Northern Goshawk (*Accipiter gentilis*) Breeding Status and Prey Relationships within the Cassia Section of the Minidoka Ranger District of the Sawtooth National Forest

2011

Summary Report for Natural Research Ltd.

"Chuck" – Nestling from Thoroughbred Spring – 26-28 days old (June 22, 2011).

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Challenge Cost Share Project No. 11-CS-11041401-015
USDA Forest Service, Sawtooth National Forest
Boise State University Admin. Code: 006G107004

Introduction

This project was initiated as a thesis project by Robert Miller of the Boise State University Raptor Biology Program in partnership with the USDA Forest Service and with significant additional funding from Natural Research Ltd. in the form of the Mike Madder's Field Research Award. This report summarizes the key accomplishments from the first field season of the project and is expected to meet the interim report requirements of the funding organizations.

The health of an ecosystem is dependent upon the interactions within and among species. Predator-prey interactions often have a disproportionately larger influence on ecosystem health and ecosystem functions than other interactions. It follows that predator-prey interactions must be understood and evaluated as part of any ecosystem health monitoring program.

The Sawtooth National Forest has recently identified the Northern Goshawk (*Accipiter gentilis*) as a local management indicator species for the Minidoka Ranger District. As such it is important to establish a baseline measure of population health of Northern Goshawks within the district. The population has been studied off and on over the last 20 years, but has not been systematically monitored over the past five years. This project, while not providing an abundance estimate of the population, does assess the breeding status within the historical territories, focuses on discovering new territories, and explores the relationship of prey abundance, forest structure, and forest health on the breeding success of the Northern Goshawk within the district.

From a research perspective, the Minidoka Ranger District is an interesting location to study the Northern Goshawk as one of the most influential prey items for Northern Goshawk breeding success, squirrels of the genera *Sciurus* (Reynolds et al. 1994, Squires 2000, Petty et al. 2003) and *Tamiasciurus* (Reynolds et al. 1994, Smithers et al 2005, Rogers et al. 2005), is naturally absent from two major sections of the Minidoka RD: the South Hills and the Albion mountains (Benkman 1999).

The research specifically focuses on four key questions:

- What prey do goshawks depend upon in the South Hills of the Sawtooth National Forest?
- Does prey abundance affect goshawk site selection and/or nest productivity, and if so, which prey elements are the key determining factors?
- Do habitat structural changes and disturbance affect nest productivity?
- Does habitat structure or prey abundance affect secondary sex ratio of successfully fledged young?

Within the first field season, significant progress was made on questions one and two, while questions three and four require some refinement within the second season. This document provides a summary of the first year findings in the form of an executive summary and includes preliminary documentation of the methods and results which are still under development for the final report.

Executive Summary

Using the search methods as defined by Kennedy and Stahlecker (1993) and Joy et al. (1994), we discovered nine occupied goshawk nests located within 22 historical territories. An additional two territories were integrated into some of the analysis after an occupied nest was discovered in one and an aggressive female response was noted in another. Thus a total of ten occupied nests were discovered in 24 territories for a nest occupancy rate of 42%, slightly above the 40% average found in a ten year study of the area (Kaltenecker et al. 2004).

The Mayfield method (Mayfield 1961, 1975) for these ten nests estimates a 52.3% nest survival rate for the study area for the 2011 breeding season. Program Mark estimates a 58.15% nest survival rate (95% confidence interval: 18.7% - 89.3%). This model also assumes a constant daily nest survival rate. Allowing for variable daily nest survival rate the estimate drops to 51.6% (95% CI: 12.2% - 89.1%), but the model fitting procedures favor the no covariate model even though daily nest survival is most likely variable.

1. What prey do goshawks depend upon in the South Hills of the Sawtooth National Forest? We installed three nest cameras to monitor prey consumption at the nest. The first nest camera captured 77 unique prey deliveries within 281 daylight hours of footage. 87% of deliveries were identified to class. Approximately 50% of prey deliveries were Belding's Ground Squirrels, which made up 76% of estimated biomass. Avian prey deliveries were generally smaller and much more difficult to identify to species. Quantification of results from the other two nest cameras is still in progress.

2. Does prey abundance affect goshawk site selection and/or nest productivity, and if so, which prey elements are the key determining factors? Based on prey surveys of avian species and mammals, we determined that avian prey abundance was a significant predictor for nest occupancy, but mammalian prey abundance was not. This was contrary to our hypothesis, but may be explained by prey abundance outside of the breeding season. A goshawk's choice in occupying a site may be influenced by prey abundance early in the season when ground squirrels are not present, or by past nesting success which is dependent upon food availability late in the season after which ground squirrels have estivated. Thus, avian prey species provide a more stable prey base. Due to the small number of "occupied but failed" nests in our sample, we were not able to perform a similar analysis examining the factors affecting nest success.

3. Do habitat structural changes and disturbance affect nest productivity? The habitat survey design required the identification of a single nest tree. In many historical territories, either no nest was found or numerous nests were found. Therefore, habitat surveys were only performed in territories where an occupied nest was located. Our analysis found no significant relationship between nest stand health or nest stand structure and nest success. This may be the result of no true relationship or of too few "occupied but failed" nests in the sample (2 out of 10).

4. Does habitat structure or prey abundance affect secondary sex ratio of successfully fledged young? Samples were gathered from four nests. Samples indicate a female dominated sex ratio, but insufficient sample size limited assessment of the relationship of sex ratio to environmental variables. A number of factors limited the sample size including unsafe nest trees, age of nestlings at time of discovery, and logistical challenges in scheduling. The first year results will be aggregated with the second year for this analysis.

Procedures will be refined and adjusted for the second year of the project which kicks off May 15, 2012.

Methods (Documentation still under development)

This study was conducted with all necessary permits and authorizations including a sub-permit (Robert Miller) under master U. S. Federal Bird Banding Permit #21633 (Dr. Marc J Bechard), a State of Idaho Wildlife Collection/Banding/ Possession permit #870115, with authorization from Idaho Fish and Game Jerome Field Office Non-Game Conservation Officer Rob Lonsinger, and under Boise State University Institutional Animal Care and Use Committee permit #006-AC11-004.

The fundamental experimental unit for this study is the goshawk nesting territory. An initial set of 22 historic nesting sites was obtained from the Forest Service. Nesting territories were established by placing a 588 hectare (1300m radius) circle centered on the historic nesting site (Hasselblad et al. 2007), even though this does not necessarily accurately represent a specific individual's home range size or shape. Lahmkuhl and Raphael (1993) demonstrated that circular home ranges were reasonable approximations of actual home range for another forest raptor, the Northern Spotted Owl. Hasselblad et al. (2007) established 588ha as the average male home range for the South Hills, which is considerably smaller than 2000-3000ha ranges measured in other regions.

Field Methods

Each historic territory was visited in an attempt to discover a nest. Due to incomplete data, changes in GPS technologies, and changing forest structure (fallen nest trees, nests blown from trees, etc), many historic nests were not found near the coordinates provided. A systematic foot search extending out from the historic coordinates to a 300m radius was conducted. If an occupied nest was still not discovered, after June 1 call broadcasts were performed within the center and every 300m within all suitable habitats out to the circular territory boundary (1300m radius) or until an occupied nest was discovered (Figure 1; Kennedy and Stahlecker 1993, Joy et al. 1994, Woodbridge and Hargis 2006).

