Seasonal Habitat Use, Movements and Vital Rates

of Greater Sage-Grouse in the Parachute/Piceance/Roan Population

Annual Progress Report

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INTRODUCTION

BACKGROUND

The Colorado Division of Wildlife (CDOW) is continuing a study of the Parachute/Piceance/Roan (PPR) population of greater sage-grouse (*Centrocercus urophasianus*) during 2007 and 2008. A pilot study was initiated in March 2006 and this annual report encompasses the research activities for 2007. The PPR is one of several small, naturally and spatially fragmented populations of sage-grouse in Colorado. This project is the result of a partnership among CDOW, industry, other land owners, and managers in the PPR area to sustain the PPR greater sage-grouse population. This information will be useful in assessing the current population status and expected future trend of PPR sage-grouse, and for identifying alternative management strategies for this population.

RESEARCH NEED

Greater sage-grouse historically inhabited sagebrush steppe habitat in at least 13 states and 3 Canadian provinces, and now occur in 11 states and 2 provinces (Schroeder et al. 2004). Sage-grouse are of particular conservation concern because populations have experienced dramatic range-wide declines over the past 4 decades (Connelly et al. 2004). In addition, some view sage-grouse as an umbrella species for sagebrush habitats (Rich and Altman 2002).

Habitat loss, fragmentation, and degradation are commonly suggested as reasons leading to the decline of sage-grouse and other sagebrush obligate avian species (Knick et al. 2003). Populations are migratory, moving >10 km to access seasonal habitats across large sagebrush landscapes, or are more sedentary, using the same habitats throughout the year to meet their life history requirements (Connelly et al. 2000). Impacts of human influences or other environmental perturbations may be more pronounced in populations that are small because

persistence of small populations is affected by stochastic environmental, genetic, and demographic parameters that may overwhelm the natural variation of these parameters in small populations (Mills et al. 2005).

The largest, most persistent (>500 breeding birds) populations of greater sage-grouse in Colorado are found in Jackson, Moffat, Rio Blanco, and Routt counties (Braun 1995). Small (<200 males), isolated populations of sage-grouse are found in Colorado in the PPR area in Garfield County, northern Eagle and southern Routt Counties (Schneider and Braun 1991), northwest Larimer County, and the Meeker/White River area in eastern Rio Blanco County. Significant oil and gas development activity is occurring in and/or planned for the Piceance Basin, and industry has expressed an interest in evaluating mitigation efforts and understanding the baseline habitat use, movements, and vital rates of the PPR population.

Sage-grouse from Eagle County, North Park, and Middle Park, Colorado function as a genetically-related group. Birds within each group are genetically similar, while genetic relatedness differs between groups (Oyler-McCance et al. 2005). The genetic relatedness of sage-grouse inhabiting the PPR area is unknown compared to other populations in Colorado or elsewhere (Oyler-McCance et al. 2005). Therefore, collection of genetic samples from grouse in the PPR will be useful in comparing genetic relatedness to other populations. Genetic information is imperative in the event that future translocations of sage-grouse to and from the PPR population are needed.

The Colorado Division of Wildlife has been concerned about the persistence of the PPR sage-grouse population since at least the early 1990s and discontinued hunting this population in the mid-1990s due to declining wing receipts and other indicators that the population may have been declining. Limited information is available for PPR sage-grouse including habitat use and

seasonal movements (Krager 1977, Hagen 1999), lek complexes (Krager 1977), and harvest data used to compute sex and age ratios (CDOW 1995). However, the limited information that does exist does not provide a clear picture as to historical or current population levels or trends in vital rates.

EXPECTED RESULTS AND BENEFITS

Results from this study are intended to provide important information that can be applied by land managers to enhance conditions that promote persistence and growth of the PPR sage-grouse population. This will be accomplished by collecting data that provide industry and agency managers a better understanding of the habitat use, seasonal movements, genetics, and vital rate demography of this small isolated population of greater sage-grouse.

The specific objectives of this proposed research project are to:

1. Obtain baseline information on genetic characteristics of sage-grouse in the PPR population. This information will be used to assess current levels of genetic variability within the PPR population, and to compare genetic characteristics of PPR sage-grouse with other sage-grouse populations. These results will be useful in planning for potential future efforts to augment the PPR sage-grouse population with grouse from other populations.
2. Acquire current estimates of reproductive parameters (nesting effort, clutch size, egg success, nesting success, and renesting success) and survival rates of PPR sage-grouse. Survival rate estimates will be obtained for adults, and if adequate resources and access are available, for juvenile sage-grouse. Information on survival and reproduction will be used to develop models of population persistence and growth, and expected impacts of various environmental changes and management strategies on the population dynamics of PPR sage-grouse.
3. Measure movements and seasonal habitat use patterns of PPR sage-grouse on a landscape

level, and measure micro-habitat characteristics at breeding, summer, and winter and nocturnal habitats. These results will be combined with results of a Bureau of Land Management habitat inventory project (Sauls et al. 2006) to validate and refine a habitat model for PPR sage-grouse, that can be used by land managers to identify important areas for sage-grouse and plan habitat restoration and enhancement projects within the range of PPR sage-grouse.

Given the current status of this small population of sage-grouse and the landscape changes that are expected to occur over the next 5-10 year, there is a pressing need to obtain current, detailed baseline information on the population ecology of PPR sage-grouse and provide this information to managers. Results from this study will also provide useful comparisons with a similar study of sage-grouse in another small, isolated population in northern Eagle and southern Routt counties (Graham and McConnell 2004, Graham and Jones 2005).

STUDY AREA

The area occupied by the PPR population of sage-grouse is located in Rio Blanco and Garfield counties (Fig. 1). Hagen (1999:9) described the area: "The Piceance Basin-Roan Plateau is bordered on the north by the White River and on the south by the Colorado River. The Utah boarder is ~80 km to the west and the Grand Hogback borders the basin on the east. The study area encompasses approximately 1,400 km2 of the ~ 3,000-km2 region. The specific boundaries of the study area are Big Duck Creek and Piceance Creek to the north; Colorado Highway 13 to the east; the Roan Cliffs to the south and southeast; Roan Creek to the south and southwest; and the Cathedral Bluffs define the western boundary. "

CDOW researchers have access to a large portion of the area occupied by the PPR population, including publicly-owned lands and private property. Public lands are primarily

managed by the BLM and the CDOW. Private lands are owned by the energy industry and other private individuals. Expanded access to additional lands used by sage-grouse is important to the success of this study in order to ensure that sample sizes are adequate to obtain accurate and precise estimates of the variables of interest, and that the sample of sage-grouse included in the study is representative of the entire PPR sage-grouse population. Based on the latest 3-year running average of strutting males counted in the PPR (128 males), this population can support at least 256 females. A desirable sample size would be 40 – 60 radio-marked females from leks across the PPR range. In a 2006 pilot study, due to access limitations, a total of 16 females and 13 males were radio-marked. These small sample sizes can provide useful information to land managers on the limited area currently included in the study, but will not provide strong inference to the entire PPR population.

"The climate of the Piceance Basin is semiarid and exhibits extreme differential levels of monthly precipitation. Consecutive months often receive little precipitation. Mean annual precipitation was 35.3 ± 18.7 cm for eight weather stations in the region for 1951-70 (Cottrel and Bonham 1992) and snowfall comprised ~ 50% of the total precipitation. The mean annual temperature varies from 7^{o} C at 1,800 m to -1^{o} C at 2,700 m." (Hagen 1999:9).

"The topography of the study areas has been described as a structural basin (Tiedeman and Terwilliger 1978) or a plateau that is dissected by narrow drainages. The sagebrush steppe consists of undulating north-south ridges parallel to each other. The ridge tops vary in width from 0.5 to 3 km, and 1 to 30 km in length. The ridges are gently rolling; however, the drainages that separate them are steep. Specifically, the ridges in the southern part of the study area are divided by canyons that drop nearly 1 km, vertically, in <500 m, horizontally; typically the elevation change is more gradual. Elevations vary from 1,800 m on Piceance Creek to 2,700 m at

the upper reaches of the plateau. The higher elevation areas are known locally as the "summer range" as they are the location for summer grazing of livestock." (Hagen 1999:9).

Vegetation is dependent upon slope, aspect, and elevation. Three subspecies of big sagebrush (*Artemisia tridentata*) occupy the basin, and location of *Artemisia tridentata ssp*. is dependent upon soil type (Cottrell and Bonham 1992). Basin big sagebrush (*A. t. tridentata*) is the prevalent vegetation throughout the drainages at elevations of 1,800 – 2,000 m (Cottrell and Bonham 1992). Typically basin big sagebrush grows taller and denser than mountain big sagebrush (*A. t. vaseyana*) and Wyoming big sagebrush (*A. t. wyomingensis*) (Cottrell and Bonham 1992). *A. t. wyomingensis* is restricted to upland ridges at elevations of 1,900 – 2,000 m (Cottrell and Bonham 1992). *A. t. vaseyana* is confined to high mountain areas at elevations > 2,100 m (hereafter all references to big sagebrush will refer to *A. t. vaseyana*, unless otherwise noted)." (Hagen 1999:9).

Pinyon pine (*Pinus edulis*) and juniper (*Juniperus spp*.) woodlands dominate the landscape until ~2,100 m. Big sagebrush, Utah serviceberry (*Amelanchier utahensis*), Gambel oak (*Quercus gambelii*), and antelope bitterbrush (*Purshia tridentata*) comprise most of the transition vegetation type. Low and rubber rabbitbrushes (*Chrysothamnus viscidiflorus*, *C. nauseosus*) are prevalent throughout the basin. Elevations of 2,400 to 2,600 are dominated by big sagebrush interspersed with bunchgrass meadows. North aspects often host substantial groves of quaking aspen (*Populus tremuloides*), serviceberry, and mountain snowberry (*Symphoricarpos oreophilus*). Big sagebrush and Douglas-fir (*Pseudotsuga menziesii*) dominate south and northwest aspects at elevations > 2,500 m, respectively. Free water can be scarce in dry years or late in the summer as most springs are in the bottom of steep canyons." (Hagen 1999:9).

METHODS

Capture and Marking of Adults and Juveniles

During the spring and fall of 2007 female sage-grouse were captured and radio-marked. Sage-grouse were captured using spot-lighting (Giesen et al. 1982, Wakkinen et al. 1994) techniques. All grouse captured were weighed using an electronic scale (to the nearest 1 g) and marked uniquely using numbered leg bands. The age and gender of each grouse captured was determined using wing (Dalke et al. 1963) and other plumage or morphological characteristics.

Female grouse were preferentially captured and equipped with 17-g necklace-mounted radio transmitters with a 4-hour mortality circuit (Fig. 2). Each transmitter has a minimum battery life of 18 months and will have a 30 cm antenna that lies between the wings and down the back of the grouse.

Additional grouse were captured and fit with radio-transmitters while they are with radio-marked females in the fall. Grouse were captured when they were estimated to be approximately 16 weeks of age or older using similar spotlighting techniques. All juveniles captured were radio-marked only if their body mass weight exceeded 900 g. Primary feather measurements and molting sequence were used to ascertain the gender of the juvenile. All grouse were banded with aluminum leg bands.

Capture and Marking of Chicks

In 2007 only, we investigated chick survival from 1- 30 days of age. Once monitoring revealed the successful hatch of a nest, all chicks in the brood were captured 1-2 days following hatch. Radio-marked females were located < 2 hours after sunrise in order to capture chicks while the female was brooding. Chicks were captured by hand and held in cotton bags for processing. All chicks within the broods were weighed and had a secondary feather collected.

Three 3 chicks within the brood were randomly selected and a 1.4 gram, 60 day radio-transmitter was attached along the dorsal midline between the chick's wings following the procedure of Burkepile et al. (2002) (Fig. 3). All chicks from the brood were placed in the same brood bag to facilitate thermoregulation and acclimation while chicks were processed. Chicks were released together on-site and monitored (<1 hr) to confirm the immediate survival of the chicks. In addition, broods were located latter in the day (> 2 hours after introduction) and < 2 hours before sunset to determine chick survival and female acceptance into the brood.

Genetics

Blood samples were obtained by clipping the toenail of all sage-grouse captured. Two to three drops of blood were placed into a microfuge tube coated with EDTA (Oyler-McCance 1999). The blood and feather samples were frozen at –20°C and stored at the Rocky Mountain Center for Conservation Genetics and Systematics in the Department of Biological Sciences at the University of Denver (S. Oyler-McCance, pers. comm.).

Seasonal and Daily Movements

Following release, the movements and survival of radio-marked grouse were monitored 1-2 times/week. General locations were determined by triangulation and radio-tagged birds were not flushed. Hand-held Yagi antennas, attached to a receiver/scanner, were used to locate radio-marked grouse. The loudest-signal method was used to locate grouse/transmitters (Springer 1979). All grouse were circled at a 50 – 100 m radius (Apa 1998) to determine habitat type use. A precise Universal Transverse Mercator (UTM) location was not possible at the time of location (birds were not flushed). Therefore, to obtain a more precise use location, the observer selected a location approximately 50 m in one of the 4 cardinal directions from the actual location of the bird. The observer a collected UTM location at that point and then manually corrected the UTM

location. General cover types were recorded as shrub steppe (sagebrush), wet meadow, mountain shrub, oakbrush, grassland or agricultural field.

Radio-marked females with radio-marked chicks were monitored daily to determine survival of chicks, and location of brood. Brood positions were ascertained by locating the female and circling to within 25 m. Position and relationship (i.e., distance) of radio-marked chicks in relation to the female were also be recorded. In addition, cover type was determined at all locations. Daily observation of broods continued for 28 days or until death. Attempts were made to find all chicks immediately after becoming separated or missing from broods to determine fate and/ or cause of mortality. After day 28, radio-marked chicks and females were located every 1-3 days depending on feasibility.

A fixed-wing aircraft was used to locate any grouse not located by ground monitoring or lost during ground monitoring efforts. General locations were identified aerially and ground locations were identified within 48 hours.

The frequency of locations depended on access and field conditions. Weekly locations were obtained from mid-April through August. A minimum of bimonthly locations were obtained from September through December.

Microhabitat Characteristics

Nests

If a female is suspected of incubation, the nest location was determined using binoculars as described by Apa (1998). Once a female was identified as incubating, she was not disturbed during the incubation bout. Diagrams of the nest location were drawn to assist in nest location after the completion of nesting. The precise UTM location was collected following the cessation of nesting (successful or unsuccessful). A nest was considered successful if ≥ 1 egg hatched. At

all nest sites four 10-m transects were placed in the cardinal directions intersecting at the nest bowl (Figs. 4 & 5). The nest shrub species and height was measured. The height of the lowest live and dead nest bush branch above the nest bowl was measured from the edge of the nest bowl. Canopy cover (foliar intercept) of the shrub species overstory was measured using line-intercept. The intercept by the lowest possible shrub taxa was measured (Figs. 4 & 5). Height of the of the nearest nest bush type shrub within 1 m of the transect line was measured at 2.5 m, 5 m, and 10 m. Grass height was measured for the nearest, tallest grass part at the points where the edge of the nest bowl and the transect's intercept, and at the 1 m point on each transect.

The percent of forbs and grass cover, bareground, and litter horizontal understory cover were estimated using 50 x 50 cm microplots (Daubenmire 1959) (Fig. 5). Eleven cover classes were used and delineated as follows: Trace: 0-2%, 1: 3-9%, 2: 10-19%, 3: 20-29%, 4: 30-39%, 5: 40-49%, 6: 50-59%, 7: 60-69%, 8: 70-79%, 9: 80-89%, 10: 90-100%. The first 2 microplots were located on opposing sides of the nest bowl. Subsequent plots were placed systematically along the transects at 2.5, 5, and 10 m. In addition, the distance to nearest visible roadways, telephone poles, powerlines, and fence posts were determined.

The same vegetation data collection techniques were applied to at least one random location for each nest. Random locations were obtained by using randomly selected UTM coordinates in the study area. Grouse movements will delineate the study area boundary.

Brood-rearing/Unsuccessful Female/Male

Females with broods, unsuccessful females, and males were located by the loudest-signal method 1-2 times per week. At each location, date, time, UTM coordinates, slope and aspect were recorded. Unsuccessful females and males were located in the same manner as females with broods. When females with broods are circled, the intersection point of flags placed in the

cardinal directions were used to identify the center of the brood location. Microhabitat measurements occurred at a minimum of 20% of the male and unsuccessful female use locations.

At the center of each brood location identified for vegetation sampling, the same vegetational structural characteristics were measured. One random site will be selected for each brood vegetation site and the same vegetation sampling occurred.

RESULTS

Staff

From January through March 2007, Aaron Pratt remained on the project from 2006. On 5 March 2007, Brandon Miller became the lead technician on the PPR project. A second technician was hired to assist with the project. Evan Phillips began work on 12 March 2007. Brandon and Evan assisted with trapping efforts on another greater sage-grouse research project for approximately 7 days in an effort to train and refine trapping techniques before commencing trapping efforts in the PPR. Brandon and Evan continued on the project through December 2007.

Trapping

Spring trapping began on 19 March 2007. The first female was captured on 22 March 2007. The last female was captured on 24 April 2007 and trapping was discontinued in lieu of obtaining nesting status information. Twenty-eight females were captured over 22 nights of trapping. Grouse were captured on or near 6 leks. Captures were distributed across the study area.

Bragg Springs, Canyon Creek, and Stewart Gulch leks had the highest trap-night effort early on due to logistic access issues. Once roads began to clear and access to other private property became accessible, trapping effort was distributed more evenly across the study area.

Birds were trapped at 6 out of the 10 leks attempted. Trapping was successful at Bar-D, Bragg Springs, Canyon Creek, Clear Creek, Stewart Gulch, and Yankee Gulch leks. Trapping was unsuccessful at Mud Springs, Mud Springs Section 4, Puddin' Ridge 2, and Red Point leks (Fig. 6).

Of the females that were captured, 14 were adults and 14 were yearlings. Only 22 of 28 birds were weighed due to equipment failure and bird stress issues. Grouse mass averaged 1,559 ± 128 g (n = 22) (Table 1).

Fall trapping began 12 September 2007 and commenced through 13 November 2007. A total of 16 females were captured and radio-marked. Sixteen females were captured over 26 nights of trapping. Of the females captured, 6 were juveniles, and 10 were adults (Table 2). Trapping was not concentrated on lek sites in the fall. Efforts were focused on open areas with higher visibility or in areas where radio-marked grouse were known to exist. Juvenile female grouse weight 1,143 ± 126 g (n = 6) while adult female grouse weighted 1,330 ± 77 g (n = 10) (Table 2).

Monitoring Movements

From 1 January through 31 March 2007, 96 (37 from male and 59 from female) use locations were recorded on 20 grouse (8 males and 12 females) captured in 2006. The locations were obtained from the ground and aerially. One mortality (a male) was recorded during this period (Table 3).

At total of 45 greater sage-grouse (6 males and 39 females) were monitored through the breeding season and 16 were added in the fall. Seventeen (6 male and 11 female) of the 28 grouse captured and radio-marked in 2006 were available to monitor in the spring of 2007 (Table 3).

During the breeding season (25 April 2007 through 30 June 2007), 288 use locations (15 from males and 273 from females) were recorded from the ground or aerially. Eleven mortalities were documented (3 male and 8 female). Thirty-eight sage-grouse were being monitored or attempted to be monitored within the PPR during this period (5 male and 34 female) (Table 3).

Brood monitoring also occurred and vegetation sampling began. These are discussed in the Sage-Grouse Nesting Chronology and Biology, Sage-Grouse Brood and Nest Monitoring, and Vegetation Sampling sections below.

During the summer period (1 July 2007 through 30 September 2007), 285 use locations (9 from males and 276 from females) were recorded from the ground or aerially. Six mortalities were documented (all female) and 3 grouse were missing or assumed to have dead radio-transmitters (2 male and 1 female). Thirty-six sage-grouse (3 male and 33 female) were monitored or attempted to be monitored during this period (Table 3).

During the fall and early winter period (1 October through 31 December 2007), 229 use locations (3 male and 26 female) were recorded from the ground or aerially from 40 radio-marked sage-grouse. Seven mortalities were documented (all female) during this time period.

In total (1 January 2007 through 31 December 2007), 898 use locations (64 male and 834 female) were recorded from the ground or aerially (Table 3, Fig. 7). We documented 25 mortalities (4 male and 21 female) (Table 4, Fig. 8). Thirty sage-grouse (all female) are currently being monitored within the PPR. A total of 56 sage-grouse (8 males and 48 females) were monitored during 2007, 20 of which remained from 2006, 28 were captured in the spring of 2007, and 16 were captured in the fall of 2007.

Annual Survival

Male and female annual survival is difficult to ascertain due to the small sample sizes and short duration of the study. Based on the results to date, survival rates can be estimated for the duration of the study (21 months) and roughly back-calculated to approximate the apparent annual survival rate. Adult female survival for the 21 months of the study was 0.51 ± 0.16 (n = 30). The annual apparent survival is 0.68 ± 0.35 (n = 30). In contrast, yearling female survival for the duration of the study (21 months) was 0.28 ± 0.15 (n = 23). The annual apparent yearling female survival rate was 0.48 ± 0.34 (n = 23). The male survival rates should be viewed with caution due to the extremely small sample sizes. The adult male survival rate for the duration of the study (21 months) was 0.30 ± 0.49 (n = 8) which calculates to an apparent annual survival rate of 0.50 ± 0.67 (n = 8). In contrast, yearling male survival through the duration of the study was zero since no yearling males survived, although the 18 month survival was .25 ± 0.42 (n = 5). The apparent annual survival rate is 0.40 ± 0.56 (n = 5).

Sage-Grouse Nesting Chronology and Biology

The earliest nest (classified as an incubating female) was confirmed 19 April 2007. The last nest was confirmed 9 June 2007. The earliest documented hatch (at least 1 egg successfully hatched) was 13 May 2007. The last documented hatch was 20 June 2007 (Fig. 9). A total of 37 nests (33 first nests and 4 renests) were located and monitored in 2007 (Fig. 10).

Nest success in the PPR study area was within reported values. Female success (the number of females successfully hatching at least 1 egg) was 54.5% (n = 18/33) (Table 5). Nest success (at least 1 egg hatches) was 48.6% (n = 18/37) (Table 4). One remaining female was not observed nesting, because it was inhabiting private property with no access.

Sage-Grouse Brood and Nest Monitoring

Eighteen broods were produced from 33 females during 2007. Three broods were depredated or died soon after hatch, therefore 15 broods were monitored. Forty-two chicks were marked in 15 broods. Broods were radio-located every other day to monitor chick survival. Chicks were monitored unless the radio-marked chicks did not survive. If no radio-marked chicks survived, females were monitored less frequently (once/week).

Of the 42 radio-marked chicks 14 have an unknown fate. These 14 either could have survived, or lost their radio-transmitter. Twenty-eight were ruled mortalities (Fig. 11). Mortalities are likely caused from avian or mammalian predators, although it is difficult to determine cause specific mortality. Three chick mortalities were due to human error and likely resulted in a loss of an entire brood.

Chick survival at 14 days was 0.31± 0.08 (n = 39) while the survival rate at 30 days was 0.12 ± 0.07 (n = 39).

Vegetation Sampling

Vegetation sampling occurred from 5 June 2007 through 21 August 2007. Sampling was conducted at all nests ($\underline{n}$ = 37), brood-rearing sites ($\underline{n}$ = 29), and paired random sites ($\underline{n}$ = 67) for both nest sites and brood-rearing sites (Fig. 12). Random points were generated using Hawth's Analysis Tools © in GIS, by plotting them within a delineated boundary of known sage-grouse movements and a predicted sage-grouse habitat vegetation layer. Random points that fell in obvious non-habitat were discarded (ie. dense pinyon-juniper types with minimal sagebrush understory).

At the writing of this report, the vegetation data was being entered electronically and will be summarized in a 2008 quarterly report.

Seasonal Use Movements

Generally it is more insightful to evaluate the seasonal use patterns for the portion of the population that is marked (Fig. 7). In some cases, it can also be insightful to investigate the seasonal use patterns of individuals if specific projects are planned in an area. Therefore, in this report we have provided, in addition to Figure 7, the detailed seasonal locations of successful and unsuccessful females monitored in 2006 and 2007 (Figs. 13 - 41).

Genetic Analysis

Greater sage-grouse in the PPR do not appear genetically different than other greater sage-grouse previously sampled in Colorado (Appendix A). Although there is a different haplotype expressed in the PPR, it is also expressed in the Cold Springs and Blue Mountain portions of the Northwest Colorado population (Appendix A).

Future Research Plans

In 2008 greater sage-grouse research will continue in the PPR. Additional female grouse will be captured in the spring (approximately 30-40). These grouse and ones previously captured will be radio-marked and movements will be monitored. Two technicians will continue on the project to monitor vital rates and movements of these grouse through 31 December 2008. Day-old chick survival will not be conducted in 2008 due to the lack of supplemental funding and on-going needs of the research project.

