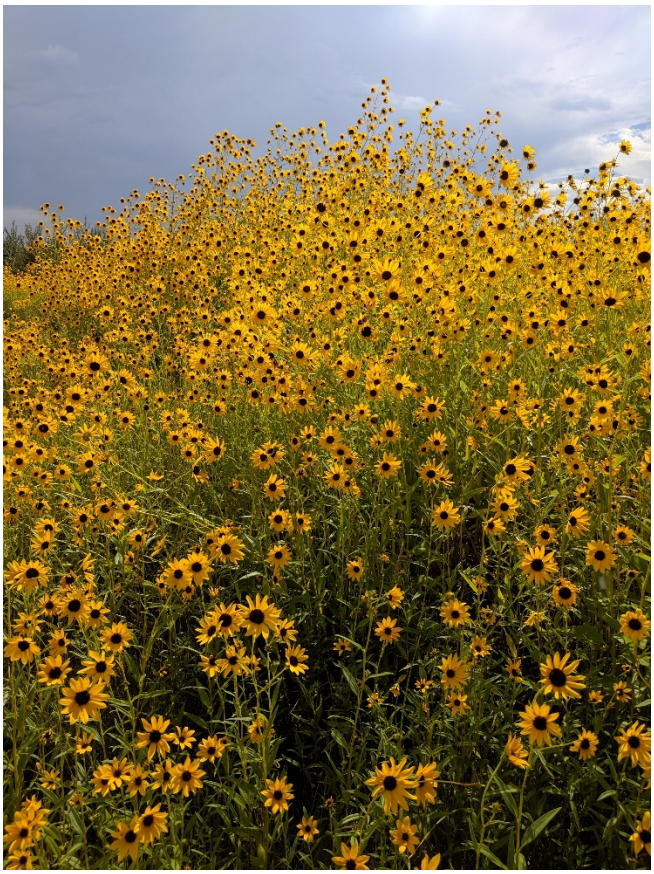
Pecos Sunflower

(*Helianthus paradoxus*)

2013 - 2019 Monitoring Report

Blue Hole Ciénega Nature Preserve
Santa Rosa, NM



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INTRODUCTION

Pecos sunflower (*Helianthus paradoxus* Heiser) is an annual wetland plant that grows on wet, alkaline soils in spring seeps, wet meadows, and along stream courses and pond margins (USFWS 2005). It has seven widely spaced populations in west-central and eastern New Mexico, and adjacent Trans-Pecos Texas. Incompatible land uses, habitat degradation and loss, and groundwater withdrawals are historic and current threats to the survival of Pecos sunflower.

Pecos sunflower was listed Threatened under the Endangered Species Act of 1973 (ESA), as amended, on October 20, 1999 (64 FR 56582-56590). The U.S. Fish and Wildlife Service (USFWS) designated Blue Hole Ciénega as Critical Habitat for Pecos sunflower in 2008 (73FR 17762-17807). In addition, the State of New Mexico lists Pecos sunflower as endangered under the New Mexico Endangered Plant Species Act (19 NMAC 21.2), and it is listed threatened by the State of Texas (31 TAC 2.69(A)). NatureServe ranks Pecos sunflowers globally and state imperiled (G2/S2). The New Mexico Rare Plant Conservation Strategy gives the species an overall conservation rank of 'moderately conserved' due to moderate to high threat scores and a limited distribution (EMNRD – Forestry Division 2017).

The USFWS Recovery Plan grouped the seven populations of Pecos sunflowers into 4 disjunct recovery regions, including the Santa Rosa region in eastern New Mexico (USFWS 2005). The recovery strategy is to protect and manage significant, sustainable portions (termed "core conservation areas") of each of the four region's sunflower habitats against the threat of future habitat loss and degradation. At least one core conservation area and one isolated stand of Pecos

sunflower need to be protected in each region to meet the recovery criteria. All core conservation habitats must contain good or excellent populations. For a population to be ranked excellent several hundred thousand individuals need to be present. A good population for Pecos sunflower recovery purposes is a stand of at least 5,000 individuals during most (7 out of 10) years. Blue Hole Ciénega Nature Preserve was identified as a core conservation area for the Santa Rosa Recovery Region (Figure 1).

Figure 1. Distribution of Pecos sunflowers and location of the USFWS Santa Rosa Recovery Region (USFWS 2005).

Blue Hole Ciénega Nature Preserve (Ciénega)

The 116-acre Blue Hole Ciénega Nature Preserve in Santa Rosa was acquired by the New Mexico Forestry Division in 2005 with funds from a USFWS Recovery Land Acquisitions grant and a mitigation settlement from the NM Department of Transportation. It is managed by the Forestry Division for the sole purpose of protecting and enhancing the Pecos sunflower population and other rare and endangered wetland plants. Management actions and associated research inform the types of management and land uses that are beneficial for this species on Blue Hole Ciénega and elsewhere, including the removal of livestock, the ongoing management of invasive woody species (tamarisk, Siberian elm, Russian olive) through cut and herbicide treatments, and prescribed fires.

Description

Pecos sunflower is an annual, herbaceous plant, up to 10 ft tall (USFWS 2005). The leaves are opposite on the lower part of the stem and alternate at the top, lance-shaped with three prominent veins, and up to 6.9 inches long by 3.3 in wide. The stem and leaf surfaces have a few short, stiff hairs. Flower heads are 2.0-2.8 inches in diameter with bright yellow rays around a dark purplish brown center. Pecos sunflowers flower during the monsoon season, from late August to October.

Associated species include *Distichlis spicata* (saltgrass), *Sporobolus airoides* (alkali sacaton), *Phragmites australis* (common reed), *Sorghastrum nutans* (Indiangrass), *Schoenoplectus americanus* (chairmaker's bullrush), *Juncus balticus* (Baltic rush), *Muhlenbergia*

asperifolia (alkali muhly), *Apocynum cannabinum* (dogbane), *Baccharis salicina* (Great Plains seep-willow), *Limonium limbatum* (southwestern sea lavender), *Flaveria chlorifolia* (clasping yellowtops), and *Solidago canadensis* (goldenrod). Other associated rare and endangered plants include *Cirsium wrightii* (Wright's marsh thistle) and *Spiranthes magnicamporum* (Great Plains lady's tresses). In addition, the Ciénega provides an important stopover for migratory monarch butterflies and provides habitat for the Santa Rosa roundnose minnow, an as of yet undescribed endemic fish species (Figure 2).

