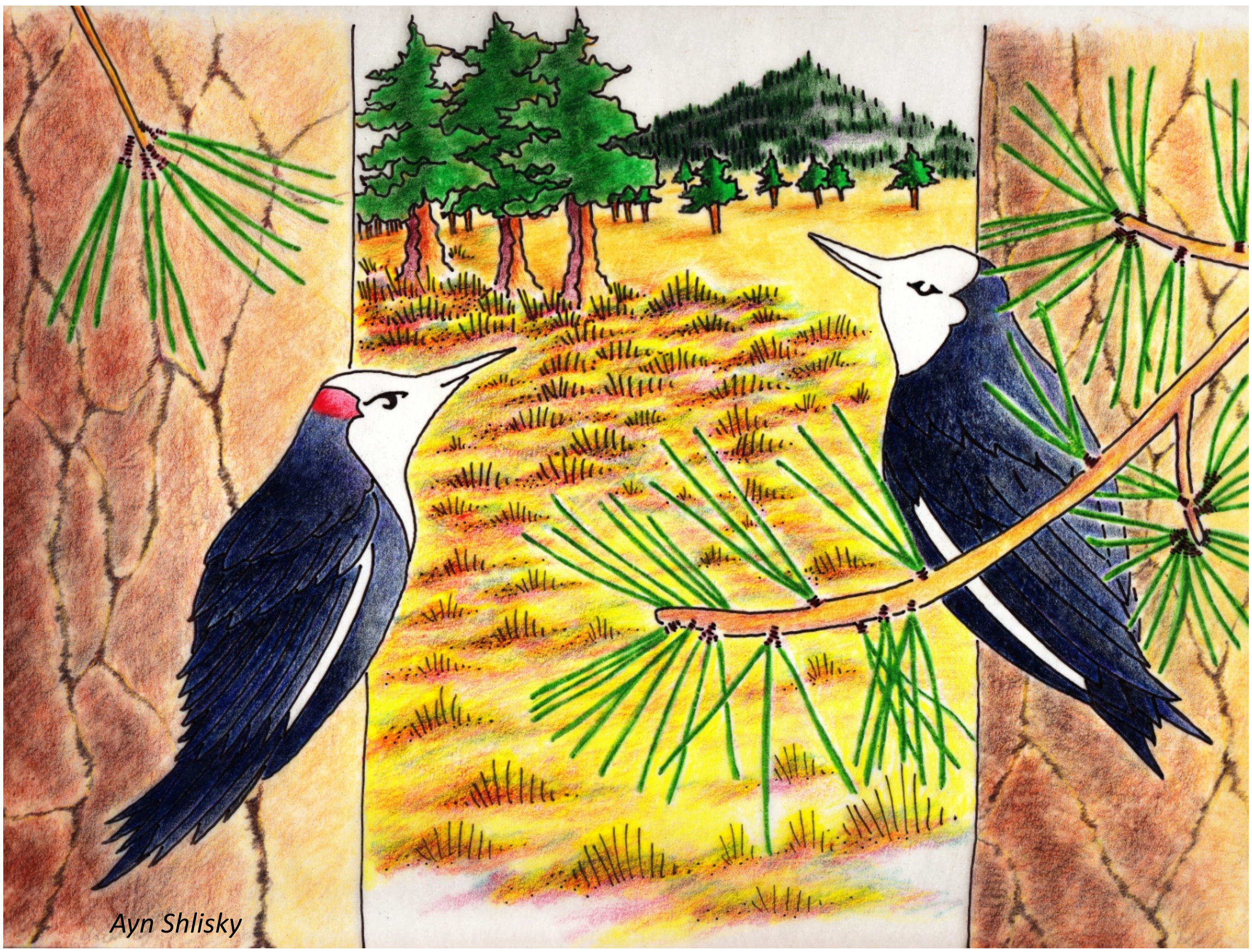
White-headed Woodpecker Monitoring

Pacific Northwest Region
Rocky Mountain Research Station
USDA Forest Service

Annual Monitoring Report - FYs 2013 and 2014



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Introduction

The white-headed woodpecker (WHWO) is a Regional Forester's sensitive species in Region 6 (R6) of the USDA Forest Service (USFS). The WHWO has also been identified as a focal species, or indicator species, for mature dry forests based on its strong association with open, dry forest habitat, and its dependence on mature ponderosa pine. WHWO feed primarily on ponderosa pine seeds during fall and winter, and mature trees produce more abundant and reliable seed crops.

