Changes in Habitat use of Montezuma Quail in Response to Pinyon-Juniper Canopy Reduction in the Capitan Mountains of New Mexico

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ABSTRACT—Montezuma quail (*Cyrtonyx montezumae*) are unique among quail with respect to clutch size, diet, covey dynamics, and habitat use. With the exception of a few notable early studies, there is relatively little information on the ecology of Montezuma quail. Previous research has indicated that one of the primary habitats utilized by Montezuma quail is pinyon-juniper woodlands. Throughout many areas of the southwestern United States, pinyon-juniper woodlands are often targeted for thinning projects. Many studies have been conducted on the amount of tree canopy cover needed by other quail species, however, no data is currently published on Montezuma quail tree canopy cover needs and their response to thinning projects. The goal of this research was to evaluate Montezuma quail responses to common silviculture practices, specifically pinon juniper thinning in the Capitan Mountains of New Mexico. Results of our research indicated that Montezuma quail selected sites thinned to reduce tree canopy cover to 30-40 percent. Selection for this habitat was much higher than selection for the surrounding area which consisted of ≥70 percent tree canopy cover (Manly-Chesson Selectivity Index=1.68). Overall, this study provides important information for managers planning pinyon-juniper thinning projects in Montezuma quail habitat.

KEYWORDS—*Cyrtonyx montezumae*, habitat management, Montezuma quail, population characteristics, tree canopy cover, thinning

INTRODUCTION

Montezuma quail (*Cyrtonyx montezumae*), also known as Mearns quail, fools quail, or crazy quail, are a cryptic species and little is known about their ecology, roosting behaviors, or behavioral changes to adjust to habitat modifications. As a result, this quail species is one of the least understood upland game birds in North America. A possible factor contributing to the paucity of literature pertaining to this species can be attributed to difficulties in locating coveys and abnormal methods required for trapping. Montezuma quail are secretive in nature (crouch and freeze instead of flushing) which can make detection of coveys

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difficult (Hernandez et al. 2006; Oberholser 1974; O'Connor 1936). Additionally, Montezuma quail differ from other quail species in that they primarily dig for subterranean plants such as soft bulbs, sedge tubers, and seeds (Bishop and Hungerford 1965, Harveson et al. 2007, Stromberg 2000). As a result of their different foraging behavior, methods of trapping that work well for other quail species (e.g., funnel traps) typically don't have a high success rate with Montezuma quail (Hernandez et al. 2006, Stromberg 1990). Due to difficulties trapping and locating this species, little is known about their preferred habitat and how they respond to various management practices such as thinning juniper (*Juniperus* spp.).

One way to assess Montezuma quail response to thinning juniper is through radio-telemetry. Aside from Stromberg (1990), Hernandez et al. (2006), and Greene (2013) little data have been collected on Montezuma quail with the aid of radio-telemetry. Montezuma quail are most frequently associated with habitat consisting of pine-juniper woodlands (*Pinus* spp. and *Juniperus* spp.), montane meadows, and desert grasslands (Brown 1982; Hernandez 2004; Holdermann 1992; Holdermann and Holdermann 1998).

It is known that even though Montezuma quail are found in a variety of habitats, there is one factor that all Montezuma quail habitats have common. Montezuma quail habitats require adequate grass cover (e.g. bunchgrasses) and forbs and grasses that support subterranean foods. It is known that Montezuma quail need bunchgrasses, but little is known about how tree canopy cover influences their habitat selection. Many studies have addressed the amount of tree or herbaceous canopy cover needed by other quail species (Bidwell et al. 1991; Guthery et al. 2000; Johnson and Guthery 1988; Kopp et al. 1998; Rice et al. 1993; Schroeder 1985). However, there is currently no data on Montezuma quail tree canopy cover preferences or how they respond to tree thinning projects. Therefore, studies are warranted to fill in this missing data, which will help to increase our knowledge on the habitat requirements of Montezuma quail and allow us to make informed decisions on thinning projects in areas occupied by Montezuma quail.

