THE EFFECTS OF WILDFIRE ON REPTILE POPULATIONS

IN THE MOJAVE NATIONAL PRESERVE, CALIFORNIA

Final Report
January 2009

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ACKNOWLEDGEMENTS

I cannot express enough appreciation for the generous funding provided by the California Desert Research Fund at the Community Foundation, the California Desert Studies Consortium, and California State University. Also, to the Desert Studies Center at Zzyzx, for use of equipment and facilities.

I would also like to thank the individuals at the Mojave National Preserve who made this research possible, particularly David Nichols and Debra Hughson. Also, my advisor Dr. James W. Archie who introduced me to the study area and supported my research decisions. My sincere gratitude goes to Dr. Dessie Underwood, Dr. Esteban Fernandez-Juricic, Dr. Simon Malcomber, Dr. Lynn Zimmerman, Terry Christopher, and Alicia Fox for assistance with experimental design and proofreading.

I am grateful to Marcello Aguirre, Matt Baxter, James Dutcher, Robert Dutcher, Cristina Francois, Erin Guinn, Ashley Jones, Stephen Jones, Sara Louwsma, Jeff Putzi, Jim Toenjis, and members of the California Conservation Core for field assistance and willingness to work long hours on this project.

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ABSTRACT

During the summer of 2005, lightning caused wildfires in the Mojave National Preserve, California. The fires burned 287 km^2 and left unburned patches surrounded by burned vegetation.

This study examined the effects of the wildfires on reptile diversity and *Uta stansburiana* (side-blotched lizard) abundance by conducting transect surveys at patches and along the fire perimeter in burned and unburned habitats. Temperature and vegetation cover data were recorded at each site. Pitfall trapping was conducted at patch sites to monitor *U. stansburiana* movements.

The wildfires resulted in higher temperatures in burned areas and more cover in unburned areas. Burned and unburned habitats had comparable reptile diversity and *U. stansburiana* was most abundant. *U. stansburiana* in unburned perimeter locations were constant, indicating this population was the least impacted. In 2006 the most were found along the burned side of the perimeter where high temperatures may have allowed for optimal basking sites. In 2007 the temperatures increased and the individuals in this area decreased by half.

The number of individuals moving out of patches was consistent but the number moving in increased, indicating a preference for unburned areas. The low numbers recorded in this study suggest that the wildfire negatively impacted the herpetological community.

INTRODUCTION

Ecological Role of Wildfire

Disturbance is common to all ecosystems and results in altered landscapes that differ from original habitat in floral and faunal composition and abundance (Reice, 2001). Natural disturbance, particularly wildfire, causes habitat changes by killing mature plants, seedlings, and seeds. Fire also alters the nutrient levels and water absorption abilities of soil. The effects of fire result in changes in microclimate, particularly post-fire soil temperature and moisture, and drastically reduce ground cover (Brooks, 2002; Odion and Davies, 2000).

In systems that are fire adapted this disturbance is essential for floral and faunal persistence (Parr and Chown, 2003). However, in areas that have not historically been subjected to frequent or intensive fire regimes, such as arid ecosystems, species diversity and abundance suffer due to mortality during the fire and the subsequent alteration of habitat (Brooks and Matchett, 2003; Taylor and Fox, 2001).

The unpredictable nature of wildfires often creates a habitat framework of small unburned patches within what was once contiguous habitat (Parr and Chown, 2003; Turner et al., 1997). Wildfire thus fragments habitat by creating small patches that are separated from one another by a habitat type that no longer resembles original conditions. Fragmentation due to wildfire does not necessarily indicate permanent habitat loss (Fahrig, 2003). The effects of wildfire are unpredictable and recovery is highly variable depending on location, burn severity, intensity, and post-fire plant succession (Davies et al., 2001; McKenzie et al., 2004; Reice, 2001; Turner et al., 1997).

Fragmentation, Wildfire, and Reptile Communities

A review of herpetofaunal response to fire found that many animals exhibit panic and experience high rates of mortality (Russell et al., 1999). Because of the need for thermoregulatory, foraging, and protected sites, reptiles are highly dependent on habitat structure and fire has been shown to reduce their abundance and limit movements (Setser and Cavitt, 2003; Valentine et al., 2007). However, unburned habitat patches may serve as refugia for reptile populations that survive in the patch, nearby rock outcroppings, or burrows in the ground (Faria et al., 2004; Friend, 1993).

While vegetated areas produce shaded microclimates where soil temperatures are less extreme and moisture is preserved, disturbed habitats generally show reduced vegetation complexity (Patten and Smith, 1975). Habitats dominated by invasive plants also show decreased numbers of invertebrates. This reduction in thermoregulatory and food resources results in a decrease in total reptile abundance. Studies in disturbed areas in southern California, Australia, and Egypt have indicated that reptile abundance and diversity were positively correlated with vegetation percent cover and native vegetation (Attum et al., 2006; Russell et al., 1999; Valentine et al., 2007).

Wildfire and Exotic Plants in Desert Regions

Historically, large wildfires in desert communities have been uncommon because without a relatively large, continuous fuel source, wildfires tend to have reduced size and intensity (Hanes, 1971; Reice, 2001). However, in North American deserts, wildfires have become increasingly frequent since the 1970s. This is because of the introduction of exotic plant species, particularly *Erodium cicutarium* (fillaree), *Bromus sp.* (foxtail, cheatgrass) and *Schismus sp*. (Mediterranean grass). These species, native to Europe, Africa, and Asia, are adapted to fire regimes in arid ecosystems and create a blanket of dry vegetation that facilitates the spread of wildfire by creating a layer of dry, fast burning fuel. Recurrent fire in the American southwest amplifies the presence of these alien species, which have been shown to replace long-lived natives, changing the floral composition (Brooks, 1999, 2000a, 2000b; Brooks and Matchett, 2003; Esque, 1999; Young, 2000). Because of these effects wildfire is currently considered one of the main threats to native species in the Mojave (Brooks, 2002).

Wildfire in the Mojave Desert

The Mojave Desert is subjected to frequent lightning strikes during the summer monsoon season (May-August) and wildfires are generally caused by dry lightning storms during this period (Esque et al., 2003). Large fires are infrequent events in areas with native vegetation. Consequently, wildfires in the Mojave have not been well studied, and their effects have yet to be well documented (National Park Service, 2003).

