upland	1490	74	5.0	80	44	18.7
NOB	Northern Okanagan Basin-West	377	3	0.8	0	0	0.0
THB	Thompson Basin	397	2	0.5	1	1	0.4
GUU	Guichon Upland	418	2	0.5	3	2	0.9
HOR	Hozameen Range	262	1	0.4	1	1	0.4
CAB	Cariboo Basin	4	0	0.0	0	0	0.0
NTU	Northern Thompson Upland	181	0	0.0	0	0	0.0
OKR	Okanagan Range	178	0	0.0	0	0	0.0
PAR	Pavilion Ranges	648	0	0.0	0	0	0.0
SCR	Southern Chilcotin Ranges	25	0	0.0	0	0	0.0
SHB	Shuswap Basin	173	0	0.0	0	0	0.0
SOB	Southern Okanagan Basin-West	1	0	0.0	0	0	0.0
TRU	Tranquille Upland	411	0	0.0	0	0	0.0
Okanagan-Boundary							
SOB	Southern Okanagan Basin-East	192	35	18.2	54	26	11.1
NOH	Northern Okanagan Highland	1644	119	7.2	193	91	38.7
	<i>NOH <10 km from SOB/SOH</i>	<i>1158</i>	<i>101</i>	<i>8.7</i>	<i>169</i>	<i>81</i>	<i>34.5</i>
	<i>NOH >10 km from SOB/SOH</i>	<i>486</i>	<i>18</i>	<i>3.7</i>	<i>24</i>	<i>10</i>	<i>4.3</i>
SOH	Southern Okanagan Highland	119	7	5.9	40	16	6.8
SFH	Selkirk Foothills	167	2	1.2	2	1	0.4
NOB	Northern Okanagan Basin-East	18	0	0.0	0	0	0.0
East Kootenay							
MCR	MacGillivray Range	849	36	4.2	23	20	8.5
EKT	East Kootenay Trench	808	17	2.1	22	18	7.7
SPM	Southern Purcell Mountains	185	1	0.5	0	0	0.0
COC	Crown of the Continent	18	0	0.0	0	0	0.0
EPM	Eastern Purcell Mountains	87	0	0.0	2	2	0.9
FLV	Flathead Valley	121	0	0.0	0	0	0.0
SPK	Southern Park Ranges	107	0	0.0	0	0	0.0
Total		9095	324		443	235	100

Table 4. Williamson's Sapsucker relative density inside and outside the main Area of Occupancy (AO), numbers of territories and nests found, and random point results (2008) by BEC variant west of Okanagan Lake.

BEC Variant	Outside AO		Inside AO		Entire West	Territories (Nests) found ³	Inside Main AO	
	CPB Points	WISA detected /100 CPB	CPB Points	WISA detected /100 CPB	WISA detected /100 CPB		Random Pts (2008)	% Random Pts with WISA detected
IDF xh 1	350	0.3	153	22.2	7.0	36 (42)	15	20.0
PP xh 2*	145	0	45	22.2	5.3	8 (6)		
IDF dk 1	1373	0.3	298	11.7	2.3	34 (32)	26	26.9
IDF xh 2	945	0.2	147	10.9	1.6	16 (18)	9	55.6
IDF dk 2	794	0.1	71	5.6	0.6	6 (9)	1	0.0
PP xh 1	19	0	0		0.0			
IDF dk 3	86	0	0		0.0			
IDF mw 1	92	0	0		0.0			
IDF mw 2	39	0	0		0.0			
IDF ww 1	5	0	0		0.0			
IDF xc	42	0	0		0.0			
IDF xw	5	0	0		0.0			
ICHmk1/mk2	26	0	0		0.0			
MS	133	0	3	0	0.0			
ESSFmw	10	0	0		0.0			
Totals	4064	0.2	717	13.8		81 (137)	51	29.4

*WISA detection CPB points in the PPxh2 were significantly closer (194 ± 75 m; Mean $\pm$ SE) to the next higher-in-elevation BEC variant than were the remainder of the CPB points (535 ± 34 m) ($F_{1, 190} = 3.76$, $p = 0.05$).

BEC Zones:

Provincially:

- 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 et al. 2007)
- relative breeding densities <25% of the maximum were in the MSdk, PPxh2, IDFdm2, IDFdk1, IDFxh2, ICHmk1 and IDFdk2

West of Okanagan Lake (Table 4):

- relative densities were highest in the IDFxh1 and the PPxh2, and lower in the IDFdk1, IDFxh2, and IDFdk2
- This did not include the entire PPxh2, but primarily a small area adjacent to the IDFxh1 where WISA detection CPB points were significantly closer (194 ± 75 m; Mean $\pm$ SE) to the next higher-in-elevation BEC variant than were the remainder of the CPB points (535 ± 34 m) ($F_{1, 190} = 3.76$, $p = 0.05$).

Based on the locations of Williamson's Sapsucker from call playback surveys and follow-up nest searches, the Area of Occupancy (AO) was defined. The AO was considered to be the area where breeding was known to occur, or suspected to occur based on habitat similarities to known breeding locations and was recommended to be mapped at a coarse-scale (minimum cell size of 1-km blocks) (see COSEWIC 2005). West of Okanagan Lake, wide-ranging surveys in 2007 to determine the extent of the AO, resulted in only 16.9% of the CPB points being inside what was eventually mapped as the AO (Table 4). Within the AO, WISA were detected at 11.5% of the CPB points. The remainder of this habitat modeling project only deals with the portion of the regions west of Okanagan Lake contained within the WISA AO as it was revised in 2008.

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.

Prior to the research initiated by B.C. Environment in 1996, there were only general habitat descriptions available as follows:

- 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);

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 returned 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 (Gyug et al. 2007, Gyug et al. 2009a):

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

West of Okanagan Lake, most occupied nest territories were in aspen trees or patches within a coniferous matrix mainly of ponderosa pine and Douglas-fir (Gyug et al 2009a). 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 areas where they primarily nest in aspen have included:

- In Colorado, favoured nest sites adjacent to open Py forest,
 - nest site selection in aspens and small aspen groves (0.5 ha) (Smith 1982),
 - 85% of nests were in aspen in Colorado and Wyoming (Crockett and Hadow 1975);
 - most common nest site was in quaking aspen within coniferous forests (Conway and Martin 1993)
- 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),
- prefer to nest in tall aspen snags near bottom of snow melt drainages and none were found on ridge tops (Conway and Martin 1993),
- nest site areas had higher snag densities (7.7 snags/ha) and taller snags with greater dbh than surrounding forest (Conway and Martin 1993)
- 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.

Resource selection analysis of data from 2006-2008 (Drever et al. manuscript) showed that the probability of nest occurrence was strongly tied to densities of potential nest trees, which were older-aged trembling aspen (*Populus tremuloides*) and ponderosa pine (*Pinus ponderosa*) west of Okanagan Lake, and open forests with large (diameter-at-breast-height >57.5 cm) western larch in the Okanagan and East Kootenay regions.

Tree species composition around nests based on habitat plots was broken down by type of nest stand, i.e., either aspen or coniferous (Table 5), and shown graphically (Fig. 2). Sites where lodgepole pine made up >60% of the crown closure were not considered to be WISA nesting habitat. Moderate nest density stands were characterized by higher densities of trees >20-cm dbh and unoccupied stands were characterized by much higher densities of very small trees <25-cm dbh (Fig. 3).

Table 5. Relative tree species composition of the 16-ha Williamson's Sapsucker nest territories west of Okanagan Lake in aspen stands (n = 31) and in coniferous stands (n = 10) within each class of woody structure. Number of trees, logs or stumps counted in each category is in ellipsis in bold (**nnn**), and percentages in each portion of the table beneath each tally in ellipsis total 100%. The most frequent species in each category is shaded in grey.

