Northern Goshawk Bioregional Monitoring in the Southwest United States:

2009 Field Season Report

May, 2010

ROCKY MOUNTAIN BIRD OBSERVATORY

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- ***Mission****: To conserve birds and their habitats*
- ***Vision****: Native bird populations are sustained in healthy ecosystems*
- ***Core Values****:*
    1. ***Science*** *provides the foundation for effective bird conservation.*
    2. ***Education*** *is critical to the success of bird conservation.*
    3. ***Stewardship*** *of birds and their habitats is a shared responsibility.*

- ***RMBO accomplishes its mission by:***
- ***Monitoring*** *long-term bird population trends to provide a scientific foundation for conservation action.*

- ***Researching*** *bird ecology and population response to anthropogenic and natural processes to evaluate and adjust management and conservation strategies using the best available science.*

- ***Educating*** *people of all ages through active, experiential programs that create an awareness and appreciation for birds.*

- ***Fostering*** *good stewardship on private and public lands through voluntary, cooperative partnerships that create win-win situations for wildlife and people.*

- ***Partnering*** *with state and federal natural resource agencies, private citizens, schools, universities, and other non-governmental organizations to build synergy and consensus for bird conservation.*

- ***Sharing*** *the latest information on bird populations, land management and conservation practices to create informed publics.*

- ***Delivering*** *bird conservation at biologically relevant scales by working across political and jurisdictional boundaries in western North America.*

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Cover Photo: Picture by Jenny Berven. The Northern Goshawk is a non-releasable bird from Rocky Mountain Raptor Program, Fort Collins, CO

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EXECUTIVE SUMMARY

The Northern Goshawk is the largest accipiter found in North America and inhabits much of the forested land in the United States. Since 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 mangers 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 a regional Northern Goshawk population.

The U.S. Forest Service contracted Rocky Mountain Bird Observatory (RMBO) to assist in the development and implementation of Northern Goshawk monitoring using the guide as a reference. A grid of 12,315, 600-ha square Primary Sampling Units (PSU) was laid across the National Forests of Arizona and New Mexico using ArcGIS. Each PSU was delineated into one of four strata based on information from the General Terrestrial Ecosystem Survey data layer. These strata were produced from habitat type and ease of access. Habitat was stratified into two categories; 1) montane or upper montane was grouped as one habitat stratum and, 2) subalpine or woodland was grouped as the other habitat stratum. All other habitats within National Forest boundaries were not considered to be nesting habitat. Ease of access was stratified into two categories; 1) Forest Service land was defined as easy access and, 2) Wilderness land was defined as difficult access. Sampling units were selected with a spatial balance design using the GRTS function (Spsurvey package) in R.

Broadcast acoustical surveys were conducted in the selected sampling units during two distinct time periods (nestling and fledgling) in the summer of 2009. At least one survey was conducted in 105 sampling units between 15 June – 5 September 2009. 17 of 91 PSUs and 8 of 90 PSUs had detections during the nestling and fledgling surveys, respectively.

Detection probability and occupancy estimates were determined using six different models and evaluated for best fit with Akaike's information criterion (AICc). Models 1 and 2 used PROC NLMIXED in SAS to determine estimates. Models 3, 4, 5 and 6 used program Mark to determine estimates. Models 1, 3 and 5 used variable detection probabilities to estimate occupancy. Models 2, 4 and 6 used a constant detection probability to estimate occupancy. And Models 5 and 6 used a covariate accounting for survey effort to determine estimates because 31 surveyed sampling units had some level of inaccessibility due to private landownership. Model 6 had the lowest AICc value (128.6) of the six models with a detection probability of 0.448 (SE = 0.155) and occupancy of 0.286 (CI: 0.154-0.357).

The Southwest occupancy estimate indicates there was a lower density of Northern Goshawks in the Southwest than in the Rocky Mountain Region in 2009 - whose preliminary occupancy estimate was 0.475 (CI: 0.3614-0.5883). 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. Therefore, frequent Northern Goshawk monitoring using a constant study design is instrumental in determining trends in the population as well as evaluating positive or negative population responses to management decisions and practices.

ACKNOWLEDGEMENTS

Ron Maes of the Unites States Forest Service was essential in the development and funding of this monitoring effort. He, along with several Forest Service professionals including Richard Reynolds, Christina Vojta, Bill Noble and Candance Bogart provided technical support for the sampling frame design, sampling unit selection and map creation needed for the field season. Jim Baldwin, of the Forest Service, provided his expertise and time to run data analysis. Several people within Rocky Mountain Bird Observatory provided input, expertise, services and support; these individuals include: Rob Sparks, who created the GIS sampling frame; Chandman Sambuu, who created the sampling maps and a database to store and manage all information collected during the field season; and David Pavlacky, who provided his modeling and statistical knowledge and who completed several endeavors of data analysis. Of course field studies could not be completed without field technicians. These individuals, Jeff Albertini, Timothy Alvey, Derek Buchner, Houston Flores, Adam Gmyrek, Sara Gumeringer, Gretchen Henne, Marcus Hopkins, Patrick Livingston, Brian Long, Courtney Marne, Jen Ottinger and Tim Weber, not only completed the tasks set before them, but completed their work with enthusiasm, eagerness and attention to detail. Finally, this report benefitted greatly from peer reviews by David Hanni.

TABLE OF CONTENTS

TABLES & FIGURES

INTRODUCTION

The Northern Goshawk (*Accipiter gentilis*) is a species of interest within the United States Department of Agriculture's Forest Service (USFS) due to the species' relationship between forest management and how management practices affect Northern Goshawk populations.

The Northern Goshawk is the largest of three accipiters found in North America (Squires and Reynolds 1997). The Northern Goshawk inhabits and nests 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, the Northern Goshawk is 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, the Northern Goshawk 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).

Due to the difficulties associated with the low density of the Northern Goshawk (≤12 nesting pairs/100-km2) 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). Also, because the Northern Goshawk generally requires 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)

The Northern Goshawk is cosseted by several facets of law and regulation both within the USFS and broader intra-agency guidance; such regulations include 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 USFS Southwest Region contracted Rocky Mountain Bird Observatory (RMBO) to develop and implement bioregional Northern Goshawk monitoring for the 2009 breeding season, using the technical guide as a reference, in all of the national forests in Arizona and New Mexico. The contract between these two entities was advantageous for the Southwest Region because RMBO was working with the U.S. Forest Service's Rocky Mountain (RMR) to conduct Northern Goshawk monitoring in forests throughout the lower Rocky Mountains during the same season.

The USFS, Southwestern Region, encompasses 20.35 million acres of forests and woodlands within 11 National Forests in Arizona and New Mexico (United States Forest Service 2009). Each of these forests are included 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 surveys of Northern Goshawks, including one of the most extensively studied populations in the Kaibab NF (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 year-to-year within a relatively small area and provides useful information on local Northern Goshawk populations, the information cannot be directly compared with other forests' data due to differences in monitoring protocols and methods. There have been no broad spatial scale surveys conducted within the bioregion therefore, no population estimates have been determined for the area. Furthermore, there remains a question of pinyon-juniper woodlands use by nesting Northern Goshawks (Reynolds et al. 1992). Researchers speculate that the birds do not use the woodlands for nesting, or only use the woodlands in years were an exceptionally high prey base can support a larger Northern Goshawk population and less dominate Northern 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). However, very little research has been conducted on nesting Northern Goshawks in the pinyon-juniper woodlands (Reynolds et al. 1992). And as stated in the "Northern Goshawk Inventory and Monitoring Technical Guide" (Woodbridge and Hargis 2006), many previous studies are examples of convenience sampling where previously known nesting sites, usually detected near roads, are continually monitored whereas the rest of the potential habitat may be neglected.

Monitoring Northern Goshawk populations, even at a local scale, 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. Although occupancy is not as accurate as abundance, it can be used as a surrogate for abundance because the two are positively correlated (MacKenzie and Nichols 2004).

