WYOMING RANGE NORTHERN GOSHAWK (*ACCIPITER GENTILIS*) NEST SEARCH AND MONITORING – PRELIMINARY REPORT

STATE OF WYOMING

NONGAME: Species of Greatest Conservation Need – Northern Goshawk

FUNDING SOURCE: United States Fish and Wildlife Service Cooperative Agreement and Wyoming Game and Fish Department

PROJECT DURATION: 24 February 2012 – 31 December 2013

PERIOD COVERED: 24 February 2012 – 31 December 2012

PREPARED BY: Jenny Berven, Rocky Mountain Bird Observatory

ABSTRACT

The Wyoming Game and Fish Department (Department) contracted Rocky Mountain Bird Observatory (RMBO) to design and conduct surveys for nesting Northern Goshawks (*Accipiter gentilis*) during the 2012 and 2013 nestling and fledgling seasons in the Wyoming Range in southwestern Wyoming. Data are needed on this State Species of Greatest Conservation Need associated with mature and older aged conifer forests, as a number of landscape-scale habitat projects have been proposed for this area of the Bridger-Teton National Forest. This work, funded through the Federal State Wildlife Grants program, continues survey efforts initiated in 2009 by the Department to locate nest sites and collect habitat data to identify and map suitable nesting habitat in the range. The Department also funded occupancy surveys by RMBO in 2009 in the Wyoming Range and the adjacent Salt River Range as part of a US Forest Service region-wide Northern Goshawk survey effort. In addition to locating new active nests, RMBO was responsible for collecting nest site habitat data at all new nests found and for checking the status of seven historic nest sites. RMBO designed an unbiased survey based on Northern Goshawk Monitoring and Technician Guide protocols (Woodbridge and Hargis 2006). We split the approximately 73,000 ha study area into 160 Primary Sampling Units (PSUs) by laying 600.25 ha grids across the study area. PSUs along the study area boundary varied in size, as they were clipped to the study area boundary. We ranked PSUs using a spatially balanced design with generalized random tessellation stratification (GRTS) and then re-ranked the grids according to the amount of primary habitat within each PSU. Technicians conducted broadcast acoustical surveys at all accessible call stations within the PSU located in safe, suitable habitat. Technicians did not survey at locations with a slope greater than 36% or within 1.6 km of previously identified nest sites. We defined suitable habitat as any location within 150 m of any tree cover.

During the 2012 field season, technicians surveyed 2,196 call stations in 38 PSUs between 10 June and 21 August. Technicians surveyed a PSU in an average of 4.7 survey days. Technicians detected goshawks in six PSUs and found four new active nests. The naïve

detection rate for PSUs was 15.8% and 0.73 detections per 100 call stations. Of the seven historic nest sites, two nests were active. Technicians recorded nest tree elevation, slope aspect, and slope percent. Technicians also recorded canopy cover, number of seedlings, downfall, live and dead trees per hectare, average ground cover height, dominant ground cover species, and average diameter of all live and dead species of trees within a 0.217 ha radius plot. Overall, new nests were found in lodgepole pine (*Pinus contorta; n*=2), Douglas-fir (*Pseudotsuga menziesii*; *n*=1) and limber pine (*Pinus flexilis; n*=1) trees within mixed coniferous stands.

INTRODUCTION

The Wyoming Game and Fish Department (Department) solicited proposals for Northern Goshawk (*Accipiter gentilis*; goshawk) nest site survey and habitat work through Request for Proposal (RFP) No. 0185-V in December of 2011. As stated in the RFP, requirements included locating new, previously unidentified Northern Goshawk nests in the Wyoming Range, Wyoming using a broadcast acoustical survey method (Fig. 1). The RFP called for survey units to be selected using an unbiased approach, while striving to survey the greatest amount of potential habitat during the nestling and fledgling seasons (June-August) of 2012 and 2013.

The Northern Goshawk is the largest of three accipiter hawks found in North America (Squires and Reynolds 1997). Goshawks inhabit and nest in several classes of woodlands and forests including coniferous, deciduous, and mixed forests ranging from Alaska to Mexico. Forest and woodland species preference varies throughout the bird's range and depends on the local forest types. For example, goshawks primarily nest in ponderosa pine (*Pinus ponderosa*), mixed coniferous, and spruce-fir forests in the southwest, and pine forests interspersed with quaking aspen (*Populus tremuloides*) groves in the forests of Colorado, Wyoming, and South Dakota (Shuster 1980, Reynolds et al. 1992, Bright-Smith and Mannan 1994, Squires and Ruggiero 1996, Reynolds and Joy 1998, Greenwald et al. 2005, Reynolds et al. 2008). In the Great Basin, goshawks inhabit small patches of aspen within the shrub-steppe communities (Squires and Ruggiero 1996). Goshawks are known to use Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*) and aspen trees for nesting in the Caribou-Targhee National Forest within the Greater Yellowstone Ecosystem (Patla 2005). Studies show a general consistency in the goshawk's need for large, mature stands of trees with a high percent of canopy cover for nesting (Reynolds et al. 1992, Anderson et al. 2005).

The goshawk has been a species of conservation concern within the US Department of Agriculture's Forest Service (USFS) due to the potential of forest management practices to affect goshawk nesting habitat and populations (Woodbridge and Hargis 2006). Out of this concern, the goshawk has been designated a Management Indicator Species or a Sensitive Species on many national forests in the west. In 2006, the US Department of Agriculture published the "Northern Goshawk Inventory and Monitoring Technical Guide" to assist USFS biologists in the development and implementation of monitoring programs to determine population trends within large administrative and biological regions using occupancy estimates (Woodbridge and Hargis 2006. Occupancy surveys determine what fraction of a landscape is occupied by a species, whereas abundance surveys determine how many individuals of a species are found within the landscape. Although occupancy does not provide as much detail on a population as abundance and does not result in locating specific nest sites, it has been proposed as a surrogate for abundance because the two are positively correlated (MacKenzie and Nichols 2004). Occupancy is the preferred method to assess status and changes in goshawk populations on a regional basis from year to year without the need for extensive abundance surveys (MacKenzie and Nichols 2004, Woodbridge and Hargis 2006). However, on the Bridger-Teton National Forest (BTNF) and many other national forests, management prescriptions for this species are based on identification and protection of nesting territories and habitat.

RMBO and the Department conducted surveys in 2009 to determine baseline data on occupancy and nest sites in suitable habitat. RMBO conducted occupancy surveys based on the technical guide (Woodbridge and Hargis 2006) with a naïve occupancy of 0.412 (CI: 0.151-0.673) in the Salt River and Wyoming Ranges in the BTNF (Berven and Pavlacky 2010). The Department independently conducted nest site searches within the Wyoming Range. RMBO found no new nest sites during the occupancy surveys in 2009, but the Department located six active nest sites in the Wyoming Range, including three new territories (Patla and Derusseau 2010).