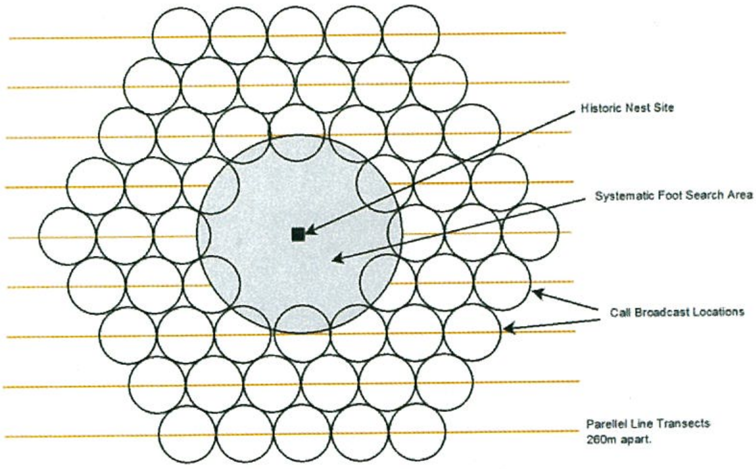

Figure 1: Orientation of historic nest site, systematic foot search area (radius 300m), and parallel transect call playback locations (transects 260m apart, points 300m apart, offset by 150m).

Each territory is classified using standardized terminology from Woodbridge and Hargis (2006). A "successful territory" is any territory with a nest where nestlings have reached an age of at least 34 days old. In our study each successful territory was visited after full fledging (40-46 days) and we received audible or visual confirmation that at least one fledgling was still alive. A "breeding territory" is any territory where breeding has been confirmed, but nestlings have not survived to reach an age of 34 days. In our study, the status of "breeding territory" was established by observing incubation posture on the nest on two or more days. "Occupied territory" refers to any territory where an adult goshawk was seen in the same area on multiple days or observed a single time with evidence of nest improvements, but no evidence of breeding. "Presence" is assigned to territories where a goshawk was seen on a single day with no evidence of nest orientation. "No detection" is assigned to any territory where no goshawks were observed.

Once found, each occupied nest was visited at least weekly to confirm continued occupation, fledging, or failure. Fledging dates, when not observed with cameras, were estimated based on earlier nestling age observations using photographic keys (Boal 1994) and an estimated average fledging age of 40 days. Nest failure dates were chosen as the mid-point between the last observation when the nest was still successful and the first observation after it had failed.

We performed a limited search for new territories in the final week of the season. Areas were prioritized using GIS techniques by first analyzing the vegetation cover of existing territories using GAP level 3 data (US Geological Survey 2010). After generalizing the results for the existing territories, a search profile for new territories was overlaid onto the study area. Search variables included percent of territory with Aspen, percent of territory with Sage, and a gentle north or east facing slope. Seven new potential territories were selected, of which only three were partially searched. Broadcast call stations were placed onto these territories using the same protocol as historic territories (Kennedy and Stahlecker 1993), but due to limited time availability we visually chose the most likely stands to include a goshawk nest and focused our search effort there.

We deployed analog and digital nest cameras to record prey consumption at the nest and gather other behavioral insights. We created a random order of nests to prioritize camera deployment, but logistical issues ultimately determined which territories would have nest cameras. Cameras were installed when nestlings were between ten and 17 days old. We used climbing spurs and slings to climb the tree for installation, either down-climbing or rappelling once installed (Figure 2).

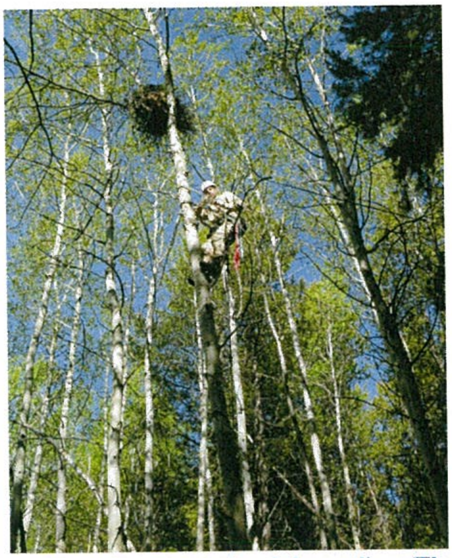

Figure 2: Climbing nest tree using spurs to band the nestlings (Thoroughbred Spring).

The cameras were placed at approximately a 45° angle and as close as possible to the nest to just cover the boundaries of the nest rim (Figure 3, Figure 4). Each camera had a long video/power cable (75m or 200ft) to allow for remote battery and tape/memory exchange with minimal disturbance of the nest occupants. The analog unit recorded for a day and a half on a single tape. The digital units recorded up to seven days on a single memory card. Recorders were configured to only record during daylight hours, 5:45am until 9:45pm local time to preserve tape and memory. Frame rates were configured for a minimum of 2 frames per second (range 2-30 fps). In addition, the digital camera units were configured to record only when motion was detected in the nest and continue recording 30 seconds after motion ceased. Total disturbance time was recorded for the camera installation from the time the adult first issued an alarm call or left the nest, to the time that all personnel were at least 80m from the nest.

Figure 3: Nest camera (upper right) viewing into Piney Creek nest (July 6, 2011).

Figure 4: View from nest camera shown in Figure 3 encompassing entire rim of nest within field of view.

To calculate prey abundance in each territory, Distance Sampling along Line Transects was implemented (Buckland et al. 2001, 2004). Four random 750m transects were overlaid onto each territory (Figure 5). Each transect was surveyed between 7:30am and 11:30am, with a few exceptions, by either Robert or Lauren. Best efforts were made to spread the surveys for each territory out over the season, between surveyors, and at different times within the four hour window. Access restrictions due to late spring weather and scheduling difficulties prevented this in many cases. Upon starting a survey, surveyors logged the date, time, survey number, and weather. Transects were walked in entirety unless safety became an issue in which case the survey was truncated and the distance surveyed recorded.