Figure 2. Migratory monarch butterflies feeding on endangered Wright's marsh thistles at Blue Hole Ciénega in Santa Rosa, October 2019.

Habitat

Pecos sunflower is a wetland plant that grows in areas with permanently saturated soils in the root zone (USFWS 2005). These are most commonly desert springs and seeps that form wet meadows called ciénegas. This sunflower can also occur around the margins of lakes, impoundments, and creeks. The soils of these desert wetlands are typically saline or alkaline and are predominantly silty clays or fine sands with high organic matter content. Although Pecos sunflowers grow in saline soils, seeds germinate and establish best when high water tables and precipitation reduce salinity near the soils' surface (Van Auken and Bush 1995).

Distribution

Pecos sunflower has a highly disjunct distribution, is known from only seven populations, two in west Texas and five in New Mexico (USFWS 2005). There are at least 8 wetland sites with documented Pecos sunflowers in the Santa Rosa Recovery Region in Guadalupe County, at least one of which consists of a few hundred thousand plants in good years (Blue Hole Ciénega Nature Preserve). Most Pecos sunflower habitats are limited to less than 2 hectares (5 acres) of wetland. The number of sunflowers per site varies from a few plants to several hundred thousand. Because Pecos sunflower is an annual plant, the number of plants per site can fluctuate greatly from year to year with changes in precipitation, disturbance regime, and depth to ground water levels during early spring when plants germinate and establish.

METHODS

In response to observed declines in the number of Pecos sunflower plants following a massive hailstorm in June of 2013, the Forestry Division established 11 monitoring transects distributed throughout the 116-acre Ciénega, wherever plants occurred (Figure 2). Each transect measures 30 m x 2 m and is permanently marked by a metal t-post on either end. All permanent markers were mapped using a Garmin Monterra GPS. Annual monitoring occurs during the first 2 weeks of October, after the majority of sunflowers are done flowering and plants are senescent. Within each transect the number of plants is recorded. Annual observations may include the observance of predators (insects, deer) or diseases, and the general vigor of plants in the transect, measured by average height of the plants. In addition, the perimeter of contiguous stands of sunflowers associated with the monitoring transects were walked in 2013, 2015, 2016, 2017, 2018, and 2019 using the tracking function of a Garmin Montana or Monterra GPS, to get a better understanding of population fluctuations between years. Following the prescribed burn in 2017, all contiguous stands of Pecos sunflowers were delineated on Blue Hole Ciénega. Area polygons are walked wherever plants are found surrounding the transect area in sufficiently large contiguous stands to be reasonably mapped. A stand is considered contiguous if plants are 5 m or less apart from each other. Tracks were later converted to polygons and occupied habitat was calculated in acres using ArcMap. In addition, a photopoint was established on the southwestern boundary of the Ciénega at the Knights of Columbus Center parking area, to provide visual documentation of sunflower abundance and distribution through time. Photos were taken in 2004, prior to the

purchase and restoration of the Ciénega, in 2015, following several years of restoration treatments, in 2017, after a prescribed burn, and in 2019. In the spring of 2019 monitoring of germination time and establishment of seedlings was initiated along the existing monitoring transects. Weekly field visits to determine the timing of germination began on February 12, 2019. Target areas were locations known to have had plants the previous year. One site was marked and checked during every visit at Blue Hole Ciénega. After this site was checked random areas were checked throughout the Ciénega. On April 18, 2019, seedling counts were conducted along the 11 existing monitoring transects at Blue Hole Ciénega. Five random numbers between 0 and 30 m were generated for each transect. At these random numbers, a 1 x 1 m sampling frame was placed on the ground in the middle of the transect line and the number of seedlings rooted inside the sampling frame (subplot) were counted. Other monitoring activities on Blue Hole Ciénega include rainfall (since July 2016), groundwater fluctuations (since 2014, LeJeune 2018), and population trend monitoring of the endangered Wright's marsh thistle (*Cirsium wrightii*) (since 2017).

Water wells to measure groundwater fluctuations on the Ciénega were installed between 2010 and 2014 and instrumented with Solinst Edge Leveloggers (pressure transducers) (LeJeune 2018). Direct data read cables attached to pressure transducers are suspended from specialized Solinst well caps, and data is downloaded using a tablet from the well head using the Solinst Levelogger App Interface device. Field recording intervals are set at 15-minutes.

Monitoring results will inform our understanding of sunflower population fluctuations in response to management activities, rainfall, and groundwater fluctuations. Since monitoring was initiated in 2013, the following management actions have been implemented on Blue Hole Ciénega:

October 2013: Retreatment (cutting and spraying of Russian olive, tamarisk, and Siberian elm)

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February 2017: Prescribed burn

October / November 2017: Retreatment (cutting and spraying of Russian olive, tamarisk, and Siberian elm)

October / November 2018: Retreatment (cutting and spraying of Russian olive, tamarisk, and Siberian elm)

October / November 2019: Retreatment (cutting and spraying of Russian olive and tamarisk)