Populations of WHWO are thought to be declining in the Pacific Northwest. In a Central Oregon study, reproductive success of WHWO was too low to offset adult mortality, thus the population declined to the point that occupancy of known territories steadily decreased over the 6-year study period (Frenzel 2004). Research in the Blue Mountains in the late 1970s and early 1980s found the birds to be relatively common, whereas research conducted in the early 2000s in the same areas found no WHWO (Altman 2000, Bull 1980, Nielsen-Pincus 2005).

Mature, open, dry forests (primarily ponderosa pine) have declined more dramatically than any other forested ecosystem in the Interior Columbia Basin (Wisdom et al. 2000). The Interior Columbia Basin Ecosystem Management Project (ICBEMP) found WHWO was one of only 8 of the 97 species analyzed that showed strong declines in habitat (>60% decline from historical conditions). WHWO also use large snags (primarily ponderosa pine) for nesting and roosting, and according to ICBEMP, large snag amounts have declined across the basin compared to historic amounts (Korol et al. 2002). Currently, these forests continue to be at high risk due to drought stress on mature pine, insect outbreaks, and uncharacteristically severe wildfires. Climate change is likely to exacerbate the risk.

Most of the R6 USFS restoration treatments occur in these dry forest types. Restoration is designed to reduce stand density, open up canopies, and reduce ground fuels to more closely resemble historical, sustainable conditions. Active management treatments are necessary to reduce the risk of losing the remaining mature, dry forests to uncharacteristically severe wildfire events. However, treatments have the potential to either have beneficial or negative effects on WHWO habitat. With some treatments a potential loss of large ponderosa pine trees and snags exists, especially with the use of prescribed fire. Large pines, in particular, are critical structural components of this ecosystem and take centuries to re-create. These components are important characteristics of mature, dry forests, which provide habitat for species associated with these ecosystems. In addition, fuels treatments that reduce shrub and down wood cover may reduce populations of small mammals (Smith and Maguire 2004), which are the main nest predators of WHWO (Frenzel 2004). Nest success of WHWOs is higher at nest sites with lower shrub cover (Frenzel 2004, Kozma and Kroll 2012).

Methods

The Monitoring Strategy

A WHWO monitoring strategy was developed for dry forest habitats. R6 has worked closely with RMRS to develop the strategy. The regional monitoring strategy focuses on:

- Broad-scale occupancy monitoring - designed to provide reliable, standardized data on the distribution, site occupancy, and population trends for WHWO across their range in Oregon and Washington.
- Treatment effectiveness monitoring – designed to assess effectiveness of stand-level treatments on WHWO occupancy and reproductive success.
- Validation monitoring – designed to validate nesting HSI models developed by RMRS and the resulting maps of habitat suitability across WHWO range in Oregon and Washington.

The purpose of the strategy is to provide guidelines and protocols for inventory and monitoring of WHWO on FS and USDI Bureau of Land Management (BLM) lands in Oregon and Washington. The strategy is designed to ensure consistent and scientifically credible sampling, data collection, and analysis protocols used by the agencies in WHWO inventorying and monitoring activities. The strategy and protocol are designed to meet standards required under the Data Quality Act.

The monitoring strategy and the protocols were developed using peer reviewed guides and protocols (Dudley and Saab 2003, Manley et al. 2006, Vesely et al. 2006). The guides and protocols used were developed by experts in ecological principles and biostatistics. This strategy was developed in consultation with WHWO species experts, research scientists, and biostatisticians.

Data analysis is conducted in coordination with Rocky Mountain Research Station (RMRS).

Broad-Scale Occupancy and Distribution Monitoring

This protocol is designed to provide reliable, standardized data on the distribution and site occupancy for WHWO across their range in Oregon and Washington. The data can be used to better define habitat associations of WHWO at the stand and landscape scales in the 2 states. Once base data are obtained, this protocol can be used to monitor change in the distribution and occupancy of WHWO.

The protocols for the occupancy and distribution monitoring are based on Management Indicator Species (MIS) survey protocols for WHWOs developed for the Payette NF in Idaho (Wightman and Saab 2008). The basic sample design is a point count/playback response survey at 10 points along 2700-meter transects established within potential habitat for WHWO. Two surveys are conducted beginning as early as April 20 with the 2 visits completed by July 7 (Wightman et al. 2010). Surveys start just after dawn and are to be completed by 11 am.