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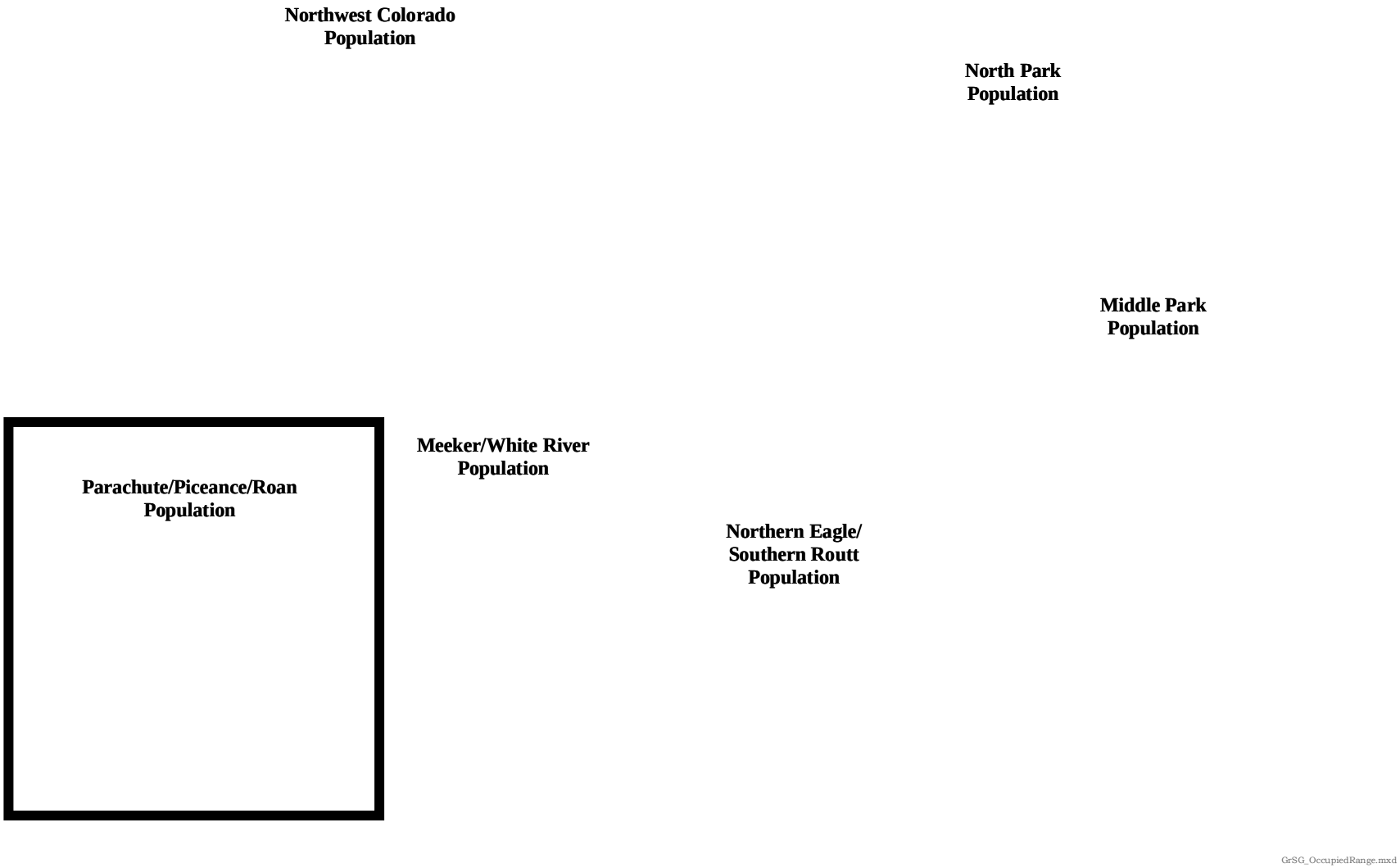

Figure 1. Location of the PPR study area in relation to the overall statewide range of greater sage-grouse in northwestern Colorado.

Figure 2. Attachment of a necklace mounted transmitter on a female greater sage-grouse.

Figure 3. Attachment of a 1.4 gram transmitter to a 1-day-old greater sage-grouse chick.

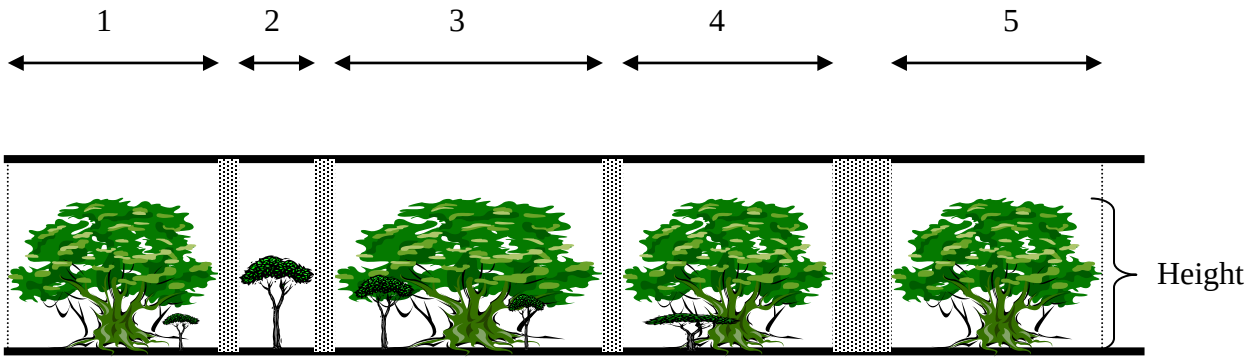

Figure 4. Visual representation of differing shrub layers in a shrub community. Intercepts 1, 2, 3, 4, and 5 represent the foliar intercept. The shaded area is not included in the shrub intercept.

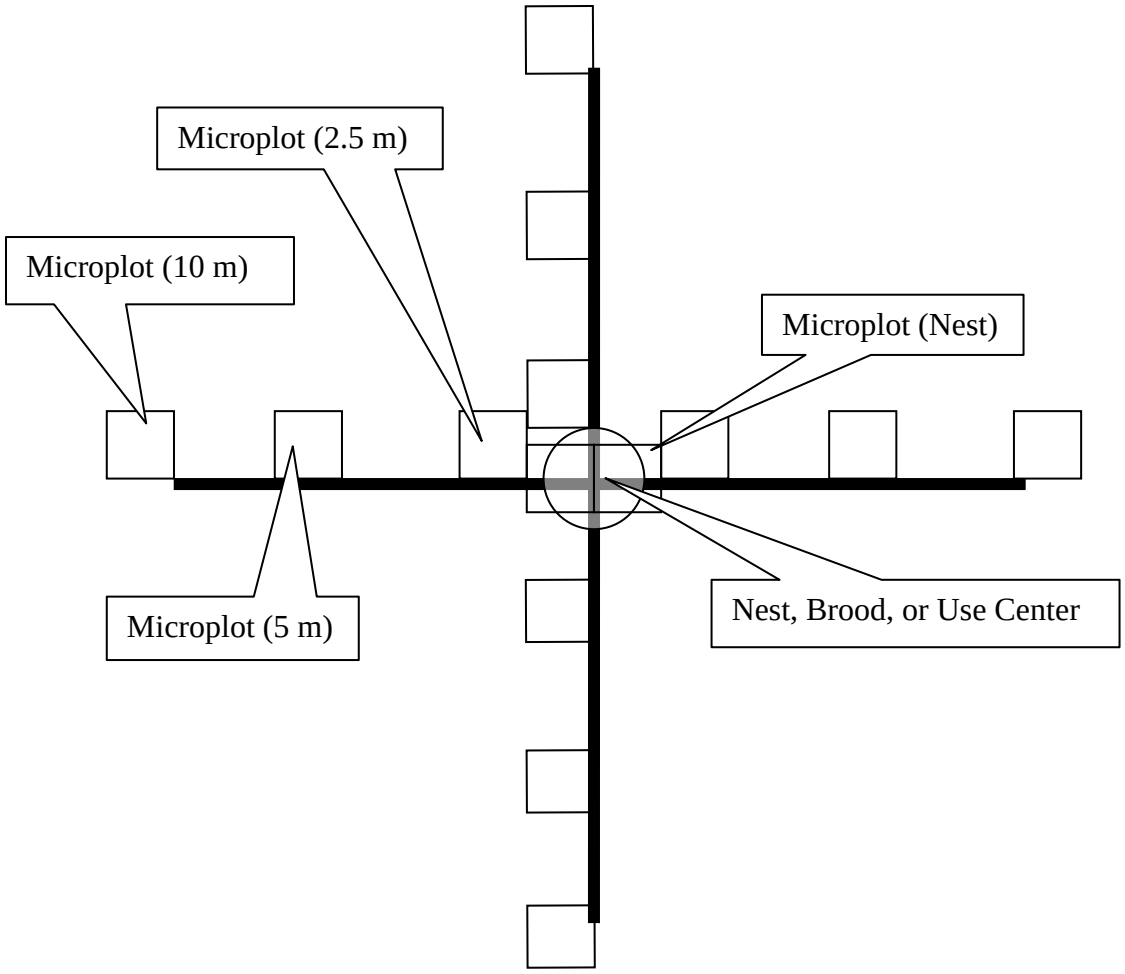

Figure 5. Vegetation sampling protocol at nest, brood, and use locations.

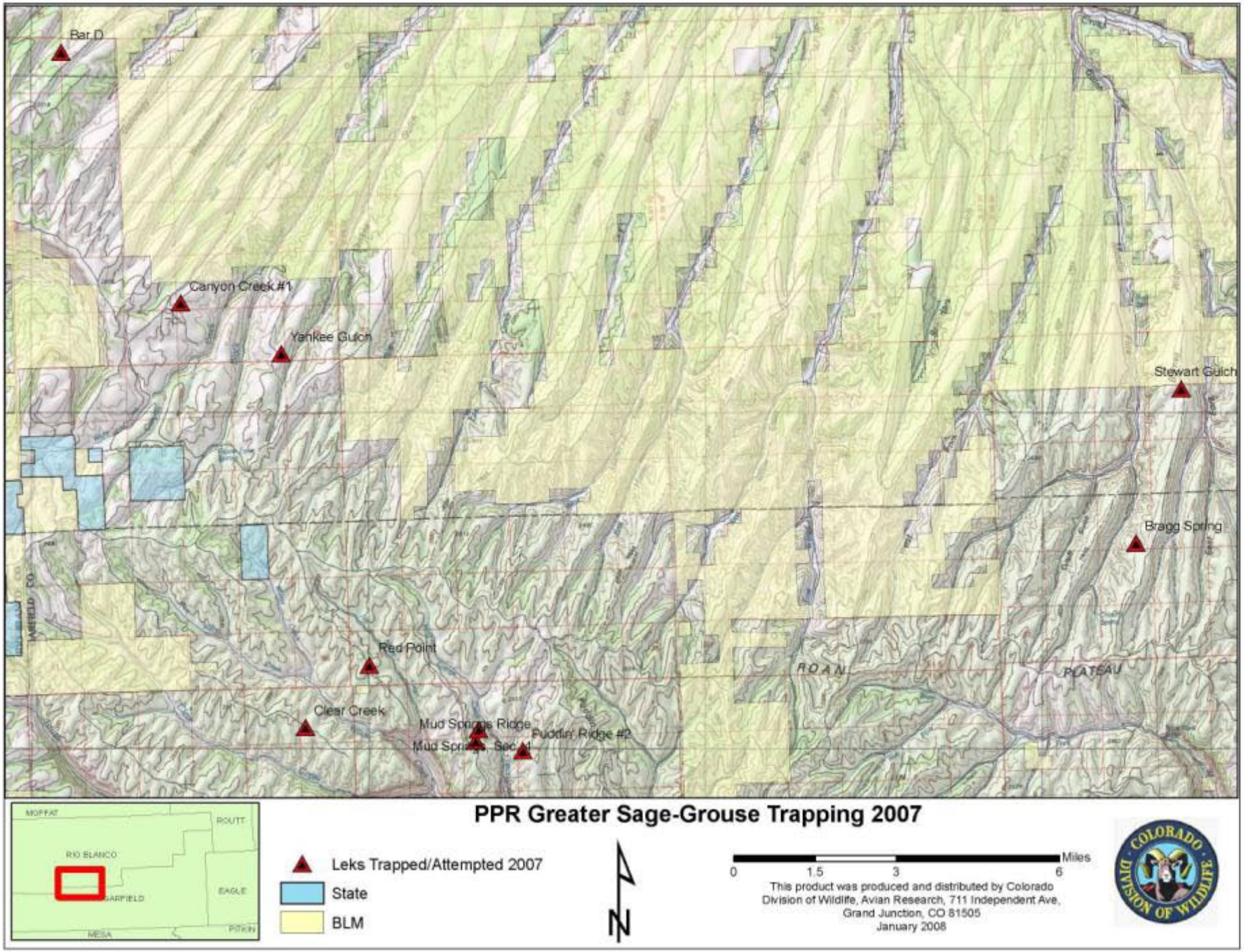

Figure 6. Spring trapping locations for greater sage-grouse in the west central Colorado PPR study area, 2007.

Table 1. Female greater sage-grouse weights in the west central Colorado PPR study area, spring 2007.

Age	**Mean ± SE (g)**
Adult	1,640 ± 77 (n = 12)
Yearling	1,463 ± 111 (n = 10)
All Females	1,559 ± 128 (n = 22)

Table 2. Female greater sage-grouse weights in the west central Colorado PPR study area fall, 2007.

Age	**Mean ± SE (g)**
Juvenile	1,143 ± 126 (n = 6)
Adult	1,330 ± 77 (n = 10)
All Females	1,256 ± 134 (n = 16)

Table 3. Number of greater sage-grouse use locations obtained by annual quarter in the west central Colorado PPR study area, 2007.

	1st Quarter	**2nd Quarter**	**3rd Quarter**	**4th Quarter**	**Total**
Male	37	15	9	3	64
Female	59	273	276	226	834
Total	96	288	285	229	898

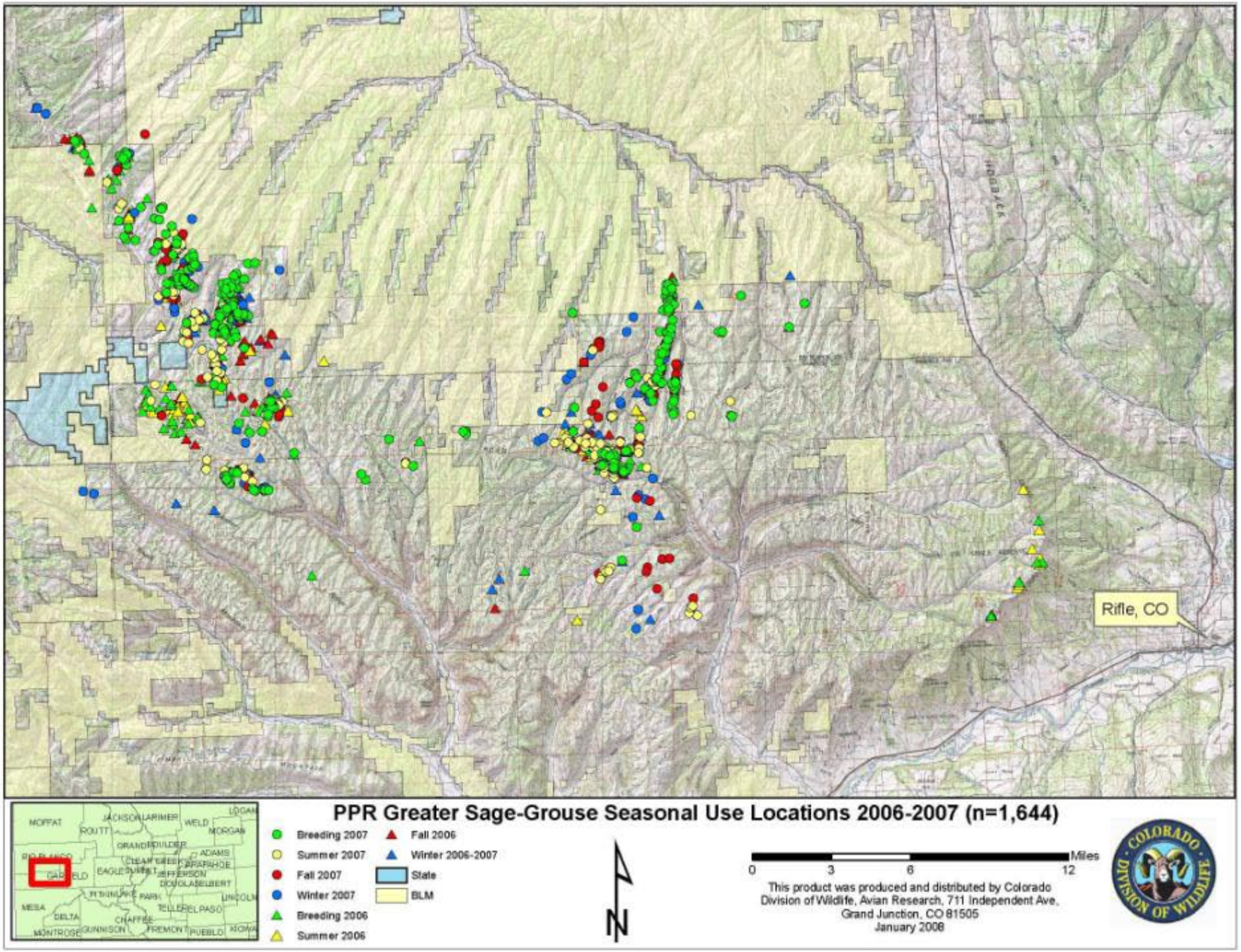

Figure 7. Seasonal use locations for greater sage-grouse in the west central PPR study area, 2007.

Table 4. Number of greater sage-grouse mortalities by annual quarter in the west central Colorado PPR study area, 2007.

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total
Male	1	3	0	0	2
Female	0	8	6	7	20
Total	1	11	6	7	22

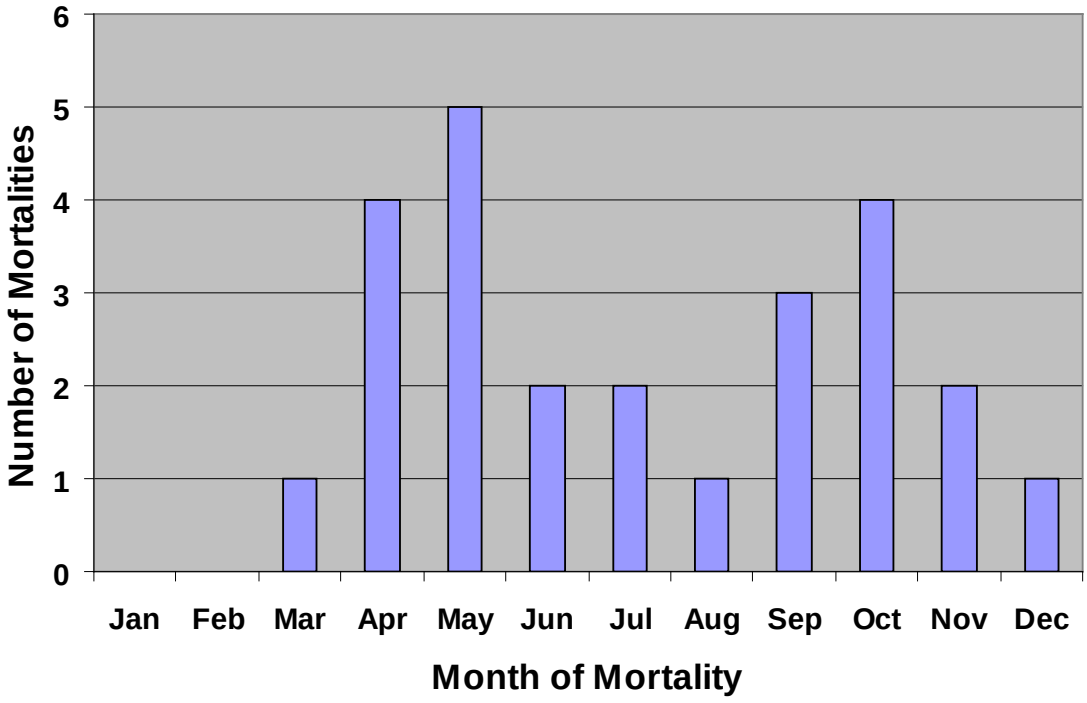

Figure 8. Greater sage-grouse mortalities by month in the west central Colorado PPR study area, 2007

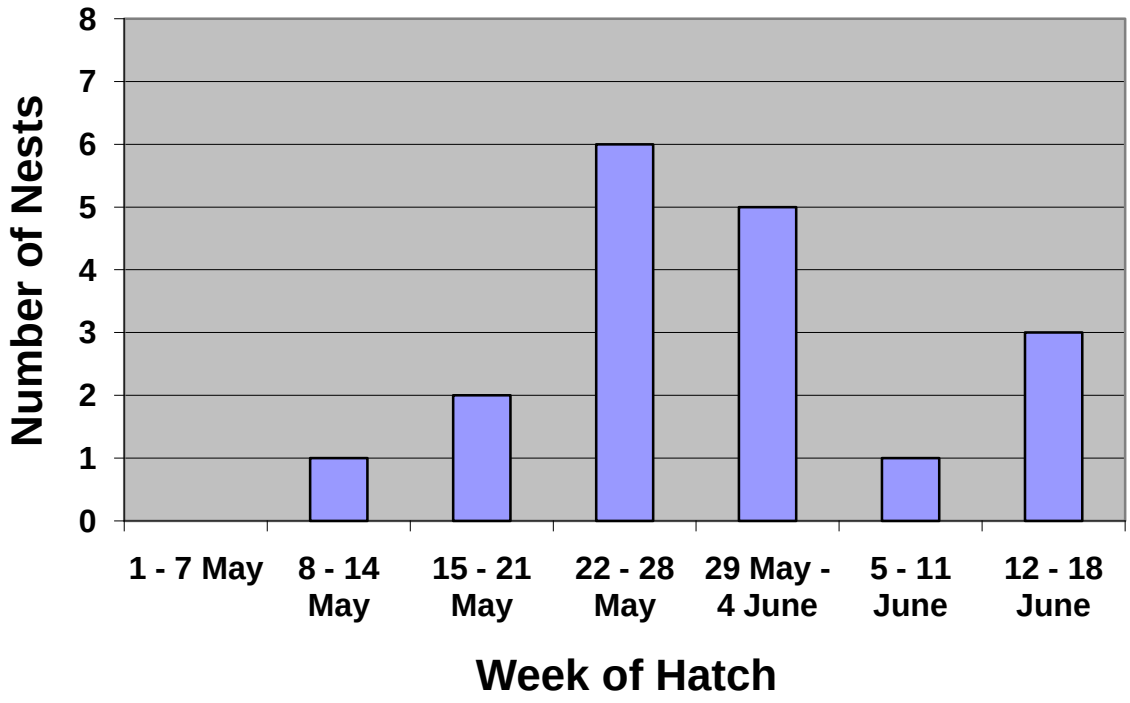

Figure 9. Number of successful greater sage-grouse nests hatched by week in the west central Colorado PPR study area, 2007.(n=18).

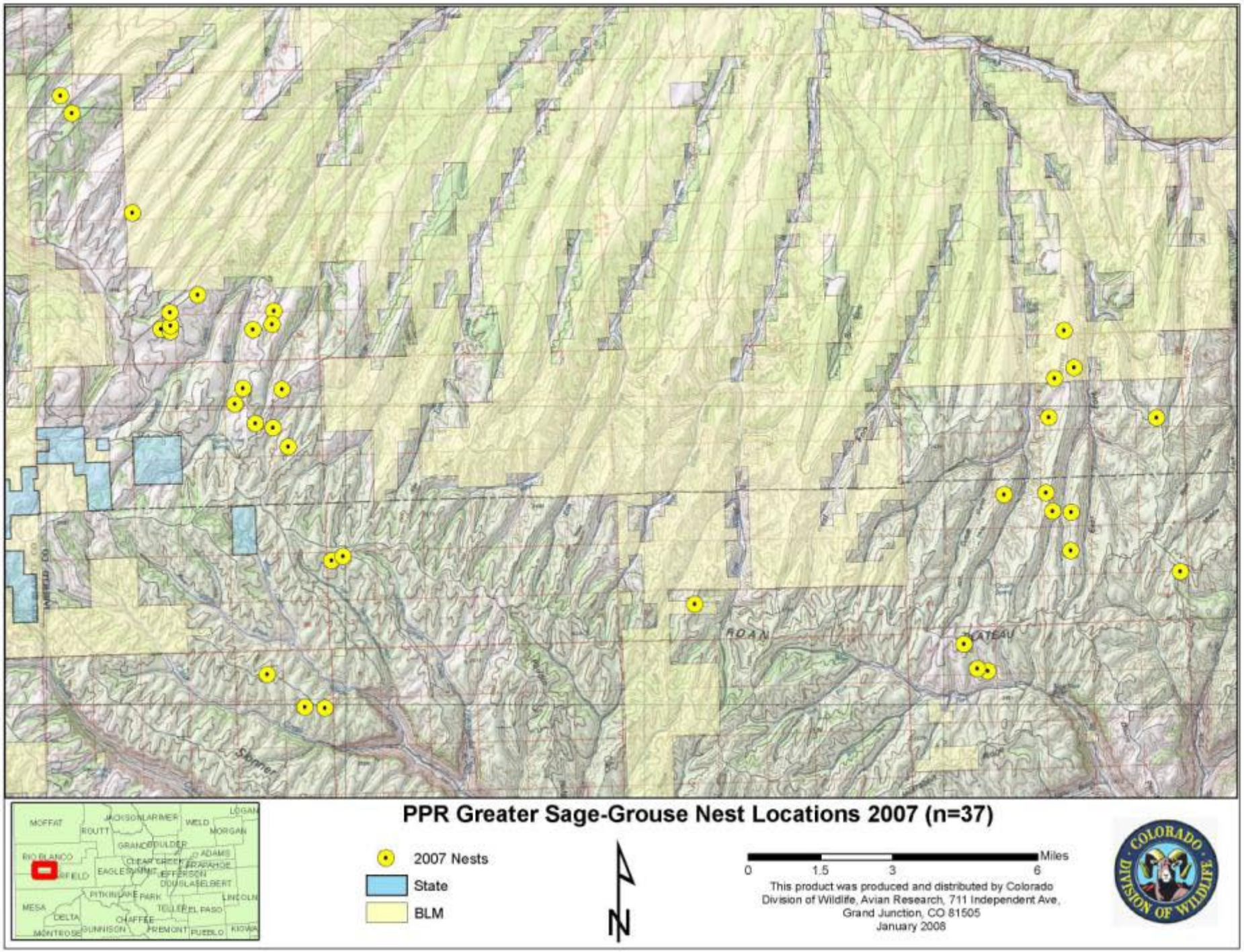

Figure 10. Nest locations for greater sage-grouse in the west central Colorado PPR study area, 2007.

