Williamson's Sapsucker Monitoring 2015: Okanagan, Boundary and West

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ABSTRACT

Trend monitoring of the Endangered Williamson's Sapsucker (WISA) using road-based early-April call-playback (CPB) points in the Okanagan-Boundary and West Areas of Occupancy (AO) began in 2012. Relative abundance from the road monitoring of the 213 CPB pts done on every survey round has not changed significantly from 2012 to 2015. Trend power analysis indicated that for this sample set with an estimated coefficient of variation of 3%, over a 10-year period there would a good power of >0.9 to detect a 10% change in relative abundance with 90% confidence with only 1 survey per year. Therefore one sampling round of the complete set of 229 road monitoring points is recommended in early April each year.

I recommend extending some early April sampling outside the AO boundaries in potentially suitable habitat as the boundaries of the AO may be changing but this will not be detected if sampling is only inside the AO. This was a recommendation of the original 2010 monitoring framework but has yet to be undertaken. Recent WISA detections outside the AO indicate this should be a priority.

In 2014 the road points were determined to be representative of the AOs at large by CPB sampling of 20% of 800- x 800-m cells aggregated by fours into 2.56 km^2 patches. Habitat changes since the habitat mapping of 2009-2010 were noted at 24% of the patches and road monitoring points in the West AO and about 5% in the Okanagan-Boundary AO. In 2015, I tested methods for a more intensive phase of patch monitoring i.e., census of WISA nests, should it be required to both confirm habitat changes and the effects on WISA habitat suitability. Nest census methods using 200-m grid spacing if done in late-May or June, or 400-m if done in April or early May, and followed by nest searches in June, were found to be effective and should include habitat plots as well. The habitat plots can be sampled during the breeding season at the same time as the nest searches.

I recommend updating habitat suitability mapping to reflect many new cutblocks and the widespread effects of pine beetle and salvage logging. However, first I recommend incorporating the results of the current WISA radio-telemetry program in a more efficient habitat suitability model that models nesting and foraging suitability separately. This can be tested on the >100 new nest locations gathered since 2009. While aerial photo surveys of the WISA AO by BC have not been undertaken since 2004-2005, more recent 2012 1-m pixel or 15-m pixel satellite imagery can verify habitat changes and are available commercially or from internet sources.

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INTRODUCTION

Williamson's Sapsucker (WISA) has been designated as Endangered in Canada (COSEWIC 2005), and is listed under Schedule 1 of the Species at Risk Act. This project was the continuation of the population monitoring begun in 2010 using call playback (CPB) methods (Marmorek and Pickard 2010), and most recently reported on by Gyug (2014). This program has evolved to become more efficient as we have learned more about WISA behaviour and biology. WISA declined in detectability to CPB sampling through May and June (Gyug et al. 2014) leading to variance too high to conduct efficient trend monitoring. Detectability was much higher in April when WISA establish breeding territories but sampling of the entire AOs is difficult at that time as many roads are still snowbound in many years.

In April 2012, CPB sampling points were set at 800-m spacing on all public roads kept open all year in the Okanagan-Boundary and West AOs with the exception of 4-lane highways. All such points within 300 m of Low or better suitability habitat were sampled twice in April in each of 2012, 2013, and 2014. Relative abundance declined through April, and declined even further in May (Gyug 2014). The early April sampling had much lower variance than later sampling and was found to be suitable for long-term monitoring.

In March 2014, a WISA-monitoring workshop was sponsored by CWS, at which it was decided to use the early April relative abundance as a long-term monitoring measure only if these could be shown to be representative, or at least correlated with, relative abundance of the AO as a whole. The West and Okanagan-Boundary AOs were sampled by dividing into 800-x 800-m cells, aggregating these into 2.56 km^2 patches of 4 adjacent cells. 20% of the patches were selected randomly for sampling in 2014 by 1 CPB point at the center of each cell as early in the season as each site was accessible (early April to mid-May) including on snowshoe in some cases. These patches were more logistically efficient to sample than random points stratified by habitat, and could provide spatial continuity for ramping up to more intensive absolute abundance monitoring including territory mapping or nest censuses. This ramping up in intensity of sampling would allow for correlating changes in abundance to possible habitat changes.

In this project, I continue the annual road CPB point sampling as the annual WISA relative abundance measure for long-term monitoring. I also tried the methods that would be used for the next phase of patch monitoring, i.e., census of WISA nests and confirmation of habitat changes and habitat suitability.

METHODS

Study Design

Annual April road monitoring of CPB points began as a volunteer effort in 2012 and continued supported by CWS in 2013-2015. Roads maintained by the BC Ministry of Transportation and Highways and open all year within the AOs, but excluding four-lane highways, were identified and points placed in a GIS setting along these roads at 800-m road distances (Figure 1). 229 points that were within 300 m of Low or better suitability habitat as of the 2009/10 habitat mapping were sampled.

In 2015, the first round of sampling began on March 31 and was completed by the late afternoon of April 3 by one surveyor in one vehicle. The second round of April sampling was delayed by contracting issues so could not take place until late May. Therefore this effort was re-directed into a test of methodology of more intensive patch sampling.

In 2014, to test how representative the road points were of the entire AOs, I divided the Okanagan-Boundary and West AOs into 2247 800-m by 800-m cells, only using cells with their center point within the AOs. I grouped adjoining 4 cells into 2.56 km^2 patches or 3 cells into 1.92 km^2 patches if at the edge of the AO. CPB sampling methods for these patches was described by Gyug (2014). In the West AO, 24% of patches had habitat changes likely to be significant to WISA suitability from 2008 to 2014 (Gyug 2014). Should WISA relative abundance change in the future, then we would have to undertake more intensive surveys to determine how these habitat changes may have affected abundance. The patch level appeared to be the best scale to do this as occupied territories often appear to shift from year to year to adjacent territories, but at the 2 - 4 km^2 scale nest densities have appeared relatively stable (Gyug, unpublished data).

In 2015, I selected two patches for a trial of methods to more intensively sample WISA nesting populations and habitat (Figure 1). These were patches where at least 2 WISA had been detected in 2014 but where no previous nest census had been undertaken. One patch was in the West AO and one was in the Okanagan-Boundary. The West patch was 065-1 north of Dodds Lake near Aspen Grove. There have been a number of new seedtree cuts in this patch that were not mapped in the 2010 suitability mapping. There is now updated VRI for this area, and there are 1-m pixel orthophotos dated to 2012 available from internet sources. The Okanagan-Boundary patch was 040-1 along Wolf Creek east of Oliver. There were no new clearcuts or other cuts in this patch since the 2010 habitat mapping.

Field Methods

Call playback equipment used for road monitoring were a FoxPro 416 digital playback unit (current equivalent is NX4) through a FoxPro SP108 speaker (a large megaphone with front bell dimensions of 25-cm x 17-cm). While walking through forest using closer point

spacing, I used a more portable FoxPro SP55 speaker (front bell 12.7-cm diameter) which in testing appeared to be as efficient at eliciting WISA responses as the larger speaker.

At each CPB point, date, time of day, air temperature, wind speed (Beaufort), cloud cover (1-4 scale where 1 = clear, 2 = <50% clouds, 3 = >50% clouds, 4 = overcast) and precipitation (None, Drizzle, Fog, Mist, Light Rain, Light Snow) were recorded. Sampling was conducted from around sunrise until before dusk (actual sampling hours in 2015 were between 630 h and 1830 h), only if winds were <Beaufort 4, and not in heavy rain. Each CPB point sample consisted of three broadcasts of a 10-15 second Williamson's Sapsucker drum and call combination repeated three times in three directions, and then a silent listening period of 3 minutes.

