

SPECIES ACCOUNT FOR WILLIAMSON'S SAPSUCKER
NEST HABITAT MODEL
OKANAGAN-BOUNDARY AND WEST REGIONS, BRITISH COLUMBIA

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This account updates the previous habitat modeling of 2009 and 2010 (Gyug 2009, Gyug 2010a, Gyug 2010b) based on 2008 conditions. For the remainder of this document, the previous suitability modeling is referred to as the 2008 version. That habitat modeling was used to delineate Critical Habitat for Williamson's Sapsucker (WISA) (Environment Canada 2014). Since 2008, a considerable amount of the area had been logged or cleared, much of it due to mountain pine beetle outbreaks. In 2014, 25% of the surveyed sites in the West and 5% in the Okanagan-Boundary had undergone habitat changes since the 2008 habitat modeling (Gyug 2014).

The purpose of this project was to bring Williamson's Sapsucker habitat mapping up to date to reflect conditions as of early 2018. This update concentrated on the nest locations and can therefore be viewed as a nesting habitat model. This project does not address the East Kootenay region.

This project was completed by Les Gyug, RPBio, of Okanagan Wildlife Consulting under contract to the Ecosystems Section of the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRO), Kamloops, BC.

Common Name: Williamson's Sapsucker

Scientific Name: *Sphyrapicus thyroideus*

Provincial Species Code: B-WISA

American Ornithological Society 4-letter Code: WISA

Status: Provincial Listing: Blue (B.C. Conservation Data Centre 2018).

Global G5; Provincial S3B for species

COSEWIC Assessment: Endangered (2005, re-confirmed in 2017);

SARA: Schedule 1

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

Project Area:

1. Williamson's Sapsucker (WISA) contiguous Area of Occupancy (AO) on the west side of Okanagan Lake within the Cascade Forest District (742.5 km²; Figure 1).

2. WISA contiguous AO on the east side of Okanagan Lake within the Okanagan-Shuswap and Arrow-Boundary Forest Districts (521.6 km²; Figure 1). This did not include the blocks of the AO north or east of Midway, BC.

Biogeoclimatic Variants (Version 10, 2016): Listed from low elevation to high elevation

1. West: BGxw1, PPxh1, PPxh2, IDFxh1, IDFxh2, IDFdK1, IDFdK2, MSxk2
2. Okanagan-Boundary: IDFxh1, IDFxh4, IDFxh1, IDFdM1, ICHmk1, MSdm1

Project Map Scale: 1:20,000 (accuracy typically ±20 m)

Map Products Used:

- Base Map was Vegetation Resource Inventory (VRI) geodatabase with projected date of January 1, 2016 was downloaded from Data BC (<https://data.gov.bc.ca/>).
 - This mapping was generally one year and in some places two years out of date as of its publication date, i.e., did not contain harvested areas from 2015, and in some cases from 2014.
 - Since 2008, new VRI mapping had only been completed for the Okanagan-Shuswap portion of the Okanagan-Boundary region that was outside of TFL49. Almost all the other mapping outside of harvested areas retained the FC polygon boundaries as originally mapped in the early 1990's that had simply been rolled over into VRI mapping. The exception was TFL 49 which had been completely remapped in the early 2000s.
 - The VRI tree layers were joined to the VRI polygon layer (which contained only the basic polygon information). Each polygon may have up to 9 tree layers. In this project area, polygons had up to 5 layers, one of which was a "dead" layer constructed in 2015 consisting of pine trees (PI or Py) killed during the Mountain Pine Beetle outbreak. Standard FLNRO two-letter tree designations are used throughout this document. Tree layers were separated based on:
 - Rank 1 (R1) layer, the layer with the highest merchantable volume.
 - L1 layer, if there was a layer that was taller and older than the Rank 1 layer, usually consisting of veteran trees, which are very important to interpret WISA nesting suitability. I have termed this the "L1R0" layer to distinguish it from when the L1 layer was also the R1 layer.
 - L2 layer, a subdominant layer with lower volumes, height and age than the R1. This only includes the L2 layer here if the L2 layer was not also the R1 layer.
 - L3 and L4 layers, which in the project area were always <15 m height.
 - Considerable interpretation had to be used to make the VRI useful for WISA habitat modeling, mainly to:
 - incorporate veteran trees that were not included in the attributes of forested stands by using the 2008 habitat model interpretations, and using the 1996-

1998 FC stand ages where these were significantly older than current interpretations, and no timber harvesting had taken place.

- to incorporate leave areas such as Wildlife Tree Patches and riparian reserves within the cutblock boundaries,
 - to incorporate leave trees, both merchantable and understory, that had been retained in harvested areas but where the vegetation attributes had been completely emptied in the VRI of the harvested areas,
 - update any changes in forest cover on private land after the original FC mapping, because VRI updates that incorporated harvesting on crown land, usually did not do any updating on private land,
 - correct cutblock boundaries that had been carelessly inserted into the VRI:
 - particularly ones that had been inserted twice, with parallel boundaries that were up to 40-m offset, and
 - a 1000-ha cut area north of Patchett Road in the Merritt TSA where one-third of the area had not been cut at all, but the entire area had been emptied of forest attributes.
- Prior VRI was available for 2008, which had been used as the base for the 2008 habitat mapping, and Forest Cover (FC, the precursor of VRI) was available for the 1996-1998 period.
 - Cutblock boundaries were used from any of several layers available on Data BC mainly the Consolidated Cutblock layer, and the Forest Tenure Cutblock Polygon layer, which includes approved Cutting Permits, even if not necessarily cut yet.
 - Only one large burn affected the area post-2016 VRI in the Princeton area. The fire boundary was used from the current fire polygon layer from Data BC, and FLNRO provided a fire severity shapefile.
 - DEM layer (20-m point grid) was available for the area but was not used here. The same elevation, slope and aspect polygon layers used in 2008 were also used here.

Imagery Products Used:

- Digital orthophotos (1-m pixel) were available for 1990-1995 (Black and white) and for 2004-2005 (colour) as used in the 2008 habitat mapping.
- Imagery used for this update included 1.5-m pixel SPOT6/7 dating to 2015 or 2016, as well as publicly available (Google Earth and Bing) aerial photos (generally 1-m pixel) of varying dates from 2012 to 2016.
- Landsat 8 (15-m pixel) and Sentinel 2 (10-m pixel) imagery was used to bring the mapping up to date to 2018 using cloud-free imagery from early 2018 of March 13 (West), January 31 (north part of Okanagan), and March 11 (south part of Okanagan and Boundary).

- In 2008, additional stereo aerial photo interpretation was done from paper versions of 1992-2004 colour aerial photos with nominal scales of 1:15,000 to 1:30,000 to verify vegetation attributes, and particularly to identify veteran trees and aspen stands, but this process was not repeated in this update.

