2009 WHITE RIVER FIELD OFFICE RAPTOR INVENTORY AND MONITORING REPORT

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ABSTRACT

The objective of this project was to acquire woodland raptor breeding season nesting habitat and nesting activity information for sharp-shinned hawk, Cooper's hawk, and northern goshawk. In 2009, a total of 187 nests, representing 178 known nesting territories were visited. Of these nest areas, 42.8% (n = 80) were classified as being occupied during the spring surveys, and 44.9% (n = 84) of the known nest areas were confirmed as being unoccupied during the 2009 breeding season. Of the nest areas that were classified as occupied in 2009, 43.8% (n = 35) of these nest areas successfully fledged young, and 47.5% (n = 38) of the occupied nest areas did not fledge young. When considering those nest areas that were successful in 2008 (n = 41), only 22% (n = 9) of these nests were successful in 2009; 78% (n = 32) of these nests did not successfully fledge young during the 2009 breeding season. Approximately 61% of all young that fledged (n = 18) from occupied Cooper's hawk nests (n = 19) fledged from nests that were within 400 to 500 m (n = 5 fledglings) and 700 to 800 m (n = 6 fledglings), respectively, from a producing well. Productivity appeared to be higher for Long-eared owl at closer distances to travel corridors, with 57% (n = 4) of the occupied nests (n = 7) occurring within 0 to 100 m of a travel corridor. Of these nests, 75% (n = 3) successfully fledged young, producing 71% (n = 12) of all Long-eared owl young that fledged (n = 17). Similarly, approximately 82% of all young that fledged from occupied Long-eared owl nests (n = 7) fledged from nests that were within 0 to 100 m (n = 10 fledglings) and 100 to 200 m (n = 4 fledglings), respectively, from a producing well. When considering all raptor species, at occupied nests, as producing well density increased the distance from occupied nests to roads, well pads, and pipelines decreased with r_s values of -0.34, -0.44, and -0.33, respectively ($p < 0.05$). Occupied nests that occurred in areas where road density was low, also tended to occur in areas where producing well density was low ($r_s = 0.35$, $p < 0.05$). At unoccupied nests, contrary to the negative correlation between well density and distance from roads to occupied nests, as well density increased, the distance from unoccupied nests to roads also increased ($r_s = 0.43$, $p < 0.05$). Moreover, as road density increased the distance from unoccupied nests to the nearest road also increased ($r_s = 0.52$, $p < 0.05$). There was no statistical difference between occupied and unoccupied nests and disturbance variables. Information collected as a result of this project will contribute to long-term, cumulative efforts to monitor reproductive success, nest site fidelity, document phenological information, and possible changes in nest distribution and abundance of breeding raptors within the project area that may be impacted by the development and extraction of natural gas and shale mineral resources on BLM-managed lands.

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INTRODUCTION

In April, 2008 the Bureau of Land Management, White River Field Office (WRFO) initiated a project designed to collect breeding season information for raptors that occurred in the Piceance Basin, Colorado (T. 1-3 S., R. 96-98 W., 6th Principle Meridian). The purpose of this project was to collect information that would allow for an assessment of nest distribution and territory occupancy over time in areas heavily influenced by oil and gas activities. The target species were Red-tailed hawk (RTHA), Cooper's hawk (COHA), Sharp-shinned hawk (SSHA), Northern goshawk (NOGH), Golden eagle (GOEA), and Long-eared owl (LEOW).

Project objectives included the following: (1) determine nesting habitat requirements for selected species; (2) refine survey criteria and survey protocols; (3) assess data management needs and requirements; (4) develop a reliable system to store and retrieve both nest geography and nest phenology information that would provide a template for future projects; (5) assess possible behavioral effects of oil and gas activities on prey delivery rates, prey diversity and prey equitability, changes in parental behavior, and productivity of COHA using video monitoring systems (review pending); and, (6) qualitatively assess distance relationships between occupied and unoccupied nests and selected anthropogenic features associated with oil and gas activities.

As a result of this project, the following work products have been developed or produced: (1) the development of a system that allows for the retrieval, analysis, and data entry of nest information; (2) a better understanding of raptor nesting requirements and habits associated with oil and gas activities in the Piceance Basin; (3) the development of a reliable technique to identify and assess the overall suitability of potential accipiter nesting habitat in the project area; (4) the development of a practical and defensible procedure to assess the validity of raptor survey results submitted by private survey contractors associated with oil and gas activities in the project area; and (5) a summary report of inventory and monitoring findings for the 2008 and 2009 breeding season.

Assuming adequate funding is available for this project in 2010, the following topics will be included in the project objectives for 2010: (1) the continuation of an assessment of possible behavioral effects of oil and gas activities on prey delivery rates, prey diversity and prey equitability, parental behavior, and productivity of Cooper's hawk using video monitoring systems; (2) the development of a sampling scheme that allows for the assessment of detection

probability for selected species; (3) the continuation of an assessment of possible cumulative impacts to raptor productivity in areas where both producing well density and road density is high. Using procedures developed in this report, the primary focus of this objective will be to first qualitatively describe the spatial relationship between distance from nests and distance to selected anthropogenic features, followed by a comparison of raptor productivity and producing well density and road density.

METHODS

Nest Inventory and Monitoring:

Efforts to monitor known nesting territories for the 2009 breeding season began on 29 April and ended on 26 August 2009 within the project area (Figure 1). The start date was defined as the time when field work was conducted full-time by a person dedicated to nest inventory and monitoring tasks, and the end date was chosen as the date when it was confirmed that, of the nests that were being monitored, all accipiter juveniles had dispersed from the nest stand.

1. Nest Inventory

Identifying suitable nest habitat manually:

During the 2008 field season, potential nesting habitat was identified manually using 1 m resolution National Aerial Imagery Program (NAIP) imagery and terrain information (e.g., Digital Elevation Model (DEM) data). Nesting habitat was identified qualitatively based on canopy closure, slope, elevation, dominant cover type, and tree stem density. The validity of using this method to identify potential nesting habitat was confirmed in 2008. Qualitative methods used to assess how well this technique identified suitable accipiter nesting habitat was accomplished by plotting call-playback stations within each survey polygon (i.e., estimated suitable nesting habitat) and collecting stand information (i.e., basal area, DBH, tree height, and canopy closure) within specific DBH categories and within a 0.0013 ha area with radius of 25 m surrounding the call-playback station (Appendix 1). This information was used to rank the overall suitability of the survey area polygon. In addition, canopy closure, slope, elevation, dominant cover type, and tree stem density for accipiter nests (n = 24) that were located by an independent third-party contractor, were compared qualitatively to known accipiter nests (n = 41) to verify that the topographic and nest stand information used to identify potential nesting habitat was reliable.

To help navigate to individual call-playback stations, stations were uploaded into Garmin GPS76CSx global positioning units (GPS) and separated by distance of approximately 200 m following Kennedy and Stahlecker (1993). In survey polygons, where tree density and canopy cover varied, and where discrete stands that exhibited higher tree density and canopy cover could

be visually delineated, call-playback stations were plotted in the interior of these stands, presumably to increase the observer's probability of detecting an occupied nest through defensive behavior of an adult, or locate unoccupied nests, by focusing his or her attention on suitable nesting habitat.

Procedure used for determining the breeding status of the nest and for locating alternate nests when the known nest is not occupied or has been occupied by another species:

Methods used to locate alternate nest structures included the combined use of call-playback, intensive pedestrian search, and on-going monitoring of nest stands with existing but unoccupied nest structures. Using a hand-held GPS unit to navigate to the nest, as the observer approached the known nest to confirm the breeding season status, the observer would broadcast the COHA alarm call at 100 m from the nest following established call-playback procedures. If a response from either the adult male, adult female or juveniles was not detected the observer would proceed to walk to the nest to document whether or not there were signs of occupancy in the nest stand or on the nest. The general procedure for locating alternate nest structures using intensive search methods involved walking concentric circles with radii of 25, 50, 75 and 100 m, respectively, and centered on the known nest. The track feature on the GPS was used to record the route the observer(s) used while searching for alternate nest structures.

2. Developing the nesting habitat model

In addition to identifying potential nest habitat manually, two models were developed in ArcGIS 9.2 using Model Builder to produce a nesting habitat suitability map. These models were developed to help identify those areas that may serve as potential nesting habitat using an automated process. Because most geoprocessing tasks require multiple steps to generate the desired output, Model Builder provides the user the flexibility of adding specific geoprocessing tools to the model, requiring the user to only modify individual model variables, as appropriate, without the need to start from scratch with each successive run of the model. In this way, the user can open the model, modify or add additional geoprocessing tools, change criteria used to build suitability maps, and save and retrieve the model to be used for subsequent applications, which can significantly reduce the time necessary to perform multiple, repetitive geoprocessing tasks.

Model I: Weighted overlay model

The first model that was developed for this application used a weighted overlay process that allows the user the ability to combine multiple input grids into one output grid (i.e., suitability map) using various weighted values (i.e., percent influence) that when summed together equal 100 (Figure 2). Thus, the user can modify how much each individual variable influences the resultant output, if necessary. Slope, aspect and elevation grids were derived from 30 m DEM data (Figure 3), and the Colorado Vegetation Classification Project (CVCP) raster data was as the dataset from which suitable vegetation cover classes were selected (Table 1).

Regarding the development of the nesting habitat suitability map using a weighted overlay procedure, though there were many steps required to prepare the data for the analysis, there are two processes common to all suitability maps. The first step included normalizing (i.e., standardizing) the data by reclassifying the input grids (i.e., slope, aspect, and elevation) based on a scale from 1 (least suitable) to 3 (most suitable) (Table 2, Figure 4). The CVCP vegetation data was reclassified based on a scale from 1 to 4, with 4 representing the most suitable cover class. The second step included combining the reclassified, normalized grids into one grid (i.e., suitability map) using the weighted overlay tool. For our purposes, and based on prior experience with *Accipiter* nesting requirements in our project area, we used the following weighted values:

Aspect: 20%
Elevation: 5%
Slope: 40%
Cover Class: 35%

Model 2: Adaptive model using zonal statistics

Using zonal statistics, an adaptive-based model was used to identify potential nesting habitat using known nest locations (Figure 6). The model used nest locations to select elevation, slope, aspect, and vegetation type to define potential nesting habitat. As such, the point locations defined the range of elevations, range of slope and aspect values, and the range of cover types that were selected. Thus, after each run of the model, the model would produce a different

output using the nest locations that were either added or subtracted from the nest database and include only those elevation, slope, aspect and cover type ranges that intersected a known nest point.

3. Monitoring tasks

Monitoring tasks included visiting known nest areas and assessing the breeding season status of known nests that occurred in these areas using established procedures. Known nest structures were relocated using a Garmin GPS76CSx unit. To help aid in navigating to each nest, the UTM coordinates for each nest was uploaded into the GPS unit using the DNR Garmin version 5.4.1 software. Once at the nest, to help alleviate any discrepancies between the Nest ID number, UTM coordinates and the actual physical location of the nest, a photo was taken of the GPS screen where both the nest ID number and UTM coordinates were displayed (Figure 7). Next, a photo of the nest tree and nest were taken (Figure 8) followed by a close-up photo of the nest (Figure 9) and a representative photo of the nest stand (Figure 10). Each series of photos were grouped by the Nest ID number and stored in separate folders using the Nest ID number as the folder name. In some cases, the datum was not recorded for a known nest or was unknown. For these nests, a procedure was developed that included converting UTM coordinates from NAD27 to NAD 83 or vice versa while in the field using the Garmin GPS76CSx unit. For a detailed description of this process, see Appendix 2. Information collected regarding raptor detections while conducting spring presence/absence surveys was recorded on the "Nest Monitoring and Raptor Detection Data Form" (Appendix 3). Ongoing monitoring information collected throughout the breeding season was recorded on the "WRFO Nest Monitoring Form" (Appendix 4).

In addition to on-going efforts to monitor nests, video monitoring systems (Figure 14) were used to record behavioral information and document food habits at 7 occupied COHA nest structures as part of ExxonMobil's (XOM) 3D seismic project. Information pertaining to nest success, fledging rates, and dispersal dates were included in this document because of their relevance; however, information pertaining to possible changes in parental behavior and prey utilization was analyzed separately and will be included in a separate document pending final analysis of these data.

Determining nest status:

Evidence which would suggest a nest had been used during the 2009 breeding season included whitewash under the nest tree or at the roost site, prey remains in the nest stand, down present on the perimeter of the nest, castings under the nest tree, or fresh nesting material on the nest (Figure 11). The condition of individual nests was used as a general guide to assess the status of the nest prior to incubation. Occupied nests most often had fresh material (e.g., branches) and tended to appear less compressed or compacted than unoccupied nests (Figure 12). Unoccupied nests tended to have a flattened or compressed appearance (Figure 13), presumably from the effects of snow compacting the nest material during the previous winter. In most cases (n = 14 nest structures), regardless of the number of young present in the nest during the brooding, nestling or fledgling phase, because of the amount of residual whitewash that was present under occupied nests, the breeding season status of the nest (i.e., "Occupied" or "Unoccupied") could be confirmed through mid September, 2009.

For spring surveys and because of limitations in both time and funding for this project, it was decided that an emphasis would be placed on documenting whether or not a nest structure was occupied, and less emphasis would be placed on evaluating whether the nesting territory was occupied. As such, an "occupied" nest structure was defined as a nest where either the adult female was observed incubating eggs, as suggested by the adult being in an incubating posture, or by direct observation of eggs in the nest with the adult bird in the nest stand. A "successful" nest was defined as a nest that fledged at least one fledgling. Nests that were determined to be occupied during the spring surveys, and where follow-up surveys indicated that the nest had failed for either known or unknown causes, was classified as a "failed" nest. In some cases (n = 1; Nest ID: 375), un-hatched eggs were documented in the nest late in the season with no adults present in the nest stand. This nest was also classified as a failed nest.

In 2008, a camera mounted to a telescopic pole was used to document the number of eggs present in the nest as well as document hatching dates. In 2009, the camera pole system was used at 5 known nest structures (i.e., 479,480,375,323,359). The number of eggs or juveniles present in occupied nests was also determined using the nest monitoring cameras which were used to monitor nest activity. At 8 of the reported occupied LEOW nest structures, the number of eggs and/or nestlings present was documented as part of an on-going study to assess seasonal movement patterns of Long-eared owl in the project area by project cooperators.

End-of-Season nest status verification:

All accipiter nest structures that were identified as being occupied during the 2009 spring nest monitoring surveys (n = 80) were visited throughout the breeding season to assess nest status. The primary objective of the end-of-season (EOS) surveys was to determine if nest structures that were identified as being occupied during the spring surveys successfully fledged young. It was determined that mid June would be an appropriate date to assess nest success for those nests that remained occupied throughout the breeding season. End-of-season nest status verification included a two month period which started on 16 June 2009 and ended on 26 August 2009, and all known nest areas that were identified as being active during the spring surveys were visited to access overall nest success. For those nest areas that remained occupied throughout the breeding season, information pertaining to fledging rates, and fledging and dispersal dates were recorded for each successful nest structure. The EOS nest status verification start date was chosen to ensure that dispersal of LEOW, RTHA, CORA, and GOEA was also represented, where appropriate. The juveniles of these species typically disperse from the nest stand before accipiter juveniles. A minimum of 2 visits to known active nest structures was required to assess the overall success of each occupied nest area.

Data Management:

Because of differences in overall data quality, two different datasets were used to record location and phenological information for individual nests. The dataset used to record location information for all known nests that were reported by BLM staff or by third-party contractors is referred to as the "Target" dataset. This dataset includes all known nest structures that have been reported since 2005, and both the location and most current species that occupied a specific nest is fairly reliable. The second dataset is referred to as the "Inventory" dataset. This dataset includes all relevant information that has been collected for specific nest structures as part of the WRFO Raptor Inventory and Monitoring Project that was initiated in 2008, and was designed to track nest occupancy, phenological information, changes in species that occupy a given nest structure within a given year, and changes in species that occupy a nest among years. This dataset represents the most reliable location and phenological information available, and this dataset was used for all the analyses included in this document.