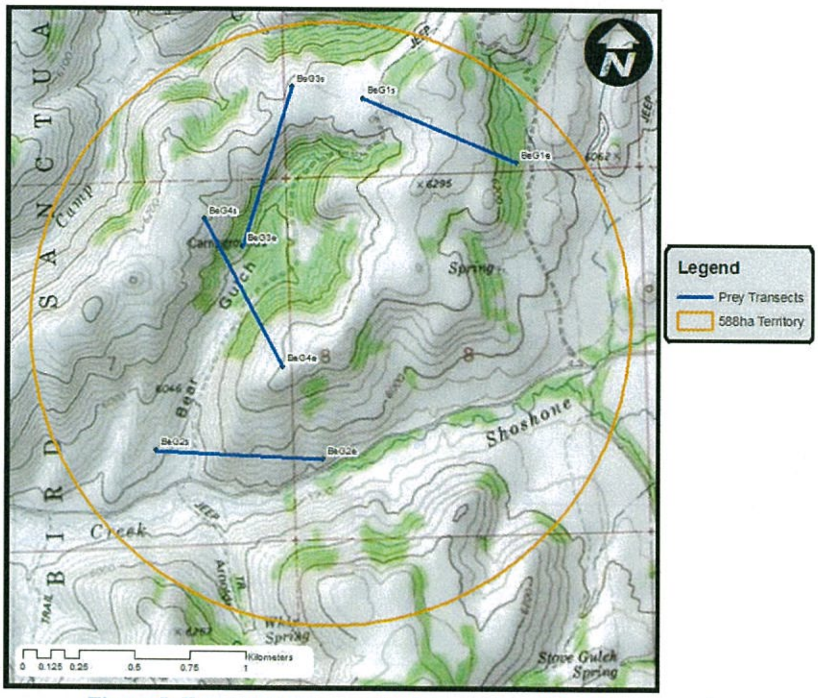

Figure 5: Example territory with four random 750m line transects.

The perpendicular distance to each prey item, whether seen or heard, was measured with a laser rangefinder and recorded (Figure 6). Surveyors also recorded the general habitat type through which the survey was conducted. Completion time and completion distance were recorded at the end of the survey. The schedule generally allowed for three surveys to be completed per person per day, but proximity occasionally allowed for four or limited to two.

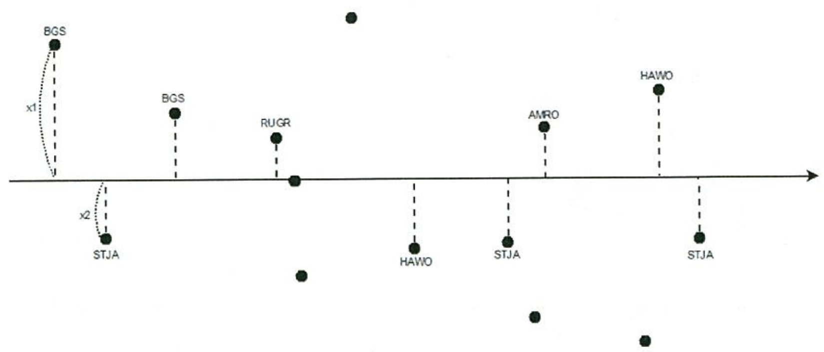

Figure 6: Hypothetical line transect illustrating perpendicular distance measurements. Line is walked, x distance is measured with rangefinder. Example species codes represent some of the likely species encountered in the study area (i.e. BGS=Belding's Ground Squirrel, STJA=Steller's Jay, RUGR=Ruffed Grouse, HAWO=Hairy Woodpecker, AMRO=American Robin).

Nestlings were banded when the occupied nest tree was suitable to safely climb, the nestlings were the correct age (26 - 35 days old), and our work schedule allowed. Nestling age was estimated using photographic keys (Boal 1994). Nest trees were climbed using the same method as described for camera installation and nestlings were banded while in the nest. Nestlings were picked up from the nest by hand, or occasionally reached with the help of a homemade "chicken grabber". In all cases the safety of the nestlings and the nest was prioritized over banding. On one leg a size appropriate (6 or 7A) USGS Bird Banding Laboratory aluminum lock-on leg band was attached (Figure 7). On the other leg a two-character vertical (Type 1) purple aluminum riveted color band was attached (Figure 7), allowing identification from a distance. Total disturbance time was recorded for banding from the time an adult or nestling first issued an alarm call to the time that all personnel were at least 80m from the nest.

Figure 7: Type 1 purple aluminum color band (left) recorded as "Northern Goshawk Type 1 Purple R4", size 7A USGS Bird Banding Lab lock-on aluminum band (right) recorded simply by number "1807-72830".

Habitat surveys were performed on a 400m^2 area centered on the nest tree for all territories with occupied nests (U.S. Forest Service 2007). A cross pattern was utilized to capture a greater distance from the tree with the same area (Figure 8), unlike circular plots of the same area used by Hayward and Escano (1989) and Drever and Martin (2010). The orientation of the survey was determined by random compass direction.

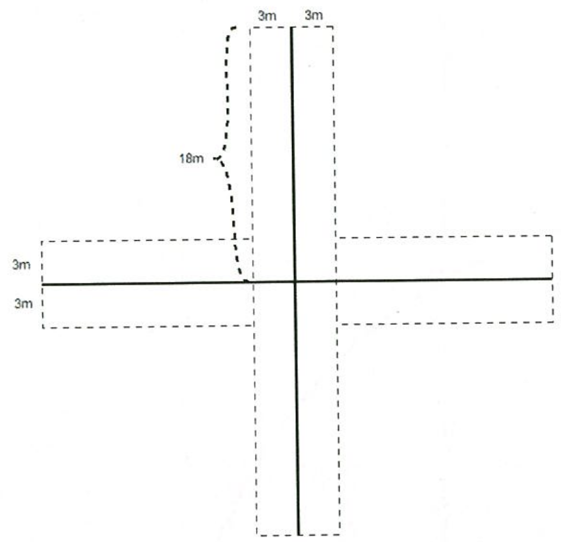

Figure 8: $400m^2$ habitat survey dimensions centered on the nest tree oriented in a random compass direction.

Habitat surveying occurred at least 2 days after the last nestling fledged to minimize disturbance, although the recent fledglings were often still within the nest stand. Surveys consisted of drawing the general habitat structure of the survey location, then counting the number, species, size, and health of each tree in the survey area. Size (sapling, medium, mature) was based on tree diameter at breast height. Dead saplings and saplings less than breast height were not counted. The health was identified as standing dead (at least breast height), highly compromised (mostly dead or top half dead), slightly compromised (some dead branches that are not expected during standard maturation of tree), or healthy (no signed of dead branches except standard maturation processes, i.e. lowest branches in Lodgepole Pine die off as tree matures, and no sign of disease).

Analysis Methods

Nest survival estimates were generated using the Mayfield method (Mayfield 1961, 1975) and using Program Mark (White et al. 1982). In both cases an assumed incubation period of 38 days from first egg to first hatching (Mañosa 1991 as reported by Kenward 2006), and a nestling period of 40 days based on our field observations were used. The Mayfield method used a constant daily nest survival rate, whereas in Program Mark model selection was performed comparing a constant daily nest survival rate, a linearly variable daily nest survival rate, and a quadraticly variable daily nest survival rate (Dinsmore et al. 2002). Program Mark provides a survival estimate with confidence intervals whereas the Mayfield method does not. Estimated fledging dates were used for the final observation date in both analyses when fledged young were seen or heard within the nest stand post fledging. Otherwise the final observation of the nestlings in the nest was used. For failed nests where the age of the nest could not be established an average age of all other nests was utilized.

