Lee's Pincushion Cactus

(*Escobaria sneedii var. leei*)

Final 5-Year
Post-fire Monitoring Report

Prepared for the USFWS
Region 2, Albuquerque

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INTRODUCTION

Lee's pincushion cactus (*Escobaria sneedii var. leei*) is endemic to New Mexico, where it is restricted to the Carlsbad Caverns National Park area and adjacent BLM lands in the Guadalupe Mountains of Eddy County. It occurs primarily in cracks of limestone outcrops, in areas of broken terrain and steep slopes in Chihuahuan desert scrub communities between 4,000 and 5,000 ft in elevation (Figure 1).

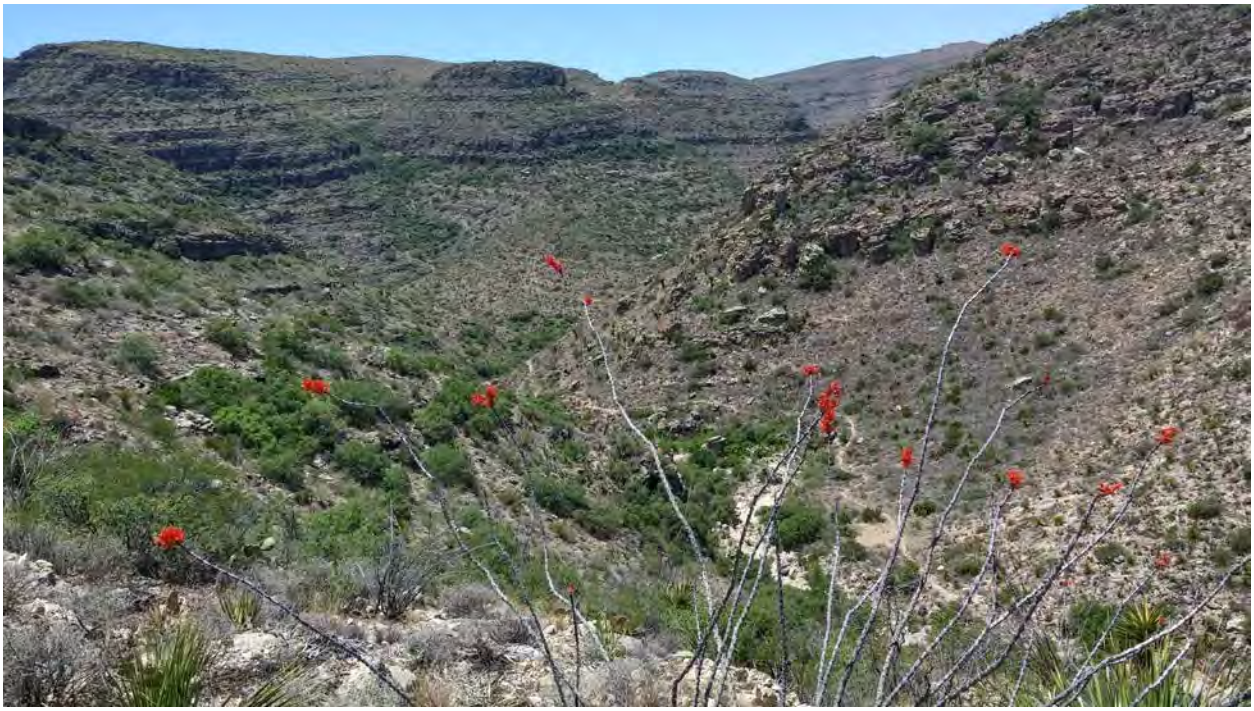

Figure 1. Habitat of Lee's pincushion cactus at Carlsbad Caverns National Park.