On 22 June 2005, a series of dry seasonal storms passed through the Mojave National Preserve (MNP), San Bernardino County, California. Dry lightning caused multiple fires that merged to become the Hackberry complex of wildfires. The fires burned for seven days and were contained on 28 June 2005. A total of 287 km^2 burned within the Preserve between elevations of 1097-2012 m (http://www.nps.gov/moja/ parkmgmt/upload/Hackberry_BAER_Plan%2006-05.pdf). Within the Hackberry region the dominant form of vegetation affected by the fires was juniper woodland (Mojave National Preserve Maps, 2005). However, the fire did not consume all of the vegetation and the burned landscape contained several patches of unburned habitat. These habitat islands were surrounded on all sides by burned vegetation resulting in a fragmentation of the habitat.

Objectives

The Mojave is home to an incredible array of reptiles and the Hackberry region supported many species. The objective of this study was to determine the effects of the Hackberry wildfires on the herpetofaunal community. Based on previous research, most of which indicates increased mortality as well as limited habitat utilization and movement following a wildfire, it was reasonable to expect populations in the Mojave would show similar responses. I expected to find increased ground and subterranean temperatures and decreased vegetation cover in burned areas, with cover increasing through time, but not

achieving pre-burn proportions or composition. The burned locations were expected to support fewer reptile species based on the resources available. As density increased with time, more individuals were expected to disperse from unburned habitat patch locations. I tested the hypothesis that movement into and out of unburned habitat patches by would change with time. I predicted that in the first year of this study more individuals would migrate into unburned habitat patches and that in the second year the individuals would disperse out of patches as lizard density and vegetation in burned areas increased.

MATERIALS AND METHODS

Site Selection

The Mojave National Preserve (MNP) lies in the eastern portion of the Mojave Desert of California. The Preserve is located to the south of Death Valley and north of Joshua Tree National Parks, between Interstates 15 and 40. The infrequency of large wildfires, remoteness of the area, and limited impact from development make the MNP an excellent area to study. Permits were obtained from the National Park Service, California Department of Fish and Game, and California State University (IACUC number 279).

Sampling for this study was concentrated in what was predominantly juniper woodland between the elevations of 1,370 m-1,675 m (Mojave National Preserve Maps, 2005). Sites were located near Cedar Canyon and Black Canyon roads, in the Mid-Hills area (Figure 1). Seven unburned habitat patches, that were surrounded by burned landscape on all sides, and seven perimeter locations along the fire edge were surveyed. Patch sites were mapped using a handheld Global Positioning System (GPS) unit and ranged in size from approximately 1,527-36,580 m^2.

Temperature Data Collection

Ambient, ground, and subterranean temperatures were collected using a handheld Ashcroft dial thermometer. All temperatures were recorded after the thermometer was placed in a temporarily shaded area for 2 minutes and collected at the start of each transect survey on both the burned and unburned sides. Air temperature was recorded after holding the thermometer several feet above the ground, ground temperature was recorded after placing the thermometer on the soil surface, and subterranean temperature was recorded after placing the tip of the thermometer 3-5 cm into the soil.

At one habitat patch an Eastman maximum/minimum thermometer was installed on a wooden stake 50 cm above the ground to determine air temperature extremes.

Transect Design

Transects were used to assess species diversity and abundance across distinct habitat types with clearly defined borders (Morris, 1995). At each sampling site three parallel transects that crossed the transition zone from burned into unburned habitat were monitored. Each transect was a straight-line 50 m in length, and bisected the habitat, with 25 m in each habitat type. Transects were separated from replicates by 20 m (Figure 2). Transects were measured out using a 25 m Lufkin tape measure. I used GPS waypoints to mark the start and end locations of each transect (Table 1).

Vegetation Point-Intercept Transect Surveys

Vegetation point-intercept transects were conducted by walking the transect lines described above and recording vegetation height every five meters. At each point a 7-cm

diameter pole was placed directly on the point and the height of each plant that touched recorded (Barbour et al., 1999). Plant height was classified as <10 cm, 10-30 cm, 30-50 cm, 50 cm-1 m, and >1 m. Dead or severely burned vegetation was not recorded. I recorded vegetation once a month from May-October 2006 and March-August 2007. A total of 504 vegetation transects were conducted (14 sites x 3 replicates x 12 times).

Reptile Transect Surveys

During the fall and spring, transect surveys were conducted throughout the day; however, in the summer, when temperatures were at their highest, transect surveys were conducted in the morning and late afternoon. In order to find lizards by direct observation in both burned and unburned areas, each transect line was walked two times and a snake stick used to flush lizards from grasses and shrubs. Sighting effort was concentrated to 5 m on either side of the transect line. Reptile species were identified, and distance along the transect line was documented in 5 m segments. During the course of this study I conducted a total of 1,542 transects (14 sites x 3 replicates x 36 times).

Pitfall Trapping

Pitfall arrays were established at the seven habitat patches to determine the diversity of reptile species in patches and monitor movements (Table 2). At each patch six 5-gallon plastic buckets were buried so the rims were flush with the soil surface. Three drainage holes were drilled into the bottom of all traps to prevent the accumulation of water. Each trap was fitted with a cover to provide shade and protection. The covers were inverted plastic bucket lids with three 5 by 5 cm tall pieces of wood attached at equal distances along the edge (Fisher et al., 2004). Attached to each cover was a 50 cm long piece of jute that served as a rodent escape string to minimize mortality. The pitfall traps were stocked with two to three small pieces of kibble, a 12 cm long by 5 cm diameter PVC pipe piece lined with small amounts of batting, and a 3-5 cm piece of wet sponge to keep trapped animals hydrated (Karraker, 2001; Persons and Nowak, 2006). When the wet sponge attracted ants it was temporarily removed (Fisher et al., 2004). When in use, traps were checked every 12 hours. When not in use, the bucket lid was securely fastened, rocks placed on the lid, and soil placed loosely over the lid to seal the trap.

Each bucket trap was separated by 7.5 m of 30 cm tall tan cloth drift fencing, which guided reptiles differentially into traps from burned and unburned habitats. Each array was arranged in a zigzag pattern, providing more intercept angles (Fisher et al., 2004). The buckets were completely fenced on three sides, with three buckets fenced on the patch side and three buckets fenced on the burn side (Figure 3). This design allowed for the study of directional movement, as individuals captured in buckets fenced on the patch side came from the burn area and individuals captured in buckets fenced on the burn side were moving away from the patch. The fencing was held in place by wooden stakes and buried 7-12 cm into the ground.