Nest camera footage was used to analyze prey deliveries to each nest. Prey deliveries were classified to class and to genus/species when possible using researcher knowledge of species and reference materials including "The Sibley Field Guide to Birds of Western North America", "Audubon Birds – A Field Guide to North American Birds", "Audubon Mammals - A Field Guide of North American Mammals.", and "A Field Guide to the Nests, Eggs, and Nestlings of North American Birds" (Harrison 1987). Since uneaten prey is often removed by the adults, best efforts were made to distinguish between returned prey items and new prey items. This worked best when the prey item was returned within a day of being removed. Prey metrics such as number of prey deliveries, deliveries by type, deliveries per hour, and estimated biomass are calculated from the tallied observations. Prey deliveries by class were compared within and among nests based on hour of the day and day of the year.

Biomass consumed at the nest was calculated using average species weights obtained from "Audubon Birds – A Field Guide to North American Birds" and "Audubon Mammals - A Field Guide of North American Mammals." These weights represent adult sizes and thus likely over estimate the mass consumed for juvenile and nestling prey. For un-identified prey items we used the average biomass of the identified prey items. Prey items were often partially consumed prior to delivery to the nest and were often partially consumed by the adult within the nest. Therefore, care was taken to not relate biomass to nestling prey consumption.

Prey abundance measures for avian prey and mammalian prey, were generated separately using Program Distance (Thomas et al. 2009). Distance measurements were truncated at 80 meters for avian prey and 60 meters for mammalian prey to decrease the influence of the long tail of observation distances and to simplify model fitting (Buckland et al. 2001, 2004, Thomas et al. 2010). Observations were grouped into intervals of 10 meters to improve the robustness of the density estimates, to account for the often poor visibility during surveys due to brush and terrain, and to allow the assumption of no animal movement prior to detection to be relaxed (Buckland et al. 2001). Separate analysis was performed to generate territory specific prey abundance estimates via stratification and nest status (success or fail, not detected) estimates via post-stratification (Buckland et al 2001). Covariates were integrated into the analysis to account for changes in detection based upon the day of the year, time of the survey, who performed the survey, whether the prey was seen or only heard, and the percent of the survey performed in open sage habitat versus forest (Buckland et al. 2004, Thomas et al. 2010). The detection function was chosen by Program Distance from among the standard functions supported by the Multiple Covariate Distance Sampling engine (half-normal key function and hazard-rate key function, each with cosine or single polynomial adjustments; Thomas et al. 2009)). The top model was selected using AIC and a sequential selection mode. After the detection function was established, covariate model selection was performed separately for avian prey and mammalian prey by evaluating models containing all permutations of the five covariates listed and choosing the top model based upon Akaike Information Criterion adjusted for small samples sizes (AICc; Buckland et al. 2004, Thomas et al. 2010).

For the analysis, mammalian prey items included Belding's Ground Squirrels (*Spermophilus beldingi*), Golden-mantled Ground Squirrels (*Spermophilus lateralis*), and Chipmunks (*Tamias* spp.). Avian prey items included American Robins (*Turdus migratorius*), Northern Flickers (*Colaptes auratus*), Hairy Woodpeckers (*Picoides villosus*), Red-naped Sapsuckers (*Sphyrapicus nuchalis*), Green-tailed Towhees (*Pipilo chlorurus*), Mountain Bluebirds (*Sialia currucoides*), Red-winged Blackbirds (*Agelaius phoeniceus*), Mourning Doves (*Zenaida macroura*), Ruffed Grouse (*Bonasa umbellus*), and Columbia Sharp-tailed Grouse (*Tympanuchus phasianellus*).

Prey abundance influences on nest success were evaluated in two ways. First, post-stratified prey density estimates and confidence intervals for nesting territories (successful and failed) and non-breeding territories (occupied, presence, and no detection) were compared for significance. Second, stratified prey abundance measures for avian prey and mammalian prey, combined with the percent of open sage in the territory were evaluated for influence on nest occupancy via logistic regression. Since some models had convergence issues due to small sample size, only those without issues were included in the set of models for selection. This approach is acceptable as all singular variable models were still included in the set. The top model was selected using AICc. Confidence intervals for the regression coefficients were used as a test of significance (Burnham and Anderson 2002). While each of these approaches have been used successfully in publications, they each suffer from fundamental limitations. Both methods likely include false negatives in the nest status component when a successful or occupied nest went undiscovered. Additionally, the logistic regression models fail to integrate the variance within the prey abundance estimates into the model weighting. For these reasons, more sophisticated analysis methods are being investigated but fell outside the scope of this document.

Two measures of forest health were generated by calculating the percentage of mature trees in the nest stand which were classified as standing dead or highly compromised, and the percent of trees within the nest stand at least breast height which were saplings (less than 5cm diameter at breast height). The forest health metrics were combined with avian and mammalian prey abundance in a model selection process using exact logistic regression to measure their influence by selecting the top model based upon AICc. This analysis was performed separately from the overall prey influence analysis as the habitat data is only available for territories where an occupied nest was discovered.

Results (Documentation still under development)

Using the search methods as defined by Kennedy and Stahlecker (1993) and Joy et al. (1994), we discovered nine occupied goshawk nests located within 22 historical territories. An additional two territories were integrated into some of the analysis after an occupied nest was discovered in one and an aggressive female response was noted in another. Thus a total of ten occupied nests were discovered in 24 territories for a nest occupancy rate of 42%, slightly above the 40% average found in a ten year study of the area (Kaltenecker et al. 2004).

Categorizing territories using terminology from Woodbridge and Hargis (2006), we discovered eight successful nests, two unsuccessful territories with evidence of breeding, four occupied territories with no evidence of breeding, five territories where goshawk presence was noted but occupation could not be established, and five territories where no goshawk detections were made (Table 1). At least four additional goshawks were observed outside of previously defined territories.

Table 1: Territory results as defined by Woodbridge and Hargis (2006). Successful territories also indicate the number of successfully fledged young in parenthesis. * indicates newly discovered territories.

Successful Territories	Breeding Territories	Occupied Territories	Presence Territories	No Detection Territories
Basin Patch Spring (2)	Bostetter Camp Spring	Elk Corral Spring	Bear Gulch	Badger Gulch
Diamondfield Jack (2)	Deer Spring	Humphrey Creek	Donahue Basin	Big Creek
Eagle Spring (3)*		Wagon Wheel Spring	Harrington Peak	Elison Hole
First Fork Rock Creek (3)		Winecup Spring	Hudson Ridge*	Junction Spring
Flatiron Peak (1)			No Name Spring	Wards Corral
Piney Creek (2)				
Porcupine Spring (3)				
Thoroughbred Spring (1)				

The Mayfield method (Mayfield 1961, 1975) for these ten nests estimates a 52.3% nest survival rate for the study area for the 2011 breeding season. Program Mark estimates a 58.15% nest survival rate (95% confidence interval: 18.7% - 89.3%). This model also assumes a constant daily nest survival rate. Allowing for variable daily nest survival rate the estimate drops to 51.6% (95% CI: 12.2% - 89.1%), but the model fitting procedures favor the no covariate model even though daily nest survival is most likely variable.