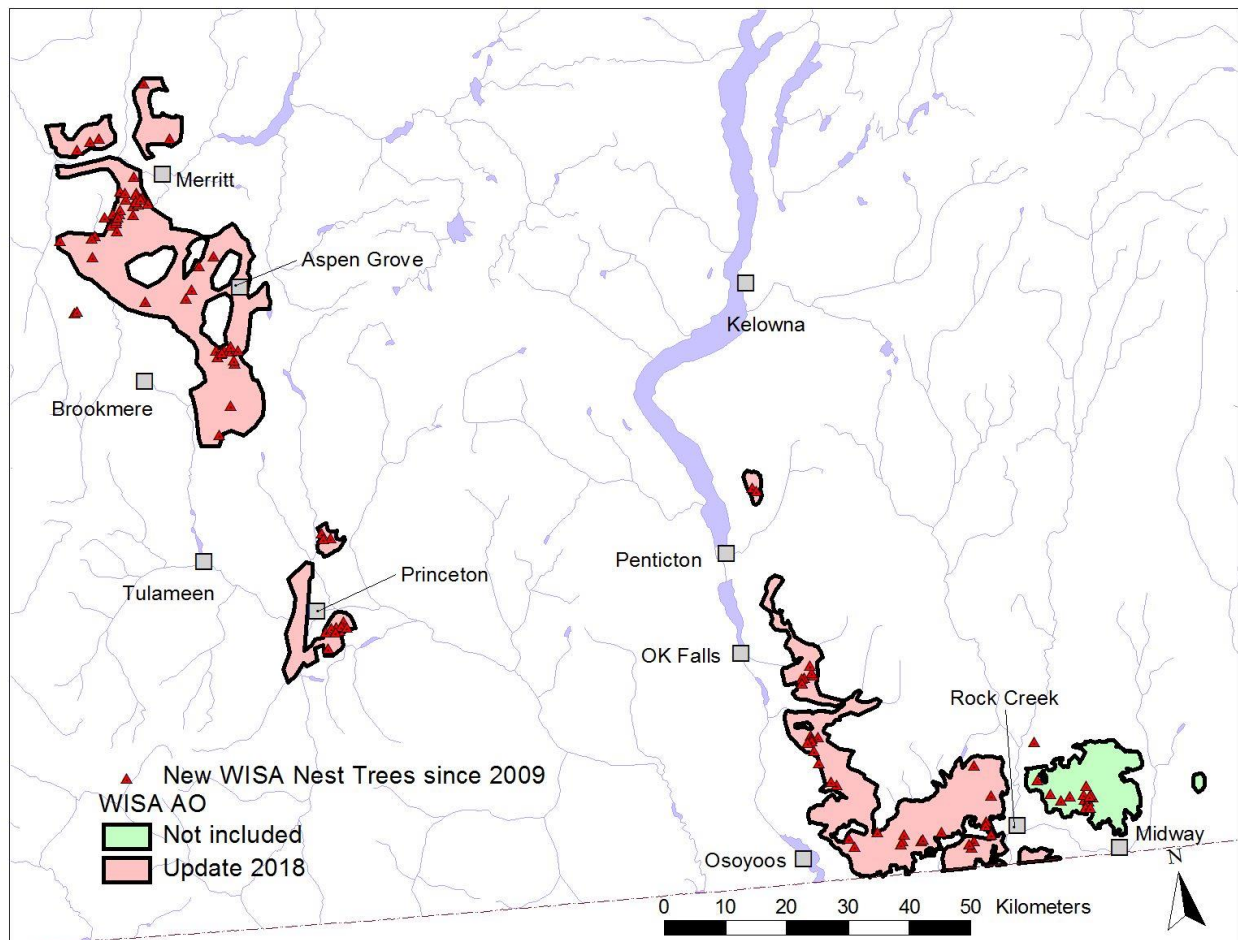


Figure 1. Project Area for 2018 WISA habitat modeling update. New nests found within project area since 2009 (n = 102) shown.

Species Biology Updates since 2008:

TERRITORY SIZES

Prior to 2008, reliable radio-telemetry data was available for only one individual breeding male WISA. His breeding range size was 54 ha in a cutover (low suitability) Lw habitat (Manning and Cooper 1996). In Lw forests, average inter-nest spacing in benchmark habitat was about 450 m (Gyug et al. 2007) from which we had inferred that a 225-m radius around a nest was the most often used habitat in ideal stands. In open habitats in B.C. where visibility was good (i.e., generally low suitability habitats), we had frequently observed WISA foraging at distances of 300-500 m from nests (Gyug, personal observations).

St-Amand (2017) completed a more intensive radio-telemetry project on WISA. He found 95% of re-locations to be within 340 m of the nest in the Okanagan, and within 410 m of the nest in the West. More detailed analyses of this data by habitat suitability class were not available.

FORAGING REQUIREMENTS

New information on foraging requirements published in the M.Sc. thesis of St-Amand (2017) based on a radio-telemetry study of WISA were not incorporated into this model. The 2008 modeling did include distance of nests to assumed foraging habitat using a very simple definition of foraging habitat i.e., either adjacent to or within 120 m of forests with Fd or Py present, >87 years old, and <30% PI, and had included several adjustments for adjacency to forests of 200 m in the Okanagan-Boundary. These simple definitions were based on observed locations of nests in very open habitats that clearly could not meet the full breeding season foraging. In 2008, the distance to forests of all nests in very open habitats were determined and those distances incorporated into the modeling.

However, the relatively simple 2008 assumptions of what constituted foraging habitat could not be tested or redefined based on the results as presented within St-Amand (2017). St-Amand (2017) did not analyze WISA foraging in relation to the full suite of VRI attributes used in this habitat modeling. The spatial data of St-Amand (2017) for this project. Therefore, the distance to assumed foraging habitat was not included as a factor in the 2018 nest habitat model whereas it had been at least partially included in 2008. Incorporation of foraging habitat into this nest habitat model remains to be done.

Ratings

This model employs the 6-Class rating scheme (Table 1) recommended in the RISC standards manual (RISC 1999). For other modeling in the West, possible Moderately High (2) areas have been grouped with the Moderate (3) as they could not be reliably separated. Nil habitats have been defined as permanently non-treed habitats that would be impossible for WISA to colonize.

The WISA model profiles only nesting 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 as previously outlined. Breeding (nesting) occurs during the spring (usually April – early July) but WISA can be present on sites from March to September, with observed earliest date being February 28, and latest date October 21.

Table 1. 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	1.6 - 2.3
26-50%	Moderate	3	M	0.8 - 1.6
6-25%	Low	4	L	0.2 - 0.8
1-5%	Very Low	5	VL	0.0 - 0.2
0%	Nil / Unsuitable	6	N	0

Provincial Benchmark

Density of 3.1 active nests/breeding pairs per km² east of Okanagan Falls (Gyug et al. 2007).

Ecoregion: 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:

The forest stands at three sites (Okanagan Falls, Lehman Springs and Naramata) 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 variable depending on local conditions and extent of Douglas-fir ingrowth since the most recent low-intensity fires. 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 were in Gyug (2009) and Gyug (2010a).

Table 2. Percentage of nest trees found (counting each nest tree only once, even if used in multiple years), used to develop the 2008 nest habitat models, and those nests discovered after 2009 used to test reliability of nest habitat models, compared to fit after 2018 model update.

Nest Habitat Suitability	Percentage of Nests within each suitability class					
	Prior to 2010		After 2009 within project area		After 2018 Model Update	
	West	Okanagan-Boundary	West	Okanagan-Boundary	West	Okanagan-Boundary
(N Nests)	(77)	(165)	(65)	(36)	(65)	(36)
1	-	10.4	-	5.5		5.6
2	-	6.1	-	2.8		5.6
3	34.3	20.1	26.1	30.5	27.7	27.8
4	57.5	57.3	58.5	41.7	66.2	55.6
5	8.2	5.5	15.4	16.7	6.2	5.6
6	0.0	0.6	0.0	2.8	0.0	0.0
Total*	100.0	100.0	100.0	100.0	100.0	100.0

*Rounding presented in table means totals may not appear to sum to 100%.

2008 Model Reliability Assessment

The 2008 habitat mapping had been found to reliably predict relative abundance as determined by call-playback responses (Gyug 2014), and had been found to predict population estimates that were in line with previous estimates (Gyug et al. 2014).

Since the 2008 habitat mapping, 114 nests had been found that could be used to independently test the reliability of the nest model. Twelve of these nests were outside the current project area, and the habitat at one of these nests had been turned into a rock quarry since 2012. For the remaining 101 nests, the 2008 habitat had not changed significantly (Table 2).

Of first concern were nests found in Unsuitable (6) habitat. The one nest prior to 2010 was in an area near the Phoenix mine that was considered part of the old cleared mine area, but which had been mapped incorrectly. This will have to be corrected when that area is re-mapped later as that particular area is not part of this project. The other nest found in 2011 was in the Okanagan within a very old homestead (~100 years) that had been cleared and then abandoned, but within which an aspen grove had grown up around the old house. Correcting this misclassification required re-assessing non-habitat areas for mature aspen intrusions.

Table 3. Assessment of forest attributes at nest trees found after 2009 that were in sites classified as Very Low (5) suitability in the 2008 habitat modeling.

N Nest Trees	Forest Attributes	Model Corrections or Adjustments
Okanagan Boundary		
2	Very young planted forest within cutover areas	Should have been corrected to ST Cuts that were not recognized in the 2008 aerial photo reviews. Need to review Cutover conditions again on orthophotos, and check age of stand before cutting from 1996-1998 FC attributes.
2	3-6 m from actual stand	Within spatial accuracy error of VRI, no corrections possible without remapping almost entire VRI
1	Partial Cut – nest in mid-diameter Lw	Impossible to correct from VRI or photos (same problem as in East Kootenay)
1	75 year age was below 80 yr cutoff for Low	Has been re-interpreted in 2016 VRI as 101 years, which makes no further correction necessary as it would now be classified as Low
Okanagan Boundary but outside March 2018 Project Area		
1	Mapped as Fd100%, so Very Low instead of Low	Lw present in the other half of this polygon across TFL boundary. The presence of Lw, even if not mapped in VRI, needs to be assessed.
1	Open Range	Re-assess Open Range polygons individually for presence of trees.
West Region		
7	Heavily affected MPB-areas.	2012 surveys showed Py areas heavily attacked by MPB could have moderate WISA nest density. This was not anticipated in the 2010 modeling. New Criteria added for Moderate (3): Polygon contains Py, Age ≥100 yrs., Ht ≥20 m, Crown Closure of layers ≥15.0 m ht. ≥10%, dead volume ≥20% of total volume.
1	Veteran Fd present on site that were not in VRI nor in 2009 corrections	Re-assess presence of veteran trees by using 1996-1998 Forest Cover ages of unharvested stands or harvested stands that have some retained trees. Older trees tended to be mapped in the older FC mapping that have been mysteriously deleted from the attributes in newer versions of the same polygons.
1	At present on site that was not in VRI nor in 2009 corrections	Re-assess presence of At from orthophotos, particularly set of photos from late Sept 2016 that show leaves turning colour (for area near Merritt only), for broad-leaved trees in imagery from all other areas
1	5 m from VRI At stand	Within mapping accuracy of VRI, no corrections possible

Proportions of Moderate (3) and Low (4) were not much different from before and after the modeling, and would be considered relatively reliable, i.e., no changes required to the nest habitat model. The proportions of High (1) and Moderately High (2) were lower than prior, but such areas were very uncommon, and most had been inventoried prior to 2010, and therefore few such areas were surveyed after 2009.