Data Analysis:

1. Disturbance-related analysis

Disturbance-related analyses included calculating distance from 4 anthropogenic features commonly found throughout the project area. The following variables were selected for the analysis: 1) distance from the occupied or unoccupied nest structure to the nearest producing natural gas well (DWP); 2) distance from the occupied or unoccupied nest structure to the nearest pipeline corridor edge of disturbance (DPL); 3) distance from the occupied or unoccupied nest structure to the nearest seismic flagging (DFL); 4) distance from the occupied or unoccupied nest structure to the nearest access corridor edge of disturbance (DRD); and, 5) distance from the occupied or unoccupied nest structure to the nearest active natural gas drill rig (DDR), which was depicted geographically as the geometric center of the well bore for the drill rig using Colorado Oil & Gas Conservation Committee (COGCC) well location data. In addition to estimating distance from these four geographically distinct features, producing well density and road density was also calculated. For density analyses, a kernel density model was used to generate the surface map for both producing well density (PWD) and road density (RDD). The unit of measure selected for these analyses was number of producing wells per square mile, and total linear units (set to miles) of access road per square mile. In addition, traffic volume and helicopter activity was qualitatively assessed and classified into three categories (e.g., High, Medium, and Low). These categories correspond to the observer's impression of the overall volume of vehicular traffic and helicopter activity observed during routine visits to nests. In most cases, it was assumed that, within the 3D seismic project area, both vehicle traffic and helicopter activity was correlated and was directly associated with the seismic project that began in April of the 2009 with the deployment of survey crews, and ended in December with the recording phase of the project.

For statistical comparison, nests where disturbance-related information was collected were considered as sampling units. Nests were opportunistically selected from a sample of all known occupied nests based on accessibility and location. Thus, nests used in this study were not randomly selected from the population of nests within the study area. Because of the uncertainty whether these data truly represent distance relationships between accipiter nest structures and anthropogenic features within our study area, whether these results can be extended to the Piceance Basin as a whole is unknown.

Two approaches were used to identify possible nests to be included in disturbance-related analyses. The first method included reviewing field notes, and identifying those nests where distance and possible disturbance-related features existed in close proximity to the occupied nest. As stated above, because the nests included in this analysis were not selected randomly, these results may not apply to the larger raptor population.

Distance from anthropogenic features to nest structures was estimated manually using the ArcMap 9.2 measure tool in conjunction with 5 m resolution Rapid Eye satellite imagery that was acquired in August of 2009. An automated process was also developed to measure distance between various anthropogenic features and associated nest structures using Model Builder in ArcMap 9.2 (Figure 15). However, because the available data for linear features was represented as a line and not a polygon, and because distance to associated pipeline and travel corridor center lines may have overestimated distance results to these features from known nest structures, and because construction widths vary both within and among constructed pipeline and travel corridors, it was decided to manually measure the distance from the nearest edge of disturbance of an associated travel or pipeline corridor to the associated nest structure.

Statistical Analysis:

Normality of experimental error was examined using the Shapiro-Wilk test procedure, and assumptions regarding homogenous variances were tested using Levene's test (Zar 1999). Because of failure to meet parametric assumptions, I used a Kruskal-Wallis single-factor ANOVA to examine differences among nests regarding distance variables for both occupied and unoccupied nests. Moreover, because distance variables did not meet parametric assumptions, I examined correlative relationships between distance variables and occupied and unoccupied nests using non-parametric test procedures. As such, I calculated Spearman rank correlation coefficients (r_s) for these variables. SYSTAT 12 was used for all statistical analyses. An alpha of 0.05 was used for all statistical tests, and results are reported as the mean ± SE.

RESULTS

1. Nest Inventory

Identifying suitable nest habitat manually:

Twelve occupied nesting territories and 15 nest structures were located in the study area using this method in 2008, and in our study area, though our results may be inconclusive (see below), using an *apriori* method to qualitatively identify potential nesting habitat appeared to aid in focusing survey efforts and locating occupied and unoccupied nesting territories. These results were also supported by the overall ranking of each survey area polygon based on stand information that was collected at each station, with the majority of points falling within areas that received a rank of moderate to highly suitable. Other noteworthy observations include that in 2008, field staff noted that, because of variation in the defensive behavioral among Cooper's hawk that most likely led to variable detection rates (i.e., most adults in occupied territories were more likely to respond to the intruder as he or she entered the nest stand and not to the call-playback), call-playback stations separated by a distance of 100 m in suitable nest habitat would most likely result in the identification of more occupied nest territories, and maximize the number of nests (both occupied and unoccupied) found per survey effort.

Because our sampling regime was not done randomly, we were not able to assess if nesting habitat that was selected, using the methods described above, is representative of overall accipiter nesting habitat that occurs in our study area. However, because of the spatial distribution (i.e., uniformity of the geographic location of nests selected within the project area), the spatial extent (i.e., size of the project area from which nests were selected) and the variation in topographic features that were included in the analysis, we assume that, on average, our results can be extended to the lager population of *accipiter* that nest within the Piceance Basin.

Modeling summary results:

After qualitatively comparing the results of techniques that used either an automated or manual process to identify potential nesting habitat, it was found that the adaptive-based model generated a map that was, in most cases, too general to be of any value and vegetation type tended to influence the model to the greatest degree. The weighted overlay model tended to underestimate total acres of potential nesting habitat, though the areas that were identified tended

to include suitable nesting habitat more often than areas that were identified using the adaptive-based model. Using the manual technique, which required the user to visually inspect aerial photography for stands of trees that exhibited higher tree stem density and higher canopy closure, in conjunction with weighted overlay results, which identified those areas that met the defined elevation, slope and aspect criteria, tended to provide the most reliable results.

3. Monitoring tasks

A total of 187 nests, representing 178 known nesting territories were visited during the 2009 field season. Of these nest areas, 42.8% (*n* = 80) were classified as being occupied during the spring surveys, and 44.9% (*n* = 84) of the known nest areas were confirmed as being unoccupied during the 2009 breeding season. Nine of the known nest structures (4.8 %) were classified as "Not Applicable" because the nest could not be found. The breeding season status for 14 nest structures (7.5%), representing 14 discrete nest areas, were classified as "Unknown". Nests that were classified as "Unknown" and "Not Applicable" were omitted from further analyses. Of the nest areas that were classified as occupied in 2009, 43.8% (*n* = 35) of the occupied nest areas successfully fledged young, and 47.5% (*n* = 38) of the occupied nest areas did not fledge young. Predation-related events resulted in 3 failed nesting attempts. The cause of nest failure was unknown for the remaining occupied nests (*n* = 35).

When considering those nest areas that were occupied in 2008 (*n* = 82; 86 total occupied nest structures with 4 occupied LEOW nest structures occurring in 4 known COHA nest clusters), 37.8% (*n* = 31) of these nesting territories were determined to be unoccupied in 2009. Moreover, 51 of 82 (62%) nest territories were occupied in consecutive years (2008 and 2009).

When considering those nest areas that were successful in 2008 (*n* = 41), only 22% (*n* = 9) of these nests were successful in 2009; 78% (*n* = 32) of these nests did not successfully fledge young during the 2009 breeding season. Six of the known nest areas that failed in 2008 were successful in 2009.

<u>Procedure for determining the breeding status of the nest and for locating alternate nests when the known nests is not occupied or has been occupied by another species:</u>

During the 2008 and 2009 field seasons 23 additional occupied alternate nest structures were located by walking concentric circles, centered on the occupied nest tree. The presence of a

surveyor in the nest stand resulted in locating 9 new occupied nest structures. The use of call-playback, while standing at the base of the nest tree resulted in mixed results, with either a raptor detection occurring after a delayed response (i.e., 8 to 24 minutes; *n* =8), the bird instantly responding to a broadcast (*n* = 4), or no response to a call-playback and the nest consequently located through an intensive search of the nest area (*n* =12). Detection rates increased dramatically after 2 June 2008. Prior to this time, adult Cooper's hawk did not readily respond to the adult Cooper's hawk alarm call. Conversely, detection rates seemed to decrease around 9 July 2008. After this date, nests were located primarily as a result of intensively searching nesting areas associated with visual detections.

End-of-Season (EOS) Nest Status Verification:

It should be noted that of the 4 Cooper's hawk nest areas that were monitored as part of the Cooper's hawk food habits and behavioral video monitoring project, through intensive monitoring, which included routine, weekly visits to each nest structure, and searching for juveniles in the nest stand, it was determined that all juveniles had moved out of the nest stand on or before 26 August 2009.

In 2009 the average number of visits to known nest structures was 3.34 (range = 2 to 7 visits/nest) (one occupied LEOW nest structure was visited only once because of its remote location and was excluded from this estimate). Average number of visits to nest structures that were monitored with video cameras was 22.8 (range = 18 to 26 visits/nest). Three of the video monitored nest structures failed and were left out of the average visits because it would have lowered the overall average. When considering those nest structures where video monitoring equipment was used (*n* = 7), on average, the observer spent 45 minutes in the nest stand downloading video footage and replacing batteries, 18 minutes searching for fledged juveniles (*n* = 4 nests), and 32 minutes listening for adults or juveniles (*n* = 4 nests) in the nest stand to document presence/absence information.

Disturbance-related Results:

For disturbance-related analyses for occupied nest areas, 19 Cooper's hawk (COHA), 2 Common raven (CORA), 7 Long-eared owl (LEOW), 2 Northern goshawk (NOGH), 2 Redtailed hawk (RTHA), and 5 occupied discrete nest areas, where the species was unknown (UNKR),

were included in the analysis (Table 17). Golden eagle, American kestrel, and sharp-shinned hawk were excluded because the analyses required more than one case for mean calculations.

For disturbance-related analyses for unoccupied nest areas, 10 Cooper's hawk (COHA), 3 sharp-shinned hawk (SSHA), and 10 occupied discrete nest areas, where the species was unknown (UNK), were included in the analysis (Table 18). Long-eared owl (LEOW) and American kestrel (AMKE) were excluded from the analyses that required more than one case for mean calculations because only one case for each was available for analysis.

For occupied nests producing well density (PWD) was statistically correlated with DRD, DWP, and DPL, and road density (RDD) was statistically correlated with DFL and PWD (Table 19, Figures 16 and 17). For unoccupied nests producing well density was correlated with DRD and DDR, and road density (RDD) was correlated with DPL and DRD (Table 19, Figure 18).

For both occupied and unoccupied nests, producing well density and road density was statistically correlated (Table 19).

At occupied nests, as producing well density increased the distance from an occupied nest to roads, well pads, and pipelines decreased with r_s values of -0.34, -0.44, and -0.33, respectively ($p < 0.05$). Occupied nests that occurred in areas where road density was low, also tended to occur in areas where producing well density was low ($r_s = 0.35$, $p < 0.05$).

At unoccupied nests, contrary to the negative correlation between well density and distance from roads to occupied nests, as well density increased, the distance from the unoccupied nest to a road also increased ($r_s = 0.43$, $p < 0.05$). Moreover, as road density increased the distance from an unoccupied nest to the nearest road also increased ($r_s = 0.52$, $p < 0.05$).

<u>Distance to Well pad (DWP):</u>

The mean DWP for COHA was 514.6 meters (± 83.9, range = 34 to 1130 meters). The mean DWP for CORA was 763.5 meters (± 6.5, range = 757 to 770). The mean DWP for LEOW was 253.7 meters (±71.0, range = 45 to 563). The mean DWP for NOGH was 1108 meters (± 950, range = 158 to 2058). The mean DWP for RTHA was 232 meters (± 28, range = 204 to 260). The mean DWP for UNKR was 374.4 meters (± 114.8, range = 101 to 678, Table 3).

Distance to Pipeline (DPL):

The mean DPL for COHA was 241.6 meters (± 61.47, range = 19 to 923). The mean DPL for CORA was 192 meters (± 177, range = 15 to 369). The mean DPL for LEOW was 94.9 meters (± 32.31, range = 23 to 271). The mean DPL for NOGH was 432.5 meters (± 202.5, range = 230 to 635). The mean DPL for RTHA was 185 meters (± 143, range = 42 to 328). The mean DPL for UNKR was 318.6 meters (± 171.17, range = 115 to 1007, Table 4).

Distance to DFL:

The mean DFL for COHA was 72.86 meters (± 38.49, range = 0 to 550). The mean DFL for LEOW was 46 meters (± 21.20, range = 20 to 88). The mean DFL for UNKR was 50.67 meters (± 28.29, range = 2 to 100, Table 5).

Distance to Roads (DRD):

The mean DRD for COHA was 215.2 meters (± 50.4, range = 25 to 920). The mean DRD for CORA was 54 meters (± 47.0 range = 7 to 101). The mean DRD for LEOW was 69.14 meters (± 19.2, range = 19 to 147). The mean DRD for NOGH was 342.5 meters (± 102.5, range = 240 to 445). The mean DRD for RTHA was 42.5 meters (± 7.5, range = 35 to 50). The mean DRD for UNKR was 158.4 meters (± 14.5, range = 125 to 207, Table 6).

Distance to Drill Rig (DDR):

The mean DDR for COHA was 1,580.73 meters (± 407.53, range = 84 to 4,506). The mean DDR for RTHA was 608.5 meters (± 248.5, range = 360 to 857). The mean DDR for UNKR was 1,193.5 meters (± 6.5, range = 1,187 to 1,200, Table 7).

Producing well density and road density (PWD and RDD):

The mean PWD for COHA was 1.4 producing wells/sq. mile (± 0.38, range = 0.19 to 6.15). The mean PWD for CORA was 0.63 producing wells/sq. mile (± 0.21, range = 0.43 to 0.84). The mean PWD for LEOW was 1.1 producing wells/sq. mile (± 0.19, range = 0.56 to 1.76). The mean PWD for NOGH was 0.24 producing wells/sq. mile (± 0.24, range = <0.01 to 0.48). The mean PWD for RTHA was 2.34 producing wells/sq. mile (± 0.10 range = 2.24 to

2.44). The mean PWD for UNKR was 1.67 producing wells/sq. mile (± 0.75, range = 0.30 to 3.87, Table 8).

The mean RDD for COHA was 2.99 miles of road/sq. mile (± 0.20, range = 1.92 to 5.13). The mean RDD for CORA was 3.08 miles of road/sq. mile (± 1.0, range = 2.08 to 4.07). The mean RDD for LEOW was 2.7 miles of road/sq. mile (± 0.30, range = 1.86 to 4.29). The mean RDD for NOGH was 2.46 miles of road/sq. mile (± 0.42, range = 2.04 to 2.87). The mean RDD for RTHA was 2.68 miles of road/sq. mile (± 0.01, range = 2.67 to 2.68). The mean RDD for UNKR was 3.29 miles of road/sq. mile (± 0.51, range = 1.86 to 5.00, Table 9).

<u>All nests merged:</u>

When considering all nests grouped together, the mean DWP was 460.3 meters (± 63.7, *n* = 40, range = 34 to 2058 meters). The mean DPL for all nests was 225.03 meters (± 39.4, *n* = 40, range = 15 to 1002). The mean DFL for all nests was 65.63 meters (± 22.57, *n* = 24, range = 0 to 550). The mean DRD for all nests was 169.8 meters (± 27.6, *n* = 40, range = 7 to 920). The mean DDR for all nests was 1703.80 meters (± 345.74, *n* = 20, range = 84 to 6237). The mean PWD for all nests was 1.4 producing wells/sq. mile (± 0.23, *n* = 40, range = 0.01 to 6.15). The mean RDD for all nests was 3.02 miles of road/sq. mile (± 0.14, *n* = 40, range = 1.86 to 5.13; Table 10).

When comparing results between occupied and unoccupied nests and disturbance variables using nonparametric test procedures, there was no statistical difference between occupied and unoccupied nests (Table 11).

Nest success results:

<u>Distance from a producing well:</u>

Because of inadequate sample size, disturbance-related results presented in this section were limited to COHA and LEOW. Moreover, because of their relevance to oil and gas operations that occur in the project area, DWP and DRD were chosen as the variables that would be reported here. If necessary, the reader can refer to Tables 12-16 for disturbance-related results for all raptor species and all variables that were included in the analysis. Two nests (1 COHA nest and 1 LEOW) were omitted from the analysis because the number of young that fledged from these nests was unknown.