Table 5. Age and number of successful and unsuccessful female greater sage-grouse in the west central Colorado PPR study area, 2007.

Age	**Unsuccessful**	**Successful**	**Success Rate**
Adults	9	12	57.1%
Yearlings	6	6	50.0%
Totals	15	18	
Overall Hen Success			54.5%

Table 6. Age and number of successful and unsuccessful greater sage-grouse nests in the west central Colorado PPR study area, 2007.

	Unsuccessful	**Successful**	**Success Rate**
Adult Nests	12	12	50.0%
Yearling Nests	7	6	53.8%
Totals	19	18	
Overall Nest Success			48.6%

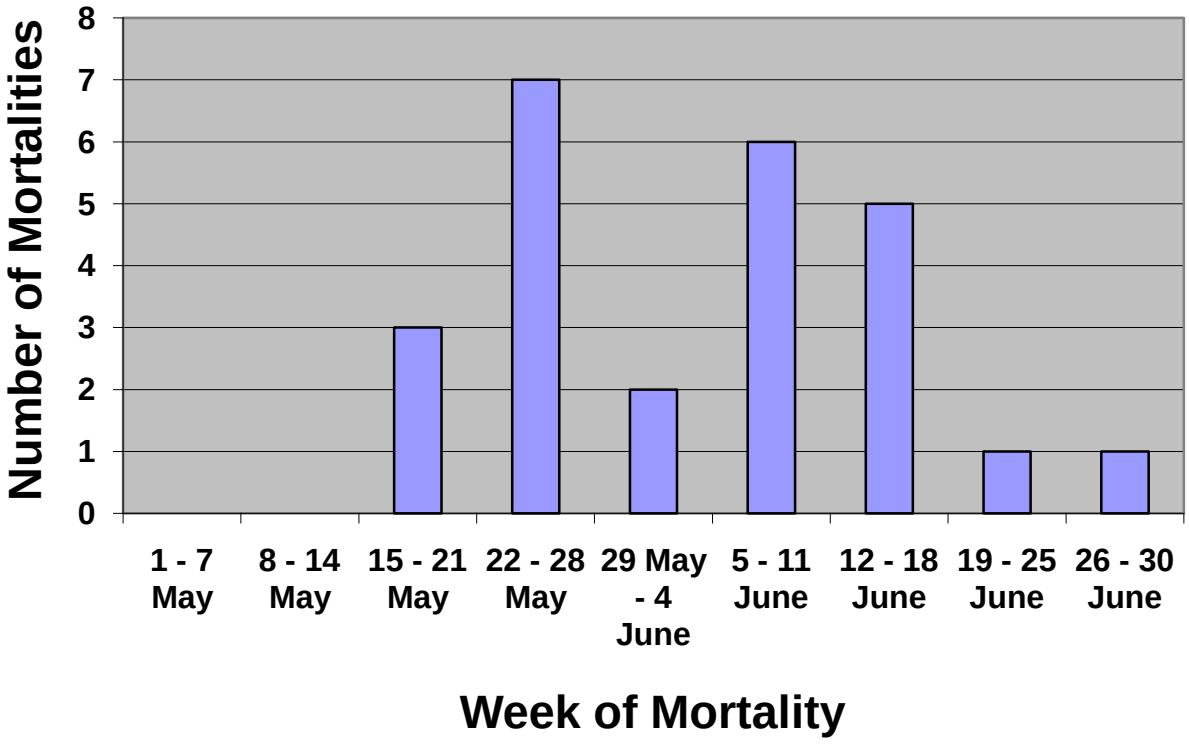

Figure 11. Number of chick mortalities (n=25) by week in the in the west central Colorado PPR study area, 2007

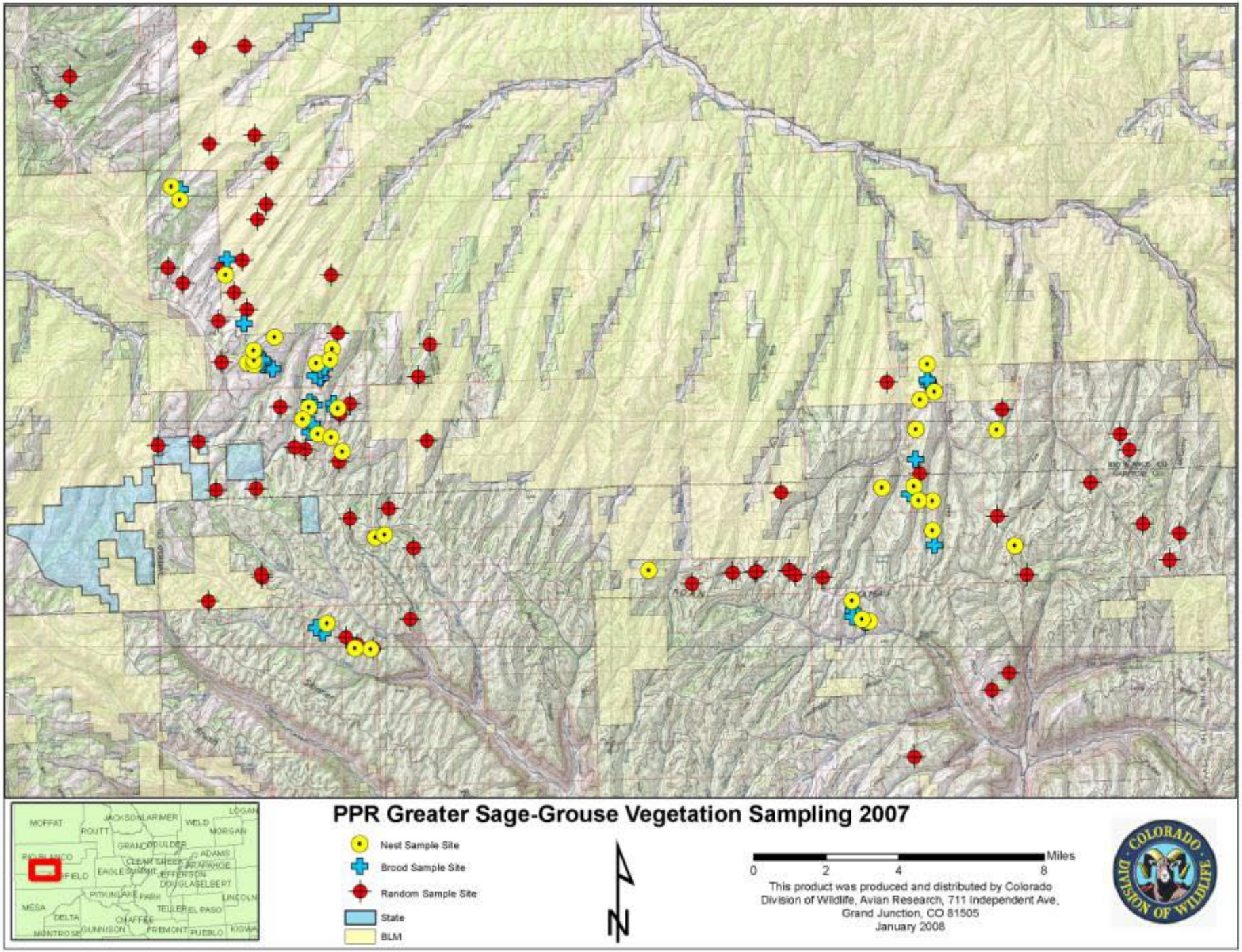

Figure 12. Vegetation sampling locations for nest, brood and associated random locations in the west central Colorado PPR study area, 2007

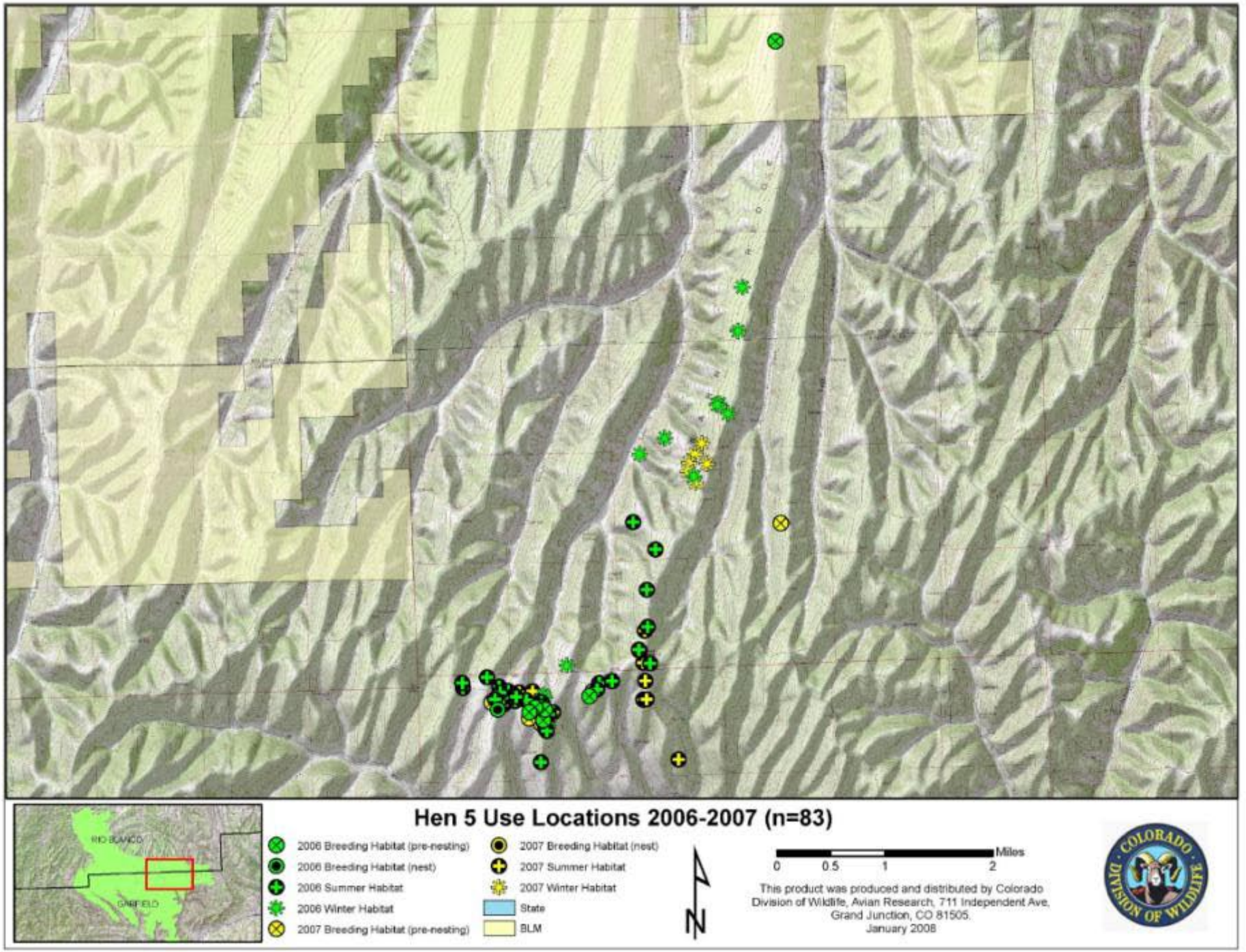

Figure 13. Female greater sage-grouse #5 use locations in the west central Colorado PPR study area, 2006-07.

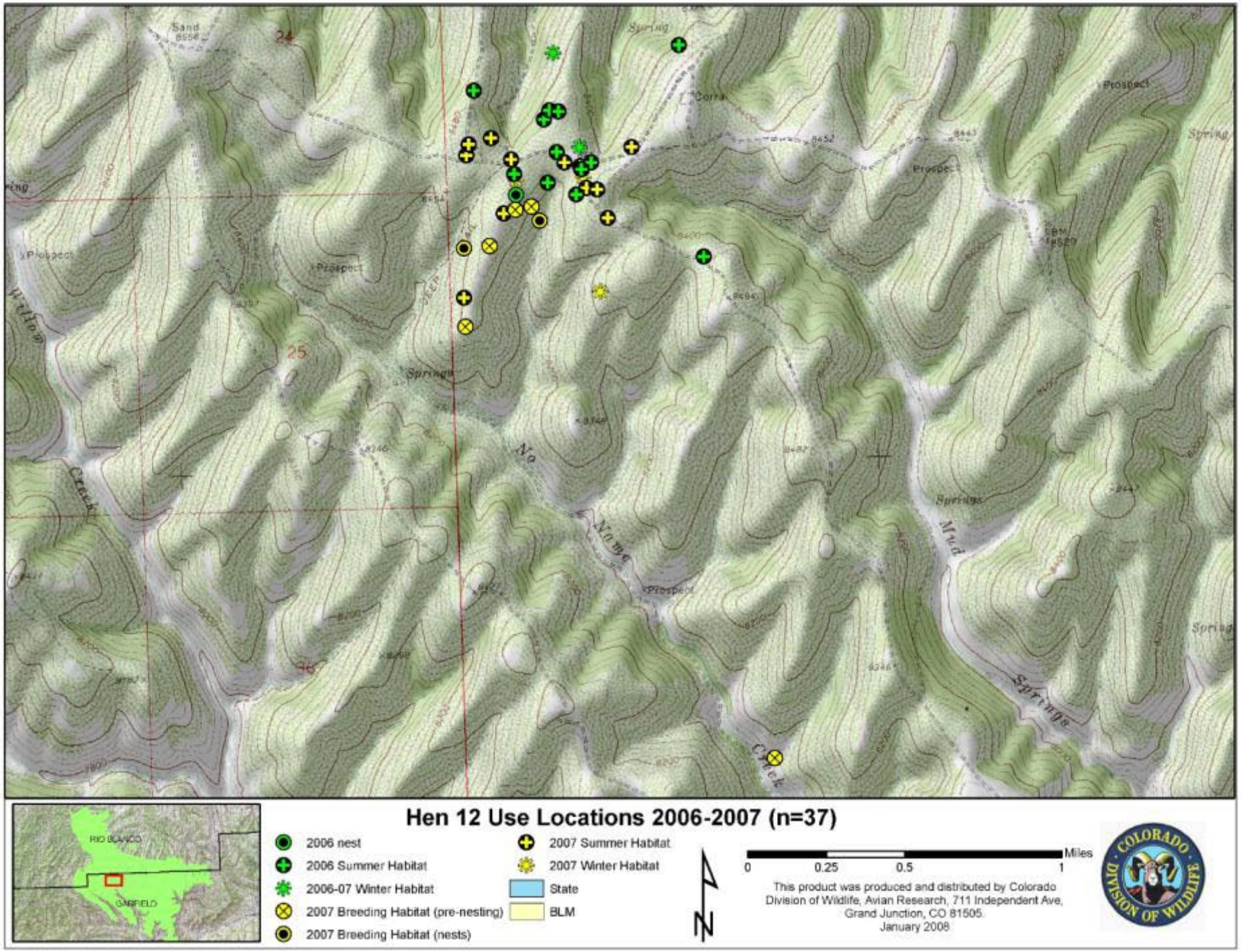

Figure 14. Female greater sage-grouse #12 use locations in the west central Colorado PPR study area, 2006-07.

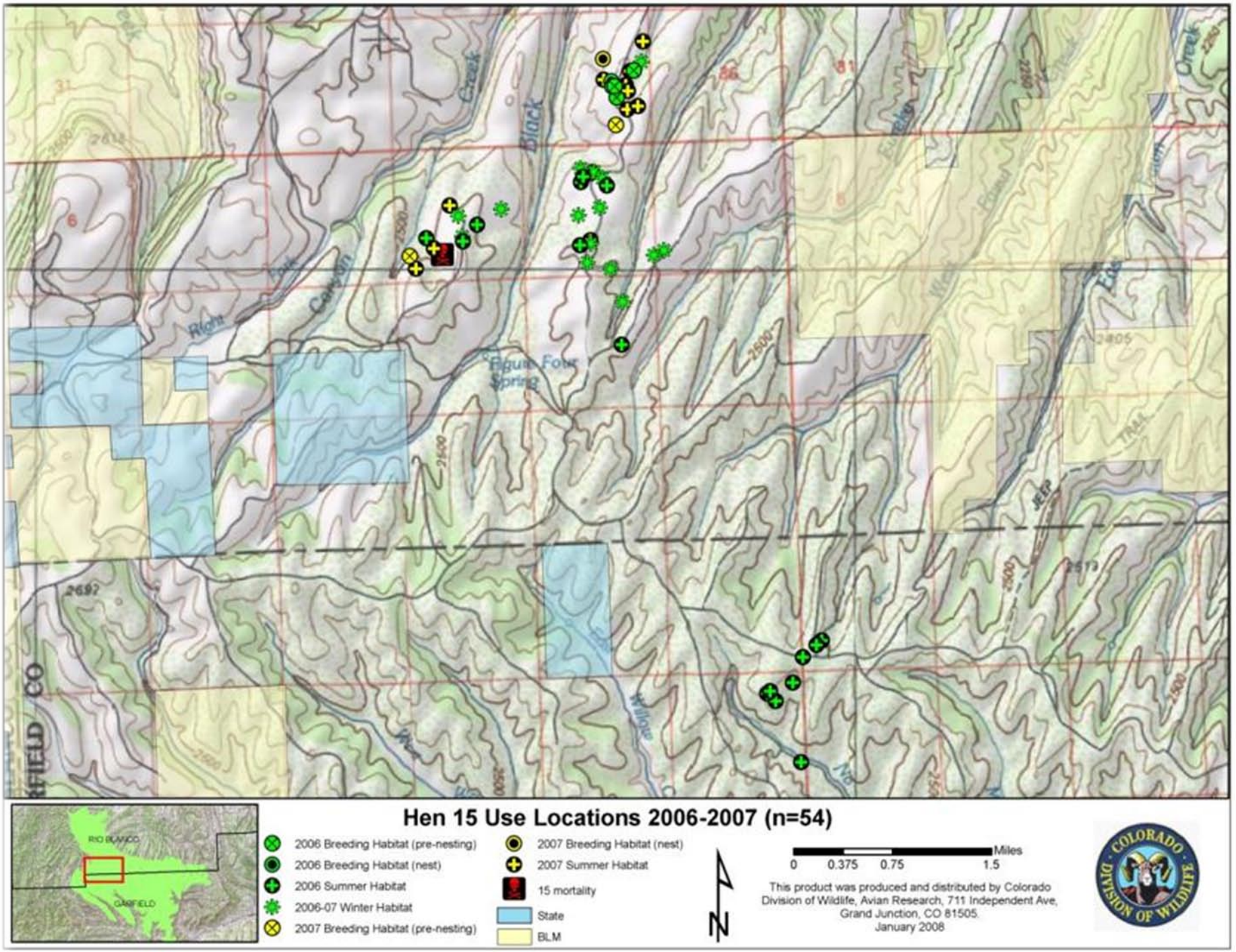

Figure 15. Female greater sage-grouse #15 use locations in the west central Colorado PPR study area, 2006-07.

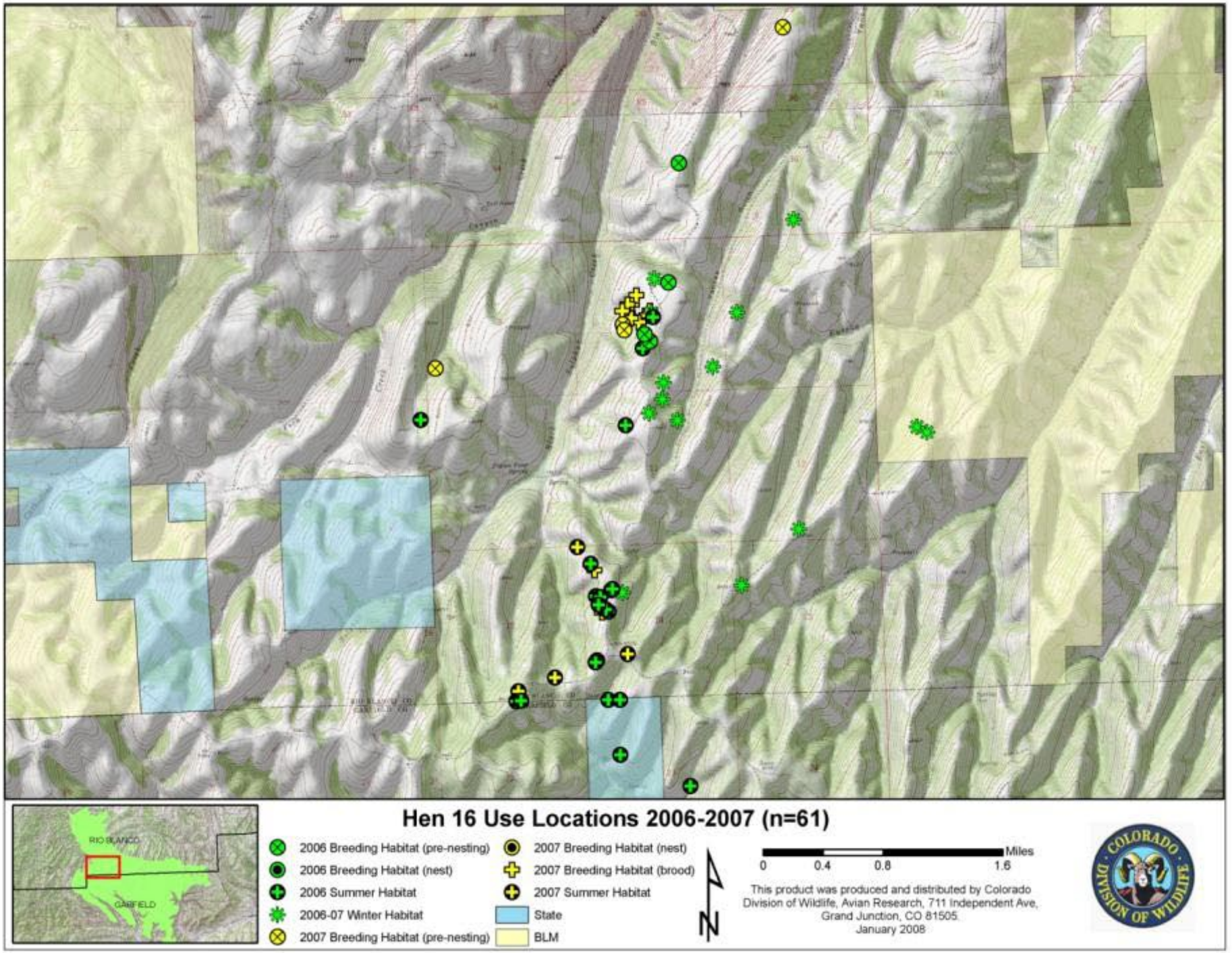

Figure 16. Female greater sage-grouse #16 use locations in the west central Colorado PPR study area, 2006-07.

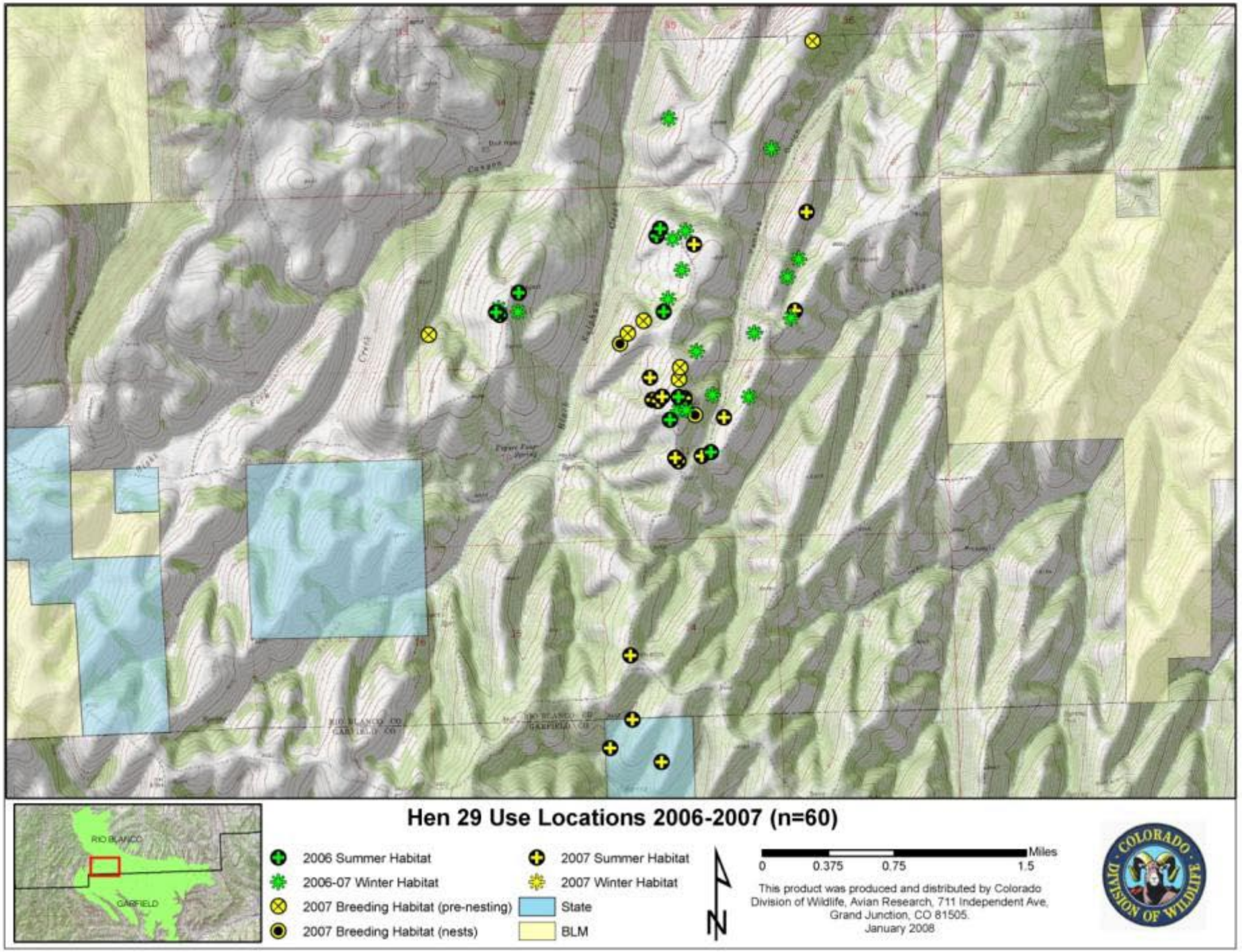

Figure 17. Female greater sage-grouse #29 use locations in the west central Colorado PPR study area, 2006-07.