Of next concern were the higher proportion of nests (15-17%) within the Very Low (5) class after 2009 compared to before. By definition, only about 5% of nests should occur in the Very Low habitat class. Each of these nests was examined to see why it was classified this way, and how the model might be revised to take into account this situation (Table 3). The possible model changes of Table 3 were applied to this update modeling.

HABITAT MODELING

Ratings Assumptions and methods– VRI Stand Attribute Models

1. These models only apply within the regional contiguous Areas of Occupancy.
2. Only the IDF and PP zones have any suitability for WISA in the West Region.
3. In the West Elevations below 600 m and above 1400 m will be considered to have no suitability.
4. 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. However, foraging stands within a certain distance of nest locations are required. It is expected this will be incorporated into a further development of this model.
5. Non-Productive Polygons were treated as follows:
 - a. Lake, Meadow, Alpine, Alpine Forest, Clearing, Cultivated field, Glacier, Ice, Gravel Bar, River, Claybank and Urban were assigned Nil/Unsuitable (6).
 - b. In the West Region, Swamps and Rock were also considered Nil (6). Swamps were handled separately in the Okanagan-Boundary (see adjustments)
 - c. Open Range assigned Very Low (5) although this will only apply within a certain distance of foraging stands, and if the Open Range is truly non-treed it can be considered Unsuitable.
 - d. Non-Productive forest or Brush, Rock and Non-Productive Burn were treated as for forested polygons from their stand attributes, or otherwise assigned Very Low (VL) (5) if there were no forest attributes.
6. Any forested polygons or potentially forested polygons not otherwise assigned to M or L using Tables 3 or 4 were assigned VL (5).
7. Stand suitability was estimated first by stand attributes as per Tables 3 and 4, and then
 - a. Other adjustments were made for slope and aspect, and
 - b. Other adjustments were made for particular situations there were not handled well by the initial suitability classification in the top part of the tables.
8. The actual protocol for applying the factors in Tables 4 and 5 sequentially to the VRI and other attributes determined from prior FC and from imagery assessments are in Appendix 1.

Table 4. Nest Habitat Suitability Model March 2018 for Williamson's Sapsucker contiguous Area of Occupancy in the Okanagan-Boundary Region east of Okanagan Lake.

WISA Habitat Suitability for Okanagan-Boundary contiguous AO						
Input Variables	High (H) (1)	Moderately High (M) (2)	Moderate (M) (3)	Low (L) (4)	Very Low (5)	Nil (6)
Rank 1 Layer Projected Age	>190 years	>190 years	>120		Any other forested, potentially forested or non-productive polygons; OR, Rock and Swamp polygons as per adjustments below	All other non-forest polygons
Rank 1 Layer Projected Ht	>29.0 m					
Rank 1 Layer Site Index	>15.0					
Rank 1 Layer Crown Closure	>30%	>20%				
Crown Closure ≥15.0 m ht			>20%			
Age of oldest layer	>190 years	>190 years	>125 years	>80 years		
Tree Species	Fd or Lw leading, contains Fd and Lw	Fd or Lw leading, contains Lw	Fd or Lw present	Fd or Lw present		
Cw %.	<10%	<10%	<10%	<10%		
Sum of PI and BI %	<30%	<30%	<30%	<60%		
Sum of Fd and Lw %				>40%		
Boundary: % Fd of all layers ≥15.0 m ht	10-90	10-90	10-90	Fd <100%		
Okanagan: Sum of Fd and Lw % of either L1 or L2 , or if Lw present in L1R0 (veteran) layer				>40%		
Adjustments:						
Reduce 1 level if	Slope >30%			Do not reduce		
Upgrade from VL to L if	1. Forested polygon (>10% Crn Clos ≥15 m ht) and Lw present at >1/ha and Lw age >125 yr					
	2. Forested polygon (>10% Crn Clos ≥15 m ht) contains Fd or Lw, contains At >4% of stand, age >55 yr, and PI <55% of stand					
	3. NP but age>125, on south or gentle slope, contains Lw, Crn Clos >10%					
Upgrade from VL to L if slope <30% and	4. Lw or At vets present in ST cut (>2 ST/ha) up to 150 m from adjacent H/M/L with >30% Crn Clos ≥15 m ht). Up to 200 m if surrounded on all sides by forested stands (NOT USED 2018)					
	5. Mature At patches >1 ha and adjacent to Fd/Lw forest, i.e., not PI/Se					
	6. Fire-origin (60-100 yr), old high-graded stands, or old light partially cut stands (1960s-1980s) if:					
	a. Lw vets scattered throughout at >0.5/ha, or					
	b. Upgrade the portions of the stand with clumps of vets					
	7. if Ep/Ew and Lw occur in Layer 1, stand is not NP, slope <30%, Crown closure >25% and >10 m tall, and >50 years old					
	8. Any other forested stands containing vets >0.5/ha but that had been assigned VL					
Upgrade from VL to L if slope >30% and if	9. Lw vets present at >1/ha, if adjacent to H/M/L, and if polygon size >1 ha					
OR, R, NP polygons	10. assign as Nil if no mature trees					
	11. if partly treed, e.g., edges or within an arm of an irregularly shaped polygon, then remain VL					
	12. if NP polygons had been rated M or L, reduce to VL if crown closure <10%					
	13. Small swamps (<1 ha) ringed by At, Ac or tall shrubs remain VL, larger Swamps reduced to Unsuitable					
	14. 20-m buffer inside large OR and SWAMP polygons adjacent to H, M or L may be rated L if boundaries not mapped precisely, i.e., OR or Swamp contains mature trees (NOT USED 2018)					
Downgrade to VL if	15a. Clearcuts with no mature trees, i.e., not really ST cuts					
	15b. ST Cuts, partial cuts or high grading but no vets and no mature At detectable					
	16. ST cuts, even if ST Lw vets, if surrounding stands were VL or young PI stands (NOT USED 2018)					
	18. 5% crown closure but >15 m ht, and not adjacent to intact forest stands –usually at lower edges of AO adjacent to open Py slopes (NOT USED 2018)					

Table 5. Nest Habitat Suitability Model March 2018 for Williamson's Sapsucker contiguous Area of Occupancy in the West Region west of Okanagan Lake.

WISA Habitat Suitability for Western contiguous AO						
Input Variables	Moderate (M) (3)	Moderate (M) (3)	Low (L) (4)*		Very Low (5)	Nil (6)
Elevation and Slope	600 -1400 m, slope <45%					<600 m, >1400 m, >45% slope
Oldest Layer Age	≥100	≥180	≥180	≥58 years	Any other forested, potentially forested or non-productive polygons; OR polygons (if partially treed)	All other non-forest polygons
Oldest Layer Ht	≥20.0	≥19.0	≥18.0	≥14.0		
Site Index	≥10.0	≥11.0	≥10.0	≥11.0		
Crown Closure ≥15.0 m ht	≥20% but variable	≥20%	≥1%	≥15%		
Tree Species	≥20% by volume dead unsalvaged MPB-killed Py	Py present	Py present	At present, Either Fd and/or Py in this or adjacent polygon		
PI % composition of Layer 1 or 2		≤30%	≤50%	≤30%		
Adjustments:						
Reduce to Low if:	600-800 m 1200-1400 m					
Reduce one level if:	Slope >25%					
Upgrade from VL to L only if:	1. veteran Py present based on photo examination or 1996-98 FC mapping indicated trees >180 years (projected to current) 2. OR if mature At patches present, based on photo examination 3. Meets 1 or 2 but NOT in polygons with Slope >25% and north aspect 4. AND Meets (1 or 2) and 3 AND either 4a. in a forested stand ≥88 years old containing Fd or Py but ≤30% PI 4b. in a ST Cut or Partial Cut					

Table 6. Summary of area changes in modeled WISA habitat suitability from 2008 to 2018.