Size Range (DBH)	Tree Species Composition within Category (%)					
	Small Live Trees	Large Live Trees	Very Large Live Trees	Large Snags	Large Logs	Cut Stumps
	8-22 cm	23-57 cm	≥58 cm	≥23 cm	≥23 cm	≥23 cm
Aspen Nests (0-60 m from nest)	(270)	(450)	(44)	(130)	(108)	(197)
Ponderosa pine	7.8	14.9	63.6	27.8	25.3	48.7
Douglas-fir	8.5	16.4	34.1	3.0	3.4	19.8
Trembling aspen	78.5	64.5	2.3	64.9	66.9	7.1
Hybrid white spruce	2.2	2.0	0.0	0.3	0.3	3.0
Lodgepole pine	3.0	2.0	0.0	4.0	4.0	21.3
Black Cottonwood	0.0	0.2	0.0	0.0	0.0	0.0
Aspen Nests (60-225 m from nest)	(1132)	(1346)	(148)	(394)	(931)	(837)
Ponderosa pine	11.1	29.7	54.7	59.7	49.3	34.4
Douglas-fir	55.5	48.0	40.5	6.6	22.2	42.2
Trembling aspen	25.8	13.8	0.0	16.7	18.8	0.7
Hybrid white spruce	3.3	3.8	3.4	0.5	1.9	1.2
Lodgepole pine	4.3	4.9	1.3	16.5	7.7	21.5
Coniferous Nests (0-225 m from nest)	(420)	(709)	(108)	(371)	(238)	(289)
Ponderosa pine	26.2	39.3	48.2	92.5	67.2	65.7
Douglas-fir	73.1	60.1	49.1	6.8	31.1	34.3
Trembling aspen	0.5	0.4	0.0	0.0	0.4	0.0
Hybrid white spruce	0.0	0.1	2.8	0.0	1.3	0.0
Lodgepole pine	0.3	0.0	0.0	0.8	0.0	0.0

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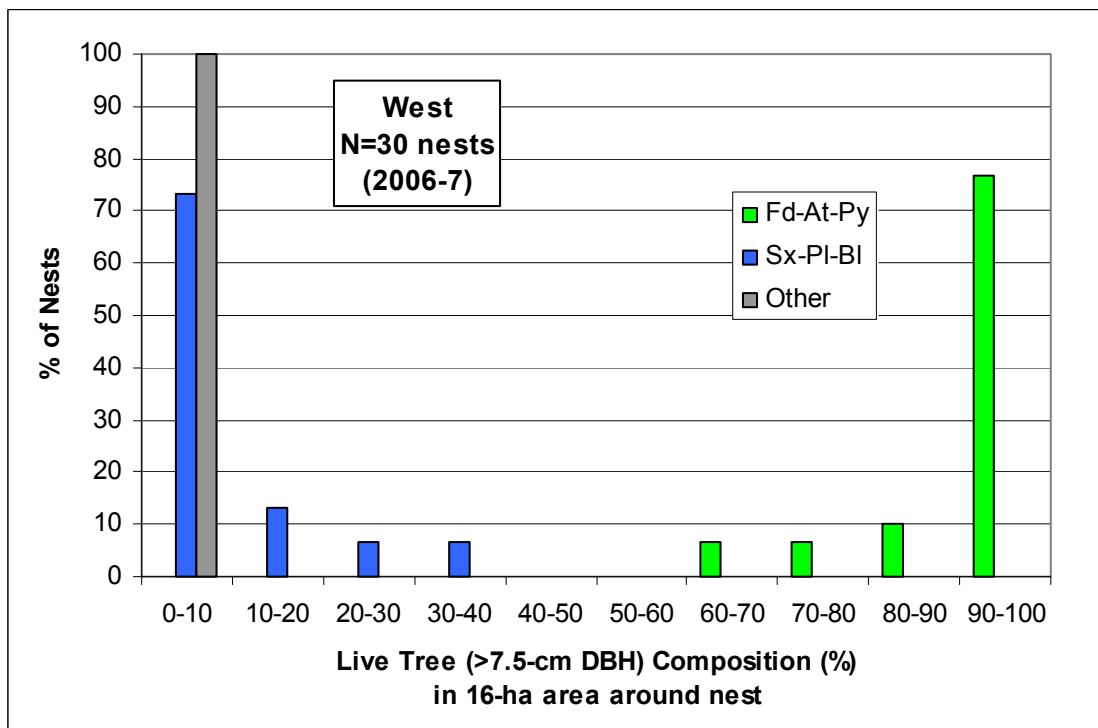


Figure 2. Tree species composition within 225 m of Williamson's Sapsucker nest trees west of Okanagan Lake, 2006-7.

Nest Attributes

- They will often reuse the same tree, and may either reuse the same nest hole or excavate a new nest hole each year (Dobbs et al. 1997).
- WISA are relatively weak excavators (Schepps et al. 1999). 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 20 nest holes found in a single At (Gyug, unpublished data) but up to 109 nest holes have been found in one Lw in the Boundary (although not all those nest holes were WISA holes, and some may have been blind holes where excavations were started and not finished).
- Age of At nest trees west of Okanagan Lake was in the 90-130 year range (n=4, Gyug et al. 2009a)
- The most commonly used nest trees west of Okanagan Lake were (n = 73 nests; Gyug et al. 2009a):
 1. large live At (mean DBH 33 cm) 58%
 2. large dead At (mean DBH 33 cm) 19%
 3. very large dead conifers (Py, Fd) (mean DBH 67 cm) 14%
 4. very large live conifers (Py, Fd) (mean DBH 85 cm) 10%

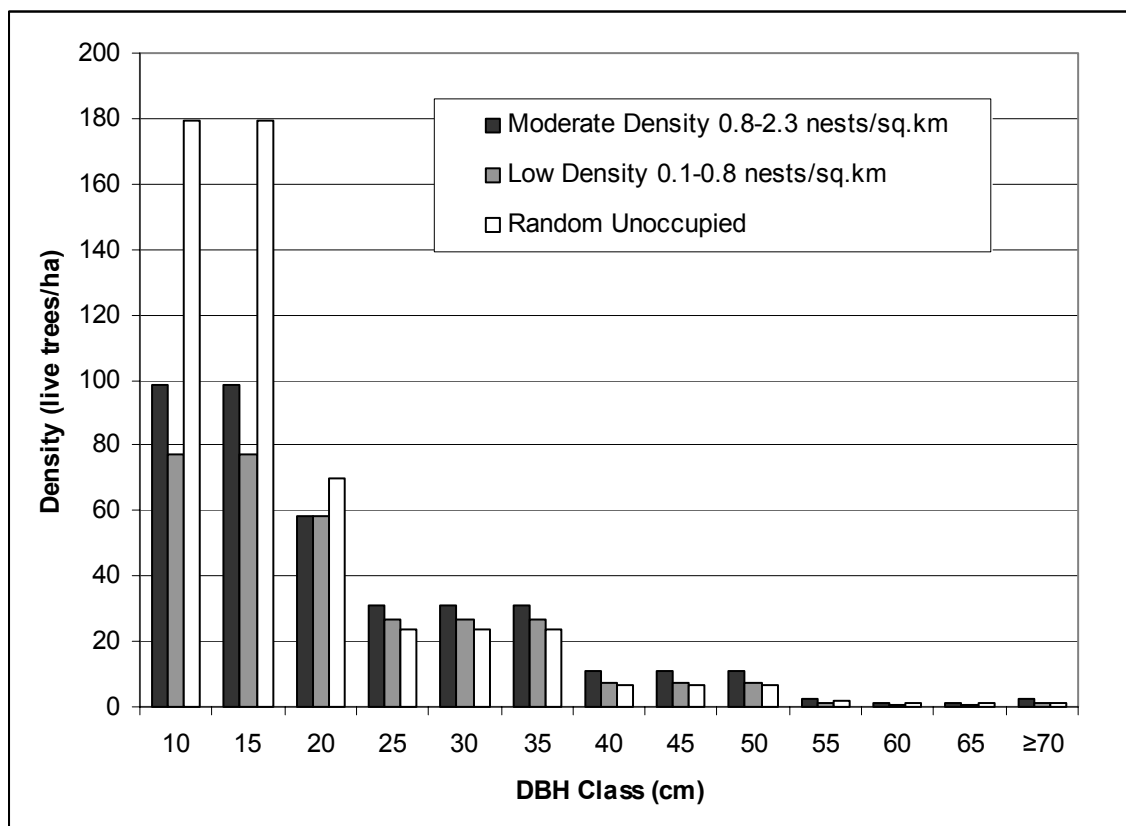


Figure 3. Mean stand structure of live standing trees within 225-m of Williamson's Sapsucker nest sites by nest density class, and of random unoccupied sites within the Area of Occupancy west of Okanagan Lake.

FORAGING

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 were identified as either carpenter ants (*Camponotus* spp.) or wood ants (*Formica* spp.) (Crockett 1975). This predominance of ants in the nestling diet has been confirmed in B.C. 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 2011).

Conifers used for sapwells are small to medium (10-50 cm dbh) Fd, Lw, Py or other conifers. Medium-sized Douglas-firs appear to be the primary (77%) sap trees west of Okanagan Lake in B.C. (Gyug et al. 2009b). Other sap trees infrequently used west of Okanagan Lake were Pl and Py. 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: Reliable radio-telemetry data is available for only one individual breeding male WISA. His breeding range size was 54 ha in a cutover (low suitability) western larch habitat (Manning and Cooper 1996). Based only on visual observations, breeding home ranges in Py/At habitats in Colorado and Arizona have been estimated as much smaller (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). In open habitats in B.C. where visibility was good (i.e. generally low suitability habitats), we have frequently observed WISA foraging at distances of 300-500 m from nests, indicating that in these areas breeding home ranges would be much larger than 4-11 ha (Gyug, personal observations). Breeding territory size may vary significantly with habitat quality, but information would be required from radio-telemetry studies to confirm this.