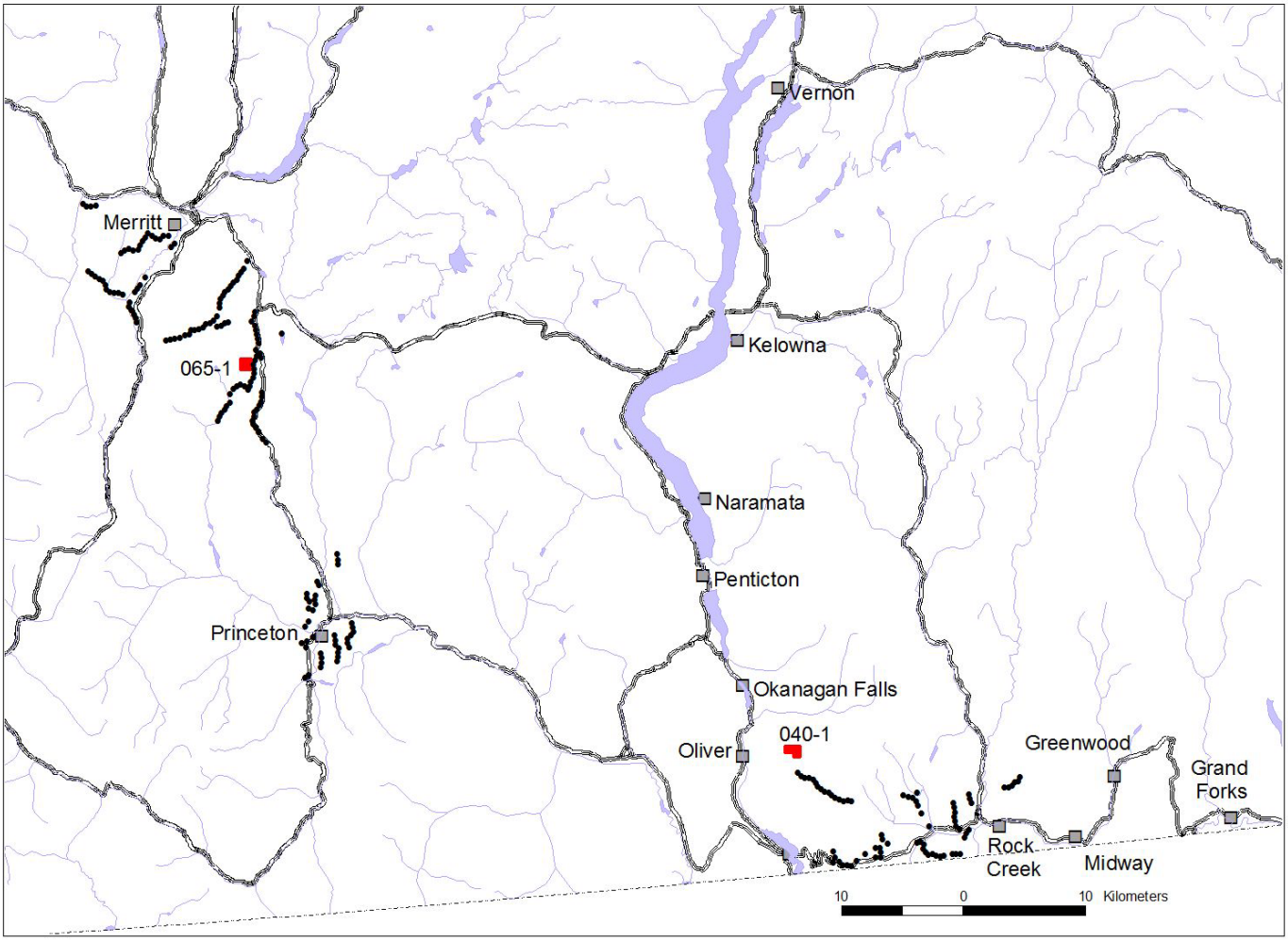

Figure 1. Overview map showing 229 April road monitoring CPB points (black dots) and the two patches (040-1 and 065-1 in red) selected for intensive monitoring including nest searches and habitat plots.

For each WISA detection, I recorded the time (sec) of the initial response from the beginning of the CPB. If we detected a WISA from a point before CPB started, it was given a time of 0 sec. CPB were still done at a point even if a WISA was detected before a CPB started because frequently the CPB prompted additional WISA to begin calling or drumming. For each detection I recorded the sex (male, female, unknown or pair), the number and the type of responses (visual, drum and/or call), the estimated distance (m) and direction (compass degrees). In open areas or over very short distances where the stand or tree where the WISA was first detected could be seen, I measured the distance using a laser rangefinder. In closed forest, I estimated distances based on the volume attenuation of the drum or call, which was not as reliable as when the WISA could be seen.

I used the methods outlined in section 2.2.2 of FIA (2006) to determine absolute density from nest searches. These combine a mixture of CPB and silent listening. While we knew WISA had been present in 2014 at these two patches (Gyug 2014), I started too late in 2015 to conduct a preliminary CPB search to determine if they were present also in 2015. CPB sampling while walking was done "on-the-fly" without 3-minute waiting periods and without recording every CPB point location and details. To provide complete coverage of the patch, regular points were established in a square grid covering the patch with 200-m spacing starting 100 m from the boundary (Figure 2). The intent was to conduct a CPB at each of these 64 points within the patch. Before starting the grid search, CPB points at at approximate 400-m spacing were sampled on roads to determine if the nest searches could be started immediately without grid sampling. If an initial search had been possible in April or early May, then 400-m grid spacing would have been used covering the entire patch. All WISA detections, whether spontaneous or in response to CPB, were recorded and location estimated to assist in nest searches and to later determine possible territory/breeding range size for a given pair. Intensive nest searches were initiated wherever WISA were detected.

Habitat sampling used similar methods to those used in 2006-2008 (e.g., Drever et al. 2015) with some modifications. For Patch 040-1, plots were done at each of the 64 200-m grid points (Figure 2E, Figure 3). Sampling intensity of 16 plots per cell or 64 plots per patch (equivalent to 1 plot/4 ha) required two very long field days by one surveyor to complete per patch. For Patch 065-1, I reduced the number of plots from 64 (Figure 4) to 25 so that they could be completed in one long field day (Figure 2C). Five extra plots were added randomly within seedtree cuts in 065-1 so that there was a larger sample to determine habitat parameters. No sampling was done in the northwest corner (27 ha) of the patch which was part of Douglas Lake Ranch's private land holdings (Figure 4).

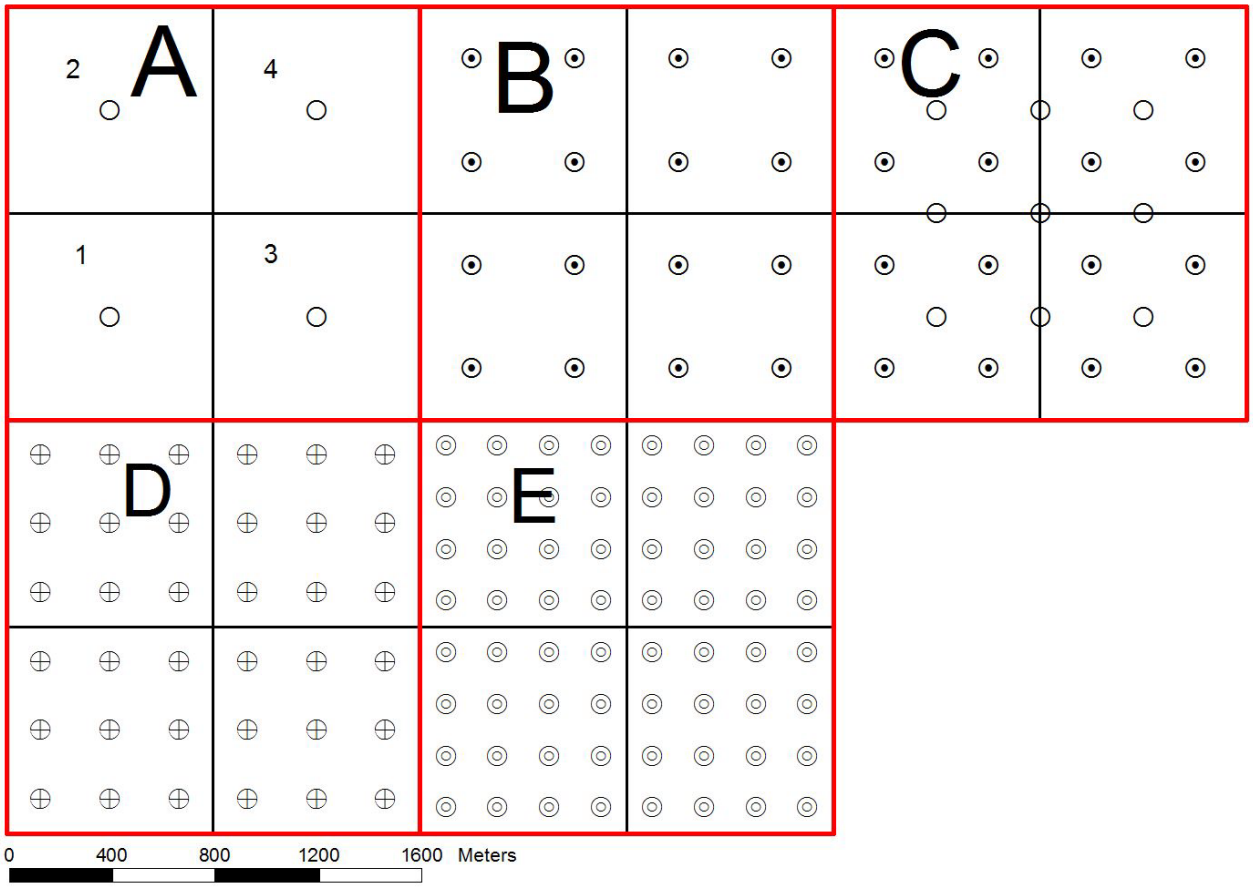

Figure 2. Example point spacing considered for sampling within 800-m cells aggregated into 1600-m patches (4 cells per patches A, B, C, D and E).