Three nest cameras were installed, one analog and two digital (Table 2). The analog unit was placed in a territory that was easily accessible as the battery and tape had to be exchanged every other day. The analog tape recorded for a day and a half on each tape (24 daylight hours), but was changed every other day, usually first thing in the morning. This resulted in a bias toward recording morning observations. To account for this bias, observations are filtered to only include the first 24 hour period on each tape. This decreased overall coverage, but removed the bias (Table 2). No other convenient territories were available for a second analog unit. One digital recorder failed in the field (Thoroughbred Spring) and was replaced with our only remaining digital unit, preventing a fourth installation. 100% daylight coverage of the nests were not recorded due to the logistics of tape and battery exchange, configuration challenges due to equipment issues, alignment of crew work schedules, and vandalism.

Table 2: Nest camera territories, recording dates, installation disturbance time, and hours of footage.

Territory	Digital/ Analog	Installed	Age at install	Date of last footage	Disturbance time (min)	Hours of footage	Notes
Diamondfield Jack	A	June 14	10 days	July 9*	33	TBD	*Cable cut, could not repair
Piney Creek	D	June 18	17 days	July 10	TBD	TBD	Recorded until fledged
Thoroughbred Spring	D	June 8	14 days	July 4	55	281.4 (68%)	Recorded until fledged

281.4 hours of coverage was obtained from the Thoroughbred Spring camera of a possible 414 daylight hours (5:45am – 9:45pm local time) between installation and fledging. 77 unique prey deliveries were recorded for this nest. 87% of prey deliveries were identified to class, and 52% were identified to species (Table 3). Eleven prey deliveries consisted of delivering the second half of a previous delivered prey item, so these counts were removed from totals included in Table 3. Figure 9 illustrates the distribution of prey deliveries throughout the day and Figure 10 represents the breakdown of prey by nest and by day of the year.

Table 3: Top ten unique prey items delivered to nests as observed via nest cameras and total numbers of unidentifiable species. Biomass represents literature values per organism used in all calculations.

Prey Item	# of deliveries	# in Diamondfield Jack	# in Piney Creek	# in Thoroughbred Spring	Biomass per animal (g)
Beldings Ground Squirrel	TBD	TBD	TBD	32	283g
American Robin	TBD	TBD	TBD	4	76g
Golden Mantled Ground Squirrel	TBD	TBD	TBD	1	223g
Chipmunk (spp.)	TBD	TBD	TBD	1	51g
Northern Flicker	TBD	TBD	TBD	1	70g
Black-headed Grosbeak	TBD	TBD	TBD	1	42g
Unidentified Avian	TBD	TBD	TBD	24	63g
Unidentified Mammal	TBD	TBD	TBD	3	186g
Unidentifiable to Class	TBD	TBD	TBD	10	120g

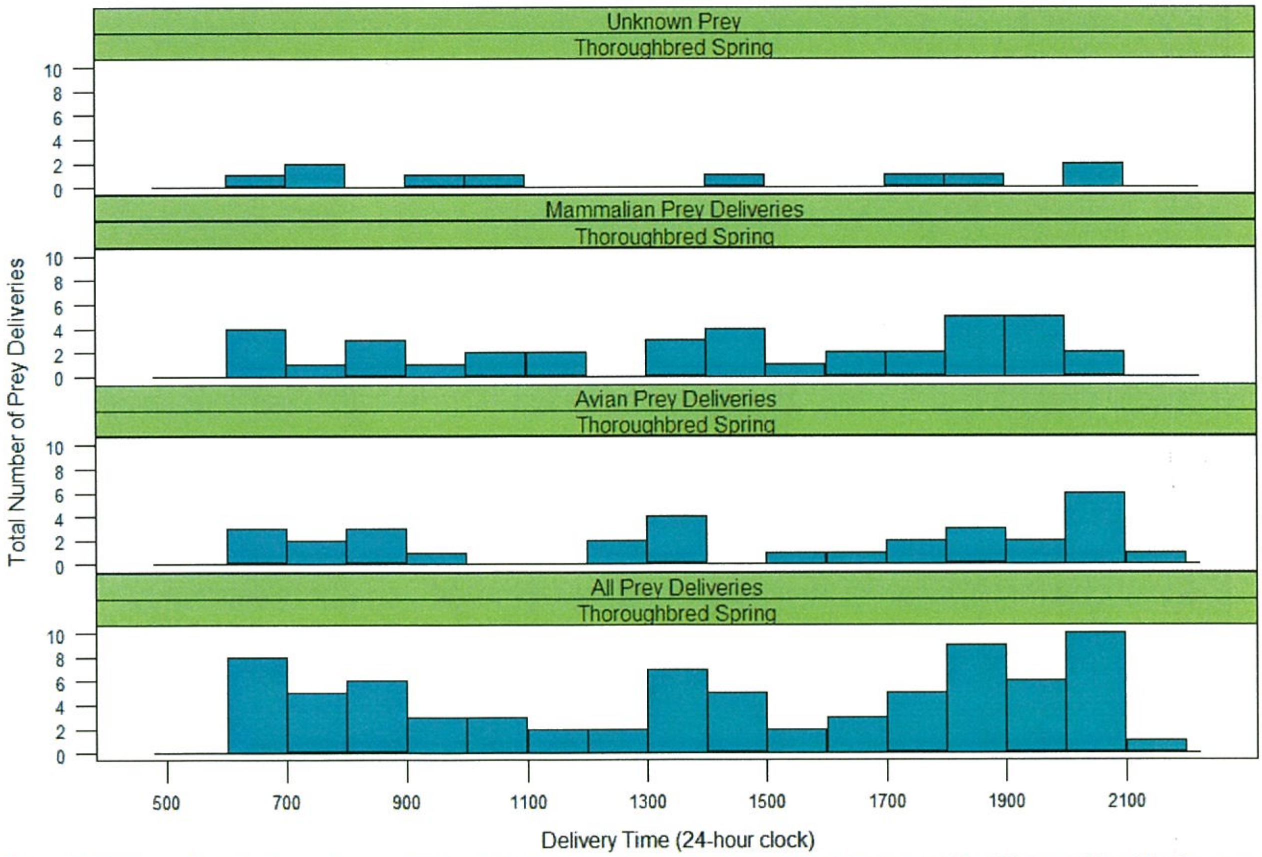

Figure 9: Delivery times by hour for mammalian, avian, and all prey (including unidentified) combined Thoroughbred Spring nest.