COHA productivity appeared to be lower at closer distances to producing wells when compared to LEOW (Figure 19). Sixteen percent (*n* = 3) of the occupied Cooper's hawk (*n* = 19) nests were within 0 to 100 meters of a producing well. Of these nests, none of them successfully fledged young. Approximately 61% of all young that fledged (*n* = 18) from occupied nests fledged from nests that were within 400 to 500 m (*n* = 5 fledglings) and 700 to 800 m (*n* = 6 fledglings) from a producing well. Moreover, the spatial distribution of occupied nests to producing well pads appeared to be more equitably distributed when compared to the spatial distribution of LEOW occupied nests.

Occupied LEOW nests appeared to be clustered closer to producing wells when compared to COHA (Figure 20). Moreover, 59 % (*n* = 10) of all young that fledged (*n* = 17) fledged from nests (*n* = 2) that were within 0 to 100 m of a producing well. Twenty-four percent (*n* = 4) and 18 % (*n* = 3) of all fledglings fledged from successful nests (*n* = 1 and *n* = 1, respectively) that were within 100 to 200 m and 300 to 400 m of a producing well.

Distance from travel corridor:

Forty-four percent (*n* = 8) of the occupied COHA nests were found within the 0 to 100 m of a travel corridor; however, only 25 % (*n* = 2) of these nests successfully fledged young (Figure 21). Thirty-one percent of the total number of young that fledged (*n* = 16), fledged from successful nests that were within 0 to 100 m of a travel corridor. Moreover, 31% (*n* = 5 fledglings from 2 successful nests) of the total number of young that fledged, fledged from nests that were within 400 to 500 m of a travel corridor, and 100% of the nests that were occupied successfully fledged young at this distance.

Productivity appeared to be higher for LEOW at closer distances to travel corridors, with 57% (*n* = 4) of the occupied nests (*n* = 7) occurring within 0 to 100 m of a travel corridor (Figure 22). Of these nests, 75% (*n* = 3) successfully fledged young, producing 71% (*n* = 12) of all young that fledged. Thirty-three percent (*n* = 2) of the occupied LEOW nests were found within 100 to 200 m of a travel corridor. Of these nests, 50% (*n* = 1) successfully fledged young, producing 29% (*n* = 5) of all young that fledged. Similarly, approximately 82% of all young that fledged from occupied Long-eared owl nests (*n* = 7) fledged from nests that were within 0 to 100 m (*n* = 10 fledglings) and 100 to 200 m (*n* = 4 fledglings), respectively, from a producing well.

DISCUSSION

Because available time and funding required to search for new territories was limited, we developed a procedure (based on qualitative methods) to help delineate potential accipiter nesting habitat in our study area. Potential nesting habitat was identified using a procedure that required the use of aerial imagery, Digital Elevation Model (DEM) data, and results generated from a separate modeling process. Twelve new occupied nesting territories and 15 new nest structures were located using this method in 2008, and in our study area, though our results may be inconclusive (see below), using an *apriori* method to qualitatively identify potential nesting habitat appeared to aid in focusing survey efforts and locating occupied and unoccupied nesting territories.

Because our sampling regime was not done randomly, we were not able to assess if nesting habitat that was selected, using the methods described above, was representative of overall accipiter nesting habitat that occurs in our study area. However, because of the spatial distribution (i.e., uniformity of the geographic location of nests selected within the project area), the spatial extent (i.e., size of the project area from which nests were selected) and the variation in topographic features that were included in the analysis, we assume that, on average, our results can be extended to the lager population of *accipiter* that nest within the Piceance Basin. Furthermore, in order to provide support regarding methods used to characterize potential nesting habitat based on topography and nest stand structure (i.e., canopy cover and tree stem density), we qualitatively compared topographic and cover type features at known accipiter nests with accipiter nests reported by an independent, third-party contractor. This comparison confirmed our assumption that topographic features and nest stand characteristics that were identified as key factors that determined the overall suitability of a nest area were captured in our analysis.

Regarding the modeling process that was used to help delineate potential nesting habitat, after qualitatively comparing the results of techniques that used either an automated or manual process to identify potential nesting habitat, it was found that the adaptive-based model generated a map that was, in most cases, to general to be of any value and vegetation type tended to influence the model to the greatest degree. The weighted overlay model tended to underestimate total acres of potential nesting habitat, though the areas that were identified tended

to include suitable nesting habitat more often than areas that were identified using the adaptive-based model. Using the manual technique, which required the user to visually inspect aerial photography for stands of trees that exhibited higher tree stem density and higher canopy closure, in conjunction with weighted overlay results, which identified those areas that met the defined elevation, slope and aspect criteria, produced the most reliable results. Furthermore, we found that the use of both the manual technique combined with use of results generated from the weighted overlay process generally identified areas that represented suitable nesting habitat, and the combined process significantly reduced the amount of time necessary to delineate suitable nesting habitat. Where necessary, we strongly recommend using a combined approach (as described above) to aid in the identification of potential accipiter nesting habitat when developing monitoring and inventory projects associated with oil and gas activities. Moreover, where NEPA actions associated with potential woodland raptor nesting habitat are concerned, and per the Migratory Bird Treaty Act, we strongly recommend, where appropriate, using the approach described above to identify those areas that may serve as potential nesting habitat, thus warranting further investigation, and providing a more rigorous examination of environmental consequences of a particular action. We also advocate that inventory of suitable nesting habitat be conducted using a systematic approach, as described by Kennedy and Stahlecker (1993), Geissler and Fuller (1986), Iverson and Fuller (1991), Mosher et al. (1990), Mosher and Fuller (1996), and McLeod and Andersen (1998). However, in areas where topography, slope, aspect, and available nesting substrate dictate the extent and availability of suitable nesting habitat (often described in our study area as being fragmented, and non-contiguous), alternative methods which include positioning call playback stations in key areas, defined by tree stem density and canopy cover, may also produce desirable survey results. However, this project was not designed to quantitatively test the effectiveness of this method, so the applicability of our results, when used in other areas, under different conditions, should be viewed with caution.

During the 2008 and 2009 field seasons 23 additional occupied alternate nest structures were located by walking concentric circles, centered on the occupied nest tree. The presence of a surveyor in the nest stand resulted in locating 9 new occupied nest structures. The use of call-playback, while standing at the base of the nest tree resulted in mixed results, with either a raptor detection occurring after a delayed response (i.e., 8 to 24 minutes; n =8), the bird instantly responding to a broadcast (n = 4), or no response to a call-playback and the nest consequently

located through an intensive search of the nest area (*n* =12). Detection rates increased dramatically around 2 June 2008. Prior to this time, adult Cooper's hawk did not readily respond to the adult Cooper's hawk alarm call. Conversely, detection rates seemed to decrease around 9 July 2008. After this date, nests were located primarily as a result of intensively searching nesting areas associated with visual detections. For reasons mentioned above we strongly advocate the use of pedestrian-based survey methods when surveying for Cooper's hawk in Pinion-juniper dominated woodlands.

A total of 187 nests, representing 178 known nesting territories were visited during the 2009 field season. Of these nest areas, 42.8% (*n* = 80) were classified as being occupied during the spring surveys, and 44.9% (*n* = 84) of the known nest areas were confirmed as being unoccupied during the 2009 breeding season. It is important to note that the 2009 survey effort focused on monitoring known nests, with less effort placed on inventory of new nesting territories. In addition, in our Resource Area, when considering all known nesting territories (*n* = 80) that were monitored during the 2009 field season, known Cooper's hawk nesting territories comprised 53% (*n* = 42). Moreover, we found that, on average, territory density for Cooper's hawk was approximately 1 breeding territory per square mile. As such, available nesting habitat and prey resources that occur in the Piceance Basin should be considered important to the local population of resident Cooper's hawk that occupy this area for breeding and/or foraging purposes.

We found that fledging success was approximately 2.7 fledglings per successful nesting attempt (*n* = 6); however, of 18 known nesting attempts by Cooper's hawk during the 2009 breeding season, only 33% successfully fledged young; 67% (*n* = 12) of the known nesting attempts were not successful. Causal factors that may have led to nest failures include predation, weather events, and disturbance to nests from oil and gas activities which may have resulted in chilled eggs and/or nestlings, resulting in death of the embryo or nestling(s).

Assuming adequate funding is available for this project in 2010, the following topics will be included in the project objectives for 2010: (1) the continuation of an assessment of possible behavioral effects of oil and gas activities on prey delivery rates, prey diversity and prey equitability, parental behavior, and productivity of Cooper's hawk using video monitoring systems; (2) the development of a sampling scheme that allows for the assessment of detection probability for selected species; and (3) the continuation of an assessment of possible cumulative

impacts to raptor productivity in areas where both producing well density and road density is high.

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Table 1. This table includes the vegetation cover classes that occurred within the project area using the Colorado Vegetation Classification Project (CVCP) raster data.

Class Name	Description
Commercial	High density urban areas, parking lots, buildings, etc.
Irrigated Ag	Irrigated crops and fields.
Grass Dominated	Rangeland dominated by annual and perennial grasses.
Grass/Forb Mix	Rangeland codominated by grasses and forbs.
Disturbed Rangeland	Disturbed or overgrazed rangeland.
Sagebrush Community	Sagebrush with rabbitbrush, bitterbrush.
Saltbush Community	Saltbrush on alkaline soils associated with snakeweed, sagebrush.
Greasewood	Low elevation shrubland dominated by greasewood.
Sagebrush/Gambel Oak Mix	Shrubland codominated by Big Sagebrush and Gambel Oak.
Sagebrush/Greasewood	Shrubland codominated by sagebrush and greasewood, with some rabbitbrush.
Shrub/Grass/Forb Mix	Mixed grass/forb and shrub/grass rangeland.
Sagebrush/Grass Mix	Codominate sagebrush shrubland and perennial grassland.
Rabbitbrush/Grass Mix	Codominate rabbitbrush and perennial grassland.
Sagebrush/Mesic Mtn Shrub Mix	Codominate sagebrush/Mesic Mtn shrub mixed with grass/forb.
Sagebrush/Rabbitbrush Mix	Codominate shrubland of sagbrush and rabbitbrush.
Pinon-Juniper	Pinon-Juniper woodland with mixed understory.
Juniper	Woodland principally dominated by JUOS and/or JUSC2.
Gambel Oak	Deciduous woodland (or tall shrubland) dominated by Gambel oak.
Mesic Mountain Shrub Mix	Oak dominant with sagebrush, snowberry, grass.
Serviceberry/Shrub Mix	Deciduous woodland (or tall shrubland) dominated by Servicberry.
PJ-Oak Mix	Codominate Gambel oak and Pinyon/Juniper woodland.
PJ-Sagebrush Mix	Codominate Pinon-Juniper and Sagebrush.
PJ-Mtn Shrub Mix	Codominate Pinon-Juniper and Oak, Mtn. Mahogany or other deciduous shrubs.
Sparse PJ/Shrub/Rock Mix	< 25% Pinon-Juniper with sagebrush and rock.
Sparse Juniper/Shrub/Rock Mix	< 25% Juniper with sagebrush and rock.
Juniper/Sagebrush Mix	Codominate Juniper and Sagebrush.
Juniper/Mtn Shrub Mix	Codiminate Juniper and Oak, Mtn Mahogany or other deciduous shrubs.
Aspen	Deciduous forest dominated by Aspen.
Douglas Fir	Coniferous forest dominated by PSME.
Talus Slopes & Rock Outcrops	Talus and scree slopes, nearly 100% rock.
Soil	Bare soil and fallow agriculture fields.
Riparian	Cottonwood, willow, sedges along waterways.
Cottonwood	Wooded riparian areas dominated by cottonwood.
Shrub Riparian	Shrub riparian areas consisting primarily of shrub willows.
Sedge	Herbaceous riparian areas dominated by sedges.
Water	Lakes, reservoirs, rivers, streams.

Table 2. The following table includes the values that were used to reclassify elevation, slope, aspect and vegetation grids. A rank of 3 or higher indicates higher suitability.

Elevation (meters)		**Slope (degrees)**	
Values	Rank	Values	Rank
1,795 to 1,981	1	0 to 6	3
1,981 to 2,286	3	6 to 12	2
2,286 to 2,451	2	12 to 18	1
Aspect (degrees)		**Cover Class**	
337.5 to 360 and 0 to 22.5	3	Pinion-juniper	4
315 to 337.5 and 22.5 to 45	2	Pinion-juniper/sagebrush mix	3
270 to 315 and 45 to 90	1	Pinion-juniper/Mtn. shrub mix	3
		Aspen and Douglas fir	2
		Juniper	1

Table 3. The following table includes descriptive summary results for the mean distance from known occupied nests to the nearest producing well pad (DWP). The following results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado. Data used to produce this table was collected during the 2009 field season as part of the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor.

Species	COHA	CORA	LEOW	NOGH	RTHA	UNKR
N of Cases	19	2	7	2	2	5
Minimum	34	757	45	158	204	101
Maximum	1,130.00	770	563	2,058.00	260	678
Median	447	763.5	229	1,108.00	232	302
Arithmetic Mean	514.579	763.5	253.714	1,108.00	232	377.4
Standard Error of Arithmetic Mean	83.867	6.5	70.977	950	28	114.813
95.0% Lower Confidence Limit	338.381	680.91	80.04	-10,962.89	-123.774	58.628
95.0% Upper Confidence Limit	690.777	846.09	427.388	13,178.89	587.774	696.172
Standard Deviation	365.568	9.192	187.787	1,343.50	39.598	256.73
Variance	133,640.15	84.5	35,263.91	1,805,000.00	1,568.00	65,910.30
Coefficient of Variation	0.71	0.012	0.74	1.213	0.171	0.68
Shapiro-Wilk Statistic	0.929	.	0.934	.	.	0.895
Shapiro-Wilk p-value	0.164	.	0.587	.	.	0.384

Table 4. The following table includes descriptive summary results for the mean distance from known occupied nests to the nearest pipeline corridor edge of disturbance (DPL). The following results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado. Data used to produce this table was collected during the 2009 field season as part of the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor.

Species	COHA	CORA	LEOW	NOGH	RTHA	UNKR
N of Cases	19	2	7	2	2	5
Minimum	19	15	23	230	42	115
Maximum	923	369	271	635	328	1,002.00
Median	112	192	70	432.5	185	163
Arithmetic Mean	241.579	192	94.857	432.5	185	318.6
Standard Error of Arithmetic Mean	61.474	177	32.311	202.5	143	171.174
95.0% Lower Confidence Limit	112.427	-2,057.00	15.796	-2,140.51	-1,631.99	-156.656
95.0% Upper Confidence Limit	370.73	2,441.00	173.918	3,005.51	2,001.99	793.856
Standard Deviation	267.958	250.316	85.486	286.378	202.233	382.757
Variance	71,801.37	62,658.00	7,307.81	82,012.50	40,898.00	146,503.30
Coefficient of Variation	1.109	1.304	0.901	0.662	1.093	1.201
Shapiro-Wilk Statistic	0.739	.	0.814	.	.	0.612
Shapiro-Wilk p-value	0	.	0.056	.	.	0.001

Table 5. The following table includes descriptive summary results for the mean distance from known occupied nests to the nearest DFL The following results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado. Data used to produce this table was collected during the 2009 field season as part of the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor.

Species	COHA	CORA	LEOW	NOGH	RTHA	UNKR
N of Cases	14	1	3	1	0	3
Minimum	0	90	20	48	.	2
Maximum	550	90	88	48	.	100
Median	30	90	30	48	.	50
Arithmetic Mean	72.857	90	46	48	.	50.667
Standard Error of Arithmetic Mean	38.486	.	21.197	.	.	28.292
95.0% Lower Confidence Limit	-10.286	90	-45.205	48	0	-71.065
95.0% Upper Confidence Limit	156.001	90	137.205	48	0	172.398
Standard Deviation	144	.	36.715	.	.	49.003
Variance	20,736.13	.	1,348.00	.	.	2,401.33
Coefficient of Variation	1.976	1	0.798	1	.	0.967
Shapiro-Wilk Statistic	0.514	.	0.858	.	.	1
Shapiro-Wilk p-value	0	.	0.261	.	.	0.977

Table 6. The following table includes descriptive summary results for the mean distance from known occupied nests to the nearest travel corridor (DRD). The following results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado. Data used to produce this table was collected during the 2009 field season as part of the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor.

