NORTHERN ARIZONA UNIVERSITY

Lab of Landscape Ecology and Conservation Biology

INTERIM REPORT

19 June 2013

For project **task (#3)** entitled:

Statistical analysis for Northern Goshawk surveys (2012)

USFS-NAU Agreement # 09-CR-11030700-019 (Mod #3; *NAU Goshawk*)

Submitted to:

The Kaibab National Forest

By:

Brett G. Dickson, Ph.D.

Principal Investigator

Recommended citation:

Dickson, B. G., V. Horncastle, and C. Ray. 2013. Preliminary analysis of Northern Goshawk occupancy surveys (2012) on the Kaibab National Forest. Interim Report to the Kaibab National Forest. Lab of Landscape Ecology and Conservation Biology, Northern Arizona University, Flagstaff, AZ. 5pp.

Analytical Methods

We estimated occupancy rates for Northern Goshawks (*Accipiter gentilis*) across 29 primary sampling units (PSUs; $n = 29$) established by the Kaibab National Forest in the Williams and Tusayan ranger districts. We used occurrence data and detection histories collected by a contractor to the Kaibab National Forest in the early summer of 2012 (*Northern Goshawk Surveys on the Williams and Tusayan Ranger Districts, Kaibab National Forest, Arizona, 2012*, EcoPlan Associates, Inc.). Occupancy models that account for imperfect detection (p) and include covariates can be less biased and improve estimates by accounting for among-site (or unit) variation (MacKenzie et al. 2004). The habitat and detection variables used in our analysis were determined through discussions with Forest Service employees. As part of a post hoc model assessment, we considered 9 different habitat and detection variables, including survey period (nestling stage or late nestling/fledgling stage), the percentile of the distribution predicted by a regional model of goshawk probability of territory occurrence (Dickson et al. in review), which also was used to place PSUs in the field (25^{th}, 25^{th}-75^{th}, and 75^{th}; Ray and Dickson, unpublished data; Fig. 1), ranger district (Williams or Tusayan), mean canopy cover, standard deviation of canopy cover, canopy cover > or < 35%, canopy cover > or < 40%, mean basal area, and standard deviation of basal area. Estimates of canopy cover and basal area were derived from digital forest structure variables (i.e., 30-m pixel resolution data layers) produced for the Kaibab National Forest as part of a separate task agreement (Dickson et al. 2011). For the 600-ha extent of each PSU, we calculated the mean and standard deviation for both canopy cover and basal area using a moving window operation within a geographic information system (ArcGIS v10.0, Environmental Systems Research Institute, Inc., Redlands, CA). These resultant data layers also were used to derive two new binary variables for canopy cover where PSU mean canopy cover was either < or > 35% and < or > 40%.

We used the single-season occupancy estimation module in program PRESENCE (v4.1; Hines 2006) to estimate occupancy rates for 2012. We used an information-theoretic approach and Akaike's Information Criterion (AIC; Burnham & Anderson 2002) to identify the 'best' model(s) among a candidate set of nested models that each represented combinations of the variables defined above. Because this was a pilot analysis, none of these models were determined a priori and therefore should not be considered 'competing hypotheses.' We considered candidate models with AIC difference (ΔAIC) values < 4.0 as those that best approximated the data. We also included null models of occupancy and detection probability (denoted by 'dot' models) within each candidate set to evaluate the performance and fit of the best model(s) (Anderson 2008). These null models held occupancy or detectability constant across sites (i.e., units) and surveys.

Preliminary Results

Our post hoc and preliminary analysis indicated the best models of occupancy included both percentile and district (Table 1). The 2012 surveys resulted in an overall occupancy rate of 0.75 (SE = 0.15). The 75^{th} percentile had the highest rate of occupancy (0.90), followed by the 25^{th} – 75^{th} percentile (0.43), and the 25^{th} percentile (0.06). The Tusayan district (0.67) had a higher occupancy rate than the Williams district (0.55). PSU's with an average canopy cover >35 (0.80) or >40 (0.75) had higher occupancy estimates than PSU's with <35 (0.59) or <40 mean canopy cover (0.51). In general, occupancy was higher at sites with a high mean basal area or a high mean canopy cover. Occupancy increased with increasing variance in basal area, but decreased with increasing variance in canopy cover (Table 1). There were no Tusayan PSUs with canopy cover >40, although occupancy was estimated to be highest on this district.

