Northern Goshawk Monitoring in the Apache-Sitgreaves National Forests: 2013 Field Season Report

February, 2014

ROCKY MOUNTAIN BIRD OBSERVATORY

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EXECUTIVE SUMMARY

The Northern Goshawk (*Accipiter gentilis*; goshawk) is the largest accipiter found in North America and inhabits much of the forested land in the United States. Because the bird's primary habitat is forested land, much of the bird's range falls within U.S. Forest Service's (USFS) administrative boundaries in the lower 48 states. However, very little is actually known about the bird's population across large spatial extents. The Northern Goshawk has been defined as a sensitive species by the USFS and is a potential candidate to be listed under the Threatened and Endangered Species Act. These concerns and classifications lead to the publication of the "Northern Goshawk Inventory and Monitoring Technical Guide" (Woodbridge and Hargis 2006) by the USFS to aid regional managers as well as local officials to develop and implement regional monitoring of Northern Goshawk populations. Through the use of presence/absence surveys, the guide outlines how occupancy modeling can be used to determine trends in goshawk populations.

The USFS contracted Rocky Mountain Bird Observatory (RMBO) to assist in the development and implementation of Northern Goshawk monitoring using the technical guide as a reference. A grid of 1,481 600-ha Primary Sampling Units (PSU) was laid across the Apache-Sitgreaves National Forests in Arizona. Each PSU was delineated into one of three strata based on information from the Apache-Sitgreaves cover-type and the Wallow Fire burn intensity data layer. We stratified the grid cells within the administrative boundary according to pinyon-juniper woodland, ponderosa pine forest and ponderosa pine forest within the Wallow Fire burn perimeter. Sampling units were selected with a spatially balanced design using the GRTS function (Spsurvey package) in R.

Broadcast acoustical surveys were conducted in the selected sampling units during two time periods (nestling and fledgling) in the summer of 2013. At least one survey was conducted in 21 sampling units between 3 June and 8 August 2013. Seven of 21 PSUs and 4 of 18 PSUs had detections during the nestling and fledgling surveys, respectively.

Detection probability and occupancy estimates were determined using four models and evaluated for best fit with Akaike's information criterion (AICc). The occupancy model that used a constant rate of detection across strata and season had the lowest AICc value of the four models with a forest-wide detection probability of 0.534 (SE = 0.206) and occupancy of 0.474 (CI: 0.232 - 0.729).

The occupancy estimate indicates there was a higher density of goshawks in the Apache-Sitgreaves National Forests in 2013 than in the USFS Southwest Region in 2009 – of which the occupancy estimate was 0.286 (CI: 0.154-0.357). However, because occupancy estimates are only used as a surrogate for abundance, occupancy should be primarily used to determine trends from year to year within a study area instead of across different study areas and years. Therefore, frequent Northern Goshawk monitoring using a constant study design is instrumental to determine population trends as well as evaluate population responses to natural phenomena and management decisions and practices.

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INTRODUCTION

The Northern Goshawk (*Accipiter gentilis*, goshawk) is the largest of three accipiters found in North America (Squires and Reynolds 1997). Goshawks inhabit and nest in several classes of woodlands and forests including coniferous, deciduous and mixed forests ranging from Alaska to Mexico. Forest and woodland age class and structure preference varies throughout the bird's range and depends on the local forest types. For example, goshawks are known to occupy ponderosa pine, mixed coniferous and spruce-fir forests in the Southwest and pine forests interspersed with aspen groves in the forests of Colorado, Wyoming and South Dakota; whereas in the Great Basin, goshawks inhabit small patches of aspen within shrub-steppe habitat (Squires and Ruggiero 1996). However, a general consistency in the need for large, mature tree stands for nesting has been found as well as a correlation between prey base and population stability (Reynolds et al. 1992, Anderson et al. 2005). Also, because goshawks generally require mature to old growth trees as nesting sites, the species can be used as an indicator of forest health (Reynolds et al. 1992, Anderson et al. 2005).

Because of the difficulties associated with the low density of goshawks (≤12 nesting pairs/100-km^2) mixed with the bird's cryptic behavior (Squires and Reynolds 1997), population estimates are undetermined across vast areas and therefore, the overall status of the Northern Goshawk's population remains unknown (Anderson et al. 2005, Woodbridge and Hargis 2006).

The Northern Goshawk is protected by several laws and regulations both within the USFS and broader intra-agency guidance, including the Migratory Bird Treaty Act of 1916, Executive Order 13186 (01-10-2001), "Responsibilities of Federal Agencies to protect Migratory Birds" (1991) and its associated Memorandum of Understanding between the USFS and the US Fish & Wildlife Service (FWS), the USFS Landbird Strategic Plan of 2001, the USFS sensitive species program - FSM R-3 Supplement 2676.3 (United States Forest Service 1995) and the National Forest Management Act of 1976 (Woodbridge and Hargis 2006). Furthermore, public involvement resulted in a petition to the FWS for federal listing of the Northern Goshawk in the Western United States in 1997 (United States Fish and Wildlife Service 1998). Listing the Northern Goshawk as threatened or endangered was deemed unwarranted after a 12-month finding because there was no evidence that Northern Goshawk populations were declining (United States Fish and Wildlife Service 1997). However, the inquiry also found that there was an overall lack of data of Northern Goshawk population trends and therefore, was also unknown if populations were increasing or stable. This interest in the Northern Goshawk population assessment within the USFS culminated with the creation of the "Northern Goshawk Inventory and Monitoring Technical Guide" (Woodbridge and Hargis) in 2006 to establish a protocol to survey national forests within all USFS administrative regions within the Northern Goshawk's geographic range.