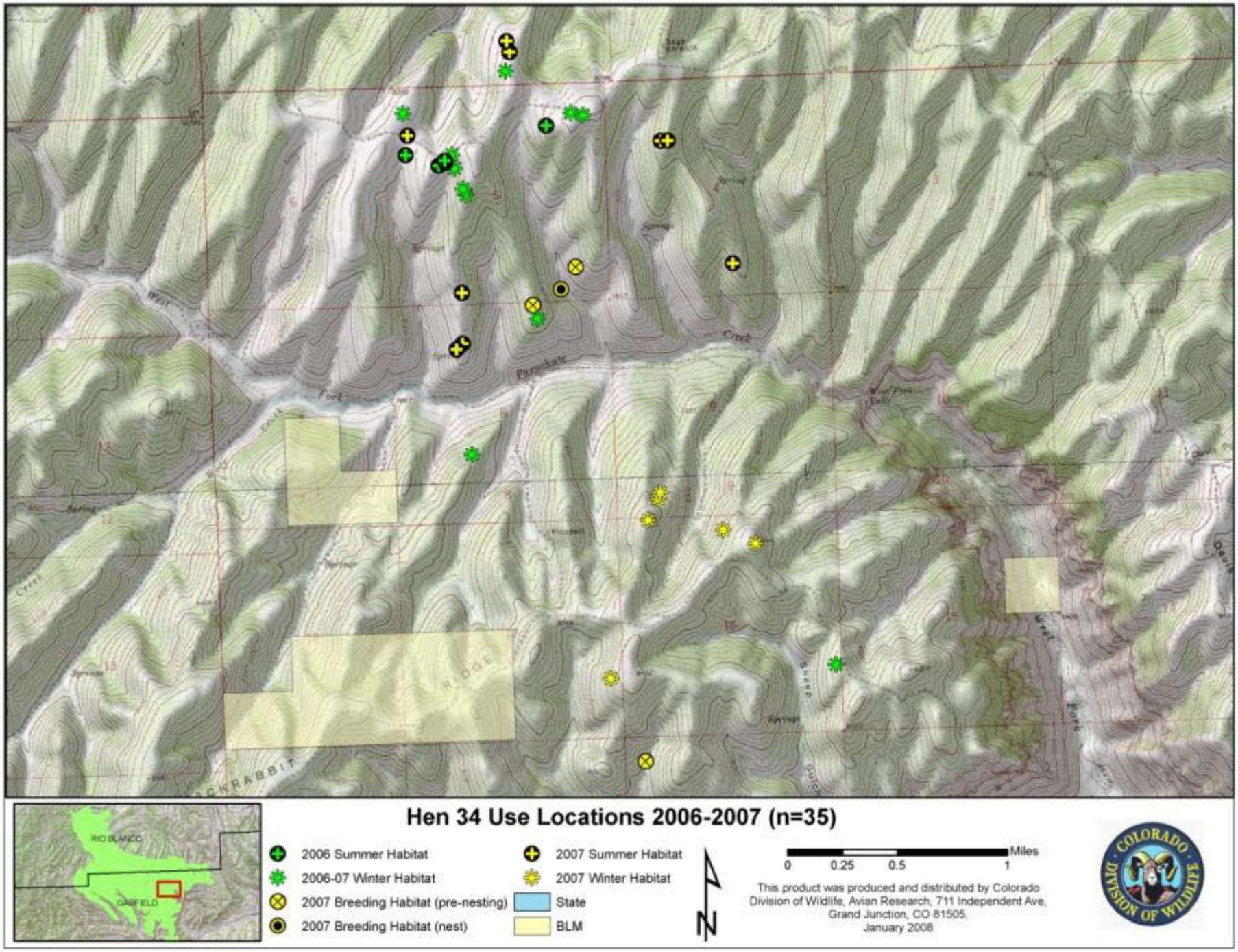

Figure 18. Female greater sage-grouse #34 use locations in the west central Colorado PPR study area, 2006-07.

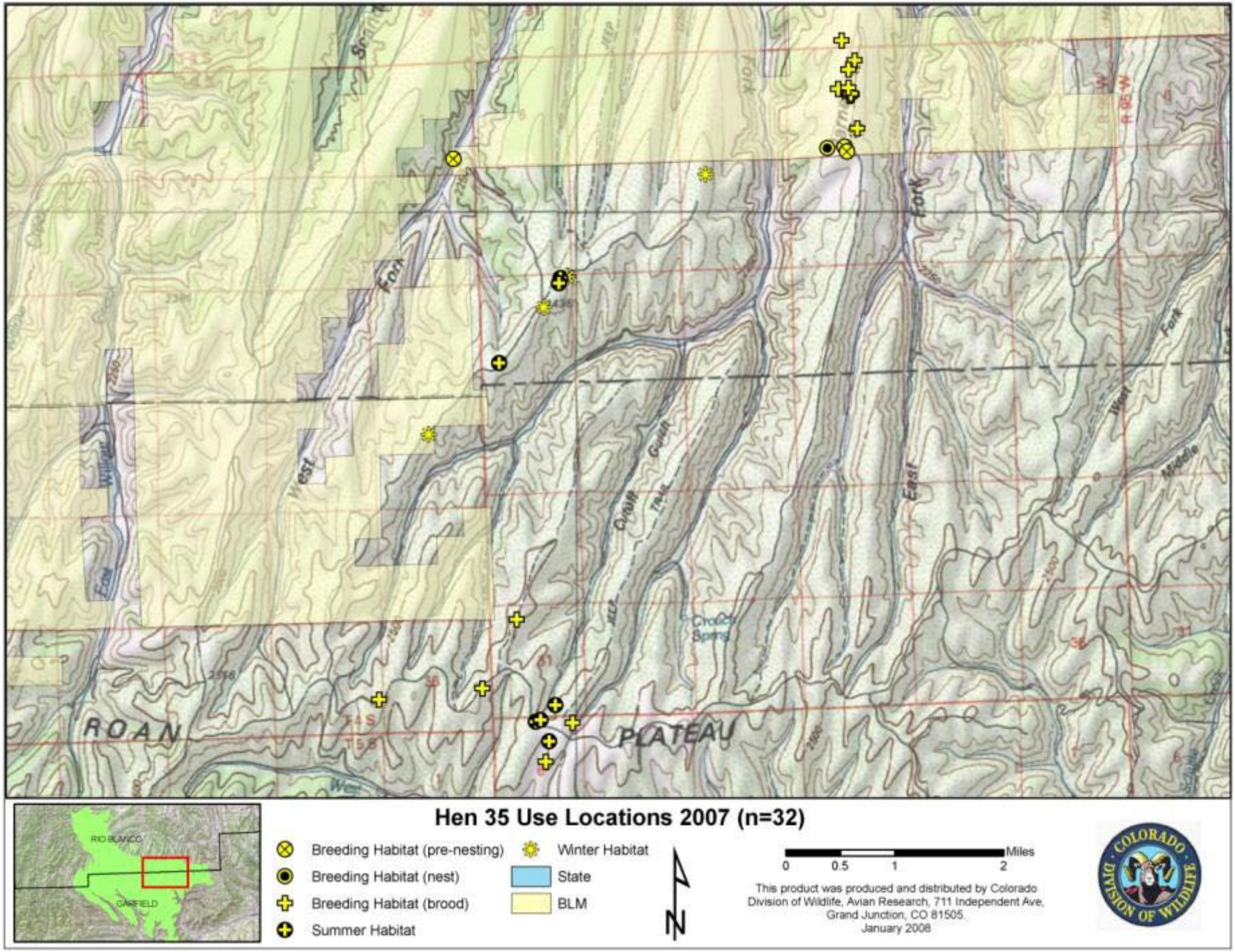

Figure 19. Female greater sage-grouse #35 use locations in the west central Colorado PPR study area, 2007.

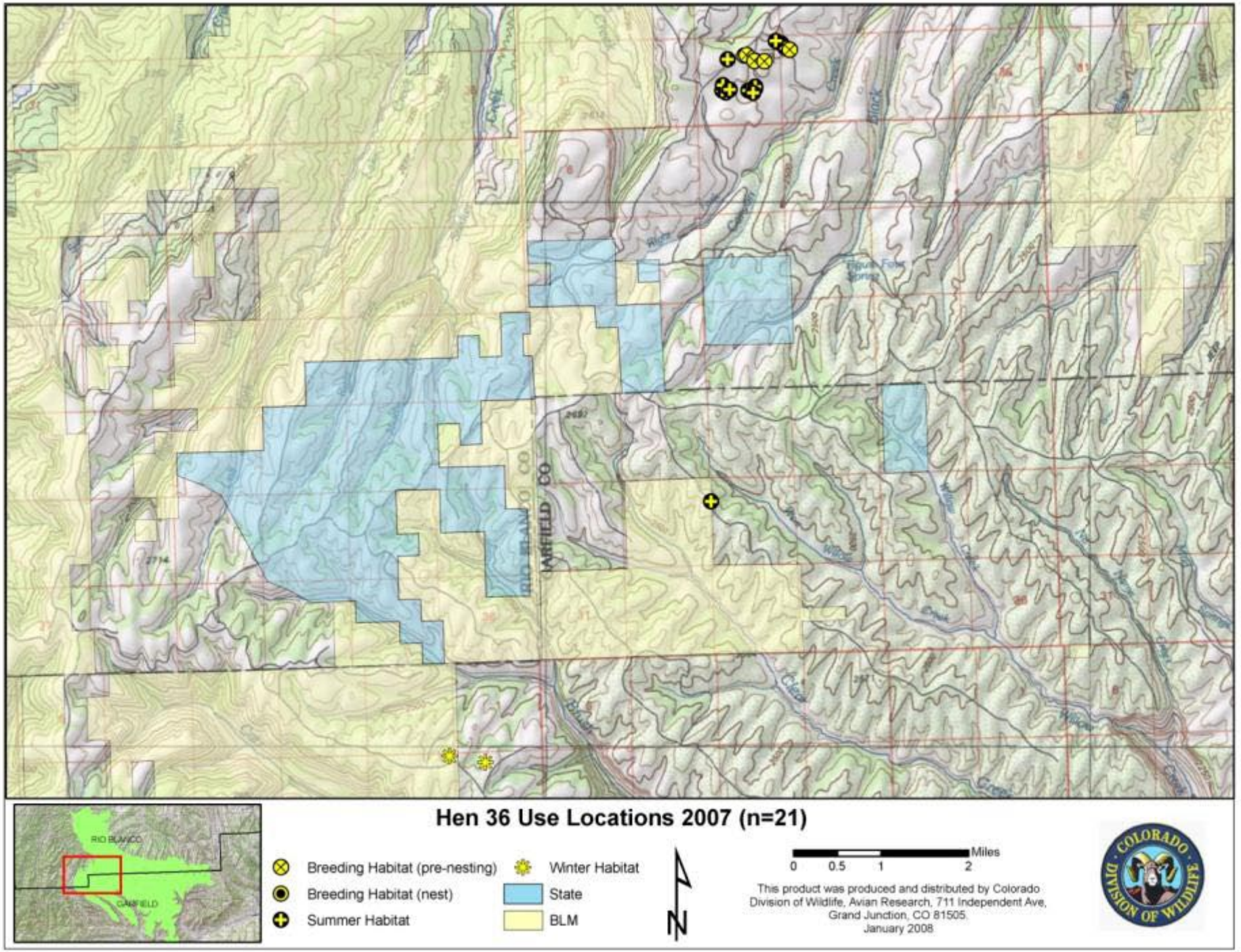

Figure 20. Female greater sage-grouse #36 use locations in the west central Colorado PPR study area, 2007.

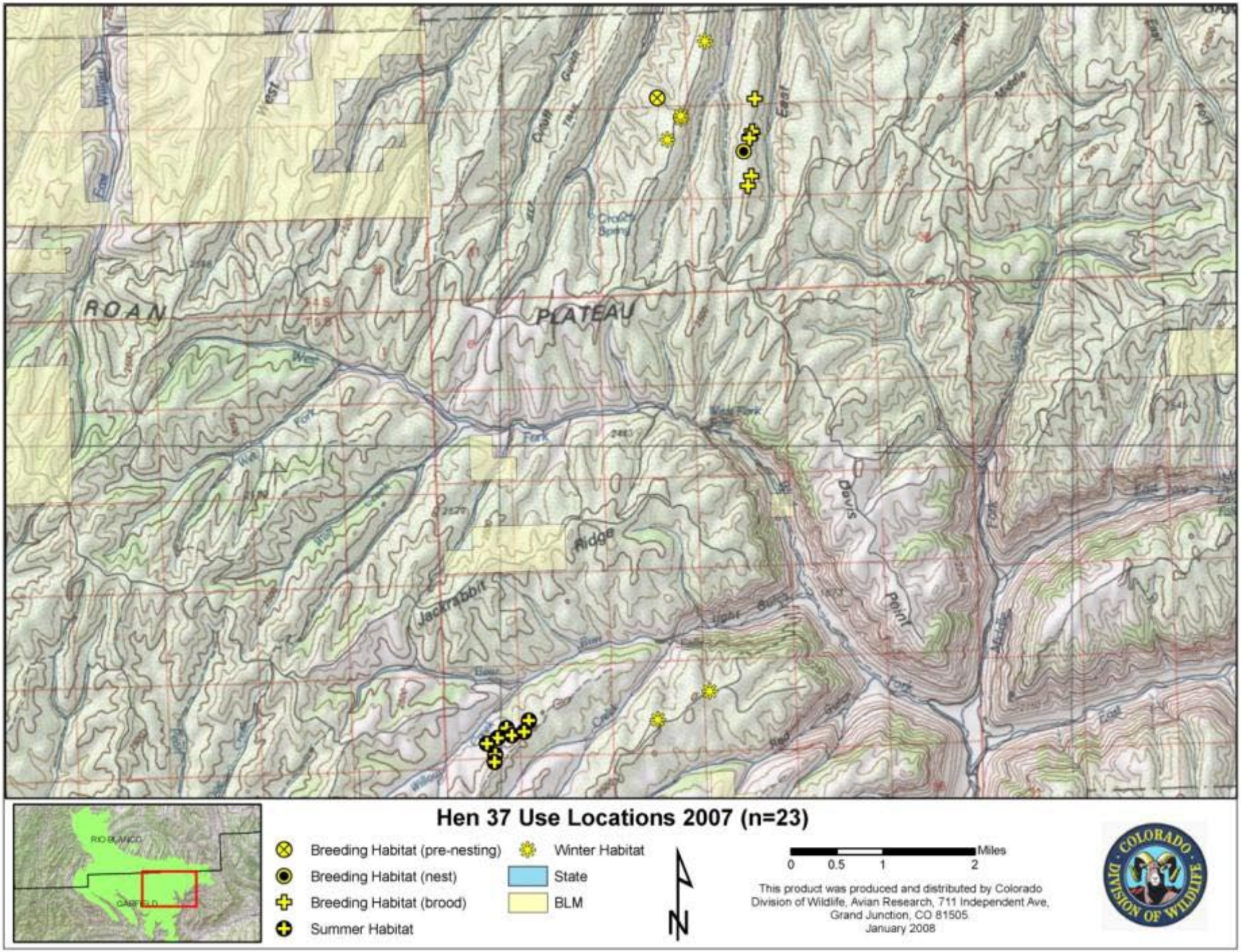

Figure 21. Female greater sage-grouse #37 use locations in the west central Colorado PPR study area, 2007.

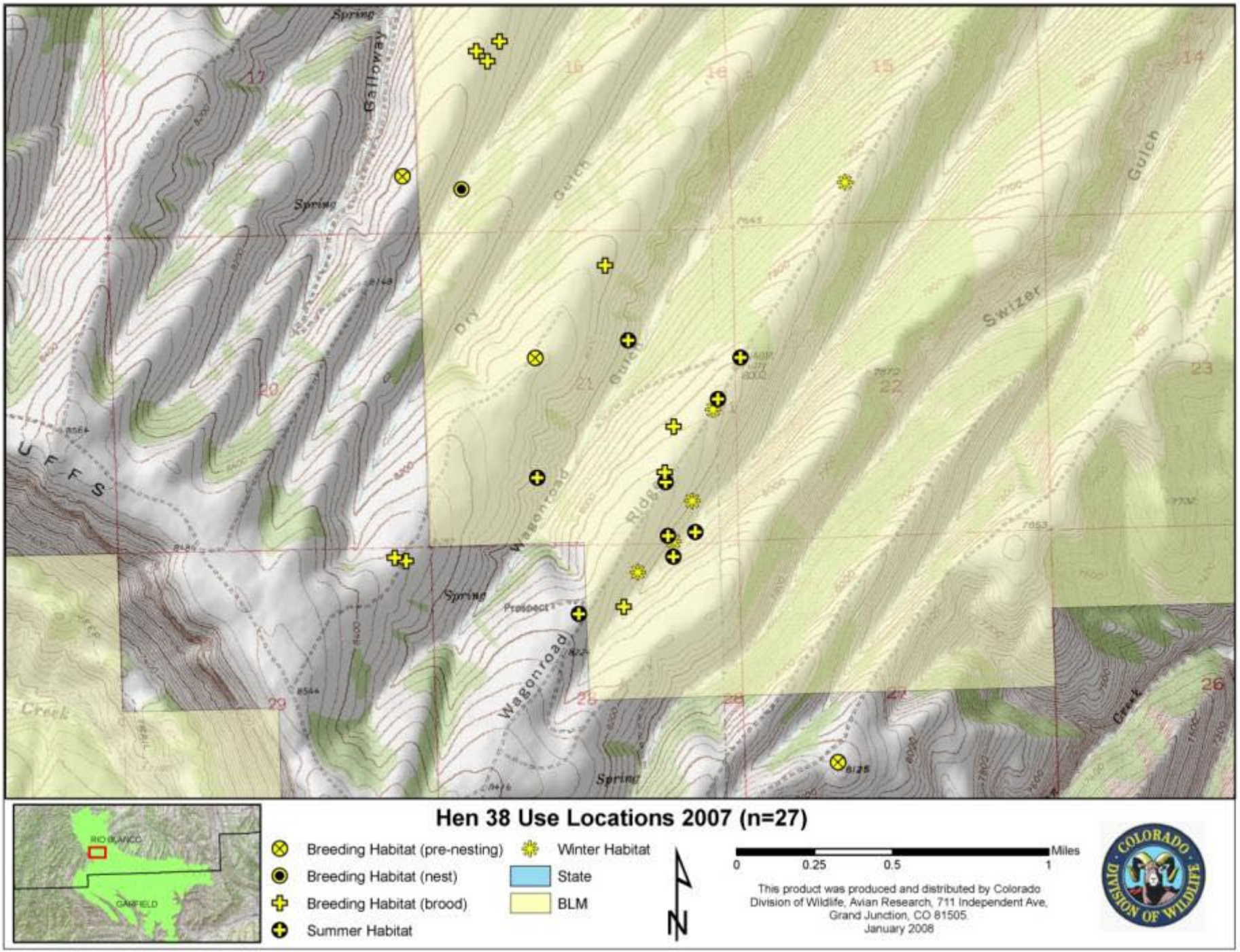

Figure 22. Female greater sage-grouse #38 use locations in the west central Colorado PPR study area, 2007.

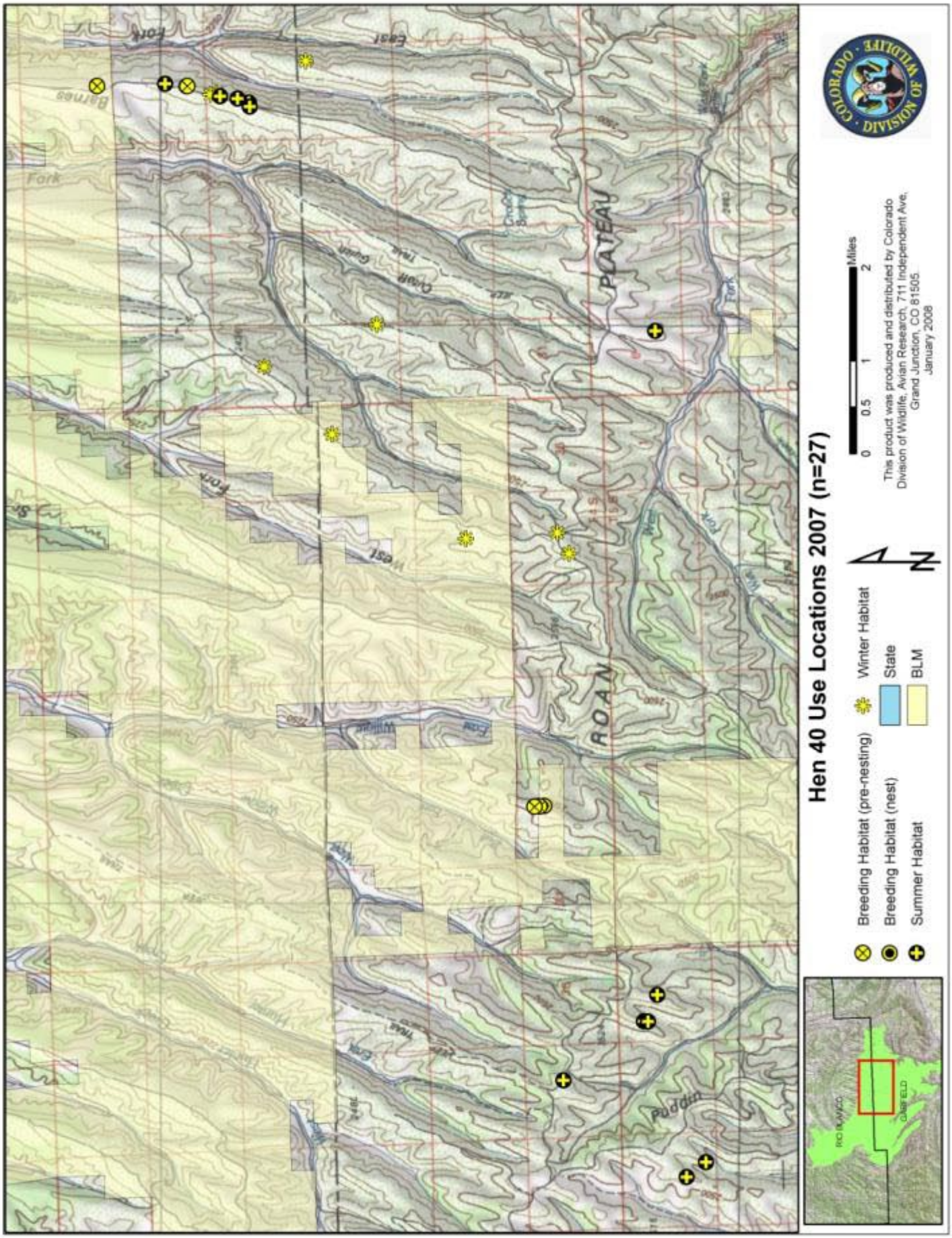

Figure 23. Female greater sage-grouse #40 use locations in the west central Colorado PPR study area, 2007.