Carlsbad Caverns National Park is located ca. 20 miles southwest of the City of Carlsbad. The average annual rainfall at Carlsbad Caverns National Park is 14.70 inches, ranging from 4.47 inches to 33.01 inches over a 61-year recording history (WRCC 2018). No consistent data is available for the years following the Loop Fire, but rainfall amounts were less than half of the average during the year of the Loop Fire in 2011(6.74 inches), which followed a year of unusually high rainfall in 2010 (24.12 inches). Significant differences between rainfall amounts were also recorded at the nearby airport in Carlsbad for these 2 years. Except for 2014 (4.89 inches), rainfall amounts since the 2011 Loop Fire were hovering near the average for the Carlsbad Caverns Airport (12.06 inches), ranging from 11.13 (2016) to 14.32 inches (2015).

Carlsbad Caverns National Park is situated in the northern portion of the Chihuahuan Desert ecosystem and stretches over 46,766 acres, including 33,000 acres of designated wilderness. Elevation ranges from 3,596 ft to 6,368 ft. Over 900 vascular plants have been documented from within the Park boundaries (NPS 2007). The Park contains a section of the Capitan Reef, one of the best preserved, exposed Permian-age fossil reefs in the world. The Tansil Formation is prevalent in the south-central and eastern portions of the park as a dolomitic "cap rock" over the Capitan Limestone and is the underlying substrate for most of the Lee's pincushion cactus populations (Muldavin et al. 2013).

Lee's pincushion cactus was listed as a threatened species under the Federal Endangered Species Act on October 25, 1979 (44 FR 61554 61556). It is also listed Endangered in the State of New Mexico (19

NMAC 21). The primary reasons for listing were illegal collection and road construction. Fire was not listed as a threat in 1979, nor in the 1986 recovery plan. In fact, the recovery plan considered fire a potential positive impact on plants, due to the elimination of competing vegetation (USFWS 1986). However, the recovery plan listed studying the impacts of fire on Lee's pincushion cactus as an action that must be taken to prevent a significant decline in the species' population or habitat quality.

Between 2010 and 2012, multiple fires have burned roughly half of the land area within Carlsbad Caverns National Park, including a significant portion of occupied habitat of Lee's pincushion cactus (Figure 2). In 2011, the Loop Fire burned 8,221 acres of desert lands within the Park, including a large number of these rare cacti. Limited data on the status of a small population of cacti immediately post-fire is available, but we do not know the long-term impacts on survival, reproduction, vigor, and recruitment in response to fire (NPS 2011, NHNM 2012). Ongoing drought and predicted increases in severity and frequency of fires in the Southwest have caused serious concerns about the continued survival of these cacti. The primary objective of this study was to document the response of Lee's pincushion cactus to fire, with the goal of documenting post-fire recovery and providing long-term population trend information.

