Urban development can fragment and degrade habitat, and such habitat alterations can have profound impacts on wildlife behavior. In urban areas, individuals may occur closer to each other and experience high levels of disturbance, which may favor increased aggression and boldness in urban-dwelling wildlife. We investigated the influence of urbanization on aggression and boldness and the relationships between these traits in Merriam’s kangaroo rat (*Dipodomys merriami*). We predicted that Merriam’s kangaroo rats living in urban areas would be more aggressive and bolder than Merriam’s kangaroo rats in wildland areas, that the 2 traits would be positively associated, and that the association would be stronger in urban areas. We live-trapped Merriam’s kangaroo rats at 4 urban and 4 wildland sites in and around Las Cruces, New Mexico, United States, and assessed aggression using a mirror-image stimulation test and boldness using a predator-scent exposure. We found no difference between urban and wildland Merriam’s kangaroo rats in either aggression or boldness. We found a positive statistical relationship between aggression and boldness, but this relationship was not affected by urban versus wildland habitat. These results indicate that Merriam’s kangaroo rats may be tolerant of urbanization, if habitat patches within urban areas are similar to wildland habitats.

Key words: aggression, behavioral syndrome, boldness, *Dipodomys*, kangaroo rat, urban development is part of the suite of human-caused environmental changes that are impacting vast regions of the world (Tilman and Lehman 2001; McKinney 2002; Theobald 2005; Magle et al. 2012; Ramalho and Hobbs 2012). Urban encroachment impacts wilderness by destroying wildlands, fragmenting landscapes, and isolating remnant habitat patches (Pickett and Thompson 1978; Bender et al. 1998; Debinski and Holt 2000). Urbanization and associated suburban growth are expected to increase worldwide to accommodate an increasing human population (McKinney 2006); in the United States, it has been predicted that the area covered by urban, suburban, and exurban development will be almost twice as large in 2020 as it was in 1980 (Theobald 2005). The impacts of urban development on wildlife are of great concern, due to this rapid rate of urbanization (Magle 2002; Theobald 2005; Ramalho and Hobbs 2012).

In increasingly urbanized landscapes, understanding the influence of urban development on wildlife behavior is critical for wildlife conservation (Collinge et al. 2005; Magle and Angeloni 2011; Shier et al. 2012). Habitat fragmentation and isolation as well as disturbances such as permanent structural alteration, habitat modification, repeated disturbances by humans and domestic predators, light, and urban noise (such as traffic noise) can profoundly impact wildlife behavior (Slabekoorn and Peet 2003; Brock and Kelt 2004; Prange et al. 2004; George and Crooks 2006; Banks and Bryant 2007; Magle et al. 2010; Magle and Angeloni 2011; Tuomainen and Candolin 2011; Shier et al. 2012; Lowry et al. 2013; Ríos-Chelén et al. 2015; Bliss-Ketchum et al. 2016). Urban noise, including traffic noise, can adversely affect animals that use vocalizations or other sounds (such as foot-drumming) to communicate (Slabekoorn and Peet 2003; Shier et al. 2012; Ríos-Chelén et al. 2015). For example, exposure to ambient levels of urban noise elicits territorial foot-drumming responses from Stephens’ kangaroo rats (*Dipodomys stephensi*) in lab trials (Shier et al. 2012). Further, prairie dogs (*Cynomys ludovicianus*) and gray squirrels (*Sciuridae carolinensis*) have higher levels of vigilance in habitats that have been isolated by urbanization for longer time periods, and in parks in urban areas (Magle and Angeloni 2011; Sarno et al. 2015), and great tits (*Parus major*) have an increased stress response to handling in urban areas (Torné-Noguera et al. 2014).
These types of behavioral responses to urban disturbances may lead to increased costs to urban-dwelling animals, such as loss of resources, loss of foraging time, loss of mating opportunities, and a decrease in reproduction or survival of offspring (Creel and Christianson 2008; Valcarcel and Fernández-Juricic 2009; Zanette et al. 2011).