Suitability Class	Okanagan-Boundary (521.1 km ²)			West (742.4 km ²)		
	2008	2010	% Change	2008	2010	% Change
1	1.4	1.8	0.5			
2	2.2	4.6	2.4			
3	9.5	11.6	2.1	8.5	8.1	-0.4
4	34.0	34.4	0.4	30.5	36.8	6.3
5	46.1	40.6	-5.6	51.3	45.4	-5.9
6	<u>6.8</u>	<u>7.0</u>	<u>0.2</u>	<u>9.7</u>	<u>9.7</u>	<u>0.0</u>
Total %	100.0	100.0	0.0	100.0	100.0	0.0

CHANGES IN HABITAT SUITABILITY 2008 TO 2018

The results of the suitability models from 2008 and 2018 are presented in map form in Figures 2-5. The changes in habitat suitability classes from 2008 to 2018 were assessed by converting both shapefiles to 25-m grids and comparing the 2008 and 2018 suitability values at each grid point.

Overall there appeared to be no habitat suitability losses in Classes 1 to 4 in the Okanagan-Boundary but only gains (Table 6). There was a small drop in Class 3 habitat in the West but an overall gain in Class 4 habitat. Overall 5.7% of the project area had been cut since the last update, which was similar in both regions. Overall, 67% of the Okanagan-Boundary Region did not change habitat suitability, 11% of the area decreased in suitability, and 22% increased in suitability (Table 7). 83% of the West Region did not change habitat suitability, 6% of the area decreased in suitability, and 11% increased in suitability (Table 8).

Given that just over 5% of each region had been cut, and most of this involved clearcutting or seedtree cuts that would lower suitability, the reasons behind the apparent increases were examined to determine if they were real, or somehow artefacts of the modeling process. Firstly, distance from “foraging” habitat was included as a factor in 2008, but this has not yet been included in the 2018 update. This extra adjustment can only downgrade nest habitat suitability, not upgrade it, so some further decreases in 2018 suitability classes can be expected. Secondly, some of the habitat “losses” come from re-interpretation or re-mapping, and may not be changes in actual habitat at all.

Table 7. Areal changes (km²) in modeled WISA habitat suitability from 2008 to 2018 broken down by suitability class in each model for the Okanagan-Boundary Region but not including the areas north and east of Midway. Areas shown in grey represent no change in suitability class. Areas shown in red indicate where these areas have decreased in suitability. Increases or decreases from 2008 to 2018 of more than 10% of a suitability class are indicated in bold.

Suitability Class 2008	Suitability Class 2018						Total
	1	2	3	4	5	6	
1	5.0	1.0	0.3	0.3	0.6	0.0	7.1
2	0.6	5.8	1.9	2.5	0.8	0.0	11.6
3	3.2	8.2	24.9	10.5	2.6	0.0	49.5
4	0.4	7.2	27.5	106.7	34.8	0.5	177.2
5	0.4	1.7	5.5	58.8	171.5	2.3	240.2
6	0.1	0.1	0.0	0.5	1.0	33.7	35.5
Total	9.1	23.6	59.5	181.1	211.3	36.5	521.1

Table 8. Areal changes (km²) in modeled WISA habitat suitability from 2008 to 2018 broken down by suitability class in each model for the West Region.

Suitability Class 2008	Suitability Class 2018				Total
	3	4	5	6	
3	39.1	22.0	2.1	0.0	63.2
4	12.6	194.0	19.3	0.1	226.1
5	8.5	56.9	315.3	0.3	381.0
6	0.0	0.1	0.2	71.8	72.1
Total	60.2	273.0	337.0	72.3	742.4

Between 2008 and 2018 in the Okanagan-Boundary, 3.2 km² moved up from Class 3 to Class 1, 8.2 km² from Class 3 to Class 2, 7.2 km² from Class 4 to Class 2, 27.5 km² from Class 4 to Class 3 and 58.8 km² from Class 5 to Class 4 (Table 7). There were 390 of the ~4500 tree plots from 2006-2015 in sites that had been upgraded in suitability class from 2008 to 2018 to help assess the characteristics typical of each suitability class and determine whether the sites that moved up in class from 2008 to 2018 did so deservedly. In particular, former 180-year old Class 3 stands may now qualify for 190-year Class 1. However, the 190-year age was a surrogate for the presence of 300+ year old vets, which were more common in >190-year old stands. If there were no 300-year old veteran trees in the 180-year old stands as originally mapped in 2008, these were not going to be created within a 10-year span. Similarly, the large increase of about half of the 2018 Class 3 from Class 4 (26.9 km² added from Class 4 to Class 3, Table 7), was a result of stands increasing in age. Most of these stands will have been high-graded sometime in the past, and the presence of veteran trees will not increase just because the stand age increased past the 120-year age criterion.

Table 9. Very Large (≥ 52.5 cm dbh) tree and snag density by suitability class based on 2006-2015 WISA tree and wood sample plots. n is the number of plots in that class used to calculate the mean and Standard Error (SE). t-test used to test for significant differences at $p=0.05$ level (grey-shaded cells) between the 2008 mean for each suitability class compared to the sites upgraded to that class in 2018.

Suitability Class	Density Trees ≥ 52.5 cm dbh						Density Snags ≥ 52.5 cm dbh					
	2008			Upgraded in 2018			2008			Upgraded in 2018		
	n	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE
Okanagan-Boundary												
1	69	25.7	3.0	11	32.4	13.4	69	6.7	2.4	11	3.6	1.0
2	64	13.1	2.4	32	18.5	4.7	64	3.0	1.5	32	3.4	1.4
3	315	17.8	1.3	100	14.6	1.9	315	2.7	1.3	100	1.0	0.7
4	818	7.4	0.5	131	3.9	1.1	818	1.2	1.0	131	0.8	0.7
5	450	3.2	0.5				450	0.8	1.0			
West												
3	353	9.2	0.7	35	3.8	1.3	353	2.7	1.7	35	2.3	2.3
4	557	6.9	0.6	81	4.5	1.3	557	1.7	1.4	81	2.1	1.3
5	476	4.3	0.5				476	1.7	1.5			

In the Okanagan-Boundary, the sites upgraded in 2018 from other classes to Class 1 had very large tree and snag densities not significantly different from the Class 1 sites of 2008. The same held true for Classes 2 and 3. Therefore no adjustments were made to the age factors used to determine suitability class in the model.

In the West, the increase in Class 3 habitat (Table 8) is a modeling effect because heavily MPB-attacked Py stands were higher suitability than previously thought. The new areas added to Class 3 habitat in 2018 had significantly lower densities of very large trees than in 2008 (Table 9). In 2008, Class 3 had only been based on veteran tree presence, whereas in 2018 it was also based on heavy MPB-attack. The current 2018 Class 3 probably reflects reality better than the 2008 model. However, given that this suitability is based on MPB attack, and dead pine trees fall over fairly quickly, i.e., within a few decades, this habitat suitability may be ephemeral, and not likely to persist.

In both the Okanagan-Boundary and the West, the apparent increase of 50-60 km² from Very Low to Low was partly a result of the lack of inclusion of distance to foraging. Therefore, much of this habitat may be expected to drop back to Class 5 when a foraging model is incorporated. The plots added to Class 5 in 2018 had very large tree densities significantly lower than Class 4 of 2008 in the Okanagan-Boundary, and more similar to Class 5 of 2008 than to Class 4 of 2008 in the West.

When the nests found since 2009 were examined for their suitability class in the updated 2018 model, only 6% were in the Very Low class 5, and none in the Unsuitable Class 6 (Table 2). This modeling was therefore successful at making adjustments to reduce the numbers of nests in Classes 5 and 6 with only

a 5 to 6% increase in total area included in Classes 1 to 4 (Table 6), i.e., those areas that would be considered for Critical Habitat inclusion.

CAPABILITY

This model was only for nest suitability, not capability. Almost any potentially forested polygon in the AO is capable of becoming suitable WISA nesting and/or foraging habitat. A capability model could be developed using the same WISA data and VRI based on tree potential, i.e., primarily on Site Index. The Site Index required to grow a Class 1 suitability habitat is only 15, and as low as 10 to 11 for lower suitability classes in the West, and was not directly considered for other lower classes in the Okanagan-Boundary.

For (very) long-term management, site capability should probably be considered just as important as suitability. Many stands that could become suitable but are currently Very Low are not considered for tree retention for long-term (decades to centuries) nest tree recruitment. However, without taking these stands into consideration, and retaining at least some trees to later become veterans on every cutover hectare within the AO with a Site Index over 11, the long-term prognosis will be for continued habitat loss, as new veterans will not be recruited into many or even most potentially suitable stands.

DATA PRODUCTS

Shapefile sets (all in BC Albers projection):

1) ***wisa_suit_20180326*** - VRI base 01/01/2016 adjusted with boundary and attribute changes to January-March 2018. This shapefile contains almost all the columns of the Excel file listed below starting with adjustment fields, followed by VRI fields, followed by WISA key factor and adjustment fields, and ending with the final suitability rating.