METHODS

Study Area

The study area encompasses all Forest Service lands located in Southwest Region of Arizona and New Mexico that include potential Northern Goshawk habitat. This includes the Apache-Sitgreaves, Coconino, Coronado, Kaibab, Prescott and Tonto National Forests in Arizona and the Carson, Cibola, Gila, Lincoln and Santa Fe National Forests in New Mexico. Each of these forests is located within the Colorado Plateau and Southwest Mountains Goshawk Bioregion (Woodbridge and Hargis 2006). The Kiowa National Grassland was not incorporated into the study area as it does not contain Northern Goshawk habitat and is not located within the Colorado Plateau and SW Mountains Goshawk Bioregion.

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 research. Furthermore, unpaid interns were hired to assist field crews with surveying. 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, feather and other indicators of Northern Goshawk presence. We also trained technicians in survey and data collection protocol. The training was conducted by USFS personnel in the first week of June near Steamboat Springs, CO. This was while Northern Goshawks were occupying known territories but before eggs had hatched. This allowed technicians to see suitable Northern Goshawk habitat.

Site 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 2005), the region-wide grid was creating using 600.25ha PSUs overlaid onto a USFS administrative boarder layer. To be included in the sampling frame, the PSU's center point was required to be located within the USFS administrative boundary. The USFS administrative boundary layer did not delineate non-USFS property owners within the boundary and thus, private lands were included as part of the sampling frame.

Stratification of habitat and survey cost was implemented to increase the effectiveness of surveying over a large geographical area. The first stratification was between habitat classes. Northern Goshawks are known to inhabit Ponderosa pine and mixed coniferous forests in the Southwest at densities comparable to primary habitat in other areas (Reynolds et al. 1992, Squires and Reynolds 1997, Reynolds and Joy 1998, Reynolds et al. 2008). Northern Goshawks in the Southwest are known to inhabit sub-alpine forests to a lesser extent than ponderosa pine forests and similarly to densities in other regions (Reynolds et al. 1992). According to the USFS's Forest Inventory Data Online system, very little of the overall forest and woodland area includes sub-alpine forests (approximately 570,000 acres or 1.6% of Forest Service land in Arizona and New Mexico (United States Forest Service 2009)). There is little research describing the use of pinyon-juniper woodlands by nesting Northern Goshawks. However, because these woodlands make up such a large percentage (approximately 57.5%) of the Forest Service land in the Southwest, excluding the pinyon-juniper habitat class is objectionable when there is at least some known use of these habitats (United States Forest Service 2009). Therefore, one stratum was defined as montane and upper montane in the GTES which include Ponderosa pine and mixed coniferous forests and the other strata was defined as woodland which incorporates pinyon-juniper woodlands and sub-alpine forests.

To maximize cost effectiveness an additional stratification between high- and low-cost survey units. PSUs located within wilderness areas were delineated as high-cost units because wilderness areas do not permit road development whereas FS land do and should be difficult to access. In theory, PSUs located near roads will take less time and effort to reach and survey because they should be easy access and thus, decreasing the cost of sampling that area compared to PSUs located further from roads.

We used the General Terrestrial Ecosystem Survey (GTES) (Carleton et al. 1991) and ArcGIS to delineate and stratify regions of potential Northern Goshawk habitat. The climate class associations within the GTES were mapped at a scale of 1:250,000 (Carleton et al. 1991). The Valles Caldera National Preserve was not covered by the GTES data. Therefore, we overlaid the Valles Caldera National Preserve with the southwest ReGAP land cover data (Lowry et al.

2005) and classified all grids within the Preserve as montane forest. We defined the sampling frame for potential Northern Goshawk habitat as all grids containing a minimum of 20% of the woodland (4), montane (5), upper-montane (6) and sub-alpine (7) climate classes from the GTES. Of the 14,865 sample grids, we selected 12,315 grids as the sample frame. We used two-way stratification to allocate the sample frame grids to two strata each with two levels. The first level of stratification divided the sampling frame into grids having their center in wilderness areas and grids having their center in Forest Service land. The second level of stratification divided the sampling frame into grids with a minimum of 20% montane (climate class 5, ponderosa pine) and upper-montane (climate class 6, mixed-conifer) vegetation and all other grids with dominant cover of woodland (climate class 4, pinyon-juniper) and subalpine (climate class 4, spruce-fir) vegetation (Figure 1).

A spatially balanced study design was implemented to select PSUs to be surveyed. Sample size was estimated with the use of an interactive spreadsheet developed by the USFS included in the "Northern Goshawk Inventory and Monitoring Technical Guide" (Woodbridge and Hargis 2006). The spreadsheet incorporates the effect of cost for each stratum while estimating samples sizes required to determine Northern Goshawk occupancy. An equal "proportion of PSU's with presence" in each of the four strata was used because little is known about Northern Goshawk occupancy in pinyon-juniper forests. The GRTS function (Spsurvey package) in R was run to select the units with a spatial balanced design. After completion of the nestling season, sample size for the fledgling season was primarily determined by nestling season survey results. All PSUs without a nestling season detection, fifty percent (randomly selected) of PSUs with a positive nestling season detection and any additional PSUs not previously surveyed that time would allow would be surveyed.

After the PSUs were selected for survey, call stations were added to the unit. One hundred and twenty call stations on ten transect lines (each containing twelve stations spaced 200 meters apart). Each transect line was placed 250 meters apart, offset by 100 meters and located at least 150 meters from the PSU boarder (Figure 2). Maps were created using online Google Earth programming that allowed technicians to access PSU and call station information with road, satellite or terrain backgrounds (Figure 3)

Survey Protocol

The "Northern Goshawk Inventory and Monitoring Technical Guide" (Woodbridge and Hargis 2006) was used to define survey protocols which were developed by Kennedy and Stahlecker (1993). Technicians were responsible for conducting 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). 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 Northern Goshawks in the region, input was received from district FS biologists and other scientists monitoring Northern Goshawk nests throughout the region to specify when eggs were expected to hatch. The nestling survey ended once the 10 PSUs were surveyed, which occurred before nestling began to fledge. The fledgling survey began once nestlings moved away from the nest (approximately when young are 34 days). Juvenile Northern Goshawks typically disperse from the area approximately 6 weeks after fledging. Once juveniles leave, broadcast acoustical surveys are no longer effective.

Broadcast acoustical surveys were conducted at any time between 30 minutes before sunrise to 30 minutes before sunset, coinciding with Northern Goshawk activity (Woodbridge and Hargis 2006). Calling procedure followed protocols described in the monitoring technical guide

(Woodbridge and Hargis 2006). Technicians broadcast one of three Northern Goshawk calls depending if it was during the nestling or fledgling surveys. During the nestling survey, an adult alarm call was broadcasted and during the fledgling survey, a juvenile food-begging call or a wail call was broadcasted. Technicians used FoxPro NX3 digital callers preloaded with the calls at a volume producing 80 to 110 dB output 1 meter 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), the technician 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, the technician would then move on to the next call station, while searching the surrounding area for any Northern 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. A call station in safe, suitable habitat was located within 150 of tree cover, on a slope less than 36 degrees and not located in water. 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 was also recorded. Aural detections should have been followed by an attempt to get a visual of the bird to determine age and sex.

Data Analysis

Locations in the Southwest Region were divided into four strata; montane and upper-montane/easy access (1f), montane and upper-montane/difficult access (1w), woodland & subalpine/easy access (2f), and woodland & subalpine/difficult access (2w; Table 1).

Table 1. Stratum codes.

Strata	Forest Service	Wilderness
Montane and Upper-Montane	1f	1w
Woodland and Subalpine	2f	2w

A presence/absence model was fit with probabilities of presence for each stratum (, , , and) and separate detection probabilities for the two seasons (and). This is considered to be a "full" model (Model 1). In addition, a simpler model (Model 2) was fit with equal probabilities of presence irrespective of access type (and) and equal detection probabilities ( ) using PROC NLMIXED in SAS (and an equivalent program in R using the function optim).

Under Model 1, the overall the proportion of PSU's with Northern Goshawks can be defined as where , , , and are the relative proportions of the four strata in the population of PSU's. The overall of the probability of presence for just the montane PSU's is

and that of the woodland and subalpine PSU's is given by

Under Model 2, we have and calculated directly (i.e., they are explicit parameters in the model) and

The estimates of all of these quantities are found by plugging in the maximum likelihood estimates of the model parameters.