The standards for precision for WHWO were set at the ability to detect 20% change in occupancy with a statistical confidence and power of 80%. Higher statistical confidence would reduce power to detect change. The worst-case scenario of failure to detect change could be failure to intervene which could ultimately result in species extirpation.

Based on 2010 Pilot Data, 30 transects were established across the region (Figure 1). Transects receive 2 repeat visits per year, based on detection probabilities calculated from 2010 Pilot data.

Vegetation data are collected at each WHWO survey station along transects. One third of transects are sampled for vegetation each year. Vegetation sampling protocols are modified from those used for the Birds and Burns project (Saab et al. 2006), from Bate et al. (2008a, 2008b), and Keane and Dickinson (2007). The sample design uses variable radius rectangular plots, and/or transects to sample trees, snags, down wood, and shrubs. Canopy cover, slope, aspect, and topographic position are derived from remotely-sensed data (e.g., USGS and GNN).

Treatment Effectiveness Monitoring

This protocol is designed to provide reliable, standardized data on the effectiveness of treatments to restore or enhance habitat for WHWO, and the impacts of treatments with other objectives (e.g., fuels reduction, salvage logging) on WHWO across their range in Oregon and Washington. The data can be used to better define habitat associations of WHWO, and to design treatments at the stand and landscape scales in the 2 states.

Specifically, this protocol is designed to answer the following questions:

- Do WHWOs occupy treated stands in the same proportion to untreated (control) stands?
- Is the reproductive success of WHWO in treated stands different than WHWO using untreated stands?
- What are stand and landscape attributes of areas used by successfully reproducing WHWOs versus unsuccessful sites?

Occupancy of stands by WHWO is determined using point count/playback stations along transects using the same techniques as for the broad-scale occupancy monitoring. Nests are located during systematic nest surveys conducted within 200 m (656 ft) of the transects, across treatment and control units (Dudley and Saab 2003). Nests are monitored during multiple visits until it is determined if the nest was a failure or a success. A successful nest is one where at least 1 young fledges from the cavity (i.e. a feathered nestling leaves the nest cavity on its own).

Vegetation data are collected at nest locations and non-nest random stations that are placed 300 m apart in both treatment and control units. The vegetation sampling uses the same plot design as for the occupancy monitoring described above.

A BACI (before-after/control-impact) study design is the preferred monitoring design. In this design units are sampled before and after a treatment in both treatment and control units. Monitoring of treatment and control units should continue for at least 3 years post-treatment. Pre-treatment monitoring should occur for at least 1 year prior to treatment.

A BACI approach is not always possible. In those cases a retrospective monitoring design can be implemented in which treatment and control units are monitored only after the treatment has occurred.

Validation Monitoring

Habitat suitability models have been developed for nesting WHWO in unburned and post-fire forests by the Rocky Mountain Research Station (Hollenbeck et al. 2011, Wightman et al. 2010, Latif et al. 2015). A leave-one-out cross validation approach was used to confirm model performance of the models, however, validation and refinement still should be done with an independent data source. In addition, the predictive ability of the models will be lower in landscapes outside of the model origin area, thus the models need to be refined for other areas outside central and southeast Oregon. New data on additional known WHWO nesting locations in both burned and unburned landscapes are needed to accomplish model refinement and validation for other areas. Validation and refinement of the unburned forest model is a priority due to the applicability to assessing and prescribing fuels reduction activities. Validation of the post-fire model is a lower priority at this time.

Specific objectives of the model validation monitoring are:

- Assess and refine applicability of current WHWO models to other landscapes across Oregon and Washington.
- Validate the model for unburned forests with known WHWO nesting locations to better understand the predictive ability of the model.
- Verify and refine the utility of using a presence-only niche modeling approach for management purposes.

Survey transects are established in study areas using the methods described for Broad-scale Distribution and Occupancy Monitoring. Nests are located by searching an area within a 400 m radius of any WHWO detection. Nest monitoring protocols are the same as for the Effectiveness Monitoring protocols. Data collected for WHWO nests through Effectiveness Monitoring protocols can also be used to calibrate and validate the habitat model for unburned forests.

Vegetation data are collected at nest locations using the same plot design as for the other types of monitoring as described above.