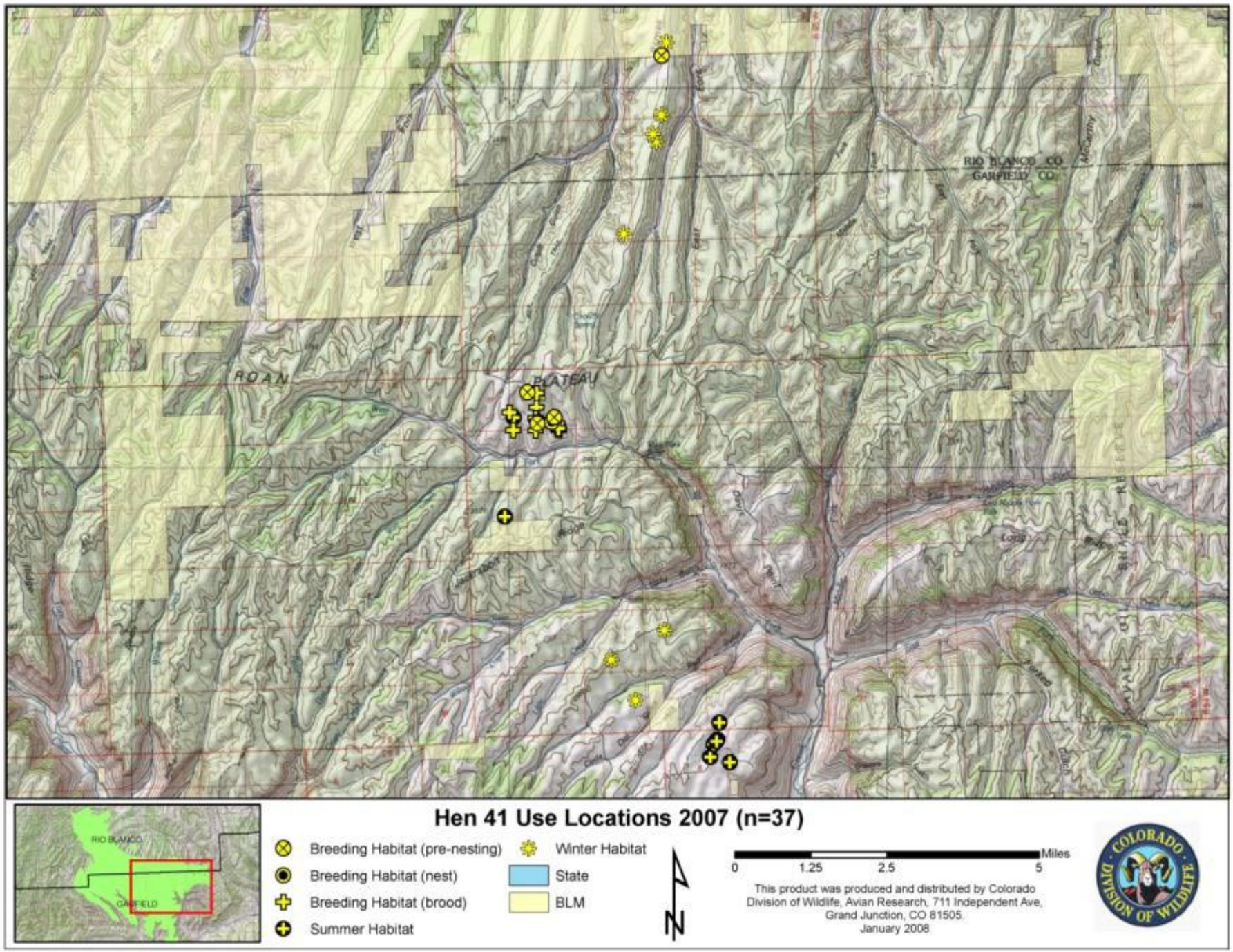

Figure 24. Female greater sage-grouse #41 use locations in the west central Colorado PPR study area, 2007.

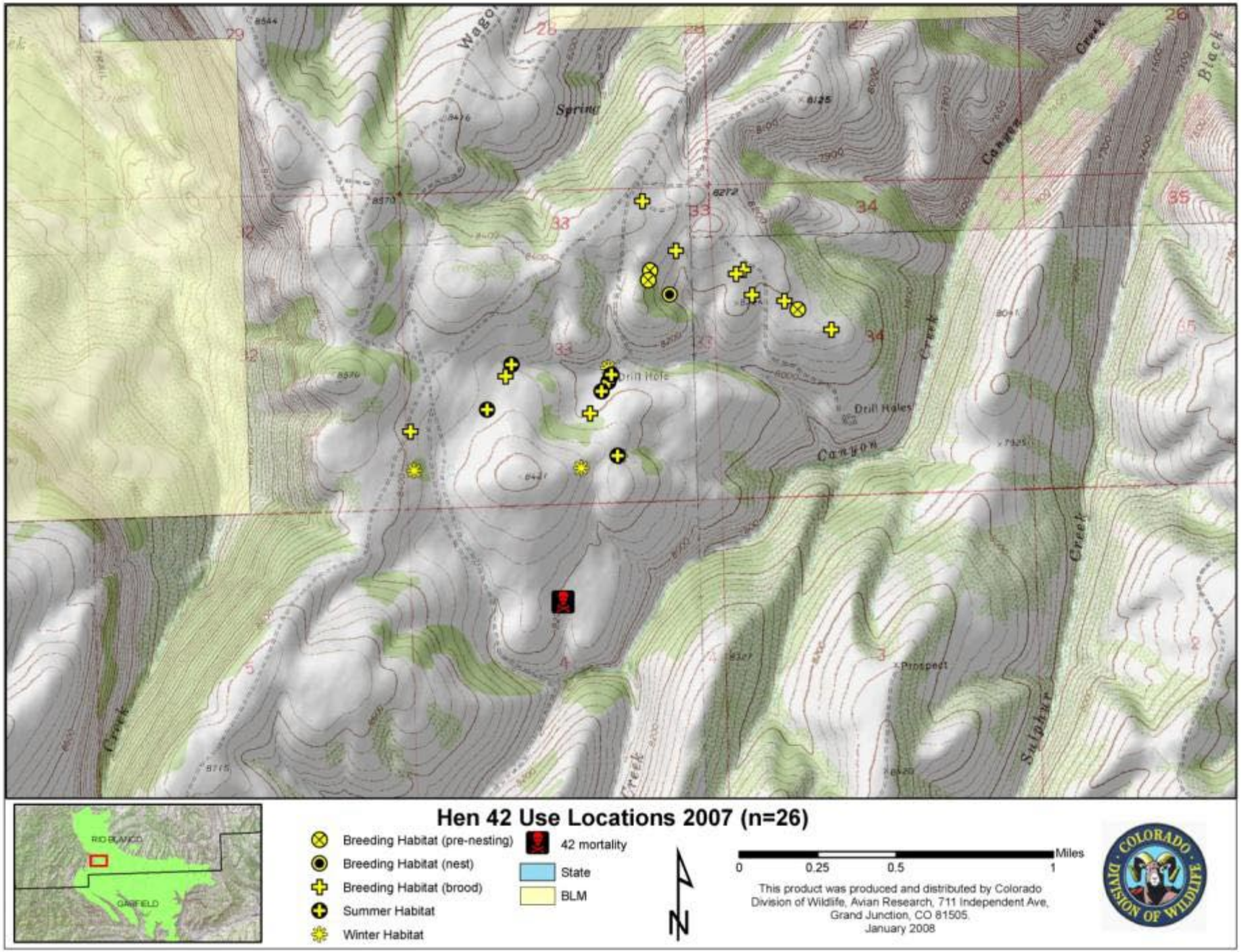

Figure 25. Female greater sage-grouse #42 use locations in the west central Colorado PPR study area, 2007.

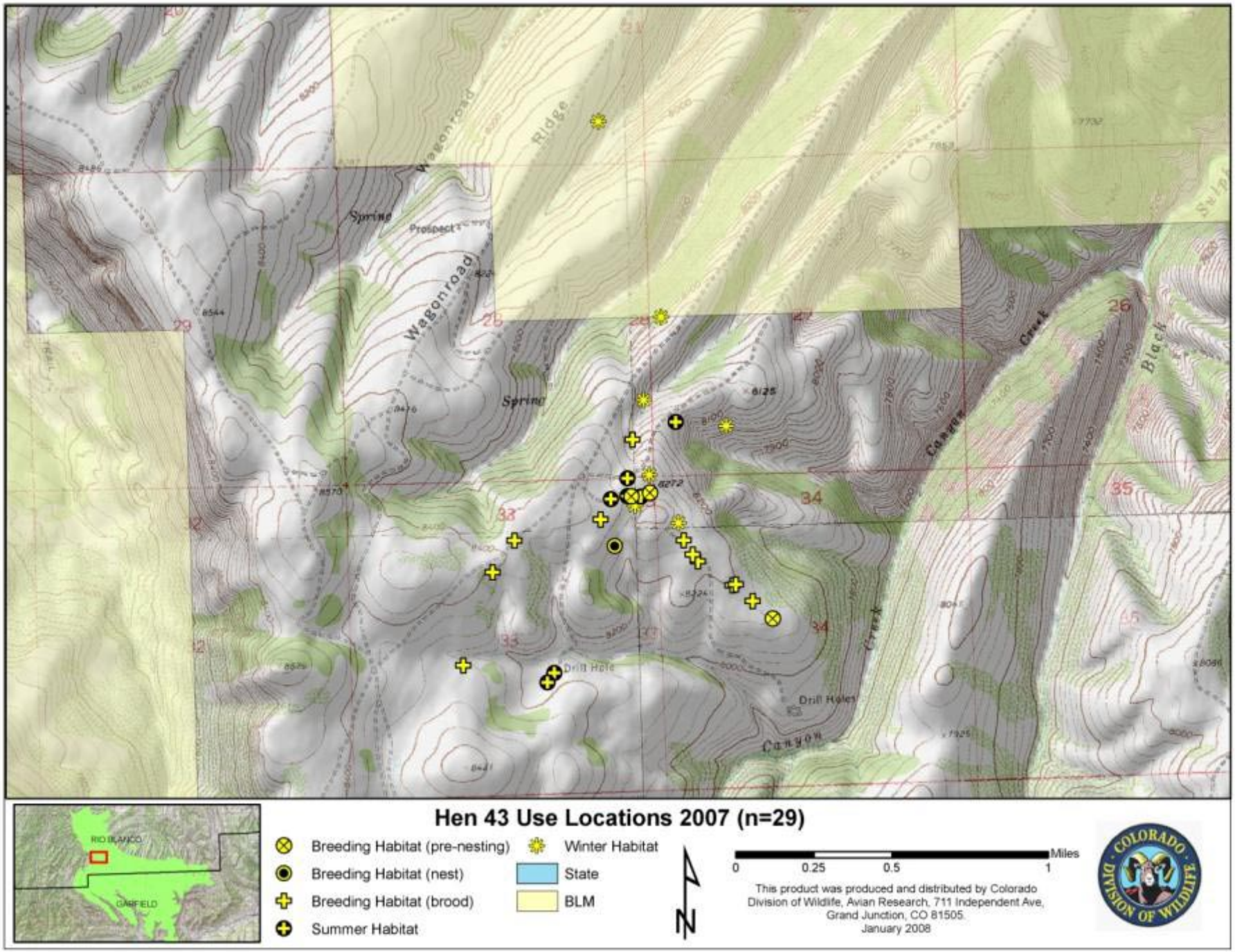

Figure 26. Female greater sage-grouse #43 use locations in the west central Colorado PPR study area, 2007.

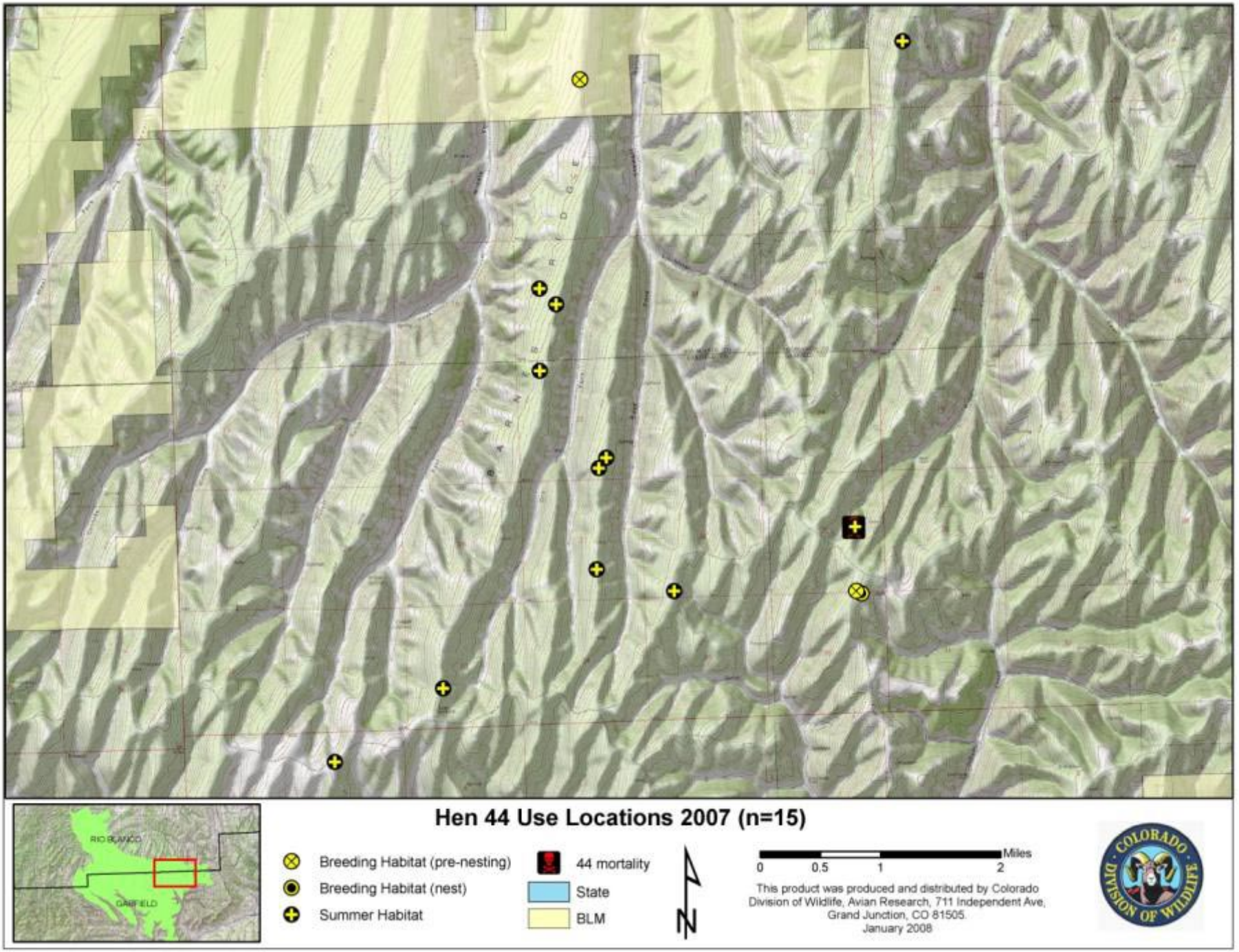

Figure 27. Female greater sage-grouse #44 use locations in the west central Colorado PPR study area, 2007.

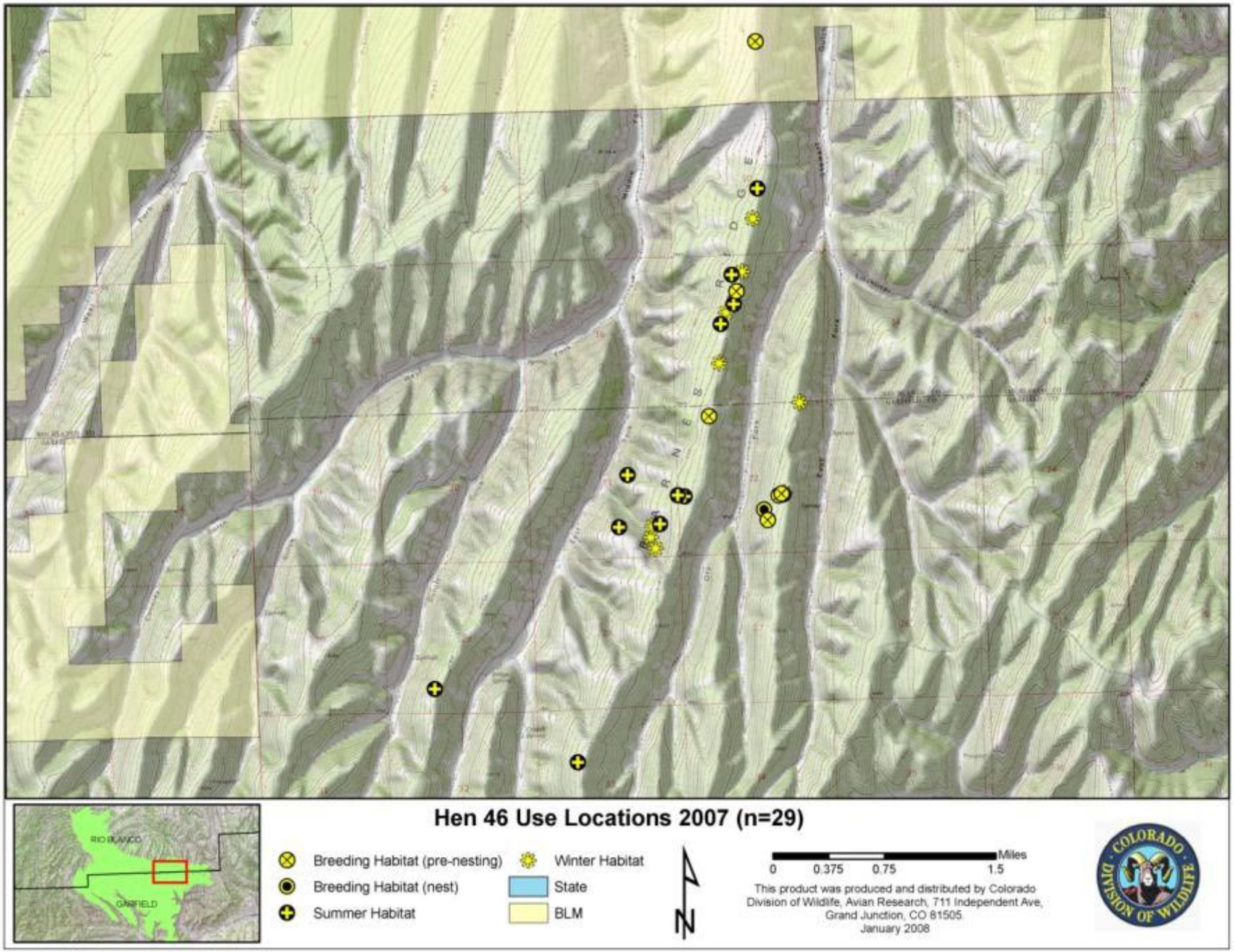

Figure 28. Female greater sage-grouse #46 use locations in the west central Colorado PPR study area, 2007.

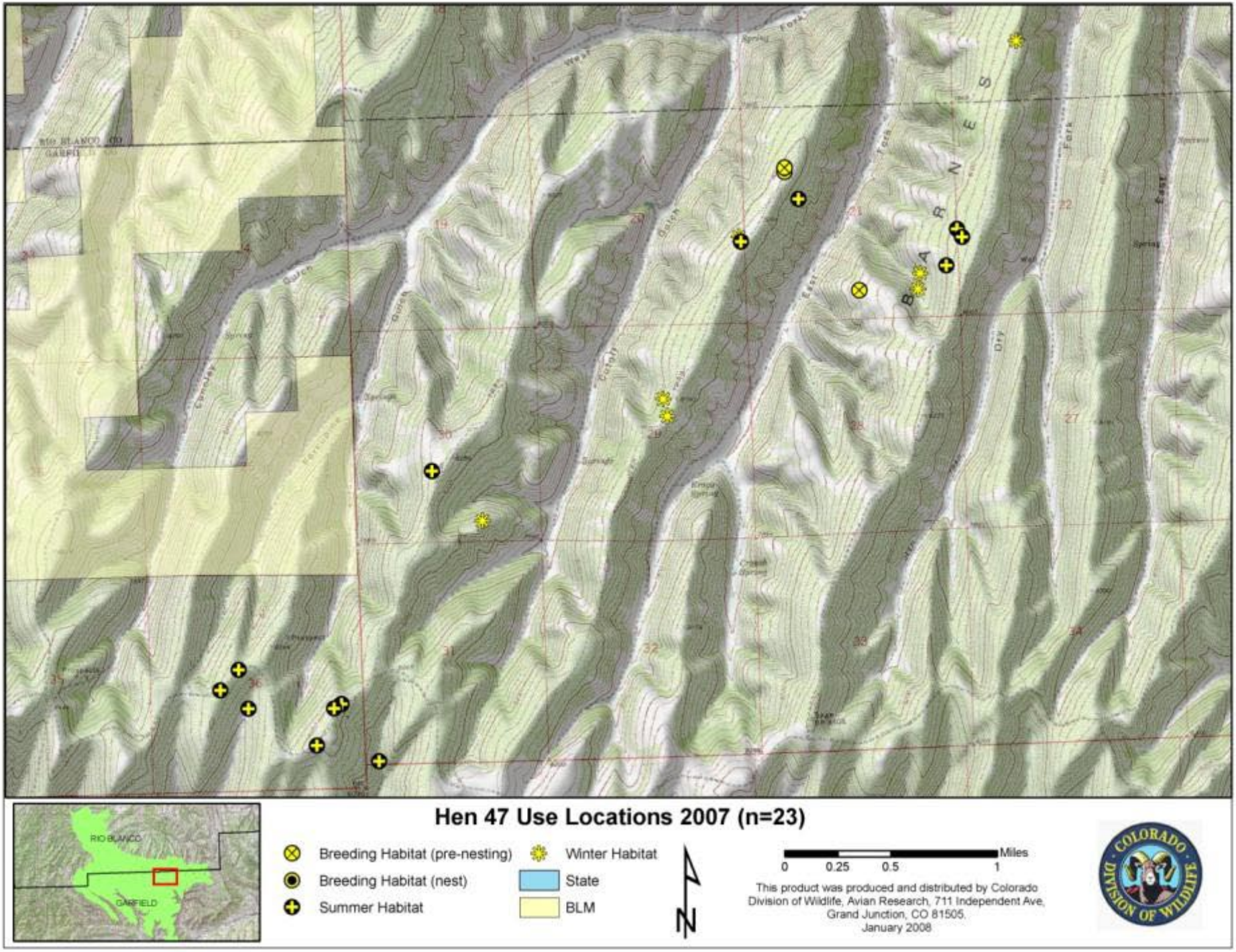

Figure 29. Female greater sage-grouse #47 use locations in the west central Colorado PPR study area, 2007.

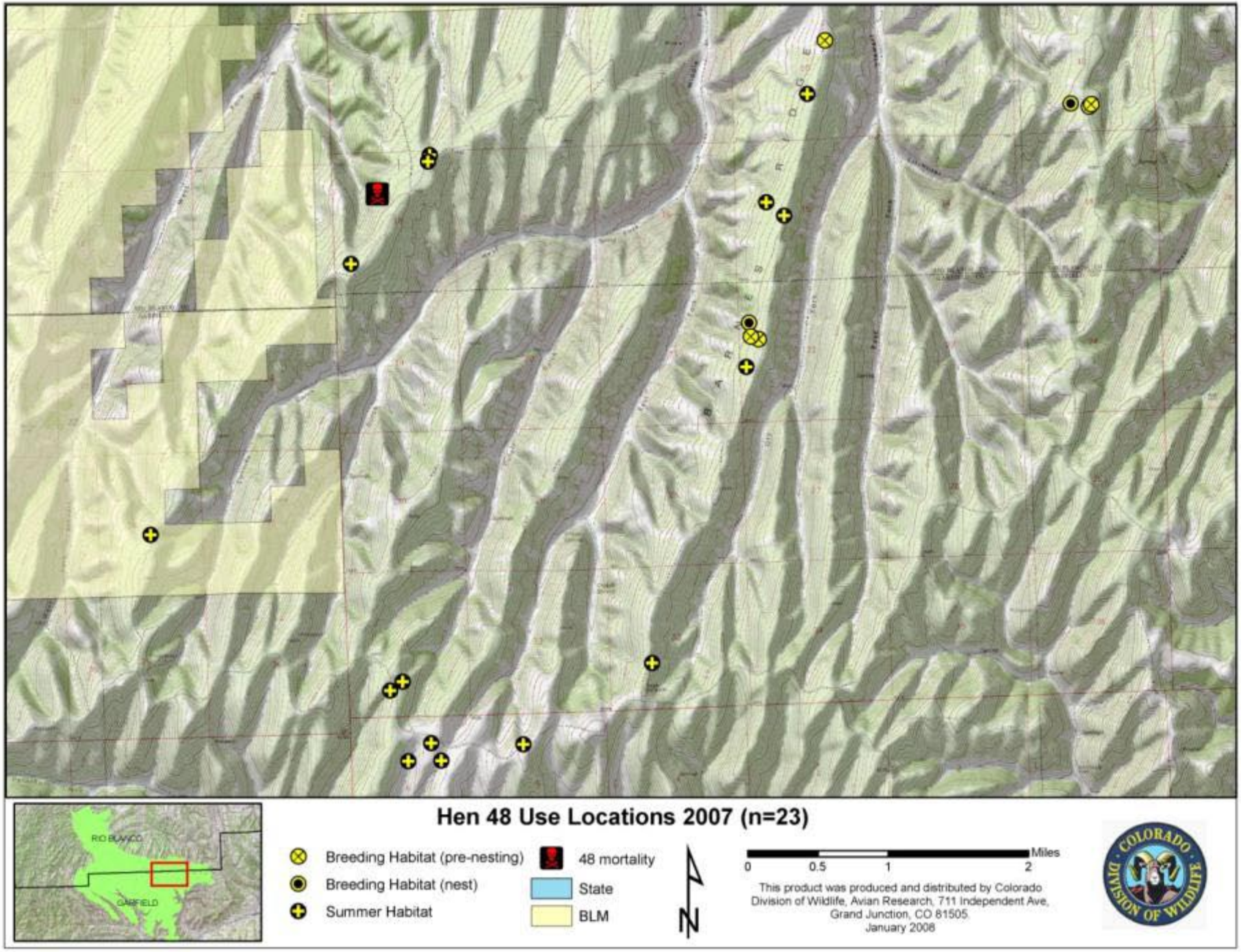

Figure 30. Female greater sage-grouse #48 use locations in the west central Colorado PPR study area, 2007.

