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BREEDING SEASON SPACE USE AND HABITAT SELECTION OF ADULT FEMALE SCALED AND GAMBEL'S QUAIL IN WEST TEXAS

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ABSTRACT

We used radiotelemetry to investigate breeding-season (1 Apr–1 Sep, 2012 and 2013) home ranges and habitat selection of adult female scaled (*Callipepla squamata*) and Gambel's quail (*C. gambelii*) in the eastern Chihuahuan Desert, Texas. Mean breeding-season home range (95% fixed kernel) for scaled quail was 145.02 ± 23.56 ha (range = 22.03–538.24 ha) and 156.32 ± 13.04 ha (range = 66.15–270.74 ha) for Gambel's quail. Mean core-use area (50% fixed kernel) for scaled quail was 31.38 ± 4.80 ha (range = 4.03–111.36 ha) and 32.87 ± 2.61 ha (range = 12.19–52.36) ha for Gambel's quail. We found evidence of home-range overlap in neighboring females in both species. Excessive drought can suppress nesting activity. However, encourage reproductive activity in both species may be encouraged by managing riparian areas to provide adequate forage and microclimatic conditions.

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Key words: breeding season, *Callipepla gambelii, Callipepla squamata,* Gambel's quail, habitat use, scaled quail

Central to the study of animal ecology is the understanding of how organisms occupy space in time. In theory, an animal should evaluate and select particular cover types that best provide the resources necessary for survival and reproduction, including access to food, suitable breeding areas, and protection from predators (Liao et al. 2007). Thus, based on the quality of resources provided, one would expect certain cover types to be used disproportionately relative to their availability (Johnson 1980, Thomas and Taylor 1990).

Home range has been defined as the space in which an individual conducts its normal daily activities (Burt 1943). Further, Samuel et al. (1985) defined the core area as the area within the home range that is used more frequently and receives the most concentrated use. Space use and habitat selection may not be constant throughout the life of an animal and may vary in response to season, age, population density, and overall habitat quality (Orians and Wittenberger 1991, Pulliam and Danielson 1991, Mysterud and Ims 1998). Hence, habitat selection can be defined as a hierarchical process involving a series of behavioral responses that may result in this disproportionate use of one cover type over others (Hutto 1985, Block and Brennan 1993, Jones 2001). Understanding patterns of habitat selection and space utilization is a critical step in understanding the ecology of a species within a given environment.

Habitat selection and use of space by northern bobwhites (*Colinus virginianus*) has been extensively studied in a variety of landscapes (Wilkins and Swank 1992, Tonkovich and Stauffer 1993, Dixon et al. 1996, Williams et al. 2000, Parnell III et al. 2002, Singh et al. 2011) but similar published information regarding scaled (*Callipepla squamata*) and Gambel's quail (*C. gambelii*) is sparse (Goodwin and Hungerford 1977, Bristow and Ockenfels 2006), particularly for the eastern Chihuahuan Desert. Although ecological processes are known to operate at varying spatial scale, previous studies have focused on habitat selection at one spatial scale, potentially creating misleading inferences about overall habitat selection (Johnson 1980, Orians and Wittenberger

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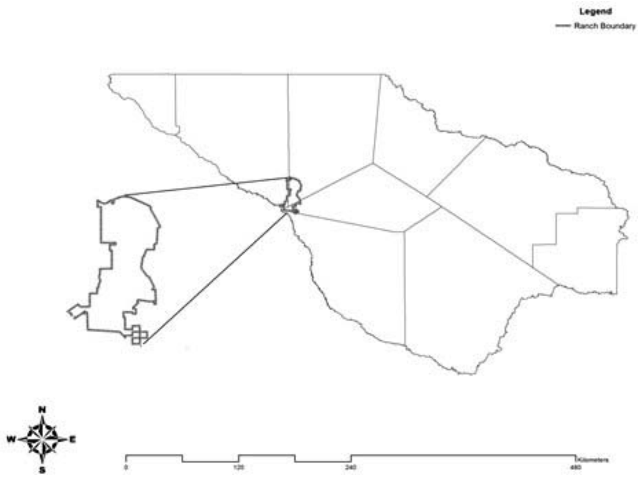

Fig. 1. Regional map of the Trans-Pecos, Texas, USA, including the Lado Ranch study site, Culberson County, where we investigated breeding-season (1 Apr–1 Sep, 2012 and 2013) home ranges and habitat selection of adult female scaled and Gambel's quail.