These results should be considered preliminary as inference about goshawk occupancy will be improved by aspects of the study design that include future surveys across multiple years. In addition, two to three visit per year (i.e., per season) are expected to be sufficient to model occupancy dynamics, including local colonization and extinction rates.

Literature Cited

Anderson, D. R. 2008. Model based inference in the life sciences: a primer on evidence. Springer, New York, New York, USA.

Burnham, K. P., and D. Anderson. 2002. Model selection and multi-model inference: a practical information-theoretic approach. Springer-Verlag, New York, New York, USA.

Dickson, B. G., T. D. Sisk, S. E. Sesnie, J. M. Rundall, R. T. Reynolds, S. S. Rosenstock, M. F. Ingraldi, and C. Vojta. In review. Models of northern goshawk territory occupancy to inform landscape and regional planning in northern Arizona. Journal of Wildlife Management.

Dickson, B. G., A. D. Olsson, S. E. Sesnie, and M. A. Williamson. 2011. Development of state-of-the-art tools and functionality for the Kaibab National Forest Monitoring Plan. Final Report to the Kaibab National Forest. Lab of Landscape Ecology and Conservation Biology, Northern Arizona University, Flagstaff, AZ. 54pp.

Hines, J. E. 2006. PRESENCE2- Software to estimate patch occupancy and related parameters. USGS-PWRC. <http://www.mbr-pwrc.usgs.gov/software/presence.html> accessed April 2013.

MacKenzie, D. I., J. A. Royle, J. A. Brown, and J. D. Nichols. 2004. Occupancy estimation and modeling for rare and elusive populations. Pages 149–172 in W. L. Thompson, editor. Sampling rare or elusive species. Island Press, Washington, D.C.

Table 1. Model results, including differences in Akaike's Information Criterion (ΔAIC), and estimates of occupancy (Ψ, SE) and detection probability (*p*, SE) for Northern Goshawk primary sampling unit (*n* = 29) surveys, 2012. P= percentile; D = district (Wil = Williams, Tus = Tusayan); 25th, 25th-75th, and 75th = the percentile of the distribution predicted by a model of goshawk probability of territory occurrence; CC>35 or CC<35 = canopy cover > or < than 35%, respectively; CC>40 or CC<40 = canopy cover > or < than 40%, respectively; CCm = canopy cover mean; CCsd = canopy cover standard deviation; BAm = Basal area mean; and BAsd = basal area standard deviation. Models in **BOLD** indicate competing models that best approximate the data (ΔAIC < 4). A 'dot' (.) indicates a parameter was assumed constant. '—' indicates parameter was not estimable.

Model	**ΔAIC**	**Ψ (SE)**	***p* (SE)**
Ψ(P),p(D)	**0**	25th 0.06 (0.093), 25th-75th 0.43 (0.148), 75th 0.90 (0.139)	Williams 0.80 (0.117), Tusayan 0.47 (0.151)
Ψ(P,D),p(D)	**1.45**	Wil 25th 0.03 (0.062), 25th-75th 0.37 (0.17), 75th 0.92 (0.136) Tus 25th 0.11 (0.215), 25th-75th 0.70 (0.398), 75th 0.98 (0.064)	Williams 0.79 (0.119), Tusayan 0.41 (0.135)
Ψ(.),p(P,D)	**2.23**	0.75 (0.149)	Wil 25th 0.12 (0.111), 25th-75th 0.43 (0.169), 75th 0.82 (0.106) Tus 25th 0.05 (0.061), 25th-75th 0.24 (0.153), 75th 0.67 (0.183)
Ψ(.),p(BAM)	**2.72**	0.68 (0.14)	
Ψ(BAM),p(P,D)	**3.46**	Range 0.45(0.396)–0.90(0.151); greater Ψ at sites with greater BAm	Wil 25th 0.12 (0.141), 25th-75th 0.44 (0.178), 75th 0.82 (0.11) Tus 25th 0.07 (0.094), 25th-75th 0.44 (0.178), 75th 0.70 (0.17)
Ψ(.),p(P,D,C40,CSD)	**3.67**	0.71 (0.125)	
Ψ(C35),p(P,D)	**3.70**	CC<35 0.59 (0.258), CC>35 0.80 (0.158)	Wil 25th 0.10 (0.104), 25th-75th 0.41 (0.162), 75th 0.82 (0.11) Tus 25th 0.05 (0.067), 25th-75th 0.27 (0.16), 75th 0.70 (0.17)
Ψ(C35,P),p(P,D)	**3.87**	CC<35 25th 0.07 (0.114), 25th-75th 0.35 (0.356), 75th 0.80 (0.41) CC>35 25th -- (--), 25th-75th 0.46 (0.182), 75th 0.86 (0.15)	Wil 25th 0.65 (0.49), 25th-75th 0.75 (0.209), 75th 0.82 (0.119) Tus 25th 0.33 (0.422), 25th-75th 0.43 (0.237), 75th 0.54 (0.266)
Ψ(P,D),p(P)	**3.92**	Wil 25th 0.20 (0.321), 25th-75th 0.524 (0.256), 75th 0.83 (0.134) Tus 25th 0.12 (0.213), 25th-75th 0.38 (0.239), 75th 0.72 (0.182)	25th 0.30 (0.465), 25th-75th 0.54 (0.253), 75th 0.76 (0.121)
Ψ(.),p(P,D,S)	4.11	0.75 (0.149)	
Ψ(BAM),p(P,D,BSD)	4.62	Range 0.47(0.588)–0.91(0.203); greater Ψ at sites with greater BAm	
Ψ(.),p(BAM,BSD)	4.66	0.68 (0.14)	
Ψ(.),p(.)	5.18	0.57 (0.111)	0.70 (0.11)
Ψ(.),p(P,D,C35,CSD)	5.39	0.80 (0.18)	
Ψ(.),p(CM)	5.46	0.62 (0.163)	
Ψ(.),p(P,D,CM,CSD)	5.57	0.77 (0.147)	