A was 800-m point spacing used to sample each patch with 4 CPB points as used for patch relative abundance CPB sampling in 2014. There is 1 sample point per cell and there are 4 sample points per patch. WISA responses to CPB from each point are usually independent.

B was 400-m point spacing that would be used as the first step in CPB sampling where follow up nest searches would determine absolute abundance, i.e. nest or territorial pair density. There are 4 sample points per cell and 16 sample points per patch. This was the spacing used in the irregularly shaped nest-census areas of the 2012 WISA sampling. WISA are often detected from multiple CPB points, which aids in focusing later nest searching.

C was combination of A and B including insertion of 400-m spacing points between “A” points on internal cell boundaries within patch as used for habitat sampling in Patch 065-1 in 2015. There are 25 sample points per patch.

D was 266.67-m point spacing considered for habitat sampling but not actually used. There are 9 point samples per cell and 36 per patch.

E was 200-m point spacing used to guide sampling during nest searches and used for habitat point sampling in Patch 040-1 in 2015. There are 64 sample points per patch.

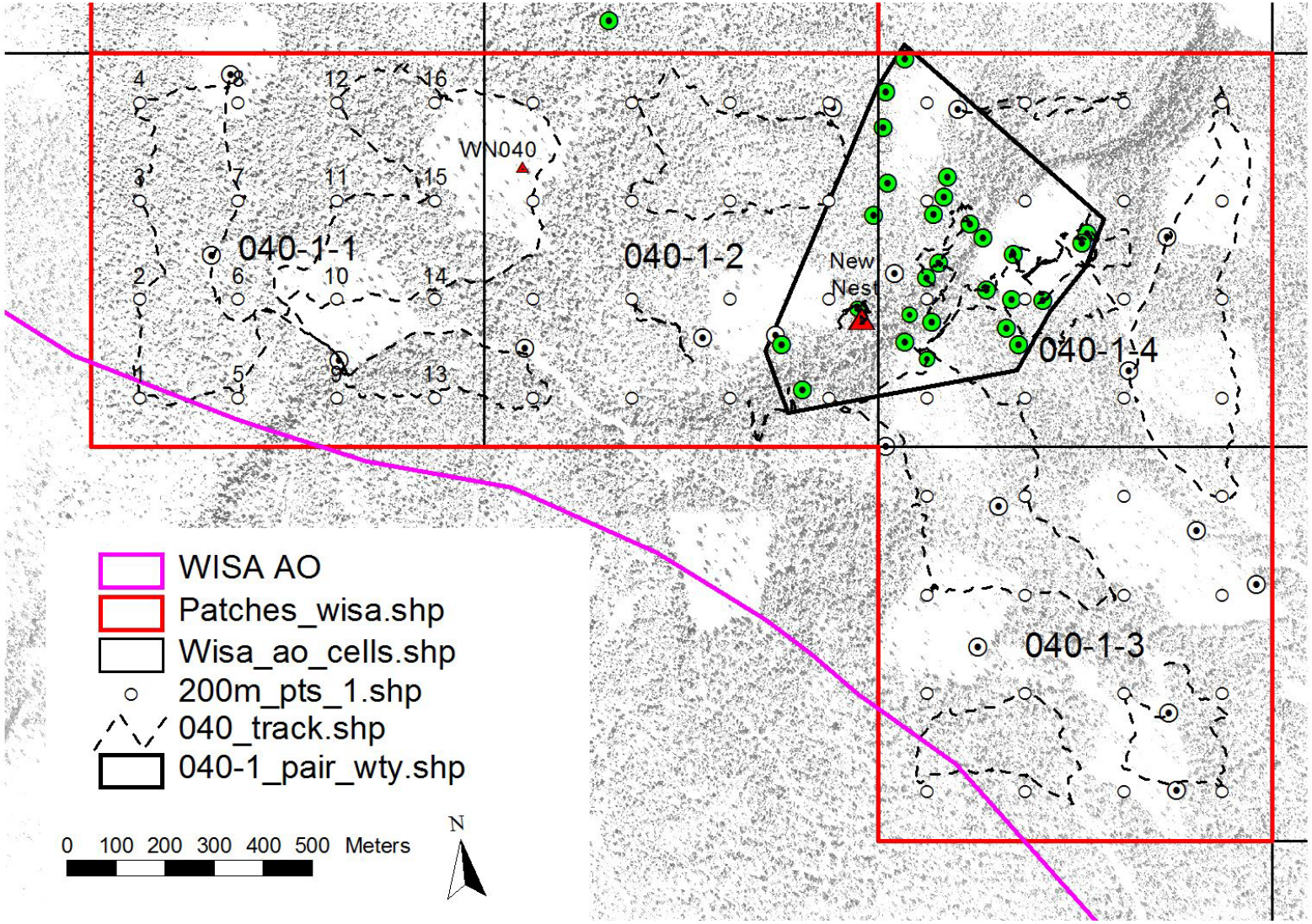

Figure 3. Patch 040-1 showing the 4 cells (040-1-1 to 040-1-4) and the 16 grid points at 200-m spacing in each cell numbered as in cell 040-1-1. WISA nests shown as red triangles, WISA observations in 2015 as green circles, irregularly spaced road CPB points (open circles with dot inside) were sampled immediately prior to beginning grid search. Orthophoto background from 2004.