1991). Landscape characteristics and resource availability are important factors that influence bird communities.

As such, our objective was to estimate space use and multiscale habitat selection during the breeding season for adult female scaled and Gambel's quail in a desert scrubland in the eastern Chihuahuan Desert. The behavior of these species in a mixed desert shrubland system with wetter areas may differ from their upland and riparian counterparts. Consequently, information gathered from upland and riparian systems may not apply to a mixed desert shrubland with riparian areas. We hypothesized that, in sympatry, scaled and Gambel's quail will show different habitat selection patterns. Establishing this information in this region is necessary for managers to determine whether management considerations for one species will also be effective for the other species.

STUDY AREA

We conducted research on a 37,636-ha private ranch (hereafter, Lado Ranch; Fig. 1) in Hudspeth, Culberson, Presidio, and Jeff Davis counties, Texas. The northern portion of Lado consists of desert flats transitioning to rolling hills with numerous draws. Southern portions include the Van Horn Mountains. Mean precipitation for the area was $<$30.5 cm/year with peak rainfall coming in August (NOAA 2012–2013). The annual mean temperature was 16.2° C. Elevation in the study area ranged from 1,220 to 1,296 m.

Vegetation within the Lado Ranch was diverse. Individual shrub species most commonly found on Lado included creosote (*Larrea tridentata*), tarbush (*Flourensia cernua*), mariola (*Parthenium incanum*), acacia (*Acacia* spp.), lechuguilla (*Agave lecheguilla*), prickly pear (*Opuntia* spp.), and mesquite (*Prosopis* spp.). Understory was composed primarily of blue grama (*Bouteloua gracilis*), black grama (*B. eriopoda*), tobosa (*Pleuraphis mutica*), threeawns (*Aristida* spp.), tridens (*Tridens* spp.), and sacaton (*Sporobolus* spp.). Soils primarily consisted of Chispa–Chilicotal complex, Culberspeth–Chilicotal complex, and Beach very gravelly, coarse sandy loam.

METHODS

We captured scaled and Gambel's quail using standard funnel traps as described by Stoddard (1931). We placed traps in areas frequented by quail. We placed 2–4 traps located in shade at each site ($n = 7$). We covered traps with additional vegetation clippings for thermal and predatory protection. We opened traps at sunrise, closed them during the heat of the day, and opened them again 4 hours prior to sunset. We baited traps with commercial grains including millet and cracked corn. We checked traps in midmorning and late afternoon to reduce stress, exposure to predation, and injury to captured birds. All quail were trapped in accordance with state laws under scientific permit SPR-0592-525 (Texas Parks and Wildlife Department) and Sul Ross State University Animal Care and Use Committee directives.

We leg-banded captured birds with serially numbered aluminum #6 leg bands (National Band and Tag, Newport, KY, USA). After capture, we recorded the species, gender, weight, and age of each bird and took measurements of the wing, tail, head and culmen, and tarsus. Each female scaled quail weighing $>$180 g and each female Gambel's quail weighing $>$160 g was selected for radiomarking with mortality-sensitive, neck-loop transmitters (Advanced Telemetry Systems, Isanti, MN, USA; and American Wildlife Enterprises, Monticello, FL, USA). We released all birds at the capture site immediately following processing.

Following release, we allowed quail 1 day to acclimate to the transmitter and thereafter we located them once every 1–3 days from 1 March to 1 April and at least once daily for the remainder of the breeding season. We used a hand-held 3-element Yagi antenna and an ATS R4000 receiver (Advanced Telemetry Systems). We immediately located mortality signals and identified causes of death by sign left on and around the transmitter. We staggered location times throughout the day and used results to determine individual home range, habitat selection, and survival.

We excluded from analysis individuals that died within 1 week of capture to remove any bias that may have been associated with capture mortality. We censored individuals who experienced radio failure or whose signal was lost over time. All females were captured during the spring and summer (15 Mar–15 May), so we did not segregate age classes because all individuals were either adults $\geq$1 year old or subadults $\leq$1 year old being recruited into the adult population.