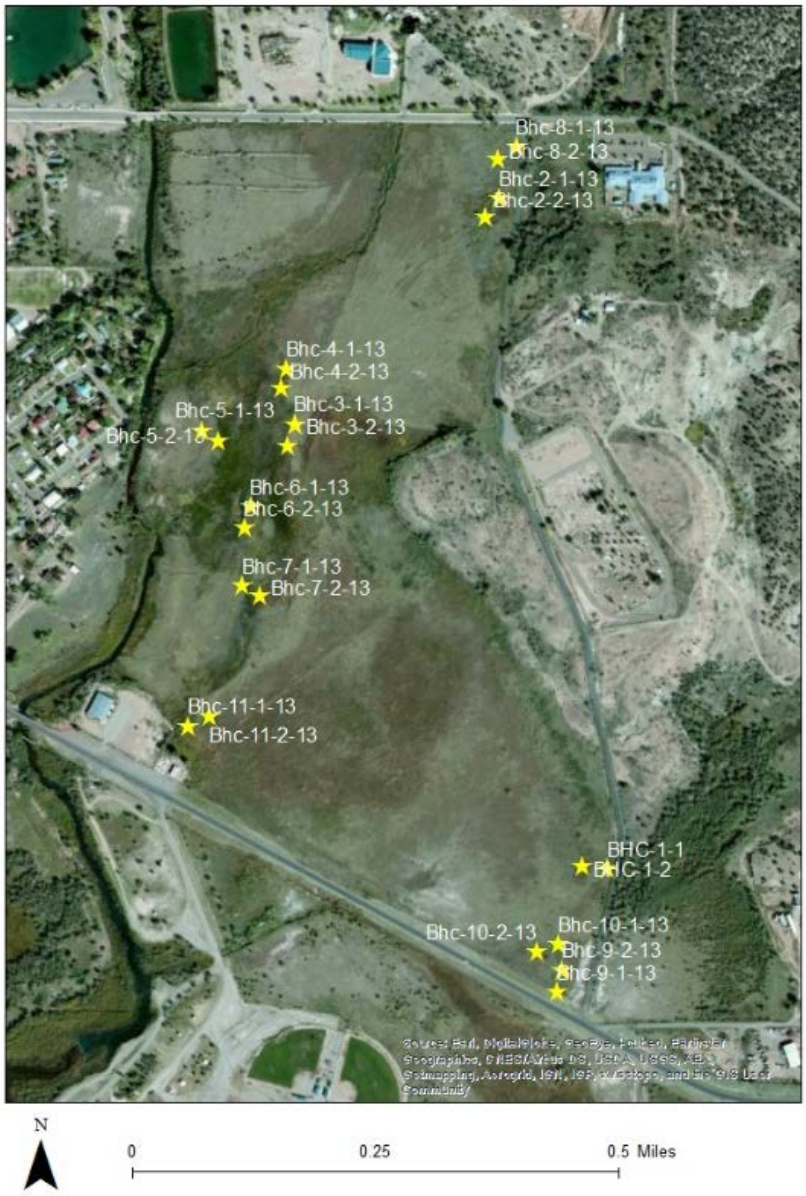

Figure 2. Locations of permanent Pecos sunflower transects at the Blue Hole Ciénega Nature Preserve in Santa Rosa.

RESULTS

The number of sunflowers within the 11 transects varied widely between the years of monitoring, ranging from a low of 1,731 plants in 2013 to a high of 8,064 in 2017 (Figure 3). Following the prescribed burn in February of 2017, the density of plants within the transects increased by 39% over the highest number counted during the previous 4 years (2014). No comprehensive data is available on the exact distribution of sunflowers on the Ciénega prior to

the burn, but population perimeters were mapped surrounding the sunflower stands associated with monitoring transects in 2013, 2015, 2016, 2017, 2018, and 2019 (Figure 4). These document a significant increase in continuous sunflower stands in the vicinity of the monitoring transects in 2017, linking some of the previously documented individual stands into one large stand. Population numbers dropped significantly during the 2018 monitoring season; only 1,737 plants were documented from the transects (Figure 3). Mapping the perimeter of the largest populations associated with the monitoring transects revealed that plants only occupied a fraction of the habitat occupied in 2017 (Figure 4). In 2018, no plants were recorded in the 2 transects that contained the most sunflowers in 2017 (Table 1). However, the population expanded significantly in 2019, resulting in the second highest number of plants found in the 11 transects during the 7 monitoring years (6,007 plants; Figure 3). Three of the 5 transects that contained no plants in 2018 were occupied again in 2019 and had some of the highest numbers of plants among the 11 transects (Table 1). The primary increase in the number of plants ocurred in the vicinity of transects 3, 4, 5, 6 and 7, all of which were within one large patch of contiguous sunflowers (Figure 5). Only one other patch, located in the SE corner of the cienega, was large enough to be mapped.

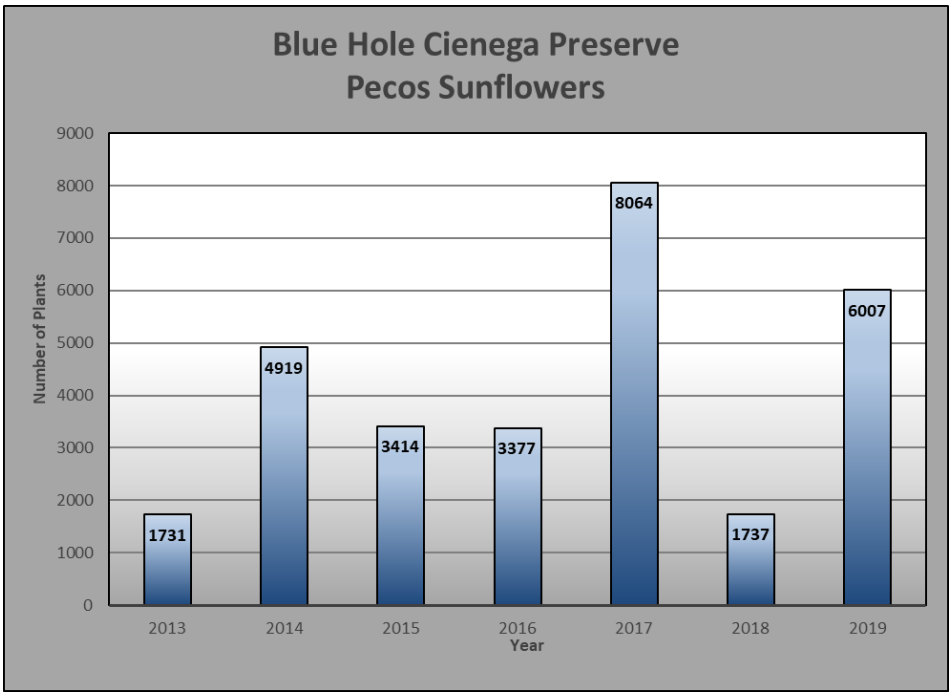

Figure 3. The total number of Pecos sunflower plants between 2013 and 2019, in 11 monitoring transects at Blue Hole Ciénega Nature Preserve in Santa Rosa, NM.