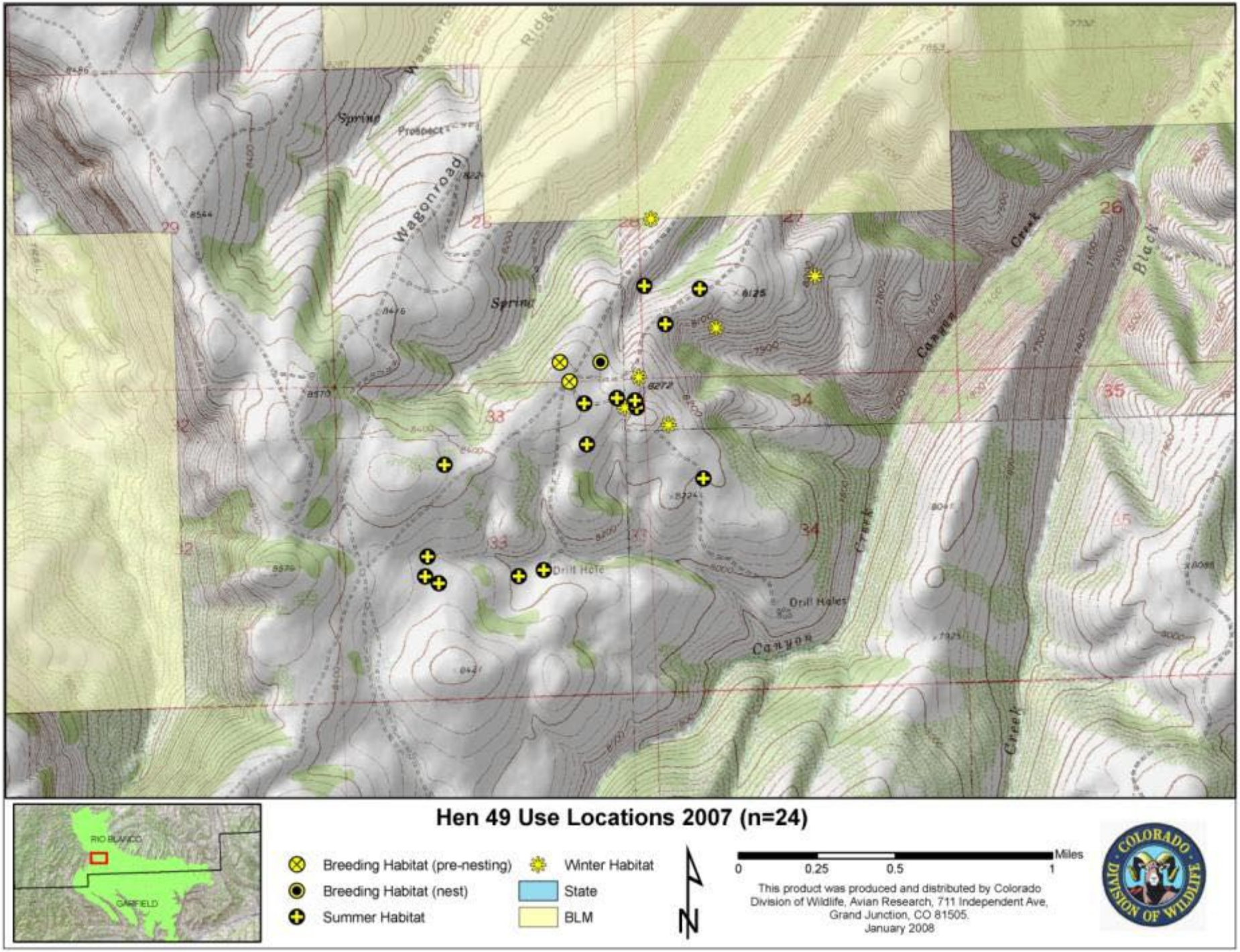

Figure 31. Female greater sage-grouse #49 use locations in the west central Colorado PPR study area, 2007.

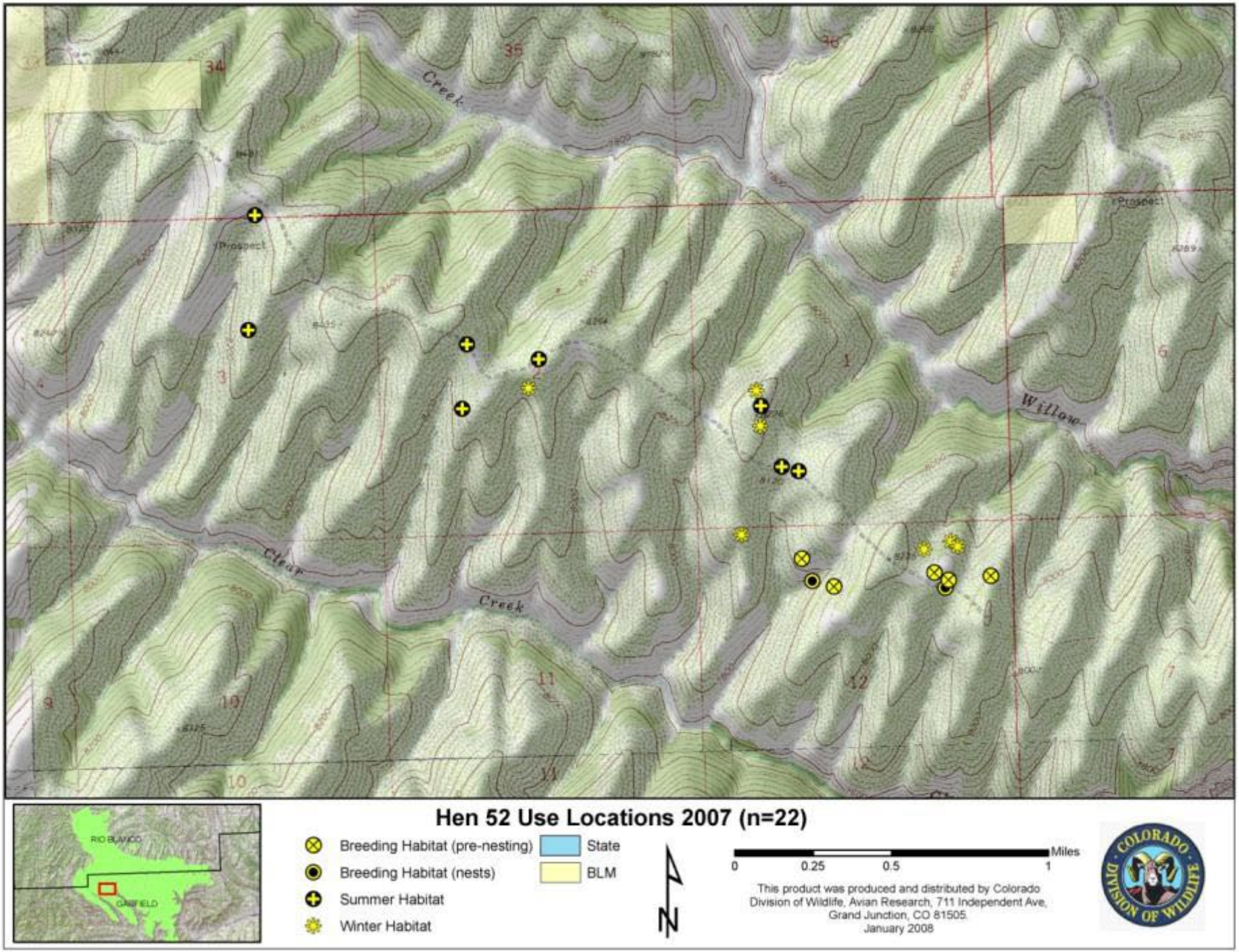

Figure 32. Female greater sage-grouse #52 use locations in the west central Colorado PPR study area, 2007.

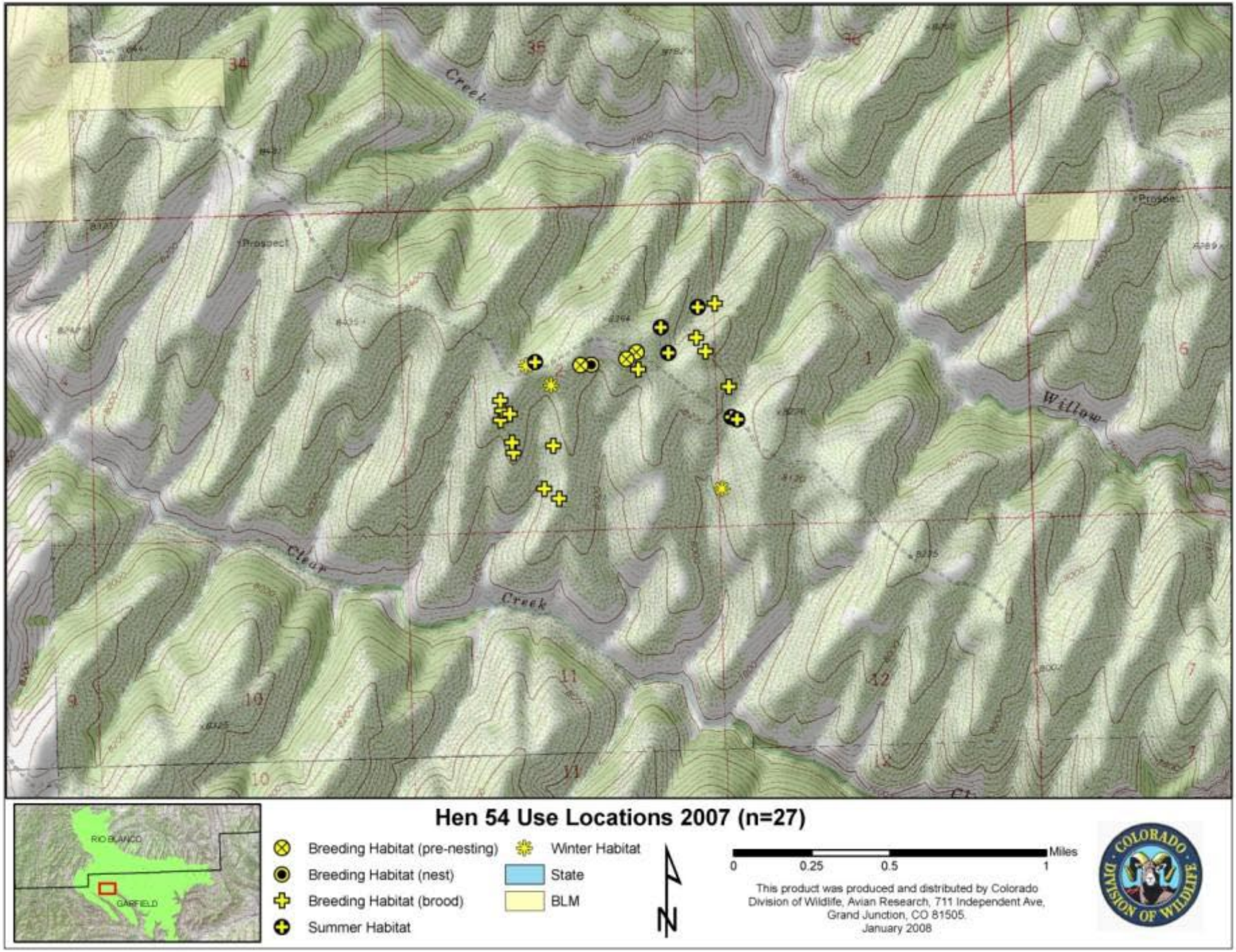

Figure 33. Female greater sage-grouse #54 use locations in the west central Colorado PPR study area, 2007.

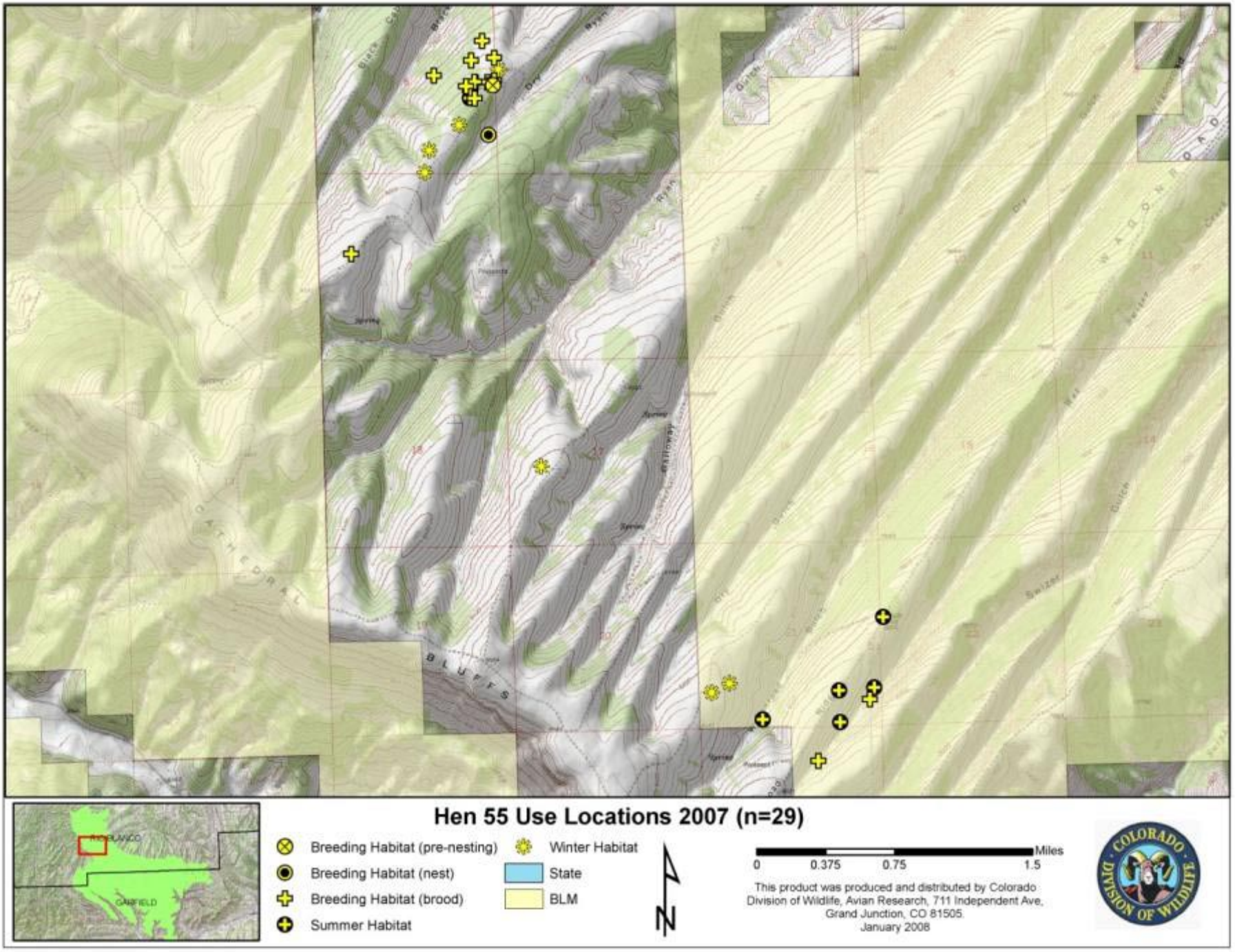

Figure 34. Female greater sage-grouse #55 use locations in the west central Colorado PPR study area, 2007.

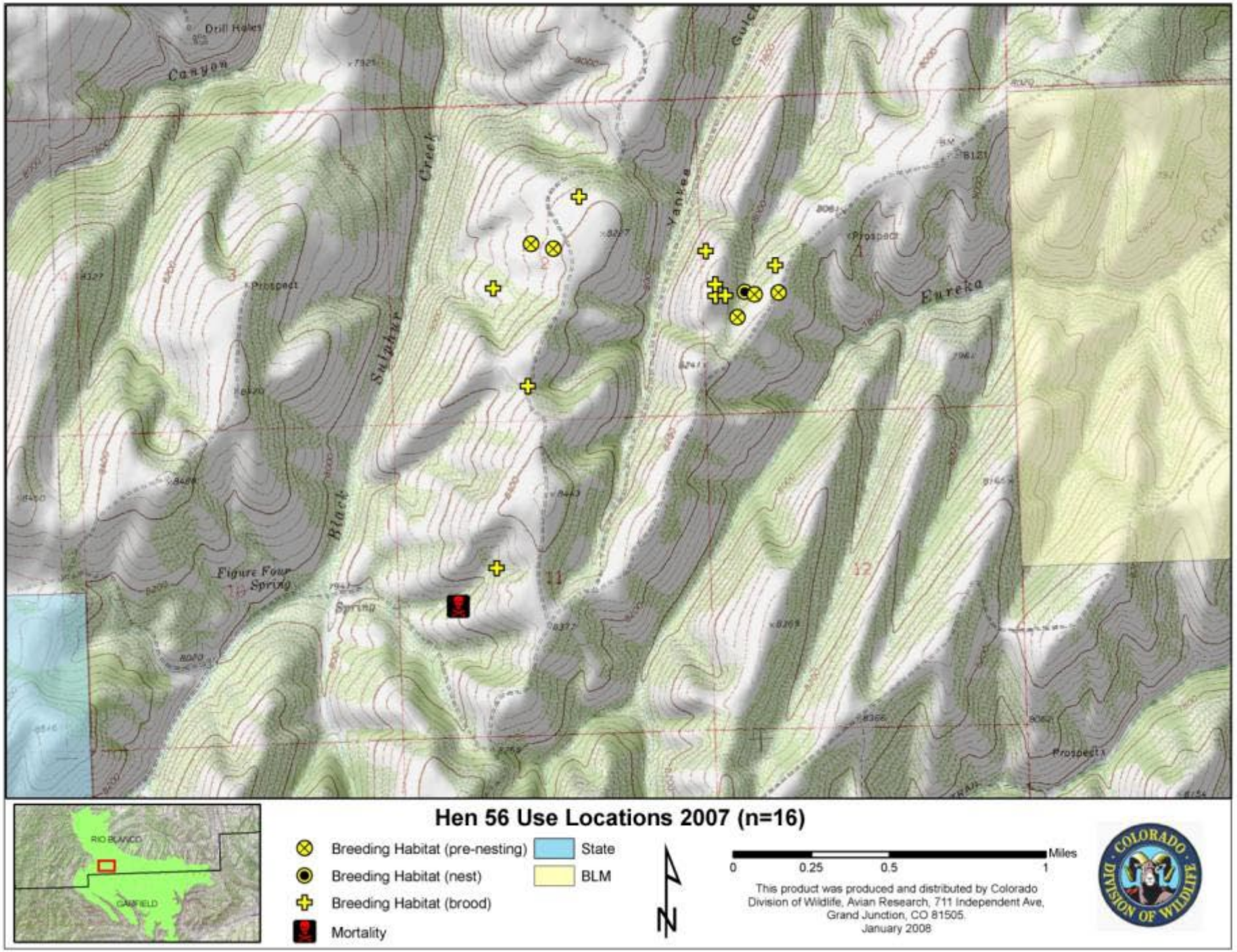

Figure 35 Female greater sage-grouse #56 use locations in the west central Colorado PPR study area, 2007.

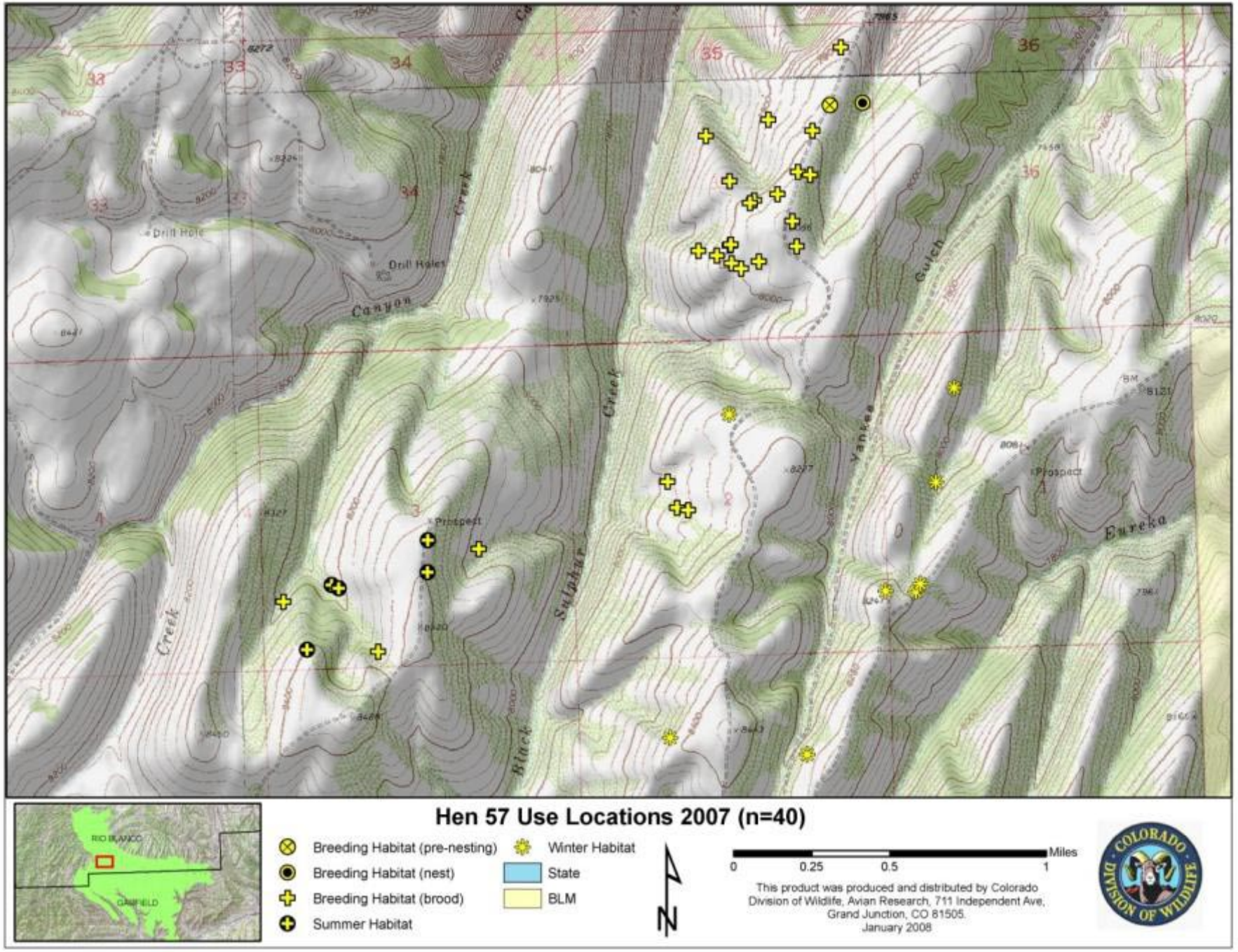

Figure 36. Female greater sage-grouse #57 use locations in the west central Colorado PPR study area, 2007.

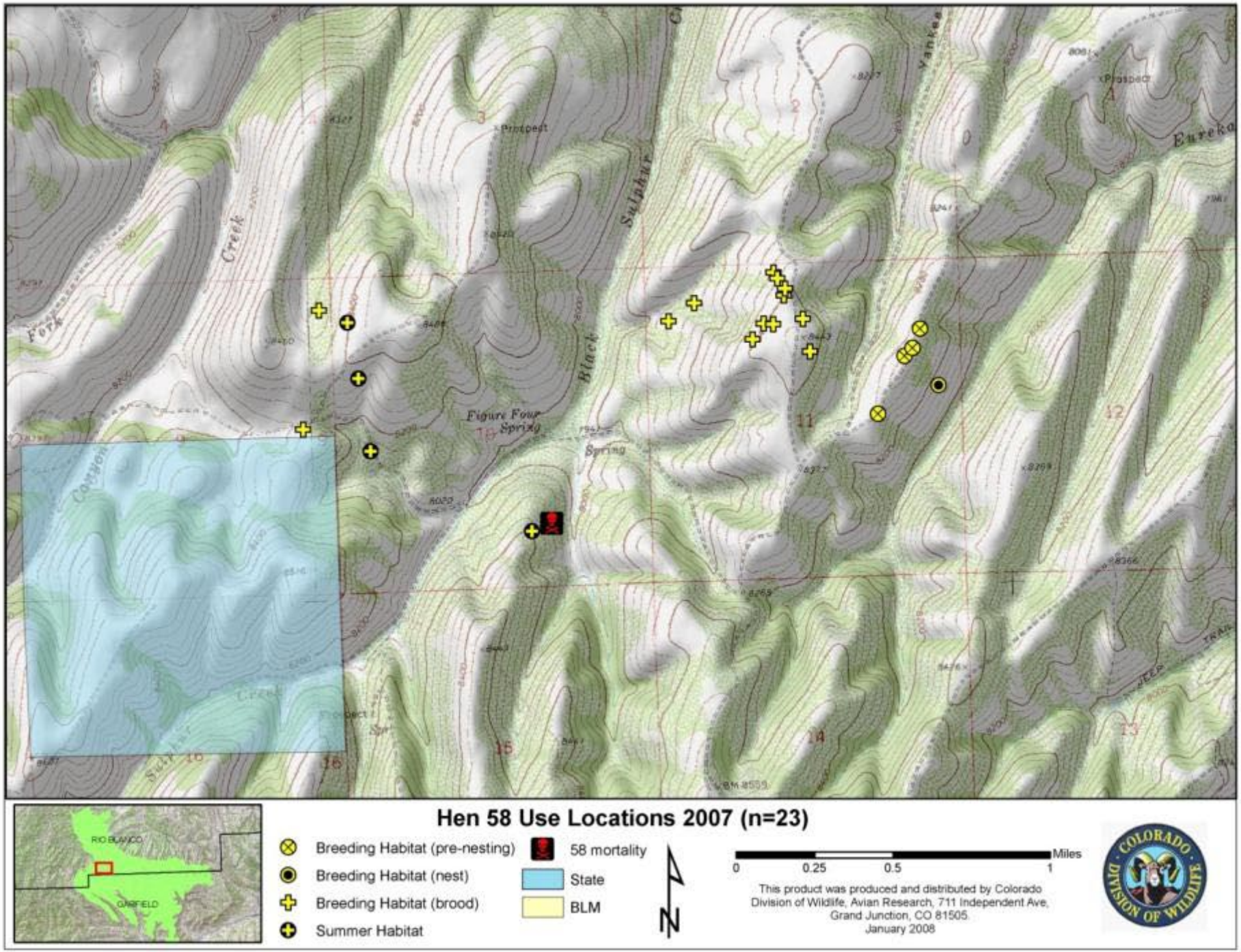

Figure 37. Female greater sage-grouse #58 use locations in the west central Colorado PPR study area, 2007.