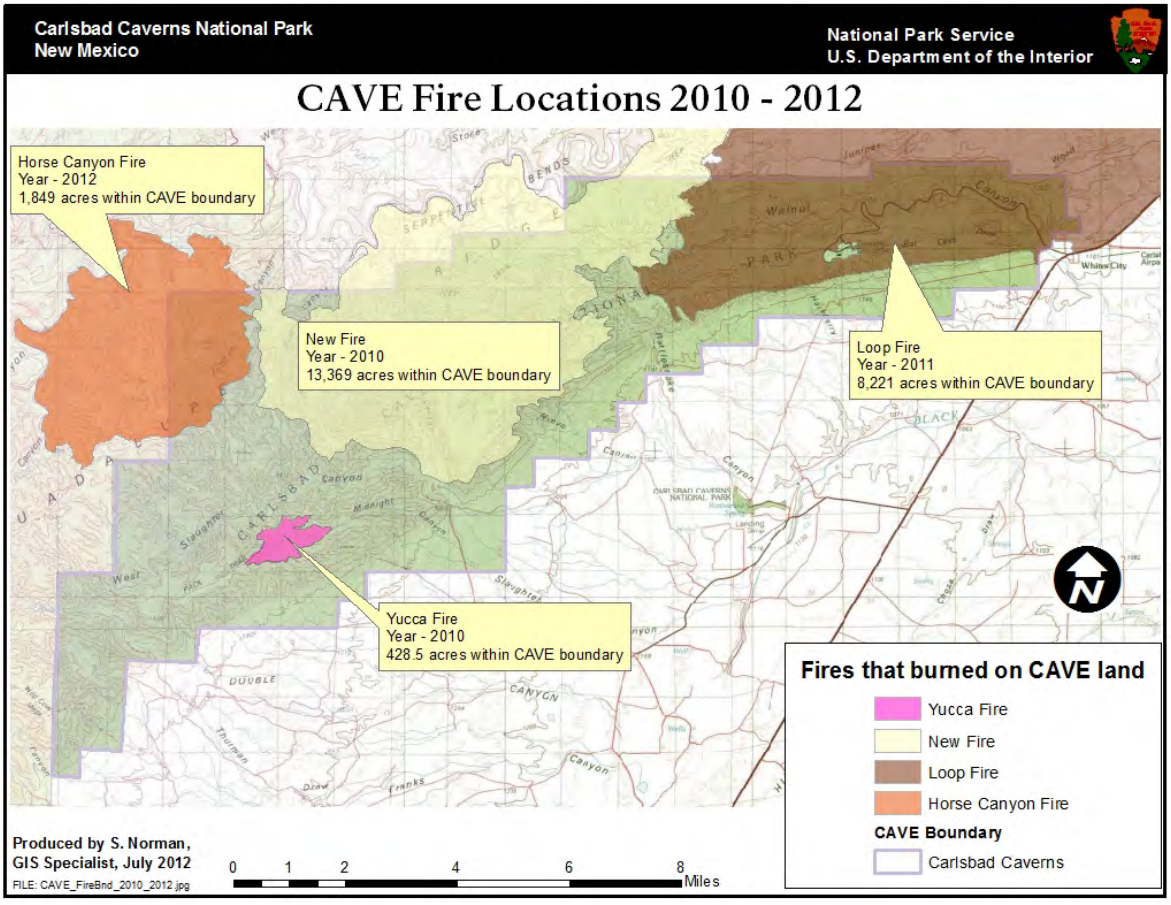

Figure 2. Recent fire history at Carlsbad Caverns National Park (2010- 2012).

METHODS

In May of 2014, sixty monitoring plots were established in an area burned in the 2011 Loop Fire and 60 monitoring plots were established in an adjacent unburned area in the Rattlesnake Canyon area. Monitoring plots were 1m in radius and contained at least one plant (dead or alive). The center of each monitoring plot was marked with a metal tag fastened on a nail (Figure 3). Monitoring plot locations were mapped using a Trimble GPS. All cacti rooted inside each monitoring plot were tagged with individually numbered round metal tags (Figure 4). Clusters of cacti were considered individuals if they were more than 6 inches apart from each other. The initial number of cacti in the 60 unburned plots was 86 (including 12 dead plants) and 85 plants (including 25 dead plants) were recorded in the 60 burned plots. Annual data collected included the overall vigor of each plant in each plot (1 = excellent, 2 = good, 3 = fair, 4 = poor, 5 = dead), the estimated number of living and dead stems, and the number of reproductive structures of each plant (flowers, fruits). Any new recruits were tagged and evaluated accordingly. Monitoring plot locations in burned and unburned areas were chosen from a sample of previously recorded cacti and cacti found during the initial site visit. Locational data for these cacti was provided by Natural Heritage New Mexico (NHNM 2012) and/or Carlsbad Caverns National Park (NPS 2011). Annual monitoring occurred for 5 years, during the last week of April (2014 – 2018).

Figure 3. Center of monitoring plot (rectangular metal tag) behind a burned Lee's pincushion cactus plant, 2014.

Figure 4. Tagged individual of Lee's pincushion cactus.