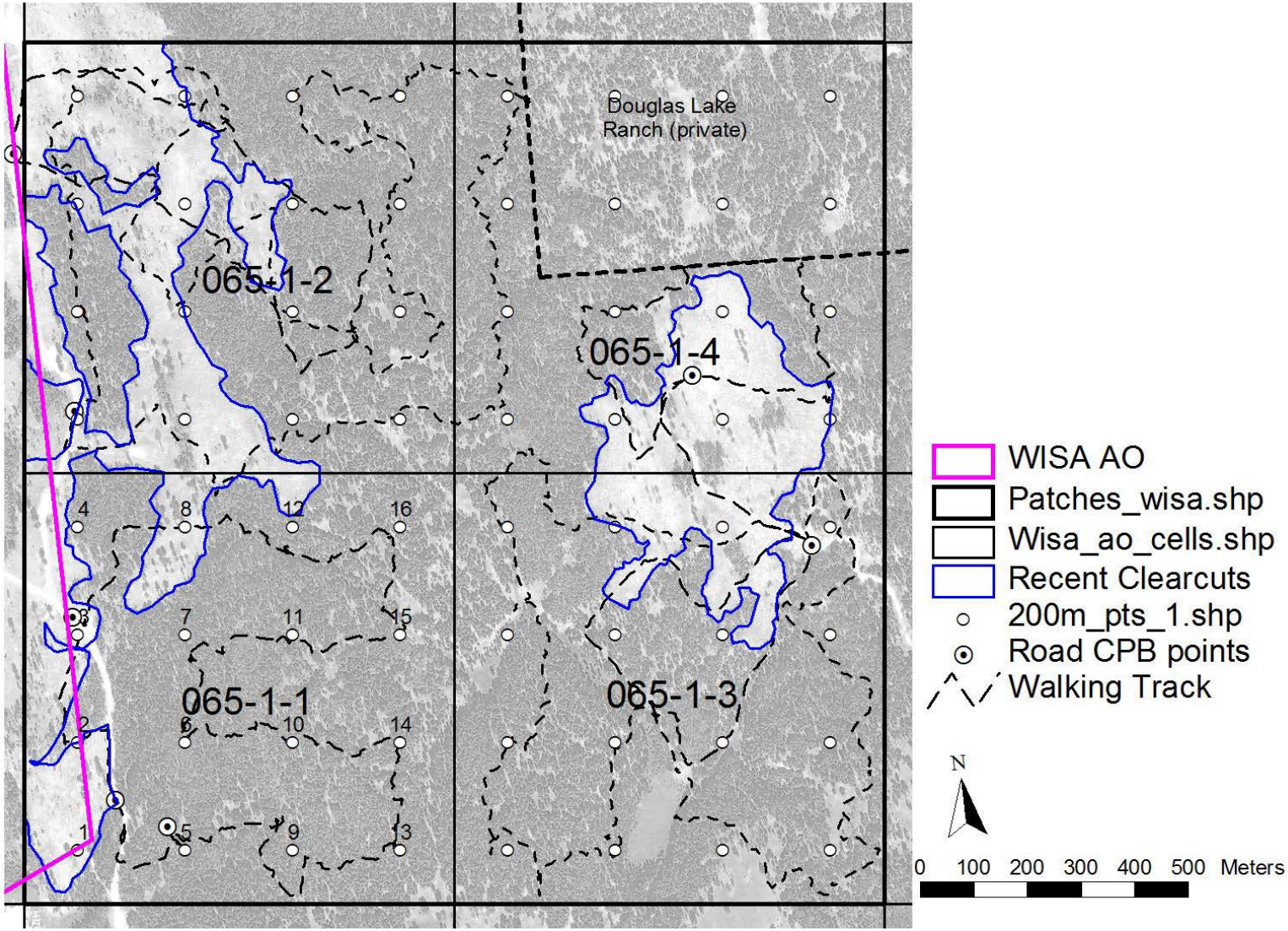

Figure 4. Patch 065-1 showing the 4 cells (065-1-1 to 065-1-4) and the 16 grid points at 200-m spacing in each cell (numbered as shown in cell 065-1-1) used to guide nest searching. No nest searching or sampling was done on private land, which had been clearcut after the 2012 satellite orthophoto background. Road CPB points were sampled immediately prior to beginning nest searches.

I had originally intended to do the habitat sampling while doing the CPB/nest searches as I had done in the East Kootenay in 2009 (Gyug 2009). However, because of the late start to this section of the project, I did not get the habitat protocol organized in time to do so.

Snags, live trees and stumps were tallied in circular plots of differing radius for different diameters (Table 1). In clearcuts or seedtree cuts, the nearest distance to a tree >22.4 cm DBH was recorded that was also within the cut, i.e. not counting trees at or beyond the cut boundary or in Wildlife Tree Patches. Seedtrees generally occur at very low densities that are difficult to estimate reliably with only a few small radius plots. LWD and SWD volumes were measured as intercept diameters on 50-m straight transects which were set at a random azimuth at each sample point using the sample point as the center of the transect. LWD densities were estimated by tallying logs with LED inside a 4-m width on each side of the 50-m transect. The suitability of potential nest trees were determined as per Gyug (2009) with species, wildlife tree class, diameter class and type of wildlife sign recorded. For documentary purposes, four photographs were taken with a 24 mm lens (35-mm equivalent) at each plot facing north, east, south and then west.

To speed up plot measurements, a laser distance measurer was used to check on plot radius as to whether trees, snags or stumps were in or out of plot. A Haglof tree caliper with Gator Eyes was used to determine DBH class of trees or snags without leaving plot center. Where logs were abundant or vegetation thick, the LWD/SWD transect was set out from plot center using a 30-m Spencer logger's tape (self-rewinding). Where logs were scarce and interfering vegetation thin, the azimuth was sighted, the laser rangefinder used to determine 25 m distance on any convenient landmark and then the transect walked and sampled.

Analyses

The results of road monitoring CPB points were adjusted to April 7 using linear regression results of 2012-2014 for the combined West and Okanagan-Boundary AOs and separately for each AO as well. This assumed that the population was stable from 2012-2014, which becomes the benchmark. Trend monitoring analysis using linear regression was applied to the first four years even though this may not be entirely correct as the assumption was that the population did not change from 2012-2014 and the actual numbers have been adjusted for date effects. The necessary effort given the observed Coefficient of Variation (CV = SE/Mean for within year samples) to detect a 10% change in relative abundance over a 10-year period with 90% confidence (alpha = 0.1) and 80% power (1-beta = 0.8) was estimated using software program Monitor (Gibbs and Ene 2010).

Table 1. Plot sizes used to estimate density of live trees, snags, stumps and suitable nest trees in WISA patches, 2015.

Patch	Live Trees					Snags		Stumps		Suitable Nest Trees†
DBH class cm*	**10-15**	**20**	**25-50**	**55**	**60+**	**25+**	**55+**	**25+**	**55+**	**All**
040-1										
Plot radius (m)	5.64	7.98	11.28	11.28	17.84	17.84		11.28	17.84	25.23
Plot Area (ha)	0.01	0.02	0.04	0.04	0.1	0.1		0.04	0.1	0.2
065-1										
Plot radius (m)	5.64	11.28	11.28	17.84	17.84	17.84		11.28	17.84	25.23
Plot Area (ha)	0.01	0.04	0.04	0.1	0.1	0.1		0.04	0.1	0.2
Recommended for plots future in typical IDF forest:										
1 plot/4 ha	5.64	7.98	11.28	17.84	17.84	17.84	25.23	11.28	17.84	25.23
<1 plot/4 ha	7.98	11.28	11.28	17.84	17.84	17.84	25.23	11.28	17.84	30.90

*In each case, the DBH class given in the table is the midpoint. E.g. the 10-cm class includes trees with DBH from 7.5 -12.4 cm, 15-cm class includes trees with DBH from 12.5 – 17.4 cm, 20-cm class includes trees from 17.5 -22.4 cm, 25-cm class includes trees from 22.5 – 27.5 cm, etc.

†If walking a straight line grid, then the grid lines between plots can be used as the suitable nest tree plot using a given width (usually 20 m or more) on either side of the line depending on visibility.

Nest density in the patches/census areas was estimated by dividing the number of active nests by the total area. Any pairs or birds where a nest could not be located were also mapped. The breeding territory size was estimated using a Minimum Convex Polygon around all the detections of a given pair. This could only be used for isolated pairs without any adjacent WISA nests, pairs or single birds.

Habitat parameters estimated included:

- Live tree ≥7.5 cm DBH composition and density,
- Dead tree (snag) ≥22.5 cm DBH composition and density
- Large Woody Debris (LWD)or logs with Large End Diameter (LED) ≥22.5 cm volume, density, and composition
- Small Woody Debris (SWD) or logs with LED 7.5-22.4 cm) volume,
- Stump ≥22.5 cm DSH densities, and
- Suitable nest tree densities,

Tree, snag, stump, CWD and suitable nest tree parameters were estimated using the entire sample first. Then regularly spaced subsets of the sample were checked for consistency of estimates and variance to determine if smaller numbers of plots may still provide reasonable estimates. These were checked for reliability of results using regularly-spaced subsets of points to determine most efficient sampling intensity in different habitats (e.g. typical IDF forest, ST cut).

Any habitat changes since the habitat suitability modeling of 2009/2010 for the patches were analyzed for predicted change in suitability. The habitat suitability and habitat parameters of WISA territories were compared to the remainder of the patches.

Data Management

CPB sampling data was entered into an Excel template designed for submission to the Wildlife Species Inventory (WSI) Species Inventory (SPI) system of the BC Ministry of Environment. This file has been quality checked for formatting and for data entry errors. CPB results and WISA detections were added to the ESRI-format shapefiles used to archive WISA data within this ongoing project. An additional shapefile for census areas was developed and submitted this year so that census area locations and results could be archived. A new format Excel file was developed for recording habitat plot data and results.

RESULTS and DISCUSSION

Road Monitoring

Using linear regression, no significant trend could be shown from 2012 – 2015 ($F_{1,2}$ = 1.46, p = 0.41) (Figure 5; Table 2). The 2015 survey was also well within the prediction limits for both AOs combined (see Figure 2 of Gyug 2014) so that a second round need not have been done to confirm if there had been any significant changes.