The Apache-Sitgreaves National Forests contracted Rocky Mountain Bird Observatory (RMBO) to develop and implement Northern Goshawk monitoring for the 2013 breeding season, using the technical guide as a reference. The contract between these two entities was advantageous for the National Forest because RMBO has already completed goshawk monitoring efforts for the U.S. Forest Service's Southwest Region in forests throughout Arizona and New Mexico (Berven 2010b).

The Apache-Sitgreaves National Forests encompasses over two million acres of forests and woodlands in Arizona (United States Forest Service 2009). The forest is included in the Northern Goshawk's breeding distribution; therefore the administrative region is responsible to assess and document the effects of proposed management actions on Northern Goshawk

populations as required by the USFS sensitive species program. Several forests within the region have conducted localized and individualized surveys of goshawks, including one of the most extensively studied populations in the Kaibab National Forest (Reynolds et al. 1992, Squires and Reynolds 1997, Reynolds and Joy 1998, Reich et al. 2004, Reynolds et al. 2008). Although this research is consistently carried out annually within a relatively small area and provides useful information on local Northern Goshawk populations, the information cannot be easily compared with other forests' data because of differences in monitoring protocols and methods.

In 2009, the first large-scale surveys were conducted within the Southwest bioregion. A detection probability of 0.448 (SE = 0.155) and occupancy estimate of 0.286 (CI: 0.154-0.357) was determined for the area (Skorkowsky unpubli. data). The 2009 bioregional effort also addressed the question of pinyon-juniper woodland use by nesting goshawks. Researchers speculate that the birds do not use the woodlands for nesting, or only use the woodlands in years when an exceptionally high prey base can support a larger Northern Goshawk population and less dominant goshawks are pushed to the woodlands only when all ponderosa pine or mixed coniferous habitat has been territorialized (Reynolds et al. 1992, Drennan and Beier 2003, Reynolds et al. 2008). In the 2009 study, occupancy was estimated at 0.473 (CI: 0.262 – 0.693) for ponderosa pine and mixed coniferous forests in the Southwest bioregion and 0.122 (CI: 0.048 – 0.274) for pinyon-juniper woodlands (Berven 2010b). These results indicate that, although goshawks show a preference for ponderosa pine and mixed coniferous forests, pinyon-juniper woodlands are occupied to some extent and cannot be excluded from the monitoring effort.

Monitoring Northern Goshawk populations is a challenging endeavor due to the cryptic nature of the bird, low population densities, and the rugged terrain associated with the bird's habitat (Woodbridge and Hargis 2006). Therefore, occupancy is the preferred method to assess status and changes in Northern Goshawk populations from year to year without the need for extensive abundance surveys (MacKenzie and Nichols 2004, Woodbridge and Hargis 2006). Occupancy determines what fraction of a landscape is occupied by a species, whereas abundance determines how many individuals of a species are found within the landscape. Occupancy can be used as a surrogate for abundance because the two are positively correlated (MacKenzie and Nichols 2004).

While bioregional monitoring can evaluate trends and bird responses over a large area, the effort is expensive and completed infrequently. Furthermore, local managers may have specific questions about their forests that cannot be answered at the bioregional scale. The Apache-Sitgreaves National Forests provides such an example with the Wallow Fire of 2011. The Wallow fire started on 29 May, 2011 and burned over 535,000 acres. Over 500,000 acres were within the National Forest boundary and almost 120,000 acres of ponderosa pine and mixed coniferous forests were moderately to severely burned (Wadleigh 2011). Wildlife managers asked the questions; what is the current status of Northern Goshawk populations in the Apache-Sitgreaves National Forests and was there an effect of the Wallow Fire on goshawk occupancy two years after a large and destructive fire? This year's monitoring effort can simultaneously address both questions by stratifying areas of interest based on habitat and where the fire burned. However, the ultimate goal should be to monitor the population over an extended period of time to fully understand occupancy trends and use of burned areas.