Results

Accomplishments prior to FY13

Broad-scale occupancy monitoring

- Development of survey protocols
- Pilot survey in 2010
- 30 survey transects identified and established across eastern Washington and Oregon (Mellen-McLean and Saab 2012)
- 1st and 2nd years of 6-year monitoring strategy completed

Treatment effectiveness monitoring

- Sisters Ranger District – conducted by Ranger District employees
- A modified regional protocol was implemented on Naches, Entiat and Cle Elum Ranger Districts to gather "pre-treatment" data for the Forest Restoration Strategy implementation.
- Development of monitoring protocols

Validation monitoring

- Publication of 2 habitat suitability models (Wightman et al. 2010, Hollenbeck et al. 2011)
- Validation using Sisters RD nest locations – 2010
- Validation using FRE-WIN nest locations – 2011
- Beginning development of refined HSI models – 2012 (Latif et al. 2012)

FY13 and 14 Accomplishments

Broad-scale occupancy monitoring

In both 2013 and 2014, playback surveys were conducted twice on each transect. Vegetation measurement data were collected on 1/3 of transects each year such that initial measurement of all transects was completed by 2013. Re-measurement of vegetation plots began in 2014 with a reduced list of data characteristics collected unless a disturbance had occurred since the first set of vegetation data were collected; data were only collected on trees, snags, and down wood. Data were entered into PDAs and then transferred to a relational database in the office.

2013: Of 586 visits to survey points, WHWO were detected 70 times on 18 of the 30 transects. Fifteen WHWO were encountered along transects, but outside the protocol. Three nests were also located adjacent to transects.

2014: Of 600 visits to survey points, WHWO were detected 48 times on 17 of the 30 transects. Seven WHWO were encountered along transects, but outside the protocol. Two nests were also located adjacent to transects.

Table 1. White-headed woodpecker (WHWO) detections on survey transects from 2010 to 2014.

Year	2010 – Pilot[1]	2011	2012	2013	2014
WHWO detected	31	36	53	70	48
Total points surveyed [2]	333	600	600	586[3]	600

[1]2010 was a pilot year. The transects used were different than those measured in 2011-2104 as part of the regional effort

[2] Each point was visited 3 times in 2010 and 2 times in 2011, 2012, 2013, and 2014; numbers reflect number of individual surveys.

[3]Some plots were not surveyed twice due to active timber sales at the plots during the 2nd visit.

Data from the FY 12 field season were entered in to the NRIS Wildlife database. Data from FYs 13 and 14 are currently being entered into NRIS.

RMRS analyzed the first 3 years of data using an occupancy model fitted to data from the 30 transects established for regional monitoring. The fitted model estimated both transect- and point-scale (individual points along transects) occupancy probabilities. There were no statistically supported trends in occupancy probabilities at either scale from 2011 to 2013.

A basic analysis of the vegetation data collected from 2010-2013 was conducted using descriptive statistics and t-tests to compare tree and snag densities between occupied points (points where WHWO were detected at least once; n=131) and unoccupied points (points where WHWO were never detected; n=277). Results indicated that mean density of smaller trees (25-50 cm (10-20 in) dbh) was less at occupied points (34.7/acre) than unoccupied points (40.9/acre) (P=0.006), and mean density of large trees (≥50 cm (20 in) dbh) was higher at occupied points (9.2/acre) than unoccupied points (8.1/acre) (P=0.07). These findings are consistent with previous findings on WHWO habitat use. Density of smaller snags (25-50 cm (10-20 in) dbh) is less at occupied points (2.8/acre) than unoccupied points (4.0/acre) (P=0.007). Densities of larger snags (≥ 50 cm (20 in) dbh) were not significantly different between occupied points (1.1/acre) and unoccupied points (1.1/acre) (P=0.50).

RMRS also modeled habitat relationships with point-scale occupancy using occupancy models within a regression context (Gelman and Hill 2007). Notable associations included a U-shaped relationship with local-scale canopy cover, a positive relationship with density of large ponderosa pine trees and snags, and a negative relationship with density of small or medium trees. The model predicted highest point-scale occupancy probabilities at relatively low and high canopy cover (U-shaped relationship), low medium-tree density, high large-snag density, and high large-ponderosa pine density.

Future analysis of the occupancy data will focus on the ability to identify WHWO population trends. Analysis will examine the ability to detect trends using current methods. Simulation modeling will also be used to compare alternative analysis approaches and sampling schemes for different possible population trend scenarios.