Additional data analyses were executed by RMBO using program MARK (White and Burnham 1999) because future analyses through our collaborators in the USFS using the methods stated above would not be possible in subsequent years. A presence/absence model was fit in program MARK to determine detection probabilities ( ) and occupancy ( ) for each survey period again using a "full" and "simple" modeling (Model 3 and Model 4, respectfully) approach with the same parameters as described above. The sampling variances (CV) and standard errors (SE) of the combined estimates were approximated using the delta method (Powell 2007) in program SAS (PROC IML, SAS Institute 2008).

An additional model accounting for variation in survey effort was created because some PSUs contained call points in suitable habitat that were inaccessible or call points on private land that were inaccessible. The model included a covariate where the probability of detection was modeled as a function of the percentage of call points completed in suitable habitat. A call station was considered to be in suitable habitat if it was within 150 meters of tree cover and on a slope no steeper than 36°. The survey effort covariate was calculated for each PSU by dividing the number of completed call points by the total number call points in suitable habitat and multiplying by 100. The data were then analyzed with a "full" and "simple" presence/absence model with the covariate using program MARK (Model 5 and Model 6, respectfully).

We compared models using Akaike's information criterion (AIC_c), (Burnham and Anderson 2002).

As stated before, the sampling variances and standard errors of the combined estimates were approximated using the delta method (Powell 2007) in program SAS (PROC IML, SAS Institute 2008). α-levels = 0.05; Confidence intervals (CI) are at 95%.

RESULTS

Of the 12,315 sampling frame grids, we classified 1,639 as wilderness and 10,676 as Forest Service land and 5,753 as montane & upper-montane and 6,562 as woodland and subalpine (Table 2). The interactive sample size spreadsheet estimated that 131 PSUs could be surveyed when cost of surveying easy and difficult access PSUs equaled $1,000 and $1,200, respectively and detection was estimated equally between the four strata at 0.3. The PSUs were then selected using the GRTS function.

Table 2. Two-way stratification of sampling grids with the number of grids allocated to the strata levels.

Strata	Forest Service	Wilderness	Total
Montane and Upper-Montane	5,030	723	5,753
Woodland and Subalpine	5,646	916	6,562
Total	10,676	1,639	12,315

Based on the input from local scientists, hatching occurred on or close to 15 June 2009. Northern Goshawks in monitored nests began leaving the immediate nest area on or close to 25 July 2009. This allowed the fledgling survey to continue through 5 September 2009.

One hundred and five PSU were surveyed at least one time (Table 3, Figures 4 & 5). Thirty-one of the surveyed PSUs contained private or non-USFS land. Ninety-one PSUs were surveyed during the nestling survey window and 90 PSUs were surveyed during the fledgling survey window. A total of 25 detections were made throughout the field season (Table 4, Figure 6 & 7). Seventeen detections were made during the nestling surveys. Eight detections were made during the fledgling surveys, four of which were in PSUs that did not record a detection during the nestling surveys.

Table 3. Primary Sampling Units sampled at least one time during the 2009 field season, allocated to the strata levels.

Strata	Forest Service	Wilderness	Total
Montane and Upper-Montane	44	6	50
Woodland and Subalpine	47	8	55
Total	91	14	105

Table 4. Total detections made in each stratum.

Strata	Nestling Season Detections	Fledgling Season Detections	Total
1f	12	5	17
2f	3	2	5
1w	1	1	2
2w	1	0	1
Total	17	8	25

There was no difference in results between using PROC NLMIXED in SAS or program MARK.

Detection probabilities determined with the "full" models were 0.641 (SE = 0.155) and 0.416 (SE = 0.169) during the nestling and fledgling periods, respectively (Table 5). Occupancy within the montane & upper-montane stratum ($_1$) was 0.443 (SE = 0.122) while occupancy in the woodland & subalpine strata ($_2$) was 0.125 (SE = 0.058) for Models 1 and 3. Overall occupancy of Northern Goshawks using the “full” models in the Southwest Region was 0.274 (CI: 0.131–0.417; Table 5).

Table 5. Modeling results for Northern Goshawk monitoring.

Model	Parameter	Estimate	Standard Error	Confidence Interval	AIC$_c$
Model 1	$\rho_{nestling}$	0.641	0.155	0.334-0.948	136.7
	$\rho_{fledgling}$	0.416	0.169	0.082-0.750	
	$_1$	0.443	0.122	0.201-0.685	
	$_2$	0.125	0.058	0.010-0.241	
		0.274	0.072	0.131-0.417	
Model 2	$\rho_{constant}$	0.581	0.140	0.303-0.859	132.3
	$_1$	0.418	0.108	0.203-0.632	
	$_2$	0.118	0.054	0.012-0.224	
		0.258	0.063	0.133-0.383	
Model 3	$\rho_{nestling}$	0.641	0.155	0.334-0.948	136.7
	$\rho_{fledgling}$	0.416	0.169	0.082-0.750	
	$_1$	0.125	0.058	0.010-0.241	
	$_2$	0.274	0.072	0.131-0.417	
		0.274	0.072	0.131-0.417	
Model 4	$\rho_{constant}$	0.581	0.140	0.303-0.859	132.3
	$_1$	0.418	0.108	0.203-0.632	
	$_2$	0.118	0.054	0.012-0.224	
		0.258	0.063	0.133-0.383	
Model 5	$\rho_{nestling}$	0.519	0.175	0.215-0.810	133.2
	$\rho_{fledgling}$	0.302	0.155	0.093-0.646	
	$_1$	0.502	0.133	0.242-0.643	
	$_2$	0.130	0.060	0.013-0.193	
		0.304	0.077	0.154-0.385	
Model 6	$\rho_{constant}$	0.448	0.155	0.193-0.734	128.6
	$_1$	0.473	0.118	0.262-0.693	
	$_2$	0.122	0.055	0.048-0.274	
		0.286	0.067	0.154-0.357	

ρ = Detection probability. $_1$ = Occupancy estimate for montane & upper montane habitat. $_2$ = Occupancy estimate for woodland & subalpine habitat. = Overall occupancy estimate.

The detection probability determined with the “simple” models was lower than with the “full” models at 0.581 (SE= 0.140). Occupancy ($_1$ and $_2$) within the two habitat strata, montane & upper montane and woodland & subalpine, were slightly lower than the occupancy estimates for Models 1 and 3 at 0.418 (SE = 0.108) and 0.118 (SE = 0.054), respectfully. Overall occupancy of Northern Goshawks (0.258, SE = 0.063) in the Southwest Region was estimated lower using the “simple” models (Table 5).

Detection probabilities determined with the “full” model accounting for effort were 0.519 (SE = 0.175) and 0.302 (SE = 0.155) during the nestling and fledgling periods, respectively.

Occupancy within the montane & upper-montane stratum ($_{1}$) was 0.502 (SE = 0.133) while occupancy in the woodland & subalpine strata ($_{2}$) was 0.130 (SE = 0.060) for Model 5. Overall occupancy of Northern Goshawks using Model 5 for the Southwest Region was 0.304 (CI: 0.154–0.385; Table 5).

The detection probability determined with the “simple” model account for effort was lower than Model 5 at 0.448 (SE= 0.155). Occupancy ($_{1}$ and $_{2}$) within the two habitat strata, montane & upper montane and woodland & subalpine, were slightly lower than the occupancy estimates for Model 5 at 0.473 (SE = 0.118) and 0.122 (SE = 0.055), respectfully. Overall occupancy of Northern Goshawks (0.286, SE = 0.067) in the Southwest Region was estimated lower using Model 6 (Table 5).

AIC_c values show that the “simple” models (AIC_c = 132.3) are a better fit for the data when compared to the “full” models (AIC_c = 136.7). However, Model 6 has the lowest AIC_c value (128.6) of all six models and therefore, has the best fit for the data (Table 5).

DISCUSSION AND RECOMMENDATIONS

Discussion

The need to develop and implement local, smaller-scale Northern Goshawk monitoring is essential to provide reliable data for the evaluation of the species’ status. Not only have the wildlife officials within the USFS determined that the Northern Goshawk is a species of special interest within the region, the national “Northern Goshawk Inventory and Monitoring Technical Guide” (Woodbridge and Hargis 2006) also calls for the development and implementation of forest-level and large-scale bioregional monitoring to obtain consistent, reliable information on local response of Northern Goshawk populations to management actions. The 2009 field season was the first step in accomplishing these goals by creating the sampling grid, selecting PSUs based on habitat types & access and implementing the field research.