Species	COHA	CORA	LEOW	NOGH	RTHA	UNKR
N of Cases	19	2	7	2	2	5
Minimum	25	7	19	240	35	125
Maximum	920	101	147	445	50	207
Median	111	54	50	342.5	42.5	150
Arithmetic Mean	215.158	54	69.143	342.5	42.5	158.4
Standard Error of Arithmetic Mean	50.406	47	19.155	102.5	7.5	14.524
95.0% Lower Confidence Limit	109.258	-543.191	22.272	-959.886	-52.797	118.074
95.0% Upper Confidence Limit	321.058	651.191	116.014	1,644.89	137.797	198.726
Standard Deviation	219.716	66.468	50.68	144.957	10.607	32.478
Variance	48,275.03	4,418.00	2,568.48	21,012.50	112.5	1,054.80
Coefficient of Variation	1.021	1.231	0.733	0.423	0.25	0.205
Shapiro-Wilk Statistic	0.783	.	0.871	.	.	0.946
Shapiro-Wilk p-value	0.001	.	0.188	.	.	0.711

Table 7. The following table includes descriptive summary results for the mean distance from known occupied nests to the nearest natural gas drill rig (DDR). The following results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado. Data used to produce this table was collected during the 2009 field season as part of the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor.

Species	COHA	CORA	LEOW	NOGH	RTHA	UNKR
N of Cases	11	0	1	1	2	2
Minimum	84	.	2,838.00	6,237.00	360	1,187.00
Maximum	4,506.00	.	2,838.00	6,237.00	857	1,200.00
Median	1,355.00	.	2,838.00	6,237.00	608.5	1,193.50
Arithmetic Mean	1,580.73	.	2,838.00	6,237.00	608.5	1,193.50
Standard Error of Arithmetic Mean	407.529	.	.	.	248.5	6.5
95.0% Lower Confidence Limit	672.696	0	2,838.00	6,237.00	-2,548.99	1,110.91
95.0% Upper Confidence Limit	2,488.76	0	2,838.00	6,237.00	3,765.99	1,276.09
Standard Deviation	1,351.62	.	.	.	351.432	9.192
Variance	1,826,879.62	.	.	.	123,504.50	84.5
Coefficient of Variation	0.855	.	1	1	0.578	0.008
Shapiro-Wilk Statistic	0.899	.	.	.	.	.
Shapiro-Wilk p-value	0.182	.	.	.	.	.

Table 8. The following table includes descriptive summary results for the mean producing well density (PWD) at occupied nests. The following results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado, and units were reported as the number of producing wells per square mile. Data used to produce this table was collected during the 2009 field season as part of the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor.

Species	COHA	CORA	LEOW	NOGH	RTHA	UNKR
N of Cases	19	2	7	2	2	5
Minimum	0.19	0.43	0.56	0	2.24	0.3
Maximum	6.15	0.84	1.76	0.48	2.44	3.87
Median	0.81	0.635	0.84	0.24	2.34	0.65
Arithmetic Mean	1.398	0.635	1.107	0.24	2.34	1.672
Standard Error of Arithmetic Mean	0.381	0.205	0.185	0.24	0.1	0.745
95.0% Lower Confidence Limit	0.598	-1.97	0.654	-2.809	1.069	-0.397
95.0% Upper Confidence Limit	2.197	3.24	1.56	3.289	3.611	3.741
Standard Deviation	1.659	0.29	0.49	0.339	0.141	1.666
Variance	2.751	0.084	0.24	0.115	0.02	2.776
Coefficient of Variation	1.187	0.457	0.442	1.414	0.06	0.997
Shapiro-Wilk Statistic	0.661	.	0.87	.	.	0.808
Shapiro-Wilk p-value	0	.	0.184	.	.	0.094

Table 9. The following table includes descriptive summary results for the mean road density (RDD) at occupied nests. The following results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado, and the units were reported as total liner units (set to miles) per square mile. Data used to produce this table was collected during the 2009 field season as part of the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor.

Species	COHA	CORA	LEOW	NOGH	RTHA	UNKR
N of Cases	19	2	7	2	2	5
Minimum	1.92	2.08	1.86	2.04	2.67	1.86
Maximum	5.13	4.07	4.29	2.87	2.68	5
Median	2.84	3.075	2.49	2.455	2.675	3.17
Arithmetic Mean	2.986	3.075	2.661	2.455	2.675	3.292
Standard Error of Arithmetic Mean	0.198	0.995	0.3	0.415	0.005	0.512
95.0% Lower Confidence Limit	2.571	-9.568	1.927	-2.818	2.611	1.872
95.0% Upper Confidence Limit	3.402	15.718	3.396	7.728	2.739	4.712
Standard Deviation	0.862	1.407	0.794	0.587	0.007	1.144
Variance	0.744	1.98	0.631	0.344	0	1.308
Coefficient of Variation	0.289	0.458	0.298	0.239	0.003	0.347
Shapiro-Wilk Statistic	0.876	.	0.847	.	.	0.97
Shapiro-Wilk p-value	0.018	.	0.116	.	.	0.878

Table 10. The following table includes descriptive summary results for all variables and all species. The following results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado. Data used to produce this table was collected during the 2009 field season as part of the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor. .

Feature class	DWP	DPL	DFL	DRD	DDR	PWD	RDD
N of Cases	40	40	24	40	20	40	40
Minimum	34	15	0	7	84	0	1.86
Maximum	2,058.00	1,002.00	550	920	6,237.00	6.15	5.13
Median	331	122	35	118	1,277.50	0.84	2.855
Arithmetic Mean	460.325	225.025	65.625	169.8	1,703.80	1.437	3.023
Standard Error of Arithmetic Mean	63.723	39.402	22.566	27.604	345.743	0.227	0.143
95.0% Lower Confidence Limit	331.432	145.327	18.944	113.966	980.151	0.977	2.733
95.0% Upper Confidence Limit	589.218	304.723	112.306	225.634	2,427.45	1.897	3.312
Shapiro-Wilk Statistic	0.838	0.74	0.511	0.773	0.84	0.773	0.914
Shapiro-Wilk p-value	0	0	0	0	0.004	0	0.005

Table 11. The following table includes results for the Kruskal-Wallis ANOVA by ranks for occupied and unoccupied nests. There was no statistical difference among occupied and unoccupied nests regarding the distance from known nests and the nearest anthropogenic feature, nor was there a difference in producing well density or road density among occupied and unoccupied nests.

Variable	Nest Status	*n*	Sum of Ranks	*H*	*p-value*
DDR	Occupied	38	1200	$H_{(1, 63)} = .0548382$	0.8148
	Unoccupied	25	816		
DPL	Occupied	40	1308.5	$H_{(1, 65)} = .0240491$	0.8768
	Unoccupied	25	836.5		
DWP	Occupied	40	1444.5	$H_{(1, 65)} = 2.818289$	0.0932
	Unoccupied	25	700.5		
RDD	Occupied	40	1157	$H_{(1, 65)} = 4.834002$	0.0279
	Unoccupied	25	988		
DFL	Occupied	35	964	$H_{(1, 48)} = 6.189821$	0.0128
	Unoccupied	13	212		
DRD	Occupied	40	1222	$H_{(1, 65)} = 1.746525$	0.1863
	Unoccupied	25	923		
PWD	Occupied	40	1254	$H_{(1, 65)} = .7922597$	0.3734
	Unoccupied	25	891		

Table 12. The following table includes nest productivity information for nests that occurred in close proximity to producing natural gas well pads. These results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado during the 2009 breeding season in conjunction with the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor.

	Distance (meters)	Active nests (%)	No. Successful (%)	Total Fledged (%)	Mean No. Fledged		Distance (meters)	Active nests (%)	No. Successful (%)	Total Fledged (%)	Mean No. Fledged
	0 to 100	3 (16)	0	0	NA		0 to 100				
	100 to 200	2 (11)	1 (50)	3 (19)	NA		100 to 200				
	200 to 300	2 (11)	1 (50)	2 (13)	NA		200 to 300	1	1	1	NA
	300 to 400	1 (5)	0	0	NA		300 to 400				
	400 to 500	2 (11)	2 (100)	5 (31)	2.5		400 to 500				
COHA	500 to 600	2 (11)	0	0	NA	**GOEA**	500 to 600				
	600 to 700						600 to 700				
	700 to 800	2 (11)	2 (100)	6 (38)	3		700 to 800				
	800 to 900	1 (5)	0	0	NA		800 to 900				
	900 to 1000	1 (5)	0	0	NA		900 to 1000				
	> 1000	3 (16)	1 (33)	2 (13)	0.67		> 1000				

Table 13. The following table includes nest productivity information for nests that occurred in close proximity to producing natural gas well pads. These results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado during the 2009 breeding season in conjunction with the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor.

	Distance (meters)	Active nests (%)	No. Successful (%)	Total Fledged (%)	Mean No. Fledged
	0 to 100				
	100 to 200				
	200 to 300				
	300 to 400				
	400 to 500				
CORA	500 to 600				
	600 to 700				
	700 to 800	2	1	3	1.5
	800 to 900				
	900 to 1000				
	> 1000				

	Distance (meters)	Active nests (%)	No. Successful (%)	Total Fledged (%)	Mean No. Fledged
	0 to 100	2 (29)	2 (100)	10 (59)	5
	100 to 200	1 (14)	1 (100)	4 (24)	4
	200 to 300	1 (14)	0	0	NA
	300 to 400	2 (29)	1 (50)	3 (18)	1.5
	400 to 500				
LEOW	500 to 600	1 (14)	1 (100)	Unk.	
	600 to 700				
	700 to 800				
	800 to 900				
	900 to 1000				
	> 1000				

Table 14. The following table includes nest productivity information for nests that occurred in close proximity to producing natural gas well pads. These results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado during the 2009 breeding season in conjunction with the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor.

	Distance (meters)	Active nests (%)	No. Successful (%)	Total Fledged (%)	Mean No. Fledged		Distance (meters)	Active nests (%)	No. Successful (%)	Total Fledged (%)	Mean No. Fledged
	0 to 100						0 to 100				
	100 to 200						100 to 200	2	2	6	3
	200 to 300	1	1	1	NA		200 to 300				
	300 to 400						300 to 400				
	400 to 500						400 to 500				
AMKE	500 to 600					**RTHA**	500 to 600				
	600 to 700						600 to 700				
	700 to 800						700 to 800				
	800 to 900						800 to 900				
	900 to 1000						900 to 1000				
	> 1000						> 1000				

Table 15. The following table includes nest productivity information for nests that occurred in close proximity to producing natural gas well pads. These results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado during the 2009 breeding season in conjunction with the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor.

	Distance (meters)	Active nests (%)	No. Successful (%)	Total Fledged (%)	Mean No. Fledged		Distance (meters)	Active nests (%)	No. Successful (%)	Total Fledged (%)	Mean No. Fledged
	0 to 100						0 to 100				
	100 to 200	1	1	1	NA		100 to 200				
	200 to 300						200 to 300				
	300 to 400						300 to 400	1	1	3	NA
	400 to 500						400 to 500				
NOGH	500 to 600					**SSHA**	500 to 600				
	600 to 700						600 to 700				
	700 to 800						700 to 800				
	800 to 900						800 to 900				
	900 to 1000						900 to 1000				
	> 1000	1	1	2	NA		> 1000				

Table 16. The following table includes nest productivity information for nests that occurred in close proximity to producing natural gas well pads. These results were generated from data collected at occupied raptor nests that occurred within the project area, Piceance Basin, Colorado during the 2009 breeding season in conjunction with the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNKR: Unknown raptor.

	Distance (meters)	Active nests (%)	No. Successful (%)	Total Fledged (%)	Mean No. Fledged
	0 to 100				
	100 to 200	2	Unk.	Unk.	Unk.
	200 to 300				
	300 to 400	1	Unk.	Unk.	Unk.
	400 to 500				
UNKR	500 to 600				
	600 to 700	2	Unk.	Unk.	Unk.
	700 to 800				
	800 to 900				
	900 to 1000				
	> 1000				

Table 17. The following table is a summary of nest status, productivity and distance information for those nests (*n* = 40) that were selected for the disturbance-related analyses. These results were generated from data collected at occupied nesting territories that occurred within the project area, Piceance Basin, Colorado during the 2009 breeding season in conjunction with the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, LEOW: Long-eared owl, NOGH: Northern goshawk, RTHA: Red-tailed hawk, UNK: Unknown raptor. Nests highlighted with an "**" were omitted from productivity estimates because the number of young that fledged from these nests was unknown.

Species	Nest ID	Nest Status	Successful (Y/N)	No. Fledged	Distance to RD	Distance to WP	Distance to PL	Distance to FL	Distance to DR	Traffic Volume	Helicopter Activity	PR Well Density	Road Density
CORA	429	Occupied	Yes	3	7	770	15	NA	NA	HIGH		0.84	2.08
LEOW**	204	Occupied	Yes	Unk	19	563	23			HIGH	MED	0.84	2.60
COHA	375	Occupied	No	0	25	128	19	19	264	HIGH	NA	6.15	5.13
AMKE	445	Occupied	Yes	1	25	217	83	NA	322	HIGH	HIGH	2.24	3.90
COHA	294	Occupied	No	0	30	251	30		NA	HIGH		1.60	2.48
LEOW	306	Occupied	No	0	30	350	30	20	NA	HIGH	NA	1.61	4.29
LEOW	337	Occupied	Yes	3	33	383	55	NA	NA	MED		0.82	2.10
RTHA	420	Occupied	Yes	3	35	260	328	NA	360	HIGH	MED	2.44	2.67
COHA	341	Occupied	No	0	43	34	55	1	84	HIGH	LOW	0.88	3.30
COHA	323	Occupied	No	0	49	834	112	49	952	MED	HIGH	0.41	3.52
LEOW	292	Occupied	Yes	4	50	116	70	30	2838	MED	MED	1.47	2.91
RTHA	432	Occupied	Yes	3	50	204	42	NA	857	HIGH	MED	2.24	2.68
COHA	292.2	Occupied	No	0	57	95	81	0	887	MED	MED	1.48	2.90
COHA	402.1	Occupied	Yes	2	58	447	52	11	3255	HIGH	HIGH	0.19	1.92
COHA	359	Occupied	No	0	59	1075	54	0	NA	HIGH	MED	0.65	2.52
LEOW	259.1	Occupied	Yes	5	76	90	86	88		HIGH	LOW	1.76	2.38
COHA	423	Occupied	Yes	3	92	123	68	NA	2516	MED	MED	4.30	2.84
CORA	311	Occupied	No	0	101	757	369	90	NA	MED		0.43	4.07
COHA	290	Occupied	No	0	108	551	98		1465	MED		0.89	2.78
COHA	299	Occupied	No	0	111	918	111	20	NA	LOW		0.42	3.06
UNK.	371	Occupied	No	0	125	302	115	NA	1187	HIGH	HIGH	3.87	5.00
LEOW	286	Occupied	Yes	5	129	45	129	NA	NA	MED		0.69	1.86
UNK.	250	Occupied	No	0	137	101	137		NA	MED		0.65	1.86

Table 17.
Cont.