Table 1. Number of Pecos sunflower plants per transect from 2013 to 2019 at Blue Hole Ciénega in Santa Rosa, NM.

Transect	2013	2014	2015	2016	2017	2018	2019	Water Well
1	628	2481	493	233	249	47	19	None
2	198	1213	1276	1731	1072	147	287	BHC 1
3	0	65	0	14	153	28	24	BHC 3
4	2	0	0	0	76	161	15	None
5	0	0	0	0	51	0	250	None
6	59	278	896	924	2542	0	1131	None
7	9	125	21	74	2225	0	2293	BHC 7
8	2	0	0	0	164	317	305	BHC 1
9	306	28	0	0	14	0	0	BHC 2
10	486	712	726	400	1508	1037	1683	BHC 2
11	41	17	2	1	10	0	0	BHC 6
Total	**1731**	**4919**	**3414**	**3377**	**8064**	**1737**	**6007**	

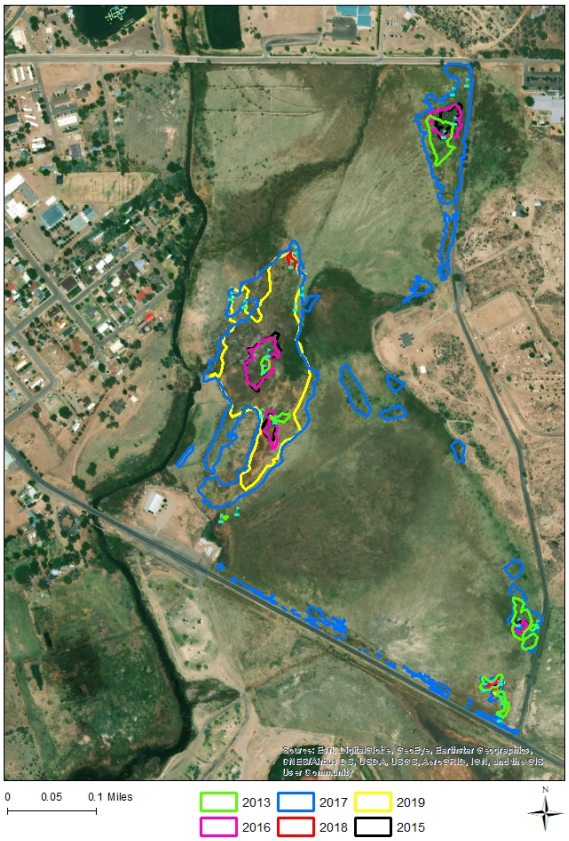

Figure 4. Distribution of Pecos sunflowers surrounding the monitoring transects, 2013 – 2019, and throughout BHC in 2017.