Boldness, or the propensity for an animal to explore and take risks (Wilson et al. 1994; Atwell et al. 2012), may be an asset to animals in urban environments, allowing them to take advantage of novel anthropogenic resources (Darrow and Shivik 2009; Poessel et al. 2014). Urban environments also tend to have clumped resource distributions, bringing animals closer to each other (Prange et al. 2004; Parker and Nilon 2008). Animals that are closer together tend to have higher rates of agonistic encounters (Macdonald et al. 2004; Parker and Nilon 2008; Foltz et al. 2015). Thus, increased aggression and boldness may be favored in urbanized areas (Evans et al. 2010; Scales et al. 2011; Miranda et al. 2013; Poessel et al. 2014). For example, urban Eurasian red squirrels (Sciurus vulgaris) are 2–3 times more bold than rural red squirrels (Uchida et al. 2016). Song sparrows (Melospiza melodia) are both bolder and more aggressive in urban areas and have aggression levels that are 3 times higher than those of rural song sparrows (Evans et al. 2009; Scales et al. 2011). However, increased agonistic encounters could be detrimental to wildlife, resulting in more physical injuries, and increased disease transmission (Riley et al. 1998; Macdonald et al. 2004; Parker and Nilon 2008).

Different authors have used a variety of terms to describe correlations between behaviors across time and contexts, including behavioral syndrome, animal personality, temperament, or coping style (Riechert and Hedrick 1993; Wilson et al. 1993, 1994; Koolhaas et al. 1999; Sih et al. 2004; Dingemanse et al. 2007; Dochtermann and Jenkins 2007; Réale et al. 2007; Conrad et al. 2011). In particular, correlations between behaviors exhibited in different contexts are typically referred to as “behavioral syndromes” (Sih et al. 2004), and individual behavioral consistency through time has been referred to as “animal personality” (Réale et al. 2007). Correlations between aggression and boldness can be strengthened by exposure to selective pressures, such as the presence of predators (Bell and Sih 2007; Dingemanse et al. 2007), and urbanization could similarly affect correlations between behavioral traits (Miranda et al. 2013). However, few studies to date have compared the structure of behavioral correlations between urban and rural populations (Miranda et al. 2013), and the results of existing studies suggest the need for further investigation. For example, anoles (Anolis sagrei) from urban areas were bolder, less aggressive, more exploratory, and tolerated humans to a greater extent than forest anoles (Lapiedra et al. 2016). In addition, there are some differences in syndrome structure between urban and rural house sparrow (Passer domesticus) populations, in which urban birds appear to be more flexible in exploiting novel food sources (Bókony et al. 2012). In song sparrows (M. melodia), urban birds are both bolder and more aggressive than rural birds (Evans et al. 2010), but the potential effect of urbanization on correlations between these traits remains somewhat unclear, and the authors indicated the need for further study. To date, most studies of behavioral correlations in urban areas have been conducted with birds (Miranda et al. 2013). To our knowledge, other than a single study suggesting a positive correlation between flight initiation distance and vigilance in woodchucks (Lehrer et al. 2012), little is known about the correlation between behavioral traits in mammals in urban areas.

We evaluated the hypothesis that aggression and boldness, and the relationship between these 2 behavioral variables, would be altered in urban areas as compared to wildland areas, using Merriam’s kangaroo rats (Dipodomys merriami) as our study species. We predicted that mean levels of aggression and boldness would be higher in urban areas, and that aggression and boldness scores would be positively related to each other. Further, we predicted that aggression and boldness would be more strongly related to each other in animals living in urban areas in comparison to those living in wildlands.