The RMR and the Great Lakes Region had each completed one field season implementing bioregional Northern Goshawk surveys before 2009. The RMR estimated occupancy at 0.329 in 2006 (Beck et al. 2009) and the Great Lakes Region estimated occupancy at approximately 0.27 in 2008 (Bruggeman et al. 2009). The RMR conducted its second field season for bioregional Northern Goshawk monitoring in 2009. Preliminary results show that overall occupancy 0.475. In this first field season for the Southwest Region, several occupancy estimates were determined and then evaluated between different models. The result indicate that a simple model that estimates occupancy based on a consistent detection probability while adjusting for survey effort is the best model for the 2009 season, thus indicating the overall occupancy for the Southwest Region is 0.286. Although each region uses the ““Northern Goshawk Inventory and Monitoring Technical Guide” (Woodbridge and Hargis 2006) as a basis for designing and implementing Northern Goshawk surveys, slight differences exists between the regions. However, the Southwest Region’s design was created to closely mimic the RMR’s design so that the occupancy estimates can be as comparable as possible. Nevertheless, these bioregions are categorized as different bioregions because of the differences between habitats and therefore, cannot be directly compared. This means that the most value information comes from within the bioregion over a period of time.

Once additional monitoring is completed in the Southwest Region, data can be compared sample-year to sample-year and population trends can be determined. Therefore, future surveys should strive for a 100 percent re-measurement of PSUs surveyed in 2009. As re-measurement approaches 100 percent, variance decreases. This allows smaller sampling sizes to be used to determine occupancy without sacrificing precision. Furthermore, maintaining sampling consistency increases survey efficiency because more is known about individual PSUs (e.g. access points). The “Northern Goshawk Inventory and Monitoring Technical Guide” (Woodbridge and Hargis 2006) states that if a 20 percent of greater change occurs in a five-year period, the bioregional coordinator should assemble wildlife and forestry professionals to evaluate if an immediate change in land management is required. Finally, consistent sampling can be used to determine how changes in occupancy are related to changes in habitat and other 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.

In addition to evaluating trends, and changes in occupancy related to changes in habitat, the bioregional monitoring can be used to determine what habitats or habitat characteristics Northern Goshawks prefer. As demonstrated in the 2009 surveys, Northern Goshawks in the Southwest occupy the montane and upper montane stratum (which equates to ponderosa pine and mixed coniferous forests) more than the pinyon-juniper woodland and subalpine forest stratum. At this time, it remains unclear how much the pinyon-juniper woodland and subalpine forests are used in relation to ponderosa pine forests. Future GIS modeling should be able to determine similarities in habitat characteristics, such as plant species, age class and edge, between PSUs that had detections versus PSUs that did not have detections and help clarify if Northern Goshawks prefer analyzed habitat characteristics over another.

Recommendations

In additions to follow-up analyses reviewed in the Discussion, a couple improvements can be made for future field season implementation.

Use GIS layers with elevation and vegetation (such as ReGAP) information to model which call stations are located within suitable habitat; again that is a call station within 150m of tree cover and located on slopes less than 36°. This allows technicians to focus on areas that are more likely to contain suitable habitat without having to visually inspect the entire PSU and helps to eliminate subjective differences between individuals surveying the area. However, in areas where lack of tree cover eliminates a call station, technicians should still field verify that the call station is still, in fact, not located within suitable habitat.

Several PSUs were located on non-USFS land, thus creating access and survey complications. RMBO has created and is refining an expansive landowner database containing contact information of individuals or businesses who own land on which transects or PSUs have been randomly placed. The use of this database for future survey efforts will greatly reduce the amount of time needed for pre-season work by 1) determining which PSUs have private land, 2) determining which call stations are located on private land, 3) determining almost every landowner who owns the land on for each call station and 4) requesting permission for access to call stations located on private land in advance of the field season. Furthermore, since the database is located on a password-protected website, technicians who need landowner contact information can easily access the information.

Figure 1. Stratification of suitable habitat for the Northern Goshawk in U.S. Forest Service land, Southwest Region.

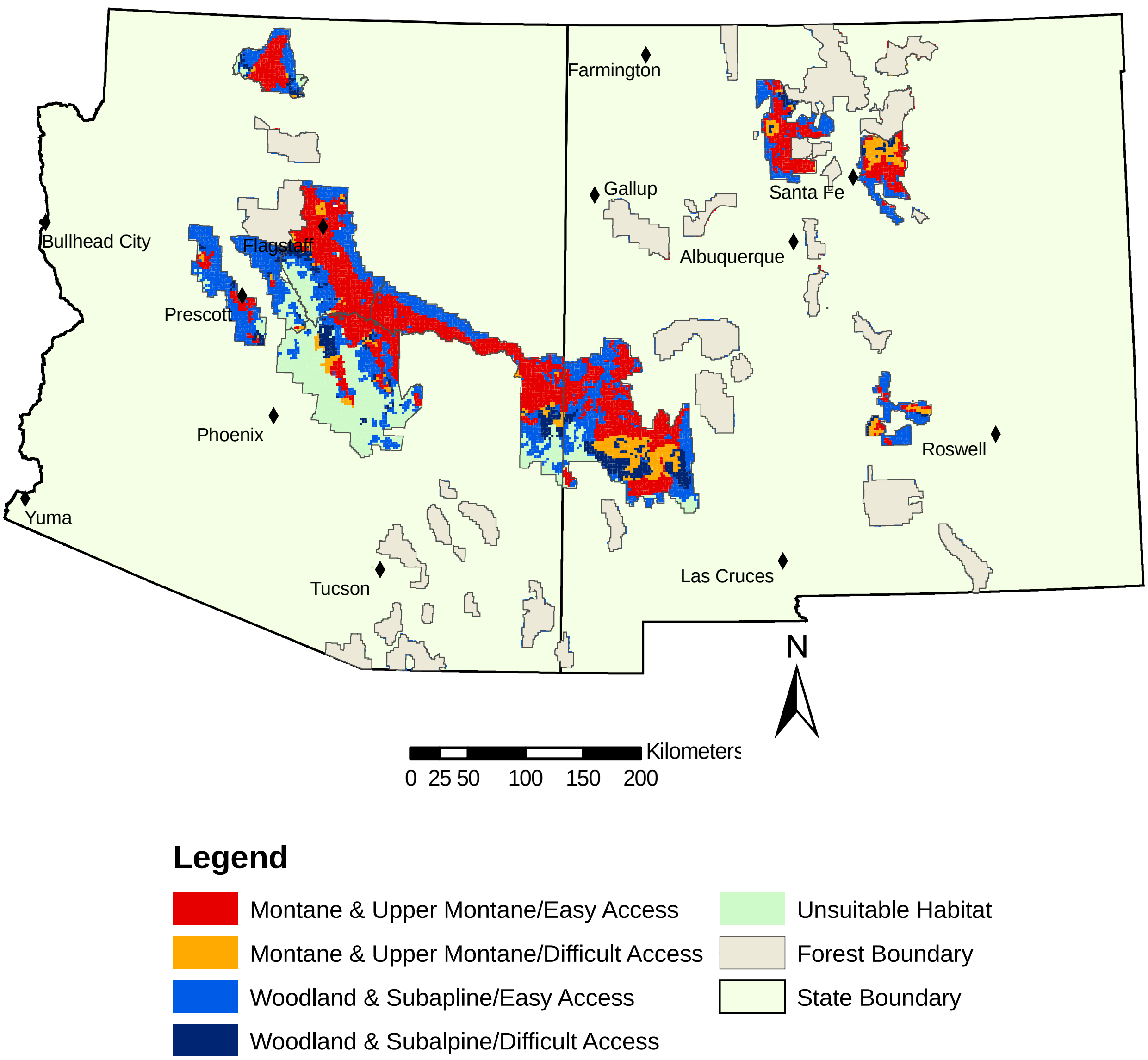


Figure 2. An example of a Primary Sampling Unit map used by technicians throughout the field season.