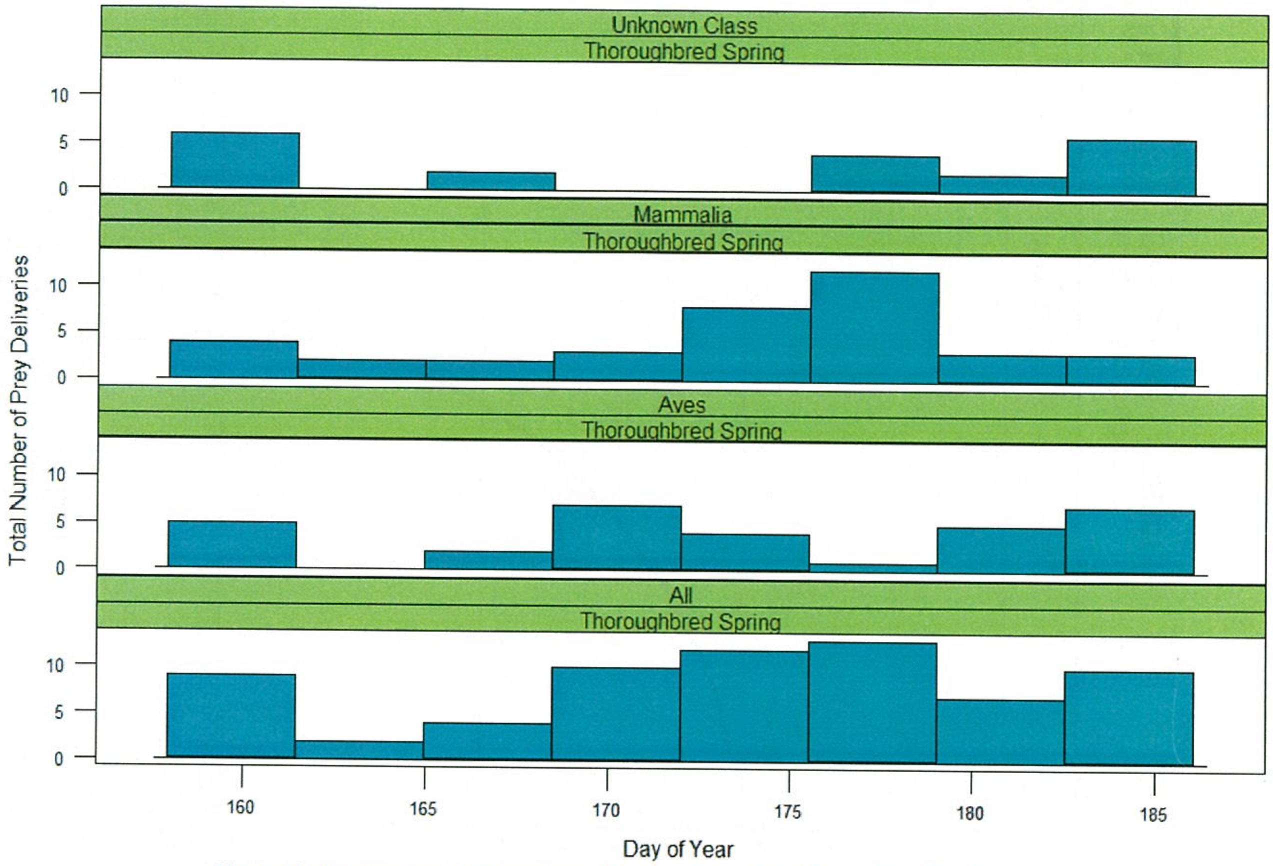

Figure 10: Prey consumption by class and by day of year for Thoroughbred Spring nest.

Total biomass consumed averaged 740g per day for the Thoroughbred Spring nest, based upon a 16 hour day (5:45am – 9:45pm local time; Table 4).

Table 4: Biomass consumption per nest. Difference in total and component sums represent prey items unidentified to class.

Territory	# of Nestlings	Total Biomass Consumed/day	Avian Biomass Consumed/day	Mammalian Biomass Consumed/day
Diamondfield Jack	2	TBD	TBD	TBD
Piney Creek	2	TBD	TBD	TBD
Thoroughbred Spring	1	740g	110g	562g

We completed 96 prey surveys, four in each of 24 separate territories. Surveys covered 69,933 meters for an average of 728 meters per survey (range: 470-750m). 507 total prey individuals were counted, including 149 American Robins, 133 Belding's Ground Squirrels, 92 Northern Flickers, 21 Chipmunks, 21 Mountain Bluebirds, 18 Hairy Woodpeckers, and a number of less abundant species. 272 individuals were detected by sight and 235 detected only by sound. After truncation and filtering, 286 relevant avian prey individuals and 157 relevant mammalian prey individuals remained in the analysis (Figure 11). A half-normal key function with cosine adjustment terms was the preferred function for fitting both the avian and mammalian prey observations with covariates for day of year, who performed the survey, whether bird was seen or only heard, and percent of territory in open habitat for avian prey, but only time of day and who performed the survey for mammalian prey (Figure 11).

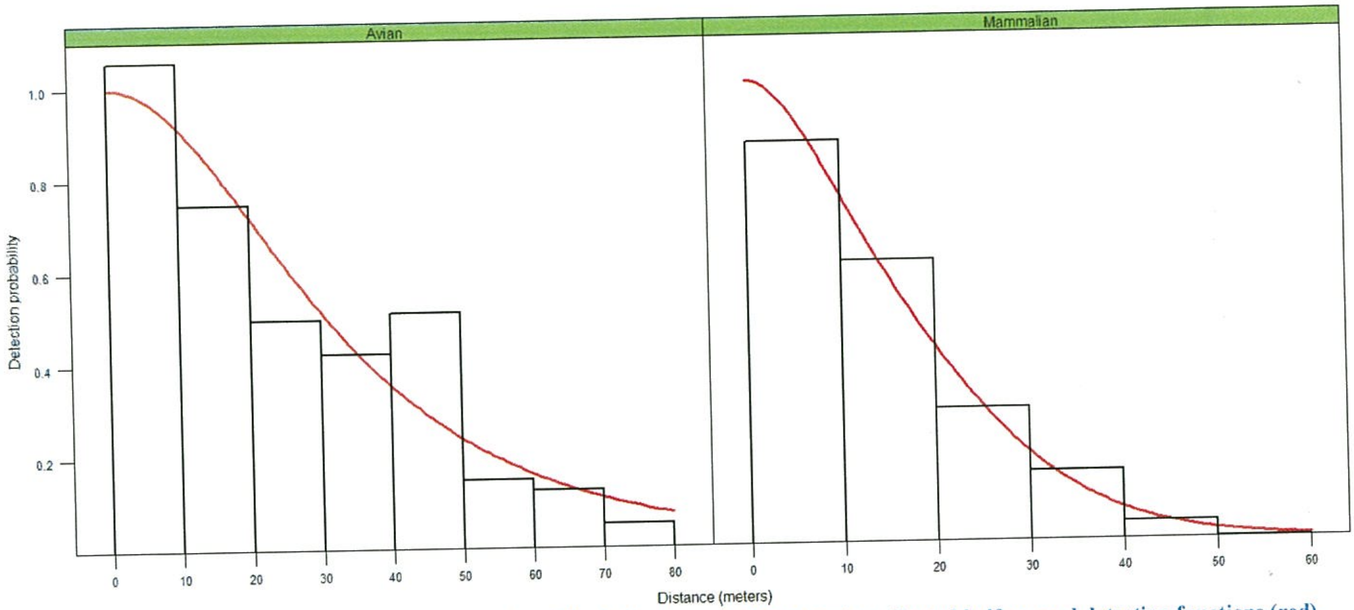

Figure 11: Truncated and grouped prey observations (black) by class with fitted cosine adjusted half-normal detection functions (red). Avian detection function fitted using covariates for day of year, who performed the survey, whether bird was seen or only heard, and the percent of territory in open habitat (selected by AICc). Mammalian detection function fitted with covariates for time of day and who performed the survey (selected by AICc).