METHODS

RMBO used the same Primary Sampling Units (PSU) grid developed for the 2009 regional monitoring effort for 2012 survey work (Berven and Pavlacky 2010). Using ArcGIS (ESRI 2006), a study area-wide grid was created using 600.25 ha PSUs overlaid onto the Department's study area border layer based on in the "Northern Goshawk Inventory and Monitoring Technical Guide" (Woodbridge and Hargis 2006). If any part of the PSU fell within the study area boundary, that PSU was included in the sampling frame and the PSU boundary was clipped to the study boundary.

A spatially balanced study design was implemented to rank all PSUs within the Wyoming Range study area by using the generalized random-tessellation stratification (GRTS) function (Spsurvey package) in R (Stevens and Olsen 2004).

Habitat selection or stratification is a common method to increase the effectiveness of surveying over a study area. Goshawks are known to nest in Douglas-fir and lodgepole pine trees in the Wyoming Range and in nearby areas of eastern Idaho and western Wyoming (Patla 2005). RMBO used a post-hoc weighting system to prioritize between preferred habitat (Douglas-fir and lodgepole pine stands) and secondary habitat (aspen, spruce, limber pine) forest types. According to the LANDFIRE (2006*a*) data set, the eastern half of the Wyoming Range is strongly dominated by spruce-fir forests with only pockets of either Douglas-fir or lodgepole pine stands. After the PSUs were ranked by the GRTS function, PSUs were re-ranked using area of preferred habitat against its GRTS function rank. Therefore, PSUs with a greater area of Douglas-fir and lodgepole pine were weighted more and ranked higher than PSUs with little or no preferred habitat.

Using ArcGIS, we added a call station grid to the study area after we completed the ranking. For unclipped PSUs, 120 call stations on 10 transect lines (each containing 12 stations spaced 200 m apart) were overlaid on the PSU. Each transect line was placed 250 m apart, offset by 100 m and located at least 150 m from the PSU border. The call station grid was expanded so all irregularly-shaped border PSUs had equally and consistently spaced call stations within the PSU. Call stations in unsuitable locations (slope >36% or >150 m away from forest cover) were identified using ArcGIS. A 30 x 30 m LANDFIRE slope layer (2006*b*) was used to identify call stations located in areas that were too steep to survey. The LANDFIRE vegetation cover layer (2006*a*) was used to identify call stations >150 m from tree cover. Goshawks maintain consistent territory sizes; therefore, we excluded call stations located within historic nest site territories as defined by the RFP (Reynolds and Joy 1998, Reich et al. 2004, Woodbridge and Hargis 2006). Call stations within 1.6 km and 2.4 km of a historic nest were identified using the buffer tool in ArcGIS. When technicians found a new nest, all remaining call stations within the PSU or within 1.6 km of the new nest were removed from the survey effort. Technicians surveyed at call stations in preferred habitat between the 1.6 km and 2.4 km nest buffer. PSUs were further scrutinized to the call station level to eliminate PSUs from the survey effort that had no call stations with suitable habitat within the study area (e.g., WY-BT-NOGO6).

Using ArcGIS, field maps were created showing PSU and study area boundaries and call stations overlaid onto 1:24,000-scaled topographic maps (ESRI 2011). Maps were scaled to 1:20,000 to help navigate between call stations. All call stations were included on the maps but were labeled according to criteria explained previously.

Broadcast survey protocols were based on methods described in the monitoring technical guide (Woodbridge and Hargis 2006). Technicians were responsible for conducting broadcast acoustical surveys during the nestling and fledgling stages of the goshawk breeding season.

Technicians, in crews of at least two, visited PSUs based on rank-order determined by the GRTS function and habitat weighting throughout the nestling and fledgling seasons. Experienced technicians could survey call stations within the PSU alone but at least two technicians were surveying the same PSU at the same time. If the crew separated, technicians had to maintain a two-transect line distance (at least 500 m) to prevent false detections caused by the other technician's call. To maximize goshawk detectability for the region, input was requested from wildlife managers (Department and USFS biologists) monitoring goshawk nests throughout the region to identify when eggs were expected to hatch, typically the first week of June (Patla 2005). Technicians could conduct broadcast acoustical surveys between 30 min before sunrise to 30 min before sunset, coinciding with goshawk activity. Technicians broadcasted one of three goshawk calls depending on the season (nestling or fledgling). During the nestling season, we used an adult alarm call and during the fledgling survey, a juvenile food-begging call or a wail call. Technicians used FoxPro NX3 digital callers preloaded with the calls at a volume producing 80-110 dB output 1 m from the speaker.

At each call station, technicians played one call for 10 sec, then watched and listened for goshawk activity for 30 sec then repeated the procedure after rotating 120°. Once this procedure was done three times (one complete rotation), the technician waited, watched, and listened for 2 min, then repeated the cycle. Technicians recorded any significant findings and time spent at each call station on a standardized field form. After two full rounds of playing the call, the technician moved on to the next call station, while keeping alert for goshawks or goshawk sign.

Technicians surveyed all call stations within a PSU located in suitable habitat that could be safely reached or surveyed until goshawk detection was made. Technicians were not required to survey call stations located in suitable habitat inaccessible due to safety reasons. Initial goshawk detections consisted of visual sightings, aural observations, finding an active nest, and/or finding a freshly molted feather. When a bird was seen, sex, age (if known), and the Universal Transverse Mercator (UTM) coordinates of the detection location was recorded. Aural and feather detections were followed by an attempt to get a visual detection. Technicians would search for the goshawk(s) up to 150 m from the call station area or until the goshawk was no longer vocalizing.

Nest search protocols are based on intensive nest search methods described in the goshawk monitoring technical guide (Woodbridge and Hargis 2006). Once a visual detection was made, technicians conducted a systematic search for the goshawk nest by walking concentric circles up to 200 m around the point of detection. During the nest search, technicians carefully looked at trees and the surrounding area for goshawk sign (including nest structures, whitewash, freshly molted feathers, etc.). If no nest was found after the detection, the technician continued to survey the PSU until another detection was made and either a nest was found or all call stations were visited. Each time a new detection was made, the technician employed the same systematic search for a nest. PSUs that had a goshawk detection during the broadcast acoustical surveys but did not result in a found nest were re-surveyed at a later date. If no detection was made on a PSU, the unit was deemed unoccupied and was not visited again.

When technicians found a nest, they recorded nest location, observations of goshawk behavior and nest use, general habitat description, and nest tree description. The nest tree was marked with flagging if there was little or no risk of stressing the birds (i.e., the adult birds were not defensive or incubating). Once the survey season was over, technicians returned to new nests to collect nest-site habitat information and digital photographs of the nest tree and stand (Patla 1997).

Technicians collected nest plot data after the juvenile goshawks fledged and the adults no longer defended the area. Vegetation was measured within a 0.217 ha circular plot and consisted of number and size of overstory trees; percent canopy cover; number of seedlings, snags and downed trees; ground cover height and species; and bare ground. Tree age was determined with the use of an increment borer. Habitat and nest tree data were collected using methods described by Patla (1997). We used a concave spherical densiometer to measure canopy cover. Vegetation results were compared to nest site data collected in 2009 (Patla and Derusseau 2010).