METHODS

Study Area

The study area encompasses all Forest Service lands located in the Apache-Sitgreaves National Forests in Arizona that include potential Northern Goshawk habitat (Figure 1).
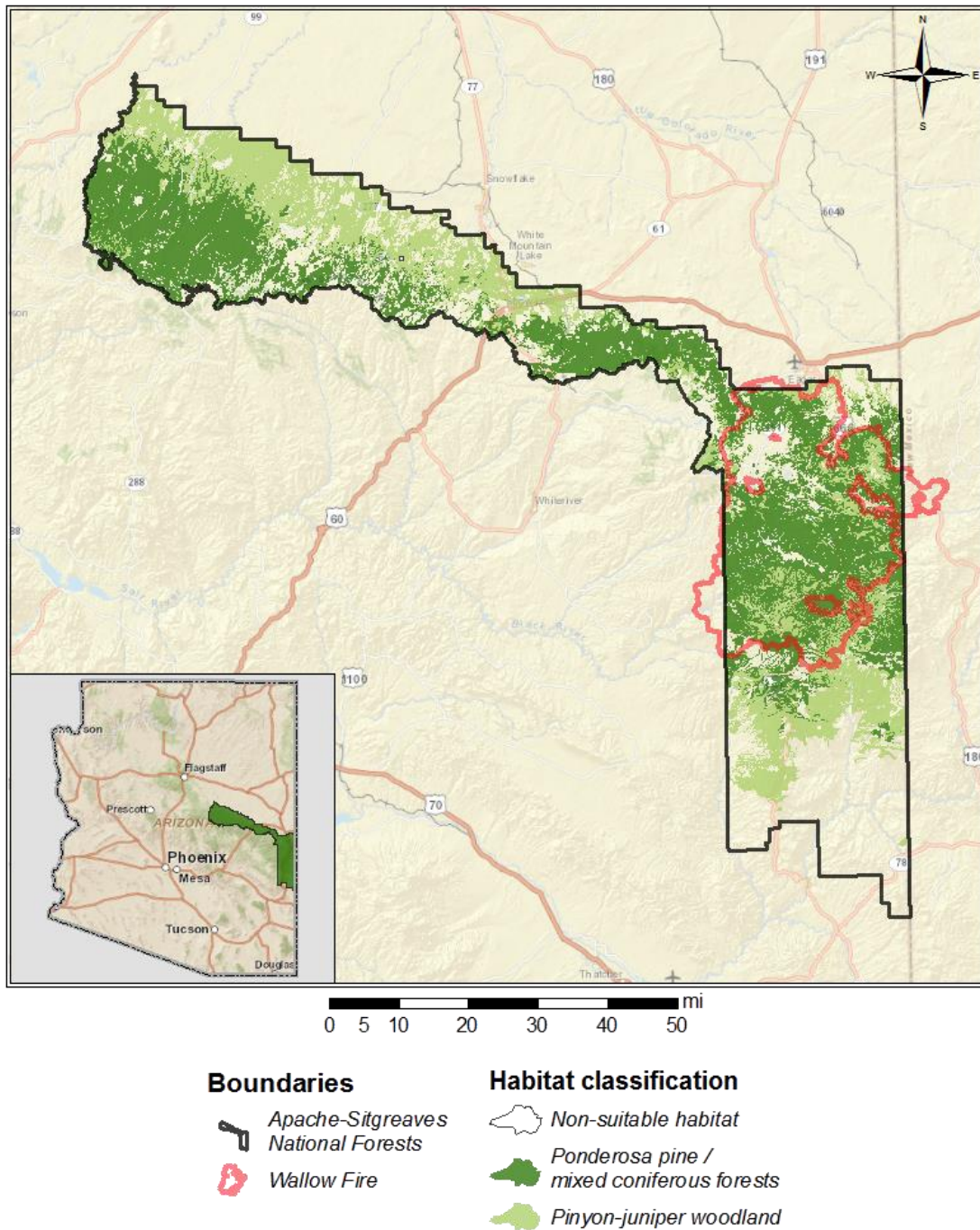

Figure 1. Classification of suitable habitat for the Northern Goshawk (*Accipiter gentilis*) in the Apache-Sitgreaves National Forests, Arizona, 2013.

Field Personnel

Biological field technicians who had previous field experience working with Northern Goshawks, including knowledge of the species' behavior, vocalizations and sign were highly desired for each team of two. However, most applicants did not have such experience and therefore, individuals were paired according to their overall field experience. Technicians with more experience (usually at least two years of avian fieldwork) were paired with an individual with less avian field skills. For all individuals, experience hiking in remote areas and a good work ethic were required.

All technicians received training in Northern Goshawk identification. Training emphasized identification by visual and aural cues, feathers and nest presence. We also trained technicians extensively in survey and data collection protocol. The training was conducted by RMBO personnel in the last week of May 2013.

Sampling Unit Selection

Primary Sampling units (PSUs) were created and selected using protocols delineated in the "Northern Goshawk Inventory and Monitoring Technical Guide" (Woodbridge and Hargis 2006). Using ArcGIS (ESRI 2006), a region-wide grid was created by overlaying 600.25ha PSUs onto a USFS administrative border layer. We defined the sampling frame as the set of PSUs containing a minimum of 20% potential Northern Goshawk habitat. We stratified the grid cells within the administrative boundary according to marginal habitat (pinyon-juniper woodland and subalpine forests; $n = 383$; Table 1), and primary habitat (ponderosa pine forest and mixed conifer) inside ($n = 293$) and outside ($n = 489$) of the Wallow Fire burn using the Apache-Sitgreaves cover-type and Wallow Fire burn intensity (Table 1) data layers (Berven 2010b, United States Forest Service. Southwest Region. 2011).

Table 1. Stratification of sampling grids with the number of grids allocated to the strata levels.

	Unburned	Burned	Total
Ponderosa pine and mixed coniferous	489	293	782
Woodland and subalpine	383	-	383
Total	872	293	1,165

A spatially balanced study design was implemented to order PSUs within the Apache-Sitgreaves National Forests by using the generalized random-tessellation stratification (GRTS) function (Spsurvey package) in R (Stevens 2004). After the PSUs were randomly selected for survey, a grid of call station points was added to each unit using ArcGIS. For PSUs located completely within the USFS Administrative boundary, 120 call stations on 10 transect lines (each containing 12 stations spaced 200 m apart) were overlaid on the PSU (Figure 2). Each transect line was placed 250 m apart and located at least 150 m from the PSU border. Points on adjacent transect lines were vertically offset by 100 m. For PSUs located on the perimeter of the USFS Administrative boundary, the call station grid was overlaid onto border PSUs as if the PSU was unclipped but all points outside of Forest Service land were removed from the survey effort. Call stations in unsuitable locations (slope >36%, >150 m away from forest cover or on private land) were identified using ArcGIS. A 30 x 30 m LANDFIRE slope layer (2006) was used to identify call stations located in areas that were too steep to survey. The Apache-Sitgreaves cover-type layer (United States Forest Service 2012) was used to identify call stations >150 m from tree cover. All call stations were included on the maps but were labeled according to suitability criteria (Figure 2).