The array and trap numbers of all captured lizards were recorded. A small tissue sample was taken from the tail tip and preserved in 95% ethanol for possible later genetic

analysis (Hirsch et al., 2002). For easy recognition of an individual from a distance captured lizards were marked, based on their site location, with nail polish. Because they were captured in higher numbers, *Uta stansburiana* (side-blotched lizard) were also marked by toe clipping one digit (Ferner, 1979; Swingland, 1978). Small mammals (that did not escape via the escape string) and captured invertebrates were recorded to species and family, respectively. No mortalities occurred during the course of this study and all individuals were released at the site of capture.

Trapping was conducted on a monthly basis, between temperatures of 2-42°C. Traps were closed during heavy rains and when temperatures reached 0°C to prevent mortality. Trap effort for this study was defined as the number of open traps per trap session, with a session being 12 hours. Trap effort was 5,324 trap days/nights (7 arrays x 6 buckets in each array x 135 trap sessions-346 trap closures due to unforeseen circumstances).

Statistical Analysis

A Shapiro-Wilk test for normality was conducted, and when data were not normally distributed transformations using $\log(x)$, $\ln(x)$, x^2, and $\sqrt{x}$ were performed. Analyses involving herpetological community structure were conducted using PRIMER. All other analyses were completed using PRISM statistical software.

The mean, standard deviation, and minimum/maximum temperatures were calculated for temperature data. Air and ground surface temperatures in warm (May-August 2006 and 2007) and cold seasons (September-October 2006 and March-April 2007) were analyzed using paired *t*-tests.

Vegetation data were analyzed using χ^2, with the means and standard deviations of each plant height class calculated to compare plant heights in burned and unburned areas.

The observation rate of reptile species seen during transect surveys was calculated. ANOSIM (analysis of similarity) of species diversity between years and in burned and vegetated habitats and SIMPER (similarity percentages) analyses were conducted (Clarke, 1993). Transect data collected on *U. stansburiana* locations by line segment through time in each habitat type were analyzed using Friedman randomized block test, χ^2, and Fisher's Exact tests.

The capture rate of each lizard species caught during pitfall trapping was calculated along with the recapture rate for *U. stansburiana*. ANOSIM and SIMPER analyses were conducted to determine dominance in the herpetological community. Abundance data collected on trapped *U. stansburiana* were analyzed with a paired *t*-test and a Fisher's Exact test. Species of mammal and family of invertebrate captured were also tallied.

RESULTS

Ambient Air, Ground Surface, and Subterranean Temperatures

The mean ambient air temperature (±*SD*) for the 2006 and 2007 warm seasons combined was 31.1 ± 5.0ºC and for cold seasons was 20.6 ± 7.2ºC. Ambient air temperatures in the warm season of 2007 were significantly higher than 2006 (t = 5.420, df = 195, p < 0.0001, $\bar{x}$ 2006 = 29.6 ± 5.1, $\bar{x}$ 2007 = 32.4 ± 4.5). The means of the cold seasons were not significantly different (t = 0.3196, df = 55, p = 0.7505, $\bar{x}$ = 20.6 ± 7.2) from one another (Figure 4a).

Ground surface temperature data for 2006 and 2007 were divided by habitat type, season, and year creating data sets for 2006 and 2007 of warm season unburned, warm season burned, cold season unburned, and cold season burned. Unburned habitats were not found to be significantly different between years in the warm season (t = 0.0206, df = 194, p = 0.9836, $\bar{x}$ = 31.5 ± 5.9). Significant differences were found in the cold season (t = 3.570, df = 55, p = 0.0007, $\bar{x}$ 2006 = 19.3 ± 5.2, $\bar{x}$ 2007 = 16.7 ± 6.9), with 2006 being warmer. In burned habitat significant differences were not found between years in the warm season (t = 1.091, df = 193, p = 0.2767, $\bar{x}$ = 32.5 ± 6.1), while the 2006 cold season showed a significant difference in means between years (t = 8.877, df = 52, p < 0.0001, $\bar{x}$ 2006 = 19.5 ± 5.6, $\bar{x}$ 2007 = 17.5 ± 7.0). Also, burned habitats in the warm season had significantly higher temperatures (t = 11.61, df = 415, p < 0.0001, $\bar{x}$ unburned = 31.5 ± 5.9, $\bar{x}$ burned = 32.5 ± 6.0) than unburned. The cold season (t = 0.6167, df = 112, p = 0.5387, $\bar{x}$ = 18.2 ± 6.3) did not have significantly higher temperatures in burned habitats (Figure 4b).

Subterranean temperatures in the warm season of 2007 were significantly higher in both habitat types (unburned t = 2.003, df = 195, p = 0.0466, $\bar{x}$ 2006 = 30.6 ± 8.2, $\bar{x}$ 2007 = 31.2 ± 5.6, and burned t = 2.239, df = 195, p = 0.0263, $\bar{x}$ 2006 = 32.4 ± 8.3, $\bar{x}$ = 32.8 ± 5.4). I found that 2006 was significantly colder in the cold seasons in both habitats (unburned t = 10.61, df = 55, p<0.0001, $\bar{x}$ 2006 = 15.2 ± 4.5, $\bar{x}$ 2007 = 11.9 ± 6.4, and burned t = 9.739, df = 55, p < 0.0001, $\bar{x}$ 2006 = 15.7 ± 4.1, $\bar{x}$ 2007 = 12.6 ± 6.2). In the warm season subterranean temperatures in the burned area were significantly higher than in the unburned area (t = 50.08, df = 417, p < 0.0001, $\bar{x}$ unburned = 30.9 ± 6.9, $\bar{x}$ burned = 32.6 ± 6.9). Subterranean temperatures in burned habitats were also higher in the cold season (t = 7.641, df = 111, p < 0.0001, $\bar{x}$ unburned = 13.5 ± 5.5, $\bar{x}$ burned = 14.2 ± 5.1) during this study (Figure 4c).

During pitfall trapping the minimum air temperature recorded was 0ºC and the maximum temperature was 42ºC.

Vegetation Point-Intercept Transect Surveys

I found that only counts of plants <10 cm tall at one site in the burned area along the fire perimeter and one site in the burned area around a habitat patch, were normally

distributed. The total number of plants in the unburned areas (1,440; 68.58% total cover) was higher than in burned areas (846; 40.28% total cover). There were differences in the distribution of vegetation heights in each habitat ($\chi^2 = 389.9$, $df = 1$, $p < 0.0001$). There were significantly more plants in the burned area under 10 cm than in any other height class in either habitat (Table 3). The number of plants in burned areas in this height class increased from 2006-2007 (264 and 345 total plants). For all heights, except <10 cm, unburned habitats had more plants per site than burned. Although all plants seen were not recorded to species, of those recorded 2% and 21% were noted as *Erodium cicutarium* or a grass species in unburned areas. In burned areas this trend was reversed with *E. cicutarium* accounting for 31% and grasses making up only 7%.