Densities in Canada range from 0 to 3.1 breeding pairs per 100 ha only using census areas of 100 ha or greater (Gyug, unpublished data). Given the relatively large possible breeding home ranges (i.e. 54 ha) breeding densities reported for smaller census areas may be overestimates as partial breeding territories may be reported. Densities for large areas reported in the U.S. are similar (see COSEWIC 2005) but with only one density higher than reported in Canada at 4.8 nests/100 ha in San Juan National Forest (Py forest with nests in At patches). Based on the presence of clusters of WISA nests, or observations of other WISA near known breeding sites, we were able to estimate approximate breeding densities on the 4-class scale (High, Moderate or Low) to all WISA breeding locations made during the inventories conducted from 1996-2008.

Table 6. Habitat capability and suitability using the 6-Class Rating Scheme 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	0.0 - 0.2
0%	Nil	6	N	0

Ratings

This model employs the 6-Class rating scheme (Table 6) recommended in the RISC standards manual (RISC 1998). For PEM ratings, all codes have been retained, and Nil suitability habitats are not necessarily a true Nil, i.e. may be <1% of benchmark habitats. For other modeling solely from VRI or FC attributes, the Moderately High (2) and the Moderate (3) have been grouped, and the Nil category has been defined as a true Nil, i.e., permanently non-treed habitats that would be impossible for WISA to colonize.

The WISA model profiles breeding (B) and foraging (F) habitats. WISA is a central-place forager when they are feeding the young at the nest so breeding and foraging habitats must occur within close proximity, usually within 500 m (Manning and Cooper 1996). These have been modeled together as the living (LI) life requisite. Breeding (nesting) occurs during the spring and foraging can extend from April to September, therefore living is modeled for the growing season.

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 km² east of Okanagan Falls (Gyug et al. 2007).

Ecosection: South Okanagan 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.

Benchmark Habitat Description:

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%). Tree DBH-class distribution histograms of benchmark habitat can be found in the Okanagan and Boundary WISA species accounts.

HABITAT MODELING

Regional Habitat Values

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

East of Okanagan Lake: NOH, SOB, SOH = H (Provincial Benchmarks)

EKT, MCR, STU, NIB = M

OKR, NOB, NOH (West), SOB (West), HOR, GUU, THB, SHB, SFH = L

Density estimates have been made for 5 sites west of Okanagan Lake that were selected as some of the highest density habitats known in that region (Gyug 2007). Breeding densities were between 0.8 and 1.4 pairs per km² indicating these were all of Moderate density class (25-50% of the benchmark). No High suitability habitat could be found in the Merritt TSA, so the maximum suitability possible in any of the ecosections west of Okanagan Lake was Moderate.

Regional habitat values were applied when an area larger than the AO was being mapped. The AO boundary was based on a relative density boundary (>1% detections on CPB inside, <1% outside) so that where suitability mapping was only considered within the AO, regional habitat values were not applied and any Ecosections and BEC Variants found within the AO would be considered of equal potential suitability.

Table 7. Areas of suitable Williamson's Sapsucker habitat from 2006 Predictive Ecosystem Mapping, the revised 2010 PEM, and the preliminary model based on Forest Cover/VRI attributes, and the numbers of nests and nest trees in each suitability class in the Merritt TSA. Areas in hectares.

Model		Habitat Suitability				Total
		Moderate	Low	Very Low	Nil	
PEM (2006)	Area (ha)	2719	2019	35352	34155	74246
	% of AO	3.7	2.7	47.6	46.0	100.0
	Nest Trees (n)	5	3	26	39	73
Revised PEM (2010)	IDF + PP Area (ha)	62049	96397	164971	240658	564076
	IDF + PP (%)	11.0	17.1	29.2	42.7	100.0
	AO Area (ha)	19370	19414	12413	17097	73784
	% of AO	33.7	26.3	16.8	23.2	100.0
	1994-2007 Nest Trees (n)	28	17	1	3	49
	2008-2009 Nest Trees (n)	13	7	2	2	24
Preliminary Nest VRI Attribute Model (Jan 2010)	IDF + PP Area (ha)	14151	23225	413254	106037	556667
	IDF + PP (%)	2.5	4.2	74.2	19.0	100.0
	AO Area	5636	6030	54504	8077	74247
	% of AO	7.6	8.1	73.4	10.9	100.0
	1994-2007 Nest Trees (n)	21	13	15	0	49
	2008-2009 Nest Trees (n)	5	6	13	0	24
Final VRI Attribute Model (Mar 2010)	IDF + PP Area (ha)	15293	31268	403452	106652	556665
	(Merritt TSA) %	2.7	5.6	72.5	19.2	100.0
	AO only – Area (ha)	6326	22543	38162	7218	74250
	% of AO	8.5	30.4	51.4	9.7	100.0
	1994-2007 Nest Trees (n)	19	27	3	0	49
	2008-2009 Nest Trees (n)	6	15	3	0	24

Evaluation of 2006 Habitat Models

Habitat modeling for the Merritt TSA using PEM without ratings adjustments had already been undertaken in 2006 using all data collected up to that point (Gyug 2006). The extensive data collected in 2007 and 2008 allowed us to evaluate the reliability of that model (Tables 7 and 8).

Evaluation of the models showed that the PEM model (2006) was very inefficient at predicting locations of nests, correctly classifying only 12% of nests found after 2006 (Tables 7 and 8). The PEM modeling (2006) was clearly too inaccurate to use for conservation purposes as it identified very few of the pre-existing nest locations (9%), and very few of the new nest locations (12%).

Therefore the ratings table was examined to determine if the model could be calibrated to make it more reliable. For model calibration, only data collected up to 2007 was considered so that data collected in 2008, particularly the random plots, could be reserved for model testing.

Table 8. Percentage of correctly classified locations based on presence/absence for PEM (2006), and the revised PEM (2010). 2006 models tested only using data collected 2007-2009. PEM (2010) calibrated using data 1994-2007 from which it was developed, and tested using data collected in 2008 and 2009. Sample size for each testing set is in ellipses.

Habitat Model	Moderate + Low Suitability		Presence ¹				Absence ¹	
	Area (ha)	% of AO	Nest Trees	Other Territories ²	Other Obsn	Random Occupied Point ³	Random Unoccupied Point ³	Unoccupied CPB point
PEM (2006)	4738	6	(32)	(35)	(34)			(431)
Model Data (1994-2006)			9%	31%	18%			94%
			(26)	(17)	(80)	(15)	(35)	(20)
Tested (2007-2009)			12%	41%	28%	13% (60%)	100% (80%)	100%
PEM (revised 2010)	38784	60	(49)	(24)	(59)			(428)
Model Data (1994-2007)			92%	100%	69%			42%
			(24)	(8)	(26)	(15)	(35)	
Tested (2008-2009)			83%	88%	77%	80% (100%)	34% (3%)	
Preliminary Nest VRI Attribute Model (Jan 2010)	11666	16	(49)	(30)	(57)			(431)
Model Data (1994-2007)			69%	63%	32%			83%
			(24)	(8)	(26)	(15)	(35)	
Tested (2008-2009)			46%	50%	35%	13% (60%)	91% (46%)	
Final Nest VRI Attribute Model (Feb 2010) with GIS and aerial photo adjustments	28869	39	(49)	(30)	(56)			(431)
Model Data (1994-2007)			94%	100%	75%			57%
			(24)	(8)	(26)	(15)	(35)	
Tested (2008-2009)			88%	100%	85%	40% (100%) (87%)	63% (14%) (34%)	

¹ Presence was considered correctly classified if observations were in Moderate or Low Suitability polygons, and Absence correctly classified if unoccupied random and call-playback (CPB) points were in Very Low or Nil polygons.

² Other territories were considered correctly classified if any of the observations were in Moderate or Low suitability polygons since the nest locations (if there were any) were not known.

³ For Random Points the first percentage is for the precise random point. The first percentage in ellipses represents the maximum suitability rating within the 225-m radius, and the second percentage in ellipses is the area-weighted average suitability within the 225-m radius (which was only calculated for the final model). The precise locations of any WISA detected at random points were recorded in one of the preceding three columns of observations.

Ratings Assumptions - Revised 2010 PEM Model

The ratings from these assumptions are included in the multiplicative ratings table (Table 9), which has been simplified from the 2006 Merritt PEM (Gyug 2006), and modified such that the product of multiplying the ratings did not result in overly low estimates.