RESULTS

There were 160 PSUs associated with the study area; 96 of which were completely within the study area. The 64 border PSUs totaled 16,738 ha. The average area within the study area of border PSUs was 261.5 ha (SD=184.3). Because of the large area and standard deviation, we decided to include all PSUs in the sampling frame and only eliminate call stations outside the study area after ranking the PSUs with the GRTS function and habitat weighting.

PSUs were selected and ranked from 1 to 160 (Fig. 2) using GRTS. The habitat weighting system effectively moved the survey effort priority to lower elevations with large stands of preferred habitat (Fig. 3). This process also helped decrease the potential of having a highly GRTS-ranked border PSU require surveying if the PSU had little or no suitable habitat.

Technicians conducted broadcast acoustical surveys from 10 June-21 August 2012. A total of 2,196 call stations were surveyed in 38 PSUs with a majority of stations visited during the nestling season (Table 1; *n*=1,395). Technicians used the adult goshawk alarm call until 25 July and then juvenile food begging or wail call for the duration of the season.

The two crews surveyed a total of 91 days. The survey window allows 110 possible workdays for two crews; 6 of those days were required office/coordination days where technicians submitted timesheets, copied data, and prepared themselves for the following pay period (purchased food, determined work, etc.). Four days within the survey window were spent conducting targeted nest searches or collecting habitat data. The remaining workdays were not spent surveying because of the following reasons: Fontenelle Fire (5 days), technician injury (2 days), and vehicle repair needs (2 days). Field crews completed PSUs, on average, in 4.7 survey days (range: 0.7-11.4 survey days). Survey days is the time each crew member spent surveying. Generally, 2 survey days equals 1 work day because each crew usually had 2 members.

Of 14,638 call stations within the study area, GIS eliminated 6,317 call stations before the field season began (Table 2). Historic nest buffers eliminated 1,427 call stations; however, technicians did survey call stations between the 1.6 km and 2.4 km historic nest buffer if no active nest had been located in the early season check of that site and the habitat was suitable. PSUs averaged 42 call stations in safe, suitable habitat after categorizing call stations with GIS.

Three factors decreased the number of call stations to survey during the field season.

1. Technicians determined the call station was in unsuitable habitat or was unsafe to access.
2. Technicians found a new nest.
3. Changing environmental factors prevented access.

In addition to call stations misidentified by GIS in steep locations or far from tree cover, technicians found call stations in recently or currently logged or burned locations (*n*=493). Additionally, there were 437 call stations deemed inaccessible, unsafe, or in unsuitable habitat by technicians in the field. At the beginning of the field season, we expected dynamic environmental factors to be access issues due to high water, snow, or hazardous wildlife. Technicians never reported issues related to those factors; instead, the large Fontenelle Fire, which started on 24 June 2012, eliminated a large survey area (see Appendix A). A total of 1,003 call stations previously expected to be surveyed were located within the burn perimeter.

Technicians conducted surveys at any location with suitable habitat that could be safely accessed and used the GIS designations of too steep or lack of tree cover only as a guide. Technicians surveyed 30 call stations designated as too steep by GIS and one call station designated as greater than 150 m from tree cover. Twenty-seven of the surveyed GIS-designated too steep call stations were at 36% slope as defined by GIS.

Considering call stations within new nest buffers and the area within the Fontenelle Fire burn perimeter, 8,250 call stations are currently not expected to be surveyed at any time during the project (Fig. 4). Eliminating the 2,196 call stations surveyed in 2012, 4,192 call stations in suitable habitat remain to be evaluated.

Goshawks were detected in 7 of the 38 surveyed PSUs throughout the field season (Table 3). One detection was determined to be invalid because it was only an aural detection and later determined to be Gray Jay calls. Of the six PSUs with true detections, technicians found four new active nests. Of the two detections that did not result in finding a nest, one detection was of a sub-adult that did not display any defensive behavior and the other was a fledgling detected late in the survey season (21 August 2012). The naïve detection rate for PSUs was 15.8% and 0.73 detections per 100 call stations. The first fledglings (n=3) were observed on 19 July and were approximately 40 days post-hatch (no down was seen) and two of the three fledglings were capable of extended flight.

Technicians found one nest during the nestling season and three nests during the fledgling season (Table 3). Technicians found two nests within 45 min of the initial detection, one of which was conducted during the nestling season and the other during the fledgling season. The nest at WY-BT-NOGO49 was found during the second nest search ten days after the initial detection. Technicians found the nest at WY-BT-NOGO88 during the third nest search over a month after the initial detection.

Of the four new nests found, three had confirmed young present (Table 3). During the initial detections, technicians reported three fledglings at PSUs WY-BT-NOGO33 and WY-BT-NOGO88 and one fledgling at WY-BT-NOGO49. Technicians were unable to count the number of young in the nest at WY-BT-NOGO5 at the time of discovery; however, they did see movement in the nest. When the technicians went back on the 24th of August to collect habitat data, no birds were seen in the area.

The Department provided coordinates for seven historical nest sites. Technicians visited all the historic nest sites one time each between 7 June and 18 June 2012. Two historic nests were active, , with aggressive or incubating adults. There was evidence of hatching at one but technicians were unable to count nestlings as the female was brooding. Technicians were unable to observe another nest because the adult female was very defensive. The Fontenelle Fire likely burned both of these active historic nest sites based on the burn perimeter and personal observation of the area surrounding the nest (Appendix A). Of the inactive historic nest sites, technicians found all but one nest tree. The technicians suspect the tree had fallen as there was significant blow-down in the area. Technicians played calls between 0 m and 500 m of the inactive nest sites and did not receive any response; no alternative nest sites were located in 2012.

Two of the four newly discovered nests were in lodgepole pine trees, one was in a Douglas-fir and one was in a limber pine (Table 4). All new nest trees were found at elevations between 2,510 and 2,595 m on gentle to moderate slopes and with northerly to northeasterly facing aspects. The plot area (0.217 ha circular plot) around each nest tree consisted primarily of lodgepole pine and Douglas-fir forests. Some plots also contained subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmanii*). The understory consisted of coniferous seedlings and low growing (≤12.7 cm) forbs at all sites. The WY-BT-NOGO49 and WY-BT-NOGO88 nest sites had denser understory (4,207 seedlings per ha and 4,622 seedlings per ha, respectively) than WY-BT-NOGO5 and WY-BT-NOGO33 (3,613 seedlings per ha and 2,041 seedlings per ha, respectively).

We combined new and historical nest data to provide descriptive statistics for the elevation, aspect and slope variables. All nests were found at elevations between 2,453 and 2,604 m with an average of 2,543 m (SE = 45.1). Slope averaged 13° (SE=1.7) and nest aspect was between 340 to 67° (NNW to ENE).

According to the LANDFIRE layer (2006*a*), only one of the historic nest sites was located in a Douglas-fir stand; all other nest sites were located in Engelmann spruce stands (Table 5). However, all the historic nest trees were all lodgepole pine, Douglas-fir trees, or subalpine fir (one nest only). Furthermore, according to the LANDFIRE layer, all of the new nest sites were located in Engelmann spruce stands, but habitat data show none of the nest trees were Engelmann spruce nor were most of the nests located in Engelmann spruce-dominated stands. Only one new nest site, WY-BT-NOGO33, had a spruce tree component. Because of these inconsistencies, we compared the NWGAP layer to new and historic nest data and found the NWGAP matched the nest tree species to the stand designation four times, whereas the LANDFIRE layer matched the species only one time.