Reptile Transect Surveys

During transect surveys five lizard and one snake species were observed (Table 4). Multi dimensional scaling (MDS) showed that transect sites clustered together by habitat type with the exception of two sites; one unburned patch and one burned perimeter transect location. These two sites were removed from the analysis because they had significantly more zero values and were outliers that made it impossible to determine how locations clustered. I found no significant differences in the species assemblages between years (ANOSIM, $R = 0.018$, $p = 0.271$ and $R = -0.043$, $p = 0.888$) or between unburned and burned habitats ($R = 0.053$, $p = 0.109$ and $R = 0.010$, $p = 0.333$) along the perimeter and in the patch locations, respectively. Therefore, data from 2006 and 2007 were combined and reanalyzed using ANOSIM. Species found at perimeter and patch sites did not differ significantly ($R = 0.038$, $p = 0.272$); however, differences were found ($R = 0.220$, $p = 0.022$) between unburned and burned locations. A SIMPER analysis showed that in the unburned areas, *U. stansburiana* accounted for 88.0% of individuals, with *A. tigris* and *S. occidentalis* making up 14.7% and 13.5% of individuals, respectively. In the burned areas *U. stansburiana* comprised 98.6% of individuals.

U. stansburiana abundance data were not normally distributed and a normalizing transformation could not be found. A Friedman randomized block test found no significant differences in the number of individuals seen by segment location along transects in each habitat type through time (Friedman statistic = 6.500, $p = 0.0897$). Differences were found between habitat types ($\chi^2 = 9.952$, $df = 3$, $p = 0.0190$). Burned areas around patches in 2006 and outside the perimeter in 2007 had the fewest individuals. Most *U. stansburiana* were recorded in burned areas along perimeter sites in 2006, followed by unburned patch sites in 2007 (Figure 5). Although combining perimeter and patch sites yielded more individuals found in unburned habitat ($n = 77$ compared to $n = 62$), there were no significant differences in the number of *U. stansburiana* in unburned and burned habitats (Fisher's Exact test; $p = 0.0624$). Also, no detectable differences were found when year data were combined (Fisher's Exact test; $p = 0.1201$), although burned patches had the fewest ($n = 22$), while burned perimeter and unburned patch habitats had the most individuals (both had $n = 39$). Surprisingly, significant differences were found when unburned and burned sites along the perimeter and at patch locations were combined (Fisher's Exact test; $p = 0.0258$).

Pitfall Trapping

During pitfall trapping six lizard species were captured (Table 5). MDS showed that pitfall trap sites clustered together by year with the exception of one site in a patch location in 2006, which had more zero data points than other sites. This site was removed in order to see patterns in the remaining data. Species abundance did differ significantly between years (ANOSIM, $R = 0.216$, $p = 0.044$). More individuals were captured in 2007 ($n = 60$) than 2006 ($n = 36$). Also, 2006 had one single species not captured in 2007, while 2007 had two that were not present in 2006. *U. stansburiana* dominated the herpetofaunal assemblages in both years; however, this species was represented in a higher percentage in the 2007 (SIMPER, 2006 = 92.6% and 2007 = 98.2%).

Of the 80 *U. stansburiana* captured over the course of this study, 19 were recaptures, resulting in a recapture rate of 23.75%. In 2006 there were very few recaptures (10.71%); however, 2007 saw an increase in recaptured individuals (30.77%). Recaptures of individuals were removed from statistical analyses. The total number of *U. stansburiana* captured by site were normally distributed in both years (2006 $p = 0.2601$ and 2007 $p = 0.7222$). No significant differences in the number of individuals caught between years ($t = 1.135$, $df = 12$, $p = 0.2787$) was found. No significant differences in the direction of movement of individuals was found when these data were combined for analysis (Fisher's Exact test; $df = 4$, $p = 0.2968$), even though the number of *U. stansburiana* moving into patches actually doubled (9 to 18) from 2006-2007 (Figure 6). During trapping more juveniles were captured (66%) than adults (34%), with most *U. stansburiana* being captured in 2007.

I also recorded the numbers of mammals and invertebrates captured in pitfall traps. As these individuals could easily climb the drift fencing their direction of movement could not be determined. Interestingly, the number of mammalian species captured decreased, as did the total number of individuals captured from the first to the second year (Table 6). Conversely, the number of invertebrate families and the total number of individuals captured increased from 2006-2007 (Table 7).

DISCUSSION

Temperature and Vegetation

Due to air temperature variation, 2007 was warmer than 2006, but both ground surface and subterranean temperatures were higher in burned areas than in unburned areas in both years.

The plant community in unburned areas had almost 30% more cover than burned areas and remained relatively stable through time. However, the burned areas had more than twice the number of plants in the <10 cm height class, and very few grew to over 10 cm during the course of this study. This indicates that most were low growing ground cover species. This is consistent with long term studies of plant communities in the Southwest that have found areas affected by wildfire are rapidly colonized by low growing ground cover species that are predominantly alien (Brooks, 2002; Brooks and Matchett, 2003). Additionally, soil nutrient research in the Mojave found that grasses were better competitors and often become dominant following disturbance (Brooks, 1999).

Comparison of Transect and Pitfall Data

Transect and pitfall surveys had comparable species diversity with each other. *Uta stansburiana* was the dominant species in all locations. I found the highest number along the fire perimeter on the burned side in 2006, which is similar to a study conducted after a wildfire in Arizona that found reptiles exhibited a preference for disturbed sites (Cunningham et al., 2002). However, in 2007 the number of individuals found in this area decreased by more than half. It may be that individuals utilized this area more heavily initially because the higher ground temperatures allowed for optimal basking sites. In 2007 temperatures may have become too high creating a less than ideal habitat type that did not provide a thermoregulatory gradient or enough cover (Wilson, 1991). The number of *U. stansburiana* in unburned perimeter locations was relatively constant through time, indicating that this population was the most stable. The numbers found at patches increased in burned and unburned areas, with unburned sites having more individuals.