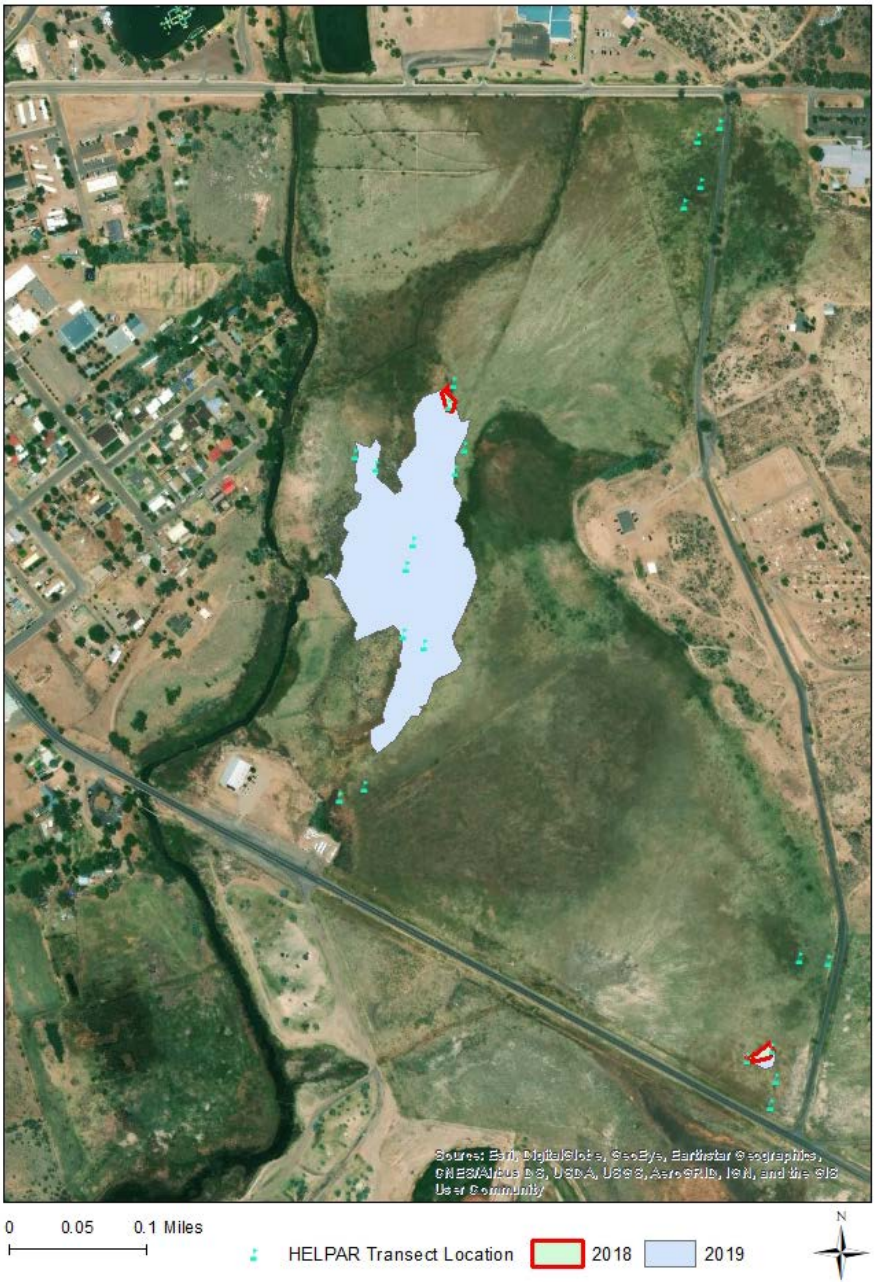

Figure 5. Changes in Pecos sunflower distribution in the vicinity of monitoring transects between 2018 and 2019.

Repeat Photography

Despite extensive restoration efforts, including the initial removal of large stands of Russian olives and other invasive woody plants, and a prescribed fire in 2008, 7 years after initial restoration treatments sunflower abundance appeared to be significantly lower in 2015, when compared to 2004 (Figure 6). In 2017, following a prescribed burn at the beginning of February, sunflower abundance and distribution appeared similar to those observed in 2004, or more.

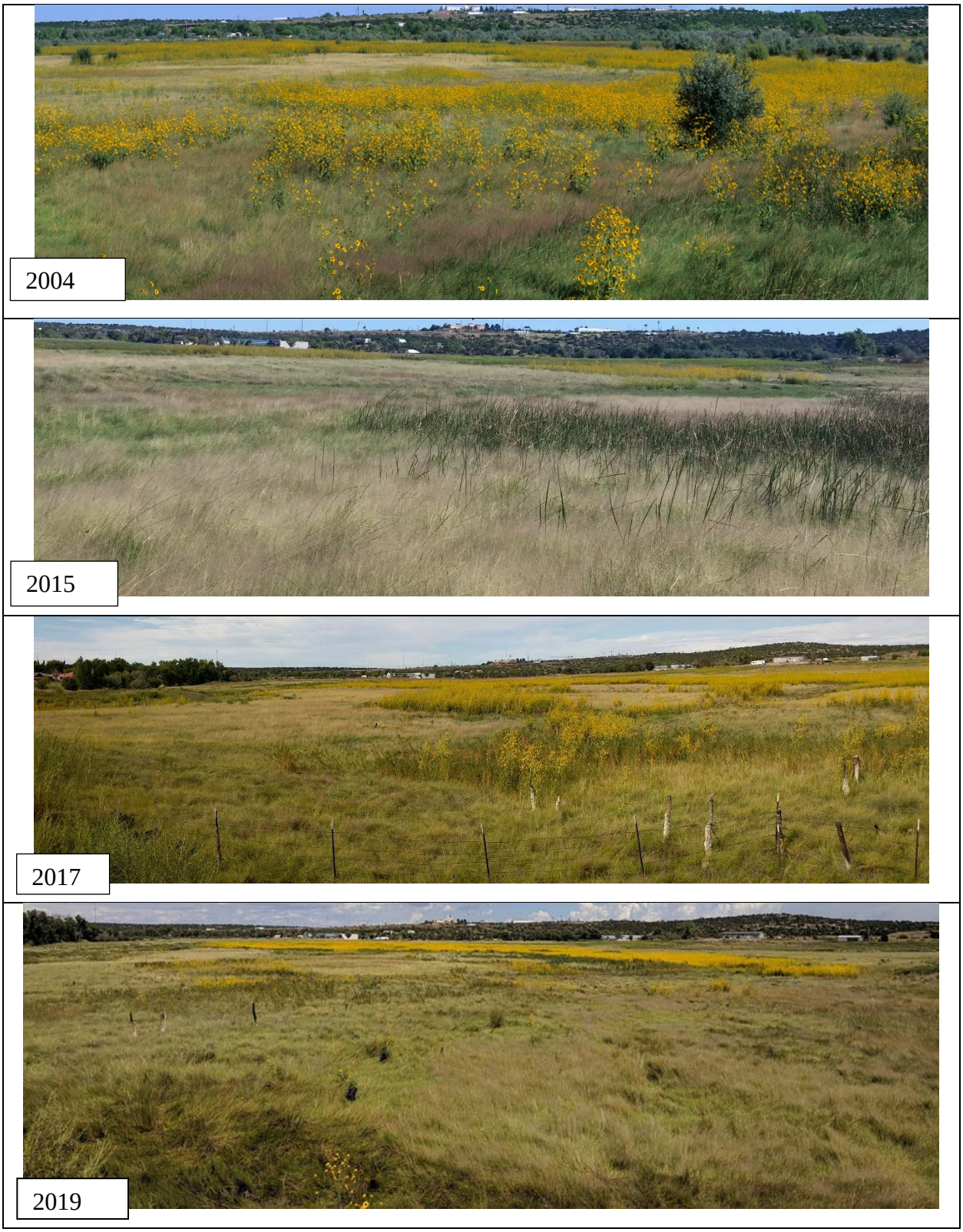

Figure 6. Sunflower abundance at Blue Hole Ciénega Nature Preserve in Santa Rosa, NM, before treatments (2004), after treatments (2015), after a prescribed fire (2017), and in 2019.

Seedlings

The first seedlings were found on March 6, 2019 (Figure 7). However, germination continued on through the beginning of April. Approximately 8% of each transect was sampled for seedlings on April 18, 2019.

