PECOS SUNFLOWER

(*Helianthus paradoxus*)

2013 - 2020 Monitoring Report

Blue Hole Ciénega Nature Preserve
Santa Rosa, NM

Daniela Roth
NM Energy, Minerals, & Natural Resources Department
Forestry Division
Santa Fe, NM

Prepared for the
U.S. Fish & Wildlife Service, Region 2
Albuquerque, NM
(USFWS Grant Award No. F19AP00929)

INTRODUCTION

Pecos sunflower (*Helianthus paradoxus* Heiser) is an annual wetland plant that grows on wet, alkaline soils in spring seeps, wet meadows (ciénegas), 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 and 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, including the primary core conservation area at the Blue Hole Ciénega Nature Preserve, which may reach a hundred thousand plants in good years. Cut and herbicide treatments at the Milagro and Robinson ciénegas, as well as additional fencing and a prescribed fire, have increased sunflower populations at these sites to several hundred thousand plants as well. Milagro Ciénega (formerly City Ciénega) is the designated secondary core conservation population for the Santa Rosa Recovery Region.

It is likely that the majority of these now disjunct sites was once one large population growing in a very large ciénega, now highly fragmented by roads and urban development. Currently most Pecos sunflower habitats in the Santa Rosa area are limited to patches of less than 17 acres of continuous wetland, depending on climatic conditions during any given year. The number of sunflowers per site can vary 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 Blue Hole Ciénega, wherever plants occurred (Figure 3). 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 counted or estimated. 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, 2019 and 2020 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 to get a better understanding of sunflower distribution on the Preserve. 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. Based on information gathered, optimum time for seedling germination and establishment monitoring was determined to be mid-April. Annual seedling counts are conducted along the 11 existing monitoring transects at Blue Hole Ciénega. Five random numbers between 0 and 30 m are generated for each 30 m x 2 m transect. At these random numbers, a 1 x 1 m sampling frame is placed on the ground in the middle of the transect line and the number of seedlings rooted inside the sampling frame (subplot) are counted.

Other monitoring activities on Blue Hole Ciénega include rainfall (since July 2016), groundwater fluctuations (2014 - 2019, 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, Figure 4). 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.

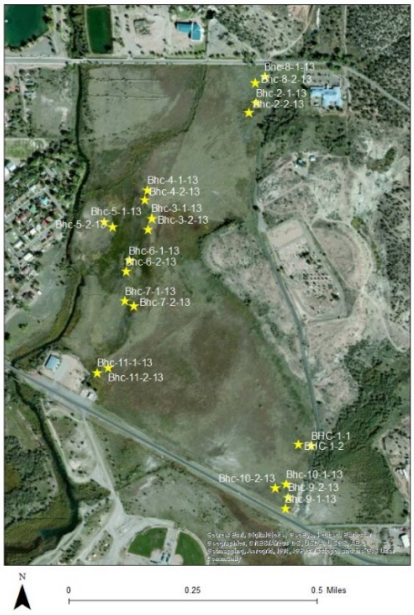

Figure 3. Locations of permanent Pecos sunflower transects at the Blue Hole Ciénega Nature Preserve in Santa Rosa.

Figure 4. Location of ground water monitoring wells on Blue Hole Ciénega in Santa Rosa, NM.

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)

October 2014: Retreatment (cutting and spraying of Russian olive, tamarisk, and Siberian elm)

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)

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 5). 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). Population numbers dropped significantly the following year, when only 1,737 plants were documented from the transects (Figure 5). Transect data corresponded with population perimeters mapped near the monitoring transects. Plants only occupied a fraction of the habitat occupied in 2017 (Figure 6). 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 8 monitoring years (6,007 plants; Figure 5). 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). Plants were found at low levels again, in 2020, three transects had no plants whatsoever and only one plant was found in Transect 1.

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, 2019 and 2020 (Figure 6). These support the documentation of significant fluctuations within the monitoring transects. The largest continuous sunflower stand found on Blue Hole Ciénega was 12.72 acres, following the prescribed fire in 2017. All sunflower stands on Blue Hole Ciénega were mapped in 2017 only, covering a total of 19.564 acres. Total occupied habitat surrounding the monitoring transects ranged between 0.141 acres in 2018 to 17.316 acres in 2017 (Figure 7). In 2020 sunflower stands associated with five monitoring transects covered a total of 8.44 acres on the cienega, which represented a decrease from 2019, when sunflowers covered 9.494 acres and were associated with only 2 of the monitoring transects (Figure 8).