1. High densities did not occur in any site west of Okanagan Lake, and benchmark (western larch) habitats also did not occur west of Okanagan Lake. Therefore the maximum density/suitability possible west of Okanagan Lake is Moderate or Moderately High.
2. Ecosections are an important factor in ratings and are to be included in the ratings (see Table 3) as they were left out in 2006 because the number of possible combinations exceeded 64,000 and therefore could not be run using the ratings table populating tools.
3. Only the IDF and PP will be rated in the Merritt TSA because WISA have not been found in any other BEC zones in the Merritt TSA (Table 4) so all BEC zones will be rated Nil. Grassland phases will be rated at about 1/3 of the non-grassland phases.
4. Ecosites drier than mesic will be rated lower than both mesic and wetter ecosites because these are poorer growing sites for the sizes of trees required for nesting.
5. Structural stages will be used as a simple approximation of snag densities because this has been related to both WISA-nesting and ant-nesting tree abundance with stages 6 and 7 highest, and 5 lower
6. Structural Stage is probably the weakest link in this model. Analysis of locations of 41 nest trees known 1994-2007 (and only considering each nesting territory once, even if used in additional years in the same or a different tree) yielded 20% in SS2, 27% in SS3, 5% in SS5, and 49% in SS6. Clearly these birds are nesting in habitats that are treed, and are not truly SS2 or SS3, so SS is an oversimplification for the purposes of WISA-habitat modeling. However, for the purposes of this stage of the model, SS 2/3 will be modeled as per the mapped SS frequencies, i.e. at half the suitability of SS6.
7. 95% of ecosites occupied by WISA 1994-2007 were in single ecosite polygons (40 of 42 nests), and in the only complex ecosite polygons were nesting in the leading ecosite (YM). Overall, 81% were in mesic potentially-forested sites: 64% were in ZM (coniferous mesic), 14% in YM (aspen mesic), and 2% in ZF (Douglas-fir mesic). 10% were in ZS (coniferous moist), and 10% in GR (grasslands) As for the SS, the nests in GR were not in true grasslands, but were in semi-forested ecosites or cleared areas and were commuting on foraging trips to forests. However, for the purposes of this modeling, these ecosites will be rated at these frequencies. Within the IDF and PP, 52% of the area was ZM, 18% ZF, 13% GR, 1% YM and 6% ZS/ZH. Therefore, YM appeared to be highly preferred, ZM, ZS/ZH, GR used approximately as available, and ZF underutilized.
8. North/cold steep (>25%) slopes will be rated lower than all other slopes and aspects as there were none of the 41 nests known 1994-2007 on steep north slopes, but they did occur on other slopes and aspects, although never above 45%, and only rarely (1/41) on slopes 26-45%.
9. While Broad-leaved, Coniferous or Mixed stand type may be an important factor, the aspen trees used for nesting tend to be rarely mapped (82% of nest sites were mapped as Coniferous), so that this factor is of limited usefulness. As it is partially already mapped in the YM ecosite component, this factor will not be used.
10. Polygons will be rated for highest suitability rating combination in the polygon, not the average rating.
11. The ratings will be adjusted for elevation with maximum ratings only between 800 and 1200 m and two step lower ratings from 600-800 and 1200-1400 m, and <600 m or >1400 m rated Nil (Tables 1 and 2) based on the location of the center of each polygon.

Table 9. Resource Ratings Modeling (RRM) factors and levels used to populate the ratings tables for the Merritt Predictive Ecosystem Mapping (PEM) for Williamson's Sapsuckers, January 2010. Simple products of all factors are converted to 6-class ratings.

ECO_SEC	B-WISA	BGC_ZONE	BGC_SUBZONE	BGC_VRT	BGC_PHASE	B-WISA	SITEMC_S	B-WISA	Description	SITE_MA	B-WISA	SITE_MB	B-WISA	STRCT_S	B-WISA
GUU	0.5	IDF	dk	1		0.50	CB	0	Cutbank,		1	1	1	0	0.0
HOR	0.5	IDF	dk	1	a	0.16	CF	0	Cultivated Field	a	1	2	1	1	0.0
NIB	1	IDF	dk	2		0.16	GB	0	Gravel Bar	c	0.2	3	0.5	2	0.5
OKR	0.1	IDF	xh	1		0.75	GP	0	Gravel Pit	h	1	4	0.1	3	0.5
PAR	0.1	IDF	xh	1	a	0.25	GR	0.5	Grassland	k	1	5	0	4	0.1
STU	1	IDF	xh	2		0.40	GS	0	Grass-Sedge Mesic	w	1			5	0.5
THB	0.5	IDF	xh	2	a	0.16	LA	0	Lake					6	1.0
		PP	xh	1		0.38	NA	0						7	1.0
		PP	xh	2		0.75	RI	0	River						
		PP	xh	2	a	0.25	RO	0	Rock Outcrop						
							TA	0	Talus						
							UR	0	Urban						
							WL	0	Wetland						
							YD	0.1	Dry Aspen forest						
							YM	1	Mesic Aspen forest						
							YS	1	Subhygric (moist) Aspen forest						
							ZD	0.1	Dry forest						
							ZF	0.1	Fd forest						
							ZH	0.8	Hygric (wet) forest						
							ZM	0.8	Mesic forest						
							ZS	0.8	Subhygric (moist) forest						

SITE_MA was used for aspect: blank for no aspect (slope class <3), a = variable, c = cold (north), h = hot (south), k = cool, (east) and w = warm (west).

SITE_MB was used for slope class: 1 = 0-10%, 2 = 11-25%, 3 = 26-45%, 4 = 46-70%, 5 = >70%.

Reliability of Revised 2010 PEM Model

While examining classification errors, it was found that 21,536 ha of the IDF and PP in the Merritt TSA (3.8%) had no structural stages mapped. While 6462 ha of these could realistically be mapped as SS0 (Rock, Rivers, Lakes, etc), 15074 ha included potentially forested ecosites. Therefore using this particular PEM product (which dated to 2002) will never allow for a perfect fit of any data or model applied.

WISA Nests and Observations

The 2010 PEM habitat suitability model was applied to the Merritt TSA PEM (Fig. 4). The 2010 PEM model was much more successful at classifying WISA locations than the 2006 PEM. The 2010 PEM had 92-100% success at classifying the data upon which the model was based, and 77-88% success at classifying data in 2008-2009 that was reserved for model testing (Tables 7 and 8).

The model was only moderately successful at correctly classifying nests into density classes. The model was quite successful at correctly classifying nests known to occur in moderate densities (1994-2007, n = 20, 75% correctly classified; 2008-2009, n = 7, 86% correctly classified) with none of those nests classified as VL or N suitability. The model was less successful for nests known to occur at low densities (1994-2007, n = 29, 45% classified as M, 41% correctly classified, and 14% classified as VL or N; 2008-2009, n = 18, 39% classified as M, 39% correctly classified, and 22% classified as VL or N). Therefore for low density nests, the model was optimistic for 39-45% of nests, and incorrectly classified 14-22% as unsuitable.

CPB locations

There were about 40,000 ha of Moderately suitable habitat outside the AO as mapped by the 2010 PEM but no WISA were detected on 1638 CPB outside the AO including 195 CPB in what the PEM mapped as Moderately suitable habitat, and 374 of which were in Low suitability habitat. Clearly the model applies best inside the AO because that was the source of the data from which it was developed, and care must be taken when extrapolating outside the AO.

The 2010 model increased the Moderate and Low suitability habitat from about 30% to about 60% of the AO. The cost of increasing the correct classification of WISA locations was an increase in errors of classifying unoccupied sites, which were only 34-43% successful. Annual occupancy rates for 2006-2007 and 2007-2008 were slightly lower (56%) for the western region compared to the Okanagan-Boundary (70%) (Gyug, unpublished data). On the long term, only 50% of known territories are likely to be unoccupied in any given year (Gyug et al. 2007), so that misclassification of unoccupied sites should not be the criterion for judging success of a Williamson's Sapsucker habitat suitability model.

Inside the AO, CPB response rate decreased with decreasing habitat suitability with 18 per 100 CPB detected in Moderate habitats, 16 in Low, and 11 in Very Low or Nil. For those CPB points in VL or N habitat, the WISA were actually detected in nearby Moderate or Low habitat 57% of the time (20 of 35 locations). The location of the CPB point itself is not a reliable location to use to evaluate a habitat model as the birds may be responding from much different habitats, or be drawn into the CPB point before being noticed (as found for Pileated Woodpecker habitat models by Psyllakis and Gillingham 2004).

CPB points used for this model development within the AO were the result of a number of projects with differing aims and objectives, and therefore, with some exceptions, were not randomly placed, nor in any regular or stratified pattern. Therefore the possibility of bias in the points exists, however any effects of bias are believed to be relatively low because of the large proportion (25%) of the AO sampled, and because once sampling was initiated on a road, points at regular 400-m intervals included all habitats, not just those thought to be relatively suitable.