Trend power analysis indicated that, for this sample set from 2012-2014 with a within year CV of 3% (Table 2), over a 10-year period there would be excellent power of 0.9 to detect a 10% net change in relative abundance with 90% confidence with only 1 survey per year. Running only 1 survey every second year, the 10% net change would be detected with a power of only 0.7. Running 2 surveys every second year yields power to detect 10% net change over 10 years of ~0.95. Running 2 surveys every year yields power of 0.9 to detect 6-7% net change over a 10-year period. As the CV of each AO was on the same order as the combined sample (Table 2), the same estimations apply to each AO.

I recommend one sampling round of the complete set of 229 road monitoring points each year, preferably in the first week of April so that any adjustment for date effect would be minimal. This can be completed in 4 calendar days (assuming weather cooperates) although some of those days will be 12 or more hours of effort. Depending on resources and capacity, and especially if this can be turned into a volunteer program, annual monitoring is preferable

as it is more likely to be regularly scheduled and is less likely to result in an abandoned plan and orphaned data. Each year, the data should be compared immediately to the prior years, and if significantly outside the 90% prediction limits or if there is a significant downward trend, then a second round of sampling should be conducted as soon as possible to verify this trend in the same year. Should the trend be verified, then further investigation should be undertaken. Relative abundance is correlated with densities determined from nest searches (r^2 = 0.48, P <0.001, N = 30 census areas with at least 10 CPB points each, and each >1.5 km^2 in area) so that a significant change in relative abundance is most likely also a significant change in absolute abundance.

Several WISA have been found nesting in the past few years outside the AO southwest of Merritt. The Princeton road sampling, in particular, and the area southwest of Merritt have shown WISA to be more abundant than previously thought. There is a very good chance that the AO is expanding in these areas into suitable habitat just beyond the mapped AO. For this reason, I recommend extending some early April sampling outside the AO boundaries in potentially suitable habitat as the boundaries of the AO may be changing but this will not be detected if sampling is only inside the AO. Only with some coordinated stratified sampling will we be able to determine if the AO boundaries should be changed.

Extending the April road monitoring points beyond the AO boundaries to determine if the AO is static in extent should be a high priority. The Adaptive Monitoring Framework (Marmorek and Pickard 2010) recommended some sampling up to 10 km outside the current AOs to determine if the AO boundaries were shifting over time but this has yet to be implemented. Incidental WISA records in the Okanagan-Boundary indicate WISA occurs in some areas not sampled or poorly sampled on the surveys prior to 2007 that delineated the AO. To define the most fruitful areas to be sampled within 10 km of the AOs, the habitat suitability model algorithms used within the AOs can be extended outside the current AO boundaries in a desktop GIS exercise. This has already been done for the West AO (Figure 5 of Gyug 2010) but would need to be completed for the Okanagan-Boundary (estimated time 2 days). Estimated field effort would be 10-20 team days depending on available funds.

Patch Nest Searches

One WISA pair was detected in Patch 040-1 on June 13, 15 and 20 (Figure 3). The active nest with young heard inside and the parents actively feeding the nestlings was found on June 15 (WNK045 UTM 11 321114 5451743). The members of this pair were detected both in response to CPB and spontaneously calling or drumming on many occasions on those days. No other WISA were detected in the patch. Minimum Convex Polygon breeding territory size was 29.56 ha. Nest density in this patch was 0.39/km^2.

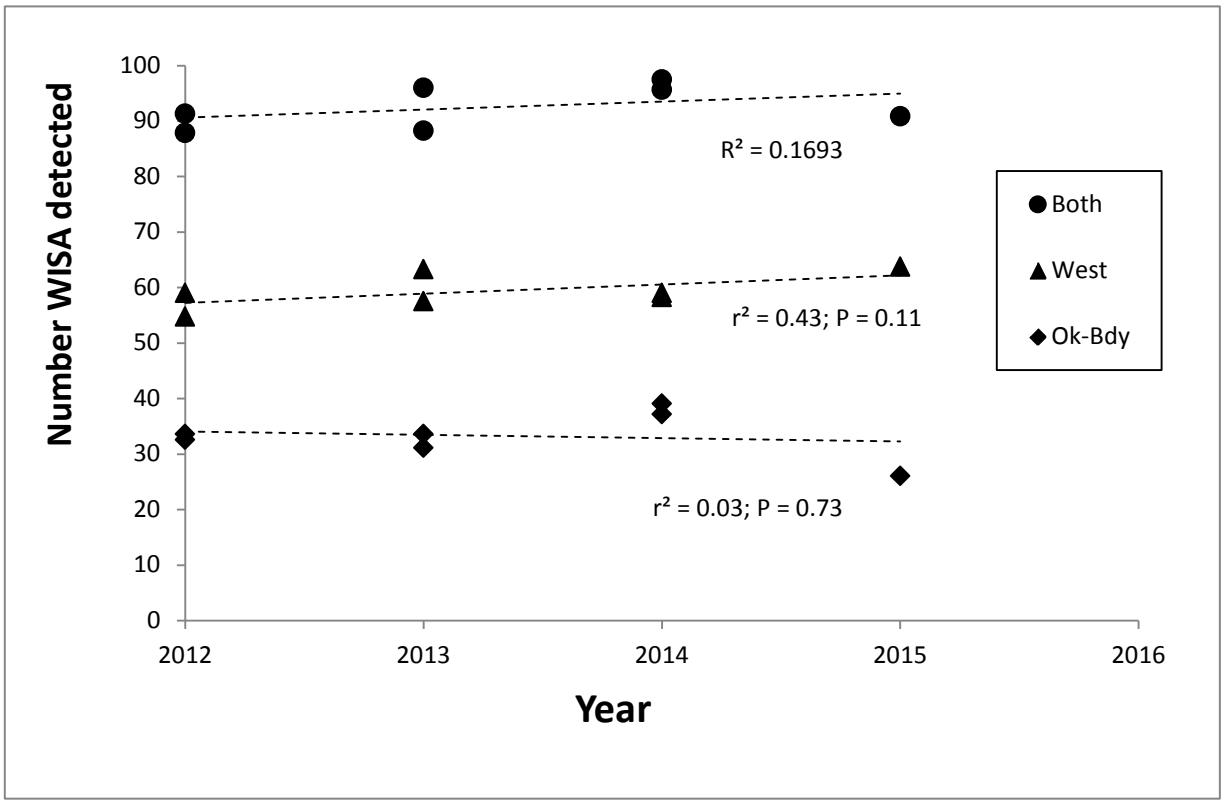

Figure 5. Number of Williamson's Sapsuckers detected on road sampling points in April adjusted for date effect to April 7. Raw data for this graph is in Table 2.

Table 2. WISA detected on April Road Monitoring CPB Points, 2012-2015.

Year	Sampling Dates	Mean Date (April 1 = 0)	Number WISA Detected	Adj. to Apr. 7*	Within Year CV% (SE/Mean)
Both Combined (n = 213 CPB pts)					
2012	April 4-9	5.5	89	87.9	1.92
	April 17-21	18	83	91.3	
2013	April 3-5	3	99	96.0	4.19
	April 8-14	10	86	88.3	
2014	March 31-April 3	1	102	97.5	0.95
	April 29-May 1	29	79	95.6	
2015	March 31-April 3	1.5	85	90.8	NA
	Mean			92.5	2.35
West AO (n = 140 CPB pts)					
2012	April 5-9	6.5	55	54.8	3.73
	April 18-21	19	53	59.0	
2013	April 4-8	5.5	64	63.3	4.76
	April 8-14	10	56	57.5	
2014	March 31 - April 3	1.5	61	58.3	0.63
	April 30	29	48	59.0	
2015	March 31 - April 3	0.5	67	63.8	NA
	Mean			59.4	3.04
Okanagan-Boundary AO (n = 73 CPB pts)					
2012	April 4-7	5.5	34	33.6	1.61
	April 17	16	30	32.5	
2013	April 3	2	35	33.6	3.83
	April 10-12	11	30	31.1	
2014	April 1	0	41	39.0	2.47
	April 29-May 1	29	31	37.2	
2015	April 1	0	28	26.0	NA
	Mean			33.3	2.64

*Total detections were adjusted to April 7 by the slope of the regression equations as follows:

Both Combined: -0.7556 * (7 – date) + number WISA detected
West AO: -0.4995 * (7 – date) + number WISA detected
Okanagan-Boundary AO: -0.2798 * (7 – date) + number WISA detected

At no time were any other WISA detected responding to the calls and drums of the single known pair in 065-1. One other WISA was detected spontaneously drumming on June 20 just outside the north boundary of the patch. The only prior nest known from this patch was nest WN040 known to be occupied in 2003, 2006 and 2007 in the dead limb of a live ponderosa pine. There were no WISA in the vicinity of this nest tree in 2015.