The goal of this research is to assess Montezuma quail responses to common silviculture and rangeland practices in the Capitan Mountains of New Mexico. The primary objective of this research was to assess habitat use of Montezuma quail before and after thinning a pinyon-juniper woodland resulting in a tree canopy cover reduction from 70-80 percent down to 30-40 percent.

METHODS

Study Area

The Capitan Mountains represent the northeastern range of Montezuma quail in the greater Sacramento Mountain complex in Lincoln and Otero counties of south-central New Mexico. The 30-year average temperature in the Capitan Mountains range from -5 to 29 °C and annual average precipitation is 6.69 cm (NOAA, 2017). Elevations of the Capitan Mountains range from 1,524m to over 3,353m. The study site is located in the Madrean Encinal and Madrean Pine-Oak Forest and Woodland area of the Apache Highlands and AZ-NM Mountains Ecoregion (TNC Ecoregions). The study site consists of approximately 500 ha within the Capitan Mountains 2 km west of Fort Stanton, New Mexico. Dominant trees on the study site were oneseed juniper (*Juniperus monosperma*), pinyon pine (*Pinus edulis*), alligator juniper (*J. deppeana*) in the higher elevations, and gray oak (*Quercus grisea*) along the rocky hillsides and canyons (USDA Plants). Woody plants in the pinyon-juniper zone include fragrant mimosa (*Mimosa borealis*), skunkbush sumac (*Rhus trilobata*), and at least two species of rabbit brush (*Chrysothamnus* spp.) are noted along draws and dry hillsides. Grass species include sandhill muhly (*Muhlenbergia pungens*), bush muhly (*Muhlenbergia porteri*), mountain muhly (*Muhlenbergia montana*), slender muhly (*Muhlenbergia monticola*), scratchgrass (*Sporobolus asperifolius*), sacaton (*Sporobolus wrightii*), alkali sacaton (*Sporobolus airoides*), Fendler threeawn (*Aristida longiseta*), Arizona three-awn (*Aristida arizonica*), common wolfstail (*Lycurus phleoides*), James' galleta (*Hilaria jamesii*), and tobosagrass (*Hilaria mutica*) (USDA Plants). Also common are tumblegrass (*Schedonnardus paniculatus*), sideoats grama (*Bouteloua curtipendula*), sixweeks grama (*Bouteloua barbata*), black grama (*Bouteloua eriopoda*), Mexican lovegrass (*Eragrostis mexicana*), western wheatgrass (*Agropyron smithii*), foxtail barley (*Hordeum jubatum*), Canada wild rye (*Elymus canadensis*), and blue grama (*Bouteloua *gracilis*) (USDA Plants). Common forbs in the study area include Carruth's sagewort (*Artemisia carruthii*), ragweed (*Ambrosia* spp.), Rocky Mountain zinnia (*Zinnia grandiflora*), common mullein (*Verbascum thapsus*), fleabane (*Eriogeron* spp.), scarlet globemallow (*Sphaeralcea coccinea*), flaxflowered ipomopsis (*Ipomopsis longiflora*), scarlet gilia (*Ipomopsis aggregata*), yellow nutsedge (*Cyperus esculentus*), and silverleaf nightshade (*Solanum elaeagnifolium*).

Tree Canopy Cover Reduction

Within the 500 ha study area, an area consisting of 151 ha was selected for pinyon juniper thinning (fig. 1). The area selected for thinning treatment had a tree canopy cover of approximately 70-80 percent. The rest of the study site had tree canopy cover that ranged from 20-80 percent. Tree canopy cover was assessed using NDVI (Normalized Difference Vegetation Index, Earth Explorer, June and September 2015-2016). Some of the study site had steep slopes and canyons. These areas were not included to undergo the tree canopy reduction due to them having too great a slope to be prime Montezuma quail habitat. Within the area selected for thinning, trees were chosen at random to be harvested by chainsaw. A 5-acre plot was thinned (August 2015) as an example of what was to be completed across the entire area designated for thinning. A commercial tree crew was hired to complete the thinning treatment. During the thinning process, slash was collected and piled, each pile with an estimated size of around 1x2x1m in width, length, height respectively. The slash was burned after it was piled. The thinning was completed in December 2015 and resulted in a tree canopy cover that varied from 30-40 percent.