Figure 7. Seedlings of *Helianthus paradoxus* emerging from a thick cover of saltgrass (*Distichlis spicata*) and other grasses**.**

A total of 2,115 seedlings were counted in 55 subplots along the 11 monitoring transects (Table 2). The number of seedlings varied widely between sampling plots along the 30 m transects, ranging from 0 to 340 individuals, and by as a much as 2 to 217 seedlings per subplot along the same transect. Hence comparison of the number of adults found later in the season and the number of seedlings documented in April is not feasible. However, high seedling numbers generally corresponded to high numbers of adults later during the season. Two of three transects where no seedlings were found also had no adults during the October counts. Percent cover of associated species (mostly saltgrass) did not appear to influence the number of seedlings found along a transect. In fact, the highest seedling numbers were found in subplots with 100% saltgrass cover, some of it very thick (Figure 7).

Table. 2. Total number of seedlings found along each of the 11 monitoring transects at Blue Hole Ciénega in April 2019.

Transect No	No of Seedlings
1	8
2	123
3	5
4	0
5	5
6	330
7	974
8	16
9	0
10	654
11	0
Total	**2,115**

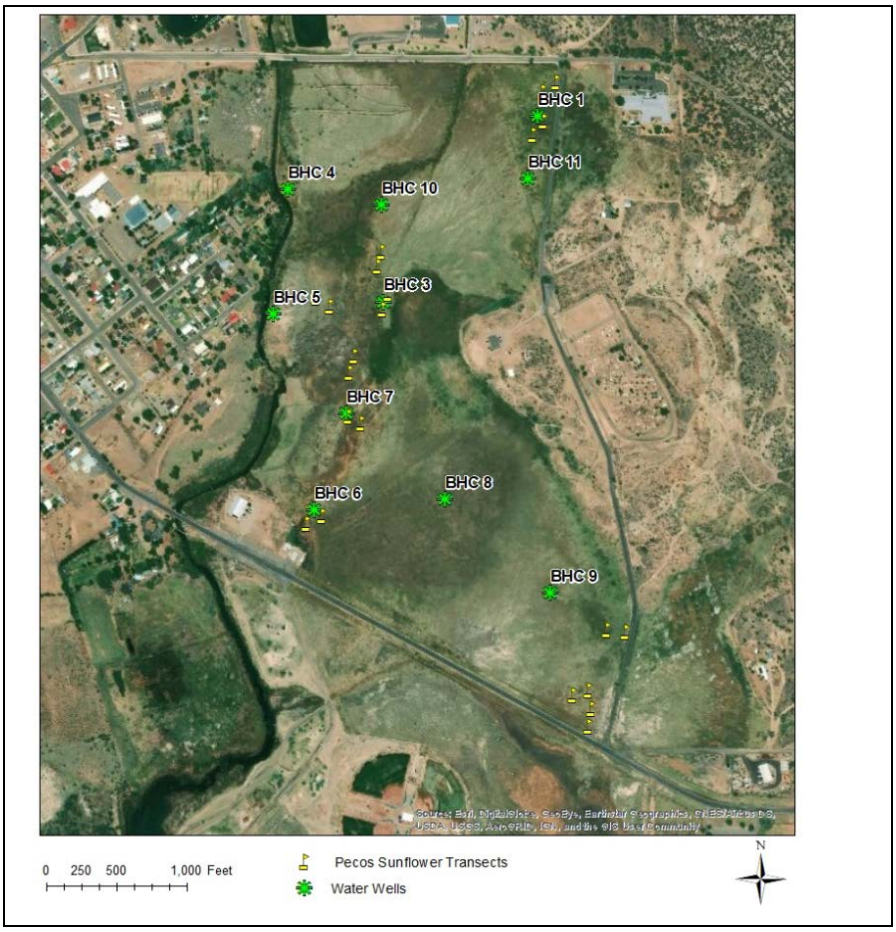

Figure 8. Location of ground water monitoring wells on Blue Home Ciénega in Santa Rosa, NM. Yellow flags indicate the location of monitoring transects.

Water Wells

Groundwater fluctuations were originally documented from 10 water monitoring wells outfitted with automated data loggers from 2014 to 2017 (LeJeune 2018; Figure 8). Monitoring paused in late 2017 but was reinitiated in the spring of 2019. Due to data capacity limitations the automated data loggers missed approximately 4 months of data collection (December 2018 – April 2019). In general, the water table rises to the surface during the winter months, between October and April. This is considered a key factor for the germination and establishment of seedlings. Prior to 2016 the water levels fluctuated considerably during the summer and early fall months, likely in response to monsoon rainfall amounts (Figure 9). However, this pattern

has not been documented since 2016, for unknown reasons. The water table remains low for all wells during the summer months, despite a very good rainfall year in 2017. The water table reached the surface for only a short period of time in the winter of 2016/2017 and remained low by February of 2017, despite above average rainfall amounts between November and April (7.64 inches). Since 2017, the groundwater no longer rises to the surface in several well locations (well numbers 3,4,5,6,7). This is especially disconcerting for well number 7, which is located near transect No. 7, the transect with the greatest fluctuations of sunflowers from one year to the next (Table 1). In addition, the largest contiguous stand of sunflowers (during good years) is associated with wells No 3 and 7. Water well No. 6 has run dry from June through December since 2016, which may explain the low number of sunflowers counted in the associated transect (No. 11) since 2015.

The mean annual depth to water table values appeared to improve for 6 of the 10 water wells on the Ciénega between 2017 and 2018, but otherwise continues to decline, in particular for well No. 7 (Figure 10). Overall depth to groundwater levels and ground water fluctuation do not appear to be influenced by rainfall amounts since 2016 for unknown reasons.