No WISA were detected in Patch 065-1 on June 12, 14 and 30. After concluding the first round of 200-m grid patch sampling on June 14, to confirm that WISA were still active in the general area, I did a CPB at a nest site known to be active in 2012 that was 300 m south of the patch. A WISA responded in <1 minute from that site. I concluded that there were no nesting WISA in Patch 065-1 in 2015, and no active territories of any sort by mid-June although I do not know if any WISA were active in this patch earlier in 2015. Two active Red-naped Sapsucker nests were found in this patch.

Habitat Parameters

Generally the habitat parameters were approximately as expected in WISA habitat (Table 3). Live tree (>17.4 cm DBH) density was <300 stems/ha. Very large tree (>52.4 cm DBH) densities were higher than average for 040-1 (16/ha) but average for 065-1 (7/ha).

The forested portions of 040-1 were dominated by Fd (67% of live trees >17.4 cm DBH) with lower proportions of Py (18%), Lw (10%), Sx (3%) and Pl (1%). The forested portions of the WISA breeding territory had a very different live tree species composition being dominated by Lw (47%), also containing Sx (22%), Fd (16%), Pl (8%) and Py (4%). In 065-1, overall live tree species were dominated by Fd (74%), followed by At(9%), Sx (9%), Py (4%) and Pl (3%). There were no WISA breeding territories present for comparison.

Stumps were difficult to tally accurately. In recent cuts harvested between 1996 and 2000 in 040-1, many stumps had been overgrown by bearberry and were no longer visible. Sufficient time was not available to try to count them reliably. In both patches, most stumps had disintegrated to where they were not suitable as ant habitat or had virtually disappeared in partial cuts or high-graded cuts harvested sometime between the 1950's and 1970's. Therefore stump counts in older forests will not be a reliable indicator of former stump densities shortly after cutting. If we wish to analyze stump density as a critical factor for WISA suitability and ant nest density, then more plots need to be done and the time taken to quantify presence and condition.

Densities of live trees and volume of SWD were fairly well estimated with a CV in the range of 10% or less by the plots (Table 3). However, CV was poorer for all parameters that were less dense such as very large trees, snags, stumps and LWD.

Table 3. Habitat parameters for WISA patches sampled in 2015. Means are followed by CV as % of Mean.

Patch/Habitat	N plots	Size Range*	Density							Volume	
			Live Trees			Snags		Stumps		LWD	SWD
			17.5-22.4	22.5-52.4	>52.4	22.5-52.4	>52.4	22.5-52.4	>52.4	>22.4	7.5-22.4
040-1	64		60.9 15%	114.5 10%	15.5 15%	3.4 42%	1.6 96%	39.5 82%	14.5 19%	42.6 29%	16.1 12%
Forest	53		77.6 12%	147.4 7%	19.7 13%	4.5 35%	2.0 86%	17.9 101%	15.2 19%	42.0 24%	14.1 13%
ST Cut	10		7.1 47%	1.8 43%	2.1 20%	0	0	107.1 42%	13.2 15%	47.8 40%	22.5 11%
Partial Cut	1		0	75	0	0	0	150	0	0	21
065-1	29		53.5 13%	131.9 11%	6.6 19%	13.1 30%	1.7 104%	25.9 97%	8.2 26%	76.2 26%	22.8 9%
Forest	18		83.4 8%	201.4 6%	9.4 16%	20.0 22%	2.8 78%	12.5 98%	12.2 21%	81.5 24%	21.9 10%
ST Cut	10		5.0 26%	17.5 21%	1.0 32%	2.0 43%	0	50.0 78%	0	16.8 22%	29.7 5%

*Size Range refers to DBH for trees and snags, DSH for stumps, and LED for logs (LWD and CWD)

Stepping down by using regularly spaced subsets of plots, showed that even small numbers of plots (e.g. 16 instead of 64) performed fairly well at estimating live tree densities where estimates were always within 7% of the full estimate. These trees were abundant and counted on all forested plots. If only live tree density is required, then very few plots are needed.

Using smaller subsets of plots for other parameters showed much higher relative divergence from the full estimate (Figure 5). For snags, step down estimates of density using up to 16 plots were within 13-28% of the full estimate. For very large live trees (>52.4 cm DBH), step down estimates of density were between 17 and 67% of the full estimate. For volume of LWD, step down estimates were within 20-34% of the full estimate. Where any of these factors are likely to be critical to an analysis, then a full set of 64 plots (16/cell) at 200-m spacing, or 1 plot/4 ha, is recommended. Many of these plots could be undertaken along with CPB sampling or nest searching as in Gyug (2009). However, some time would need to be added for plots which were not actually visited during the CPB sampling or nest search phases.

Estimating live tree densities in seed tree or partial cuts is problematic using small plots as trees are very sparse, often at densities <10/ha. Live tree densities >22.4 cm DBH in these cuts were estimated at 4.2/ha in 040-1 and 3.0/ha in 065-1. These were based on only 4 trees counted in 14 plots in 040-1 and only 3 trees in 10 plots in 065-1. However, I had added 5 random plots in 065-1 to get a higher sample size in that habitat. Using nearest individual distances on each plot, there is 1 tree counted per plot, so the density is based on a much higher number of trees and more likely to be more reliable. Estimated seed tree density using this method in 040-1 was 8.1/ha and in 065-1 was 2.6/ha. It is recommended that this method be used in conjunction with plots in seed tree cuts to increase reliability of results. Other methods using nearest neighbour or point-centred-quarter methods are certain to be more reliable (Engeman et al. 1994) but require many more trees to be counted which could significantly increase time per plot.

WISA Habitat Suitability

As previously discussed, most of 040-1 was dominated by Fd but the WISA breeding territory (Figure 7) was dominated by Lw. Live tree densities were similar outside the WISA breeding territory (199/ha) and inside the territory (230/ha). Those densities were averages including seedtree and partial cuts, which were weighted by area inside the WISA territory as plots did not sample each habitat evenly within this smaller area. Density of very large live trees >52.4 cm DBH was much higher inside the WISA breeding territory (57/ha) than outside (14/ha). Using a different diameter cutoff, density of very large live trees >57.4 cm DBH were still higher inside the WISA breeding territory (18/ha) than outside (10/ha). Density of snags (5.2 vs 5.3/ha) and volume of LWD (32 vs 44 m^3/ha) were similar both inside and outside the WISA breeding territory.