Table 1. Continued.

Ψ(C35,D),p(P,D)	5.63	CC<35 Williams 0.67 (0.378), Tusayan 0.56 (0.271) CC>35 Williams 0.84 (0.203), Tusayan 0.77 (0.213)	Wil 25th 0.08 (0.1), 25th-75th 0.38 (0.172), 75th 0.81 (0.116) Tus 25th 0.05 (0.064), 25th-75th 0.27 (0.16), 75th 0.72 (0.172)
Ψ(.),p(D)	5.69	0.58 (0.11)	Williams 0.79 (0.117), Tusayan 0.55 (0.17)
Ψ(C40),p(.)	5.70	CC<40 0.50 (0.123), CC>40 0.79 (0.197)	0.70 (0.077)
Ψ(C35),p(D)	6.34	CC<35 0.38 (0.184), CC>35 0.65 (0.122)	Williams 0.79 (0.122), Tusayan 0.58 (0.163)
Ψ(CM),p(D)	6.38	Range 0.29(0.15)–0.86(0.116); greater Ψ at sites with greater CCm	
Ψ(C35),p(P,D,C35,CSD)	6.57	CC<35 0.55 (0.258), CC>35 0.85 (0.159)	
Ψ(C40),p(D)	6.62	CC<40 0.51 (0.125), CC>40 0.75 (0.183)	Williams 0.80 (0.116), Tusayan 0.54 (0.169)
Ψ(.),p(P,D,CM,CSD,BSD)	7.34	0.76 (0.149)	
Ψ(CSD),p(D)	7.45	Range 0.47(0.245)–0.64(0.166); greater Ψ at sites with lower CCsd	Williams 0.79 (0.121), Tusayan 0.58 (0.167)
Ψ(D),p(D)	7.52	Williams 0.55 (0.129), Tusayan 0.67 (0.272)	Williams 0.80 (0.113), Tusyan 0.50 (0.217)
Ψ(BSD),p(D)	7.62	Range 0.53(0.191)–0.66(0.278); greater Ψ at sites with greater BAsd	Williams 0.79 (0.121), Tusayan 0.58 (0.167)
Ψ(C40,D),p(D)	7.85	CC<40 Williams 0.42 (0.163), Tusayan 0.67 (0.272) CC>40 Williams 0.74 (0.181), Tusayan -- (--)	Williams 0.80 (0.113), Tusayan 0.50 (0.217)
Ψ(C35,D),p(P,D,C35,CSD)	8.43	CC<35 Williams 0.68 (0.436), Tusayan 0.51 (0.266) CC>35 Williams 0.90 (0.191), Tusayan 0.81 (0.222)	
Ψ(C40),p(D,CSD)	8.48	CC<40 0.51 (0.127), CC>40 0.74 (0.181)	
Ψ(C40),p(D,CSD,C40)	10.10	CC<40 0.51 (0.123), CC>40 0.75 (0.190)	
Ψ(C35),p(P,D,C35,CSD,BAM,BSD)	10.44	CC<35 0.54 (0.261), CC>35 0.83 (0.161)	
Ψ(C40,D),p(D,CSD,C40)	11.08	CC<40 Williams 0.41 (0.158), Tusayan 0.67 (0.272) CC>40 Williams 0.75 (0.189), Tusayan -- (--)	