The directional design of the pitfall arrays allowed me to assess whether individuals were moving into or out of habitat patches. However, no directional pattern was detected, likely because of the low numbers of individuals captured. However, in 2006 the number of *U. stansburiana* captured in pitfall traps at patch sites (n = 28) was comparable to the number seen during transect surveys at the same locations (n = 25). In 2007 more were captured (n = 52) than seen (n = 37). It may be that the increased temperatures in 2007 altered the movements of *U. stansburiana*, decreasing their daily activity.

Future Research Recommendations

This research would have benefited from a longer study period. Two years is not a sufficient amount of time to accurately determine trends in a fragmented system that is

undergoing post-wildfire successional stages. Many environmental parameters, including yearly temperature and rainfall fluctuations, could account for the trends seen and result in notable year-to-year variability (Hirsch et al., 2002).

Conservation Implications

Although the results of a study conducted in a single location and affected by a single event may not be fully extrapolated to other locations or events, it is clear that wildfire is a serious threat to biodiversity in the Mojave. The effects of large desert fires are poorly understood, largely because this is a relatively new problem (Brooks, 2002; Brooks and Matchett, 2003). Information on floral community succession and faunal survival is useful to help understand the long-term consequences of altering landscapes, and could lead to increased control of invasive species. These species have created a positive feedback system, or a grass-fire cycle, in the Mojave. The resulting habitats are increasingly homogeneous, and provide few resources (Esque, 1999; Esque et al., 2003; Valentine et al., 2007).

The presence of *U. stansburiana* is a good indicator of the possible establishment of healthy populations of many other species. *U. stansburiana* is an abundant and widespread lizard that is a food source for many species that cannot reoccupy an area until suitable numbers of prey are present (Stebbins, 2003). Low numbers will negatively impact the community, decreasing both diversity and abundance. This study suggests that wildfire in the Mojave negatively affects the reptile community.

Due to the hostile conditions and already limited resources, desert environments are not able to maintain dense populations of wildlife, creating fragile systems composed of highly specialized species. Deserts, although coming under increasing pressure from human expansion and activities, are some of the most inhospitable and therefore remote and unexploited areas in the continental United States. Wildlands are becoming increasingly rare worldwide and few ecosystems contain organisms with such unique adaptations to extreme conditions as desert regions, making conservation in these areas a critical concern.

TABLE 1. Transect Locationss in the Hackberry Region, Mojave National Preserve

Site	Starting Easting	Starting Northing	Ending Easting	Ending Northing	Elevation (m)
Patch 1	645412	3892561	645405	3892517	1596
	645409	3892565	645438	3892531	
	645431	3892589	645438	3892543	
Patch 2	645425	3892203	645476	3892204	1591
	645422	3892195	645470	3892178	
	645438	3892181	645467	3892157	
Patch 3	642829	3887189	642812	3887237	1661
	642821	3887185	642789	3887221	
	642806	3887173	642777	3887208	
Patch 4	642810	3887316	642814	3887365	1665
	642786	3887307	642798	3887350	
	642754	3887298	642787	3887342	
Patch 5	642814	3887533	642841	3887575	1670
	642788	3887525	642821	3887566	
	642708	3887531	642806	3887571	
Patch 6	645913	3887650	642933	3887695	1684
	642929	3887649	642944	3887699	
	642954	3887662	642962	3887709	
Patch 7	643023	3887958	643039	3887909	1679
	643050	3887969	643049	3887917	
	643077	3887972	643063	3887927	
Perimeter 1	646600	3892811	646555	3892819	1594
	646598	3892786	646549	3892794	
	646586	3892763	646540	3892786	
Perimeter 2	646545	3892659	646493	3892658	1604
	646552	3892636	646500	3892638	
	646536	3892610	646488	3892620	
Perimeter 3	646524	3892565	646480	3892567	1656
	646522	3892553	646480	3892546	
	646538	3892529	646492	3892526	
Perimeter 4	646513	3892468	646465	3892474	1660
	646506	389245	646457	3892448	
	646498	3892431	646458	3892678	
Perimeter 5	646586	3892634	646587	3892681	1580
	646595	3892616	646611	3892668	
	646623	3892625	646623	3892678	
Perimeter 6	645283	3892595	645259	3893556	1582
	645262	3892604	645247	3893560	
	645244	3892615	645237	3893568	
Perimeter 7	645167	3893604	645186	3893568	1580
	645153	3893610	645175	3893571	
	645132	3893600	645150	3893554	

Note: All locations in map datum NAD83, UTM zone 11.

TABLE 2. Locations of Pitfall Trap Arrays in the Hackberry Region of the Mojave National Preserve

Array	Easting	Northing	Elevation (m)
1	645395	3892528	1596
2	645456	3892203	1591
3	642811	3887222	1661
4	642804	3887343	1665
5	642873	3887558	1670
6	642942	3887683	1684
7	643035	3887924	1679

Note: All locations in map datum NAD83, UTM zone 11.

TABLE 3. Percent Vegetation Cover in Unburned and Burned habitats by Height Class

Height Class (cm)	Unburned		Burned	
	Number	Percent Cover	Number	Percent Cover
<10	220	10.48	631	30.05
10-30	295	14.05	133	6.33
30-50	248	11.81	63	3.00
50-100	345	16.43	16	0.76
>100	332	15.81	3	0.14
Total	1440	68.58	846	40.28

TABLE 4. Reptile Species Observed During Transect Surveys

Species	2006		2007		Unburned		Burned	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Aspidocelus tigris Western whiptail	7	0.3684	4	0.2105	11	0.2895	0	0
Gambelia wislizenii Long-nosed leopard lizard	2	0.1053	0	0	1	0.0263	1	0.0263
Masticophis taeniatus Striped whipsnake	1	0.0526	0	0	0	0	1	0.0263
Phrynosoma platyrhinos Desert horned lizard	0	0	1	0.0526	0	0	1	0.0263
Sceloporus occidentalis Western fence lizard	8	0.4211	7	0.3684	5	0.1316	10	0.2632
Uta stansburiana Side-blotched lizard	80	4.2105	56	2.9474	75	1.9737	61	1.6053
Total	98	5.1579	68	3.5789	92	2.4211	74	1.7105

Note: Observation rates were calculated using number of observations/number of transects conducted (Persons and Nowak, 2006).

TABLE 5. Reptile Species Captured During Pitfall Trapping

Species	2006		2007	
	Number	Capture Rate	Number	Capture Rate
Aspidocelus tigris Western whiptail	5	0.0725	1	0.0145
Gambelia wislizenii Long-nosed leopard lizard	1	0.0145	0	0
Sceloporus magister Desert spiny lizard	0	0	3	0.0435
Sceloporus occidentalis Western fence lizard	2	0.0290	5	0.0435
Uta stansburiana Side-blotched lizard	28	0.4056	52	0.7536
Xantusia vigilis Desert night lizard	0	0	1	0.0145
Total	36	0.5216	62	0.8969

Note: Capture rates were calculated using number of captures/number of pitfall trap sessions conducted (Persons and Nowak, 2006).