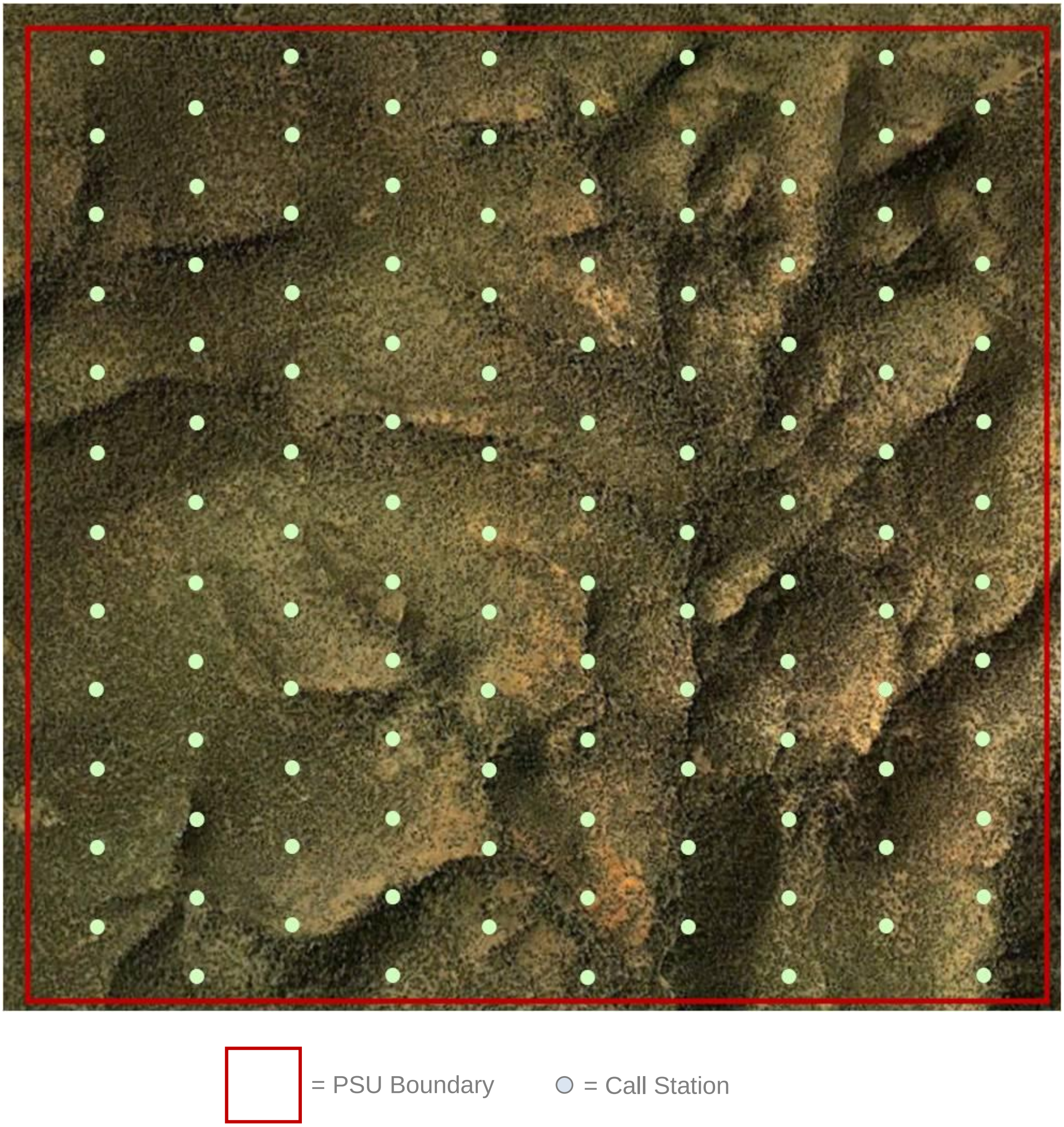
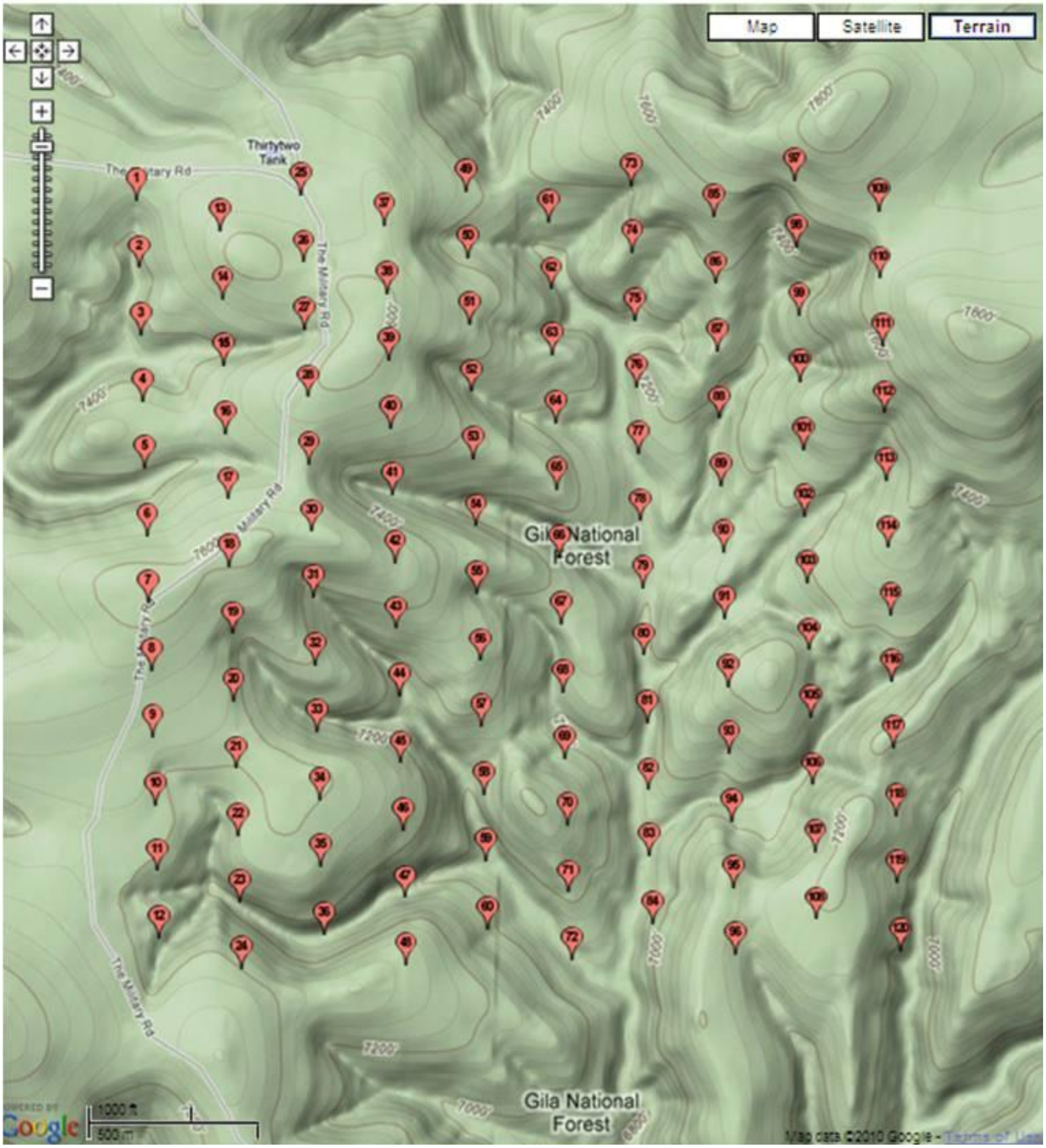


Figure 3. An example of a Primary Sampling Unit map used by technicians throughout the field season.



= Call Station

Figure 4. Surveyed Primary Sampling Units (PSUs) located in Arizona's U.S. Forest Service land, Southwest Region.