We imported all locations into ARCGIS 10.1 mapping software (Environmental Systems Research Institute, Inc., Redlands, CA, USA) and converted them to point themes. We calculated kernel-density home ranges (95%) and core-use areas (50%) seasonally for each individual using GEOSPATIAL MODELING EN-

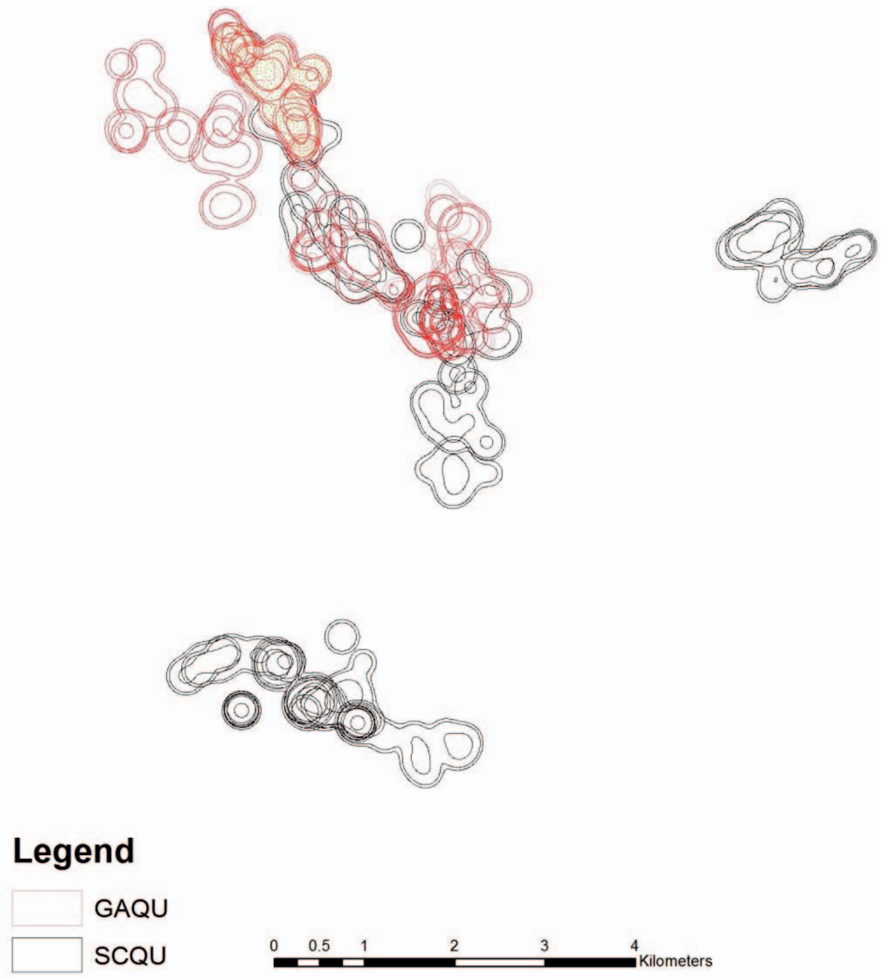

Fig. 2. Home range areas (95% and 50% Adaptive Kernel Density) of scaled and Gambel's quail at the Lado Ranch, Texas, USA, between April and September 2012.

VIRONMENT (Beyer 2012; Figs. 2 and 3). We used fixed-kernel densities as opposed to adaptive kernel to minimize overestimation of space use (Seaman and Powell 1996). We performed area-observation curves on 5 representative quail from each species with >30 locations and determined that home range sizes generally stabilized at ≥ 22 locations; as such, we used only individuals with ≥ 22 locations for analysis. We used one-way analysis of variance to test whether home range and core area sizes (ha) were different between species and years.

We created a digital land-cover map of the Lado Ranch in ARCGIS 10.1 using 2010 National Agriculture Imagery Program (NAIPs, 1-m^2 resolution) and digital elevation models (5-m^2 resolution) derived from 2010 LIDAR data (available at http://tnris.org). We delineated habitats into 3 broad categories using visual characteristics of the landscape visible on NAIPs, elevation data, and ground-truthing. Habitat types included desert grassland (lower elevation flats consisting of various gramas, tobosa grass, bluestems [*Bothriochloa* spp.; *Schizachyrium* spp.] and burrograss [*Scleropogon brevifolius*]), desert shrub (shrub-lands commonly found on hillsides and mountains adjacent to arroyos that consist of creosote bush, honey mesquite [*Prosopis glandulosa*], and tarbush), and riparian (lower elevation arroyos that consist primarily of Gregg's catclaw [*Acacia greggii*], littleleaf sumac [*Rhus microphylla*], and desert willow [*Chilopsis linearis*]). Using ARCGIS 10.1 mapping software (Environmental Systems Research Institute, Inc.), riparian habitats were defined by a 50-m buffer around all flow-line shapefiles and all other habitat not contained within the riparian habitat buffer was defined as desert grassland or desert shrub. We evaluated each scaled and Gambel's quail radio location for each habitat variable.