TABLE 6. Mammal Species Captured During Pitfall Trapping

Species	2006	2007
Dipodomys deserti Desert kangaroo rat	6	3
Lagurus curtatus Sagebrush vole	3	0
Perognathus longimembris Little pocket mouse	1	1
Perognathus penicillatus Desert pocket mouse	0	1
Peromyscus sp. Pygmy mouse species	3	0
Thomomys bottae Valley pocket gopher	1	1
Total Number of Individuals	14	6
Total Number of Species	5	4

TABLE 7. Invertebrate Families Captured During Pitfall Trapping

Family	2006	2007
Caraboctonidae (Desert scorpions)	35	71
Cerambycidae (Long-horned beetles)	0	1
Cicadidae (Cicadas)	0	1
Eremobatidae (Windscorpions)	31	35
Gryllacrididae (Camel crickets)	98	152
Gryllidae (Crickets)	3	0
Mantidae (Mantids)	1	1
Mutillidae (Velvet ants)	0	2
Myrmeleontidae (Antlions)	0	1
Pompilidae (Tarantula hawks)	0	1
Reduviidae (Assassin bugs)	0	13
Scolopendridae (Multicolored centipedes)	2	0
Tenebrionidae (Darkling beetles)	483	623
Theraphosidae (Blonde tarantulas)	0	1
Total Number of Individuals	653	902
Total Number of Families	7	12

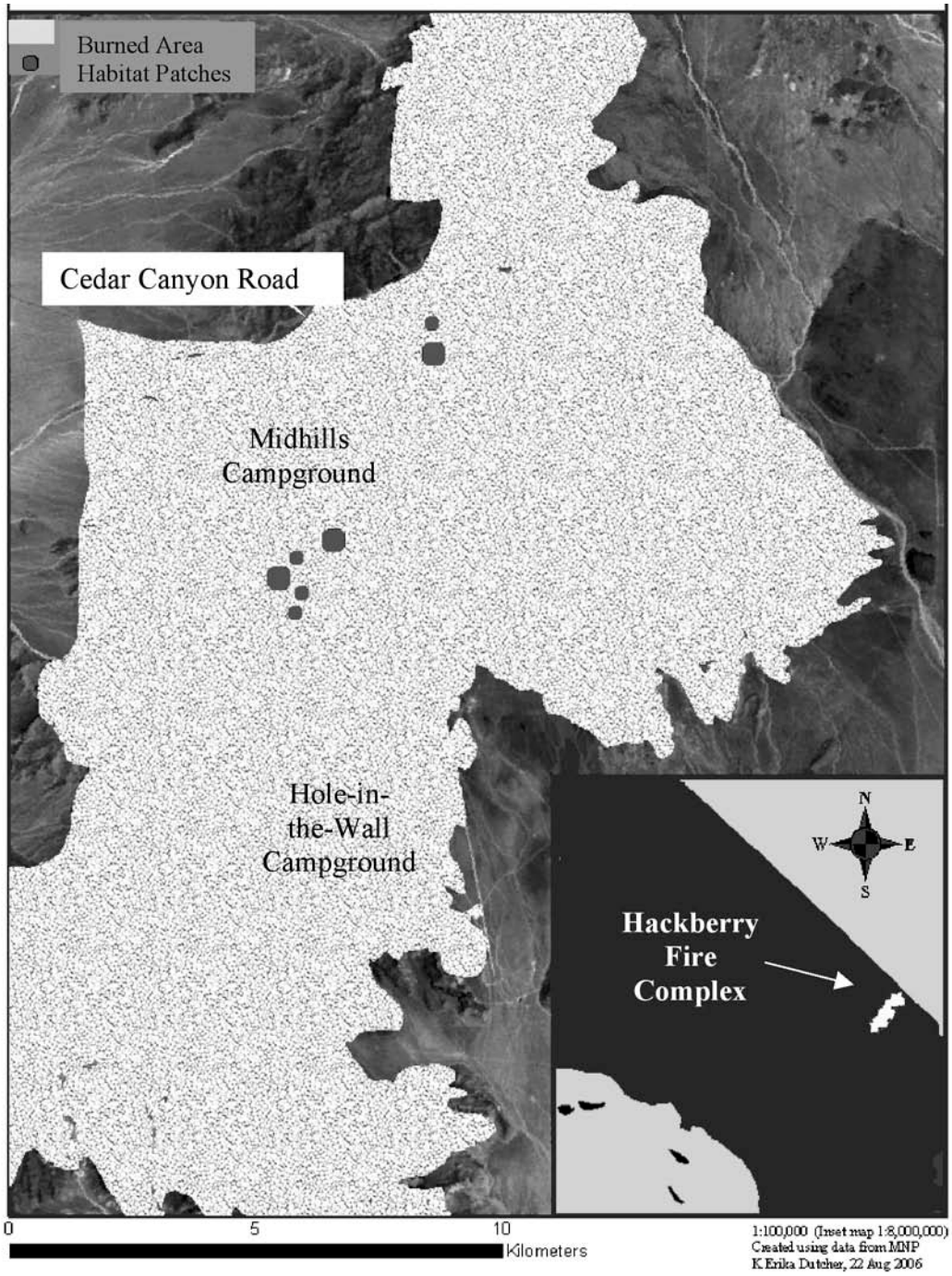


FIGURE 1. Habitat patch locations within the Hackberry region of the Mojave National Preserve. Habitat patch size not to scale. The subset map shows the location of the Hackberry wildfire in Southern California. Map created by K. Erika Dutcher and Dr. D. Underwood using data from the National Park Service, 2006.