DISCUSSION

The number of PSUs surveyed for the season was less than expected (55 PSUs) but still greater than the minimum estimate of 22 surveys. The average time it took to survey each PSU (4.7 survey days) was higher than predicted (4.0 survey days), which overestimated the completion of about five PSUs. The largest factor increasing the PSU survey time and decreasing the number of surveyed PSUs was the impact of the Fontenelle Fire, which prevented each crew from working for about 5 days (10 survey days). Technicians were able to work while the fire was actively burning, but had to leave the study area at times because of evacuations, smoke, and logistical planning needs. Not only did technicians spend more time hiking in and out of PSUs because of the fire, they also surveyed together more often for safety reasons.

While the technical guide establishes methods to determine occupancy using broadcast acoustical surveys, it also provides two methods for nest searches, one of which is conducting area nest searches. This method is used in deciduous forests early in the nesting season. This method was not considered for this project because the Wyoming Range is primarily covered in coniferous forests (LANDFIRE 2006*a*). The other method is conducting intensive search surveys. This method requires the identification of primary forest stands most likely to contain nesting goshawks. Once the forest stands are identified, teams of technicians walk along pre-determine transects broadcasting goshawk calls at 250 m intervals. Although research suggests goshawks in the Greater Yellowstone Area prefer Douglas-fir and lodgepole pine stands, there is no current definitive research on nest-habitat preference in the Wyoming Range. About 4% of the study area is classified as Douglas-fir and lodgepole pine (LANDFIRE 2006*a*). Furthermore, the cover type in the Wyoming Range study area is predominantly Engelmann spruce-subalpine fir (36.7%) and some of these stands are over a thousand hectares in size (LANDFIRE 2006*a*). If survey effort concentrated only in the Douglas-fir and lodgepole pine stands, a significant portion of potentially suitable habitat within the study area would be ignored. Furthermore, preliminary results indicated GIS would misidentify potential nest locations. There would also a be significant loss of cost effectiveness if technicians were to survey only the smaller, widely-spaced Douglas-fir and lodgepole pine stands randomly across the study area.

Road-based selection can be used to maximize cost effectiveness between high- and low-cost survey units. Because of the scale of the 600.25-ha PSUs, the size and location of the study area, and road coverage, almost all PSUs were within 1.6 km or less of a road. Therefore, cost-stratification or selection based on roads was not relevant. Furthermore, this design did not include road/trail stratification because research suggests that goshawks prefer nesting away from human disturbance (Bosakowski 1994, Morrison et al. 2011).

The nest search protocol was effective once a detection was made. Four of six detections resulted in a found nest in, on average, less than two site visits. We did not expect a nest in the PSU where technicians detected the sub-adult goshawk. Although sub-adult goshawks are capable of breeding, successful nest attempts are unlikely (Squires and Reynolds 1997). Combined with the bird's lack of defensive behavior, we believe there was no nest in that PSU. Adjusting for the sub-adult detection, four of five detections resulted in a found nest. Technicians did conduct a nest search after a fledgling was detected at WY-BT-NOGO35, but the nest search was conducted at the end of the day and technicians were unable to spend an appropriate amount of time conducting a thorough search. Technicians were unable to return to the PSU before the end of the field season. Technicians will resurvey that PSU in 2013.

Since nest searches were successful after a detection was made, increasing the total number of nests found could be achieved with an increased detection rate or by prioritizing survey effort within the suitable nesting habitat. Since detection probabilities and rates vary within populations season-to-season and most factors are beyond control (e.g., fire, weather, species productivity), we recommend concentrating on methods to prioritize survey effort (MacKenzie et al. 2002, Reich et al. 2004, Patla 2005).

Since finding new goshawk nests is the primary objective of this project and complex, statistical analyses are not, we have the ability to adjust our sampling design to improve our chances of finding additional sites while still maintaining unbiased methods. Changing some of the protocols may be a favorable approach especially since the Fontenelle Fire decreased the amount of suitable habitat to survey within the study area. We recommend using a different vegetation layer (NWGAP or BTNF vegetation layer) for habitat ranking and isolating sites by using aspect and elevation layers for the 2014 field season. We initially used the LANDFIRE layer because we thought it better differentiated between vegetation coverage/non-coverage and specific tree species. However, in the field, very few of the LANDFIRE attributes matched what was seen at the nest sites; the NWGAP vegetation layer appears to match actual habitat more accurately. We will also assess a BTNF vegetation layer as a potential tool to help to improve the habitat criteria. We believe we can improve detection rates by determining specific locations within the study area where we are more likely to find goshawks. Based on summary statistics from new and historic nests, there is evidence we are likely to find goshawk nests between about 2,454 and 2,636 m on NNW to ENE facing slopes with mild to moderate slopes (Table 6). Although we do not recommend changing the PSU ranking system or eliminating call stations in response to the topographical variables, we recommend prioritizing survey locations within the PSUs based on those variables. We do not recommend prioritizing call stations by GIS based on cover type because remote sensing layers may not be accurate (as seen with this year's habitat data collection). However, once technicians are in the field, they can plan their survey route to target lodgepole pine and Douglas-fir stands before other forest types.

Finally, we do not recommend changing slope elimination procedures. We believe the GIS-determined call station elimination was an effective tool for increasing the cost effectiveness and safety of the fieldwork without significantly decreasing the likelihood of a technician surveying at suitable locations. While in the field, technicians agreed with GIS designations more often than not and when inconsistencies arose, GIS was conservative with the elimination. For example, there was one call station eliminated by GIS because of tree cover that was actually within 150 m of tree cover. There were 213 call stations labeled by GIS as safe and within 150 m of suitable habitat that were actually more than 150 m from tree cover. In addition, only 1 of the 11 nests (historical and new) was located on a hill with a slope >36%.

ACKNOWLEDGEMENTS

S. Patla (Wyoming Game and Fish Department) was essential in the development and funding of this monitoring effort. She provided technical support for the sampling design and field logistics, as well as field assistance. Several people within Rocky Mountain Bird Observatory provided input, expertise, services and support; these individuals include: R. Sparks, who oversaw the GRTS ranking process and D. Pavlacky, who provided modeling and statistical knowledge. Field studies could not be completed without field technicians; we thank J. Benson, G. Henne, K. Nolan, M. Roes, and A. Rosenberg for completing their work with enthusiasm, eagerness, and attention to detail. Finally, this report benefitted greatly from peer reviews by S. Patla and C. White (RMBO).

LITERATURE CITED

Anderson, D. E., S. DeStefano, M. I. Goldstein, K. Titus, D. C. Crocker-Bedford, J. J. Keane, R. G. Anthony, and R. N. Rosenfield. 2005. Technical review of the status of northern goshawks in the Western United States. Journal of Raptor Research 39:192-209.

Berven, J. M., and D. C. Pavlacky. 2010. Northern Goshawk Monitoring in the Bridger-Teton National Forests: 2009 Field Season Report. Rocky Mountain Bird Observatory, Brighton, Colorado, USA.