Trapping and Handling

To assess how Montezuma quail respond to pinyon-juniper thinning projects, we collected pre-thinning (2014, 2015) and post-thinning data (2015, 2016) from November through May. To adequately survey the 500 ha study site, we used ArcGIS to generate a stratified random sampling pattern consisting of 10 transects. Each of these transects were 500m in length. We traversed each transect with trained pointing dogs every other week in November and again in February (2014 and 2015) to facilitate detection of Montezuma quail. We employed 2 methods of capture for Montezuma quail. The first method was a modified version of the capture technique described by Brown (1978) using trained pointing dogs and large O-shaped dip nets. The majority of transects were searched within 4 hours of sunset. Once coveys were located during the day, a global positioning system (GPS) was used to mark the covey location. When a dog went on point, a researcher equipped with a large O-shaped dip nets net would try to locate the covey and place the net over them prior to covey flush.

The second and main trapping technique that we used for capturing Montezuma quail involved trained dogs, large hoop nets, and captures at night similar to methods described in Hernandez et al. 2006. Transect searches were conducted in the evenings (2 hours prior to sunset) using the dogs. Once a dog located a covey, the covey was marked on a GPS, and the research team backed out of the area until nightfall. Capture crews revisited the GPS covey locations ≥1hour after sunset accompanied by a bird dog. A lighted collar and tracking device (Garmin Alpha TT15) was used for monitoring the dog at night. Search efforts at night were focused in the general area of the original detection site but expanded to approximately a 200-m radius. If the dog was able to relocate the covey and went on point, we used headlamps to locate the exact location of the roost. The researcher in closest proximity to the covey would then attempt to maneuver a hoop net on top of a covey prior to covey flush.

Captured birds were carefully removed from the net and placed individually in 18x28cm soil sampling bags. Each individual bird was weighed, aged and sexed. Captured birds were then fitted with either a VHF (2014, 2015) or GPS (2015) backpack style radio transmitter (4-6 g, GPS: Telemetry Solutions Quail_5219, Lotek Pinpoint 120, VHF: Advanced Telemetry Systems quail, Frequency range 148-151Mhz), and banded with an individually numbered aluminum leg band. After all data were obtained from the captured birds, we released them at the site of their capture. During 2014, VHF backpacks were attached to record Montezuma quail movements. In 2015, technology advanced so that store on board GPS units were available for quail. Therefore, in 2015, we primarily deployed GPS backpacks. These GPS backpacks were programed to obtain a location every 4 hours between the hours of 06:00 and 22:00. The