Repeat Photography

Despite extensive restoration efforts, including the removal of livestock, 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 9). In 2017, following a prescribed burn at the beginning of February, sunflower abundance and distribution appeared similar to those observed in 2004, or more.

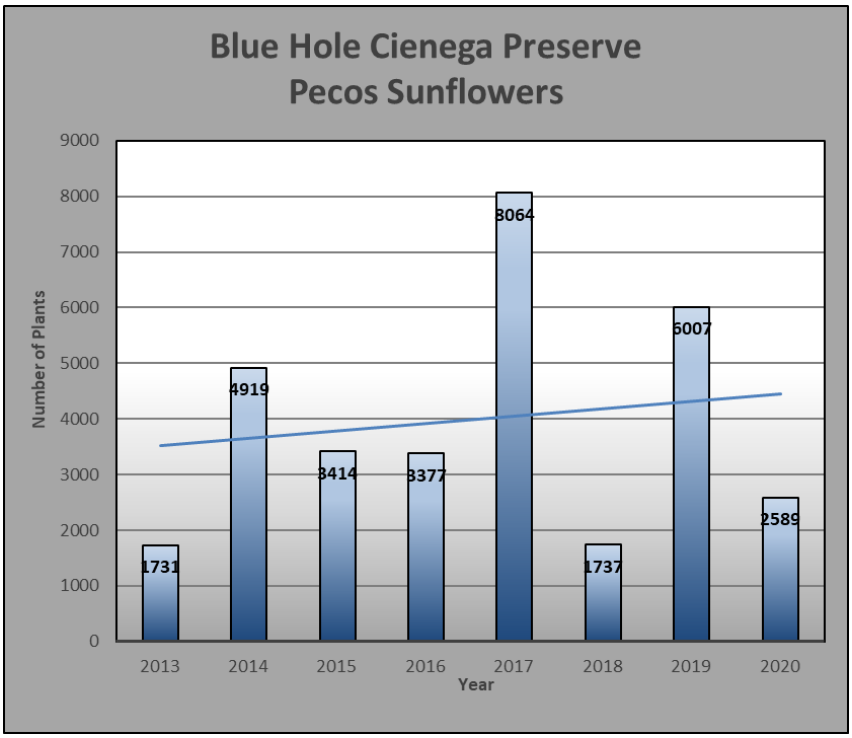

Figure 5. The total number of Pecos sunflower plants between 2013 and 2020, in 11 monitoring transects at Blue Hole Ciénega Nature Preserve in Santa Rosa, NM.

Table 1. Number of Pecos sunflower plants per transect from 2013 to 2020 at Blue Hole Ciénega in Santa Rosa, NM.

Transect	2013	2014	2015	2016	2017	2018	2019	2020	Water Well
1	628	2481	493	233	249	47	19	1	None
2	198	1213	1276	1731	1072	147	287	323	BHC 1
3	0	65	0	14	153	28	24	33	BHC 3
4	2	0	0	0	76	161	15	10	None
5	0	0	0	0	51	0	250	53	None
6	59	278	896	924	2542	0	1131	0	None
7	9	125	21	74	2225	0	2293	1522	BHC 7
8	2	0	0	0	164	317	305	103	BHC 1
9	306	28	0	0	14	0	0	0	BHC 2
10	486	712	726	400	1508	1037	1683	544	BHC 2
11	41	17	2	1	10	0	0	0	BHC 6
Total	**1731**	**4919**	**3414**	**3377**	**8064**	**1737**	**6007**	**2589**	