2) ***wisa_ao_elev_slope_aspect*** (self-explanatory file name).

Excel file: ***wisa_vri_base2018_forattr_20180326.xlsx*** The file containing the VRI and adjusted attributes for every polygon. Polygons have each been given a new OBJECTID unique to this file. Text and other layer information can be joined to this file using the Feature ID of the VRI 01/01/2016 which has been renamed in the Excel file (and the shapefile set) as ORIGVRIFID.

Text files. The R1, L1, L2, L3, L4 and Dead Layers to join via Feature ID, i.e., ORIGVRIFID in shapefile and Excel file. Each name ***WISA_VRI_*** followed by the layer name and ***.txt*** e.g., ***WISA_VRI_L1R0.txt***

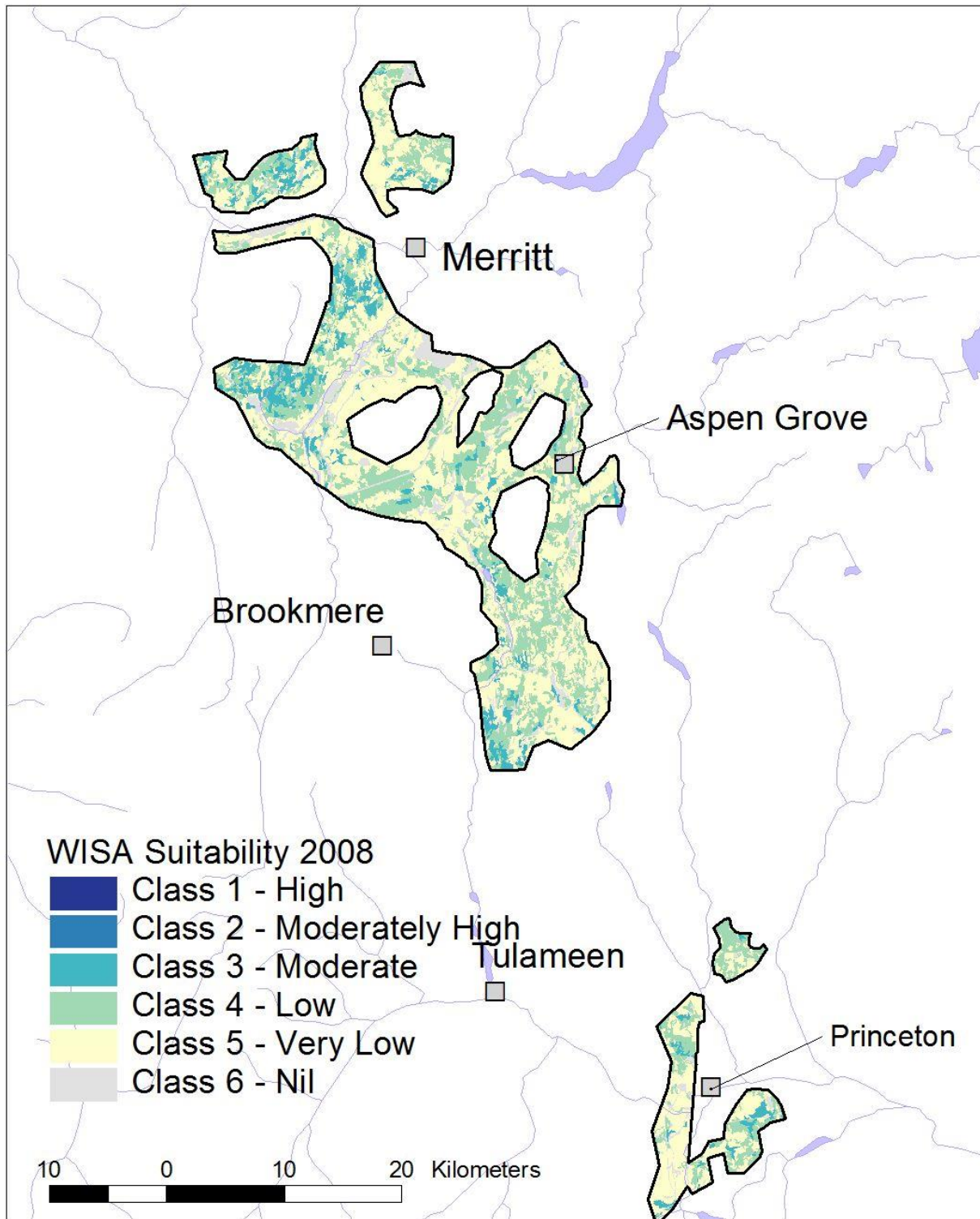


Figure 2. Williamson's Sapsucker 2008 nest habitat suitability model west of Okanagan Lake (Gyug 2010b).

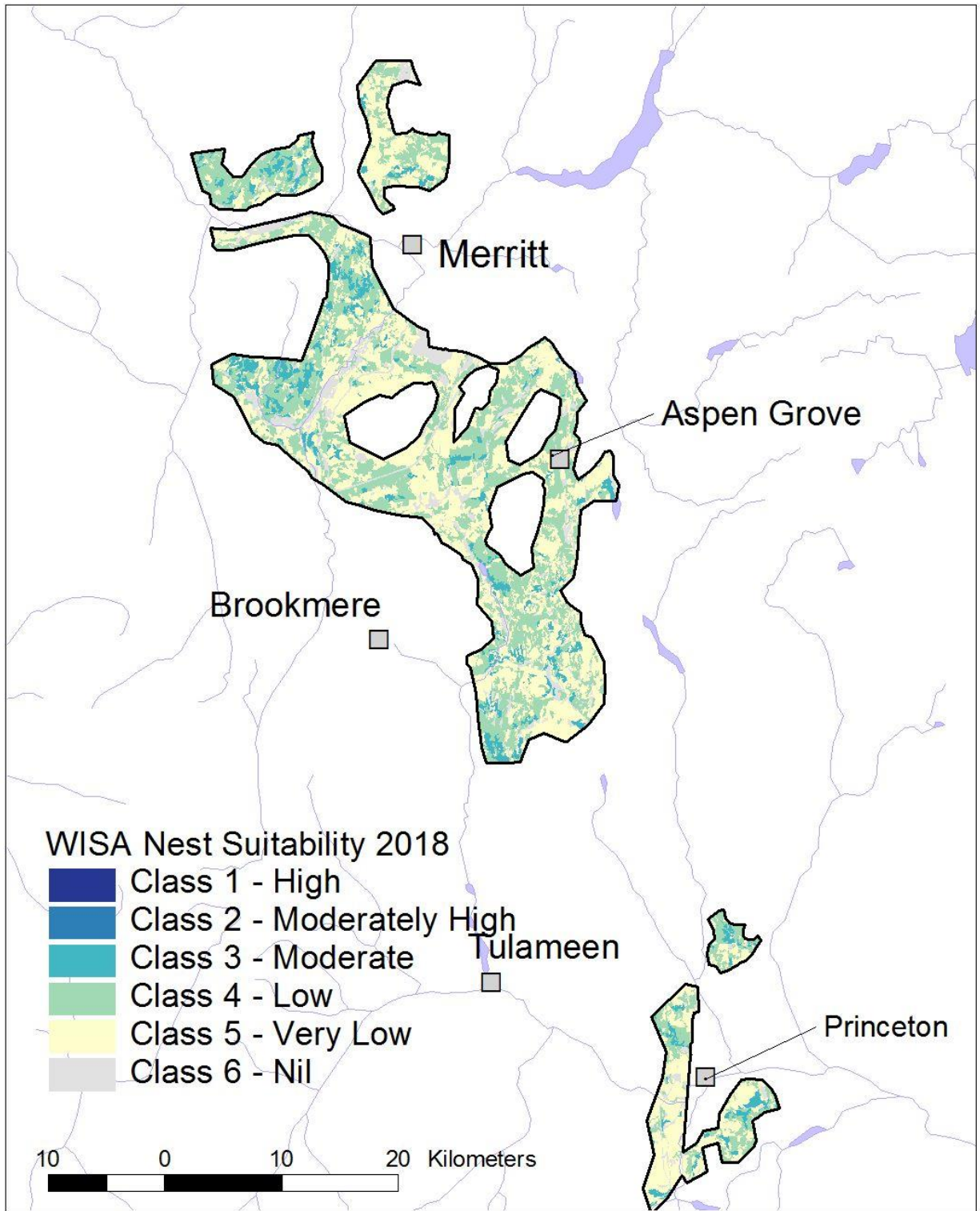


Figure 3. Williamson's Sapsucker 2018 nest habitat suitability model update west of Okanagan Lake (this project).