We intersected home ranges, core areas, and point themes with the land cover in ARCGIS to quantify habitat selection across seasons assuming that all habitats, in their respective proportions, were equally available to scaled and Gambel's quail. We calculated selection ratios (S) as $S' = ([U + 0.001]/[A + 0.001])$ where U was the observed use based on radiolocations and A was availability of the habitat variable class (Lopez et al. 2004). Aebischer et al. (1993) suggested adding 0.001 to use and availability to avoid 0 in the numerator or denominator. We described quail habitat use as preferred when selection ratios were ≥ 1 and avoided when selection ratios were <1 (Lopez et al. 2004). We evaluated habitat selection ratios at 3 spatial

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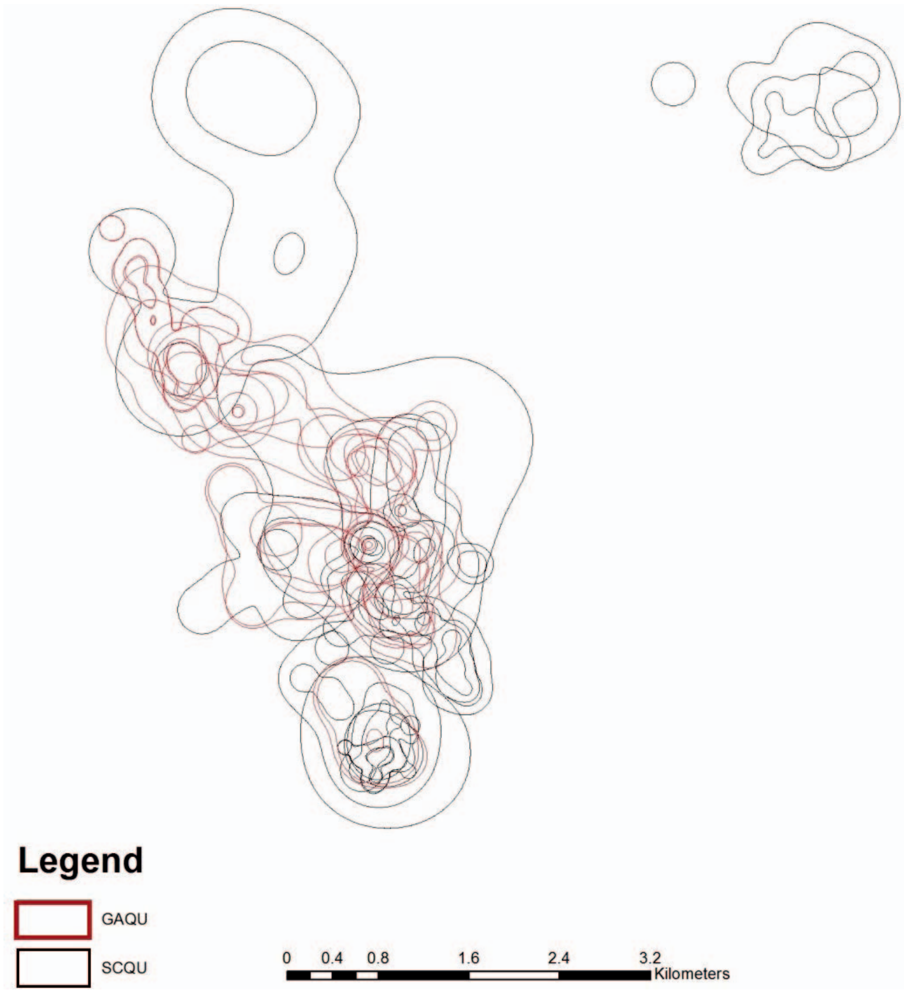

Fig. 3. Home range areas (95% and 50% Adaptive Kernel Density) of scaled and Gambel's quail at the Lado Ranch, Texas, USA, between April and September 2013.

scales based loosely on the recommendations of Johnson (1980): home ranges vs. habitats available on the study area (first order); core use areas vs. habitats available in home ranges (second order); and individual locations vs. habitat available in home ranges (third order).