**Materials and Methods**

**Study species.**—Kangaroo rats (genus *Dipodomys*) are an ideal group in which to study the impact of urbanization on behavior. Ubiquitous throughout the southwestern United States, kangaroo rats range from northern Mexico to southern Canada and from the Pacific Ocean to as far east as Nebraska and Kansas (Kennedy and Schnell 1978; Sullivan and Best 1997). Specifically, Merriam’s kangaroo rat (*D. merriami*) is a frequent subject of behavioral studies (Behrends et al. 1986; Dochtermann and Jenkins 2007; Jenkins 2011; Dochtermann et al. 2012) and is found in both wildland and urban environments (Germaine et al. 2001; DaVannon et al. 2016).

**Study area.**—We conducted this study in and around the city of Las Cruces, New Mexico, United States (32°19′35.7414″, −106°46′31.569″). Las Cruces is an expanding urban area: the total human population of Las Cruces increased from 74,267 in 2000 to 101,408 in 2014, a > 25% increase in human population in 14 years (U.S. Census Bureau 2015). Las Cruces encompasses a variety of urban parks and open spaces with remnant natural vegetation and is surrounded by undeveloped wildlands. The study area is part of the Chihuahuan Desert ecoregion, and typical vegetation includes creosote (*Larrea tridentata*), mesquite (*Prosopis glandulosa*), purple pricklypear (*Opuntia macrocentra*), scarlet hedgehog cactus (*Echinocereus coccineus*), ocotillo (*Fouquieria splendens*), yucca (*Yucca baccata*, *Y. elata*, *Y. treculeana*), limoncillo (*Pectis papposa*), portulaca (*Portulaca spp.*), roundleaf buckwheat (*Eriogonum rotundifolium*), zinnia (*Zinnia acerosa*), and various grasses, including *Bouteloua barbata*, *B. aristidoides*, *Panicum spp.*, and *Dasyochloa pulchella*.

We chose study sites that maintained native vegetation in both urban (*n* = 4 within Las Cruces city limits) and wildland environments (*n* = 4 on federal and state properties surrounding Las Cruces; Fig. 1). Each site was large enough to accommodate a 100 × 100 m grid. All wildland sites were located ≥ 500 m from all paved roads, and study sites were at least 1 km from each other.
Site characteristics.—We used Web Soil Survey soil maps to calculate the percentage of each soil type at each trapping site (USDA 2013). Vegetation was characterized at all sites using the line-point intercept method. Six 50-m line-point intercepts were randomly placed in each 100 × 100 m trapping site, resulting in a total of 300 m surveyed per site. We compared the percent cover by vegetation class (grass, shrubs, and forbs), percent bare ground, and percent rock cover between urban and wildland sites using Wilcoxon rank sums tests.

Urban index.—Landsat Thematic Mapper imagery at the 30-m spatial resolution was used to create the urban index (http://www.ngdc.noaa.gov/metadata). Each pixel in the Landsat Thematic Mapper data contains spectral information for a 30 × 30 m block on the Earth’s surface; we used a modified version of the Normalized Difference Vegetation Index (NDVI) to determine the proportion of pixels representing impervious surface (urban-associated materials such as cement, roads, buildings; a proxy for urbanization). All processing was conducted in ArcGIS 10.1 (ESRI, Redlands, California). To create the urban index, data from the National Agriculture Imagery Program (2011) were used as the map base and a shapefile of Doña Ana County, New Mexico, was added to create a raster file of the overall study area. To maintain consistency in spectral data between sites, the overall study area data were joined and compiled, and a focused analysis of each study site was completed simultaneously. A buffer with radius of 500 m was overlaid on each study site; buffers were larger than the study sites themselves to incorporate the urban environment surrounding each site in the urban index. These buffers were then used to clip the pixels containing spectral data around each site. These clipped sites were then used to calculate the urban
index for each study site (Table 1; Yuan and Bauer 2007; NASA Earth Observatory 2016; Song et al. 2016). The urban index was strongly correlated with the number of structures within the 500-m buffers (Pearson’s correlation: \( r^2 = 0.825, t_p = 5.83, P < 0.01 \)), indicating that this index is a good proxy for urbanization. A Wilcoxon rank sums test was used to compare the urban index between urban and wildland sites.