Species	Nest ID	Nest Status	Successful (Y/N)	No. Fledged	Distance to RD	Distance to WP	Distance to PL	Distance to FL	Distance to DR	Traffic Volume	Helicopter Activity	PR Well Density	Road Density
LEOW	302	Occupied	No	0	147	229	271		NA	MED		0.56	2.49
UNK.	287	Occupied	No	0	150	678	1002	2	1200	HIGH		3.06	3.56
UNK.	190	Occupied	No	0	173	191	163	100	NA	MED	MED	0.48	2.87
GOEA	218	Occupied	Yes	1	204	237	94	80	1560	MED		4.73	4.88
UNK.	389	Occupied	No	0	207	615	176	50	NA	MED		0.30	3.17
COHA	315	Occupied	No	0	208	53	208	NA	1355	MED	MED	0.93	2.30
COHA	373	Occupied	No	0	210	378	197	70	523	HIGH	HIGH	4.41	4.89
NOGH	422	Occupied	Yes	1	240	158	230	NA	NA	MED	MED	0.48	2.87
COHA	314	Occupied	No	0	290	520	300	NA	NA	MED		0.61	2.00
COHA	401	Occupied	Yes	3	295	750	279	30	NA	MED	MED	0.81	3.30
COHA	406	Occupied	Yes	3	310	780	300	30	NA	MED	MED	0.24	3.37
SSHA	399	Occupied	Yes	3	321	312	358	47	2127	HIGH	HIGH	1.40	3.88
COHA**	313	Occupied	Yes	Unk	395	287	923	170	4506	MED		0.56	2.15
COHA	400	Occupied	Yes	2	400	1130	370	40	1581	LOW	HIGH	0.63	2.73
COHA	300	Occupied	Yes	3	428	415	413	30	NA	MED		0.45	3.30
NOGH	266.2	Occupied	Yes	2	445	2058	635	48	6237	MED	HIGH	0.00	2.04
COHA	293	Occupied	No	0	920	1008	920	550	NA	MED	MED	0.95	2.25
N (Mean)	40			38 (1.32)	40 (170)	40 (460)	40 (225)	23 (66)	20 (1704)			40 (1.44)	40 (3.02)

Table 18. The following table is a summary for all nests, and productivity and distance information that was collected for all unoccupied nests. These results were generated from data collected at nests that occurred within the project area, Piceance Basin, Colorado during the 2009 breeding season in conjunction with the WRFO Raptor Inventory and Monitoring Project. The following codes apply: COHA: Cooper's hawk, CORA: Common Raven, NOGH: Northern goshawk, MAKE: American kestrel, SSHA: Sharp-shinned hawk, and UNK: Unknown raptor.

Species	Nest ID	Nest Status	Successful (Y/N)	No. Fledged	Distance to RD	Distance to WP	Distance to PL	Distance to FL	Distance to DR	Traffic Volume	Helicopter Activity	PR Well Density	Road Density
COHA	301.2	Unoccupied	NA	NA	29	212	21		NA	MED		0.56	1.88
SSHA	208	Unoccupied	NA	NA	53	156	53	10	1240	HIGH	LOW	1.90	3.58
COHA	388	Unoccupied	NA	NA	58	139	58	90	NA			0.30	3.18
COHA	189	Unoccupied	NA	NA	65	496	55	3	NA	MED	MED	0.48	2.91
UNK.	127	Unoccupied	NA	NA	73	116	57		195	HIGH	MED	1.08	2.78
COHA	233	Unoccupied	NA	NA	77	749	77		NA	MED		3.08	3.58
UNK.	98	Unoccupied	NA	NA	89	183	122		NA	MED		0.19	2.47
COHA	310	Unoccupied	NA	NA	92	135	110	20	1434	HIGH	LOW	2.08	3.62
SSHA	199	Unoccupied	NA	NA	92	168	101	10	NA	HIGH		0.32	3.16
SSHA	539	Unoccupied	NA	NA	98	214	151	50	NA	HIGH	MED	0.34	3.16
UNK.	309	Unoccupied	NA	NA	115	103	107		NA	HIGH		1.72	2.56
UNK.	428.1	Unoccupied	NA	NA	118	494	118		2048	HIGH		1.63	2.16
UNK.	96	Unoccupied	NA	NA	128	121	165		1140	HIGH		1.84	3.58
COHA	247	Unoccupied	NA	NA	137	42	71	5	1094	HIGH	MED	5.28	5.60
UNK.	207	Unoccupied	NA	NA	152	134	163	90	1138	HIGH	LOW	1.84	3.58
COHA	284	Unoccupied	NA	NA	229	764	172	15	2174	HIGH		0.83	2.60
LEOW	256	Unoccupied	NA	NA	245	15	226	4	122	HIGH		0.76	3.30
AMKE	109	Unoccupied	NA	NA	285	663	250	70	NA	MED	MED	0.38	3.50
UNK.	304	Unoccupied	NA	NA	303	54	202	4	151	HIGH		0.73	3.22
COHA	383	Unoccupied	NA	NA	318	682	297	30	3379	MED	MED	0.75	3.34
COHA	386	Unoccupied	NA	NA	330	345	350		385	HIGH	MED	6.61	5.88
UNK.	234	Unoccupied	NA	NA	419	126	323		258	HIGH		0.66	3.22
UNK.	479	Unoccupied	NA	NA	496	446	532		508	HIGH		6.16	5.06
UNK.	480	Unoccupied	NA	NA	510	441	503		522	HIGH		6.16	5.06
COHA	390	Unoccupied	NA	NA	512	507	229		559	HIGH	MED	6.24	5.06
N (Mean)	25				25 (201)	25 (300)	25 (181)	13 (31)	25 (1022)			25 (2.08)	25 (3.52)

Table 19. This table shows the Spearman correlation coefficients (r_s) for occupied nests (above) and unoccupied nests (below). Values marked in bold were significant at $p < 0.05$.

	DRD	DWP	DPL	DFL	DDR	PWD	RDD
DRD	1.00						
DWP	0.23	1.00					
DPL	**0.80**	0.30	1.00				
DFL	0.11	-0.16	0.20	1.00			
DDR	0.16	0.00	0.12	0.04	1.00		
PWD	**-0.34**	**-0.44**	**-0.33**	0.12	0.22	1.00	
RDD	-0.08	0.04	0.00	**-0.35**	0.03	**0.35**	1.00

	DWP	DPL	DFL	DRD	DDR	PWD	RDD
DWP	1.00						
DPL	0.21	1.00					
DFL	0.27	0.19	1.00				
DRD	0.13	**0.93**	0.01	1.00			
DDR	0.09	0.29	0.02	0.38	1.00		
PWD	0.05	0.29	-0.22	**0.43**	**0.55**	1.00	
RDD	0.00	**0.45**	0.16	**0.52**	0.37	**0.74**	1.00

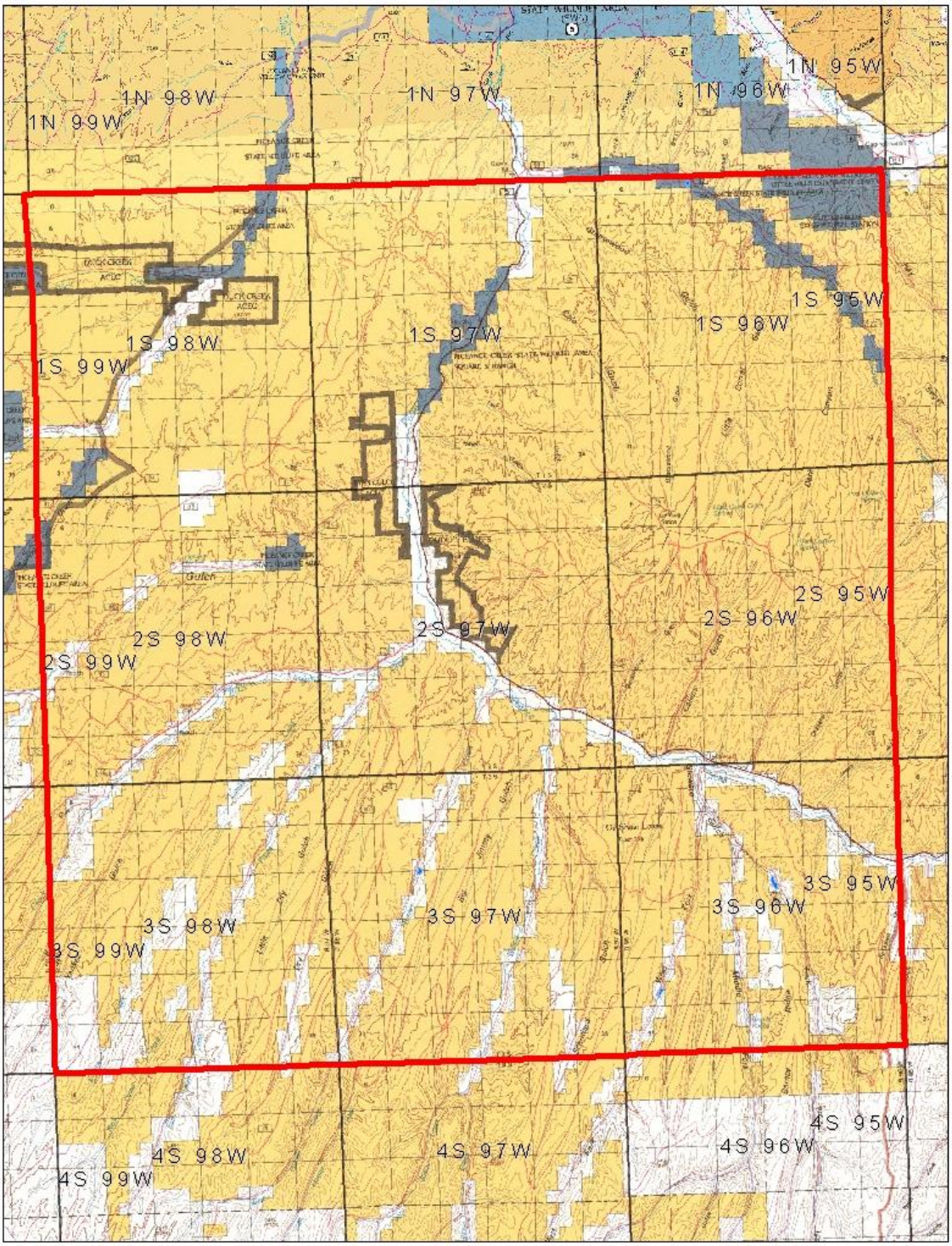


Figure 1. This figure depicts the study area (in red) where raptor breeding season information was collected during the 2008 and 2009 breeding seasons in Piceance Basin, Colorado.

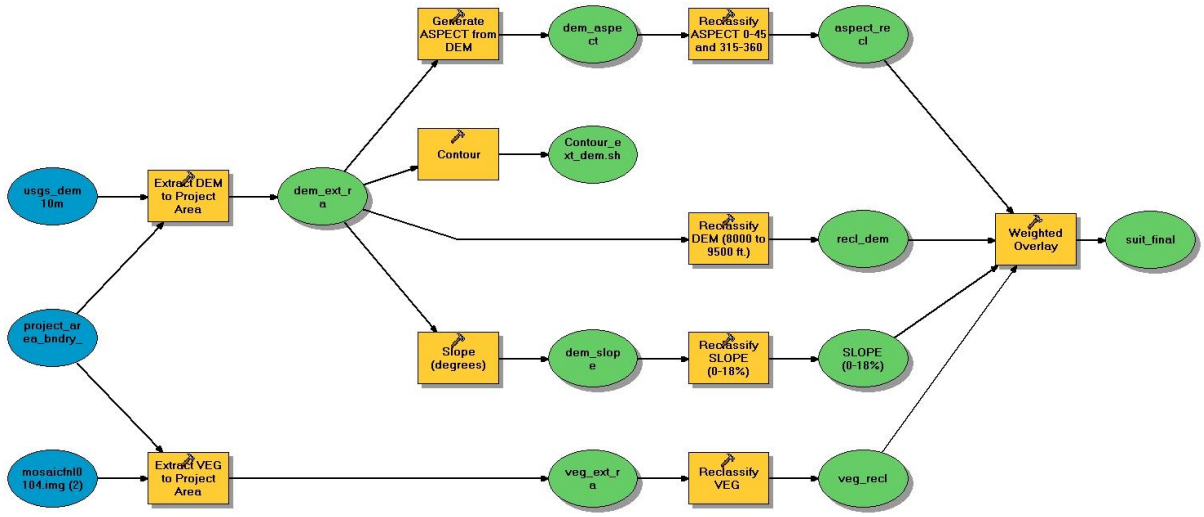


Figure 2. The figure above illustrates the processes used in the weighted overlay analysis using Model Builder in ArcGIS 9.2. The weighted overlay tool allows the user the ability to combine multiple input grids into one output grid (i.e., suitability map) using various weighted values (i.e., percent influence) that when summed together equal 100. Thus, the user can modify how much each individual variable influences the resultant output, if necessary. Slope, aspect and elevation grids were derived from 30 m DEM data, and the Colorado Vegetation Classification Project (CVCP) raster data was used to select suitable vegetation cover classes.

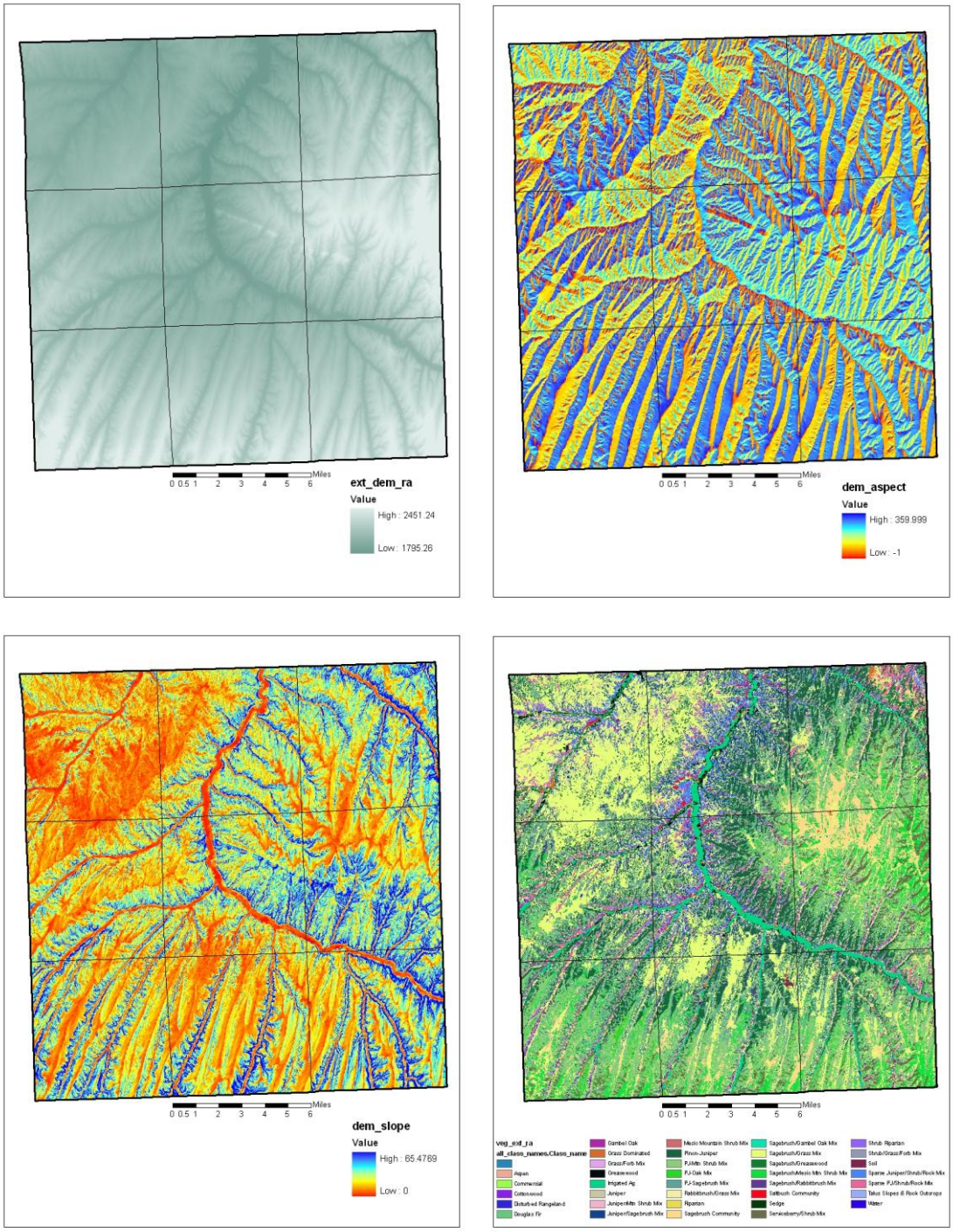


Figure 3. This figure shows the input grids that were used for the weighted overlay analysis. Slope (bottom left) and aspect (upper right) grids were derived from 30 m DEM data (upper left), and the basin-wide Colorado Vegetation Classification Project (CVCP) grid data (lower right) was used for vegetation cover analyses.