Figure 2. An example of a Primary Sampling Unit (PSU) map used by technicians throughout the field season to survey for Northern Goshawks (*Accipiter gentilis*) in the Apache-Sitgreaves National Forests, Arizona, 2013.

Using ArcGIS, field maps were created showing PSU and study area boundaries and call stations overlaid onto 1:24,000-scaled topographic maps (ESRI 2011). Maps were scaled to 1:20,000 to help navigate between call stations.

Survey Protocol

The "Northern Goshawk Inventory and Monitoring Technical Guide" (Woodbridge and Hargis 2006) was used to define survey protocols. Technicians conducted broadcast acoustical surveys during the nestling and fledgling stages of the Northern Goshawk breeding season.

Up to two visits were made to each PSU, one during the nestling season and one during the fledgling season. Fifty percent of randomly selected PSUs with a detection during the nestling season were resurveyed during the fledgling season. The nestling season usually occurs from June 1st through the end of June and the window for the fledgling season occurs from the end of June through August 15; however, to maximize detectability of goshawks in the region, input was received from district USFS biologists and other scientists monitoring goshawk nests throughout the region to specify when eggs were expected to hatch. The nestling surveys ended once all planned PSUs were surveyed once, which occurred before nestlings began to fledge. The fledgling surveys began once nestlings moved away from the nest (approximately when young are 34 days). Juvenile goshawks typically disperse from the area approximately 6 weeks after fledging. Once juveniles leave, broadcast acoustical surveys are no longer effective.

Broadcast acoustical surveys could be conducted anytime between 30 minutes before sunrise through 30 minutes before sunset, coinciding with goshawk activity (Woodbridge and Hargis 2006). However, most surveys were conducted between 0830 through 1600 MST. Calling procedure followed protocols described in the monitoring technical guide (Woodbridge and Hargis 2006). Technicians broadcast one of three Northern Goshawk calls depending on whether it was during the nestling or fledgling survey. During the nestling survey, an adult alarm call was broadcast and during the fledgling survey, a juvenile food-begging call or a wail call was broadcast. Technicians used FoxPro NX3 digital callers preloaded with the calls at a volume producing 80 to 110 dB output 1 m from the speaker.

At each call station, technicians played one call for 10 seconds, then watched and listened for Northern Goshawk activity for 30 seconds then repeated the procedure after rotating 120 degrees. Once this procedure was done three times (and the circle completed), technicians would wait, watch and listen for two minutes then repeat the cycle. Technicians recorded any significant findings and time spent at each call station on a standardized field form. After two full rounds of playing the call, technicians would then move on to the next call station, while searching the surrounding area for any goshawks.

Technicians surveyed all call stations located in suitable habitat that could be safely reached until all surveyable stations were visited or until a Northern Goshawk detection was made in that PSU. A positive detection consisted of a visual or aural observation, finding an active nest and/or finding a freshly molted feather. If a bird was seen, sex and age was recorded, if known. Compass bearing of bird's approach and departure, station number and distance from transect were also recorded. Aural detections were followed by an attempt to get a visual of the bird to determine age and sex.

Occupancy Estimation

The MacKenzie et al. (2011) occupancy model was used to estimate Northern Goshawk occupancy probability within the Apache-Sitgreaves National Forests. Program MARK was used for parameter estimation (MARK Version 6.1, www.phidot.org, accessed 10 Jun 2011) and the R package RMark for model construction (RMARK Version 2.1.3, accessed 11 December 2012; R Version 2.15.2, www.R-project.org, accessed 26 October 2012). The probability of

occupancy was estimated separately for each stratum group (pinyon-juniper woodland, ponderosa pine forest, burned ponderosa pine forest).

The probability of detection was evaluated for four models:

1. Detection probability was held constant [$p(.)$],
2. Detection probability could vary by season (nesting and fledging periods) [$p(t)$],
3. Detection probability could vary by strata [$p(g)$], and
4. Detection probability could vary by season and strata [$p(t+g)$].

Survey effort was measured as the percentage of call point stations completed in suitable habitat ($\bar{x}$ = 93%, range = 46%, 100%). However, the detection model including the survey effort covariate did not converge due to small sample size.

Northern Goshawk occupancy and detection was estimated for the Apache-Sitgreaves National Forests using the mean of the estimates weighted by strata area. For example, the occupancy rate for the Apache-Sitgreaves National Forests was estimated by $\widehat{\psi}_{\text{Forest}} = \sum_{i=1}^{3} w_i \, \widehat{\psi}_i$, where the number of strata was three, the weight w_i was the proportion of PSUs in stratum i, and $\widehat{\psi}_i$ was the estimated probability of occupancy for stratum i. The delta method (Berven 2010a) (R Version 2.15.2) approximated sampling variances and standard errors for the estimates. The delta method estimated the standard errors of the occupancy estimates by accounting for the covariance between the stratum-specific estimates (Berven 2010a). The occupancy asymmetric 95% confidence intervals (CI) were estimated by back-transforming the logit confidence limits.

Model Selection and Model Averaging

When models were used to approximate conceptual truth, the relative loss of Kullback-Leibler Information (Burnham and Anderson 2001, ESRI 2006) was estimated by information-theoretic model selection (Burnham and Anderson 2002). Models were ranked by the Akaike Information Criterion (Avery and Burkhart 2002), adjusted for small sample size (AIC$_c$) (Hurvich and Tsai 1989), measured strength of evidence for alternate hypotheses by AIC$_c$ weights (w_i) and quantified the likelihood of modeled hypotheses given the data by evidence ratios (w_i/w_j).