Bosakowski, T., and R. Speiser. 1994. Macrohabitat selection by nesting Northern Goshawks: implications for managing eastern forests. Studies in Avian Biology 16:46-49.

Bright-Smith, D. J., and R. W. Mannan. 1994. Habitat use by breeding male Northern Goshawks in northern Arizona. Studies in Avian Biology 16:58-65.

ESRI. 2006. ArcGIS. Environmental Systems Research Institute, Inc., Redlands, California, USA.

ESRI. USA Topographic Map. 2011. National Geographic Society. http://services.arcgisonline.com/ArcGIS/rest/services/USA_Topo_Maps/MapServer (accessed January 2012).

Greenwald, D. N., D. C. Crocker-Bedford, L. Broberg, K. F. Suckling, and T. Tibbits. 2005. A review of Northern Goshawk habitat selection in the home range and implications for forest management in the western United States. Wildlife Society Bulletin 33:120-129.

LANDFIRE. LANDFIRE.US_110EVT_LF_1.1.0. 2006*a*. Existing vegetation cover layer. US Department of the Interior, Geological Survey. http://landfire.cr.usgs.gov/viewer/ (accessed January 2012).

LANDFIRE. LANDFIRE.US_SLP_LF_1.0.0. 2006*b*. Slope. US Department of the Interior, Geological Survey. http://landfire.cr.usgs.gov/viewer/ (accessed March 2012).

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248-2255.

MacKenzie, D. I., and J. D. Nichols. 2004. Occupancy as a surrogate for abundance estimation. Animal biodiversity and conservation 27:461-467.

Morrison, M. L., R. J. Young, J. S. Romsos, and R. Golightly. 2011. Restoring Forest Raptors: Influence of human disturbance and forest condition on Northern Goshawks. Restoration Ecology 19:273-279.

Patla, S. M. 1997. Nesting ecology and habitat of the Northern Goshawk in undisturbed and timber harvest areas on the Targhee National Forest, Greater Yellowstone Ecosystem. Thesis. Idaho State University, Pocatello, USA.

Patla, S. M. 2005. Monitoring results of Northern Goshawk nesting areas in the Greater Yellowstone Ecosystem: is decline in occupancy related to habitat change? Journal of Raptor Research 39:324-334.

Patla, S. M., and S. Derusseau. 2010. Wyoming Range raptor inventory and monitoring study completion report. Pages 104-121 in Threatened, Endangered, and Nongame Bird and Mammal Investigations (A. C. Orabona, Editor). Wyoming Game and Fish Department, Nongame Program, Lander, USA.

Reich, R. M., S. M. Joy, and R. T. Reynolds. 2004. Predicting the location of Northern Goshawk nests: modeling the spatial dependency between nest locations and forest structure. Ecological Modelling 176:109-133.

Reynolds, R. T., R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce Jr., G. Goodwin, R. Smith, and E. L. Fisher. 1992. Management recommendations for the Northern Goshawk in the southwestern United States. US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Reynolds, R. T., and S. M. Joy. 1998. Distribution, territory occupancy, dispersal, and demography of Northern Goshawks on the Kaibab Plateau, Arizona. Final report for Arizona Game and Fish Heritage Project Number 194045. http://www.rmrs.nau.edu/wildlife/research/northern_goshawks.shtml.

Reynolds, R. T., R. T. Graham, and D. A. Boyce. 2008. Northern Goshawk habitat: an intersection of science, management, and conservation. Journal of Wildlife Management 72:1047-1055.

Shuster, W. C. 1980. Northern Goshawk nest site requirements in the Colorado Rockies. Western Birds 11:89-96.

Squires, J. R., and L. F. Ruggiero. 1996. Nest-site preference of Northern Goshawks in southcentral Wyoming. Journal of Wildlife Management 60:170-177.

Squires, J. R., and R. T. Reynolds. 1997. Northern Goshawk (*Accipiter gentilis*). *In* The Birds of North America (A. F. Gill, Editor). The Academy of Natural Sciences, Philadelphia, Pennsylvania, USA and the American Ornithologists' Union, Washington, D.C., USA.

Stevens, D. L., Jr., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

Woodbridge, B., and C. D. Hargis. 2006. Northern Goshawk inventory and monitoring technical guide. United States Department of Agriculture, Forest Service, Washington, D.C., USA.

Table 1. Surveyed Primary Survey Units (PSU) and call stations during the June-August 2012 Northern Goshawk (*Accipiter gentilis*) nest search and monitoring field season. Technicians or GIS eliminated call stations that were located in unsuitable, unsafe areas or inaccessible due to surrounding terrain. PSUs can have a maximum of 120 call stations, but less are possible if the PSUs were located on the study area boundary and clipped by GIS.

PSU ID	Survey date	Points surveyed	Points eliminated	Total points
WY-BT-NOGO1	6/15,6/18,6/19	41	5	46
WY-BT-NOGO2	6/11-6/15	101	0	101
WY-BT-NOGO3	6/19,6/20	10	62	72
WY-BT-NOGO4	7/5, 7/8	55	65	120
WY-BT-NOGO5	6/27, 6/30, 7/1-7/3	87	33	120
WY-BT-NOGO7	8/4, 8/5, 8/7	87	33	120
WY-BT-NOGO8	6/21, 6/22, 6/25, 6/26	119	1	120
WY-BT-NOGO9	7/5-7/7, 7/9	100	20	120
WY-BT-NOGO11	8/8, 8/14, 8/15	44	76	120
WY-BT-NOGO13	6/20	19	53	72
WY-BT-NOGO14	6/11	13	107	120
WY-BT-NOGO15	6/26, 8/20, 8/21	32	88	120
WY-BT-NOGO16	6/29, 7/10, 7/11, 7/12	70	50	120
WY-BT-NOGO17	7/9-7/11	52	10	62
WY-BT-NOGO20	7/2-7/4	89	31	120
WY-BT-NOGO21	7/17-7/19, 7/21, 7/22	75	45	120
WY-BT-NOGO23	8/16, 8/17	34	86	120
WY-BT-NOGO29	7/26, 7/27	68	4	72
WY-BT-NOGO30	6/12, 6/14, 6/17, 6/20	96	24	120
WY-BT-NOGO31	6/25, 6/26, 8/18	76	44	120
WY-BT-NOGO32	8/2, 8/3	99	21	120
WY-BT-NOGO33	8/4, 8/6	74	46	120
WY-BT-NOGO35	8/21	15	0	24
WY-BT-NOGO36	7/8, 7/9	79	41	120
WY-BT-NOGO37	7/23, 7/25	23	97	120
WY-BT-NOGO42	8/8	10	15	25
WY-BT-NOGO45	7/27, 7/29-7/31	119	1	120
WY-BT-NOGO49	8/7, 8/8, 8/14	106	14	120
WY-BT-NOGO51	8/9	26	94	120
WY-BT-NOGO52	7/15	6	6	12
WY-BT-NOGO54	6/21	19	101	120
WY-BT-NOGO56	7/2, 7/3	38	82	120
WY-BT-NOGO58	6/19, 6/20, 6/21, 6/24	75	45	120
WY-BT-NOGO68	7/1, 7/9, 7/12	49	71	120
WY-BT-NOGO73	8/15, 8/17	54	66	120
WY-BT-NOGO83	7/17	21	30	51
WY-BT-NOGO88	7/15, 7/16, 7/18, 7/19	104	16	120
WY-BT-NOGO108	7/11	11	109	120
Total		2196	1692	3897

Table 2. Call stations identified as "not to survey" by GIS and reason(s) for Northern Goshawk (*Accipiter gentilis*) nest search and monitoring in the Wyoming Range, Wyoming for the 2012 field season. GIS identified call stations within 2.4 km of a known Northern Goshawk nest, located on a slope >36°, or >150 m from tree cover.