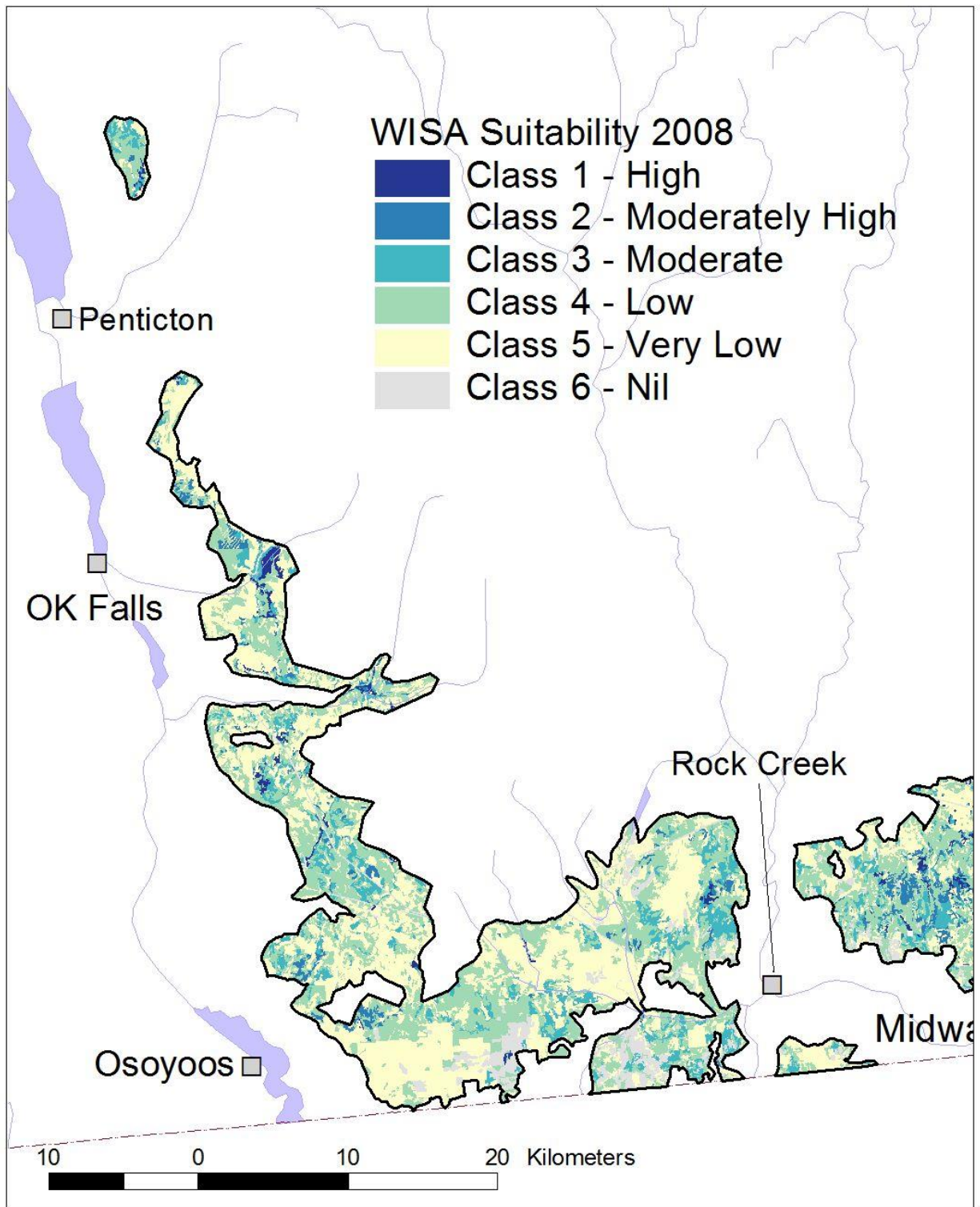


Figure 4. Williamson's Sapsucker 2008 nest habitat suitability model east of Okanagan Lake (Gyug 2009, 2010a).

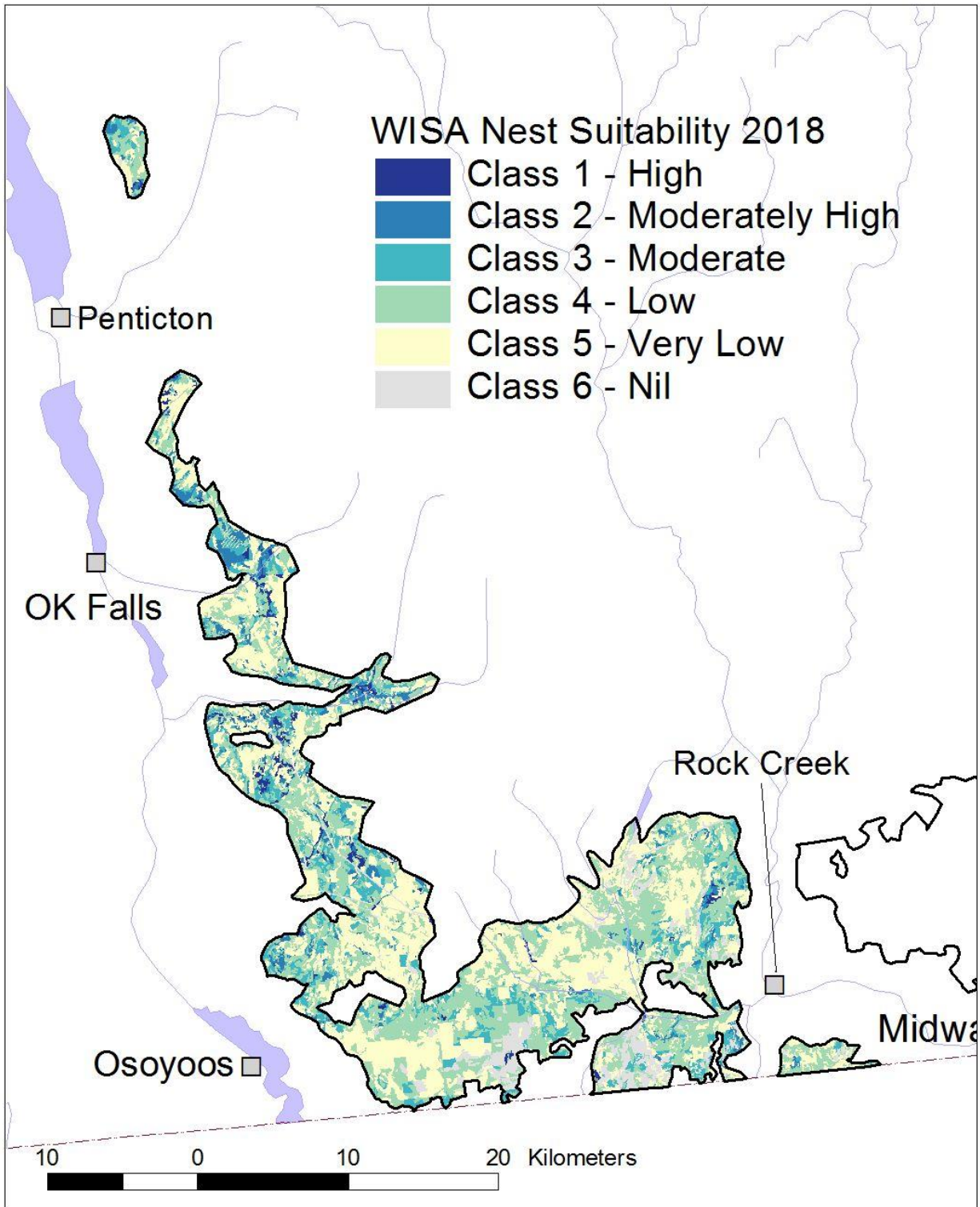


Figure 5. Williamson's Sapsucker 2018 nest habitat suitability model update east of Okanagan Lake (this project).

References

- B.C. Conservation Data Centre. 2018. BC Species and Ecosystems Explorer. B.C. Ministry of Environment, Victoria, B.C. Available: <http://a100.gov.bc.ca/pub/eswp/> (accessed Mar 25, 2018).
- COSEWIC. 2005. Status Report on Williamson's Sapsucker, *Sphyrapicus thyroideus*. Committee on the Status of Endangered Wildlife in Canada, Canadian Wildlife Service, Ottawa.
- Environment Canada. 2014. Recovery Strategy for the Williamson's Sapsucker (*Sphyrapicus thyroideus*) in Canada. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa.
- 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. 2010a. Final species account for species-habitat model for Williamson's Sapsucker West of Okanagan Lake. Report prepared for Environment Canada, Canadian Wildlife Service, Delta, B.C., and Ministry of Environment, Victoria, B.C.
- Gyug, L.W. 2010b. Final species account for species-habitat model for WISA in the Okanagan. Report prepared for Weyerhaeuser Co. Ltd., Princeton, B.C.
- Gyug, L.W. 2014. Williamson's Sapsucker monitoring 2014: Okanagan, Boundary and West. Report prepared for Environment Canada-Canadian Wildlife Service, Delta BC
- Gyug, L. W., J. M. Cooper, and C. Steeger. 2014. Distribution, relative abundance and population size of Williamson's Sapsucker in south-central British Columbia. *British Columbia Birds* 24:9-19
- 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.
- Resources Inventory Standards Committee (RISC). 1999. BC Wildlife Habitat Ratings Standards Version 2.0. Ministry of Environment, Lands and Parks, Victoria, B.C.
- St-Amand, J. 2017. Foraging ecology of endangered Williamson's Sapsuckers in Canada: multi-scale habitat selection in two biogeoclimatic zones. M.Sc. Thesis, University of British Columbia, Vancouver, BC.