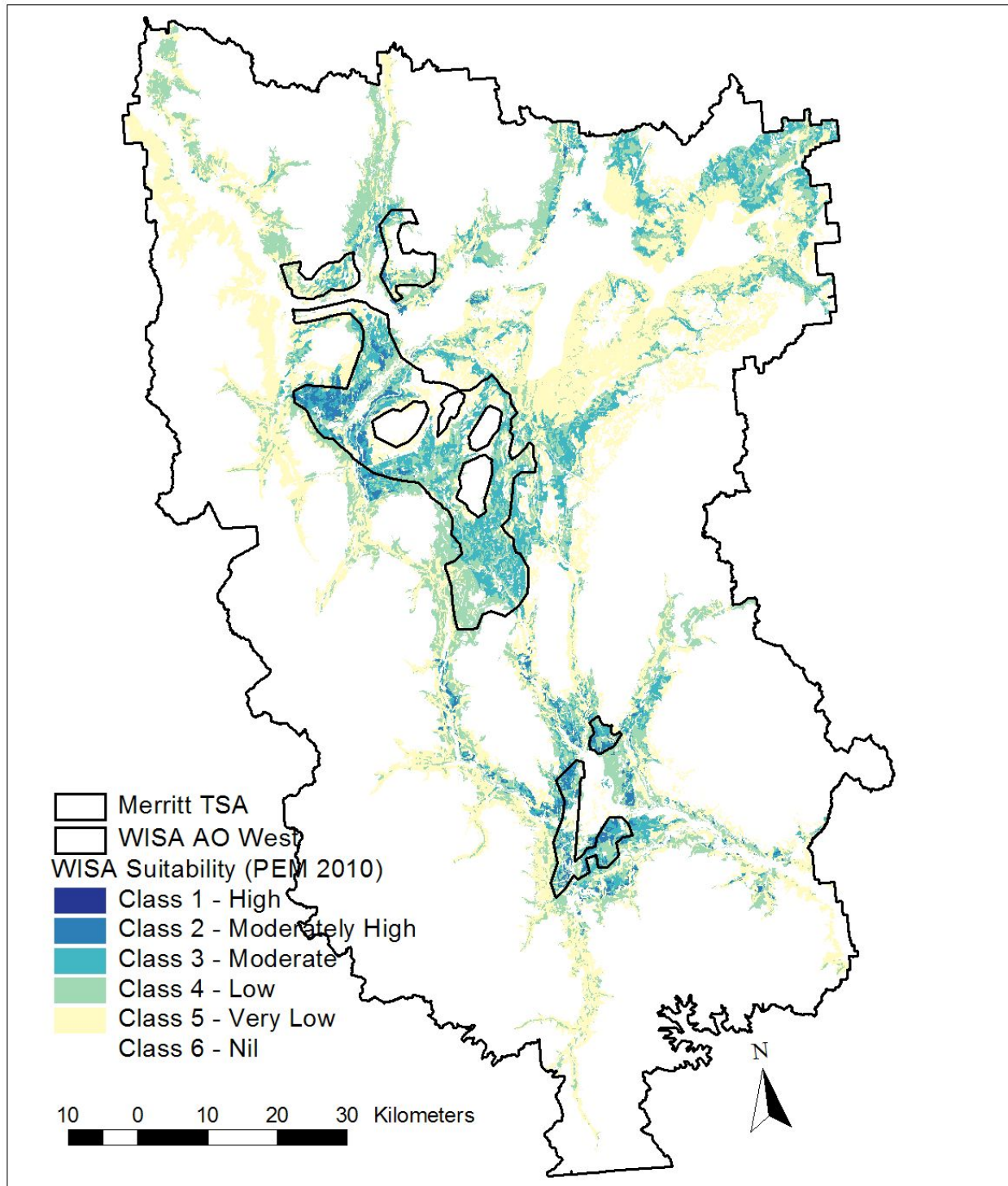


Figure 4. Revised 2010 Predictive Ecosystem Mapping (PEM) of Williamson's Sapsucker suitability in the Merritt TSA.

HABITAT MODELING using FC/VRI attributes

The reliability of the 2010 version of the PEM model was 80-90% successful at predicting locations of Williamson's Sapsucker, but achieved this by including a relatively percentage of the total available area (60%). In particular, incorporation of detailed forest cover attributes may allow for more reliable models. These may have been incorporated either as ratings adjustments to the PEM model, or may be based on a model developed separately. A separate model was chosen based on certain features in common with the PEM mapping combined with forest attributes from the Forest Inventory Planning (FIP) database. The database used for this assessment was a Forest Cover shapefile set and associated FIP attributes from 1999 because the data collected for this model spanned a number of years from 1994-2007. Therefore any use of ages in the model implies that these are a lower limit, and many nests were actually nesting in stands that were up to 8 years older than the 1999 projected age.

The modeling was based on assessment of the data and development of a model using the environmental envelope method to encompass known data (Guisan and Zimmermann 2000).

As for the PEM modeling, nest data up to the end of 2007 (n = 53) were used for model development. The 1994-2007 nest data, other observation data and call playback data had already been used to develop the wider-scale habitat associations at the BEC variant, elevation and slope/aspect level. Data used for model validation/calibration/testing of reliability from 2008-2009 included 25 newly discovered nests in 2008 and 2009, 8 other territories, 26 other observations and the 2008 random plot data (Gyug 2008).

Variables available for modeling at this stage included Ecosection, and BEC variant and phase from provincial-level GIS layers, elevation, slope and aspect from the TRIM Digital Elevation Model, and VRI attributes including non-forest stand descriptor, projected stand age, projected stand height, site index, crown closure, and species composition for each layer. Only up to two layers (not including "silvicultural" layers recently planted) were found in any given polygon.

Nest trees (nests were counted only once, even if used in multiple years) were clearly associated with two stand types: old (>180 yr) coniferous stands with veteran trees, and old (>58 yr) aspen stands, or a combination of both (Table 9). No site where conifers were used for nesting lacked Py, and only 2 lacked Fd. Eight nest trees were in At or Py in what was mapped as Open Range or non-treed clearcut, and consequently had no trees in the VRI attributes, even though trees were present and could be seen on aerial photos.

Table 9. Ranges of VRI stand attributes at 53 nest trees west of Okanagan Lake, 1994-2007. Nest trees were only counted once, even if used in multiple years.

Stand Layers	N nests	Ranges				Tree Species	Comments
		Stand Age (yr projected to 1999)	Ht	CC	SI (L1)		
Py/Fd nest trees							
1 layer	1	OR					Unmapped At-Py visible on photos 115 m from 88y forest stand Vets present but not mapped (59y) At present and mapped (99y) Remnant Py snag-not mapped and not correctable (120y)
	3	59, 99, 120	18.2-31.6	40	14.6-20.1	Py-Fd (At-1)	
	2	191, 300 (2)	23.7-30.2	30-40	11.5-13.5		
2 layers	9	V Layer 188-228	28.4-38.4	4-5		Py-Fd	
		L1 78-107	19.1-26.6	30-40	15.3-18.9	Py-Fd (At 1)	
Subtotal	15						
At nest trees							
No layers	7	Mapped as OR	0	0	NA	NA	Unmapped At visible on photos (m) 115, 108, 82, 78, 46, 46, 7 (error)
	1	Clearcut	0	0	16.0	NA	Unmapped At visible on photos 105 m from 280yFd
1 layer	13	58-118	18.0-27.4	10-50	14.1-19.2	At-present (13) Fd present (13) At-leading (7) Py present (8) PI = 30% (1) Py90Fd10 Fd65Py30PI5 (2) Fd90PI10 PI60Fd40	6 of 13 also contain unmapped Py/Fd vets based on plot data
	5	89-140	20.3-26.0	18-50	14.0-20.8		Unmapped At visible on photos
	1	132	31.2	50	18.0	Ac90Fd5S5	Ac mapping error-actually At
	6	188-250	20.9-27.4	20-40	12.3-15.7	Py-Fd-At (3) Py-Fd (3)	Unmapped At visible on photos
2 layers	5	V Layer 228-308	30.2-38.1	1-10		Py-Fd	
		L1 88-99	18.0-19.9	30-70	13.4-16.1	At-Fd-Py (n=4) Py-Fd (n =1)	
Subtotal	38						