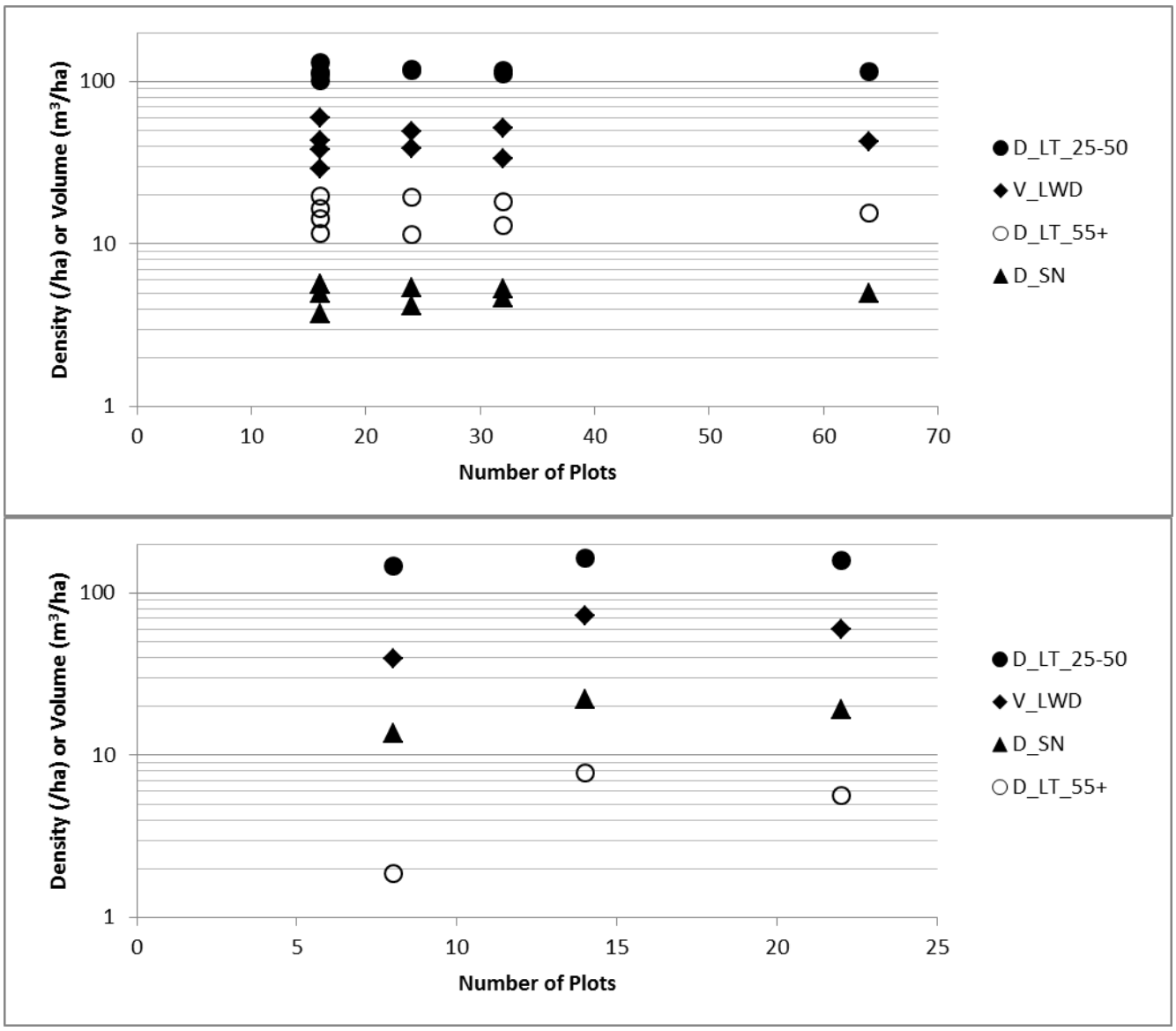

Figure 6. Selected habitat parameters for Patch 040-1 (top) and 065-1 (bottom) showing estimated results using regularly-placed grid subsets of the complete set of plots. Note that y-axis is logarithmic scale.

D_LT_25-50 is live tree (22.5-52.4 cm DBH) density.

D_LT_55+ is density of live trees >52.4 cm DBH.

V_LWD is volume of Large Woody Debris (LED >22.4 cm).

D_SN is snag density for all snags >22.4 cm DBH.

The Moderate suitability habitat through the center of the WISA breeding territory (Figure 7) is an old-growth stand dominated by Lw veteran trees estimated at 300-600 years of age along Wolf Creek. This narrow stand has never been logged. All the upland areas around, excepting to the northeast, have also been partially logged in the 1950's or 1960's or more recently logged in the 1990's. This area was modeled as Moderate because it was mapped as <190 years old in the forest cover/VRI mapping. However, after field inspection, this polygon should be mapped as >200 years old. This polygon within the WISA breeding territory and to the northwest is actually High suitability habitat with dense (>20/ha) very large Lw >57.4 cm DBH.

The remainder of the large amorphous Moderate polygon immediately to the west is part of the Wolf Creek draw and to the northwest is an upland area. These areas were all logged in the 1950's or 1960's. This area has a lower density of remnant veteran trees >57.4-cm DBH (10/ha vs 20/ha) and is dominated by Fd (79% of live trees) rather than Lw (5% of live trees). This polygon would be correctly mapped as Moderate suitability. This area has been occupied in the past with nest WN040 known to be occupied in 2003, 2006 and 2007 but was not occupied in 2015.

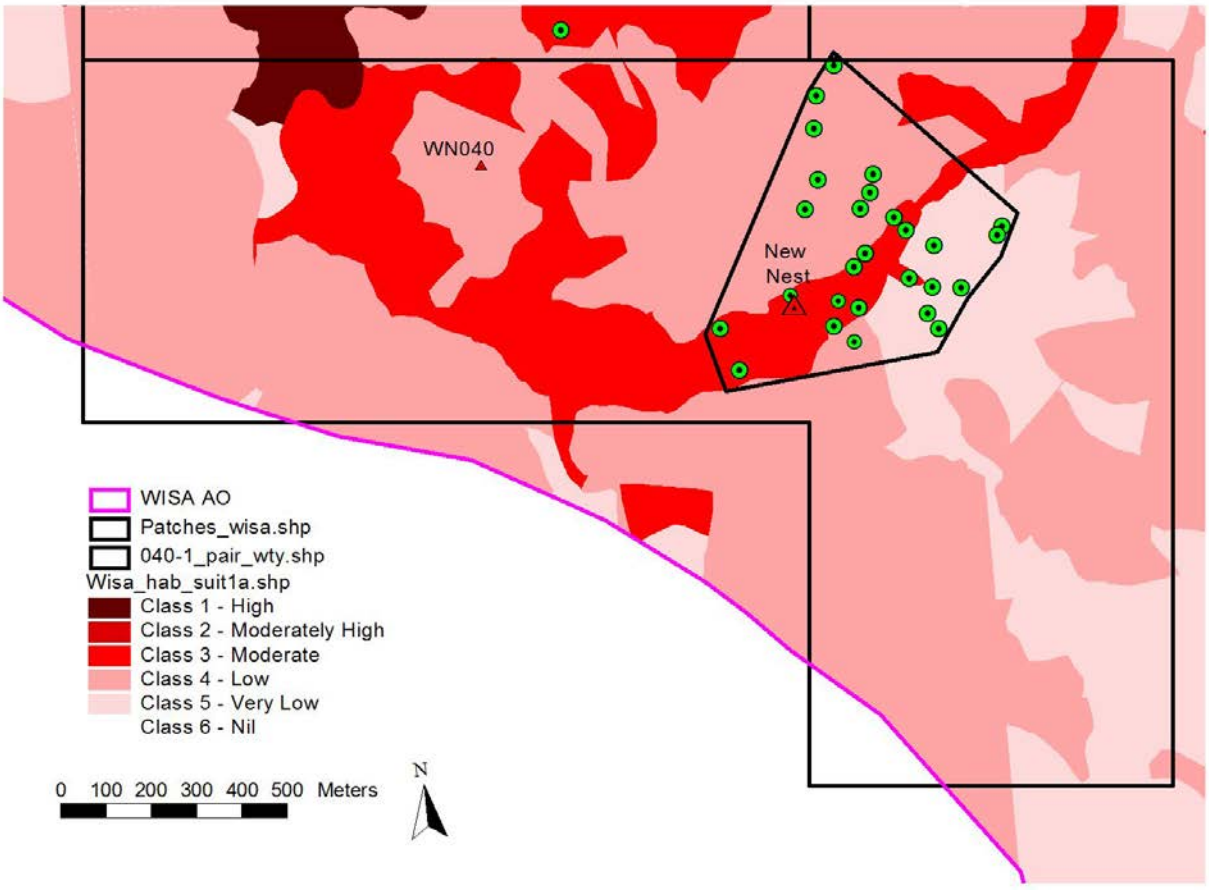

Figure 7. Patch 040-1 in the Okanagan-Boundary showing WISA habitat suitability mapping and WISA breeding territory Minimum Convex Polygon with WISA locations (green dots) and the nest tree (red triangle) shown.

Within the WISA breeding territory of 040-1, a plot spacing of 200-m giving (1 plot/4 ha) was barely adequate to describe the habitat of this relatively small area and contrast with the remainder of the patch as there were very few plots within the WISA territory. If comparing the WISA breeding territory to the surrounding habitat was the object of the analysis, the WISA breeding territory should be sampled more intensively with more sample points inserted to provide a more reliable comparison.

In Patch 065-1, 50 ha of the 256-ha patch had been logged from 2005-2012 and had not been included in the habitat suitability mapping (Figure 3). This did not include the 27 ha of Douglas Lake private land at the northeast corner which had also been very recently logged since 2012. In total, 30% of the habitat in this patch has changed significantly since habitat mapping.