Livetrapping.—Merriam’s kangaroo rats were livetrapped for behavioral trials from June to September 2014 and May to October 2015. Traps were placed along trap lines in locations likely to maximize captures (e.g., near burrows and kangaroo rat trails) located within the 100 \( \times \) 100 m study sites. Merriam’s kangaroo rats were trapped during the 6 days before and after the new moon to minimize potential behavioral variation due to variation in moonlight. Traps were baited with sufficient millet-sunflower seed mix to sustain animals overnight. Sherman live traps (model XLKGDT with short doors to avoid catching the long tails of Merriam’s kangaroo rats; H.B. Sherman Co., Tallahassee, Florida) were set in the field shortly before sunset. To protect animals from direct sunlight, traps were positioned under vegetation. Traps were checked between 0100 and 0800 h, earlier in the morning at sites that had high use by humans, or on nights that were projected to be below 4.5°C. Traps in urban areas were removed daily and reset before sunset each day. Traps in wildland sites were checked and left in place and closed during the day to avoid the accidental capture of non-target diurnal species. Merriam’s kangaroo rats were individually marked with numbered Monel ear tags (National Band and Tag, Newport, Kentucky) and standard data were recorded (e.g., sex, reproductive condition, foot length, mass). All animals were released at the site of capture after behavioral testing was complete. All research procedures were consistent with the guidelines of the American Society of Mammalogists (Sikes et al. 2011) and conducted under an approved New Mexico State University IACUC protocol (2013-014).

Behavioral trials.—We used adult male Merriam’s kangaroo rats in behavioral trials to minimize the potential effects of age and sex on behavioral variation. Merriam’s kangaroo rats were considered adult if they had enlarged testes or weighed \( \geq 30 \) g. All behavioral trials were conducted under consistent temperature and light conditions at the New Mexico State University Animal Care Facility. The behavioral testing arena measured 61 \( \times \) 61 \( \times \) 36 cm and was made of opaque white plexiglass and covered with a clear plastic top to allow filming from above. This arena is similar to those used in other behavioral studies of Merriam’s kangaroo rat (Dochtermann and Jenkins 2007; Dochtermann et al. 2012). All behavior experiments were recorded on a digital camera (Sony HDR-SR10 1080) under standardized minimal light conditions, and recordings were scored at a later date.

Merriam’s kangaroo rats underwent 2 behavioral trials: a mirror-image stimulation (MIS) to measure aggression (Svendsen and Armitage 1973), and a predator-scent exposure to measure boldness (Dochtermann and Jenkins 2007). All animals went through each behavioral trial once. Previous studies have found MIS and predator-scent trials in Merriam’s kangaroo rats to be highly repeatable, and MIS is highly correlated with intraspecific aggression in this species (Dochtermann and Jenkins 2007; Dochtermann et al. 2012). In the MIS test, the animal was exposed to a mirror to elicit a response to a simulated conspecific (the animal’s own reflection) during a 7-min trial. Merriam’s kangaroo rats were exposed to the scent of coyotes (Canis latrans), a locally abundant predator, for 7 min in the boldness assay. Merriam’s kangaroo rats are known to be responsive to predator-scent cues and will adjust their behavior to avoid predator cues, thus making response to predator scent an effective measure of boldness (Herman and Valone 2000). A sand substrate was saturated with coyote scent and 10 g of sunflower seeds were placed on the scented sand. Because exposure to predator scent may alter subsequent behavioral responses (Bell 2012), we conducted predator-scent experiments after the MIS trials, rather than randomizing the order of presentation. The arena was cleaned with 70% ethanol between trials to remove scent cues, and at the end of each morning of testing the arena was cleaned with 10% Lysol solution.