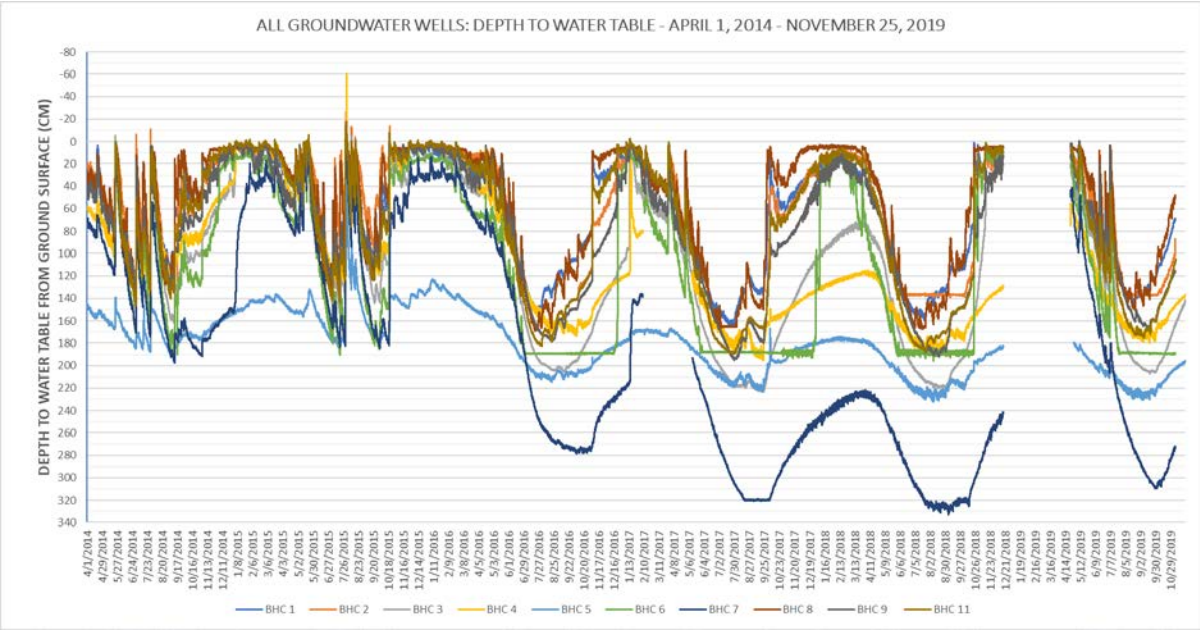

Figure 9. Ground water fluctuations at 10 monitoring wells on Blue Hole Ciénega in Santa Rosa, NM.

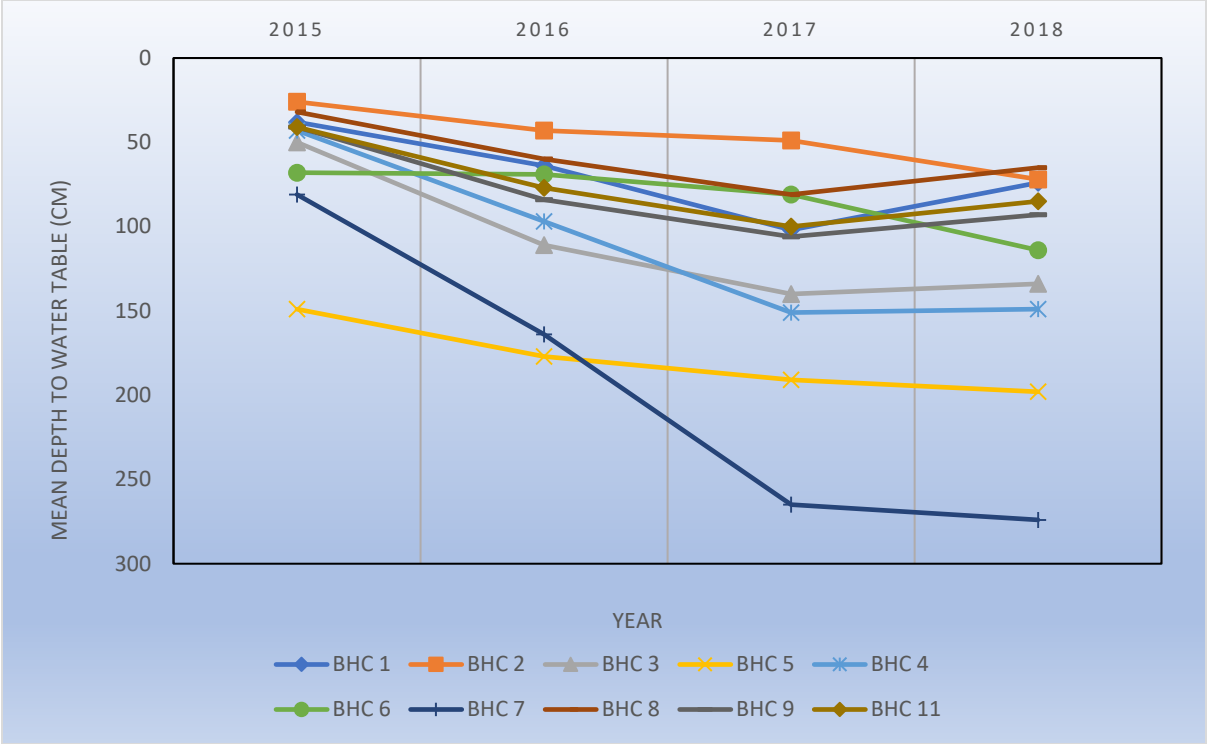

Figure 10. Mean ground water table to surface levels at 10 monitoring wells on Blue Hole Cienega in Santa Rosa, NM.

DISCUSSION

Although Pecos sunflowers can be locally abundant, they are globally rare and are known from only seven isolated populations in New Mexico and Texas. The main factors influencing density and growth of plants include water availability, competition with other species, grazing, and other disturbances. These factors do not act independently. Water availability and salinity combined with disturbances control the growth of Pecos sunflowers (Van Auken and Bush 1995). Annual plants are often found in disturbed areas where there is little competition from perennial plants. Pecos sunflowers appear to respond favorably to certain types of disturbance such as fire and tilling, but negatively to grazing (Van Auken and Bush 2004). The number of sunflowers on Blue Hole Ciénega has fluctuated widely from one year to the next, primarily driven by water availability, but also in response to disturbances, such as hail storms and prescribed fires. Reduced competition in combination with increased availability of soil nutrients following the fire likely contributed to the germination and establishment of seedlings in the spring following the fire of 2017. Above average rainfall increased survival of established

plants and contributed to abundant flowering in August and September of 2017(100 year average for Santa Rosa: 14.31 inches; total rainfall at Blue Hole Ciénega 2017: 16.54 inches). Surface moisture influenced by rising groundwater levels during the winter and spring months and rainfall amounts are critical to the germination and establishment of Pecos sunflower seedlings. Rainfall amounts were plentiful during the winter and spring of 2016/2017, contributing to an abundant sunflower crop following the prescribed burn of February 2017 (7.64 inches between November and April). However the following winter and spring was extremely dry; only 0.36 inches of rain were recorded between November 2017 and April 2018. The dry winter is considered the main cause for low numbers of sunflowers in 2018. The winter and spring of 2018/2019 yielded average amounts of rainfall and sunflower populations rebounded (3.65 inches between November and April).