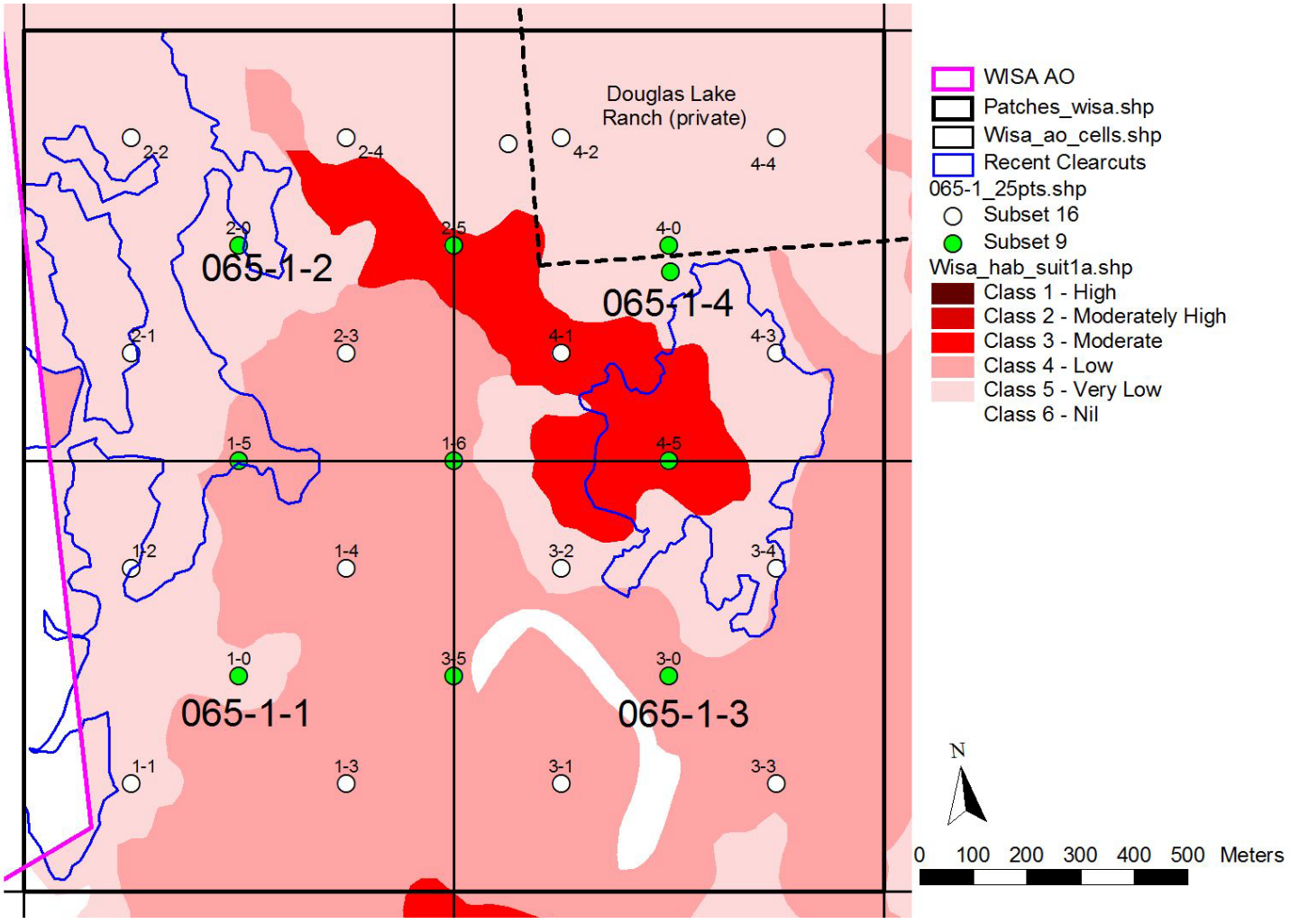

Figure 8. Patch 065-1 showing the 4 cells (065-1-1 to 065-1-4) and the habitat sampling set of 25 points set as in Figure 2C. Points 4-0 and 4-2 were shifted by 50 and 100 m respectively to be on Crown land. Point 4-4 was not sampled.

With one exception, these cuts would not alter the suitability mapping because they overlap with habitat mapped as Very Low. The exception is the large Moderate polygon in the upper right of the patch (Figure 8). The southeast part of this polygon had been logged recently. While veteran Py were not logged, pine beetle has since killed most of them. Two of these were two of the three only suitable nest trees counted in the plots (the other was an aspen elsewhere). This polygon was mapped as Moderate because there was a veteran layer of Fd and Py at 4% by crown closure. However, field inspection shows all the Py to be concentrated in the logged portion with the remainder in a deep gully where the large trees are either Sx or Fd. The remainder of this polygon essentially lacks Py, has almost no At, and would be mapped as Very Low.

The example of Patch 065-1 in particular shows the need to update habitat suitability mapping to reflect many new cutblocks and the widespread effects of pine beetle and salvage logging, particularly in the West AO where 24% of the patches show some habitat changes since mapped (Gyug 2014). The example of Patch 040-1 also shows how the suitability of polygons may be underrated by using the VRI-estimated ages which are of limited reliability and which may typically be underestimated when the stand is dominated by veteran Lw. This type of error is hard to correct without field inspections, which are not feasible to conduct over the entire AO.

However, before updating habitat suitability mapping, first I recommend examining the results of the current WISA radio-telemetry program for inclusion in a possibly more efficient habitat suitability model that models nesting and foraging suitability separately. This could be tested on the >100 new nest locations gathered since 2009. Aerial photo surveys of the WISA AO have not been undertaken by the Ministry of Forests, Lands and Natural Resource Operations since 2004-2005. Habitat mapping need not wait for new aerial photos as more recent 2012 1-m pixel digital satellite photos can verify habitat changes and are available commercially or from internet map sources. At the very least, 15-m pixel Landsat 8 images that are taken year round at 16-day intervals can confirm gross habitat changes.

Recommended Intensive Patch Protocol

If sampling can be done early in the season prior to mid-May, then recommended is 400-m CPB spacing (Figure 2B; 4 points per cell, 16 points per patch) including habitat plots while doing CPB. Wherever WISA are found in patches, initiate a nest search requiring 2-3 visits in late May through June depending on breeding timing in that particular season. Do additional "fill-in" habitat plots at per Figure 2C in June or later to make minimum of 25 plots per patch. Insert additional random plots in any areas receiving inadequate coverage (≤5 plots) such as recent ST cuts, high suitability habitat or WISA breeding territories.

If sampling is delayed until after mid-May, use 200-m CPB spacing (Figure 2B) in late May or June including habitat plots while doing CPB. Wherever WISA are found in patches, initiate nest searches immediately which may require follow-up visits through June.

SUMMARY of RECOMMENDATIONS

1. Continue one round of annual road monitoring in early April of the 229 CPB pts on public roads open all year round using trend analysis annually. If the result of this single survey round is outside the predicted 90% limits of the regression of Figure 2 of Gyug (2014) or if a significant trend is found, then the entire survey round should be repeated as soon as practicable. If still outside the predicted limits, then further investigation will be required to determine the cause of the change in relative abundance.

2. WISA relative abundance monitoring of the entire AO, i.e., in addition to the annual road monitoring, should continue to be in patches, i.e. groups of 3 or 4 800-m x 800-m cells sampled with 1 CPB point each. This need not be done annually but only when perceived changes in habitat suitability or relative abundance warrant, or on a schedule that has yet to be determined.

3. Based on the two trials here, when or if intensive sampling of the patches to confirm habitat suitability or abundance changes is undertaken, nest searches to census selected patches should be undertaken as per recommendations outlined in the text. Estimated time per patch is 6 field days by a team of either one or two surveyors.

4. Extend the April road monitoring points beyond the AO boundaries to determine if the AO is static in extent. Estimated effort would be 10-20 field days by a team of either one or two surveyors. To define the most fruitful areas to be sampled within 10 km of the AOs, the habitat suitability model algorithms of 2009-10 can be extended outside the current AO boundaries in a desktop GIS exercise (2 days).

5. Updated habitat suitability mapping reflecting new cutblocks and the widespread effects of pine beetle and associated salvage logging is recommended once the WISA radio-telemetry program is finished. The radio-location data should be examined for inclusion in a more efficient habitat suitability model. Habitat mapping need not wait for new aerial photos by the Ministry of Forests, Lands and Natural Resource Operations as recent 1-m pixel or 15-m pixel satellite imagery is available commercially or from internet mapping sources to verify habitat changes.

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