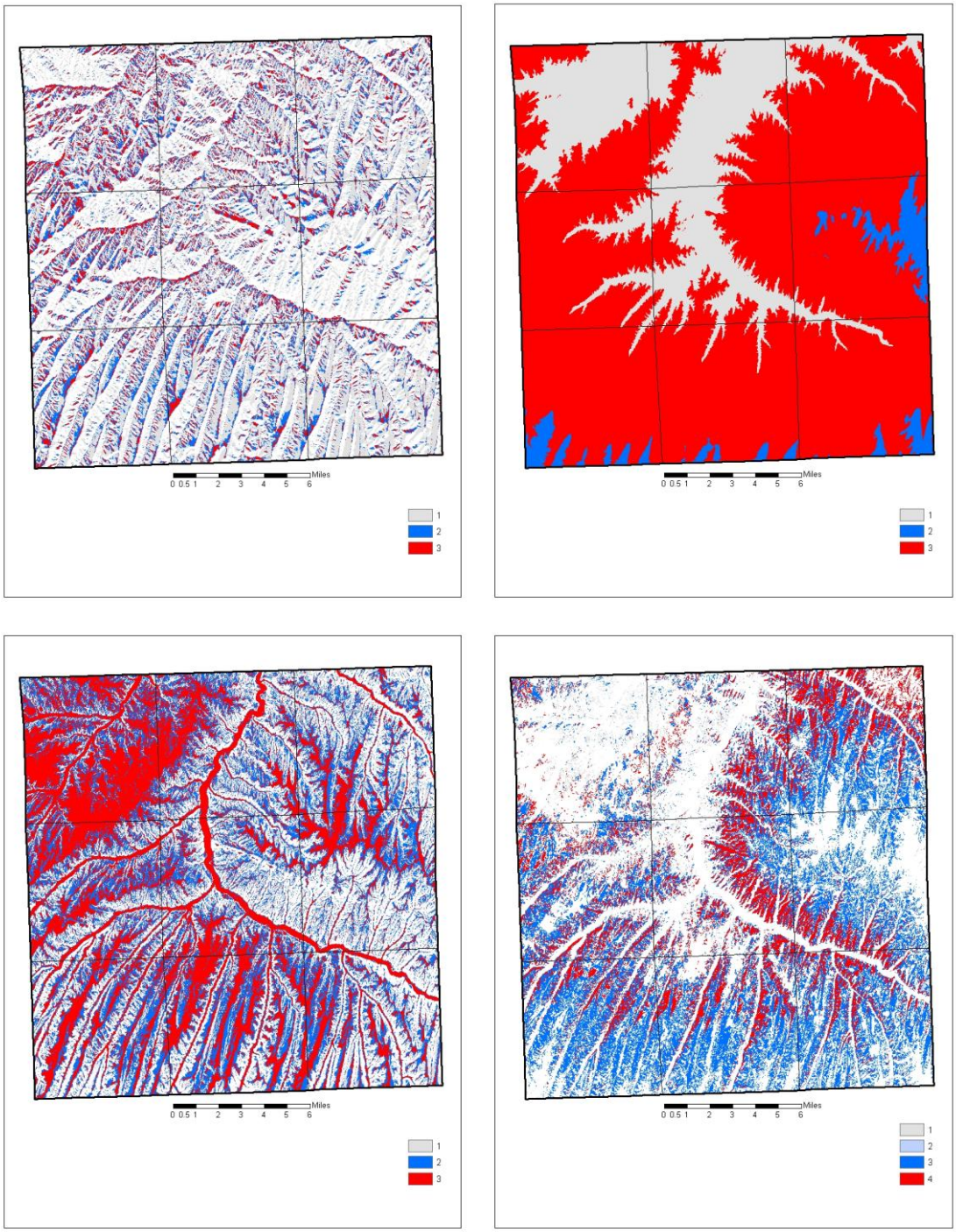


Figure 4. The figure above shows the reclassified aspect (upper left), elevation (upper right), slope (bottom left), and vegetation (bottom right) grids that were used in the weighted overlay analysis. A suitability rank of 3 or higher indicates the highest suitability.

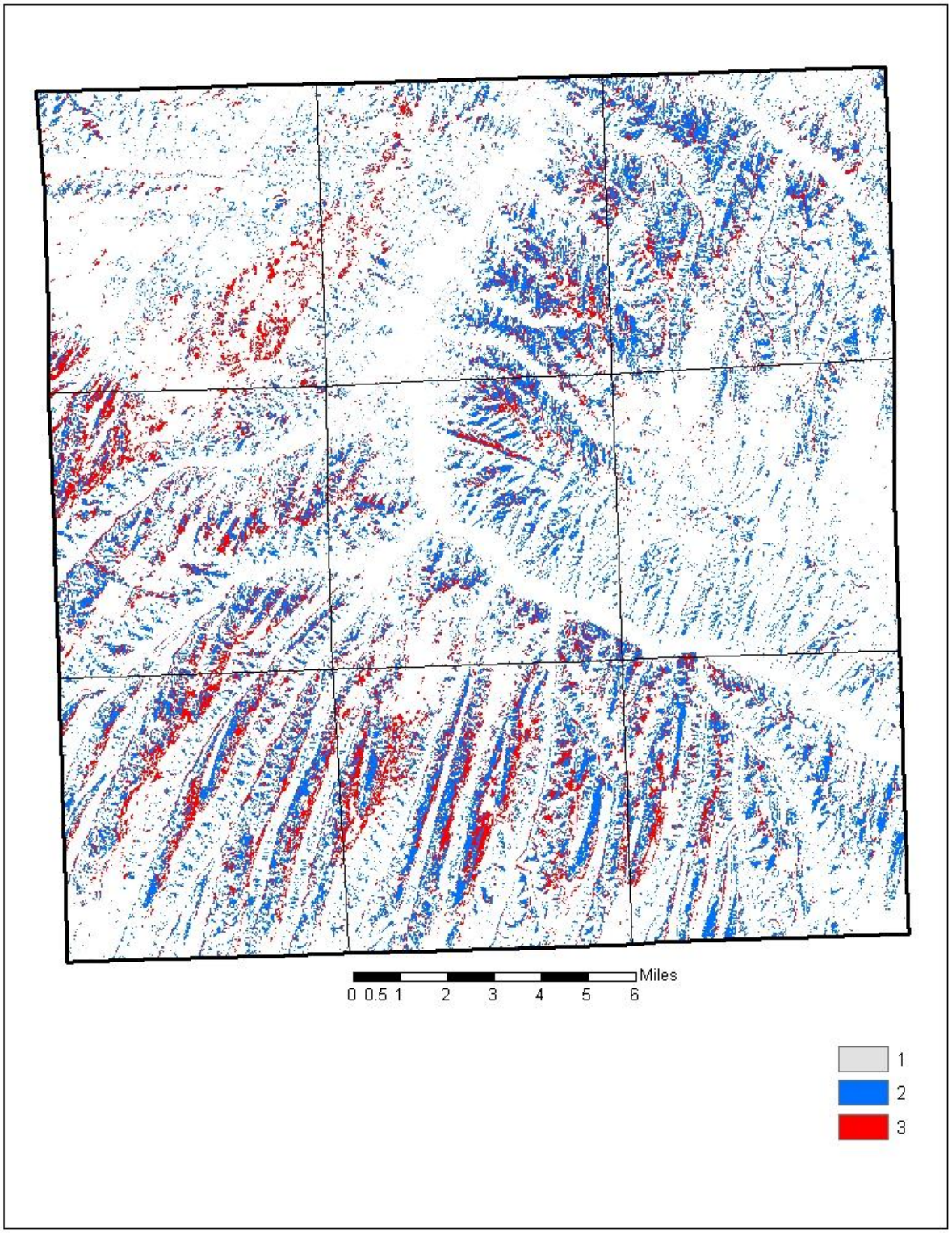


Figure 5. The figure above illustrates potential woodland raptor nesting habitat that was selected, using a weighted overlay analysis (with a score of 3 being the most suitable).

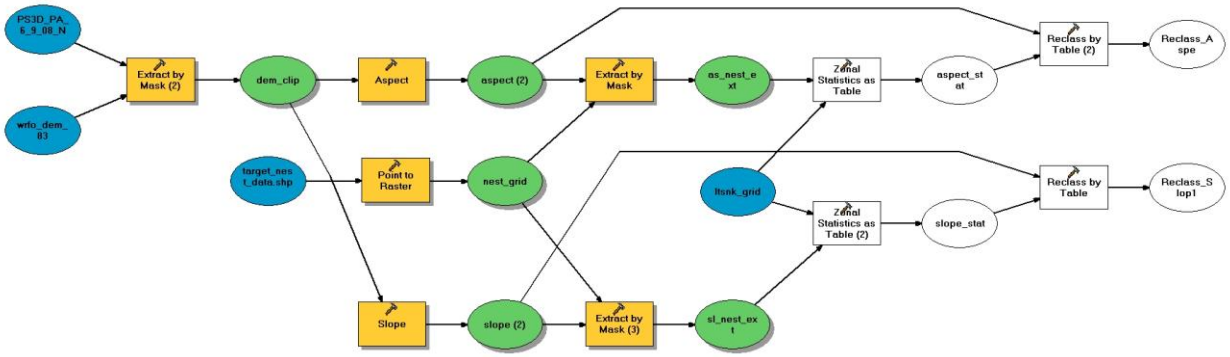


Figure 6. Based on zonal statistics, this adaptive model was used to identify potential nesting habitat using known nest locations. The model uses these nest locations to select elevation, slope, aspect, and vegetation type to define potential nesting habitat. As such, the point locations define the range of elevations, range of slope and aspect values, and the range of cover types that are selected. Thus, after each run of the model, the model adapts to nest locations that are added or subtracted from the nest database to include only those elevation, slope, aspect and cover type ranges that intersect a known nest point.

Figure 7. To help alleviate any discrepancies between the Nest ID number, UTM coordinates and the actual physical location of the nest, a photo was taken of the GPS screen where both the nest ID number and UTM coordinates were displayed.

Figure 8. The image above includes a representative photo of the nest tree and nest structure. These photos were taken while visiting the known nest area and nest structure to assess the breeding season status. Ideally, the photo should include as much of the nest tree as possible and the nest structure.

Figure 9. This photo is an example of a close-up photo taken of the nest while visiting the nest to confirm the breeding season status of nesting territory. This nest was confirmed in 2009 as being occupied by Cooper's hawk.

Figure 10. This photo is an example of a representative photo taken of the nest area while visiting the nest to assess the breeding season status of the nesting territory. It was common for the observer to take multiple photos of the nest stand to accurately document the dominant tree species present, tree age, ground cover and litter, tree density and canopy cover.

Figure 11. These figures show the typical “signs” of activity left behind by juvenile raptors or signs that would indicate an occupied territory. Nestlings start to defecate over the edge of the nest around 5 d of age (upper right photo). Down on the perimeter of the nest, and discarded egg shells under the nest or in the nest stand is a good indication that the nest is occupied (middle left and bottom middle photo). It was noted during the 2009 field season that mutes existed well into September and withstood a substantial amount of rainfall, thus allowing multiple observers the ability to assess the breeding status of the nest in the fall.

Figure 12. These photos illustrate the general appearance of an occupied nest. Nests that are occupied tend to have a less compressed appearance when compared to nests that are not occupied.

Figure 13. These photos illustrate the general appearance of an unoccupied nest. The effects of snow on the nest tends to flatten the nest out, resulting in a compressed or flattened appearance.

Deep cycle, 12 volt battery for power. A 5 amp solar trickle charger was used to help maintain a charge on the battery (not pictured).

Box containing Digital Video Recorder (DVR).

Laptop used to upload video footage and heavy duty carrying case used to transport laptop to and from the nest.

Close up view of contents in the DVR Utility Box. Contents include power inverter, power strip with surge protector, and Digital Video Recorder (DVR).

Figure 14. Photos of the video monitoring equipment used in 2009 to collect behavioral and food habits information at 7 occupied Cooper's hawk nests, Picance Basin, Colorado.

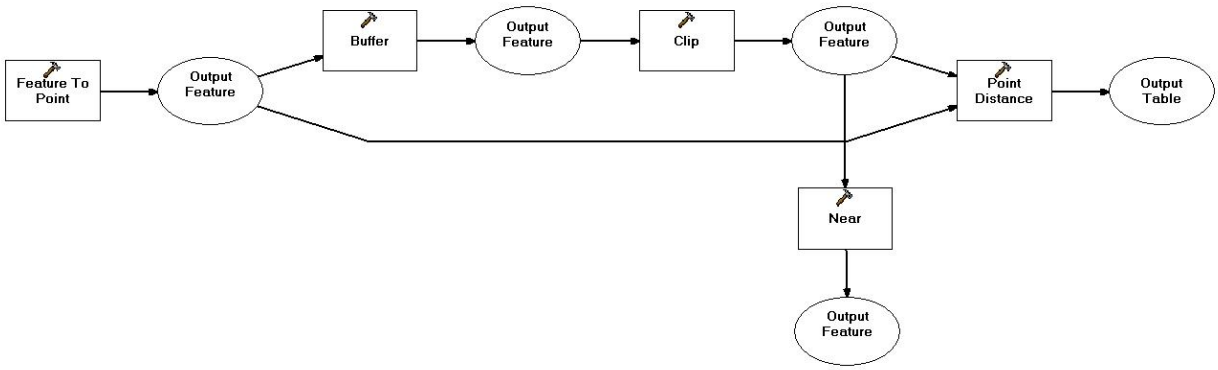


Figure 15. Graphic showing the flowchart for the model used to automate distance measurements from the nearest edge of disturbance of an associated pipeline or travel corridor and the known nest structure. .

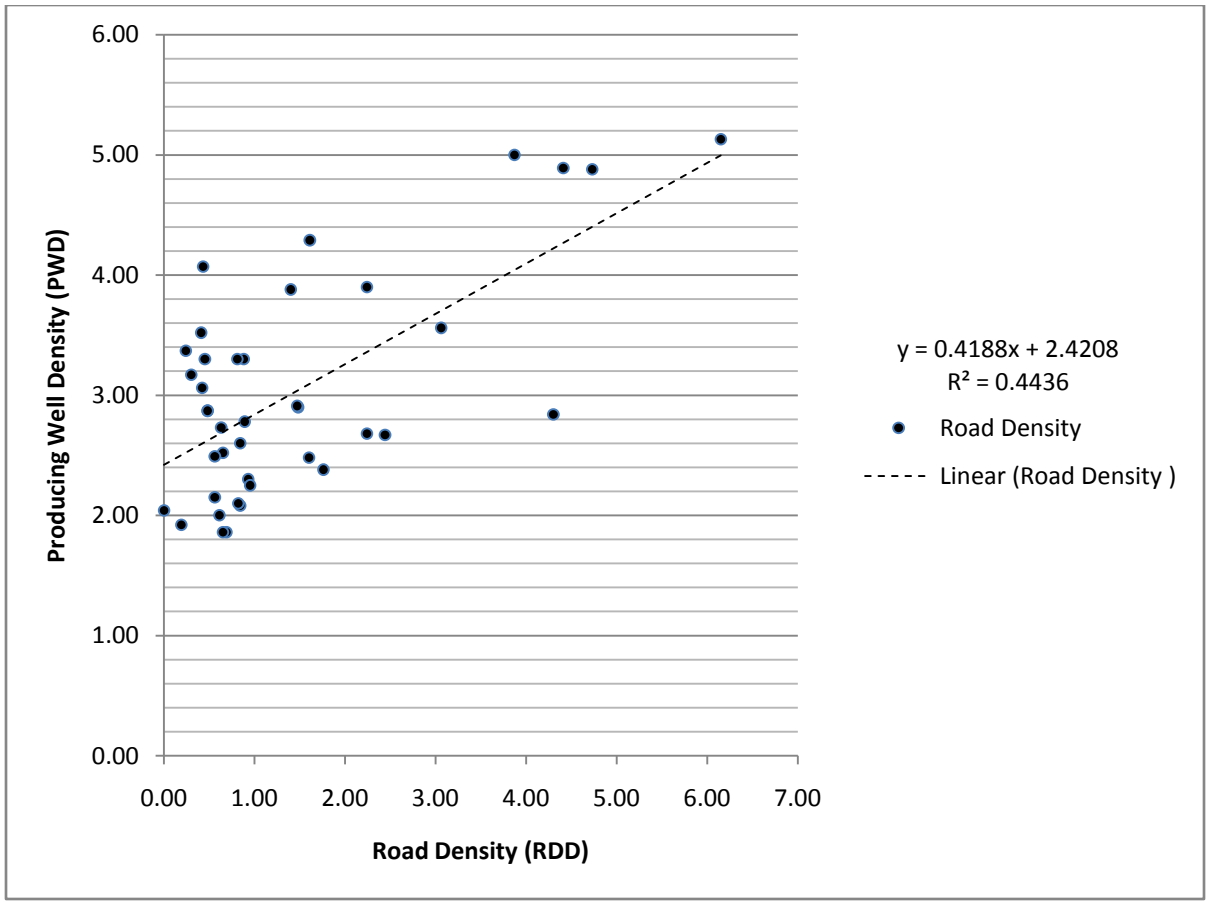


Figure 16. The figure above shows the correlation between road density (RDD) and producing well density (PWD). Using nonparametric statistics, it was found that these two variables were statistically correlated (n = 40, r_s = 0.35, t_{38} = 2.28, p = 0.029).