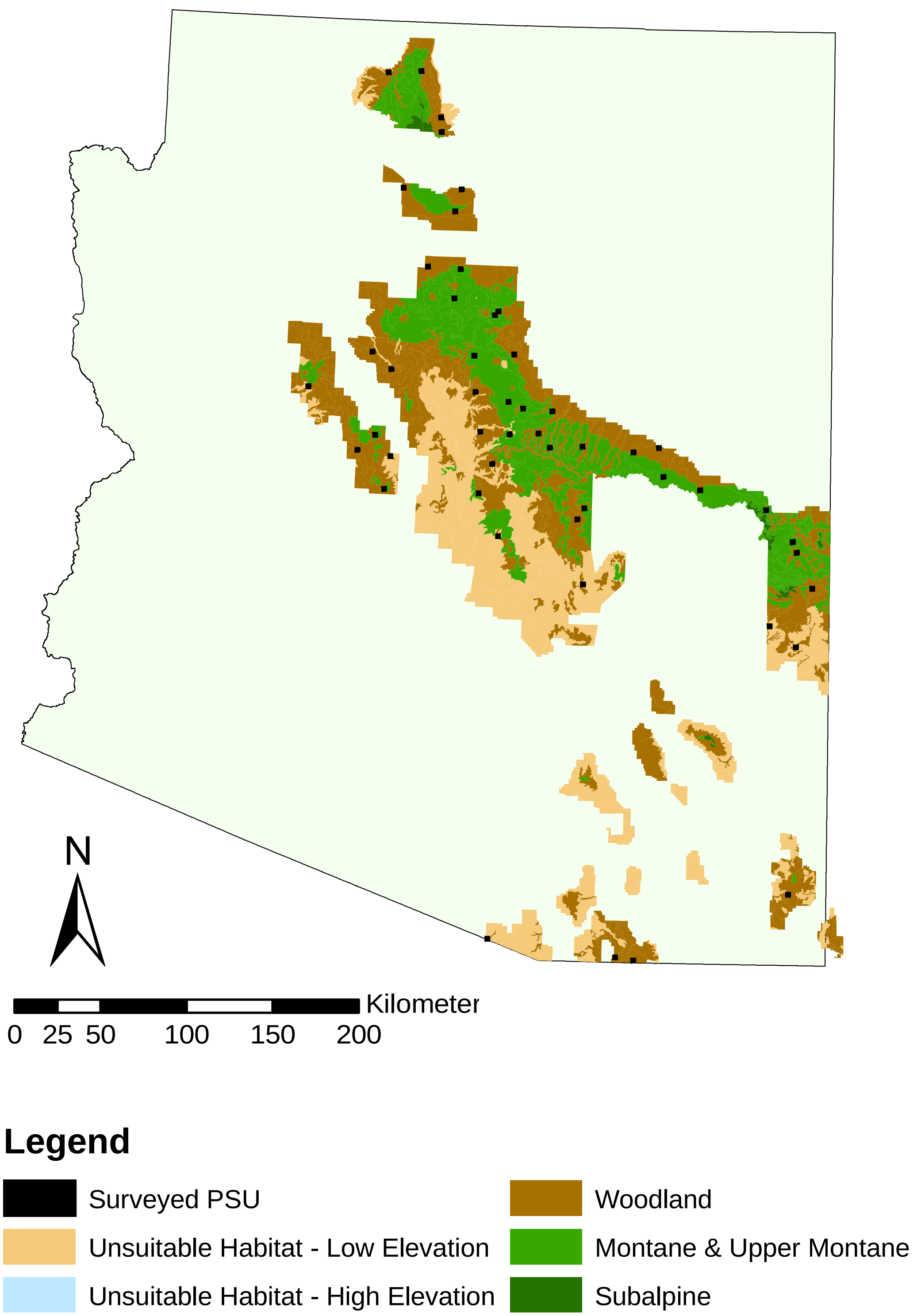


Figure 5. Surveyed Primary Sampling Units (PSUs) located in New Mexico's U.S. Forest Service land, Southwest Region.

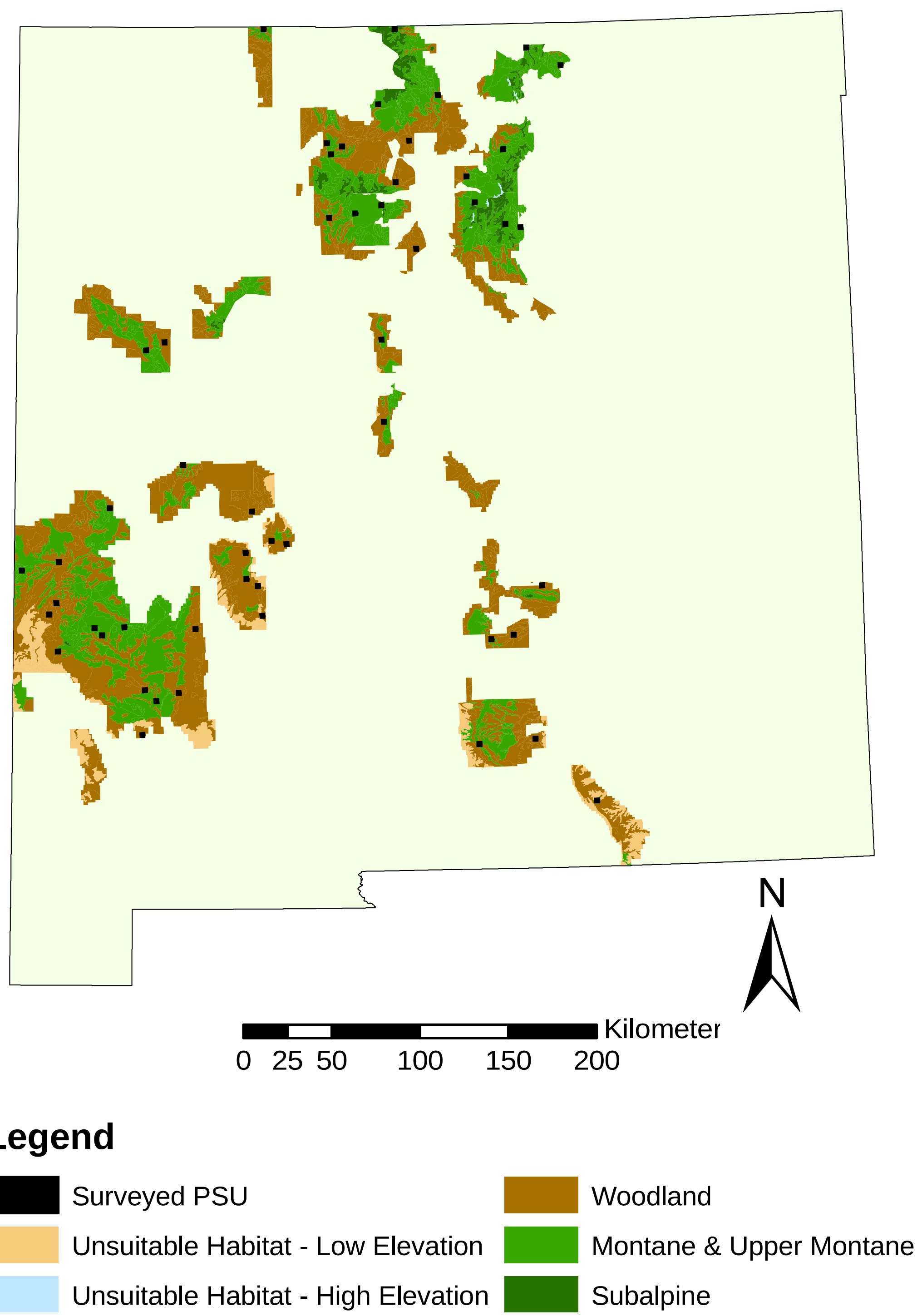


Figure 6. Surveyed Primary Sampling Units (PSUs) with detections located in Arizona's U.S. Forest Service land, Southwest Region.