Seed banks of annual plants are important to the reestablishment of populations after periods of unfavorable environmental conditions including climatic variability, salinity, and drought (Van Auken 2001). Although the majority of Pecos sunflower seeds have shown to germinate within 4 to 6 months after dispersal, some remain dormant and act as an insurance for species survival in response to adverse environmental conditions by remaining viable in the seedbank (Van Auken 2001). In the Santa Rosa area, sunflower populations flower in early- to mid-September and seed dispersal occurs through October. Seeds germinate in early March, after the potential for killing frosts is low, the water table is at or near the surface, and longer daylight hours and temperatures favor germination and establishment of seedlings. Low population numbers recorded in 2018 are likely the result of the extremely dry winter of 2017/2018 (0.39 inches between November 1, 2017 and April 30, 2018; 100-year average for Santa Rosa = 3.39 inches). Based on the results of this study, it appears that ground water levels are less important to the germination and establishment of seedlings than rainfall amounts during winter and early spring.

2018 field observations of sunflower occurrences on adjacent ciénegas documented similar abundance of sunflowers from the previous years' observations, despite the presence of livestock. One site was irrigated and grazed through the flowering season, the other was grazed through May, but not irrigated. Grazing may have reduced the competition for water from other perennial plants, which may be favored by livestock over sunflowers. Although Pecos sunflowers are palatable to livestock and livestock impacts can be detrimental to sunflowers,

perennial grasses are favored over sunflowers. The impacts of seasonal grazing and stocking rates need further study.

Photopoint monitoring may lead to conclude that restoration efforts have little or inconclusive responses from the sunflower populations. However, competition from other species is just one part of what drives sunflower abundance on the Ciénega. In years of good rainfall competition for essential resources, such as water, may not impact the abundance of sunflowers as it would during drought years. 2004 was an exceptional wet year in the Santa Rosa area, producing more than 6 inches above average rainfall values (WRCC 2018). Therefore, the abundant sunflower population in the 2004 photo may be a product of ample moisture, not influenced by the strong presence of competing invasive woody species. In addition, the site was at least seasonally grazed by livestock until 2004, which may have reduced competition by perennial grasses. No reliable rainfall data is available for Santa Rosa after 2009 and we have no photos or population data on how sunflower abundance may have responded to rainfall amounts following herbicide treatments and a prescribed burn in 2008. Effects of fire are unlikely to last for more than 1 or two years after the fire. However, similar high amounts of total annual rainfall were recorded in 2004 and in 2015 in Tucumcari, located approximately 60 miles to the east, with similar large rainfall events in the spring for both recording years. Monitoring results show the third highest number of sunflowers recorded over the 7-year monitoring period occurred in 2015, although this increased number of plants is not evident in the 2015 panoramic photo. An automated rain gauge installed at the Ciénega in July of 2016 may give us better insights on how localized rainfall and timing of rainfall influences the abundance of sunflowers.

The highest numbers of sunflowers since 2013 were recorded in 2017and 2019. Significantly more sunflowers were recorded in the 11 monitoring transect in 2017 over any of the previously recorded years. This is likely the response to the prescribed burn in early February of 2017, approximately 1 month before sunflowers germinate. In addition, the 2016/2017 winter months and the following August and September of 2017 incurred unusually large amounts of rainfall, likely contributing the survival of plants established in the spring. Large amounts of summer rainfall were also reported for 2004, but not during 2015 (August or September). More likely than not, sunflower abundance is driven by multiple environmental factors, including the height of the water table in the spring, rainfall amounts during the winter and early spring months, monsoons, and the type and degree of disturbance within the habitat of the species.

LITERATURE CITED

EMNRD- Forestry Division. 2017. New Mexico Rare Plant Conservation Strategy. Prepared and developed by Daniela Roth and the New Mexico Rare Plant Conservation Strategy Partnership. Santa Fe, NM.

LeJeune, C. 2018. Blue Hole Ciénega Nature Preserve, Santa Rosa, New Mexico. Groundwater Monitoring Project Final Report FY 2016-2017. Unpublished report prepared for EMNRD - Forestry Division, Santa Fe, NM, by Wetwater Environmental Services, Albuquerque, NM.

USDI-Fish & Wildlife Service. 2005. Pecos sunflower (*Helianthus paradoxus*) recovery plan. Albuquerque, New Mexico.

Van Auken, O.W. and J.K. Bush. 1995. Factors affecting the growth and distribution of *Helianthus paradoxus*. Performance Report for Section 6 Grant No. E-1-7, Project No. 60, Texas Parks and Wildlife Department, Austin.

Van Auken. 2001. Germination requirements of seeds of *Helianthus paradoxus* (Asteraceae). Texas Journal of Science 53(2):157-170.

Van Auken, O.W. and J.K. Bush. 2002. Growth of Helianthus paradoxus, the puzzle or Pecos sunflower (Asteraceae) in response to disturbances. Proceedings of the 2002 Texas Plant Conservation Conference, Lady Bird Johnson Wildflower Center, Austin, TX.

Western Regional Climate Center. 2018. Precipitation listings, New Mexico, monthly totals. Accessed online on 03/26/2018 at https://wrcc.dri.edu/summary/Climsmnm.html