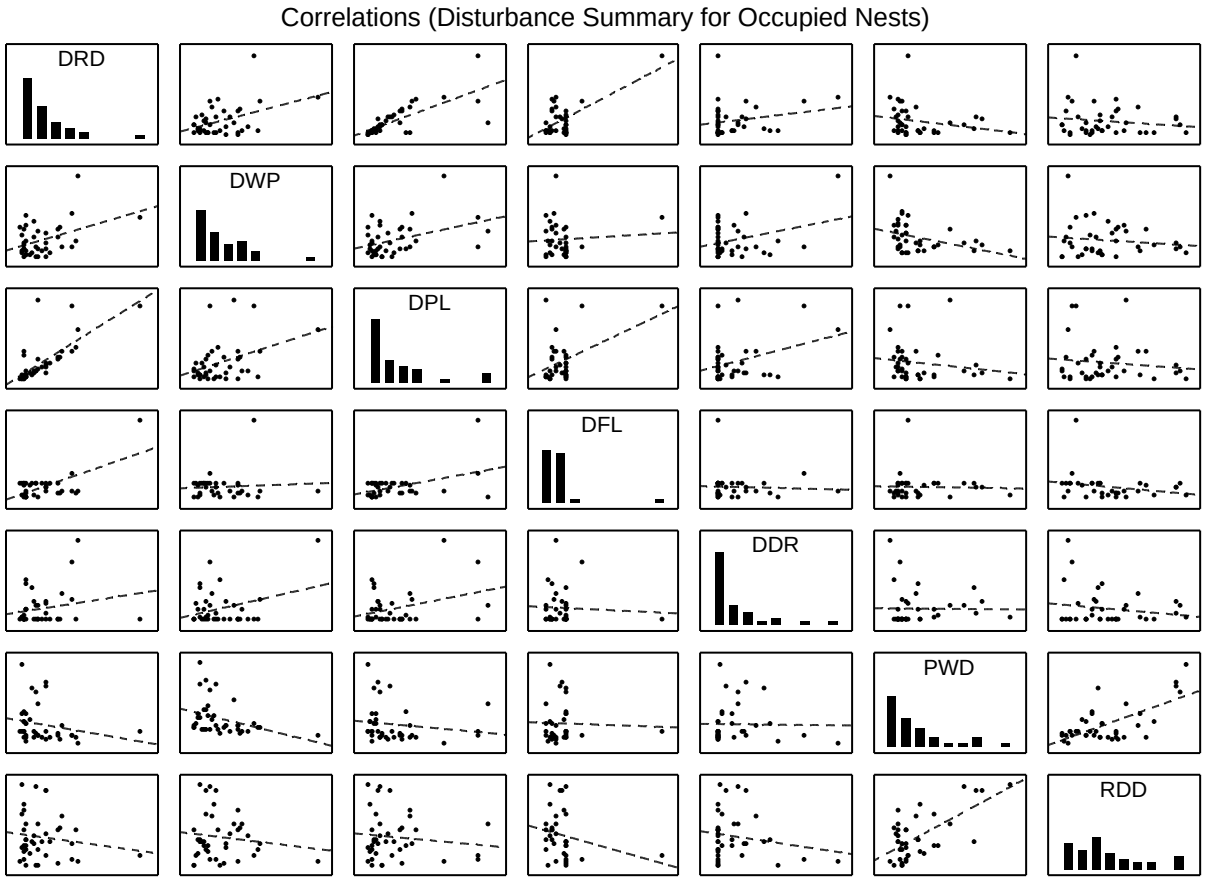


Figure 17. The above correlation matrix shows the relationship between the various distance variables and occupied nests. Spearman correlation coefficients (r_s) were significant for the following variables: DRD and DPL, PWD and DRD, PWD and DWP, PWD and DPL, RDD and DFL, and RDD and PWD at $p < 0.05$. The following codes apply: Distance to Pipeline (DPL), Distance to Road (DRD), Distance to Producing Well Pad (DWP), Distance to seismic flagging (DFL), Producing Well Density (PWD), Road density (RDD).

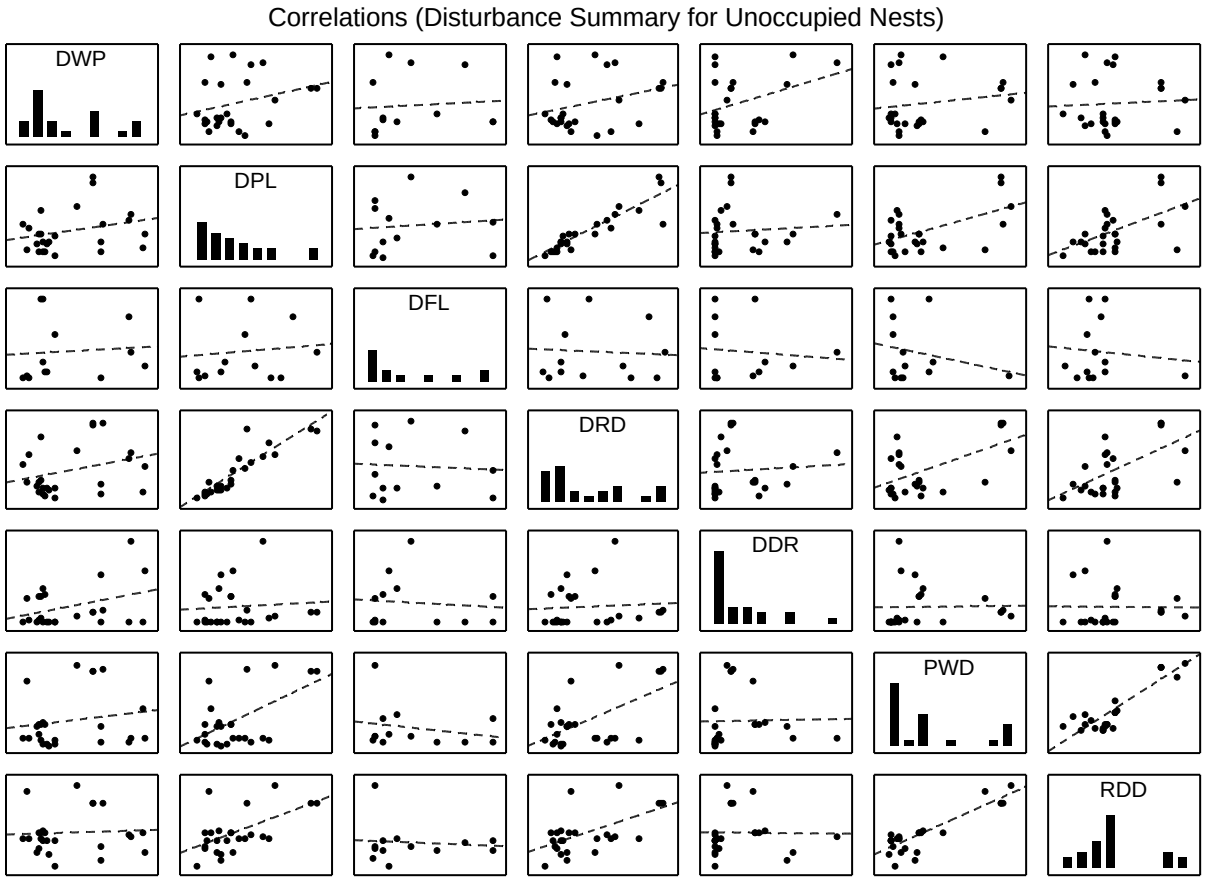
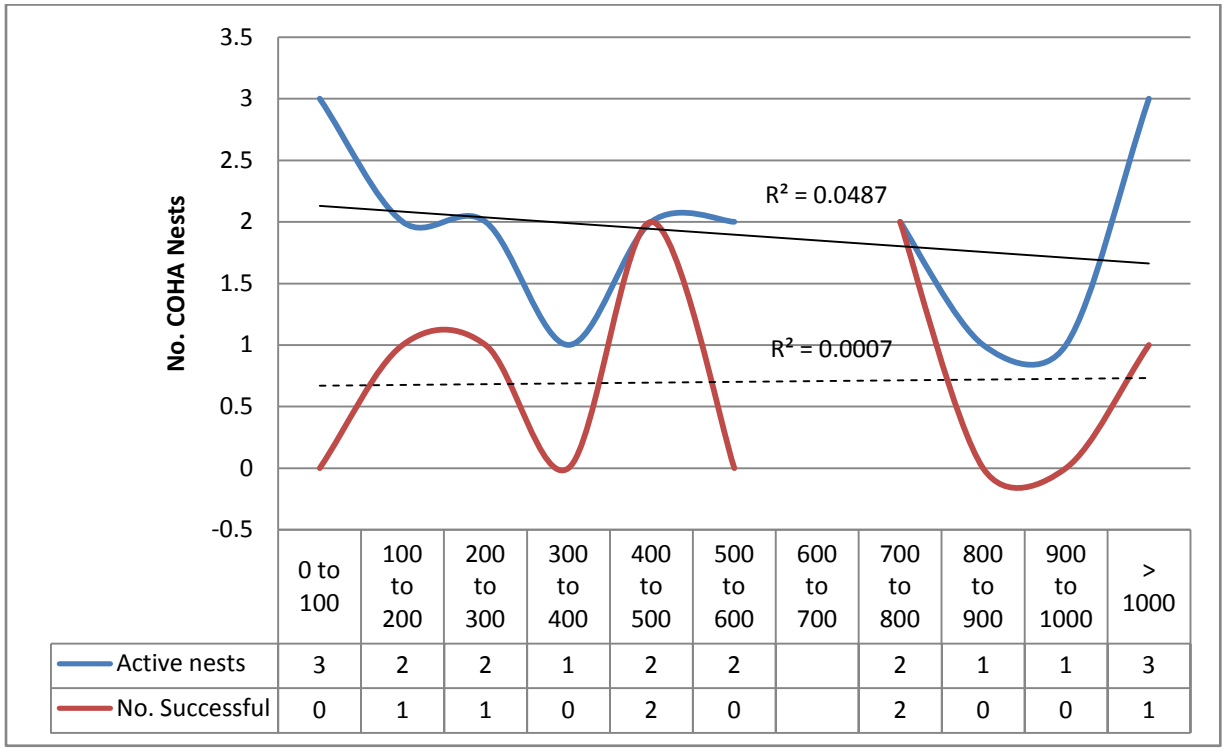
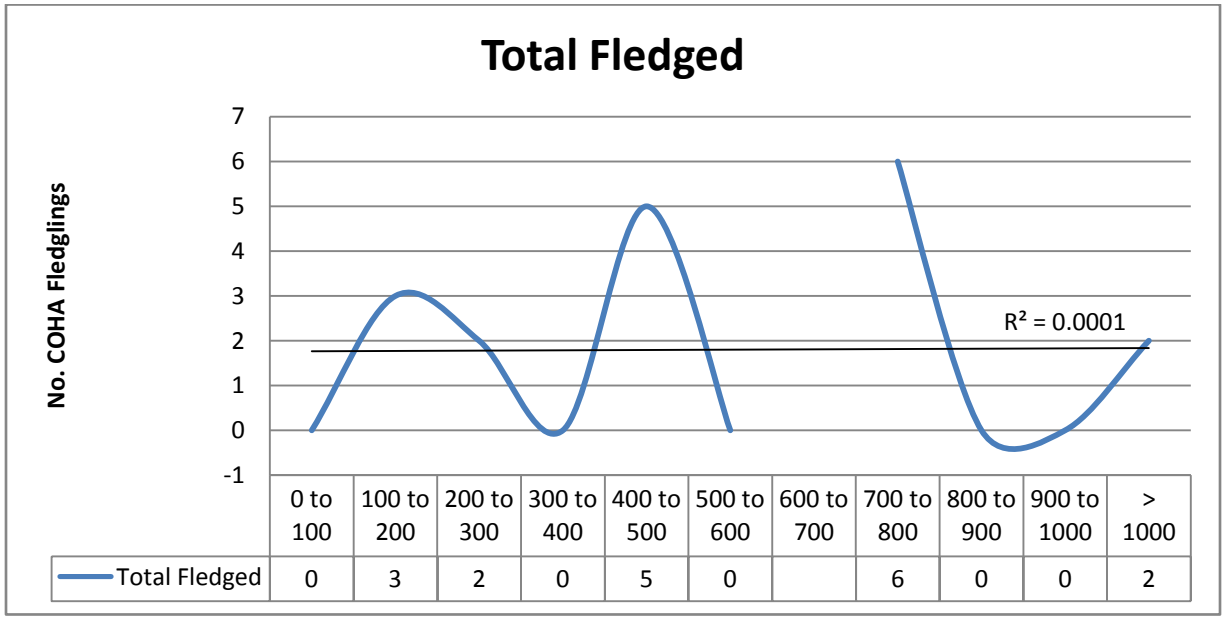


Figure 18. The above correlation matrix shows the relationship between the various distance variables and unoccupied nests. Spearman correlation coefficients (r_s) were significant for the following variables: DRD and DPL, PWD and DRD, PWD and DDR, RDD and DPL, RDD and DRD, RDD and PWD at $p < 0.05$. The following codes apply: Distance to Pipeline (DPL), Distance to Road (DRD), Distance to drill rig (DDR), Producing Well Density (PWD), Road density (RDD). The observed correlation between DPL and DRD was most likely due to autocorrelation between these two variables. Pipeline corridors often follow travel corridors. Thus, the nearest edge of the disturbed area should be similar when these features are used to estimate distance.

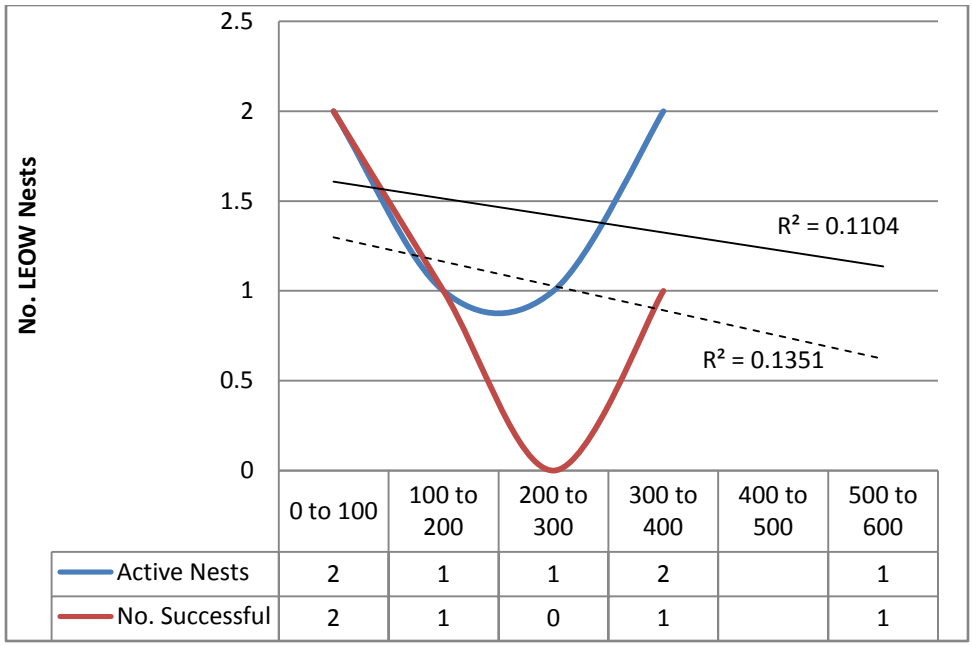


	0 to 100	100 to 200	200 to 300	300 to 400	400 to 500	500 to 600	600 to 700	700 to 800	800 to 900	900 to 1000	> 1000
Active nests	3	2	2	1	2	2		2	1	1	3
No. Successful	0	1	1	0	2	0		2	0	0	1



	0 to 100	100 to 200	200 to 300	300 to 400	400 to 500	500 to 600	600 to 700	700 to 800	800 to 900	900 to 1000	> 1000
Total Fledged	0	3	2	0	5	0		6	0	0	2

Figure 19. The upper figure shows the number of active vs. successful Cooper's hawk nests that were documented in the project area, and the lower figure shows the number of young that fledged from successful nests. The x axis is categorized by distance (reported in meters) from the associated active nest and the nearest producing well.