The predictions and parameter estimates were model averaged, and unconditional standard errors and 95% confidence intervals were estimated for all models in the candidate set (Burnham and Anderson 2002).

RESULTS

Nestling surveys began on 3 June 2013. Hatching was estimated to have occurred late-May to early-June 2013. Northern Goshawks in monitored nests began leaving the immediate nest area on or close to 5 July 2013. Fledgling surveys began 5 July and continued until all planned PSUs were resurveyed (8 August 2013).

Twenty-one PSUs were surveyed at least one time (Table 2, Figure 3, Appendix A) during the nestling survey window and 18 were surveyed during the fledgling survey window. A total of 11 goshawk detections were made throughout the field season (Table 3, Figure 4); 7 during the nestling surveys and 4 during the fledgling surveys.

Table 2. Primary Sampling Units sampled at least one time in the Apache-Sitgreaves National Forests during the 2013 field season, allocated to the strata levels.

	Unburned	Burned	Total
Ponderosa pine, mixed coniferous	11	7	18
Woodland and Subalpine	3	-	3
Total	14	7	21
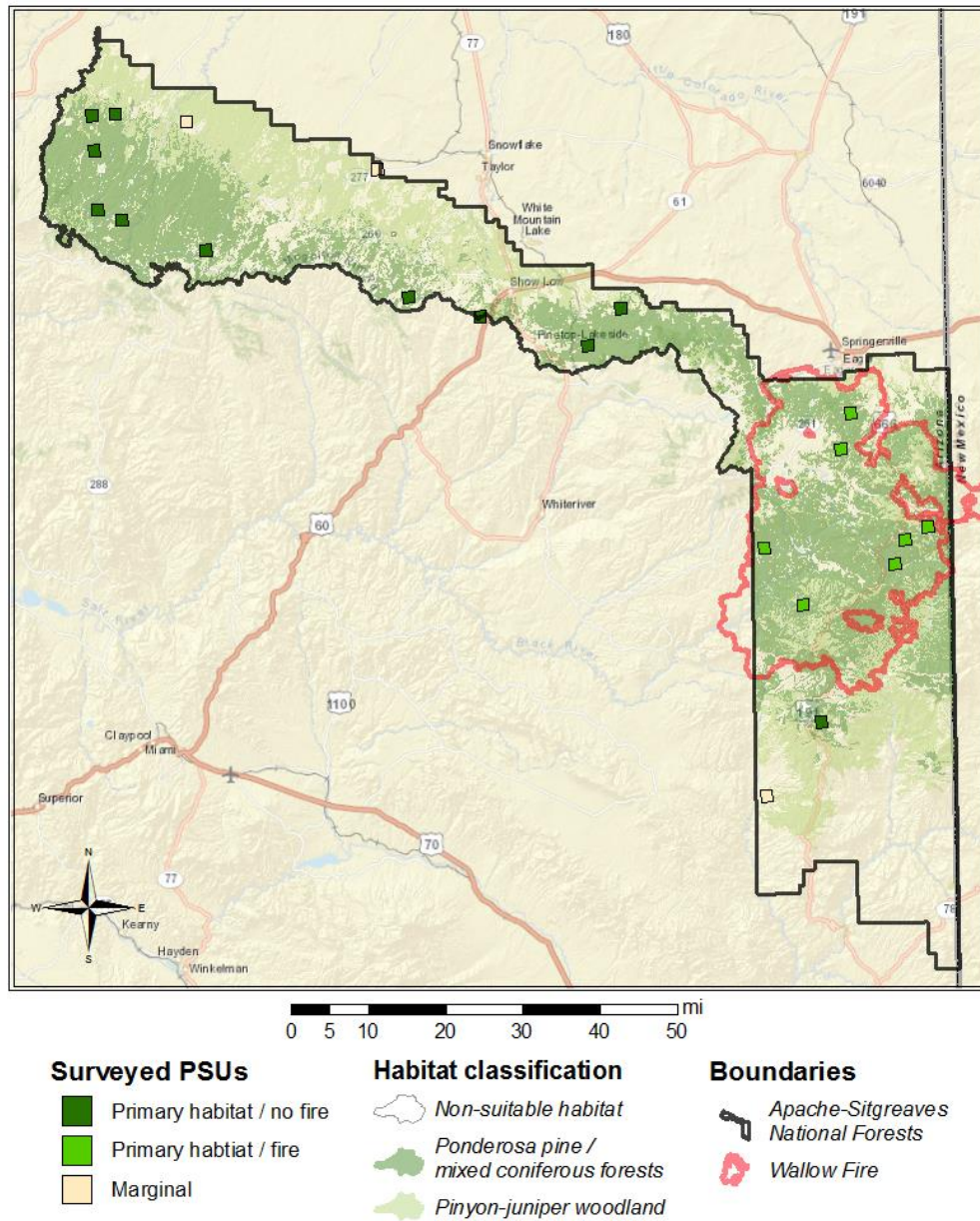
Figure 3. Primary Sampling Units (PSUs) surveyed for Northern Goshawks (*Accipiter gentilis*) in the Apache-Sitgreaves National Forests, June-August, 2013.

Table 3. Total Northern Goshawk (*Accipiter gentilis*) detections in the Apache-Sitgreaves National Forests, June-August, 2013.