Ratings Assumptions – VRI Stand Attribute Model

1. The preliminary habitat suitability model was developed to apply to the entire Merritt TSA, and could be applied to the entire western Extent of Occurrence (EO) of WISA. Two final models were developed. The first could be applied to a very wide regional area (EO), but the second applied only to the WISA Area of Occupancy in the western region. In particular, elevation, slope and aspect were treated differently in the model that only applied to the AO. Table 10 was a modified final model that could be applied to the entire western Extent of Occurrence, but Table 11 was the final model applied only within the AO.
2. Only the IDF and PP zones have any suitability for WISA in the Merritt TSA.
3. This model was derived from nest locations, and will therefore be a nest stand model. It will not be expected to accurately predict all non-nesting observations since WISA will forage in a much wider variety of stands than it will use for nesting, that is, they can, and will, forage in almost any stand that has both trees and ants within a certain proximity of a nest. Any management decisions based on this model must acknowledge that this model only predicts nest stands, and foraging stands will need to be included when stand management prescriptions near nest stands are developed. The relative value/suitability of foraging stands would require unbiased location data and foraging observations from radio-telemetry, but such studies have yet to be done.
4. Application of the attributes from Table 9 should result in 36 of 53 (68%) mapped correctly by the preliminary version of a relatively simple model (Table 10). However, only with aerial photo corrections applied to the final model covering only the AO would another 15 of 53 (28%) be mapped correctly. This final modeling should result in 96% of known nests up to 2007 correctly mapped.
5. Before Tables 10 and 11 were applied NP polygons were treated as follows:
 - a. Lake, Meadow, Alpine, Alpine Forest, Clearing, Cultivated field, Glacier, Ice, Gravel Bar, River, Claybank, Rock, Swamp, Non-productive Brush and Urban assigned Nil,
 - b. Open Range assigned Very Low (VL) (5) but this really only applies to portions within 120 m of forested polygons as per the later adjustments,
 - c. Non-productive forest and non-productive burn were treated as for forested polygons from their stand attributes, or otherwise assigned Very Low (VL) (5).
6. Any forested polygons or potentially forested polygons not otherwise assigned to M or L using Tables 10 or 11 were assigned VL (5).
7. Moderately High (2) and Moderate (3) of the 6-class rating scale have been grouped.
8. 14 of 15 nests in Fd/Py nest trees occurred in sites with Moderate breeding density, therefore the description of Fd/Py nest tree VRI attributes will equal Moderate suitability.
9. 32 of 38 nests in At nest trees occurred in sites with Low breeding density. The exceptions for five of the sites occurred where age >180, which would have been mapped as Moderate suitability.
10. In the final model, an additional value for Low density/suitability habitats where veteran Py were present but less abundant than for Moderate suitability habitats was also used (middle column in Table 11).
11. Stand suitability within the IDF and PP zones was estimated first by stand attributes as per Tables 10 and 11 derived from the attributes of nest sites in Table 9, and then other adjustments were made as outlined below.

Table 10. Final Nest Habitat Suitability Model (Feb 2010) for Williamson's Sapsucker west of Okanagan Lake based on VRI attributes and DEM layers applied to wide areas, i.e. entire Merritt TSA.

Input Data	Moderate (M) (2-3) (Py)	Low (L) (4) (Py)	Low (L) (4) (At)
BEC Zone	IDF or PP	IDF or PP	IDF or PP
Oldest Layer Projected Age	≥180 y	≥180 y	≥58 y
Oldest Layer Projected Ht	≥19.0 m	≥18.0 m	≥14.0 m
Site Index	≥11.0	≥10.0	≥11.0
Crown Closure ≥15.0 m ht	≥20%	≥1%	≥15%
Tree Species	Py present	Py present	At present, Fd and/or Py present
PI % composition of Layer 1 or 2	≤30%	≤50%	≤30%
Adjustments based on location of VRI polygon centre:			
Elevation			
Do not reduce one level if:	600-800 m or 1200-1400 m, and M or L (Py) apply and L (At) applies		
Reduce one level if:	600-800 m or 1200-1400 m, and line above does not apply		
Reduce to Nil if:	<600 m or >1400 m		
Slope and Aspect			
Reduce to Nil if:	Slope >45%	Slope >45%	Slope >45%
Do not reduce one level if	Slope >25% and M or L (Py) apply and L (At) applies		
Reduce one level if:	Slope >25% and line above does not apply		
Reduce to VL if:	Slope >25% and aspect = north		
Ecosection:			
Reduce one level but remain above Nil if:	Any ecosection other than STU or NIB		

12. Adjustments made for elevation with maximum ratings only between 800 and 1200 m and one step lower ratings from 600-800 and 1200-1400 m, and <600 m or >1400 m rated Nil (Tables 1 and 2) based on the location of the center of each polygon for TSA-wide modeling.
13. Adjustments were made for broad-scale slope and aspect derived from 1:250,000 NTS scale DEM (90-m grid). For TSA-wide mapping, VRI polygons were assigned the value of the center of the polygon.
 - a. North/cold steep (>25%) slopes were rated Nil as there were none of the 41 nests known 1994-2007 on steep north slopes,
 - b. Slopes >45% rated Nil as there were no nests found on very steep slopes,
 - c. Slopes 26-45% other than north rated one step lower because nests only rarely (1/41) were on slopes 26-45%.
14. For AO-only final modeling elevation, slope and aspect polygons were combined and all polygons <4 ha were dissolved into adjacent polygons. After intersection with the VRI coverage, any polygons <1 ha in size were dissolved into their parent FC polygons. Adjustments were made as per Table 11.
15. Adjustments made for Ecosection only where Ecosections other than NIB and STU were downrated by one level but to remain above Nil. No adjustments were made for BEC variant because equivalent adjustments were already handled by elevation, tree species and Ecosection. For final modeling within the AO only, no adjustment was made for Ecosection.

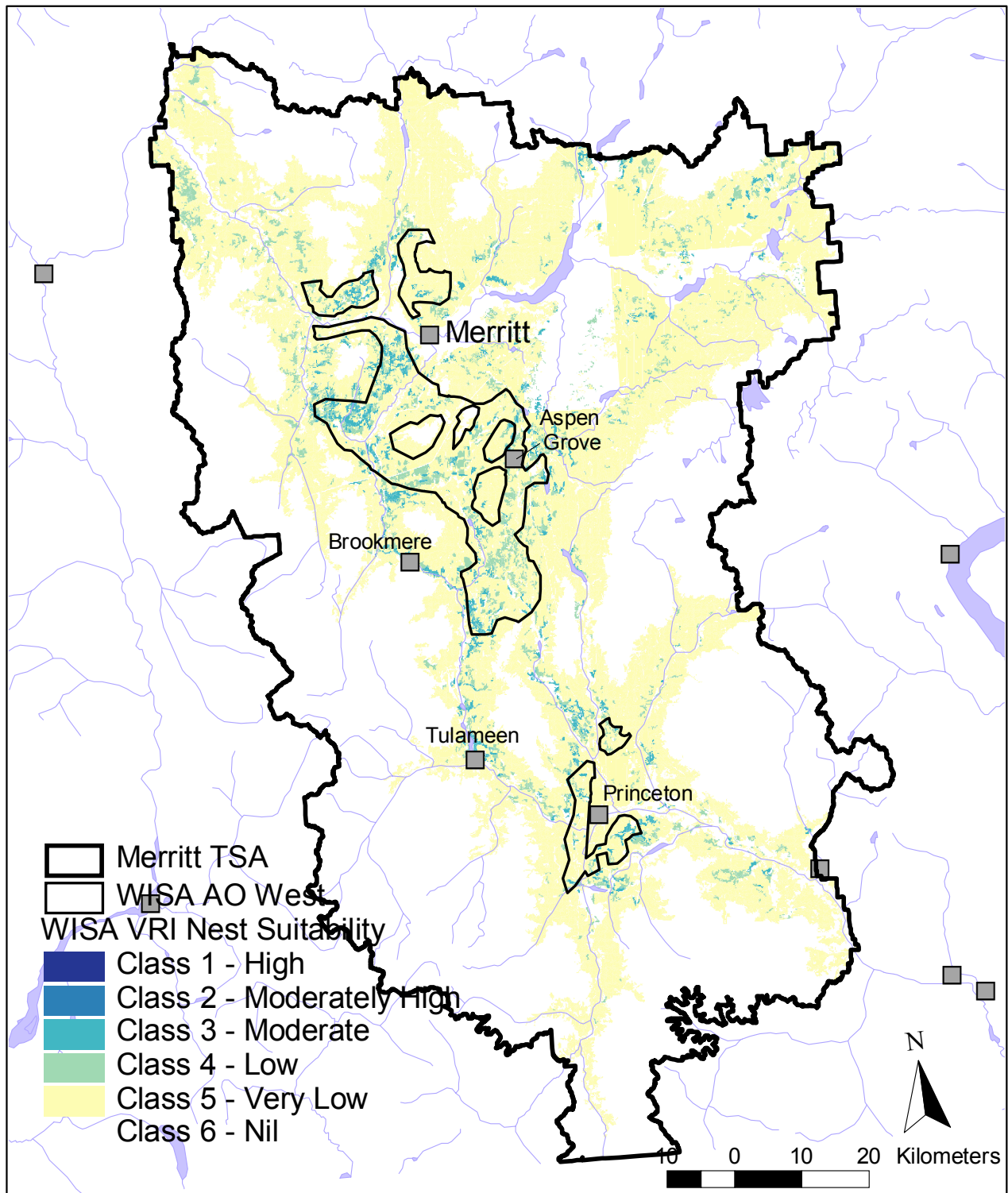


Figure 5. Final (Feb 2010) Williamson's Sapsucker nest habitat suitability model based on VRI attributes west of Okanagan Lake applied to the entire Merritt TSA but without any aerial photo adjustments. There was no suitability higher than Moderate mapped.