RESULTS

Home range size for scaled and Gambel's quail did not differ across seasons (scaled: $F_{1,18} = 0.98$, $P = 0.33$; and Gambel's: $F_{1,18} = 0.22$, $P = 0.65$) or between species ($F_{1,24} = 0.17$, $P = 0.68$). Similarly, core area size did not differ across seasons ($F_{1,18} = 1.28$, $P = 0.27$; and $F_{1,18} = 0.98$, $P = 0.33$) or between species ($F_{1,24} = 0.55$, $P = 0.47$). During both years, the home range of every study animal was overlapped by the home range of >1 other study animal. Each study animal's home range also overlapped the home range of ≥ 1 collared individual of the other species.

For the 2012 breeding season, the average home range was 151.27 ± 66.66 ha and 129.15 ± 25.08 ha for scaled and Gambel's quail, respectively. During the 2013 breeding season, the average home range was 95.84 ± 8.27 ha and 105.04 ± 9.38 ha for scaled and Gambel's quail, respectively (Table 1; Fig. 4). The largest home range estimated for scaled quail was 538.24 ha for 2012 and 166.97 ha for 2013; for Gambel's quail, it was 235.44 ha for 2012 and 179.59 ha for 2013.

Table 1. Breeding season characteristics ($\bar{x}$ ± SE) of radiomarked scaled and Gambel's quail including adaptive kernel and 95% home ranges (HR) and 50% core area (CA) at Lado Ranch, Texas, USA, 2012 and 2013.

	Scaled quail		Gambel's quail	
Variable	2012 ($n = 7$)	2013 ($n = 13$)	2012 ($n = 7$)	2013 ($n = 12$)
CA (ha)	33.51 ± 13.52	23.32 ± 2.47	27.23 ± 4.64	24.65 ± 2.02
HR (ha)	151.27 ± 66.66	95.84 ± 8.27	129.15 ± 25.08	105.04 ± 9.38

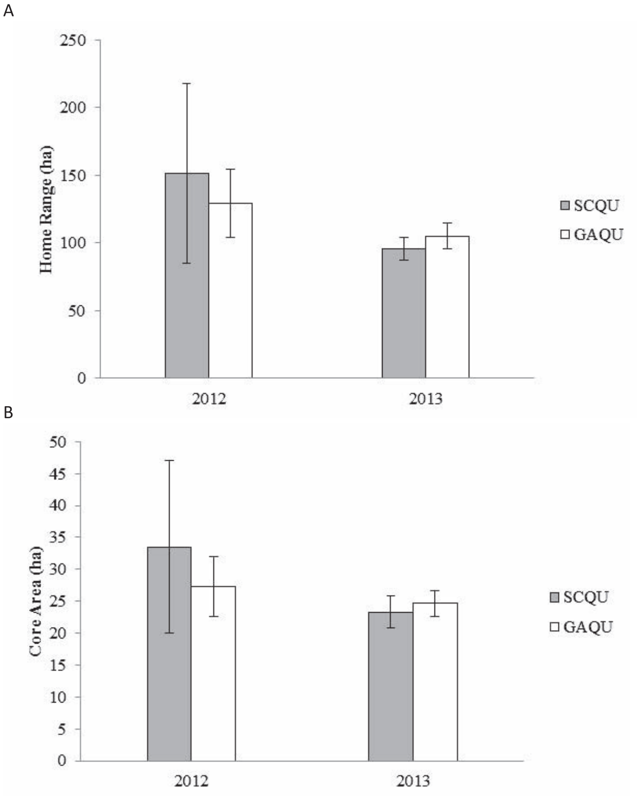

Fig. 4. Means and 95% confidence intervals of (A) 95% and (B) 50% home-range sizes of adult female scaled and Gambel's quail during the 2012 and 2013 breeding seasons Culberson County, Texas, USA.