RESULTS

Initial Recruitment and Mortality

Little mortality was recorded in the five years following the initial set-up of the monitoring plots in both burned and unburned areas. The cause of mortality of the 12 dead plants initially recorded in the 2014 unburned plots is unknown but was likely due to drought conditions in 2014 and perhaps 2011 (WRCC 2018) (Table 2). The cause of the observed higher mortalities in the burned plots (25 plants) is presumed to be primarily from direct impacts caused by the 2011 Loop Fire (Tables 1 & 2). Sixty-two of the 85 plants recorded in the 60 burned monitoring plots in 2014 were plants that were also recorded in 2011 (NPS 2011) and/or 2012 (NHNM 2012) (Table 1). Seventeen of the 25 dead plants recorded in 2014 were reported as burned or partially burned in 2011and/or 2012. Six of the 10 plants found dead in 2011 showed no signs of recovery and were still considered dead in 2014. Four of the plants found dead in 2011 had recovered some live stems in 2014. Nine additional plants had died between 2011 and 2012 and four additional plants died between 2012 and 2014. Three plants recorded as dead in 2012 recovered and were alive in 2014 and three additional plants died between 2012 and 2014.

Table 1. Number of Lee's pincushion cactus plants found alive or dead immediately after the 2011 Loop Fire at Carlsbad Caverns National Park, in 2012 and 2014.

	NPS 2011	NHNM 2012	EMNRD 2014
Live	37	43	45
Dead	10	17	17
Unknown Status	12	3	0
Total Number of Plants	**59**	**63**	**62**

2014 – 2018 Results

In 2018, the 60 unburned area plots established in 2014 contained a total of 88 cacti, 71 of which were alive (Table 2). Only three plants died since the initial set-up of the plots in 2014 and none had died since 2017. Only one new plant was found in the unburned plots during any of the 5 study years.

The 60 burned area plots contained a total of 91 cacti in 2018, 56 of which were alive in the spring of 2018. A total of 10 plants died since the initial set-up of the plots in 2014, five plants had died between 2017 and 2018. Two dead plants recorded in 2015 were previously reported as burned or partially burned. Only one of the 8 dead plants found in the burned plots in 2017 and 2018 was initially recorded as burned. A total of 6 new plants were recorded in the 60 burned monitoring plots since they were established in 2014; no new plants were found in the burned monitoring plots in 2018.

Table 2. Changes in Lee's pincushion cactus study parameters in burned and unburned monitoring plots over a 5-year period post-fire at Carlsbad Caverns National Park, New Mexico.

Burned	**2014**	**2015**	**2016**	**2017**	**2018**
Total number of plants	85	86	86	91	91
Total number of plants alive	60	60	61	61	56
Total Number of stems	2692	2303	2534	2847	3107
% dead stems	29	14	8	5	2
% live stems	71	86	92	95	98
Total number of plants reproductive	30	29	33	35	32
Percent of total alive reproductive	50	48	55	57	57
Total Number of Reproductive Structures	576	480	368	465	297
Recruits		2	1	3	0
Dead	25	2	0	3	5

Unburned	2014	2015	2016	2017	2018
Total number of plants	86	87	89	89	88
Total number of plants alive	74	75	75	71	71
Total Number of stems	3307	3015	3154	3228	3325
% dead stems	24	13	8	5	3
% live stems	76	87	92	95	93
Total number of plants reproductive	51	57	59	54	45
Percent of total alive reproductive	69	76	78	76	63
Total Number of Reproductive Structures	669	732	528	577	462
Recruits		1	0	0	0
Dead	12	0	1	2	0

Over the 5 year of study reproductive effort in unburned plots ranged from 63% of live plants in 2018 to 78% in 2016 (Figure 5). The number of flowers and fruits ranged from 462 flowers and fruits on 45 reproductive plants in 2018 to 732 on 57 reproductive plants in 2015. In burned plots reproductive effort ranged from 48% of live plants in 2015 to 57% in 2017 and 2018. The number of flowers and fruits in burned plots ranged from 297 on 32 reproductive plants in 2018 to 576 on 30 reproductive plants in 2014. A simple t-test revealed significant differences in the number of reproductive plants in burned vs. unburned plots. The mean number of reproductive plants was 53 in the unburned plots and 32 in the burned area plots over the 5 study years. The number of reproductive plants remained higher in unburned plots vs. burned plots through 2018, although the percentage of reproductive plants in burned vs. unburned plots was within 5% by 2018.