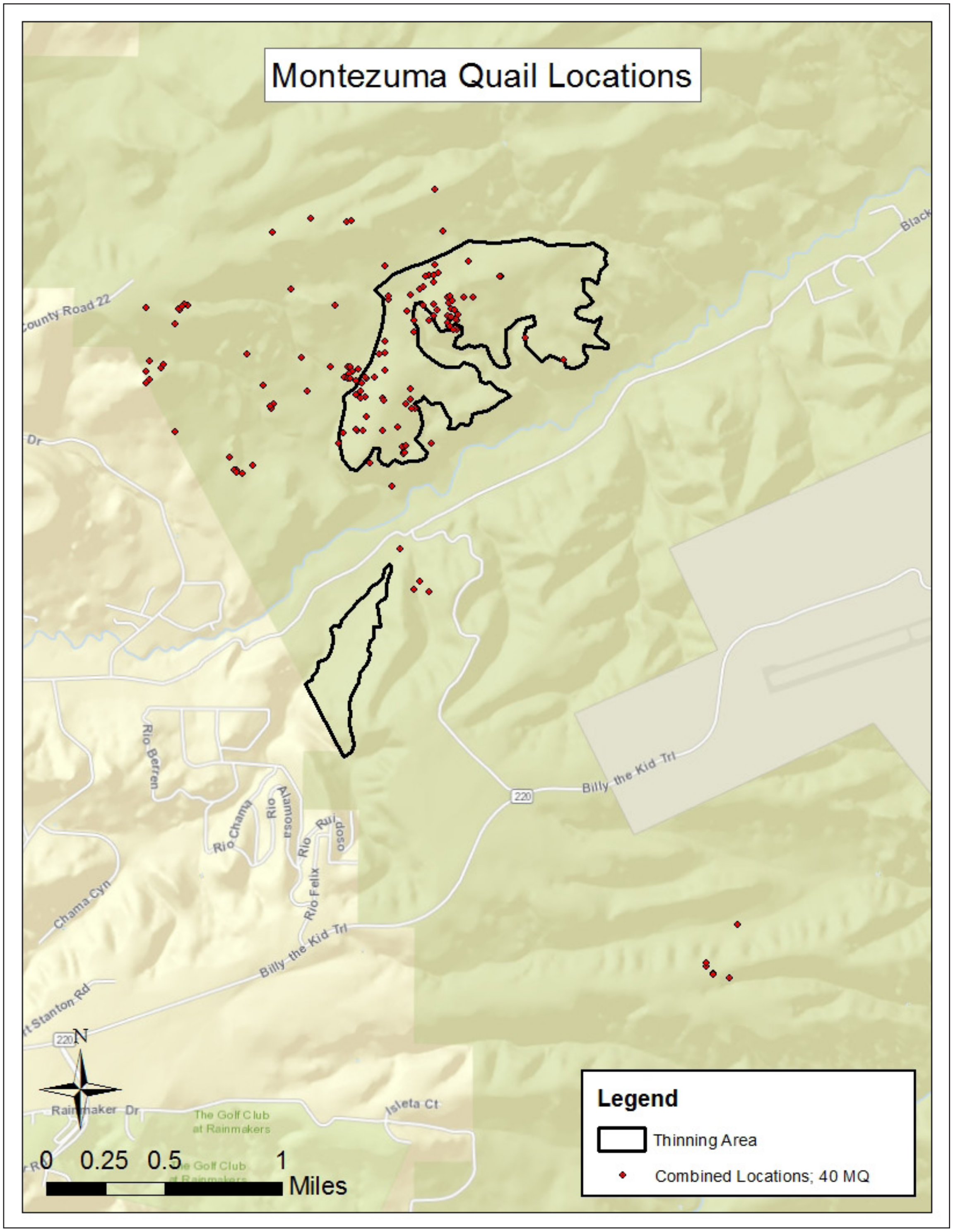

Figure 1—Montezuma quail habitat use on the study area prior to commencing the pinyon-juniper thinning project (November 2014 through May 2015).

goal was to have a minimum of 2 birds from each covey fitted with the GPS backpacks, while remaining birds were fitted with VHF backpacks. We determined VHF locations 1 time per day, 5 days a week, every other week. The GPS backpacks were used to assess finer scale daily movements. Once a covey had ≥1 transmitted bird, the covey was relocated at night using a night-netting technique initially described by Labisky (1959, 1968). Researchers located the radio-marked birds at night with the use of a radio receiver and a yagi antenna (ATS, R4000). When a covey was located, an O-shaped dip net was placed over as many birds in the covey as possible. Previously captured birds were examined and weighed, while newly captured individuals were aged, sexed, and had backpacks and leg bands attached. All trapping activities were conducted in accordance with state (New Mexico Department of Game and Fish Scientific Authorization Permit #3595) and university policy (SRSU IACUC #SPR-0592-525).