Treatment effectiveness monitoring

In addition to the Regional transects, some forests and districts conducted surveys using the R6 effectiveness monitoring protocols (Mellen-McLean et al. 2013), through Collaborative Forest Landscape Restoration Projects (CFLRPs). RMRS, R6, and R4 are leading the effort to provide consistency in monitoring the effectiveness of CFLRP treatments at reducing fuels and restoring dry conifer forest habitats of the Interior Northwest. Monitoring is a key component of the CFLR program and our work is designed to address how well CFLRPs are meeting their forest restoration and wildlife habitat conservation goals. Monitoring in CFLRPs contributes to the regional efforts to monitor effectiveness of silvicultural and prescribed fire treatments for white-headed woodpeckers throughout their range in Idaho, Oregon and Washington. Monitoring for treatment effectiveness in improving WHWO habitat is currently occurring on the Weiser-Little Salmon headwaters CFLRP (Payette NF) and the Southern Blues Coalition CFLRP (Malheur NF), the Tapash Sustainable Forest Collaborative (Okanogan-Wenatchee NF, Yakima nation, and state of Washington). Monitoring will begin on the Lakeview Stewardship CFLRP (Fremont-Winema) in 2015.

Tapash CFLRP - Okanogan-Wenatchee NF - On Naches Ranger District, pre-treatment surveys were conducted on 4 transects (40 points) in the Nelli Project Area for a total of 1,219 acres. Each transect was surveyed 2 times in both 2013 and 2014. In 2013, 7 WHWO were detected, 5 detections were in units that will be treated and 2 in control units. In 2014, 17 WHWO were detected, all in units to be treated. Treatments will occur in 2015.

Southern Blues CFLRP - The first year of data collection on the Southern Blues CFLRP was conducted in 2014. Data were collected on occupancy rates and nest locations. Fifteen transects were established in untreated forests and 15 transects in forests proposed for treatment. Nest searches were conducted along the 30 transects within a 200-m belt width. WHWO were detected 82 times during 37 surveys at 65 points along 13 control- and 11 treatment-transects. Crews located 24 nests, but they were not able to monitor nest survival due to budget and logistical constraints associated with the pilot year. Twelve nests each were associated with 6 control- and 7 treatment-transects.

Vegetation data were collected at all nest locations, and at point-count survey locations for three of 30 monitoring transects in the CFLRP. Nests were located in areas with lower tree and snag densities compared to non-nest, point-count survey locations measured in 2014. Seventy-one percent of nest cavities were located in ponderosa pine, 25 % in western juniper (*Juniperus occidentalis*), and 4 % in grand fir (*Abies grandis*). Three nests were located in downed wood (e.g., logs, rootwads), six were in live trees (western juniper), and 15 in snags. Point-count survey plots contained higher percentages of Douglas-fir, grand fir, and lodgepole pine (*Pinus contorta*) than nest plots. WHWOs nests were located primarily in ponderosa pine forest with relatively low percentage of canopy cover (< 40% at 1 ha (~ 2 ac) scale surrounding nests).

In 2015, surveys for WHWO occupancy and nests will continue and nest survival will be monitored. The nest survival analysis in conjunction with occupancy, nest location, and nest densities will help us identify landscape and stand attributes important to WHWOs, and aid in the development of current and future forest restoration activities.

Validation monitoring

Habitat Suitability Index (HSI) Models for white-headed woodpecker **nesting habitat** developed previously by Hollenbeck et al. (2011) were refined by Latif et al. (2015) using validation data collected in 2010 and 2011. Updated models were developed using both a partitioned Mahalanobis model (Rotenberry et al. 2006) and a Maxent model (Phillips et al. 2006). Both modeling techniques generated HSIs describing the relative suitability of each 30 x 30-m pixel on a 0−1 scale (HSIs = 0 indicate minimal suitability; HSIs = 1 indicate maximum suitability).

Environmental variables used in model development were from remotely sensed data at a 30-m resolution. The vegetation data were from the Gradient Nearest Neighbor (GNN) data (LEMMA 2014). The variables included:

- Slope
- Aspect (cosine)
- Local-scale canopy cover (1 ha)
- Landscape-scale canopy cover (314 ha)
- Percent ponderosa pine dominated forest (at 314 ha scale)
- Edge density between open and closed forest (at 314 ha scale)

The refined models were developed for the East Cascades and Blue Mountains of eastern Oregon. The models were evaluated using nest locations from the East Cascade Mountains withheld from model development and point count data collected from both the East Cascade and Blue Mountains, including those from regional broad-scale occupancy monitoring.