Post-stratified distance estimates and 95% confidence intervals generated by Program Distance show that "nest occupied" territories (successful and occupied but failed) have on average significantly higher avian prey abundance than territories where no breeding was detected (Figure 12). However, mammalian prey abundance was not significantly different based on nest occupancy status (Figure 12).

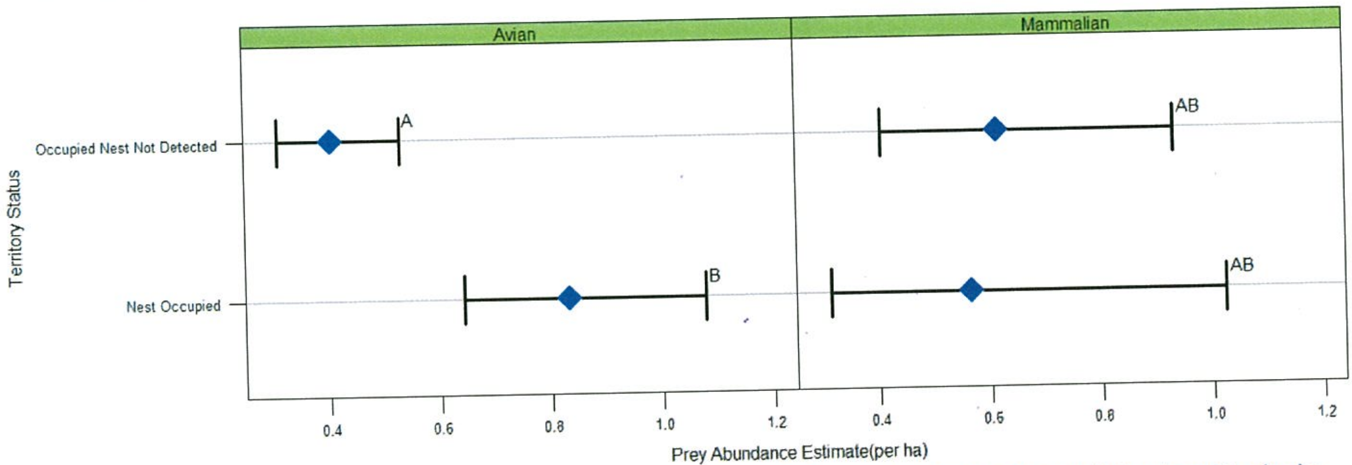

Figure 12: Prey abundance (per ha) comparisons with 95% confidence intervals between territories with occupied nests and territories where no breeding was detected. Significance measures indicated with letters (A, B). Note: some "not detected" territories possibly had occupied nest that went undiscovered.

Distance estimates stratified by territory (Figure 13) are used as the basis of logistic regression model selection. The only assumptions of logistic regression are that the independent variables are not overly correlated and the residuals behave acceptably. None of the variables have a correlation coefficient above 0.35 and the residuals are acceptable so the assumptions are met (Figure 14).

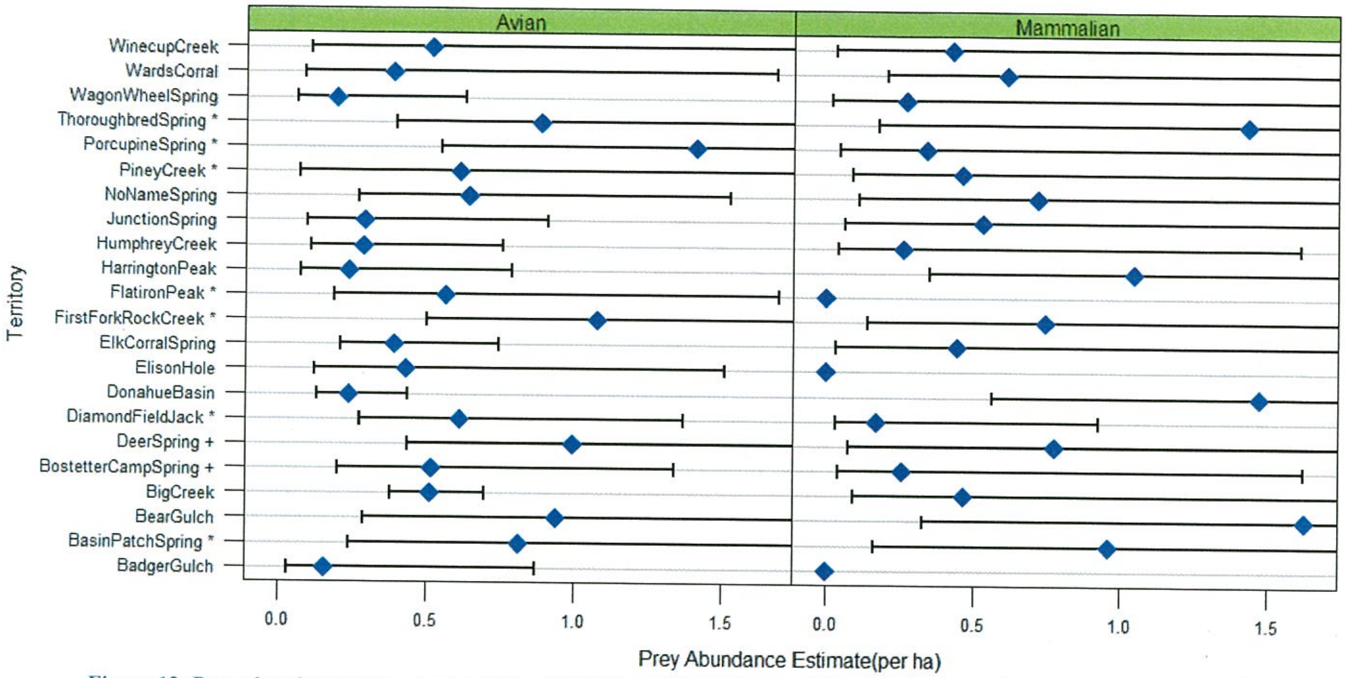

Figure 13: Prey abundance estimates (per ha) with 95% confidence intervals for all territories. Upper confidence interval clipped to enable better comparison between territories. * indicates successful territories, + indicates "breeding but failed" territories.