Appendix 1. Sequential Application of Factors to Model Suitability used in Excel file
wisa_vri_base2018_forattr_20180323.xlsx

This is divided into two sections. In the first section I outline the steps to make the VRI suitable for WISA habitat modeling. In the second section I outline the steps to apply the habitat models of Tables 4 and 5 to the VRI once it has been made suitable for modeling.

Section 1: Making VRI suitable for WISA habitat modeling.

In essence, I:

- updated the VRI layer to 2018 (from 01/01/2016),
- split polygons where necessary with new harvested areas and burns,
- assessed all areas harvested after 2008 as Clearcuts, ST Cuts or Partial Cuts, and then for any such polygons harvested or burned, changed any of the VRI attributes used in the key to match the current state including:
 - For Clearcuts, all attributes set to 0 and Crown Closure to 0%
 - For ST Cuts, keep maximum age and species, set CC to 1%
 - For PartCuts, keep maximum age and species, set CC to 15% (because that is <20% of the key, meaning always Low, not Moderate)
 - For sites with no current 1.5-m pixel imagery or better, and if state was unknown, add a “?” to indicate the actual level of cut will have to be assigned later.

In more detail:

- The most recent provincial VRI geodatabase polygons and tables were downloaded from Data BC. In this case, the latest was Projected Date of 01/01/2016. However, it did not contain many cutblocks from 2015 and some from 2014, some from even earlier, and did not contain anything cut after 2015.
- All VRI layers were required. The polygons of interest intersecting the WISA AO were selected by location and saved as a shapefile because I intended to use ArcView 3.2 for at least part of the process. As it turned out there were there were corruptions introduced somewhere in the process that continually crashed crashed ArcView 3.2, and could only be identified and fixed in ArcGIS 10.1. The VRI shapefile manipulations were carried out in ArcGIS 10.1 while ArcView 3.2 was only used for dissolving small polygons, slivers and overlaps, and joining the text layer files to the shapefile. In the future, I would conduct the entire process in the ESRI geodatabase format from beginning to end.
- This polygon shapefile contained the polygon info but no tree species info. The tree species info was in a separate gdb table.
- The records from the gdb tables that matched the Feature ID of the above shapefile were found by attaching the shapefile (temporarily) to the table. Those records were selected and saved as a separate table.
- I determined how many layers each polygon had, and which layer was Rank 1 (the highest volume layer). I manipulated the .txt file to make a separate .txt file for each layer including:
 - Rank 1 layer, and
 - then for any polygons that had separate Layers 1, 2, 3, 4 and Dead.

- If there was only one layer for a polygon, it was the Rank 1 layer. Non-forest polygons would not have any Layers. About 2000 of 12000 polygons had >1 layer. About 200 also had Layers 3 and 4, but these were all under 15 m ht, so not crucial to the WISA model. About 2500 had a Dead layer, which was populated as PI 100%, but in fact many of these polygons only contained many Py.
- For polygons with dead layer, I estimated the % dead from the % dead of the total Rank 1 live and dead volume estimates.
- The VRI appears to have NOT been updated since the original (early 1990s?) mapping on the extensive private ranch land holdings in the Merritt TSA, nor on private lands in the Boundary. Given the high amount of MPB salvage on private lands, the actual status of each polygon had to be determined by examining each against the aerial photos from 1995, 2004 and 2015. The VRI had been more currently updated for the Okanagan TSA and included new VRI for private lands as well.
- To be able to attach the .txt file with the layers to the shapefile, I renamed the field headings to 10 characters so that they can be used in the dbf file created when attached to the shapefile. These were only attached in a much later step.
- I obtained the latest Consolidated Cutblock (includes blocks sensed by satellite imagery as well, as some blocks appear never to have an approved CP, or are just missed by the system), the Harvest, the Forest Tenure Cutblock Polygon (approved CPs, not necessarily cut yet), and the fire polygon layers. There was only one fire from summer 2017 that was not in the VRI and that impacted the project area near Princeton. I also obtained the fire severity shapefile for that fire.
- ± 1 -m pixel orthophotos were available from:
 - 1994-1995 (black-and-white)
 - 2004-2005 (colour, excellent quality)
 - 2012-2016 (Google Earth, Bing, FLNRO licenced SPOT6/7)
- The 2008 modeling was based on primarily on the 2008 VRI, the 2004-2005 orthophotos, and paper-copy stereo colour aerial photos of different vintages (going as far back as 1990).
- Landsat 8 15-m pixel and Sentinel 2 10-m pixel imagery were used to assess status of cutblocks up to March 11, 2018, for the West, January 31, 2018, for the north part of the Okanagan, and March 13, 2018, for the south part of the Okanagan and the Boundary. Additional snow-free Landsat 8 images from 2017 (July to October) were used as required to assist interpretation of recent cutblock status.
- Cutblocks on public land that were not already in the 01/01/2016 VRI layer were identified from the orthophotos, or from the Landsat 8 imagery. These were cut into the VRI layer using the Forest Tenure Cutblock layer, or done manually where there was no cutblock polygon.
- Any forest clearing on private land was entered manually by reshaping polygons into the cleared and uncleared portions.
- Any VRI polygons that were split in this process were labeled and then the current state was estimated as:
 - Clearcut (<2 trees/ha),
 - ST Cut (2-50 trees/ha)
 - Partial Cut >50 trees/ha.

- Estimates of tree densities were very approximate and not necessarily reliable.
 - Where no high-resolution imagery was available, and I had no personal knowledge of the site after harvest, the current condition was estimated and marked as an estimate with a “?” to be verified later.
- Where the FLNRO VRI update was last done, cutblocks were cut in but often contained Wildlife Tree Patches or uncut portions. Where these were large enough to be visible on orthoimagery, those sections were split and the forest attributes were retained for those sections. These manual fixes are not 100% as I am sure many WTPs were missed as it would have been too time consuming to fix them all. Where the cutblocks that had been cut in between 2008 and 2016 included the WTPs (if >1 ha, and as time permitted) in the block area, these were made into separate polygons and given back their forest attributes.
- Manually fixed areas included a 1000-ha cutblock north of Patchett Road, Midday Creek area in the Merritt TSA, where the entire cutblock polygon outline had been cut into the VRI, and the resulting polygon emptied of forest attributes. However, the actual cutting only took place over about 2/3 of the area, and many places had remaining intact forest. The 2008 VRI polygons were cut back into this area, the 2009 suitability rating re-applied, and then the actual cutover areas traced manually over the polygons, and the suitability rating modified for just the cutover areas.
- The VRI polygons were clipped to the WISA contiguous AO shapefile in the project area. The block of the AO north and east of Midway, most of which was TFL 8 was not included in this update because TFL 8 VRI is not available in the provincial VRI. The VRI also contained many boundary/edge matching issues adjacent to TFL 8, so that this block should be done all in one effort, rather than piecemeal. The VRI portion of this project began in March, when time was too limited to include this particular area.
- Where intersections of polygons or clipping to the AO boundary created sliver or tiny polygons of <0.1 ha, these were dissolved back into their parent polygons.
- I created a Slope, Elevation and Aspect layer in 2008 for the modeling. This layer was re-created by dissolving the 2008 WISA suitability model shapefiles as I no longer had the original shapefiles (only the raster grids) on which these had been based. This shapefile required extensive cleaning as the original shapefiles were based on VRI in which mapsheets had been stitched together, with many sliver gaps at map boundaries. The 2016 VRI is clean and free of map-edge gaps, so this problem will not be re-created in the updated WISA model shapefile.
- The VRI shapefile was unioned with the Slope-Elevation-Aspect shapefile. Any resulting sliver and small polygons of <0.1 ha were dissolved into adjacent polygons.
- I had made many adjustments to the VRI attributes and polygons in 2008 where forest attributes or species were actually present based on colour stereo aerial photo examination but were not present in the VRI. Examples were veteran trees, At presence, trees within Open Range polygons, and retained ST or more dense tree retention within “clearcuts”. There was no way to join these spatially (even millimeters rounding difference in the polygon boundaries prevents spatial matching) or by any common field, or by the centroids, so these were rejoined manually polygon by polygon, which took 3 days. This included splitting polygons where polygons had been split in 2008, or attaching the adjustment attributes to the entire polygon where the polygons remained almost unchanged.