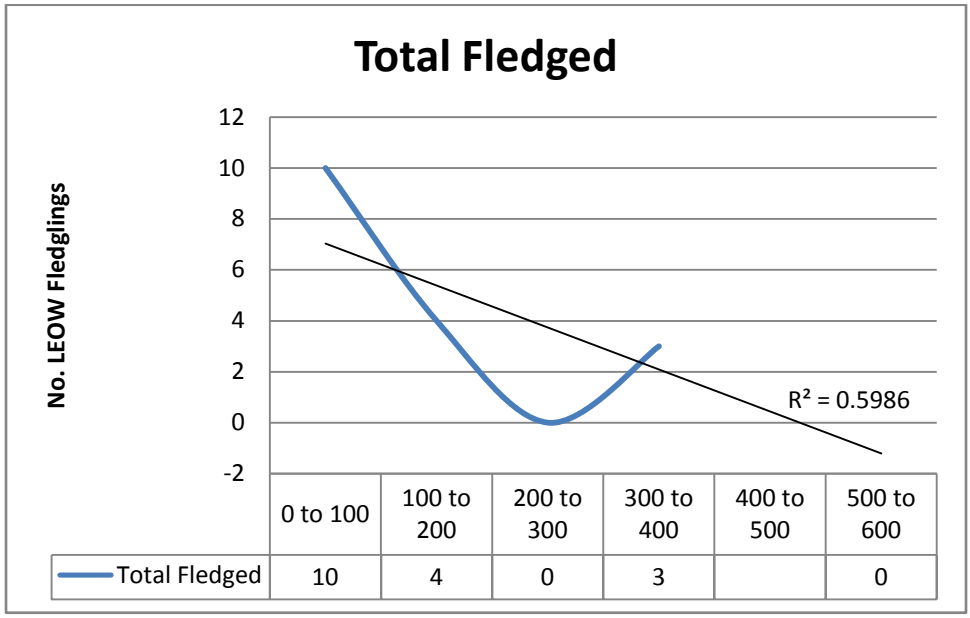
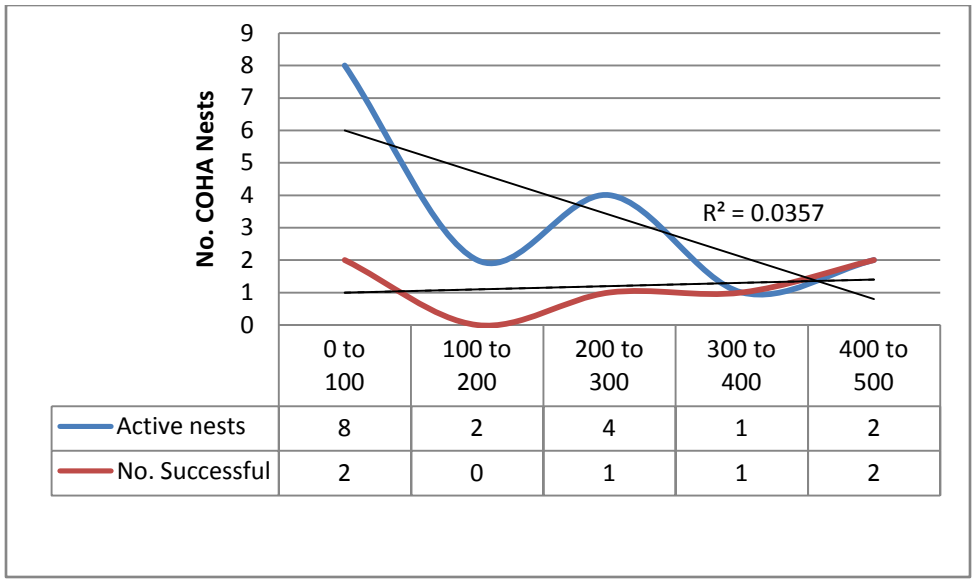


Figure 20. The upper figure shows the number of active vs. successful Long-eared owl nests that were documented in the project area, and the lower figure shows the number of young that fledged from successful nests. The x axis is categorized by distance (reported in meters) from the associated active nest and the nearest producing well.



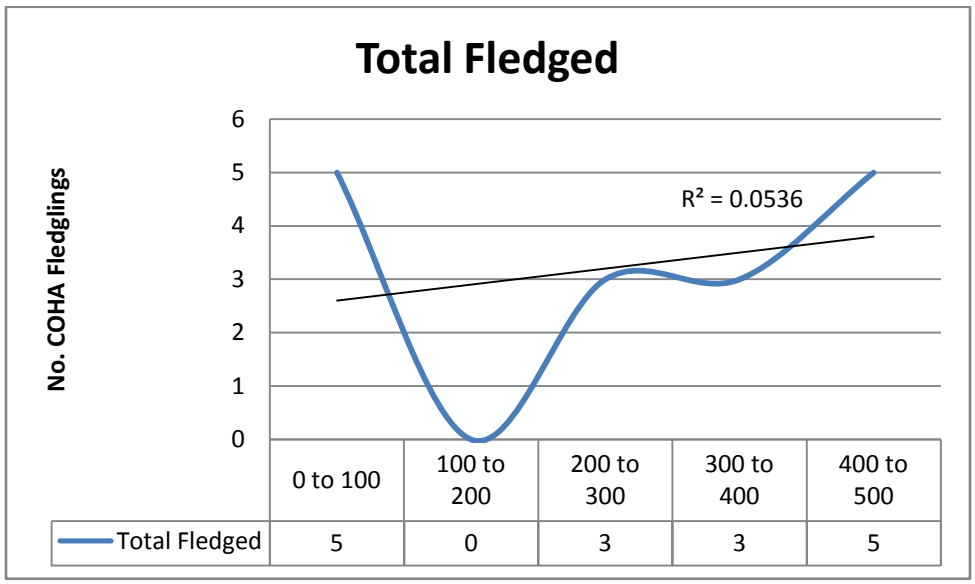
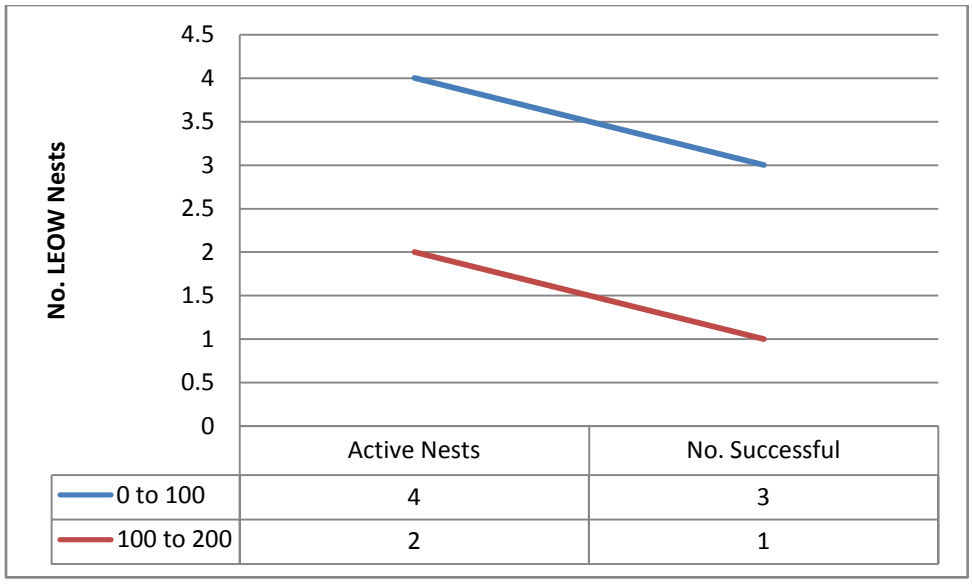


Figure 21. The upper figure shows the number of active vs. successful Cooper's hawk nests that were documented in the project area, and the lower figure shows the number of young that fledged from successful nests. The x axis is categorized by distance (reported in meters) from the associated active nest and the nearest travel corridor (i.e., road).



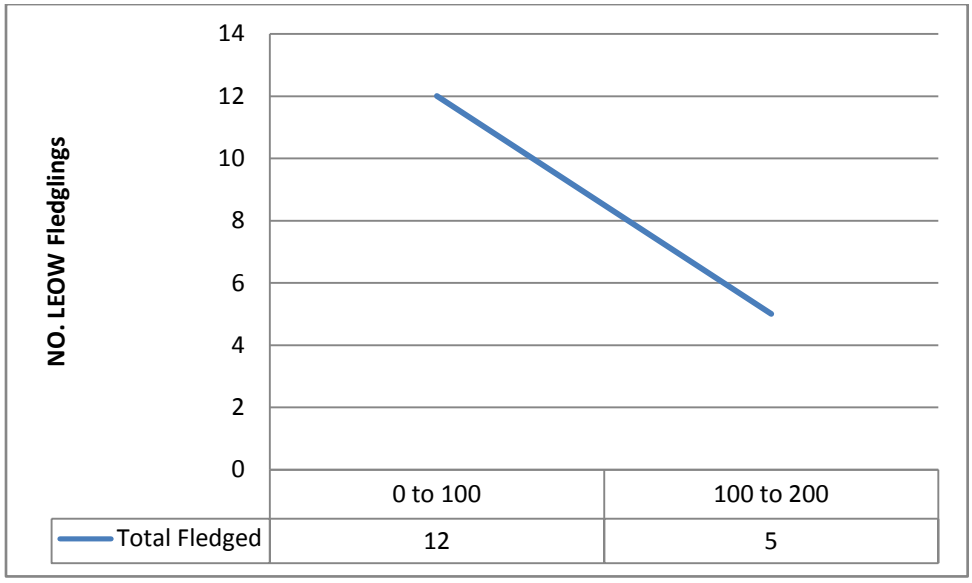


Figure 22. The upper figure shows the number of active vs. successful Long-eared owl nests that were documented in the project area, and the lower figure shows the number of young that fledged from successful nests. The *x* axis is categorized by distance (reported in meters) from the associated active nest and the nearest travel corridor (i.e., road).

APPENDIX 1: WRFO RAPTOR NEST HABITAT INVENTORY FORM

WRFO RAPTOR HABITAT INVENTORY FORM (03-27-08)

POLY_GROUP_ID	DATE	NEST_ID (if applicable)	FISCAL_ YEAR	OBSERVER	PAGE
					/

STATION	RAPTOR DE-TECTED (Y/N)	TYPE OF DETECTION (**V**isual, **C**all, **B**oth V/C, **M**oulted feather)	SPECIES	NEST FOUND (Y/N)	X_COORD FOR NEST (NAD83, ZONE 12)	Y_COORD FOR NEST (NAD83, ZONE 12)	ASSIGNED BLM NEST ID

NOTES

S:\Wildlife\Raptor_info_fldr\GIS_data\WRFO_raptor_database\2008_project_data\Tables\08_WRFO_raptor_habitat_inventory_form.xls

APPENDIX 1: continued.

QUALITY ESTIMATE (1=Excellent, 2=Good, 3=Poor, 4=Non-habitat)

POLY_GROUP_ID			25 m = 82 ft	DBH CLASS (No. of trees)				PAGE
STATION	**QUALITY**	**% COVER**	**No. TREES WITHIN 25 m**	0 to 8 in (20.3 cm)	8 to 16 in (40.6 cm)	> 16 in	**AVG. TREE HEIGH**	/

S:\Wildlife\Raptor_info_fldr\GIS_data\WRFO_raptor_database\2008_project_data\Tables\08_WRFO_raptor_habitat_inventory_form.xls

APPENDIX 2: PROCESS USED TO CONVERT NEST LOCATIONS REPORTED IN NAD83 TO NAD27 OR VICE VERSA

In those instances where a nest tree was not located near the provided UTM coordinate (GPS set to NAD83), two different coordinate conversions were made while in the field. First, the NAD83 coordinates were written down. Next, the GPS unit was switched to the NAD27 datum and the coordinates were written down, followed by entering the NAD83 coordinates into the GPS unit. Finally, the GPS unit was switched back to NAD83 and the NAD27 coordinates were entered into the GPS. These conversions created two new potential locations (215 meters North/South) in which the nest tree was searched for. The first conversion (NAD83 coordinates to NAD27 datum) and subsequent search of this new location was completed before searching the area associated with the point that resulted from the NAD27 to NAD83 conversion). For those nests that could not be found using UTM's that were provided, most of these nests were found using the NAD27 to NAD83 conversion process.

APPENDIX 3: NEST MONITORING AND RAPTOR DETECTION DATA FORM

Nest Monitoring Data Form (05/19/09) DRAFT

Nest ID No.

Type of Detection: (**VO**cal, **VI**sual, **BO**th):

Survey Date:

Adult on Nest:

Type of Call (Alarm, Food begging, Chup):

Distance first heard raptor:

Nestling observed (Y/N):

No. Nestlings:

Down on Perimeter of Nest (Y/N):

Nest Condition (Excellent, Good, Poor):

Whitewash Under Nest (Y/N):

Spp. last reported using nest:

Survey Year:

Photos of Nest (Y/N):

Predation Event (Y/N):

Flagging in nest stand (Y/N):

Distance from Well Pad (meters):

Distance from road or pipeline (meters):

Comments:

Call Playback Information

Broadcast call played (Y/N):

Type of Call (COHA Alarm, GHOW, NOGH Food Begging, NOGH Alarm):

Broadcast Call Played at a Distance of meters.

Raptor Detected (Y/N):

Total Number of Visits to Nest:

Date Detected (MM/DD/YR):

Type of Detection (Visual, Aurally, Both):

Overall Aggressiveness (See Page 2)

Raptor Detected on _____ visit to nest.

APPENDIX 3: continued**.**

Overall Aggressiveness: **1**: for a bird that does not respond aggressively. Bird maintains distance and may not vocalize. May only see bird once or sporadically during visit. **2**: Bird is not overly aggressive, but vocalizes because of your presence. Bird may only vocalize repeatedly at a distance. **3**: Bird is obviously upset, and makes repeated passes overhead, or perches nearby and vocalizes.

APPENDIX 4: WRFO NEST MONITORING FORM

WRFO WOODLAND RAPTOR NEST MONITORING FORM

NEST ID	SPECIES	CONDITION	OBSERVER	DATUM	ZONE	FISCAL YEAR

X_1	Y_1	X_2	Y_2	X_3	Y_3	X_4	Y_4

STATUS_1	STATUS_2	FLEDGE_NO	YEAR

This block is to be completed at the end of the season after the status of the nest has been confirmed.

DATE_1	NOTES

DATE_2	NOTES

DATE_3	NOTES

DATE_4	NOTES

DATE_5	NOTES

S:\Wildlife\Raptor_info_fldr\GIS_data\WRFO_raptor_database\2008_project_data\Tables\nest_monitoring_table

APPENDIX 4: continued**.**

DATE_6	NOTES
DATE_7	NOTES
DATE_8	NOTES
DATE_9	NOTES
DATE_10	NOTES
DATE_11	NOTES