The total number of stems recorded for the live cacti in unburned plots ranged from 3,015 in 2015 to 3,325 in 2018 (Table 2). The percentage of dead stems among live plants ranged from 3% in 2018 to 24% in 2014. The total number of stems recorded for the live cacti in the burned plots ranged from 2,303 stems in 2015 to 3,107 stems in 2018. The percentage of dead stems among live plants ranged from 2% in 2018 to 29% in 2014. The majority of plants in both burned and unburned areas were considered in excellent or good condition during all monitoring years ranging from 70% in unburned plots in 2014 to 92% in 2017, and in burned plots from 61% in 2014 to 89% in 2015 (Figure 6).

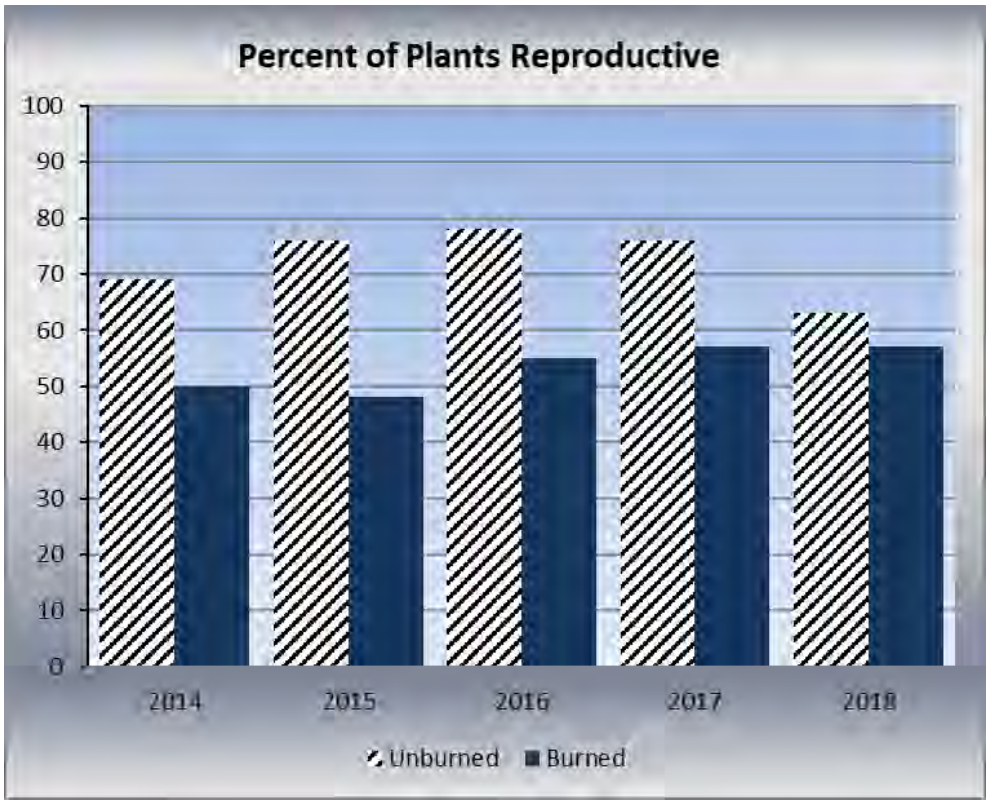

Figure 5. Lee's pincushion cactus reproductive effort in burned and unburned monitoring plots at Carlsbad Caverns National Park, New Mexico.