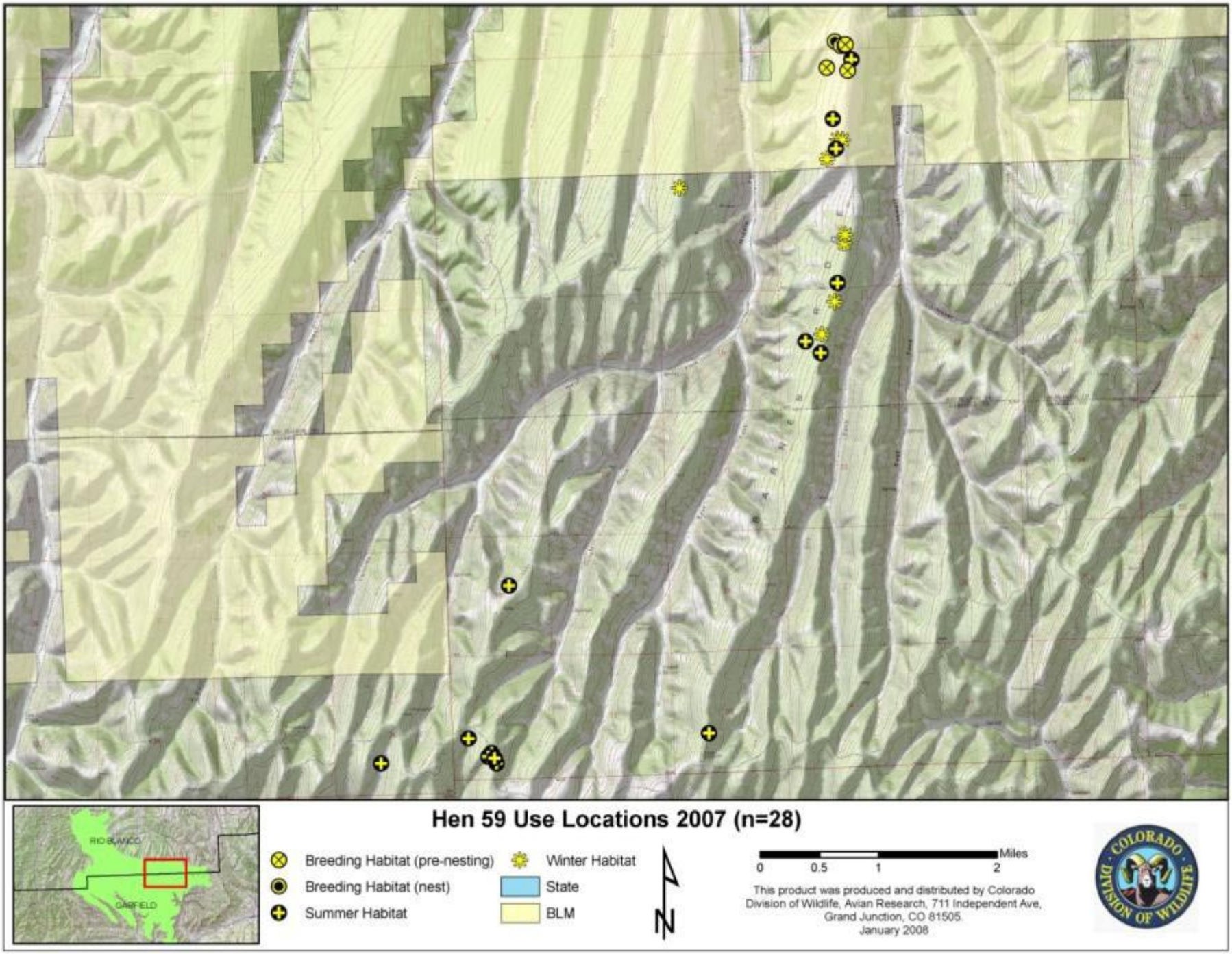

Figure 38. Female greater sage-grouse #59 use locations in the west central Colorado PPR study area, 2007.

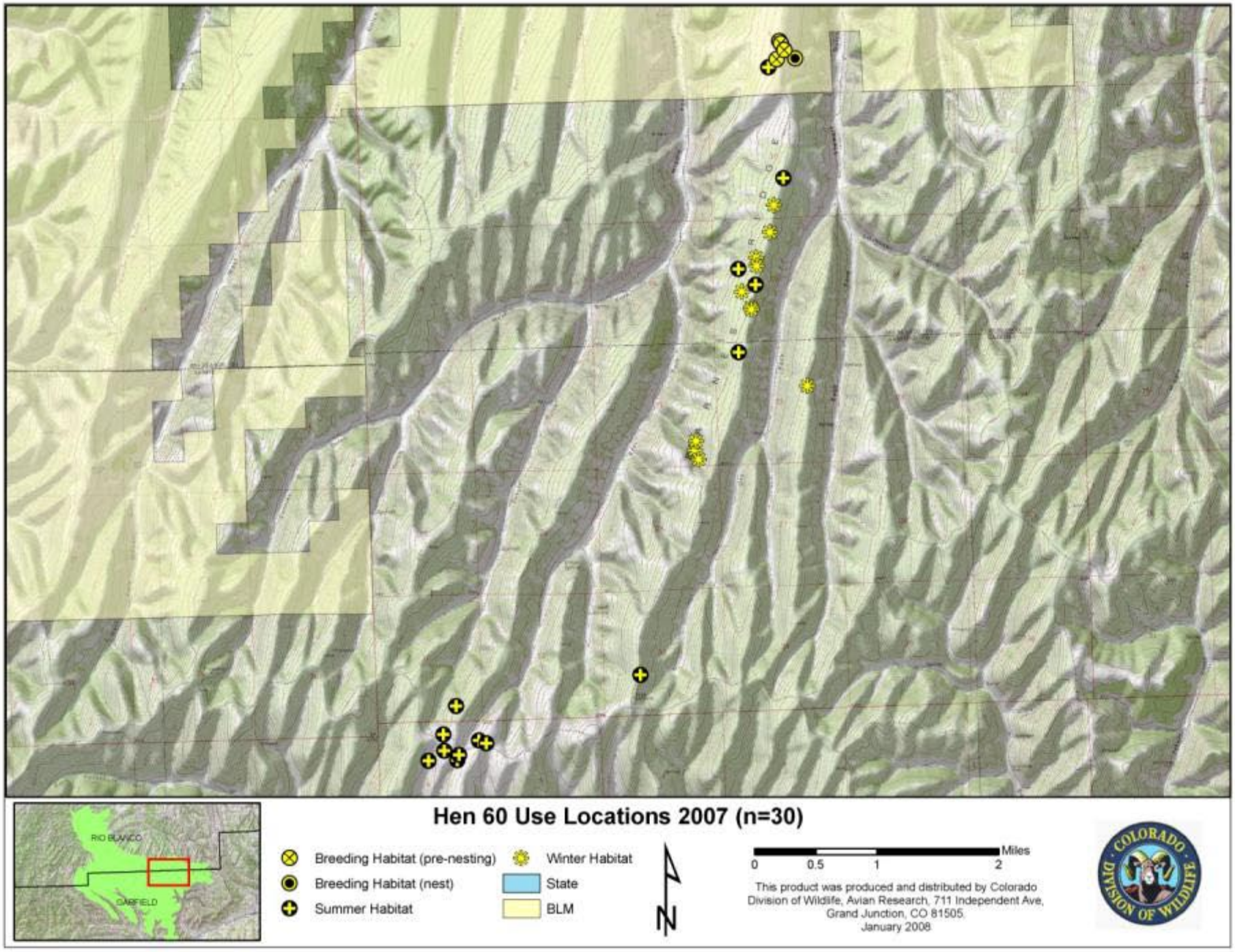

Figure 39. Female greater sage-grouse #60 use locations in the west central Colorado PPR study area, 2007.

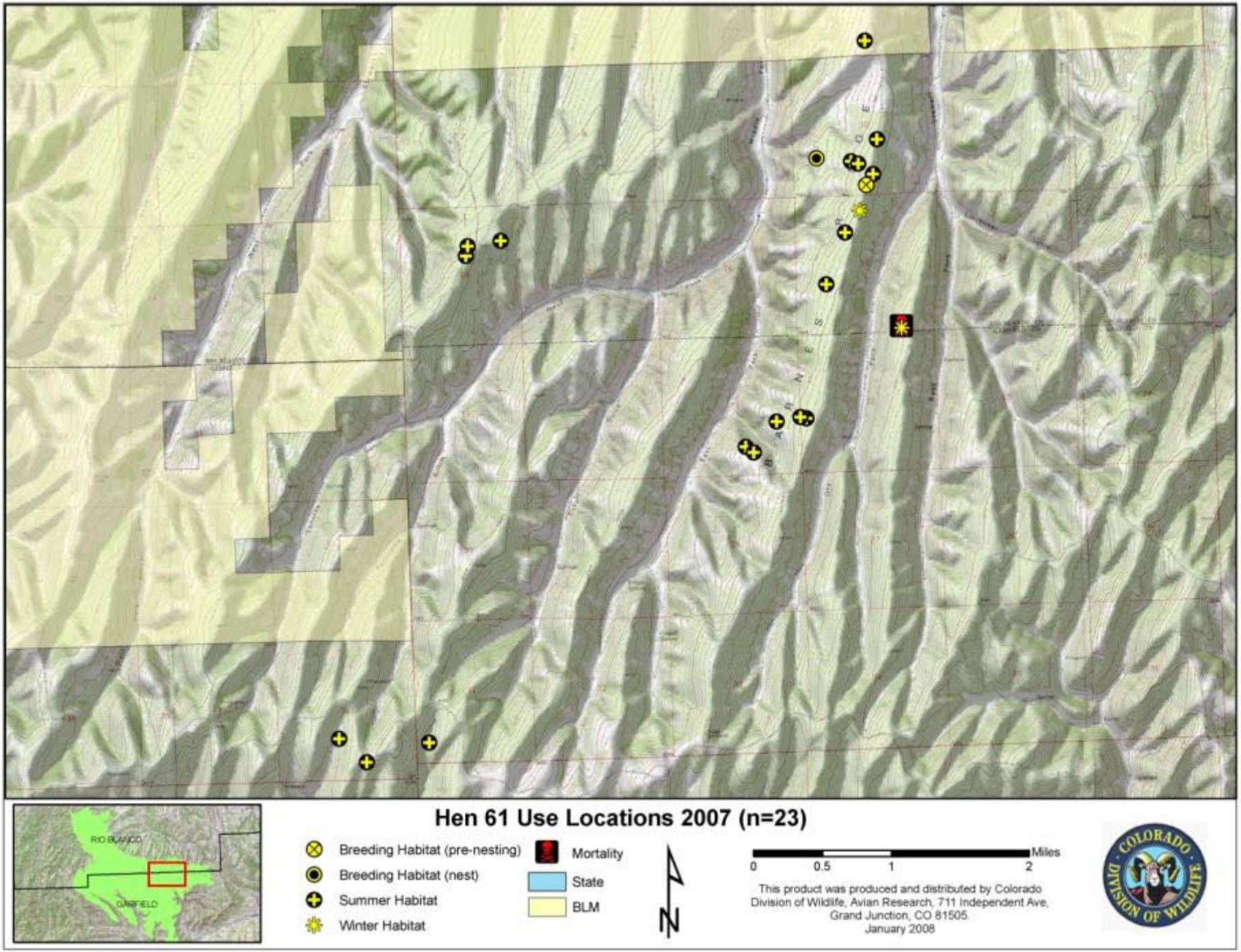

Figure 40. Female greater sage-grouse #61 use locations in the west central Colorado PPR study area, 2007.

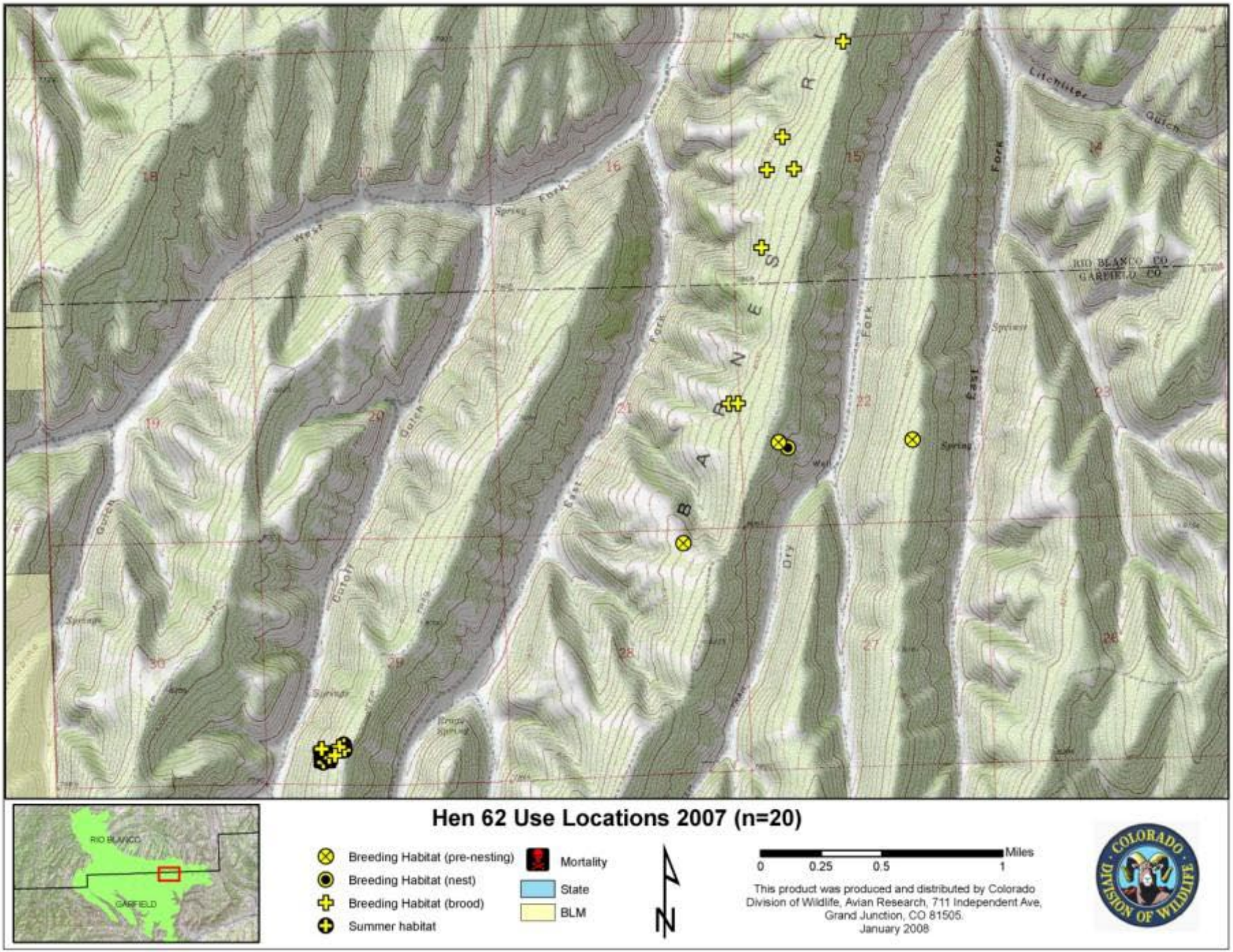

Figure 41. Female greater sage-grouse #62 use locations in the west central Colorado PPR study area, 2007.

Appendix A

Genetic Make-up of the Parachute/Piceance/Roan Population of Greater Sage-grouse

FINAL REPORT

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Introduction

The Parachute/Piceance/Roan (PPR) population of Greater Sage-grouse (*Centrocercus urophasianus*) is one of several small, isolated populations of Sage-grouse (*Centrocercus spp.*) in the state of Colorado. Habitat for Greater Sage-grouse in this area is naturally fragmented and is undergoing rapid oil and gas development. For this reason, it is important to identify baseline information on the genetic characteristics of this population, as it will be used to assess current population status and to help identify future management strategies for this population.

Previous genetic studies (Kahn et al. 1999, Oyler-McCance et al. 2005a) have characterized the genetic make-up of five Greater Sage-grouse populations in Colorado using mitochondrial DNA (mtDNA) sequence data and data from nuclear microsatellites. The populations used in these studies included North Park, Middle Park, Eagle, Cold Springs, and Blue Mountain. The objective of this study was to characterize the PPR population using the same mtDNA and nuclear markers as have been used previously (Kahn et al. 1999, Oyler-McCance et al. 2005a) so that a direct comparison could be made between PPR and the five other characterized Greater Sage-grouse populations in Colorado.

Materials and Methods

Tissue collection and DNA extraction

Seventy blood and feather samples were collected from the PPR population during various research projects. DNA was extracted from blood samples using the GenomicPrep Blood DNA Isolation Kit (Amersham Biosciences) using the modifications of Oyler-McCance et al. (2005b).

Mitochondrial sequencing

A 146 base pair portion of hypervariable control region I was amplified using the Polymerase Chain Reaction (PCR) and sequenced using a dye terminator cycle sequencing reaction (Beckman Coulter CEQ8000) as

described by Benedict et al. (2003). This region was used because it was known to contain approximately 92% of the variable sites in a larger 380 base pair region spanning control region I (Kahn et al. 1999).

Microsatellite fragment analysis

Seven nuclear microsatellite loci (LLST1, SGCA5, SGCA9, SGCA11, LLSD3, LLSD8, and ADL0230) were screened using the methods described in Oyler-McCance et al. (2005b). Briefly, PCR reactions were performed using a dye-labeled forward primer and amplified products were then run on the CEQ 8000 Genetic Analysis System (Beckman Coulter). One locus, SGCA11, was dropped due to difficulty comparing it to previous data.

Data analysis

All mtDNA sequences were edited and aligned using Sequencher Version 4.1.4 and haplotypes were identified. Measures of genetic diversity were calculated in Arlequin 2.000 (Schneider et al. 2000) as were pairwise population F_{ST} tests. Populations were deemed to be significantly different using a Bonferroni corrected P value of 0.003. Pairwise F_{ST} values were then used to construct a neighbor-joining network in PHYLIP 3.57 (Felsenstein 1989) that was viewed using the program TREEVIEW (Page 1996).

The mean number of alleles for each population were calculated and the observed and expected levels of heterozygosity were estimated using Genalex (Peakall and Smouse 2006). Microsatellite loci were tested (by population) for departures from Hardy-Weinberg equilibrium (Guo and Thompson 1992) using the computer program Arlequin 2.000 (Schneider et al. 2000). Pairwise population genetic distances (R_{ST}) were calculated in Arlequin 2.000 (Schneider et al. 2000). Populations were deemed to be significantly different using a Bonferroni corrected P value of 0.003. Pairwise R_{ST} values were then used to construct a neighbor-

joining network in PHYLIP 3.57 (Felsenstein 1989) that was viewed using the program TREEVIEW (Page 1996).

Population structure was also examined using STRUCTURE 2.00 software (Pritchard et al. 2000). In this program, individuals are grouped into clusters without regard to the assigned population using a model-based clustering analysis. The number of "populations" (K) was initially estimated by conducting five independent runs each of K = 1- 10 with 100,000 Markov Chain Monte Carlo (MCMC) repetitions and a 100,000 burnin period using the model with admixture, correlated allele frequencies, and no prior information. An additional set of five independent runs was then conducted with K= 1 - 5 with 500,000 MCMC repetitions and a 500,000 burnin period using the above model.

Results

Mitochondrial Sequence Analysis

Of the 65 individuals sequenced, 8 different haplotypes were found (Table 1, Fig. 1). Of those 8 haplotypes, 5 were found elsewhere in Colorado. Three of those haplotypes (A, B, and C) were common in Colorado, found in at least 4 of the 5 other populations. Haplotypes E and H are also shared with Colorado populations (Table 1) yet with three or less populations. Haplotype W, which occurs in PPR and not elsewhere in Colorado, is found in Wayne and Rich counties in Utah and also in the Strawberry Valley population in Utah (Oyler-McCance et al. 2005a). Haplotype EU is also found in the Rawlins, Wyoming population (Oyler-McCance et al. 2005a). A new haplotype (labeled New3) was found in PPR and is not found elsewhere among Greater Sage-grouse (Oyler-McCance et al. 2005a). This haplotype is very closely related to haplotype B with only one substitution differing between them.

Levels of genetic diversity in PPR were similar to other populations in Colorado (Table 2). PPR had 8 haplotypes, which is well within the range of the other Colorado populations with the number of haplotypes ranging from 5 in Eagle to 11 in Blue
Mountain. In terms of haplotype diversity, PPR also falls well within the range of the other populations (Table 2).

Pairwise population F_{ST} tests revealed that PPR was significantly different from three other Colorado populations (Blue Mountain, Cold Springs, and Eagle). The only other significant difference in Colorado was between Blue Mountain and Eagle. This metric, however, is influenced by comparisons using widely different sample sizes. It is possible that there are more significant comparisons with PPR due to the unusually high sample size in that population. The neighbor-joining network (Fig. 2) showed that PPR was associated most closely to North Park and did not appear to be more different than other populations in Colorado.

Microsatellite Analysis

Tests for departures from Hardy-Weinberg Equilibrium (HWE) within PPR showed that no locus was out of HWE. Levels of genetic diversity in PPR, measured using microsatellite data, were comparable to other populations in Colorado. The mean number of alleles per locus in PPR was 5.67 (Table 4), which again is well within the range of other populations in Colorado with a low of 5.33 in Eagle and a high of 5.83 in Cold Springs and North Park (Oyler-McCance et al. 2005a). The mean observed heterozygosity in PPR was slightly lower (0.55) than other values in Colorado, which ranged from 0.61 in Cold Springs to 0.69 in Middle Park.

Pairwise population R_{ST} significance tests revealed that most populations in Colorado are not significantly different. PPR was found to be significantly different from Blue Mountain and Cold Springs,

however. Cold Springs was shown to be the most different as it was significantly different from PPR, Blue Mountain, Eagle, and Middle Park. The neighbor-joining network (Fig. 3) showed that PPR was most closely related to Middle Park, followed by Eagle and North Park.

The STRUCTURE analysis revealed that the most appropriate number of populations (K) given the data was 1. This suggests that there is little genetic structure among populations.

Discussion

This analysis of the PPR population compared with 5 other Greater Sage-grouse populations in Colorado revealed that the genetic make-up of PPR is generally consistent with the other 5 populations. Using mtDNA sequence data, 5 of the 8 haplotypes found in PPR (66% of the PPR birds) were also found in the other populations in Colorado (Table 1, Fig 1.). Of the three PPR haplotypes not found in Colorado, 2 (EU and W) were found in the neighboring states of Utah and Wyoming. One haplotype was unique to PPR (New3) and at relatively high frequency (20%). Two other Colorado populations (Blue Mountain and Cold Springs) each also had a unique haplotype representing 10 and 8% of the populations respectively (Oyler-McCance et al. 2005a). The PPR population, had a much higher sample size (65 compared to ~ 20 in the other populations) and the sampling method was different (trapped birds in PPR vs. hunter killed birds in the rest of the Colorado birds), which may influence the potential for relatedness among samples. Additionally, the PPR population did have similar levels of genetic diversity (both in the number of haplotypes and in haplotypes diversity) as the other Colorado populations (Table 2) yet again, a higher sample size likely resulted in more haplotypes being identified. Nonetheless, it appears that the PPR population does not suffer from low diversity and appears to have diversity levels that are comparable to the other Colorado populations. The mtDNA neighbor-joining network (Fig. 2), which was constructed using F_{ST} genetic distances among populations, suggests that PPR is more closely related to North Park, Cold Springs, and Blue Mountain, than to Middle Park and Eagle. The fact that PPR is not shown to have branch lengths longer than the other

Colorado populations suggests that it is not genetically distinct from all other Colorado Greater Sage-grouse populations.