Spatial Patterns and Habitat Use

Monitoring of radio-marked birds was carried out with the use of a receiver (ATS R4000, Isanti, MN) and a yagi antenna. Locations of each individual were determined 2-5 times every other week from November 2014 through May 2015. Locations were imported into ArcGIS (ESRI, Redlands, California, USA) where 95 percent and 50 percent MCPs (Minimum convex polygons) were determined for each individual and covey. MCPs were determined to ensure that covey breakup had not been initiated. If the covey was still intact, MCPs were used to assess overall covey habitat use instead of individual habitat use.

We developed habitat use maps for the study site and evaluated habitat selection pre and post thinning, with specific interest in post thinning data (use of unthinned versus areas where thinning projects reduced tree canopy cover to 30-40 percent). A Manly-Chesson Selectivity Index was used to assess selection of the thinned area versus those areas with greater tree canopy cover.

RESULTS

From the pre-thinning sample period, a total of 292 Montezuma quail locations were obtained between November 2014 and May 2015. The locations were acquired from 40 Montezuma quail that we captured from 5 different coveys (fig. 2). Of the 292 locations, 60 percent were within the area designated to undergo the pinyon-juniper canopy reduction. Assessing the covey movements, the 95 percent MCP was 50.65ha ±14.2ha, and ranged from 2 to 103 ha over the 7 month study period. The 50 percent core use area for the coveys was 8.65ha ±4.68ha. After the tree canopy reduction had taken place, we were able to capture 53 individuals and equip them with radio-telemetry (GPS) backpacks. The 95 percent MCP was slightly larger than the previous year/pre-thin period. The post-thin 95 percent MCP was 70.67ha ± 36.80ha with a range of 3.2ha to 94.6ha. However, the 50 percent MCP core use area was less than the pretreatment. The post-thinning 50 percent MCP was 5.36ha ± 3.38ha. Overall, the area that had undergone the pinyon-juniper canopy reduction accounted for 85 percent of the total locations obtained from Montezuma quail. Given the assumption of equal use between thinned and non-thinned areas, our Manly-Chesson Selectivity Index was 1.68. This selectivity index centered at 1, which would indicate use at the level of availability. Any number below 1 would indicate less use or avoidance, and any number above 1 would indicate that it is selected for, or used more than available. Our selectivity index indicates Montezuma quail on our study site were selecting for the 30-40 percent tree canopy cover over the ≥70 percent tree canopy cover surrounding the thinning project (fig. 1). An unintentional finding of this study was that Montezuma quail also utilized the slash piles created on the thinning site. We recorded coveys as well as individuals using these slash piles for cover during loafing and roosting periods. However, use of slash piles could not be fully determined due to the piles being burned as part of the thinning contract.