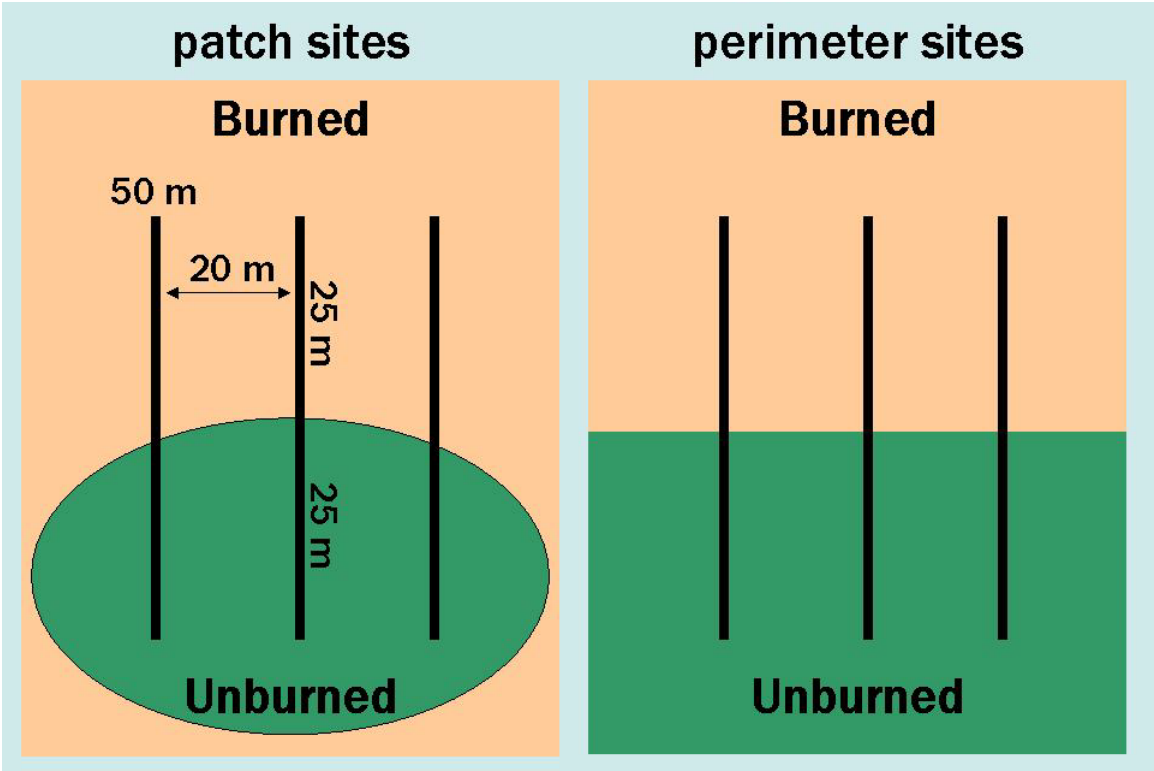


FIGURE 2. Transect design. Each site had three 50 m transects separated by 20 m. Half (25 m) of each transect was located in burned habitat and 25 m in unburned habitat.

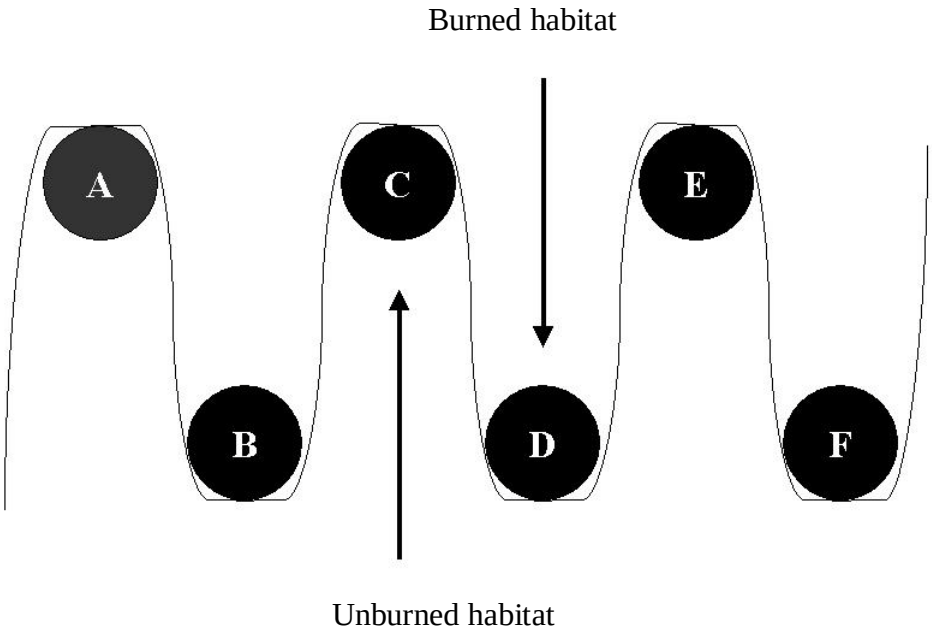
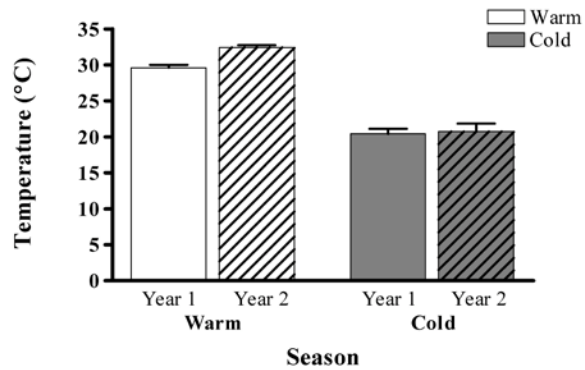
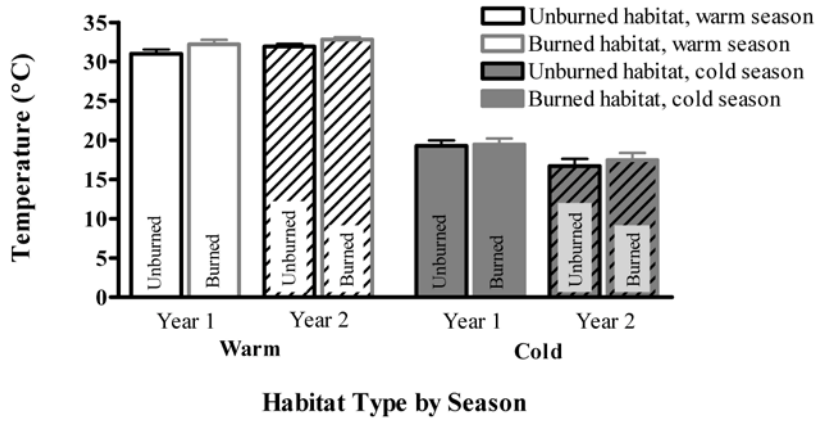


FIGURE 3. Pitfall array design. Buckets were fenced on three sides to prevent reptiles from the burned area entering traps A, C, and E and reptiles from the unburned area entering traps B, D, and F.