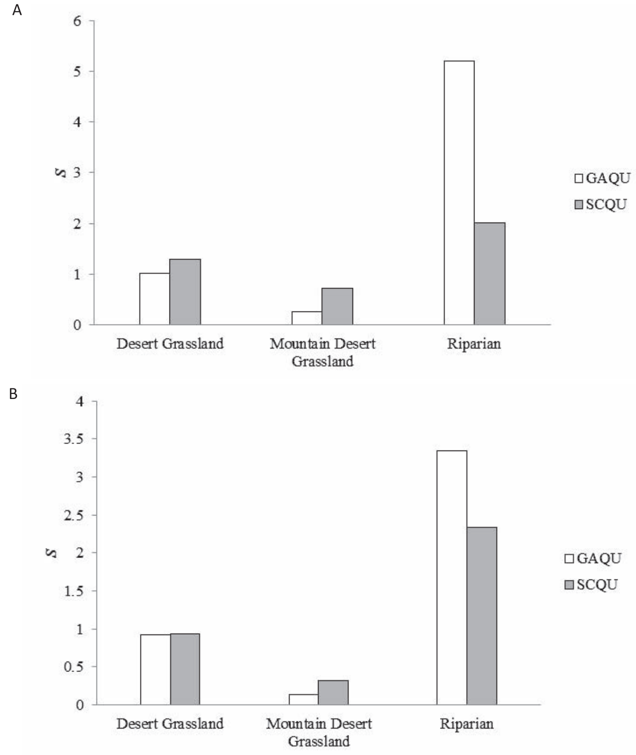

Fig. 5. Third-order habitat selection by scaled and Gambel's quail during the 2012 (A) and 2013 (B) breeding season in Culberson County, Texas, USA.

For the 2012 breeding season, the average core area was 33.51 ± 13.52 ha and 27.32 ± 4.64 ha for scaled and Gambel's quail, respectively. During the 2013 breeding season, the average core area was 23.32 ± 2.47 ha and 24.65 ± 2.02 ha for scaled and Gambel's quail, respectively (Table 1; Fig. 4). The largest core area for scaled quail was 111.36 ha for 2012 and 40.70 ha for 2013; for Gambel's quail, it was 43.02 ha and 37.54 ha.

Riparian habitat on the study area was 11.5% of 4,046 total ha. From 282 locations in 2012, scaled and Gambel's quail selected for native riparian vegetation at second-order level 23.4% and 60.6% of the time, respectively. From 229 locations in 2013, scaled and Gambel's quail selected for native riparian vegetation at the second-order level 35.3% and 56.6% of the time, respectively.

For third-order habitat selection (Fig. 5), scaled and Gambel's quail individuals used riparian habitat in greater proportion to its availability ($S > 1.1$) and desert grassland in equal proportion to its availability ($S =$ 1.0–1.2). Mountain desert grassland was selected the least ($S < 1.0$) by both species.

DISCUSSION

Average home ranges (95% Adaptive Kernel Density) did not differ between years or species. Core use areas (50% Adaptive Kernel Density) also did not differ between years or species. Vegetation diversity and landscape homogeneity could be partly responsible for similar home ranges. However, home range size is often interpreted as a surrogate for habitat quality (Burt 1943, Kurzejeski and Lewis 1990). As such, the increase in home range size observed during the breeding seasons may be indicative of poor nesting habitat, requiring females to sample large areas to find suitable nesting locations. However, Gray (2005) found that range sizes of Gambel's quail exceeded previous range estimates from the Mojave Desert.

Large home range sizes may also be a function of habitat structure and limited food availability during the summer months. Annual precipitation measured in Van Horn, Texas, was below average in 2012 (15.85 cm, 52% of annual average) and above average in 2013 (34.24 cm, 112% of annual average; NOAA 2012–2013). Arid landscapes can be productive ecosystems during times of adequate rainfall when succulent vegetation is widely available and adequate brooding habitat is likely abundant enough to restrict female movements when foraging and protecting broods. As such, the slight decreases in home-range size observed in this study from 2012 to 2013 may be a direct result of increased precipitation in 2013. One would expect that, at high food densities, home range sizes would decrease and be similar sized among individuals (Börger et al. 2008).

Riparian areas were selected by both species relative to desert grassland and desert shrubland at all spatial scales during the 2012 and 2013 breeding seasons. Optimal brood-rearing habitat generally contains herba-