Table 11. Final Nest Habitat Suitability Model (Feb 2010) for Williamson's Sapsucker west of Okanagan Lake based on VRI attributes and DEM layers applied only to the Area of Occupancy.

Input Data	Moderate (M) (2-3)	Low (L) (4)	Low (L) (4)
BEC Zone	IDF or PP	IDF or PP	IDF or PP
Oldest Layer Projected Age	≥180	≥180	≥58 years
Oldest Layer Projected Ht	≥19.0	≥18.0	≥14.0
Site Index	≥11.0	≥10.0	≥11.0
Crown Closure ≥15.0 m ht	≥20%	≥1%	≥15%
Tree Species	Py present	Py present	At present, Either Fd and/or Py present, or present in adjacent polygon
PI % composition of Layer 1 or 2	≤30%	≤50%	≤30%
Adjustments:			
Elevation			
Reduce to Low if:	600-800 m 1200-1400 m		
Reduce to Nil if:	<600 m, >1400 m	<600 m, >1400 m	<600 m, >1400 m
Slope and Aspect			
Reduce to Nil if:	Slope >45%	Slope >45%	Slope >45%
Reduce one level if:	Slope >25%		
Reduce to VL if:	Slope >25% and aspect = north	Slope >25% and aspect = north	Slope >25% and aspect = north

Model Calibration/Ratings Adjustments:

The preliminary Nest VRI habitat suitability model (January 2010) was compared to see how well it fit the original 1994-2007 nest data from which it was developed, and fit the data reserved for testing the model (2008-2009). The model only occupied 16% of the western AO, but included 69% of the nests from which it was developed, and a similar amount of other non-nest breeding territories (Tables 7 and 8). Testing the model with the 2008-2009 test data showed it successful at classifying only 46% of nests, and a similar amount of newly discovered non-nest breeding territories.

As previously identified during the model development, the most effective single calibration (potentially as high as 96% correct classifications) to make the model better fit the input data would be to apply corrections to the stand attributes from interpretation of aerial photography—particularly for presence of aspen stands and presence of unmapped very large veteran trees.

Based on the correctable errors listed in Table 9, and examination of the nests from 2008-2009, changes were made to the wide-area EO model (Table 10). These included reducing the height limitations for Low stands from 18 to 14 m, Site Index from 14 to 12.3, crown closure range to 15-60% from 18 to 50%, and At present with either Fd or Py present (not just Fd).

The final Nest VRI habitat suitability model (Feb 2010) without any aerial photo corrections was compared to see how well it fit the original nest data (1994-2007) from which it was developed, and fit the data reserved for testing the model (2008-2009). Applying only GIS adjustments (Table 10), there

was no difference in the number of 1994-2007 nest trees correctly classified, but was a 16% improvement in the 2008-2009 nests classified as Moderate or Low (Table 7). Applying only GIS adjustments, 19.4% of the AO was Moderate or Low suitability habitat, and accounted for 69% of the model nests, and 63% of the nests reserved for testing.

Changes were made to the FC/VRI layer to better model WISA habitat suitability using stereo aerial photo interpretation for the west AO in the Merritt and Princeton areas. These changes included modifying the attribute table if the change applied to the entire polygon, or modifying the linework and then the attribute table if changes were to be applied to only a portion of the polygon.

Corrections made using aerial photo interpretation of veteran trees/crown closure:

1. Upgraded from VL to L if veteran Py visible,
 - a. in forested stands ≥ 88 years old containing Fd or Py but $\leq 30\%$ Pl,
 - b. in potentially forested stands < 150 m from stands ≥ 88 years old, and containing Fd and/or Py, but $\leq 30\%$ Pl,
 - c. in open range within 150 m of forested stands ≥ 88 years old and containing Fd and/or Py, but $\leq 30\%$ Pl,
2. Upgraded from VL to L if mature At patches visible,
 - a. in forested stands ≥ 88 years old containing Fd or Py but $\leq 30\%$ Pl,
 - b. in potentially forested stands < 120 m from stands ≥ 88 years old, and containing Fd and/or Py, but $\leq 30\%$ Pl,
 - c. in open range within 120 m of forested stands ≥ 88 years old and containing Fd and/or Py, but $\leq 30\%$ Pl,

Total area revised by altering attributes—either veteran Py or mature At—was about 6700 ha or about 9% of the total AO. Area revised by splitting polygons, mainly the treed edges of Open Range, was about 1400 ha, or about 2% of the total AO.

Reliability of Final 2010 VRI Stand Attribute Model

WISA Nests and Observations

Overall this model would be considered very reliable based on the fit to the data from which it was derived (94% of nests), and the fit of the data reserved for testing the model (88% of nests) (Table 8). After application of the GIS and aerial photo adjustments, 39% of the AO was Moderate or Low suitability habitat (Tables 7 and 8, Fig. 6). All other breeding territories where we could not find nests contained at least some of the observations associated with the territory in Moderate or Low suitability habitat (Table 8). Other observations not associated with known breeding territories were most often (75-85%) in Moderate or Low suitability habitat (Table 8).

CPB locations

The majority of CPB points (57%) where WISA were not detected were in Very Low or Nil suitability habitat (Table 8) but the same caveats apply to the use of CPB points to judge model performance as outlined under the PEM model testing. The 225-m radius areas around occupied random points always contained some Moderate or Low suitability habitat, and the average suitability was either Low or Moderate for 87% of the points (Table 8).

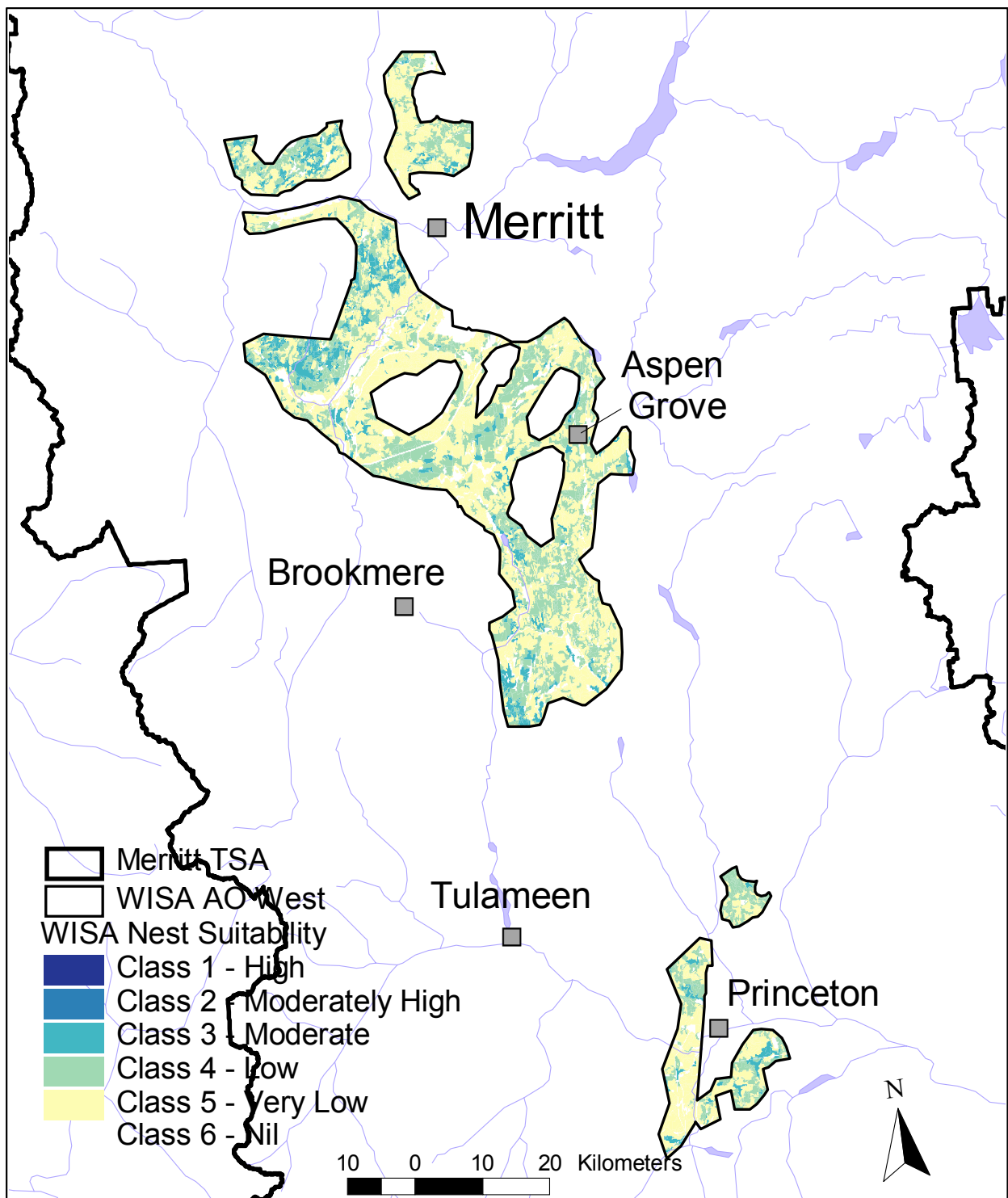


Figure 6. Final (Feb 2010) Williamson's Sapsucker nest habitat suitability model based on VRI attributes west of Okanagan Lake applied to the WISA AO in the Merritt and Princeton areas with aerial photo adjustments. There was no suitability higher than Moderate mapped.