Strata	Nestling Season Detections	Fledgling Season Detections	Total
Ponderosa pine	4	1	5
Burned ponderosa pine	3	3	6
Marginal habitat	0	0	0
Total	7	4	11
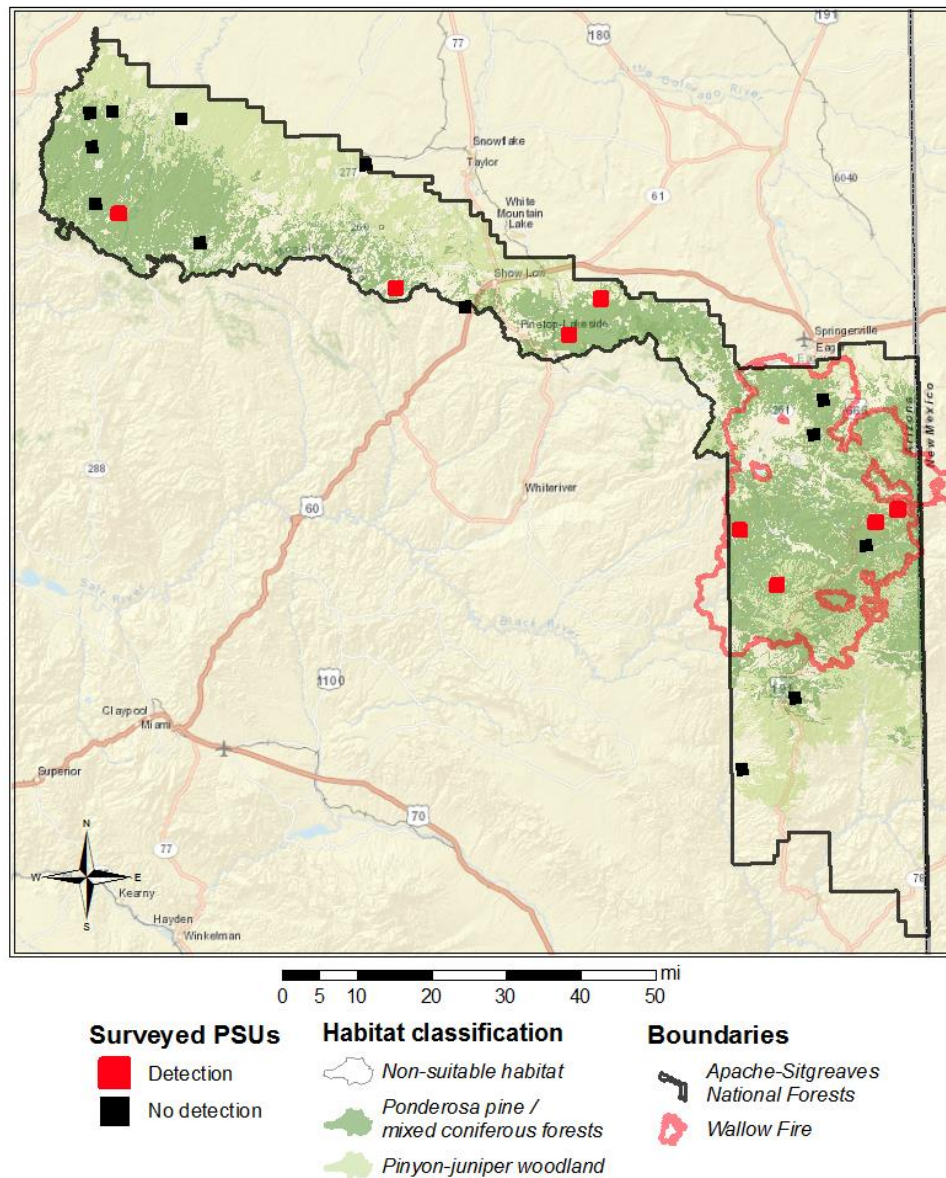
Figure 4. Surveyed Primary Sampling Units (PSUs) in the Apache-Sitgreaves National Forests with Northern Goshawk (*Accipiter gentilis*) detections, June-August, 2013.

The best approximating model for the occupancy of Northern Goshawks contained a constant rate of detection across strata and season (Table 4). There was nearly equal support for the second best model containing the effect strata on detection. There was little support for the effect of the nesting and fledging seasons on the detection rate of Northern Goshawks. The model containing the effect of season [$p(t)$] was four times less probable than the model with constant rate of detection [$p(.)$], and was three times less plausible than the model with the effect of strata [$p(.)$]. There was evidence for a mean rate of detection of 0.53 for the Forest, but there was also evidence that the detection rate of the Northern Goshawk was 36% lower in ponderosa pine forest than in burned ponderosa pine forest (Table 5). Considering the variation in detection rates, the model averaged occupancy rate of Northern Goshawks was somewhat greater in ponderosa pine forest than burned ponderosa pine forest (Table 6). However, the standard errors of the estimates for ponderosa pine forest and burned ponderosa pine forest overlapped, indicating the occupancy estimates were similar in the two strata.

Table 4. Model selection for estimating the detection and occupancy rates of the Northern Goshawk (*Accipiter gentilis*) in the Apache-Sitgreaves National Forests, 2013, Arizona, USA. The model selection metrics are the number of parameters (K), minimized -2 log-likelihood of the model [-2log(L)], Akaike Information Criterion adjusted for sample size (AIC_c), change in AIC_c (ΔAIC_c) and AIC_c weight (w_i).

Model	K	-2log(L)	AIC_c	ΔAIC_c	w_i
$p(.)$ $\psi(g)$	3	40.15	47.56	0.00	0.455
$p(g)$ $\psi(g)$	4	37.60	48.10	0.54	0.347
$p(t)$ $\psi(g)$	4	39.80	50.30	2.74	0.116
$p(g+t)$ $\psi(g)$	5	37.00	51.00	3.44	0.082

Table 5. Model averaged estimates of the probability of detection, unconditional standard errors (SE), coefficients of variation (CV), and lower (LCL) and upper (UCL) 95% confidence limits for the Northern Goshawk (*Accipiter gentilis*) in the Apache-Sitgreaves National Forests, 2013, Arizona, USA.