Behavioral responses were scored using Kinovea v. 0.8.15 software (Kinovea 2015). This software captures information on spatial locations from videos and provides a series of time-stamped x-y coordinates as output. We considered the 1st minute of each trial as an acclimation period and recorded data on spatial location within the arena for the remaining 6 min of each trial. Kinovea recorded 14 subsamples per second, generating

| Latitude  | Longitude  | Type of site | Urban index | Proportion Bluepoint soil | Proportion Caliza-Yturide soil |
|-----------|------------|--------------|-------------|--------------------------|-------------------------------|
| Arrow Head (AH) | 32.2734 | −106.7363 | Urban | 0.31 | 1.00 | 0 |
| Cooperstone Dam (CD) | 32.3407 | −106.7578 | Urban | 0.30 | 1.00 | 0 |
| Desert Trails (DT) | 32.3426 | −106.7444 | Urban | 0.38 | 0.80 | 0.20 |
| Park Place (PP) | 32.2918 | −106.7297 | Urban | 0.35 | 1.00 | 0 |
| Aggie Rodeo (AG) | 32.2761 | −106.7085 | Wildland | 0.05 | 0.80 | 0 |
| Geothermal (GEO) | 32.2830 | −106.7132 | Wildland | 0.04 | 0 | 1.00 |
| Las Alturas (LA) | 32.2431 | −106.7043 | Wildland | 0.02 | 0.80 | 0.10 |
| Two Towers (TT) | 32.2951 | −106.7091 | Wildland | 0.02 | 0.91 | 0 |
4,000 x-y coordinates over 6 min of video. We then averaged these coordinates over 2-s periods to generate 180 points per Merriam’s kangaroo rat per trial. Aggression was quantified as the total number of points in the front half of the arena (within 30 cm of the mirror), divided by the total number of points (180). Boldness was quantified as the total number of points in the front half of the arena with the predator scent, divided by the total number of points (180). Measures of both aggression and boldness were continuous and ranged from 0 to 1. To compare aggression and boldness between urban and wildlands, we used separate univariate generalized linear models (GLMs) with the behaviors as dependent variables and habitat as a fixed effect, with binomial errors in R 3.1.2 (R Core Team 2015). To determine if the relationship between aggression and boldness varied depending on habitat, we then used a GLM with quasi-binomial errors (to account for overdispersion), with boldness as the outcome variable, and fixed effects of aggression, habitat, and the 2-way interaction between aggression and habitat. A significant effect of aggression on boldness would be consistent with previous observations of a behavioral syndrome in this species, and a significant interaction term would indicate that syndrome structure varied between urban and wildland habitat types. Initial analysis suggested that individual mass was not related to behavior, so we did not include mass in the final models.

**RESULTS**

**Site characteristics.**—Four soil types were present at our study sites: Bluepoint loamy, Bluepoint-Caliza-Yturibe, Riverwash-Arizo, and Canutio and Arizo. However, the vast majority of soils found at our sites were either Bluepoint loamy sand or Bluepoint-Caliza-Yturibe, which together accounted for 80–100% of the soil at each study site (Table 1). Bluepoint loamy and Bluepoint-Caliza-Yturibe are highly similar; each is characterized by deep, nearly level, well-drained soil formed from alluvium, flood plains, or stream terraces (USDA 2013). Urban sites had a higher proportion of impervious surface (urban index) than did wildland sites (Table 2). We found no differences in percent cover by grasses, shrubs, forbs, bare ground, litter, or rocks between urban and wildland sites (Table 2).