The Maxent model performed well and out-performed the Mahalanobis model both for discerning WHWO nest locations from the sampled landscape and predicting which point count stations were occupied by WHWO during the breeding season. As a result, the Maxent model is recommended to help guide habitat management and restoration (Figure 2).

HSI values from the Maxent model were highest for pixels with high amounts of ponderosa pine forest, low to moderate canopy cover (<40%) at the local scale, and moderate canopy cover (25-50%) at the landscape scale. Though not the selected model, Mahalanobis model performed well for predicting nesting habitat; the HSI values from the were highest for pixels with landscape-scale attributes of moderate canopy cover (25-50%), a high percentage of ponderosa pine forest, and high amounts of edge.

The use of remotely sensed data limits use of variables describing fine-scale habitat features, such as density of large trees and snags. Large trees were identified as an important attribute at occupied sites using the regression and multilevel/hierarchical models (Gelman and Hill 2007) described above under the Broad-scale occupancy monitoring section. Accuracy of remotely sensed tree density estimates is poor, however, so relationships with tree size and density were not represented in the most recent models of nesting habitat suitability (see Latif et al. [2015] for details).

The manuscript describing HSI models has been published in a peer-reviewed journal, the Journal of Wildlife Management (Latif et al. 2015). RMRS provided a geodatabase with spatially explicit HSI values for central and eastern Oregon. Advice on translation of HSI values (i.e., relative indices of suitability) into more easily interpretable suitability classes was also provided.

Literature cited

Altman, Bob. 2000. Conservation strategy for landbirds in the northern Rocky Mountains of eastern Oregon and Washington. Version 1.0. Oregon and Washington Partners in Flight. Unpubl. Rpt., 128 pp. http://www.orwapif.org/pdf/northern_rockies.pdf

Bate, Lisa J., Torolf R. Torgersen, Michael J. Wisdom, Edward O. Garton, and Shawn C. Clabough. 2008a. Log sampling methods and software for stand and landscape analyses. USDA Forest Service, Pacific Northwest Research Station, Portland,OR. PNW-GTR-746. 100pp. http://www.fs.fed.us/pnw/pubs/pnw_gtr746.pdf

Bate, Lisa J., Michael J. Wisdom, Edward O. Garton, and Shawn C. Clabough. 2008b. SnagPRO: Snag and tree sampling and analysis methods for wildlife. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. PNW-GTR-780. 88 pp. http://www.fs.fed.us/pnw/pubs/pnw_gtr780.pdf

Bull, Evelyn L. 1980. Resource Partitioning among woodpeckers in northeastern Oregon. PhD Dissertation, University of Idaho, Moscow. 109 pp.

Dixon, R.D. 1995. Ecology of white-headed woodpeckers in the central Oregon Cascades. M.S. thesis. University of Idaho, Moscow, ID.

Dudley, J. and V. Saab. 2003. A field protocol to monitor cavity-nesting birds. USDA Forest Service. Rocky Mountain Research Station, Fort Collins, CO., Research Paper. RMRS-RP-44. 16 p.

Frenzel, R.W. 2004. Nest-site occupancy, nesting success, and turnover rates of white-headed woodpeckers in the Oregon Cascade Mountains in 2004. Audubon Society of Portland, Oregon Department of Fish and Wildlife, Bureau of Land Management, and U.S. Forest Service, Portland, OR. Unpubl. Rept. 35 pp.

Gelman, A., and J. Hill. 2007. Data analysis using regression and multilevel/ hierarchical models. Cambridge University Press, New York, NY.

Hollenbeck, Jeff, Victoria A. Saab, and Richard W. Frenzel. 2011. Habitat suitability and nest survival of white-headed woodpeckers in unburned forests of Oregon. Journal of Wildlife Management 75:1061-1071.

Keane, R. E., and L. J. Dickinson. 2007. The photoload sampling technique: estimating surface fuel loadings from downward-looking photographs of synthetic fuelbeds. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station General Technical Report RMRS-GTR-190, Fort Collins, CO.