- The forest layer tables (L1R0, R1, L2, L3, L4, Dead) were attached to the altered VRI polygon layer. The projected date was changed to 01/01/2018 with all ages updated to match this new date. Other forest attributes (e.g. height, BA) were not updated.
- VRI no longer uses the Non-Forest descriptors used in the old Forest Cover Mapping (e.g. L for Lake, OR for Open Range). These codes were used in the 2008 WISA modeling. Where newly interpreted VRI had blanks for these codes in non-forest polygons, I interpreted what the code would have been so that some areas (truly non-treed) could be assigned Unsuitable, and that potentially treed SWAMP or OR could be identified and assessed for presence of mature trees and WISA suitability. Most of these assessments were already done in 2008, and the 2008 polygon attributes copied into the new VRI.
- New fields were created to hold attributes used in the WISA habitat modeling. These included Maximum Age of any layer within a polygon, maximum R1 age and height (since each polygon and within each layer may have two ages or heights), presence of Fd, Lw, Py, At, Ew/Ep, Cw, Pl, Bl, and the percent cover of each in R1 layer.
- Crown Closure (CC) had to be adjusted for any polygons harvested or burned since the VRI of 01/01/2016, or that had not been updated in previous VRIs (see next bullet). For Clearcuts, CC set to 0%, for ST Cuts CC set to 1%, and for Partial Cuts, CC set to 15%, which was arbitrary rather than assessed for each polygon. A field was created called "CC_GT15Fnl" to hold this adjusted info and the original VRI CC_GT15 not changed.
- Very little effort appears to have been made in the FLNRO VRI update to deal with private land changes after the original interpretations in the early 1990s. This required extensive manual updating using orthophotos and satellite imagery with current forest attributes estimated for the key factors required in WISA modeling.
- Often cutblocks or partially cut areas were added during the FLNRO VRI update, and the tree attributes changed, but the veteran tree attributes disappeared in the process. Where these were ST Cuts or Partial Cuts, polygons had to be checked individually vs older FC or VRI mapping to determine the age of the stand before harvest, and the likely age of at least some of the leave trees. Where these were veteran trees (>125, >180, or >190 years depending on the circumstances) these were noted as a ratings adjustment to be applied to the polygon later. GIS layers of Forest Cover were available from ~1998, and VRI from 2008.

Section 2: Applying the WISA habitat modeling to the adjusted VRI.

Okanagan-Boundary

Sequential Criteria for Keys. Each Key Factor has its own field in the Excel file named file sequentially as “KeyFctr_01”, “KeyFctr_02” etc. as per the bullets below.

The coded values assigned are in brackets. If no criteria fit, then coded value was set to 0 (default).

1. NP Codes, all but OR, R, S, NSR, NP, NPBU, NPBR (1)
2. NP Codes OR, R, S (1)
3. R1 Age >190 (1), >120 (2)
4. R1 Ht >29.0
5. SI of any layer >15.0
6. R1 CC >30% (1), >20% (2)
7. CC >15 m ht >20% (1)
8. Age of oldest Layer >190 (1), >125 (2), >80 (3)
9. Fd/Lw (assigned codes in order from a to b)
 - a. Fd or Lw leading, Fd and Lw present (1),
 - b. Fd or Lw present (2),
10. Cw <10% (1)
11. Sum Pl + Bl <30% (1), <60% (2)
12. Sum Fd and Lw% of R1 >40% (1)
13. % Fd of all layers >14.9 m ht 10-90% (1), Fd 91-99% 2
14. Sum of Fd+Lw % >40% of either R1, L2, or just present in L1R0 (1)

Assign First Stage Suitability if not already 5 or 6 (Keys 1 and 2). These Assignments are listed in the Excel file as fields FSuit156, First_Suit3, etc.

FSuit156: Suit 6 if 1 =1, Suit 5 if 2 =1, and Suit 1 if 3, 4, 5, 9, 10, 11 all=1, and for Bdy, 13 = 1

First_Suit2 = 2 if 3 = 1, 6 = 2, 8 = 1, 9 = 1, 10 = 1, 11 = 1, and for Bdy 13 = 1

First_Suit3 =3 if 3 = 1 or 2, 7 =1, 8 = 1 or 2, 9 = 1 or 2, 10 = 1, 11 = 1, and for Bdy 13 =1

First_Suit 4 =4 if 8 =1, 2, or 3, 9 = 1, 2 or 3, 10 =1, 11 = 1 or 2, 12 = 1, for Bdy 13 = 1 or 2, for Okanagan 14 = 1.

First_Suit = whichever of the above first applies, and Suit 5 for any polygons not yet classified

Second Stage Suitability

15. Slope >30%, and Suit 1 to 4, Reduce 1 level (add 1 to Suit).

Third Stage Suitability Adjustments were done individually for each polygon as per numbered bullets in lower half of Table 4. These included fields corrected from 2008 (field CORREC2009 as adjusted from stereo aerial photos) and NEWFCINFO (new adjustments from orthos, satellites and attributes).

To get Final Suitability, a final check of polygons was made against imagery and ages.

This included an additional adjustment factor as a check on veteran age using old FC. If Age >190 (1996-2003 projected to 2018), then upgrade VL to L (if not already downgraded) and if Fd or Lw present, and sum Pl+Bl <60%.

West

Sequential Criteria for Keys. Each Key Factor has its own field in the Excel file named file sequentially as “KeyFctr_01”, “KeyFctr_02” etc. as per the bullets below.

The coded values assigned are in brackets. If no criteria fit, then coded value was set to 0 (default).

1. NP Codes, all but OR, NSR, NP, NPBU (1); <600 m or >1400 m (1)
2. NP Code OR (1)

Assign First Stage Suitability if not already 5 or 6 (Keys 1 and 2)

FSuit156: Suit 6 if Field 1 =1; Suit 5 if Field 2 =1

First_Suit2 = 3 if Max Age ≥ 100 ; Max Height ≥ 20.0 ; Max SI ≥ 10.0 ; CC_GT15 $\geq 16\%$, Py present, unsalvaged MPB-killed pine $\geq 20\%$ volume dead.

First_Suit3 = 3 if Max Age ≥ 180 ; Max Height ≥ 19.0 ; Max SI ≥ 11.0 ; CC_GT15 $\geq 20\%$, Py present.

First_Suit4 = 4 if Max Age ≥ 180 ; Max Height ≥ 18.0 ; Max SI ≥ 10.0 ; CC_GT15 $\geq 1\%$, Py present.

FS4At-FdPy = 4 if Fd or Py in polygon: Max Age ≥ 58 ; Max Height ≥ 14.0 ; Maximum SI ≥ 11.0 ; CC_GT15 $\geq 12\%$, At present and either Fd and/or Py in same or adjacent polygon

FSuit_4At = 4 if no Fd or Py in polygon: Max Age ≥ 58 ; Max Height ≥ 14.0 ; Maximum SI ≥ 11.0 ; CC_GT15 $\geq 12\%$. In the 2010 modeling I included whether Fd and/or Py were present in an adjacent polygon which resulted in a 4, otherwise 5. I did not do this foraging adjacency adjustment in 2018 yet, and am waiting until a foraging model can be overlaid. However, this was kept in its own field so that it can be identified easily for foraging adjacency consideration later.

First_Suit = whichever of the above first applies, and Suit 5 for any polygons not yet classified.

Second Stage Suitability

15. If Suit 2 or 3, Reduce to Low if 600-800 m or 1200-1400 m

Within Second Stage final calculation: Reduce one level if slope >25%

Third Stage Suitability Adjustments

Upgrade from 5 to 4 if:

1. vet Py (1) based on manual corrections of 2008, or max age >180.
2. mature At present (1), “At” when At in stand attributes or “A” when I added At based on photo interpretation adjustments.
3. NOT Slope >25 % and North Aspect (1)
4. In a forested stand ≥ 88 years old containing Fd or Py but $\leq 30\%$ PI (1)

Either 1 or 2 must be 1, both 3 and 4 must be 1.

5. Potential adjacency and distance factors 5 and 6 of semi-treed sites to forests were used in 2008 but not used in 2018 where this would be added later when a foraging model is overlaid. Based on corrections made in 2008, In a potentially forested stand <150 m from stands ≥ 88 years old, and containing Fd and/or Py, but $\leq 30\%$ PI (Stands not split by distance from forest, so only applies to whole polygons- splitting by buffer will wait until foraging analysis model developed and applied).

Additional factor using old FC (1997). If Age >190 (projected to 2018), then consider if VL should be upgraded to L if not already downgraded or clearcut, and if Py present.