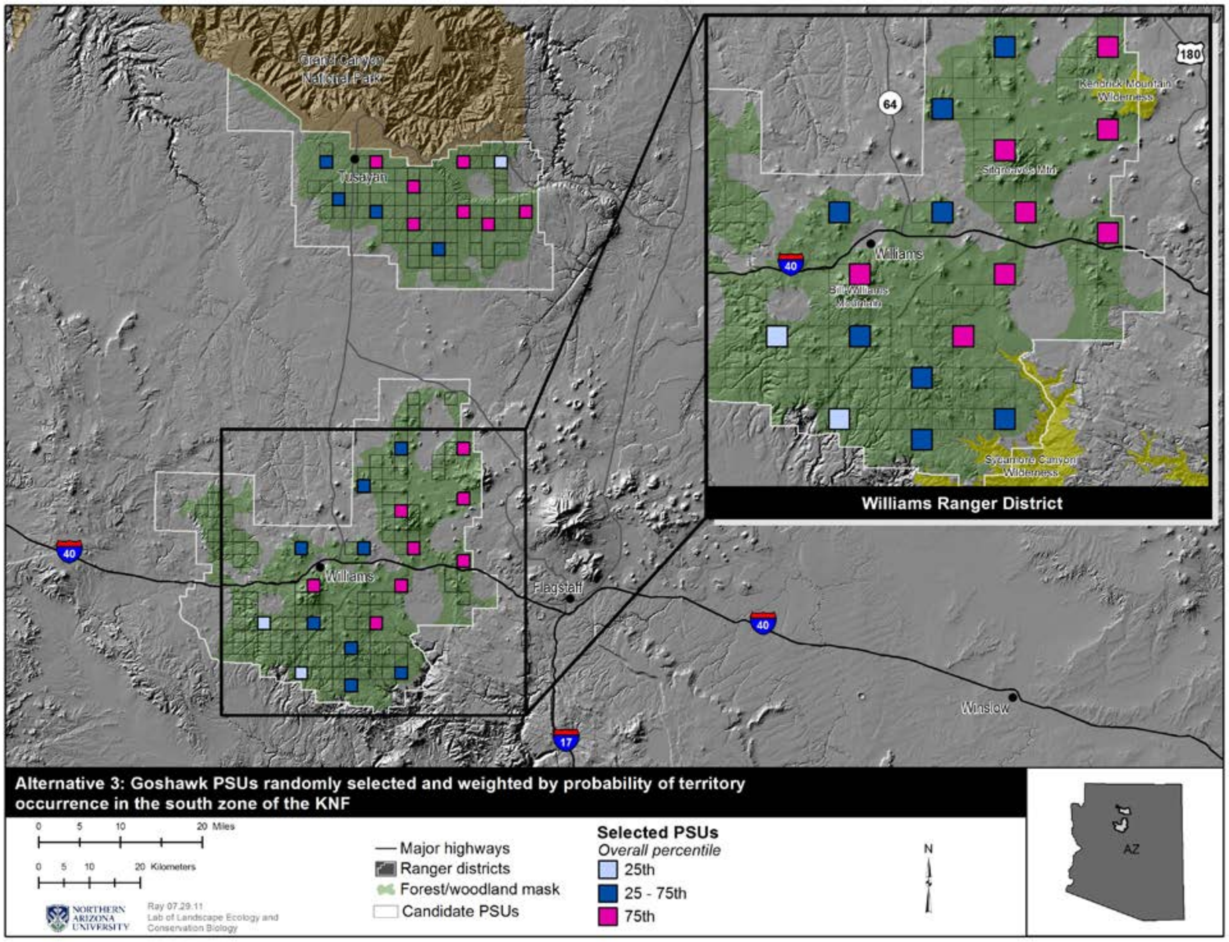

Figure 1. Location of primary sampling units (PSUs) and based on the 25th, 25th-75th, and 75th percentile categories predicted by a regional model of northern goshawk probability of territory occurrence.