Korol, Jerome J., Miles A. Hemstrom, Wendel J. Hann, and Rebecca Gravenmier. 2002. Snags and down wood in the Interior Columbia Basin Ecosystem Management Project. In: Laudenslayer, William F., Jr.; Valentine, Brad; Weatherspoon, C. Philip; Lisle, Thomas E., technical coordinators. Proceedings of the symposium on the ecology and management of dead wood in western forests. 1999 November 2-4; Reno, NV. Gen. Tech. Rep. PSW-GTR-181. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. http://www.fs.fed.us/psw/publications/documents/gtr-181/049_Korol.pdf

Latif, Q., V. Saab, K. Mellen-McLean, and J. Dudley. 2015. Evaluating Habitat Suitability Models for Nesting White-headed Woodpeckers in Unburned Forest. Journal of Wildlife Management 79:263-273.

LEMMA. 2014. Landscape ecology, modeling, mapping, and analysis. http://www.fsl.orst.edu/lemma/main.php?project = imap&id = home. Accessed Dec 2011, Mar 2012, and May 2014.

Manley, Patricia N., Beatrice Van Horne, Julie K. Roth, William J. Zielinski, Michelle M. McKenzie, Theodore J. Weller, Floyd W. Weckerly, and Christina Vojta. 2006. Multiple Species Monitoring Technical Guide. Version 1.0. USDA Forest Service, Washington Office, Washington D.C., Gen. Tech. Report WO-73.204 p.

Mellen-McLean, Kim and Victoria Saab. 2012. White-headed woodpecker Monitoring - Annual Monitoring Report - FY 2012. USDA Forest Service, Pacific Northwest Region and Rocky Mountain Research Station. Unpublished Report [on file Portland, OR].

Mellen-McLean, K., V. Saab, B. Bresson, B. Wales, A. Markus, and K. VanNorman. 2013. White-headed woodpecker monitoring strategy and protocols. USDA Forest Service, Pacific Northwest Region, Portland, OR. 18 p. https://fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5434067.pdf

Nielsen-Pincus, Nicole. 2005. Nest site selection; nest success, and density of selected cavity-nesting birds in northeastern Oregon with a method for improving accuracy of density estimates. M.S. Thesis. University of Idaho, Moscow. 96 pp.

Phillips, S. J., R. P. Anderson, and R. E. Schapire. 2006. Maximum entropy modeling of species geographic distributions. Ecological Modelling 190:231-259.

Rotenberry, J. T., K. L. Preston, and S. T. Knick. 2006. GIS-based niche modeling for mapping species' habitat. Ecology 87:1458-1464.

Saab, Victoria, Lisa Bate, John Lehmkuhl, Brett Dickson, Scott Story, Stephanie Jentsch, and William Block. 2006. Changes in down wood and forest structure after prescribed fire in ponderosa pine forests. pp 477-487. *In*: Andrews, Patricia L.; Butler, Bret W., comps. *Fuels Management—How to Measure Success: Conference Proceedings.* 2006 28-30 March; Portland, OR. Proceedings RMRS-P-41. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Smith, T. G., and C. C. Maguire. 2004. Small-Mammal Relationships with Down Wood and Antelope Bitterbrush in Ponderosa Pine Forests of Central Oregon. Forest Science 50(5):711-728.

Vesely, David, Brenda C. McComb, Christina D. Vojta, Lowell H. Suring, Juraj Halaj, Richard S. Holthausen, Benjamin Zuckerberg, and Patricia Manley. 2006. Development of protocols to inventory or monitor wildlife, fish, or rare plants. USDA Forest Service, Washington Office, Washington D.C. Gen.Tech. Report WO-72. 100 p.

Wightman, Catherine, and Vicki Saab. 2008. Management Indicator Species Surveys on the Payette National Forest 2008: Field testing of methods. USDA Forest Service, Rocky Mountain Research Station, Bozeman, MT, Unpublished Report. 24 p.

Wightman, C., V. Saab, C. Forristal, K. Mellen-Mclean, and A. Markus. 2010. White-headed woodpecker nesting ecology after wildfire. Journal of Wildlife Management 74(5):1098-1106.

Wisdom, Michael J., Richard S. Holthausen, Barbara C. Wales, Christina D. Hargis, Victoria A. Saab, Danny C. Lee, Wendel J. Hann, Terrell D. Rich, Mary M. Rowland, Wally J. Murphy, and Michelle R. Eames. 2000. Source Habitats for Terrestrial Vertebrates of Focus in the Interior Columbia Basin: Broad-Scale Trends and Management Implications. General Technical Report PNW-GTR-485, Portland, OR.