Reason	Number of call stations
Historic Nest	1,174
Historic Nest and Slope	240
Historic Nest, Slope and Tree Cover	1
Historic Nest and Tree Cover	12
Slope	4,453
Slope and Tree Cover	161
Tree Cover	276
Total number of calls stations identified by GIS	6,317

Table 3. Summary of Northern Goshawk (*Accipiter gentilis*) detections and nests found during 2012 field season. Locations are considered sensitive and have not been included in this report. [a] Two defensive adults; movement seen in nest but unable to count nestlings. [b] False detection (mimicking jays). [c] Non-defensive sub-adult. UTMs in Zone 12 NAD 83. Wyoming Range, Wyoming.

PSU ID	Initial detection	Detection type	Nest found	No. young
WY-BT-NOGO5	7/3/2012	Active Nest, Visual	7/3/2012	unk[a]
WY-BT-NOGO33	8/6/2012	Aural, Visual	8/6/2012	3
WY-BT-NOGO49	8/7/2012	Active Nest, Aural, Visual	8/17/2012	1
WY-BT-NOGO88	7/16/2012	Aural, Visual	8/23/2012	3
WY-BT-NOGO2	6/11/2012	Aural[b]		
WY-BT-NOGO36	7/9/2012	Aural, Visual[c]		
WY-BT-NOGO35	8/21/2012	Aural, Visual		1

Table 4. Northern Goshawk (*Accipiter gentilis*) nest tree habitat data collected after the 2012 field season in the Wyoming Range, Wyoming. Elevation, slope aspect, and slope were determined using GIS. All GIS elevation figures are within 50 ft of GPS readings. All GIS slope aspect figures are within 10° of compass readings by technicians. All GIS slope figures are within 5° of clinometer reading by technicians. Note: table is presented in English rather than metric units because these type of data are typically used by the US Forest Service in English units.

PSU ID	Nest tree species	Nest tree alive?	Age (years)	DBH (in)	Tree height (ft)	Nest height (ft)	Live canopy height (ft)	Elevation (ft)	Slope aspect	Slope
WY-BT-NOGO5	Douglas-fir	Yes		24.2	69	44	42	8,343	353°	13° (23%)
WY-BT-NOGO33	Limber pine	Yes	31	24.7	77	46	48	8,287	356°	16° (29%)
WY-BT-NOGO49	Lodgepole pine	No	65	12.7	75	57	n/a	8,514	50°	16° (29%)
WY-BT-NOGO88	Lodgepole pine	Yes	13	14.9	68	35	35	8,235	39°	8° (14%)

Table 5. Comparison of Northern Goshawk (*Accipiter gentilis*) nest tree and plot (0.217 ha) field data to GIS layers. Wyoming Range, Wyoming. Douglas-fir (DF), Engelmann spruce (ES), lodgepole pine (LLP), limber pine (LMP), subalpine fir (SAF).

Nest site	Plot habitat	Nest tree species	LANDFIRE	NWGAP
MDG		LPP	ES	ES, SAF
MDP		DF	ES	LPP
MB		DF	ES	LPP
NPC		LPP	ES	LPP
SFC		LPP	ES	LPP
SPC		DF	DF	LPP
TP		LPP	ES	ES, SAF
WY-BT-NOGO5	DF (64%), LPP (33%), SAF (3%)	DF	ES	ES, SAF
WY-BT-NOGO33	ES (37%), SAF (34%), DF (21%), LMP (5%), LPP (3%)	LMP	ES	LPP
WY-BT-NOGO49	LPP (51%), DF (49%)	LPP	ES	LPP
WY-BT-NOGO88	DF (59%), LPP (35%), SAF (6%)	LPP	ES	LPP

Table 1. Wyoming Range, Wyoming new and historical Northern Goshawk (*Accipiter gentilis*) nest (*n*=11) topographical summaries. All data were determined using ArcGIS. Nests have been active at least 1 year between 2009 and 2012.

Variable	Average	SE	SD	Minimum/maximum	Range
Elevation (m)	2,543	13.7	45.6	2,453/2,604	151
Aspect (°)	18	7.8	25.8	340/67	87
Slope (%)	23	3.2	10.5	5/45	40