The microsatellite data are relatively concordant with that of the mtDNA data. The STRUCTURE analysis found that the most appropriate number of discrete genetic clusters (K) was 1 given the data from these 6 populations, suggesting that there was little genetic structure within the data. Pairwise population R_{ST} tests (Table 5), based on allele frequencies of populations, revealed a few significant differences among populations yet these differences were primarily between Cold Springs and the other populations. This finding is highlighted with the microsatellite neighbor-joining network (Fig. 3) that shows Cold Springs as the most genetically distinct population. This network suggests that PPR is more closely related to Middle Park and Eagle, contrary to the network built with mtDNA data. This discrepancy is likely due to the different patterns of inheritance of these two types of genetic markers (maternal vs. biparental). An additional factor that could lead to minor differences between the two data sets has to do with the number of loci sampled (sampling error). While the mitochondrial genome represents one locus, multiple sites were sampled in the nuclear genome. Levels of genetic diversity in PPR (Table 4) were again similar to what had been previously been reported for populations in Colorado (Oyler-McCance et al. 2005a). The levels of mean observed heterozygosity in PPR were the lowest reported in Colorado (Table 4) yet the values are only slightly lower than those reported elsewhere (0.55 as opposed to 0.61-0.69). This could be due to a number of factors including smaller population sizes, increased fragmentation among sagebrush habitat resulting in sampled birds being more related, or merely due to the different sampling method used in this study (trapped birds vs. hunter killed birds).

In summary, the Greater Sage-grouse in PPR do not appear to be substantially different from other Greater Sage-grouse sampled in Colorado. There is some level of uniqueness (as represented by the new haplotype found in 20% of the PPR birds) yet this is not unusual as both Cold Springs and Blue Mountain also

contained haplotypes that were unique to that particular population. Additionally, the levels of genetic diversity in PPR do appear to be comparable to other populations although they were reported to have the lowest levels of observed heterozygosity levels.

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Table 1. Sampling locations and mtDNA haplotype frequencies of Sage-grouse in Colorado (from Kahn et al. 1999)

		Haplotypes																		
Location	*n*	A	B	C	D	E	H	L	S	W	X	Z	AA	AC	AD	AE	AF	AL	AM	EU	New3
PPR	65	1	10	13		6	13			1										8	13
Blue Mountain	21	1	8	1	1				1			3	1	1	1	2	1				
Cold Springs	25	3	7	10	1			2				1		1							
Eagle	26	2	2	15	4		3														
Middle Park	21		7	9	2	1	1											1			
North Park	23	4	5	6	3	2	1				1								1		

Table 2. Mitochondrial DNA genetic diversity measures of Greater Sage-grouse populations in Colorado. Standard errors are in parentheses.

Population	Sample size	Number of Haplotypes	Haplotype Diversity (SE)
PPR	65	8	0.85 (0.01)
Blue Mountain	21	11	0.85 (0.07)
Cold Springs	25	7	0.77 (0.06)
Eagle	26	5	0.64 (0.09)
Middle Park	21	6	0.72 (0.07)
North Park	23	8	0.86 (0.04)

Table 3. Pairwise population F_{ST} significance tests. F_{ST} values in bold represent significant differences using a Bonferroni correct P value of 0.003.

	Population				
	PPR	Blue Mountain	Cold Springs	Eagle	Middle Park
Blue Mountain	**0.09110**				
Cold Springs	**0.07643**	0.06103			
Eagle	**0.11458**	**0.20377**	0.03766		
Middle Park	0.07123	0.07353	-0.01906	0.03400	
North Park	0.04689	0.03997	-0.00657	0.05395	0.00509

Table 4. Microsatellite genetic diversity measures of Greater Sage-grouse populations in Colorado. Standard deviations are in parentheses.

Population	Sample size	Mean # of alleles per locus	Mean observed heterozygosity	Mean expected heterozygosity
PPR	70	5.67	0.55 (0.17)	0.61 (0.20)
Blue Mountain	25	5.50	0.68 (0.22)	0.65 (0.23)
Cold Springs	30	5.83	0.61 (0.13)	0.64 (0.17)
Eagle	26	5.33	0.66 (0.24)	0.67 (0.17)
Middle Park	21	5.50	0.69 (0.10)	0.66(0.15)
North Park	22	5.83	0.66 (0.15)	0.61(0.15)

Table 5. Pairwise population R_{ST} significance tests. R_{ST} values in bold represent significant differences using a Bonferroni correct P value of 0.003.

	Population				
	PPR	Blue Mountain	Cold Springs	Eagle	Middle Park
Blue Mountain	**0.09560**				
Cold Springs	**0.21178**	**0.08328**			
Eagle	0.01375	0.03431	**0.13454**		
Middle Park	-0.03364	0.01800	**0.11034**	-0.01182	
North Park	-0.01793	-0.00044	0.06848	0.00119	-0.01986

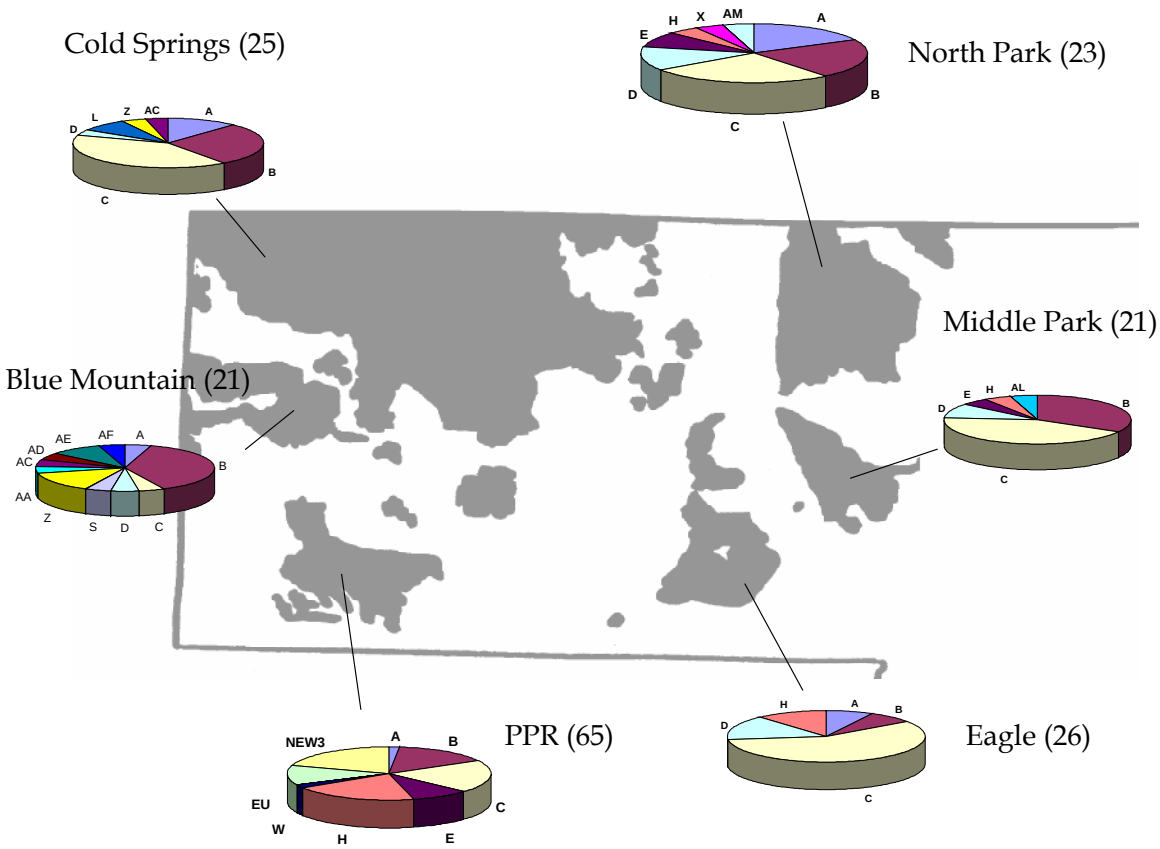

Figure 1. Distribution of mtDNA haplotypes found in PPR and 5 other previously studied populations of Greater Sage-grouse in northern Colorado (Kahn et al. 1999).

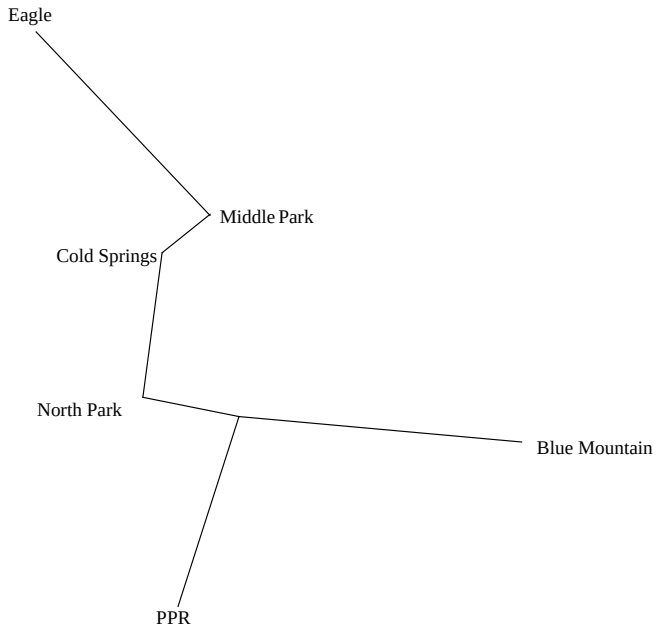

Figure 2. Mitochondrial DNA neighbor-joining network constructed using pairwise F_{ST} values as a genetic distance.

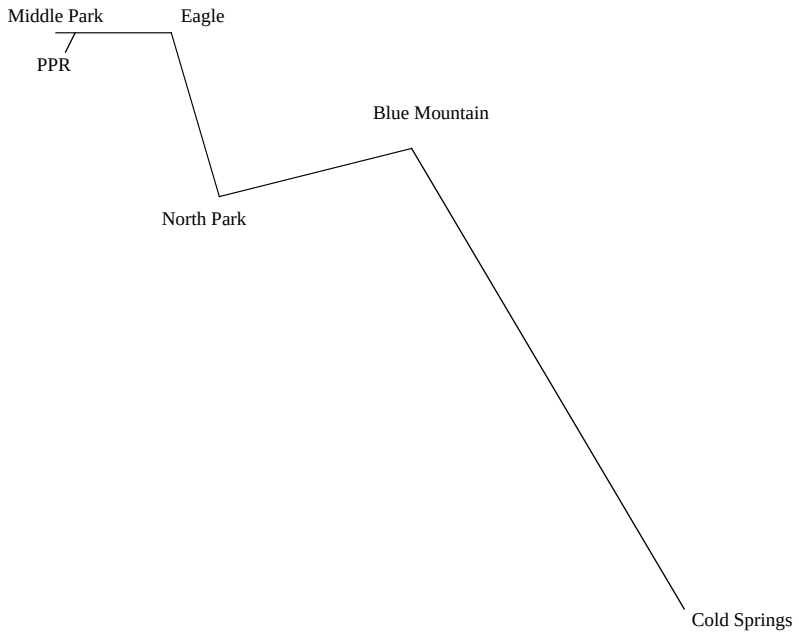

Figure 3. Microsatellite neighbor-joining network constructed using pairwise R_{ST} values as a genetic distance.

Appendix 1. Microsatellite alleles across 6 loci for PPR and the 5 other Greater Sage-grouse populations in Colorado included in this study.

		Loci											
Individual	Population	L1		S5		S9		L3		L8		ADL230	
PI 1	PI	143	146	265	275	322	332	137	145	139	139	109	111
PI 2	PI	143	143	259	265	318	332	137	137	139	139	107	113
PI 3	PI	143	143	259	265	318	318	137	137	139	139	109	113
PI 4	PI	143	143	273	275	340	340	137	137	139	139	105	111
PI 5	PI	143	146	263	265	318	340	137	137	139	139	105	111
PI 6	PI	0	0	0	0	0	0	0	0	139	139	109	109
PI 7	PI	143	143	265	275	328	332	0	0	145	145	105	107
PI 8	PI	0	0	265	273	0	0	137	137	139	139	107	111
PI 9	PI	143	143	261	265	326	342	137	145	139	139	111	113
PI 10	PI	143	143	259	275	326	342	137	145	139	145	111	113
PI 11	PI	0	0	0	0	0	0	0	0	139	139	0	0
PI 12	PI	146	146	265	265	0	0	0	0	139	139	105	111
PI 13	PI	143	146	259	259	318	332	137	145	139	145	105	107
PI 14	PI	143	143	261	265	340	342	137	141	139	139	105	111
PI 15	PI	143	146	265	265	318	364	0	0	139	139	105	113
PI 16	PI	0	0	265	265	338	364	0	0	139	139	109	109
PI 17	PI	143	143	265	275	326	340	0	0	139	145	105	113
PI 18	PI	143	146	265	265	318	342	137	147	139	145	109	109
PI 19	PI	143	143	265	275	0	0	137	145	139	139	109	109
PI 20	PI	143	143	255	275	340	364	137	141	139	145	105	105
PI 21	PI	143	143	259	265	318	318	0	0	139	139	111	113
PI 22	PI	143	143	265	271	332	366	137	141	139	139	0	0
PI 23	PI	143	143	259	265	332	366	137	137	139	139	105	109
PI 24	PI	143	143	261	275	318	338	137	141	139	139	105	107
PI 25	PI	143	146	261	275	0	0	0	0	139	159	111	113
PI 26	PI	143	146	265	275	0	0	137	137	139	159	107	107
PI 27	PI	143	146	265	271	318	358	145	145	139	159	109	109
PI 28	PI	143	146	265	271	318	318	0	0	139	159	109	109
PI 29	PI	143	143	271	275	318	360	137	145	139	159	109	109
PI 30	PI	143	146	265	271	318	322	0	0	139	139	109	113
PI 31	PI	143	143	265	265	0	0	137	137	139	139	105	105

PI 32	PI	0	0	261	273	318	332	0	0	0	0	109	109
PI 33	PI	143	143	259	261	318	340	137	137	145	145	109	109
PI 34	PI	143	143	259	273	318	340	0	0	139	145	109	109
PI 35	PI	143	146	263	265	0	0	137	137	139	139	105	109
PI 36	PI	143	146	265	265	318	318	137	137	139	139	0	0
PI 37	PI	143	143	265	265	318	360	0	0	139	139	109	111
PI 38	PI	143	143	263	265	318	340	137	137	139	139	105	111
PI 39	PI	143	143	0	0	0	0	0	0	139	145	111	113
PI 40	PI	0	0	271	271	318	332	0	0	139	145	105	113
PI 41	PI	143	143	263	275	0	0	145	145	159	159	105	109
PI 42	PI	143	146	261	273	0	0	141	145	139	145	111	113
PI 43	PI	143	143	0	0	318	358	137	145	139	139	109	109
PI 44	PI	143	143	265	265	0	0	137	145	139	139	109	113
PI 45	PI	143	143	271	273	0	0	137	145	139	139	109	113
PI 46	PI	143	143	261	273	322	332	137	147	139	145	107	109
PI 47	PI	143	146	273	275	0	0	145	145	139	139	0	0
PI 48	PI	0	0	261	265	0	0	0	0	145	159	0	0
PI 49	PI	143	143	0	0	326	364	137	137	139	145	109	109
PI 50	PI	143	146	265	273	0	0	137	147	139	139	109	109
PI 51	PI	143	143	271	275	318	318	137	145	139	139	109	109
PI 52	PI	146	146	0	0	0	0	137	141	139	139	0	0
PI 53	PI	143	146	261	265	318	326	137	137	139	139	109	109
PI 54	PI	143	143	265	265	322	332	137	137	139	139	109	109
PI 55	PI	143	143	261	271	322	322	0	0	139	139	107	109
PI 56	PI	143	143	259	261	326	326	137	137	139	139	0	0
PI 57	PI	143	143	261	265	326	326	141	141	139	145	109	113
PI 58	PI	143	146	263	263	326	326	137	145	139	139	109	113
PI 59	PI	143	143	0	0	0	0	137	137	0	0	109	109
PI 60	PI	143	146	0	0	326	326	137	137	139	159	107	109
PI 61	PI	143	143	261	265	326	326	0	0	139	145	105	105
PI 62	PI	143	146	261	271	0	0	137	141	139	159	109	111
PI 63	PI	143	146	0	0	322	322	0	0	139	145	107	109
PI 64	PI	143	143	271	273	332	332	0	0	139	139	109	111
PI 65	PI	143	146	261	265	326	342	0	0	139	139	109	113
PI 66	PI	143	143	265	265	340	340	0	0	139	145	109	109
PI 67	PI	146	146	0	0	326	332	145	145	145	159	109	111

PI 68	PI	143	146	265	275	326	332	137	137	139	145	105	109
PI 69	PI	143	146	259	261	322	332	137	141	139	159	109	109
PI 70	PI	143	143	265	271	326	326	137	147	145	145	109	109
BM1	BM	143	143	0	0	340	340	137	141	139	145	105	107
BM10	BM	143	143	259	265	322	342	137	145	145	145	105	109
BM11	BM	143	146	255	265	342	342	137	141	139	139	105	111
BM12	BM	143	143	259	273	340	342	137	145	139	159	107	107
BM13	BM	143	146	0	0	0	0	137	145	0	0	0	0
BM14	BM	143	146	259	265	318	340	137	145	139	139	105	113
BM15	BM	143	146	265	265	318	342	137	137	139	159	105	109
BM16	BM	143	146	259	263	340	340	137	137	139	159	109	109
BM17	BM	143	143	259	265	322	326	137	145	145	159	109	111
BM18	BM	143	143	265	273	318	342	137	157	139	159	105	107
BM19	BM	143	143	255	273	318	336	137	145	139	147	101	109
BM2	BM	143	143	263	273	318	328	137	145	139	145	101	109
BM20	BM	143	143	255	273	322	326	137	145	139	145	105	109
BM21	BM	143	143	255	259	318	340	137	141	139	159	101	113
BM22	BM	143	143	255	259	318	326	137	137	159	159	109	109
BM23	BM	143	143	261	265	318	340	137	137	139	159	107	111
BM24	BM	143	143	259	265	326	342	141	145	139	145	107	111
BM25	BM	143	143	255	265	322	326	137	141	139	159	105	107
BM3	BM	0	0	0	0	0	0	0	0	0	0	101	109
BM4	BM	143	143	259	259	326	326	145	145	159	159	101	111
BM5	BM	143	143	265	265	318	326	137	137	139	159	109	109
BM6	BM	143	146	261	271	322	340	139	141	139	139	109	111
BM7	BM	143	143	255	255	318	322	145	145	139	139	107	109
BM8	BM	143	143	273	275	318	326	145	145	139	165	105	111
BM9	BM	143	143	255	271	340	342	137	137	139	159	109	111
CS10	CS	143	143	0	0	318	342	137	141	139	145	105	105
CS11	CS	143	143	0	0	0	0	0	0	139	139	105	109
CS12	CS	143	146	259	273	338	340	137	137	139	159	105	109
CS13	CS	143	143	265	265	322	322	137	137	139	145	105	109
CS14	CS	143	146	273	273	318	318	137	137	139	159	105	113
CS15	CS	143	146	273	273	318	318	137	137	139	159	105	113
CS16	CS	143	143	259	265	318	318	139	145	159	159	105	111
CS18	CS	143	146	265	273	322	322	141	145	139	145	109	111

CS19	CS	143	143	259	265	322	322	137	145	139	145	105	105
CS2	CS	143	143	255	265	318	322	137	145	145	145	109	109
CS20	CS	143	146	259	277	318	324	137	137	159	159	105	109
CS22	CS	143	143	271	275	326	326	141	145	0	0	101	107
CS23	CS	143	143	255	265	318	318	141	157	145	145	101	107
CS24	CS	143	146	255	273	318	326	137	137	139	145	99	107
CS25	CS	0	0	259	265	318	324	145	157	159	159	0	0
CS26	CS	143	146	259	265	318	322	145	145	139	157	101	109
CS27	CS	143	143	259	259	318	322	137	137	145	159	101	101
CS28	CS	143	146	265	273	326	340	137	145	139	159	101	101
CS29	CS	143	143	0	0	318	340	137	145	145	159	107	109
CS3	CS	143	146	259	273	318	318	137	137	145	145	105	109
CS30	CS	143	143	255	275	322	322	145	145	145	159	103	105
CS32	CS	143	143	263	277	318	340	137	145	145	159	101	101
CS33	CS	143	146	255	263	326	340	137	137	139	159	105	109
CS34	CS	143	146	265	265	0	0	137	141	139	139	99	105
CS4	CS	143	143	265	275	318	322	137	137	145	145	105	105
CS5	CS	143	143	255	265	318	322	137	137	145	145	105	109
CS6	CS	143	143	0	0	318	342	137	137	145	145	105	105
CS7	CS	143	143	259	259	322	324	137	141	139	159	105	109
CS8	CS	143	146	259	261	318	322	137	145	139	145	105	109
CS9	CS	143	143	265	277	318	326	137	139	159	159	105	109
EG10	EG	143	143	265	265	326	342	137	145	145	159	105	111
EG11	EG	143	143	265	273	342	356	137	141	0	0	105	109
EG12	EG	143	146	265	275	318	326	145	157	139	139	109	111
EG13	EG	143	143	255	261	342	350	137	137	139	159	105	109
EG14	EG	143	146	259	273	350	350	137	141	139	159	109	109
EG16	EG	143	143	265	275	342	342	141	141	139	159	111	111
EG17	EG	143	143	261	265	326	326	137	145	139	145	111	111
EG18	EG	143	143	0	0	0	0	137	157	139	145	109	111
EG20	EG	146	146	265	273	326	326	141	141	139	159	105	109
EG21	EG	143	146	265	265	318	342	137	145	139	139	105	109
EG22	EG	143	143	265	275	318	318	137	141	145	159	109	111
EG24	EG	143	143	265	265	342	350	137	145	139	145	109	111
EG4	EG	143	146	259	273	350	350	137	141	139	159	109	109
EG5	EG	146	146	265	275	342	342	145	157	139	159	109	109

EG50	EG	143	143	265	265	344	352	141	157	139	159	103	107
EG51	EG	143	146	267	267	326	342	141	145	139	159	105	107
EG52	EG	143	143	275	275	318	318	137	141	145	159	105	107
EG53	EG	143	146	273	275	318	318	137	141	139	159	103	105
EG6	EG	143	143	265	275	318	326	137	141	139	159	0	0
EG7	EG	143	143	269	271	322	322	137	145	139	139	105	109
EG8	EG	143	143	269	271	322	322	137	145	139	139	105	109
EG9	EG	143	146	265	273	318	326	137	141	139	159	105	111
MEG1	EG	143	143	265	273	322	322	137	145	139	145	111	113
MEG2	EG	143	143	265	273	322	322	137	145	139	145	111	113
MEG3	EG	143	146	261	273	0	0	137	141	139	145	111	111
SEG1	EG	143	143	0	0	322	322	137	145	139	145	111	113
MP1	MP	143	143	259	265	328	328	137	157	139	139	105	111
MP10	MP	143	146	255	263	340	340	137	145	139	145	105	105
MP11	MP	143	143	261	277	326	328	137	137	139	145	105	113
MP12	MP	140	146	255	263	318	352	137	145	139	159	109	109
MP13	MP	143	146	271	277	318	326	137	141	139	159	105	111
MP14	MP	143	143	273	275	348	350	137	157	139	139	105	109
MP15	MP	143	143	265	265	326	350	137	137	139	139	105	105
MP16	MP	140	146	259	273	318	326	137	145	139	145	111	113
MP17	MP	143	146	273	275	342	348	137	157	139	159	109	109
MP18	MP	143	143	259	265	318	318	137	139	139	139	105	111
MP19	MP	140	143	259	273	318	326	137	141	139	145	105	111
MP2	MP	143	146	255	261	318	326	145	157	139	159	105	109
MP20	MP	143	143	255	261	0	0	137	137	139	145	109	113
MP21	MP	143	146	265	265	0	0	137	137	139	139	105	111
MP3	MP	143	143	265	265	328	342	137	145	139	139	105	111
MP4	MP	143	146	259	273	328	342	137	157	139	159	105	105
MP5	MP	143	143	265	265	0	0	137	137	145	159	109	113
MP6	MP	143	146	271	277	318	326	137	141	139	159	105	111
MP7	MP	143	143	261	265	326	328	145	157	139	145	105	105
MP8	MP	143	143	265	273	328	342	137	145	139	159	111	111
MP9	MP	143	152	275	275	318	318	141	145	139	139	105	109
NP1	NP	143	143	259	273	318	342	137	137	139	145	105	105
NP10	NP	143	143	259	271	318	318	137	145	139	139	107	111
NP11	NP	143	146	259	265	318	342	137	137	139	159	105	111

NP12	NP	143	143	259	261	318	322	145	157	139	159	105	111
NP13	NP	143	146	271	273	0	0	145	157	0	0	105	105
NP15	NP	143	143	259	265	0	0	137	145	139	145	105	105
NP16	NP	143	143	263	265	318	318	137	157	139	139	105	109
NP17	NP	143	146	265	273	322	328	153	157	145	145	105	109
NP18	NP	143	143	259	273	318	318	137	145	145	159	105	105
NP19	NP	143	143	259	259	328	328	137	137	139	159	105	109
NP2	NP	143	152	265	273	342	342	137	145	139	159	105	109
NP20	NP	143	143	265	273	318	360	137	145	139	145	105	111
NP22	NP	143	146	273	275	326	342	137	137	139	159	105	105
NP23	NP	143	146	265	271	318	350	137	137	139	145	105	105
NP24	NP	143	146	257	265	330	362	141	145	139	145	105	109
NP3	NP	143	152	259	265	318	326	137	147	139	139	105	111
NP4	NP	143	152	265	265	318	364	137	137	139	159	105	107
NP5	NP	143	143	259	273	342	342	137	137	145	159	107	111
NP6	NP	143	143	257	273	318	318	137	137	139	159	105	109
NP7	NP	143	152	265	273	318	342	137	145	139	145	105	107
NP8	NP	143	143	263	265	324	342	137	137	139	139	105	105
NP9	NP	143	143	265	265	318	328	137	137	145	159	105	109