Parameter	Detection Probability	SE	CV	LCL	UCL
Nesting - burned ponderosa pine	0.702	0.223	0.318	0.225	0.950
Fledging - burned ponderosa pine	0.677	0.236	0.349	0.202	0.946
Nesting - ponderosa pine	0.455	0.239	0.525	0.112	0.847
Fledging - ponderosa pine	0.428	0.242	0.565	0.097	0.839
Nesting	0.547	0.210	0.383	0.187	0.864
Fledging	0.522	0.216	0.413	0.167	0.856
Burned ponderosa pine	0.689	0.225	0.326	0.220	0.946
Ponderosa pine	0.441	0.233	0.527	0.110	0.834
Apache-Sitgreaves National Forest	0.534	0.206	0.385	0.185	0.853

Table 6. Model averaged estimates of the probability of occupancy, unconditional standard errors (SE), coefficients of variation (CV), and lower (LCL) and upper (UCL) 95% confidence limits for the Northern Goshawk (*Accipiter gentilis*) in the Apache-Sitgreaves National Forests, 2013, Arizona, USA.

Parameter	Occupancy	SE	CV	LCL	UCL
Pinyon-juniper	0.000	0.000	-	-	-
Burned ponderosa pine	0.646	0.243	0.376	0.178	0.981
Ponderosa pine	0.742	0.275	0.371	0.167	0.994
Apache-Sitgreaves National Forests	0.474	0.139	0.293	0.232	0.729

DISCUSSION AND RECOMMENDATIONS

Nationally, the status of the Northern Goshawk remains of interest because not enough is known about their population. USFS wildlife officials classified the Northern Goshawk as a species of special interest within the Southwest Region and in the Apache-Sitgreaves National Forests. The "Northern Goshawk Inventory and Monitoring Technical Guide" (Woodbridge and Hargis 2006) calls for the development and implementation of forest-level and large-scope bioregional monitoring to obtain consistent, reliable information on Northern Goshawk population trends and responses to management actions. The 2009 field season was the first step in accomplishing regional goals by creating the sampling grid, selecting PSUs based on habitat types and access and implementing the field research at a large scope. There remained a need to develop and implement local, smaller-scope Northern Goshawk monitoring to provide reliable data for the evaluation of the species' status at a smaller management unit. This study attempts to do this.

The occupancy estimates determined by the 2013 sampling effort provide a baseline status of goshawks in the Apache-Sitgreaves National Forests. In a single monitoring season, we determined that suitable habitat within the forest is a little less than half occupied by goshawks. Occupancy in 2013 in the Apache-Sitgreaves National Forests was higher than occupancy in the entire Southwest Region in 2009 (0.286; CI: 0.154-0.357). However, this comparison means little because annual goshawk breeding success varies significantly among years (MacKenzie et al. 2002, Reich et al. 2004, Patla 2005) and the Bioregional effort methodology and analyses were different from this year's methodology and analyses. The best practice is to continually and consistently monitor populations, whether it be at the Bioregional or forest scale. Once additional monitoring is completed within the same scale, data can be compared sample-year to sample-year and population trends can be estimated within each scale.

The effect of fires on goshawk populations has recently become an important question because of changes in burn regimes within goshawk habitats in North America. Until recently, there has been little research on how fire affects goshawks (Stone 2013). The 2013 monitoring effort provides evidence that goshawks occupy burned ponderosa pine forests (0.646; CI: 0.178 – 0.981) at the same level as unburned ponderosa pine forests (0.742; CI: 0.167 – 0.994) two years after a burn. Also, as seen in Figure 5, goshawks occupied PSUs in 2013 that suffered significant basal area loss due to the 2011 fire. Unfortunately, the current monitoring effort cannot address if goshawk occupancy in the burned area is significantly different from before the burn. Because these results seem counterintuitive, the data collected for monitoring purposes might be used to investigate how, or if, burn intensity, regeneration or other fire