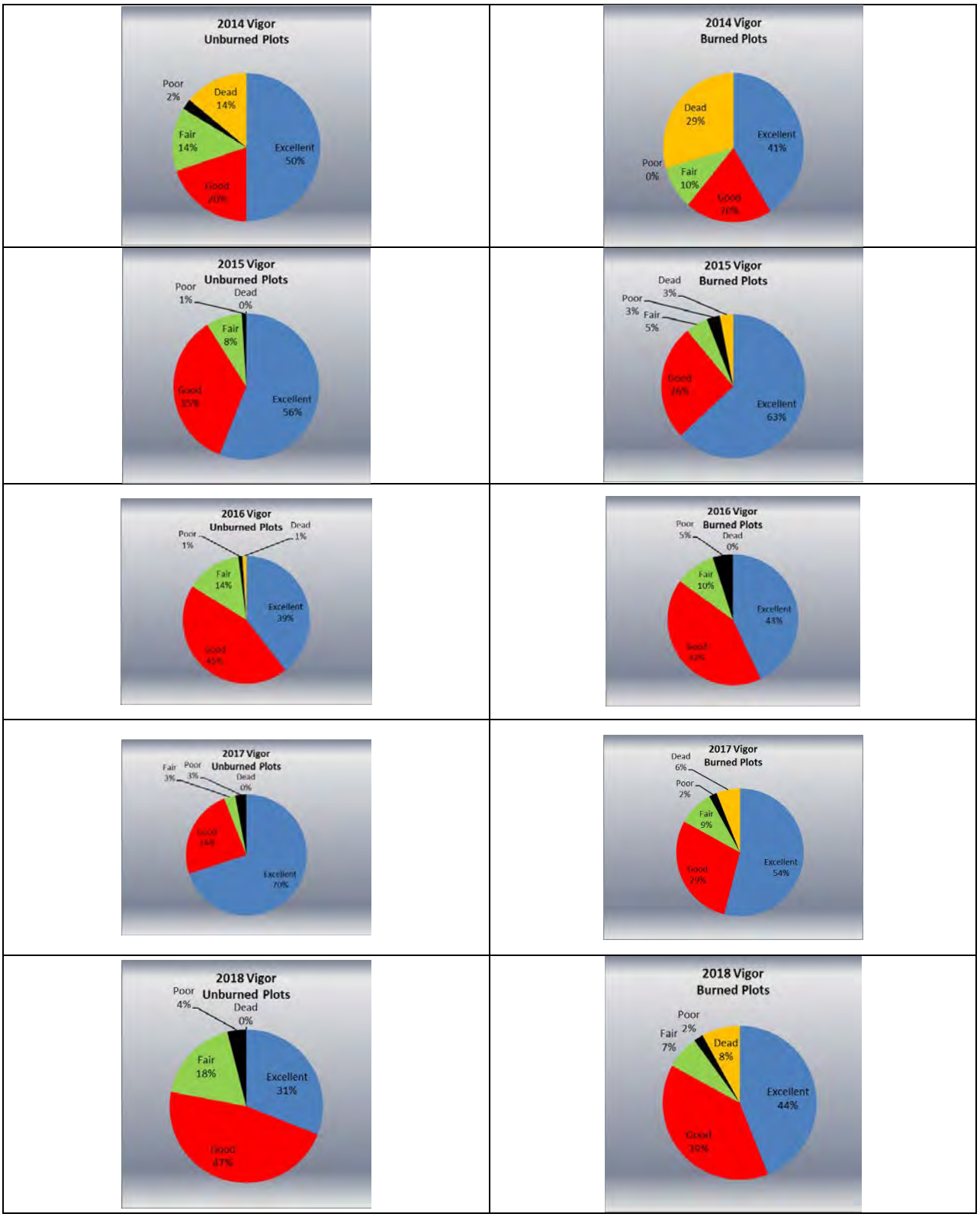

Figure 6. Vigor of Lee's pincushion cactus plants in burned and unburned monitoring plots at Carlsbad Caverns National Park, New Mexico.

DISCUSSION

A total of 35 plants of the 91 plants recorded in the burned area were dead in 2018. Seventeen of these were documented as partially burned or dead and burned in 2011. Eight plants that were found dead in the initial set-up of the monitoring plots had no previous records and therefore we do not know for certain whether they were burned in 2011, or not. Although it is likely that some of these 8 cacti also died as a consequence of the fire, by 2014 it was difficult to estimate where microsites had burned and impacted the cacti because the habitat was largely recovered (Figure 7).