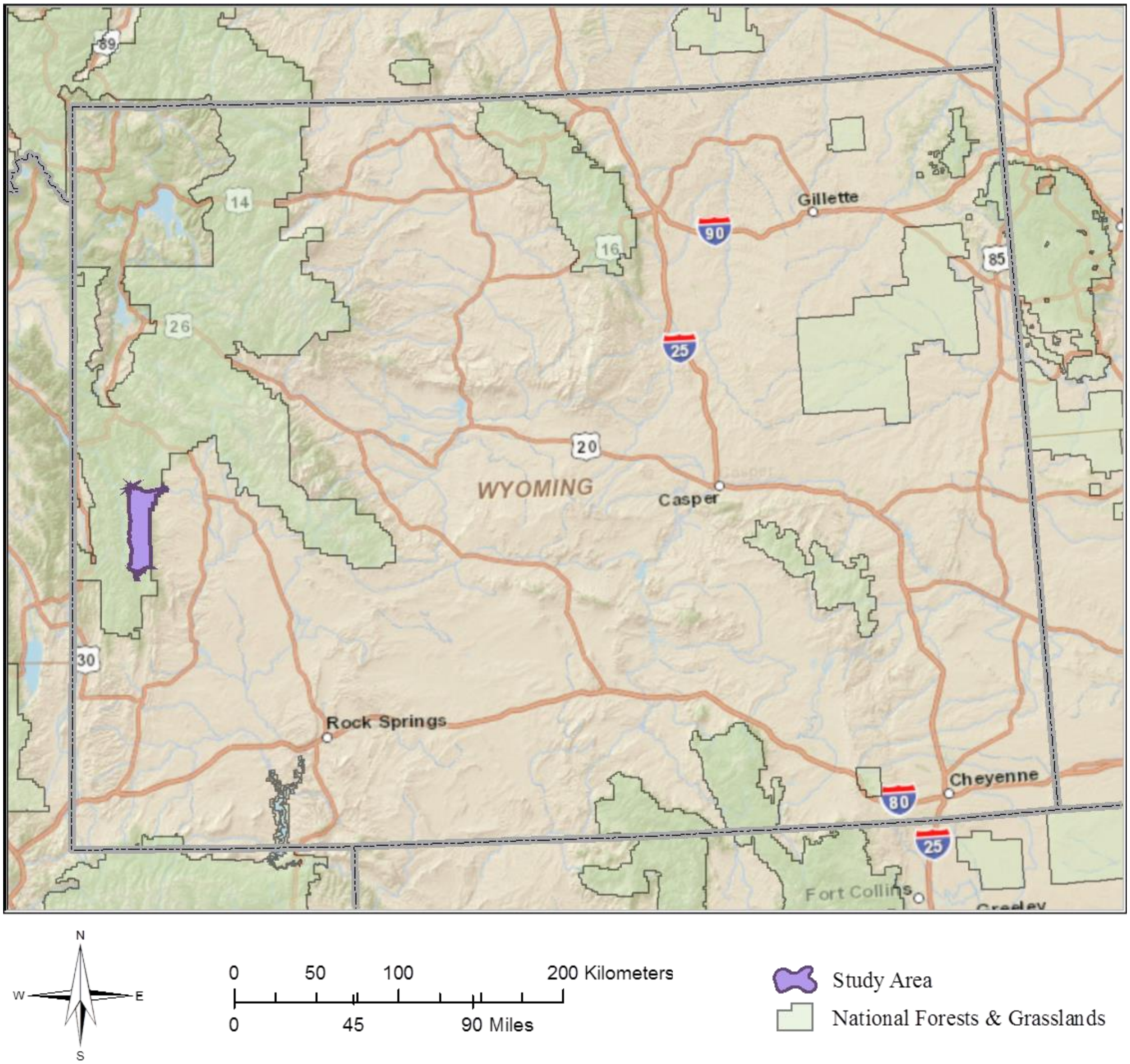

Figure 1. The Wyoming Range, Wyoming Northern Goshawk (*Accipiter gentilis*) nest search and monitoring study area, 2012-2013. Scale is 1:3,500,000.

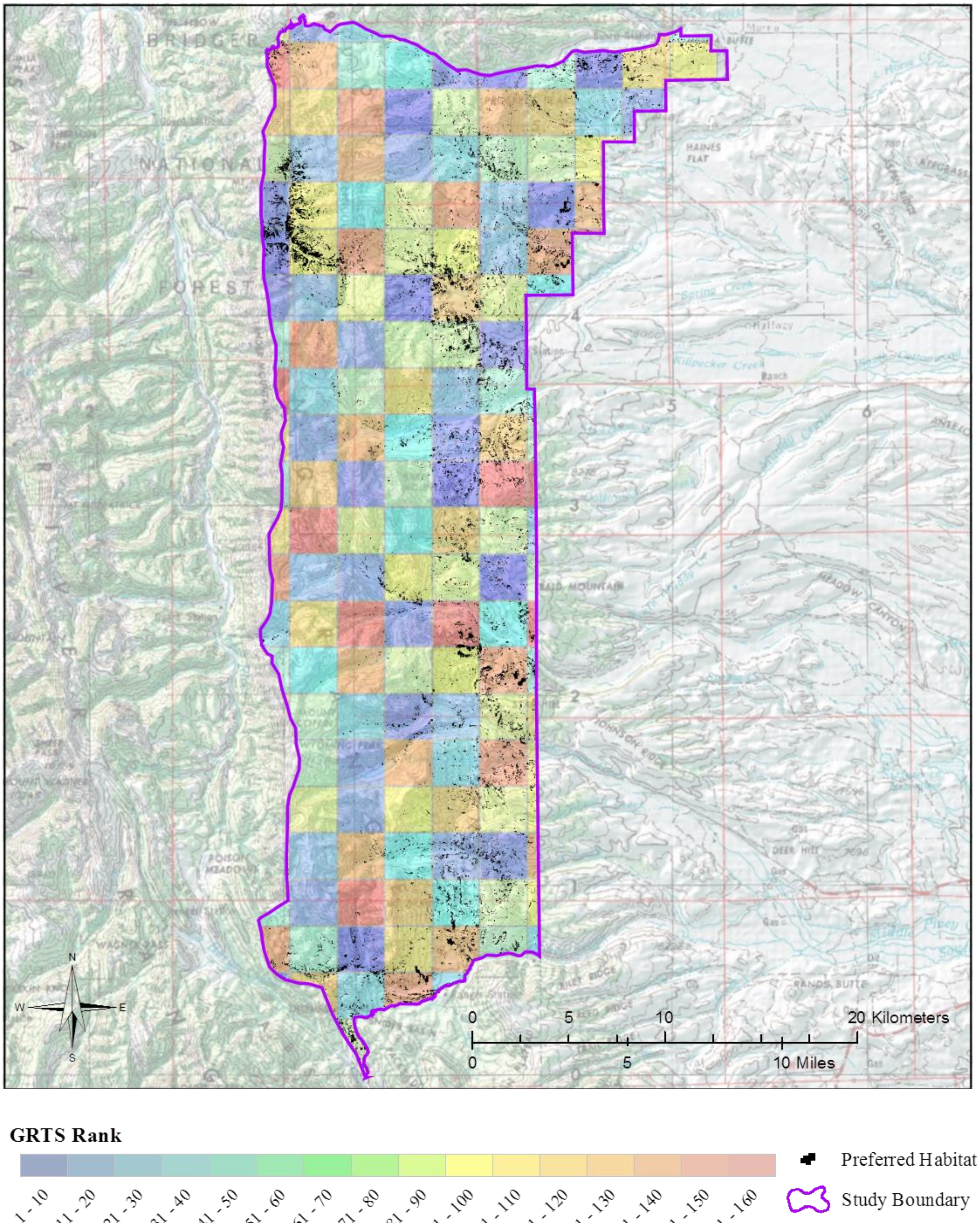

Figure 2. Primary Sampling Unit (PSU) ranking for Northern Goshawk (*Accipiter gentilis*) nest search and monitoring determined by GRTS function in R. Wyoming Range, Wyoming, 2012. Scale is 1:265,000.