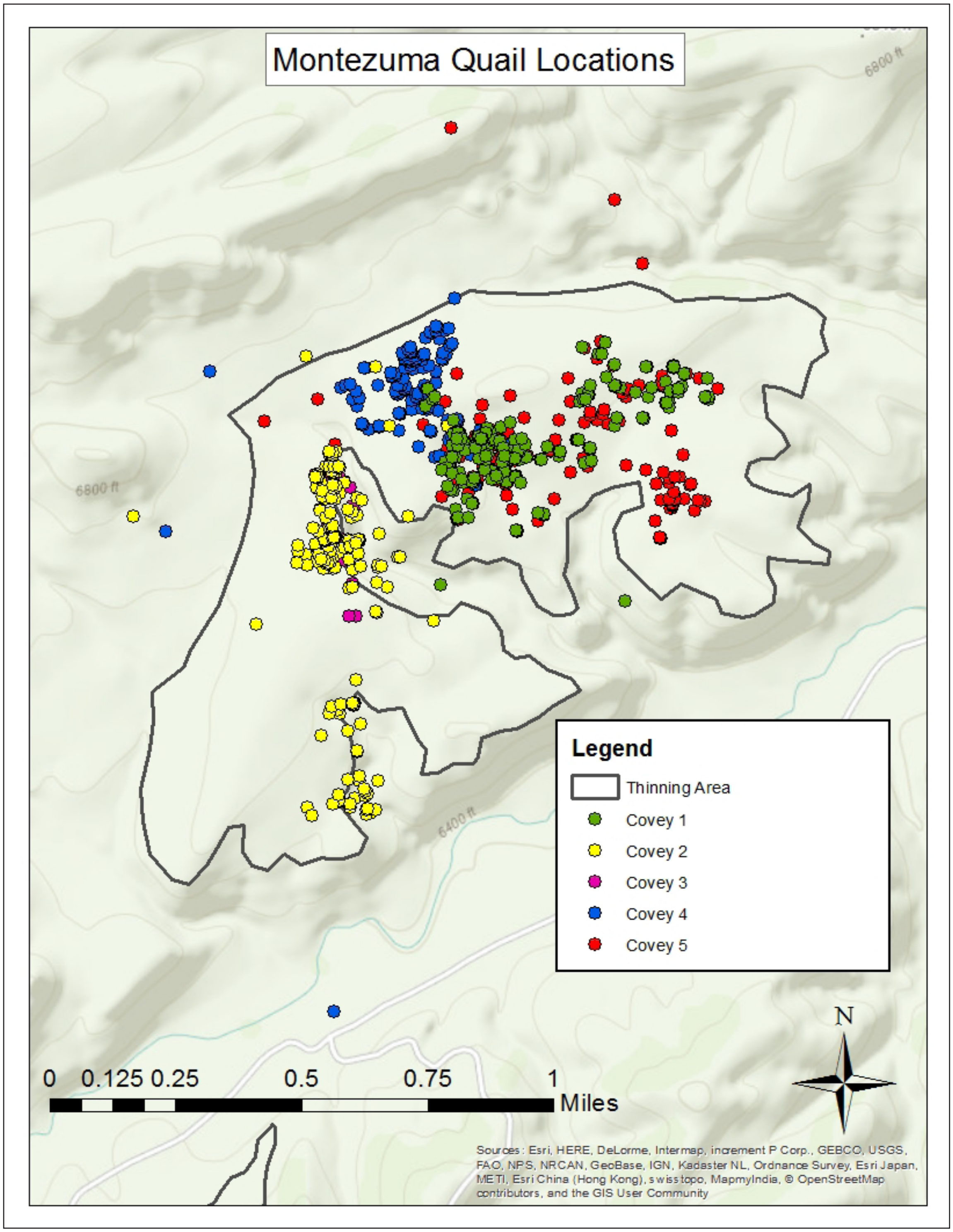

Figure 2—Montezuma quail locations from November 2015 through May 2016. Locations indicate habitat use with respect to utilization of a thinning project that reduced the tree canopy cover from ≥70% to 30-40% in the Capitan Mountains near Ft. Stanton, New Mexico.

Each of our coveys monitored during the post-thinning treatment had what appeared to have been exploratory movements of up to 2.4 km, thereby inflating overall home range estimates. However, each covey returned to their core range after these movements. One of the coveys had a very small home range (3.21 ha, SD = 0.01). If this covey is excluded from the overall average, the average home range size for coveys on the study site would increase to 70.68 ha (SD =24.33).

DISCUSSION

Our study indicated that by reducing the tree canopy cover of pinyon-juniper woodlands from 70 percent down to around 30-40 percent, use of the area by Montezuma quail increased by 25 percent. Additionally, our selectivity index indicated that areas that underwent thinning were selected for compared to other available habitat. Future studies should incorporate factors to assess Montezuma quail use of slash piles post-thinning.