**Behavior.**—We found no significant differences in aggression (mean ± 1 SE; urban: 0.47 ± 0.08, n = 27, wildland: 0.52 ± 0.07, n = 27; GLM: Zγ = 0.546, P = 0.585) or boldness (mean ± 1 SE; urban: 0.56 ± 0.07, n = 31, wildland: 0.63 ± 0.05, n = 26; GLM: Zγ = 0.093, P = 0.926) between Merriam’s kangaroo rats from urban or wildland sites. We found evidence of a behavioral syndrome, with a positive effect of aggression on boldness (Fig. 2; GLM: β = 2.99 ± 1.03, tγ = 2.912, P = 0.005, n = 51). However, the relationship between aggression and boldness was not affected by habitat type (GLM aggression × habitat: β = −0.97 ± 1.71, tγ = −0.570, P = 0.571, urban: n = 27, wildland: n = 24). We were unable to examine behavioral variation among sites or between reproductive and nonreproductive males due to an insufficient sample size of individuals within these subcategories.

**DISCUSSION**

Contrary to our predictions, we found no difference in overall aggression or boldness for Merriam’s kangaroo rats living in urban versus wildland areas. We did find a positive effect of aggression on boldness, consistent with previous work on this species (Dochtermann and Jenkins 2007); however, this relationship was not statistically different for animals from urban versus wildland areas. Potential explanations for the observed lack of behavioral differences between urban and wildland habitats include: 1) urban habitat fragments and wildland habitats were similar, 2) Merriam’s kangaroo rats may be tolerant of urbanization, or 3) behavioral differences do exist but were not detected in this study.

Because we intentionally selected the urban habitat sites used in this study to be similar to nearby wildland habitats in aspects other than urbanization, habitat characteristics within all of our study sites were similar (Table 2). We chose to use impervious surface as a proxy for urbanization because impervious surface is highly correlated with related measures of urbanization, such as structures, streets, and sidewalks (Arnold and Gibbons 1996). However, although the area surrounding urban habitat patches was much more urbanized than wildland sites, within the patches themselves, there were no differences in percent cover by any measured vegetation class. In particular, regardless of urbanization level, all study sites had a high percentage of bare ground (urban sites: 53–76%, wildland sites: 41–67%). This similarity of habitat within the study sites themselves may explain the lack of effect of urbanization on aggression, boldness, or the relationship between these behavioral traits.

![Table 2](https://academic.oup.com/jmammal/article-abstract/98/2/410/2962925)

**Table 2.** Mean (± 1 SE) urban index and percent cover for urban and wildland sites (n = 4 of each habitat type) in and near Las Cruces, New Mexico, United States, with the Wilcoxon test statistic (W) and P value for between-habitat comparisons.
and solid line; wildland = open circle and dashed line.

Further, trapping is the only way to obtain the predator scent (Fig. 2), suggesting that trapped animals are tested in the predator-scent assay spent 0% of their time near the behavior of only the boldest individuals in each population trapped more often than shyer animals, we may have measured for example, if trapping bias resulted in bolder animals being but we were unable to detect those differences in this study. In Merriam’s kangaroo rats from urban and wildland habitats, et al. 2015; McDonnell and Hahs 2015). Our results suggest that Merriam’s larger, older, and more connected to nearby prairie dog colonies is more likely to persist in urban areas when habitat patches are connected to other fragments or wildland habitats. The conservation and management of large urban habitat fragments with native vegetation and the surrounding wildlands. The conservation and management of large urban habitat fragments with native vegetation and the maintenance of corridors connecting urban habitat patches to the surrounding wildlands are found in both shrub and grassland habitats (Lightfoot et al. 2012) and are made throughout the major deserts of the western United States (Beatley 1976; Germaine et al. 2001; Lightfoot et al. 2012) and are found in both shrub and grassland habitats (Lightfoot et al. 2012). The ability of Merriam’s kangaroo rats to live under a range of conditions may translate into tolerance for urban habitat fragments; it is thought that generalist species may be more tolerant to urbanization (Markovchick-Nicholls et al. 2008). Other researchers have found that wild mammals are able to live in urban environments if habitat fragments are large enough and are connected to other fragments or wildland habitat (Markovchick-Nicholls et al. 2008; Magle and Crooks 2009; Kertson et al. 2011; Goad et al. 2014). For example, another fossorial mammal, the black-tailed prairie dog (C. ludovicianus), is more likely to persist in urban areas when habitat patches are larger, older, and more connected to nearby prairie dog colonies (Magle and Crooks 2009). Our results suggest that Merriam’s kangaroo rats may be considered an urban adapter or urban-dwelling species (sensu Blair 1996; McKinney 2002; Fischer et al. 2015; McDonnell and Hahs 2015).