Fires burn patchy and not all cacti inside the fire perimeter were burned during the 2011 Loop Fire (NPS 2011, NHNM 2012). Some plants did not burn because they were growing on rocky outcrops were the fire did not impact them (Muldavin *et al.* 2013). In addition, it can take a cactus several years to succumb to injury sustained by fire or other disturbances. The initial rate of mortality among 131 plants located inside the Loop Fire was estimated at 40.5 %, two growing seasons after the fire (Muldavin *et al.* 2013). Considering the initial relatively high numbers of dead cacti and dead stems in burned and unburned plots, likely due to drought conditions, some of the dead plants and stems found in the burned areas must have also died from drought. A total of 10 plants died during the 5-year monitoring period in the burned plots. Two additional mortalities were recorded in 2015, none in 2016 and a total of 8 dead plants were recorded in 2017 and 2018. Seven of the eight dead plants found in 2017 and 2018 could not be traced to previously burned plants and the cause of mortality is unclear. Hence the majority fire related mortalities occur within one to two years of a fire.

Initial mortality in the unburned areas was likely caused by drought conditions in 2011 and 2014. This is also supported by the large percentage of dead stems recorded in 2014 (in burned and unburned plots). Dead plants and individual dead stems were still present in 2014, showing no signs of damage or predation (Figure 8). Plants are covered by dense spines and therefore it can be difficult to determine whether a plant is dead or alive, especially if the stems remain after the plants died from drought or insect predation (stems hollowed out). Dead stems can remain on site for several years. Only three additional mortalities were documented in five years of monitoring unburned plots.

Even after a plant has been removed by fire or predation, it can resprout from the root, or reestablish from the seedbank, which is expected to be in the immediate surrounding area where the parent plant once grew. Therefore, any recovery is likely to occur in areas immediately adjacent to dead plants. However, even though rainfall amounts were near average since 2014, recruitment of new individuals was limited;

only one new recruit was documented from unburned plots and six new recruits were documented in burned plots over the 5-year study period.

The percentage of reproductive effort was significantly larger in unburned plots for the first 4 years of this study but was within 5% in year 5, 7 years following the fire. This is likely a result of having significantly fewer mature live stems present in the burned plots during the initial 4 years of study. The total number of stems in unburned areas remained fairly constant and increased in the burned plots. The percentage of dead stems decreased sharply after the first year of monitoring in burned and unburned areas and was similarly low over the next 4 years. Recovering stems may be too young to be reproductive for several years following a fire.

Recruitment of new plants was low in both burned and unburned plots, despite relatively good years of rainfall since the 2011 fire. Although recruitment was higher in the burned plots, mortality outpaced recruitment in both sites. Reproductive effort is significantly reduced in burned areas for up to 7 years following a fire. Therefore, fire does not benefit these cacti by initiating increased reproduction or recruitment, but provides a setback in population trends for a species that naturally already exhibits low recruitment rates. In fact, these cacti may have benefitted from fire suppression. The preferred habitat of this species is in crevices of rocks and on rock ledges. There is no evidence to suggest that these cacti may be negatively impacted by increased resource competition from neighboring native plants. No invasive introduced plants were documented in the vicinity of the study plots. Prescribed fires are not recommended in the habitat of Lee's pincushion cactus.

Several other potential threats to the species were documented during this study. Large groups of barbary sheep (up to 40 individuals) were seen within park boundaries and sheep droppings were documented in the immediate vicinity of plants (Figure 9). While the occasional trampling from deer might be expected, damage incurred by large herds of exotic invasive ungulates could be significant and result in substantial declines of local populations. In addition, plants were documented in the immediate vicinity of gravel deposits below the Walnut Canyon Desert Drive, displaced by flooding and road maintenance (Figure 10). It is likely that some plants were covered by the gravel flow.

Figure 7. Recovering habitat of Lee's pincushion cactus, 7 years after the Loop Fire.

Figure 8. Dead Lee's pincushion cactus plant in the unburned area.

Figure 9. Barbary sheep droppings on Lee's pincushion cactus

Figure 10. Gravel deposits from road erosion in Lee's pincushion cactus habitat.

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