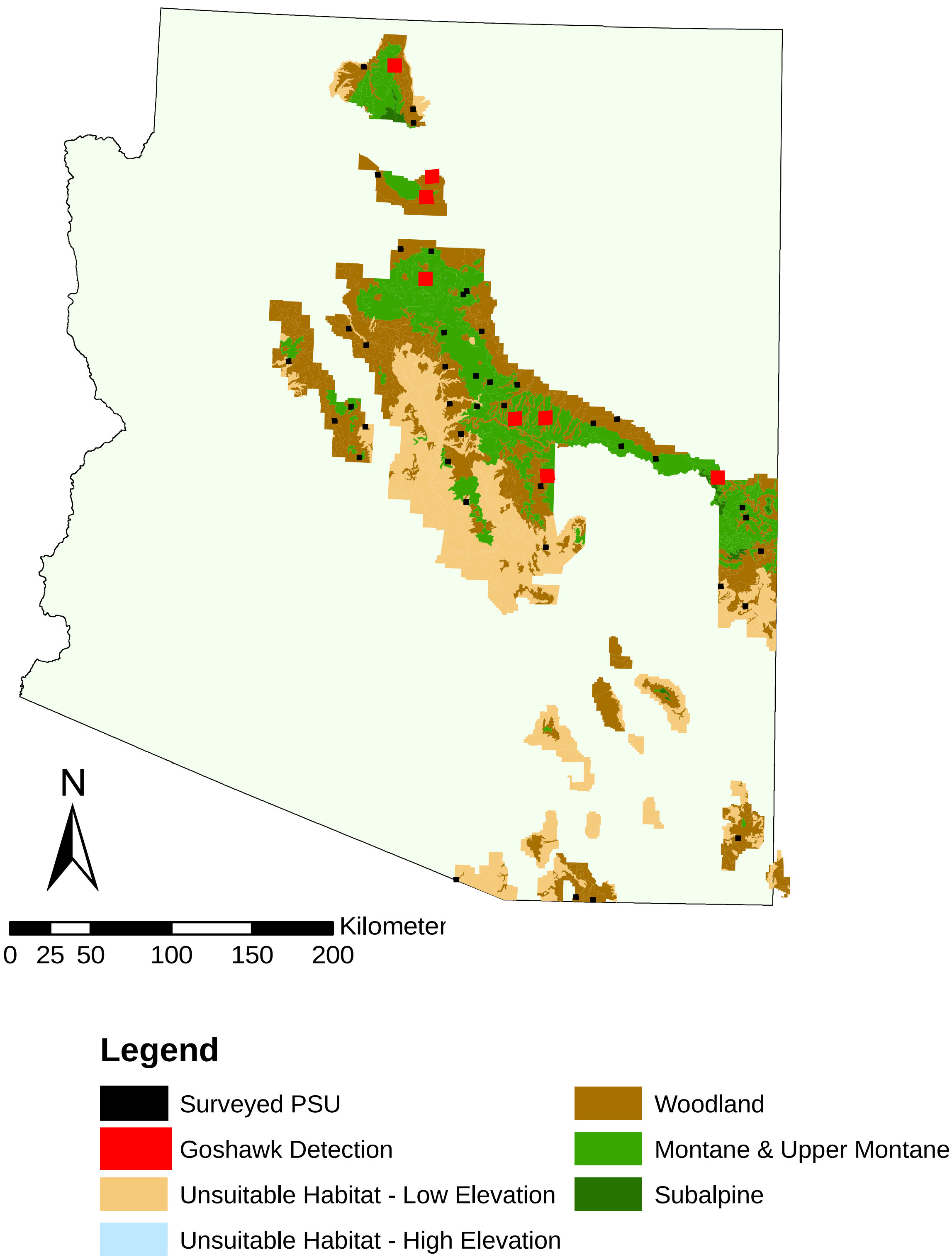
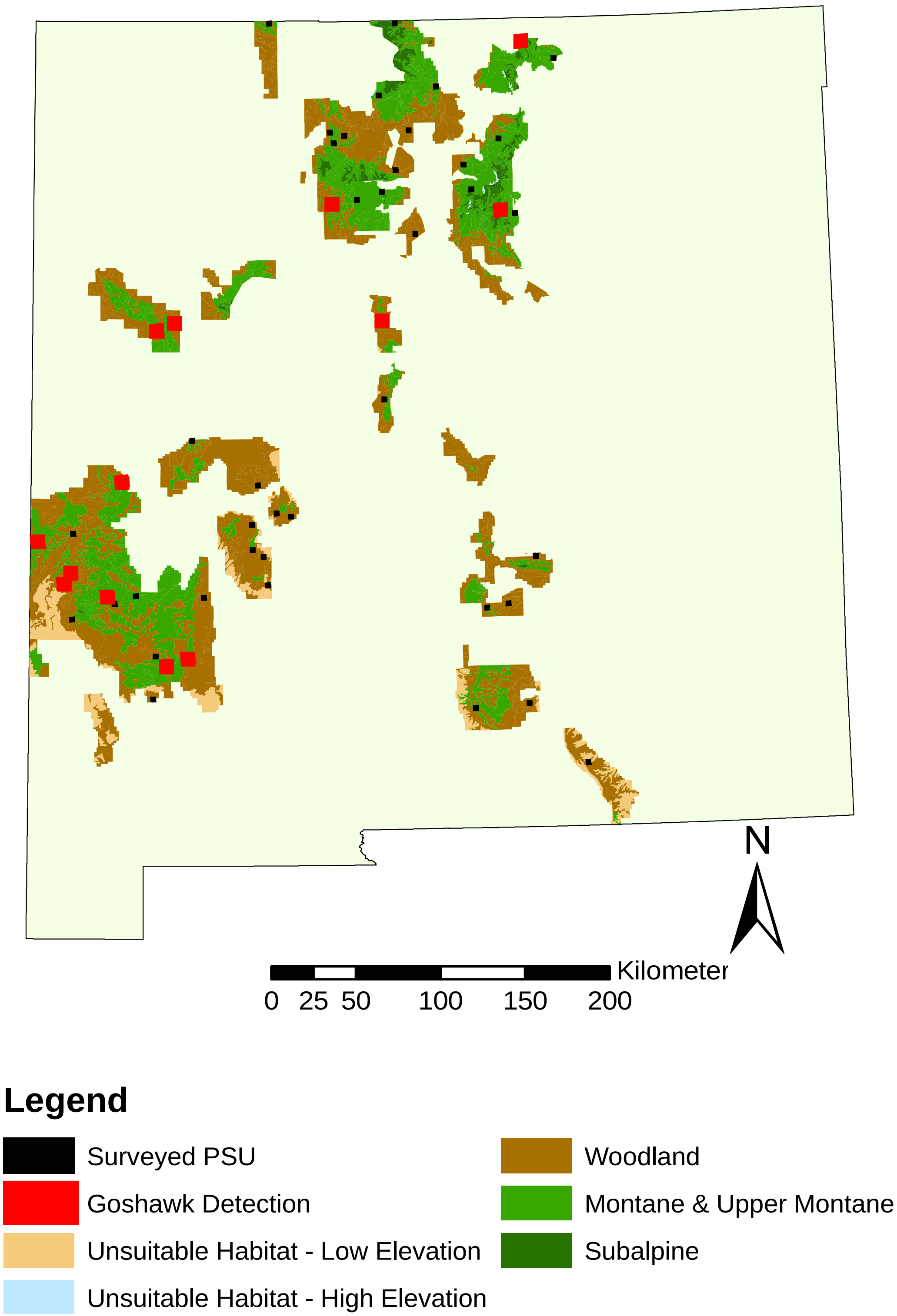


Figure 7. Surveyed Primary Sampling Units (PSUs) with detections located in New Mexico's U.S. Forest Service land, Southwest Region.



APPENDIX A

Survey Results for each Primary Sampling Unit (PSU) visited.