It is also possible that Merriam’s kangaroo rats are tolerant of urbanization. Merriam’s kangaroo rats are widely distributed throughout the major deserts of the western United States (Beatley 1976; Germaine et al. 2001; Lightfoot et al. 2012) and are found in both shrub and grassland habitats (Lightfoot et al. 2012). The ability of Merriam’s kangaroo rats to live under a range of conditions may translate into tolerance for urban habitat fragments; it is thought that generalist species may be more tolerant to urbanization (Markovchick-Nicholls et al. 2008). Other researchers have found that wild mammals are able to live in urban environments if habitat fragments are large enough and are connected to other fragments or wildland habitat (Markovchick-Nicholls et al. 2008; Magle and Crooks 2009; Kertson et al. 2011; Goad et al. 2014). For example, another fossorial mammal, the black-tailed prairie dog (C. ludovicianus), is more likely to persist in urban areas when habitat patches are larger, older, and more connected to nearby prairie dog colonies (Magle and Crooks 2009). Our results suggest that Merriam’s kangaroo rats may be considered an urban adapter or urban-dwelling species (sensu Blair 1996; McKinney 2002; Fischer et al. 2015; McDonnell and Hahs 2015).

Finally, it is possible that there are behavioral differences in Merriam’s kangaroo rats from urban and wildland habitats, but we were unable to detect those differences in this study. For example, if trapping bias resulted in bolder animals being trapped more often than shyer animals, we may have measured the behavior of only the boldest individuals in each population (Landry 2008; Carter et al. 2012). However, several individuals tested in the predator-scent assay spent 0% of their time near the predator scent (Fig. 2), suggesting that trapped animals are not universally bold. Further, trapping is the only way to obtain individuals for a study such as this. Another possibility is that individuals are sufficiently plastic in their behavior that differences that are exhibited under natural conditions may not manifest under the standardized testing conditions that we used, or that individuals differ in behavioral variables that we did not measure (Fisher et al. 2015; Lapiedra et al. 2016; Stamps 2016). However, this is true of any study that requires the quantification of a limited number of behaviors under controlled conditions. Finally, it is possible that we did not capture the full range of behavioral variation within the population due to our focus on reproductive males. However, others have found that males tend to be more aggressive than females (Dochterman et al. 2012), and because the vast majority of adult males are in reproductive condition during the breeding season, it is extremely difficult to tease apart potential effects of reproductive condition on behavior due to sample size limitations. Although our finding that Merriam’s kangaroo rats did not differ behaviorally between urban and wildland habitats contradicts our predictions, it may bode well for the species. Large habitat fragments with native vegetation in the city of Las Cruces, New Mexico, appear to be similar to wildlands in environmental attributes, allowing Merriam’s kangaroo rats to persist in this and perhaps other recently urbanized areas. Newly urbanized areas tend to have more open space as compared to older urban areas, which tend to have a higher density of urban development and highly isolated habitat fragments (Bolger et al. 1997). Most recent urban growth has occurred in the western and southern United States (U.S. Census Bureau 2015), where the type of development is likely to be similar to that in Las Cruces. Las Cruces is a relatively young and growing city, with open space with native vegetation within the city limits, and arroyo corridors connecting urban habitat patches to the surrounding wildlands. The conservation and management of large urban habitat fragments with native vegetation and the maintenance of corridors connecting urban habitat fragments and wildland habitats may allow Merriam’s kangaroo rats to persist in urban environments.

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