Table 12. Means and standard deviations for habitat plot variables contrasted by local density of Williamson's Sapsucker nests west of Okanagan Lake. Only variables significantly different at $p = 0.05$ are shown. 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. Notable differences shaded in grey.

Variable Name	Nest Density									p
	Moderate			Low			Random-Unoccupied			
	n =16			n =23			n = 28			
	Mean	SD		Mean	SD		Mean	SD		
D_LT_S	221	132	ab	158	90	a	359	277	b	0.002
D_LT_AT	7.7	25.7	a	41.4	52.9	b	6.9	11.5	a	0.001
D_LT_FD	115	64	a	59	45	b	113	82	a	0.010
D_LT_PL	0.0	0.0		9.4	15.6		7.8	12.4		0.053
D_LT_PY	62	45	a	38	38	ab	23	31	b	0.005
D_LT_SPB	0.0	0.0		18	24		21	34		0.039
P_LT_AT	5.0	10.2	a	25.6	23.2	b	11.1	25.9	ab	0.013
P_LT_FD	60	23	ab	41	28	a	61	30	b	0.026
P_LT_PL	0.0	0.0	a	5.2	7.9	b	3.6	5.0	ab	0.023
P_LT_PY	35	21	a	24	20	ab	16	21	b	0.019
P_LT_FAPY	100	0.0	a	90	11	ab	88	16	b	0.010
P_LT_SPB	0.0	0.0	a	9.5	10.7	ab	10.6	15.4	b	0.014
P_LT_VL_FD	39	24	a	48	40	ab	68	35	b	0.019
D_LT_VL_PY	3.0	1.5	a	1.4	2.0	b	1.1	2.1	b	0.006
D_LG_ALL	30.7	14.7	ab	30.8	18.3	a	47.4	29.1	b	0.017
V_LG_MN	17.9	7.5	a	20.6	12.6	a	36.1	23.6	b	0.001

For variable names:

D = Density, P = Percentage; LT = Live Trees, SN = Snags, ST = Stumps, LG = Logs;
S = Small (7.5-17.5-cm dbh), L = Large (17.5-57.5-cm dbh), VL = Very Large (>57.5-cm dbh),

Field Ratings Adjustments:

Adjustments may be made in the field to ascertain actual site suitability. A field key for the areas west of Okanagan Lake has yet to be prepared, and is not part of this project. This field key would be based on a summary of the habitat plot data differences between Moderate and Low density sites, and unoccupied random plots as outlined in Drever et al. (manuscript) and in Table 12.

References

- Bull, E. L., S. R. Peterson and J. W. Thomas. 1986. Resource partitioning among woodpeckers in northeastern Oregon. U.S. Forest Service Research Note PNW-444.
- Campbell, R.W., A.K. Dawe, I. McTaggart-Cowan, J. Cooper, G. Kaiser and M.C. McNall. 1990. Birds of British Columbia: Volume 2, Nonpasserines; Diurnal Birds of Prey through Woodpeckers. Royal British Columbia Museum.
- Cannings, R.A., R.J. Cannings and S.G. Cannings. 1987. Birds of the Okanagan Valley, British Columbia. Royal British Columbia Museum.
- Conway, C.J. and T.E. Martin. 1993. Habitat Suitability for Williamson's Sapsuckers in Mixed-Conifer Forests. *J. Wildl. Manage.* 57(2): 322-328.
- Cooper, J.M. 1995. Status of the Williamson's Sapsucker in British Columbia. Ministry of Environment Lands and Parks, Victoria, B.C.
- COSEWIC. 2005. Status Report on Williamson's Sapsucker, *Sphyrapicus thyroideus*. Committee on the Status of Endangered Wildlife in Canada, Canadian Wildlife Service, Ottawa.
- Crockett, A.B. 1975. Ecology and behavior of the Williamson's Sapsucker in Colorado. Ph.D. dissertation, Univ. of Colorado, Boulder, CO
- Crockett, A.B. and H.H. Hadow. 1975. Nest Site Selection by Williamson and Red-Naped Sapsuckers. *Short Communications. Condor.* 77:365-368.
- Dobbs, R.C., T.E. Martin and C.J. Conway. 1997. Williamson's Sapsucker (*Sphyrapicus thyroideus*). *In* The Birds of North America, No. 285. (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
- Drever, M.C., L.W. Gyug, A.K. Stuart-Smith, I. Ohanjanian, K.T. Fort and K. Martin. Manuscript (2009). Habitat selection by nesting Williamson's Sapsuckers in southern British Columbia.
- Guisan, A. and N.E. Zimmermann. 2000. Predictive habitat distribution models in ecology. *Ecological Modelling* 135:147-186.
- Gyug, L.W. 2006. Species account for species-habitat model: Williamson's Sapsucker (Merritt TSA). Nicola-Similkameen Innovative Forestry Society, Merritt, BC
- Gyug, L.W. 2007. Williamson's Sapsucker, Western Region, 2007. British Columbia Conservation Foundation, Surrey, B.C. and Ecosystems Branch, Ministry of Environment, Victoria, B.C.
- Gyug, L.W. 2008. Williamson's Sapsucker Critical Habitat Phase 1: Random Plot Occupancy in the West and Okanagan-Boundary. Canadian Wildlife Service, Delta, B.C.
- Gyug, L.W. 2009. Final species account for species-habitat model for Williamson's Sapsucker in the Boundary. Report prepared for BC Timber Sales, Kootenay Business Region, Nelson, BC.
- Gyug, L.W., I. Ohanjanian, C. Steeger, I.A. Manley, and P.W. Davidson. 2007. Distribution and density of Williamson's Sapsucker (*Sphyrapicus thyroideus*) in British Columbia, Canada. *British Columbia Birds*: 16:2-15.
- Gyug, L. W., C. Steeger, and I. Ohanjanian. 2009a. Williamson's Sapsucker (*Sphyrapicus thyroideus*) nest tree characteristics and densities in British Columbia. *Canadian Journal of Forest Research* 39:2319-2331.

- Gyug, L. W., C. Steeger, and I. Ohanian. 2009b. Williamson's Sapsucker (*Sphyrapicus thyroideus*) sap trees in British Columbia. *British Columbia Birds* 19: (in press).
- Johnson, N.K. and R.M. Zink. 1983. Speciation in sapsuckers (*Sphyrapicus*): I. Genetic differentiation. *Auk* 100:871-884.
- McClelland, B. R., S. S. Frissell, W. C. Fischer, and C. H. Halvorson. 1979. Habitat management for hole-nesting birds in forests of western larch and Douglas-fir. *Journal of Forestry* 77(8): 480-483.
- McClelland, B. R., and P. T. McClelland. 2000. Red-naped Sapsucker nest trees in northern Rocky Mountain old-growth forest. *Wilson Bulletin* 112: 44-50.
- Manning, E.T. and J.M. Cooper. 1996. Progress Report (Year 1 – 1996). An assessment of woodpecker foraging, home range and patch utilization at Wallace Creek, British Columbia. Prepared for B.C. Ministry of Environment, Penticton, B.C.
- Nielsen-Pincus, N., and E.O. Garton. 2007. Responses of cavity-nesting birds to changes in available habitat reveal underlying determinants of nest selection. *Northwestern Naturalist* 88: 135-146.
- Psykallis, J.M., and M.P. Gillingham. 2007. Considerations for the validation of species-habitat models. Paper presented at the “Monitoring the Effectiveness of Biological Conservation” conference, 2-4 November 2004, Richmond BC. Available at <http://www.forrex.org/events/mebc/papers.html> [Accessed March 11, 2010]
- Resources Inventory Standards Committee (RISC). 1999. BC Wildlife Habitat Ratings Standards Version 2.0. Ministry of Environment, Lands and Parks, Victoria, B.C.
- Schepps, J., Lohr, S., and Martin, T.E. 1999. Does tree hardness influence nest-tree selection by primary cavity nesters? *Auk* 116: 658–665.
- Smith, K.G. 1982. On habitat selection of Williamson's and “Red-naped” yellow-bellied sapsuckers. *Southwest. Nat.* 27: 464-466.