PSU	Stratum	Visit Results: Nestling Phase	Visit Results: Fledgling Phase
AZ-Ap1f-15	1f	0	0
AZ-Ap1f-19	1f	1	-1
AZ-Ap1f-21	1f	1	1
AZ-Ap1f-31	1f	0	0
AZ-Ap1f-35	1f	0	0
AZ-Ap1f-7	1f	0	0
AZ-Ap2f-24	2f	0	0
AZ-Ap2f-30	2f	0	0
AZ-Ap2f-40	2f	0	0
AZ-Ap2f-44	2f	0	0
AZ-Ap2f-58	2f	0	0
AZ-Ap2w-3	2w	0	0
AZ-Co1f-18	1f	0	0
AZ-Co1f-2	1f	0	0
AZ-Co1f-22	1f	0	0
AZ-Co1f-25	1f	0	0
AZ-Co1f-29	1f	1	-1
AZ-Co1f-33	1f	1	1
AZ-Co1f-34	1f	0	0
AZ-Co1f-50	1f	0	0
AZ-Co1f-6	1f	0	0
AZ-Co2f-10	2f	0	0
AZ-Co2f-22	2f	0	0
AZ-Co2f-34	2f	0	0
AZ-Co2f-38	2f	0	0
AZ-Co2f-42	2f	0	0
AZ-Co2f-50	2f	0	0
AZ-Co2f-54	2f	0	0
AZ-Co2f-6	2f	0	0
AZ-Co2w-1	2w	0	0
AZ-Ka1f-45	1f	0	0
AZ-Ka1f-48	1f	1	-1
AZ-Ka1f-9	1f	1	0
AZ-Ka2f-1	2f	0	0
AZ-Ka2f-17	2f	0	0

PSU	Stratum	Visit Results	
		Nestling Phase	Fledgling Phase
AZ-Ka2f-21	2f	1	0
AZ-Ka2f-33	2f	0	0
AZ-Ka2f-49	2f	0	0
AZ-Ka2w-2	2w	0	0
AZ-Pr1f-1	1f	0	0
AZ-Pr1f-41	1f	0	0
AZ-Pr2f-13	2f	0	-1
AZ-Pr2f-2	2f	0	0
AZ-Pr2f-29	2f	-1	0
AZ-Pr-2f-41	2f	-1	0
AZ-Pr2f-61	2f	0	0
AZ-To1f-5	1f	1	-1
AZ-To2f-25	2f	0	0
AZ-To2f-37	2f	0	0
AZ-To2f-53	2f	-1	0
AZ-To2f-9	2f	-1	0
AZ-To2w-5	2w	0	-1
NM-Ca1f-10	1f	0	0
NM-Ca1f-14	1f	0	0
NM-Ca1f-26	1f	0	0
NM-Ca1f-38	1f	0	1
NM-Ca1f-42	1f	0	0
NM-Ca1f-46	1f	0	0
NM-Ca1w-2	1w	0	0
NM-Ca2f-36	2f	0	0
NM-Ca2f-8	2f	0	0
NM-Ci1f-16	1f	1	0
NM-Ci1f-8	1f	0	0
NM-Ci1w-6	1w	0	1
NM-Ci2f-11	2f	0	0
NM-Ci2f-15	2f	0	0
NM-Ci2f-27	2f	0	0
NM-Ci2f-3	2f	0	0
NM-Ci2f-31	2f	0	0
NM-Ci2f-43	2f	0	0
NM-Ci2f-47	2f	0	0
NM-Ci2f-55	2f	1	-1
NM-Ci2w-4	2w	0	0

PSU	Stratum	Visit Results	
		Nestling Phase	Fledgling Phase
NM-Gi1f-11	1f	-1	0
NM-Gi1f-20	1f	0	0
NM-Gi1f-23	1f	1	-1
NM-Gi1f-36	1f	1	-1
NM-Gi1f-4	1f	0	0
NM-Gi1f-43	1f	0	1
NM-Gi1f-52	1f	1	1
NM-Gi1w-3	1w	0	0
NM-Gi1w-4	1w	0	0
NM-Gi2f-19	2f	0	0
NM-Gi2f-46	2f	0	1
NM-Gi2f-56	2f	1	1
NM-Gi2f-62	2f	0	0
NM-Gi2w-7	2w	-1	0
NM-Gi2w-8	2w	1	-1
NM-Li1f-3	1f	0	0
NM-Li1f-32	1f	0	0
NM-Li2f-16	2f	0	0
NM-Li2f-23	2f	0	0
NM-Li2f-35	2f	0	0
NM-Li2f-7	2f	0	0
NM-Sa1f-24	1f	1	0
NM-Sa1f-30	1f	0	0
NM-Sa1f-40	1f	0	0
NM-Sa1f-44	1f	0	0
NM-Sa1w-1	1w	1	-1
NM-Sa1w-5	1w	0	0
NM-Sa2f-20	2f	0	0
NM-Sa2f-4	2f	0	0
NM-Sa2w-6	2w	0	0
NM-Va1f-12	1f	0	0
NM-Va1f-28	1f	0	0

Visit Results: 1 = Surveyed with Detection; 0 = Surveyed without Detection; -1 = Not Surveyed
Red text indicates at least one call station is located on private land.

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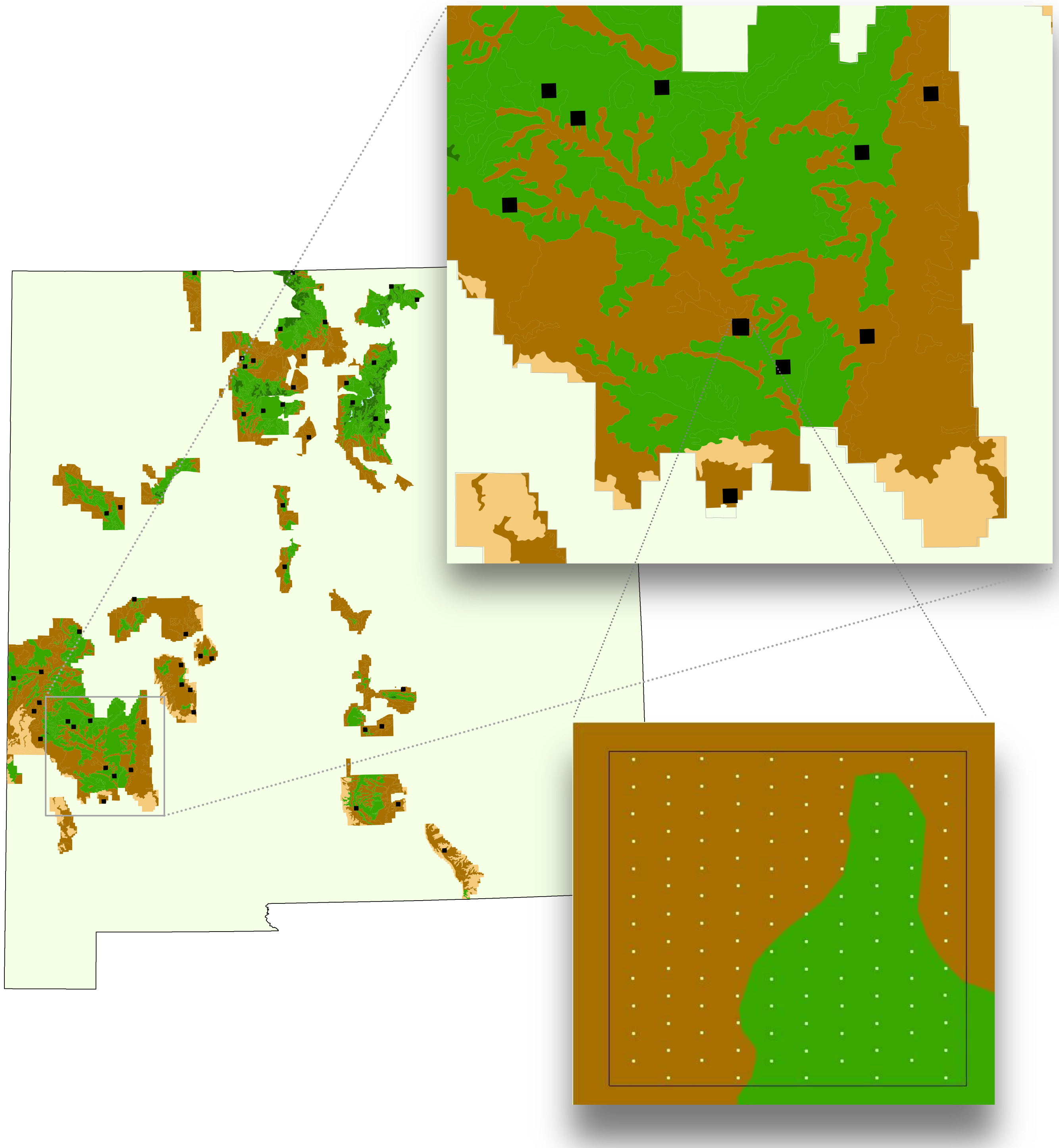

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