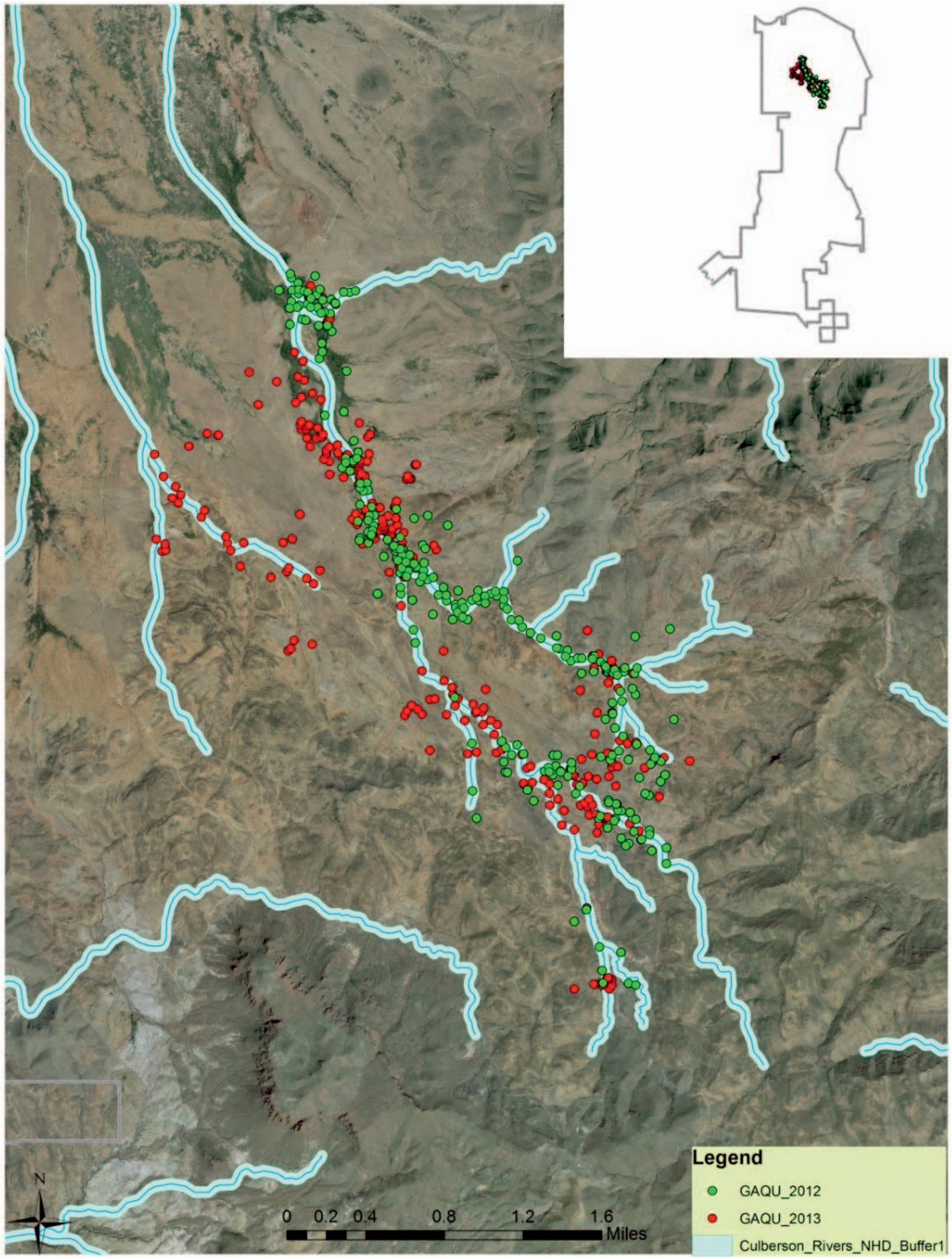

Fig. 6. Locations of radiomarked Gambel's quail and delineation of riparian habitat within the study area, Culberson County, Texas, USA, 2012–2013.

ceous ground cover that provides food resources for the nutritional needs of chicks and cover from predators. Female scaled and Gambel's quail at the Lado Ranch were likely forced to concentrate their nest site selection and movements to riparian areas because these areas provided the best brood-rearing habitat during severe drought (Figs. 6 and 7). During both years, home ranges of every radiomarked quail overlapped the home range of >1 other study animal. However, overlapping core areas between collared quail were less common than overlapping home ranges. The results did not support our initial predictions. However, because of the small sample sizes and relative difficulty of tracking quail, differences in home-range size may not have been detectable.

Home ranges link animal movements to the distribution of resources necessary for survival and reproduction (Börger et al. 2008). Competition theory states that 2 species with similar life-history traits should partition resources when sympatric (Hardin 1960, Brunjes et al. 2009). However, this does not appear to drive habitat partitioning between these 2 species. Similar home-range sizes may be a direct result of sympatry because both species co-exist on the same resources.