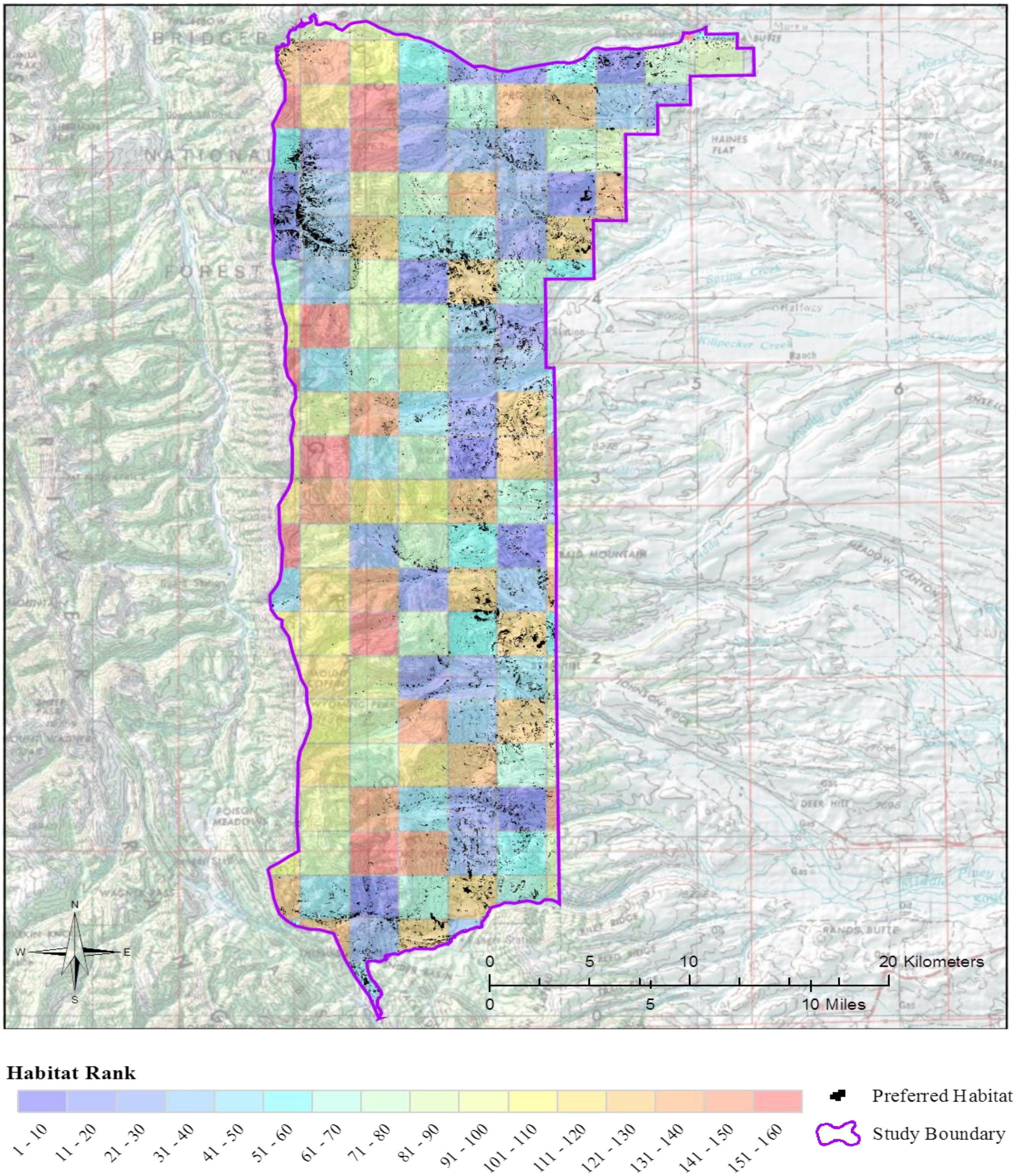

Figure 3. Primary Sampling Unit (PSU) ranking for Northern Goshawk (*Accipiter gentilis*) nest search and monitoring determined by generalized random-tessellation stratification (GRTS) and habitat weighting. Preferred habitat for Northern Goshawks includes Douglas-fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*) stands. Wyoming Range, Wyoming, 2012. Scale is 1:265,000.

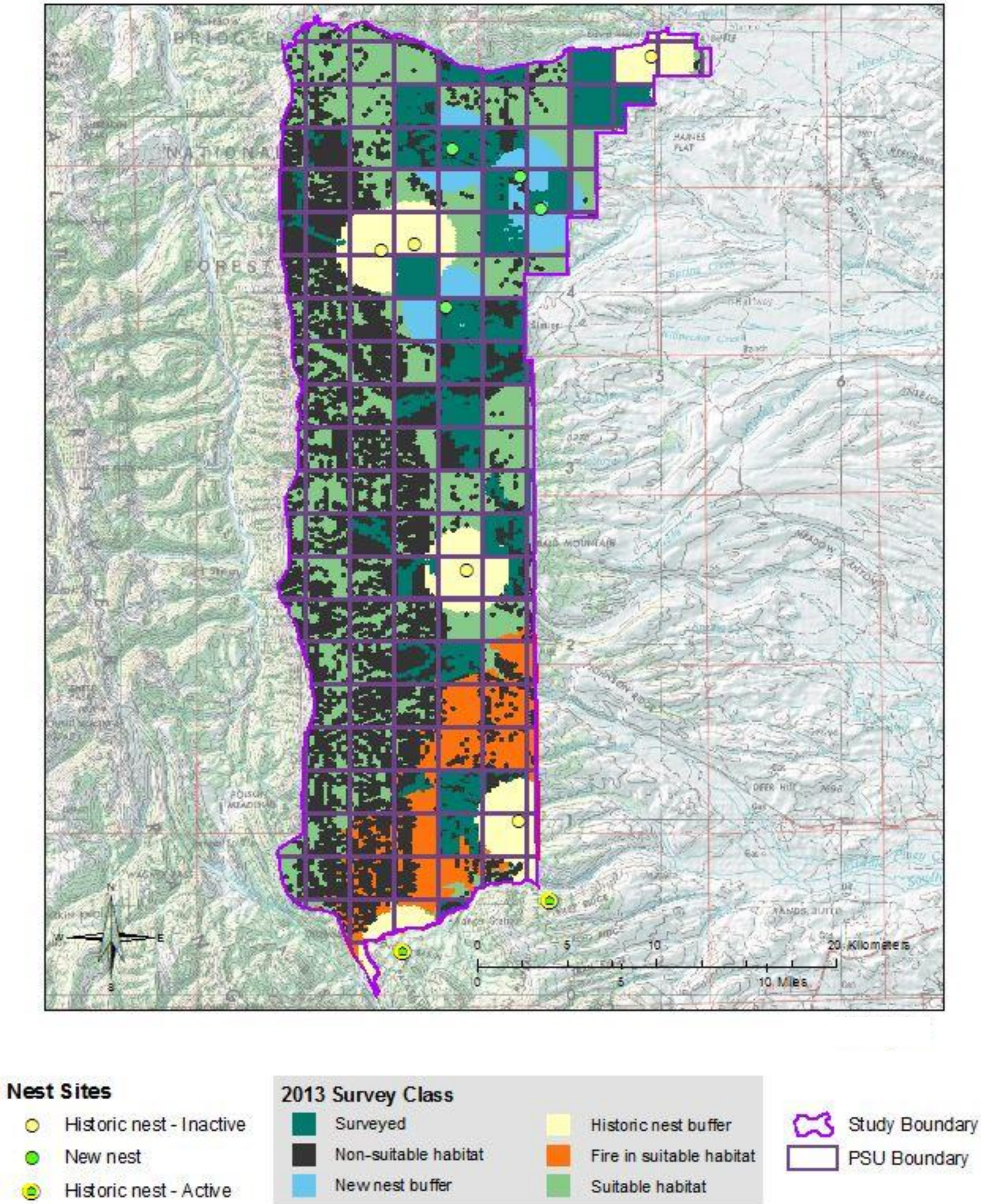

Figure 4. Survey class results determined by Northern Goshawk (*Accipiter gentilis*) nest search and monitoring in the Wyoming Range, Wyoming during the 2012 field season, 10 June-21 August. Scale is 1:265,000.