WHWO Transects - Region 6

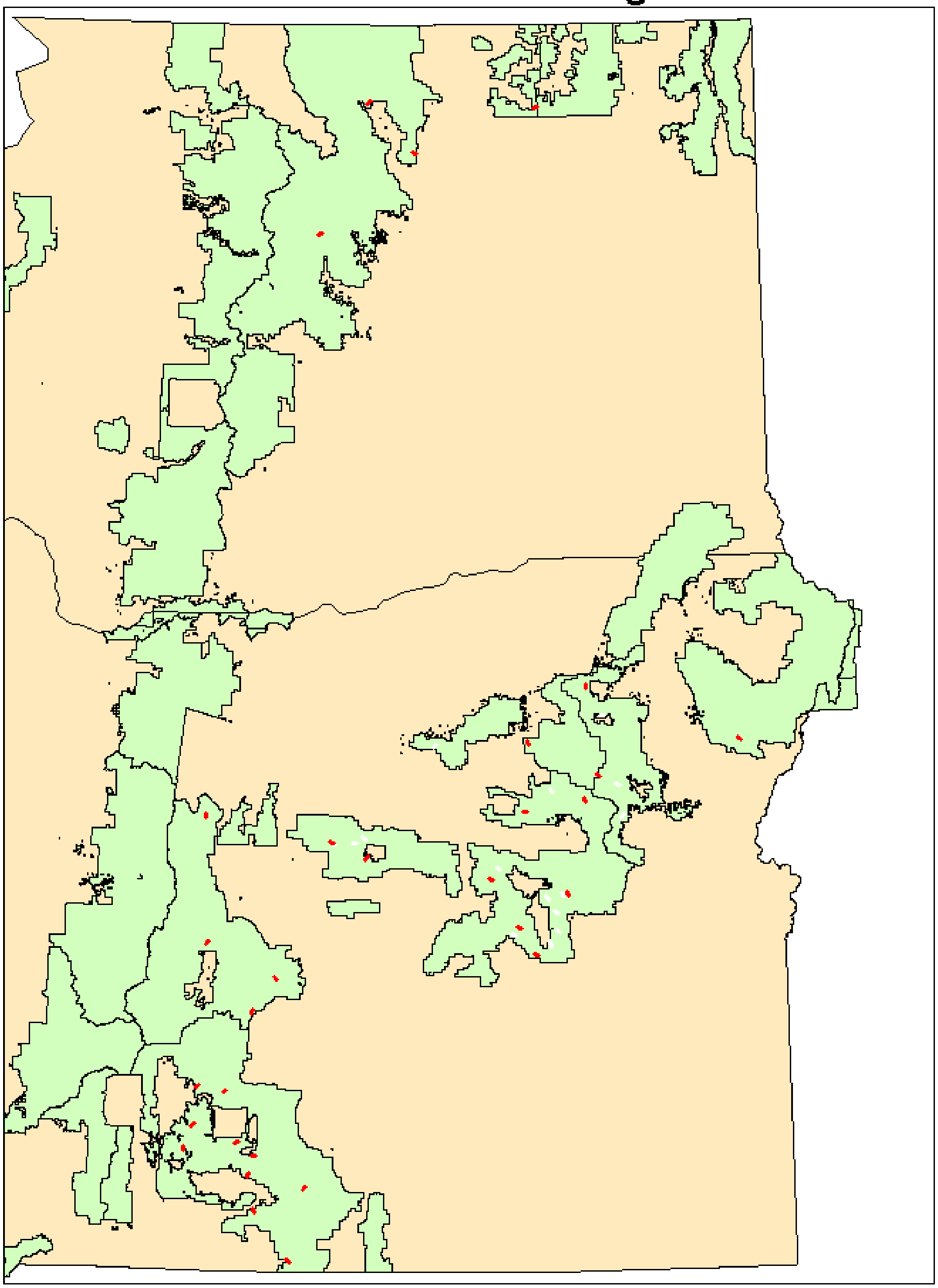

Figure 1. The 30 FY11 WHWO transects are shown here in eastern Oregon and Washington as red dots. The National Forests are the green polygons.

Figure 2. White-headed woodpecker nesting habitat as modeled using Maxent (Latif et al. 2015). Low HSI values (<0.36) should be considered non habitat, moderate HSI values (0.36-0.46) represent potentially suitable habitat, and high HSI values (>0.46) represent highly suitable habitat.