MANAGEMENT IMPLICATIONS

The degree of home range similarity and overlap suggests that habitat management for one species is likely

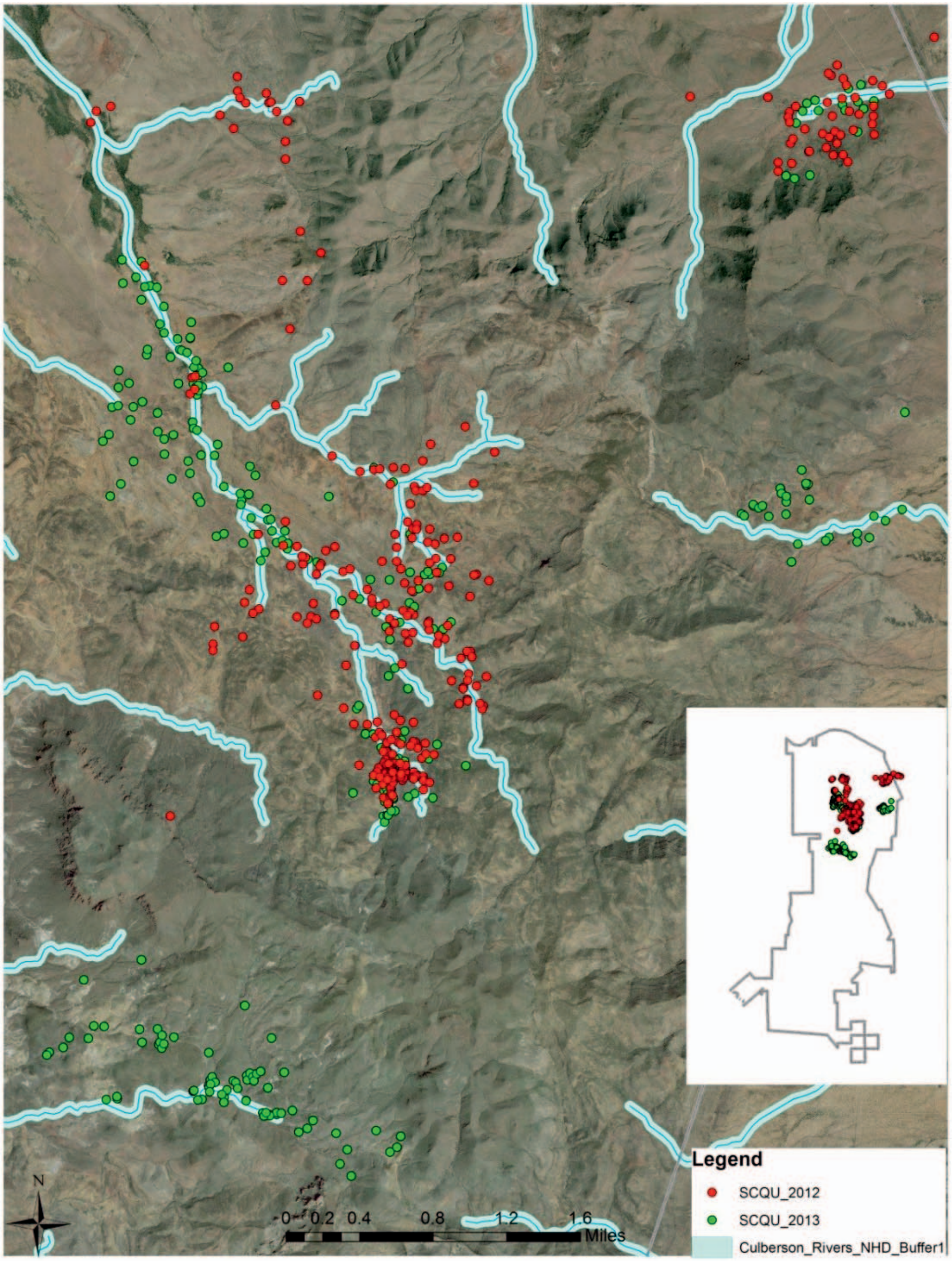

Fig. 7. Locations of radiomarked scaled quail and delineation of riparian habitat within the study area, Culberson County, Texas, USA, 2012–2013.

to benefit both species. As such, riparian habitat should be managed primarily to benefit both species through increased thermal cover and diversity. Excessive drought can suppress nesting activity of scaled and Gambel's quail; however, these riparian areas may encourage reproductive activity in both species by providing adequate forage and microclimatic conditions for broods.

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