(a)



(b)



(c)

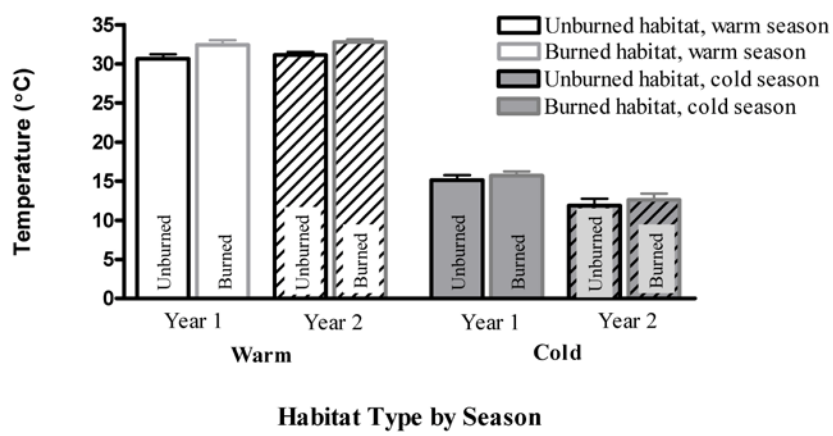


FIGURE 4. Ambient, ground, and subterranean temperatures ($\bar{x} \pm$ SD). (a) Average ambient temperatures by year in the warm and cold seasons. (b) Average ground temperatures for unburned and burned habitats by year in each season. (c) Average subterranean temperatures for both habitats by year in each season.

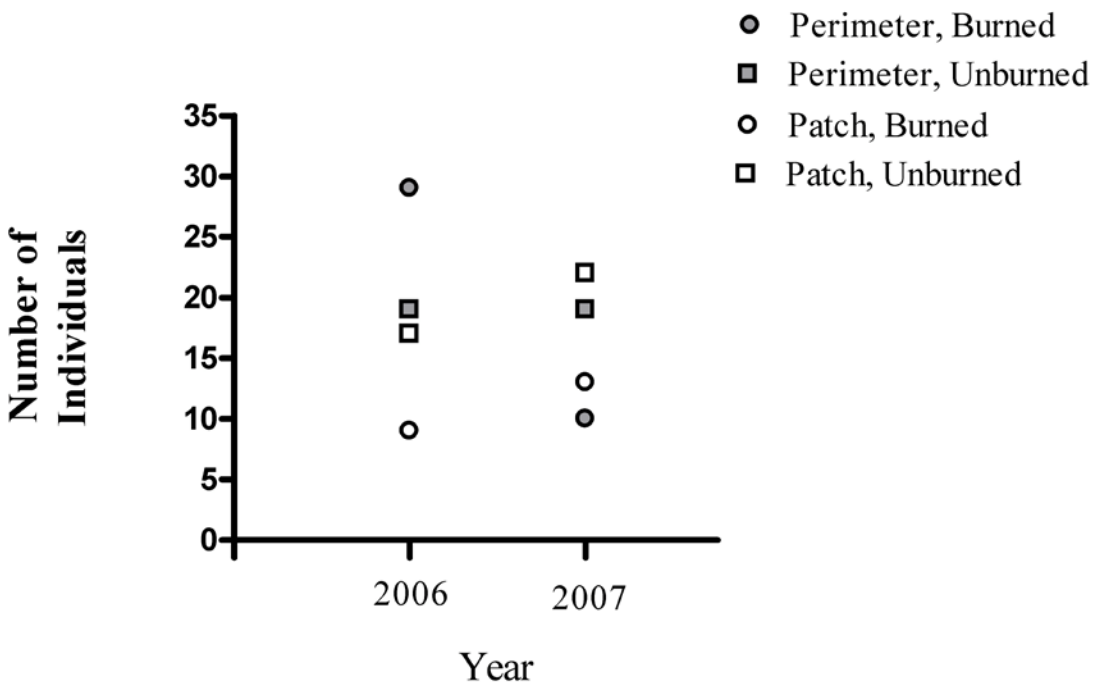


FIGURE 5. Total number of *Uta stansburiana* observed during transect surveys in each habitat type by year.

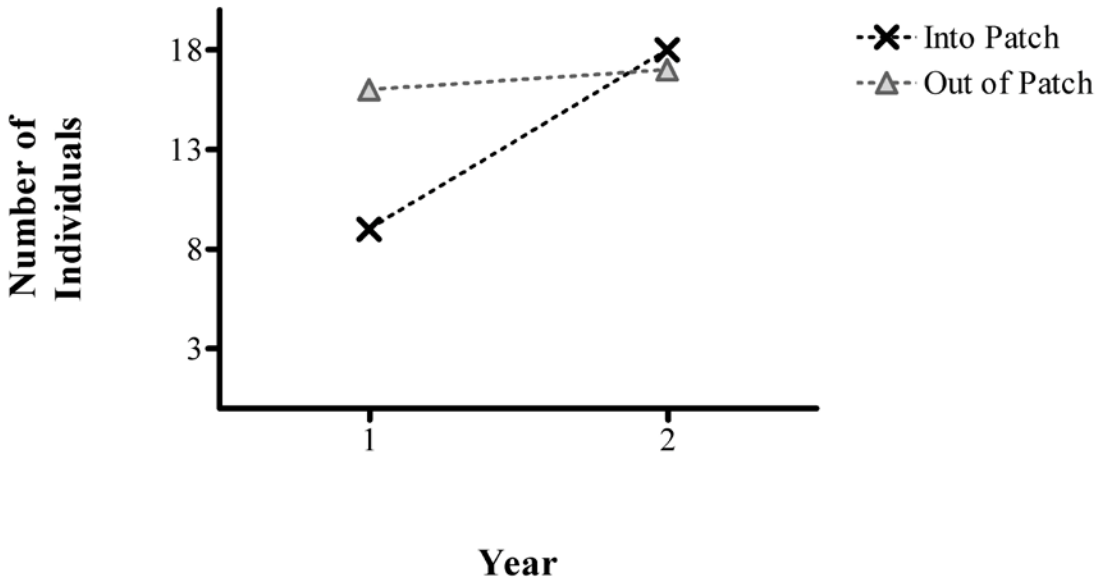


FIGURE 6. Total number of *Uta stansburiana* captured in pitfall traps moving into or out of habitat patches by year. Recaptured individuals were removed from the totals.

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