During the pre-thinning data collection period, the Montezuma quail coveys that we were able to locate on the study site seemed to be relatively dispersed throughout the 500 ha study area. After the thinning was completed, transects that were close to or in thinned areas of the study site were much more productive than those that were in the non-treated portions of the study area. This observation was supported by the radio-telemetry data we received from the coveys. Overall, the majority of the movements were associated with the area that had undergone tree canopy reduction. Each covey did have what appeared to be exploratory movements. During these movements, the covey ventured off of the area where tree canopy reduction had taken place and made a large loop, only to return back to the area that had undergone tree canopy reduction. These exploratory movements increased the 95 percent MCP and resulted in a post-thinning 95 percent MCP (70.67ha) that was greater than the pre-thinning 95 percent MCP (50.65ha). However, the 50 percent core range MCP was smaller post-thinning (5.36ha versus 8.65ha), which could indicate that habitat requirements were met on a smaller scale in the treatment area. Further experiments are warranted to determine if this is actually the case. Overall, our home range estimates during the study period were similar to those reported in other Montezuma quail literature (Chavarria et al. 2017; Stromberg 1990).

Stromberg (1990) was the first to describe home range and movements of Montezuma quail. However, his sample size (15 radio-marked birds) and the number of relocations (<25) could be a limiting factor to determine true Montezuma quail home range size. Because of our greater sample size, the results of this study should be more indicative of true habitat use during the study period. Leopold and McCabe (1957) suggested 4–10 ha for general home range estimates, but these estimates were based on observations of non-marked coveys in Mexico. One key component that previous studies did not account for was the difference between total home range size and that of core areas. Other studies, namely Greene et al. (2013), recorded movements up to 12.7 km in the Davis Mountains of Texas. The much smaller movements observed during our study compared to those reported in Greene et al. (2013) are likely the result of our study being conducted prior to the breeding season while Greene et al. (2013) incorporated breeding season movements. Another factor that could be influencing movements is the differences in habitat between study sites in the literature. Differences in the Montezuma quail habitats in the Davis Mountains in Texas or study sites in Arizona could influence how much individuals are able to travel in attempts to locate mates. Home range estimates recorded during this study were much closer to those reported by Stromberg (1990) which indicated home ranges of 50.65 ha and core use areas of 1.69 ha. Home range estimates for Montezuma quail are thought to be generally less than scaled quail, but similar to Gambel's quail. Zornes and Bishop (2009) estimated home range sizes for Gambel's quail that were similar to those of Montezuma quail (8–38 ha), while scaled quail home ranges estimates were generally much larger and ranged from 10-882ha.

The small core areas recorded in our study indicate that these coveys are likely showing feeding site fidelity. Leopold and McCabe (1957) suggested Montezuma quail showed feeding site fidelity which could result in limited daily movements. Brown (1978) observed that coveys normally have home ranges <6 ha. Before pairing season, coveys generally do not make as large of movements as they do in the breeding season; however, movements observed in our study were still larger than the 6 ha suggested by Brown (1978). During our post-thinning study period, home ranges spanned from 3.21 ha to 94.63 ha. Although this is a wide margin between individual covey home range sizes, there appeared to not be major differences attributed to the type of habitat selected between each covey since all were primarily utilizing the area that underwent thinning. Overall, our study indicated a positive response with habitat selection and use associated with reducing tree canopy cover from ≥70 percent down to 30-40 percent.

MANAGEMENT IMPLICATIONS

Montezuma quail habitat use can be influenced by tree canopy cover. This could be associated with escape cover. Thick tree canopies likely restrict flight movements, and might influence a Montezuma quail's ability to evade predators. Therefore in some areas, tree canopy reductions may be warranted. Our research provides a baseline for future thinning projects in pinyon-juniper woodlands that contain Montezuma quail. This research indicated that quail spent approximately 85 percent of their time in areas that have tree canopy cover in the 30-40 percent range. Within our study area, habitat that contained tree canopy cover that exceeded 40 percent received relatively little use. The 50 percent MCP core use area resided within the thinning project boundary for all 5 coveys that we tracked during this study. This study yields vital information for managers considering implementing thinning projects in pinyon-juniper woodlands that contain Montezuma quail. By reducing tree canopy cover to 30-40 percent, one can greatly increase habitat that is selected for by this enigmatic quail species.

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