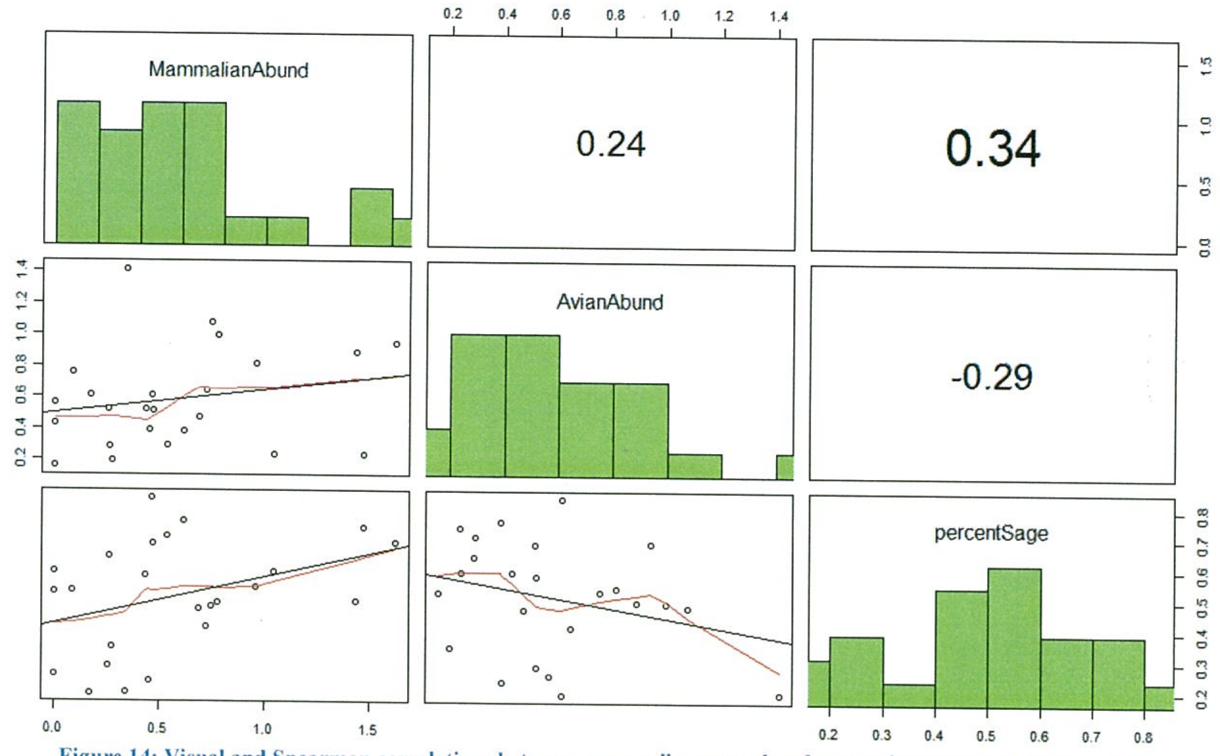

Figure 14: Visual and Spearman correlations between mammalian prey abundance, avian prey abundance and the percentage of territory occupied by sage (non-forested). Central graphs represent histogram of each variable.

Using logistic model selection, avian prey abundance, but not mammalian prey abundance or percent of territory in sage, was an important predictor for nest success as the model containing only avian abundance produced the lowest AICc value (Table 5). Furthermore, avian abundance was a significant predictor of nest success within this model as the 95% confidence interval does not overlap zero (Table 5).

Table 5: AICc table with coefficient estimates and 95% confidence intervals for mammalian prey abundance, avian prey abundance, and percent territory in sage as predictors for nest success using logistic regression.

	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
avian	2	22.35	0.00	0.50	0.50	-8.86
avian + sage	3	22.41	0.05	0.49	0.98	-7.54
sage	2	30.55	8.19	0.01	0.99	-12.96
null	1	31.97	9.61	0.00	1.00	-14.88
mammal + sage	3	32.72	10.36	0.00	1.00	-12.69
mammal	2	34.37	12.01	0.00	1.00	-14.87

Coefficients:

(Intercept)	avian
-4.561038	7.202232

95% Confidence Interval:

	2.5%	97.5%
(Intercept)	-9.35	-1.67
avian	2.51	15.37 - does not overlap zero - significant

The health analysis was only performed within the ten territories where an occupied nest was confirmed. We used exact logistic regression to evaluate avian prey abundance, mammalian prey abundance, nest stand health, and sapling/mature ratio as predictors for nest success. AICc model selection chose avian prey abundance combined with sapling ratio as the top influence on nest success (Table 6). However, none of these models produced significant results.

Table 6: AICc table for avian prey abundance, mammalian prey abundance, nest stand health, and sapling ratio as predictors for nest success ordered by delta AICc.

Model	AICc	Delta AICc	AICcWeight
avian + sapling	9.23	0.00	0.21
health + sapling	9.28	0.05	0.20
sapling	9.79	0.56	0.16
health	11.10	1.87	0.08
avian + health + sapling	11.18	1.95	0.08
mammal + avian + sapling	12.15	2.92	0.05
mammal + sapling	12.51	3.28	0.04
mammal + health + sapling	12.59	3.36	0.04
mammal + health	12.62	3.39	0.04
avian + health	13.34	4.11	0.03
avian	13.52	4.29	0.02
mammal	13.63	4.40	0.02
mammal + avian + health + sapling	14.08	4.85	0.02
mammal + avian + health	15.16	5.93	0.01
mammal + avian	15.65	6.42	0.01
null	29.53	20.30	0.00

Eight total nestlings were banded from four separate nests (Table 7). Other occupied nests were skipped due to tree climbing safety (Basin Patch Spring, Porcupine Spring), age of nestlings at nest discovery (Eagle Spring), and crew scheduling issues (Flatiron Peak). In two cases the sex of the nestling could not be established so a large 7A band was applied. In both of these cases we believed the nestlings to be female.

Table 7: List of nestlings banded during the 2011 nesting season.

Date	Nest	Coordinates	Sex	Band #	Band Size	Color Band
6/22/2011	Thoroughbred Spring	NAD83 11T 719860,4670479	U (F?)	1807-72821	7A	Purple C/4
6/30/2011	Piney Creek	NAD83 11T 732458,4658262	U (F?)	1807-72824	7A	Purple A/4
6/30/2011	Piney Creek	NAD83 11T 732458,4658262	F	1807-72825	7A	Purple B/4

7/6/2011	Diamondfield Jack	NAD83 11T 724736,4672482	F	1807-72826	7A	Purple D/4
7/6/2011	Diamondfield Jack	NAD83 11T 724736,4672482	M	2206-33307	6	Purple E/4
7/13/2011	First Fork Rock Creek	NAD83 11T 732412,4673599	M	2206-33308	6	Purple H/4
7/13/2011	First Fork Rock Creek	NAD83 11T 732412,4673599	F	1807-72827	7A	Purple K/4
7/13/2011	First Fork Rock Creek	NAD83 11T 732412,4673599	F	1807-72828	7A	Purple M/4

Acknowledgements

Special thanks to USDA Forest Service, Minidoka Ranger District for their financial, consulting, and equipment support for the completion of this project. Additional funding and/or assistance was received from Natural Research Ltd. in the form of the 2011 Mike Madder's Field Research Award.

Logistic and equipment support was also received from Boise State University's Raptor Research Center, Idaho Bird Observatory, and the Department of Biological Sciences. Inovus Solar donated critical equipment to the cause.

General consulting was received from the lead author's thesis committee: Dr. Marc Bechard, Dr. Jay Carlisle, and Dr. Jennifer Forbey, from previous goshawk researchers Kristin Hasselblad and Susan Patla, and from BSU statistician Laura Bond.

Much of this work was completed using volunteer time from field volunteers including: Heidi Ware, Karyn deKramer, Michelle Jeffries, Dusty Perkins, Cristen Walker, Kerry Rogers, Nicole Rogers, Uri Rogers, Jeri Albro, Cathy Lapinel, Dave Wike, Carol Wike, Mike, Sara, and Grant.

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