characteristics affect goshawk occupancy. Long-term monitoring efforts can be used to determine how fires affect occupancy because, theoretically, you will eventually collect occupancy data from an area before and after a fire.
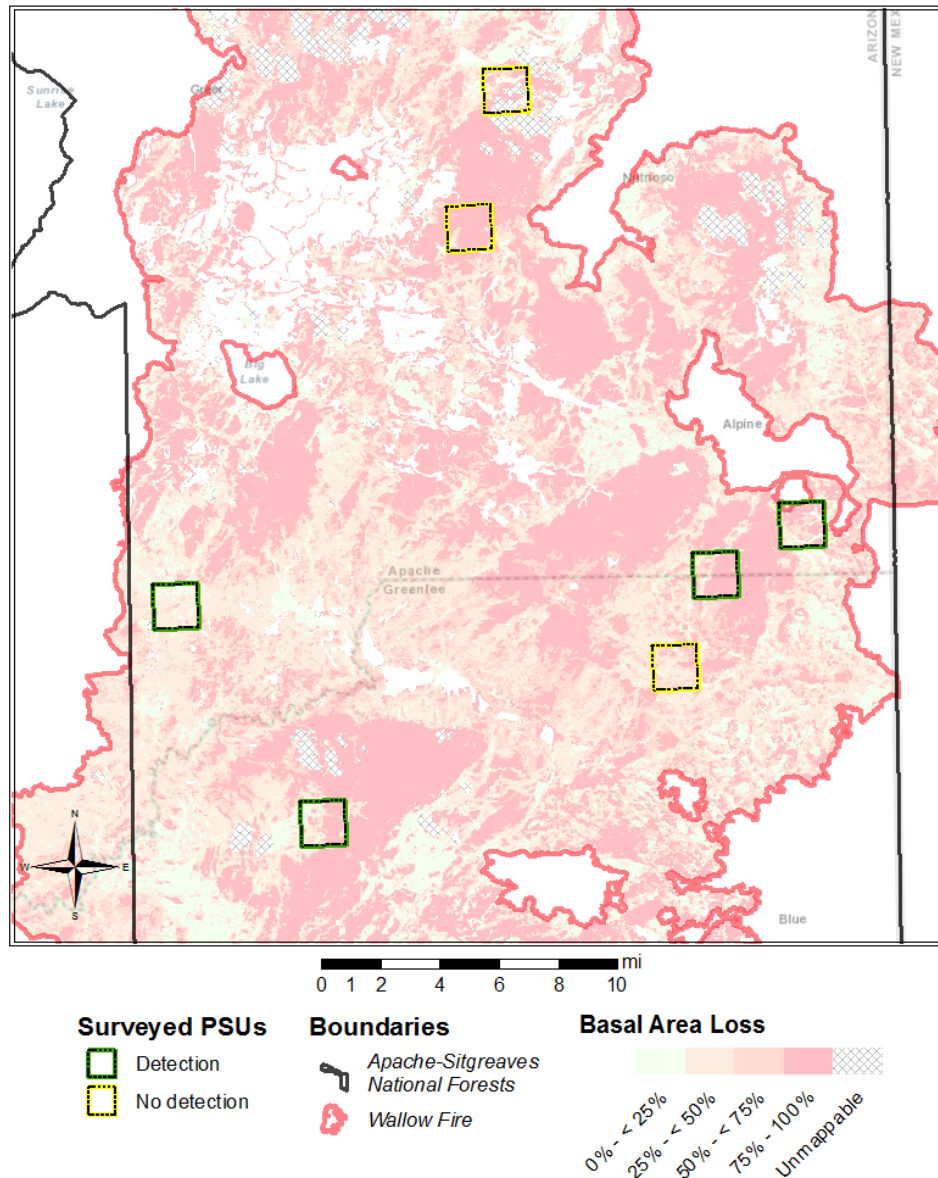

Figure 5. Occupied Northern Goshawk (*Accipiter gentilis*) Primary Sampling Units (PSU) surveyed in 2013 and Wallow Fire burn intensity (based on basal area loss).

Consistent sampling can be used to determine how changes in occupancy are related to habitat, changes in habitat and management practices. With this knowledge, recommendations can be made to officials to modify management practice to help maintain or increase Northern Goshawk populations within the area of study. RMBO and the Apache-Sitgreaves National Forests already plan on completing the same survey effort during the 2014 field season and should have trend analysis completed by early 2015.

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APPENDIX A

Northern Goshawk (*Accipiter gentilis*) survey results for each Primary Sampling Unit (PSU) visited during the Nestling (2 June – 4 July) and Fledgling seasons (5 July – 8 August), 2013 in the Apache-Sitgreaves National Forests, Ariz. Strata: MA = marginal habitat (pinyon-juniper woodland and subalpine forests); PF = primary habitat (ponderosa pine and mixed conifer forests) within the Wallow Fire burn perimeter; PN = primary habitat outside of the Wallow Fire burn perimeter. Detection Results: 1 = Surveyed with Detection; 0 = Surveyed without Detection; -1 = Not Surveyed.

PSU	Stratum	Rank	Nestling Season Completion Date	Results	Fledgling Season Completion Date	Results
AS-NOGO-MA1	MA	1	6/4/2013	0	7/5/2013	0
AS-NOGO-MA3	MA	3	6/5/2013	0	7/21/2013	0
AS-NOGO-MA4	MA	4	6/6/2013	0	8/6/2013	0
AS-NOGO-PF1	PF	1	6/7/2013	0	7/9/2013	0
AS-NOGO-PF2	PF	2	6/9/2013	1	NA	-1
AS-NOGO-PF3	PF	3	6/11/2013	0	7/7/2013	1
AS-NOGO-PF4	PF	4	6/18/2013	1	7/10/2013	1
AS-NOGO-PF5	PF	5	6/19/2013	1	7/15/2013	1
AS-NOGO-PF7	PF	7	6/22/2013	0	7/16/2013	0
AS-NOGO-PF8	PF	8	6/24/2013	0	7/17/2013	0
AS-NOGO-PN1	PN	1	6/7/2013	1	NA	-1
AS-NOGO-PN2	PN	2	6/8/2013	0	7/23/2013	0
AS-NOGO-PN3	PN	3	6/10/2013	0	7/31/2013	0
AS-NOGO-PN5	PN	5	6/11/2013	1	NA	-1
AS-NOGO-PN6	PN	6	6/17/2013	1	8/3/2013	0
AS-NOGO-PN7	PN	7	6/19/2013	0	7/31/2013	0
AS-NOGO-PN8	PN	8	6/25/2013	0	8/8/2013	0
AS-NOGO-PN9	PN	9	6/25/2013	1	7/19/2013	0
AS-NOGO-PN10	PN	10	6/21/2013	0	8/4/2013	0
AS-NOGO-PN11	PN	11	6/23/2013	0	8/1/2013	0
AS-NOGO-PN12	PN	12	7/2/2013	0	8/7/2013	1