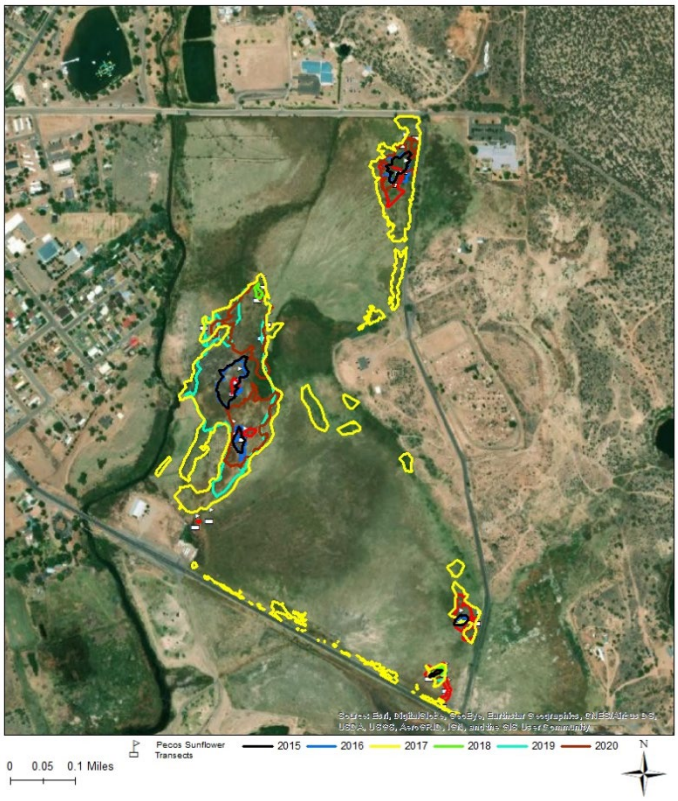

Figure 6. Distribution of Pecos sunflowers surrounding the monitoring transects, 2013 – 2020, and throughout BHC in 2017.

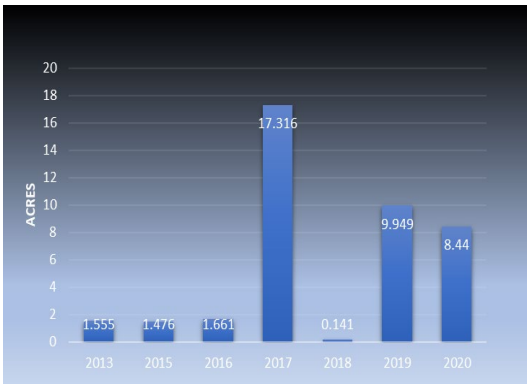

Figure 7. Fluctuations of occupied habitat surrounding 11 monitoring transects between 2013 and 2020.

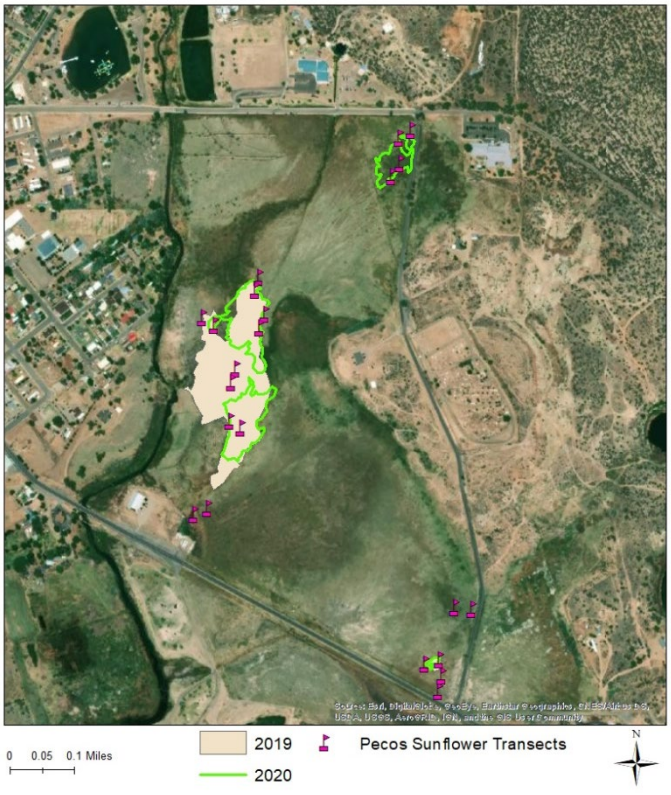

Figure 8. Changes in Pecos sunflower distribution in the vicinity of monitoring transects between 2019 and 2020.

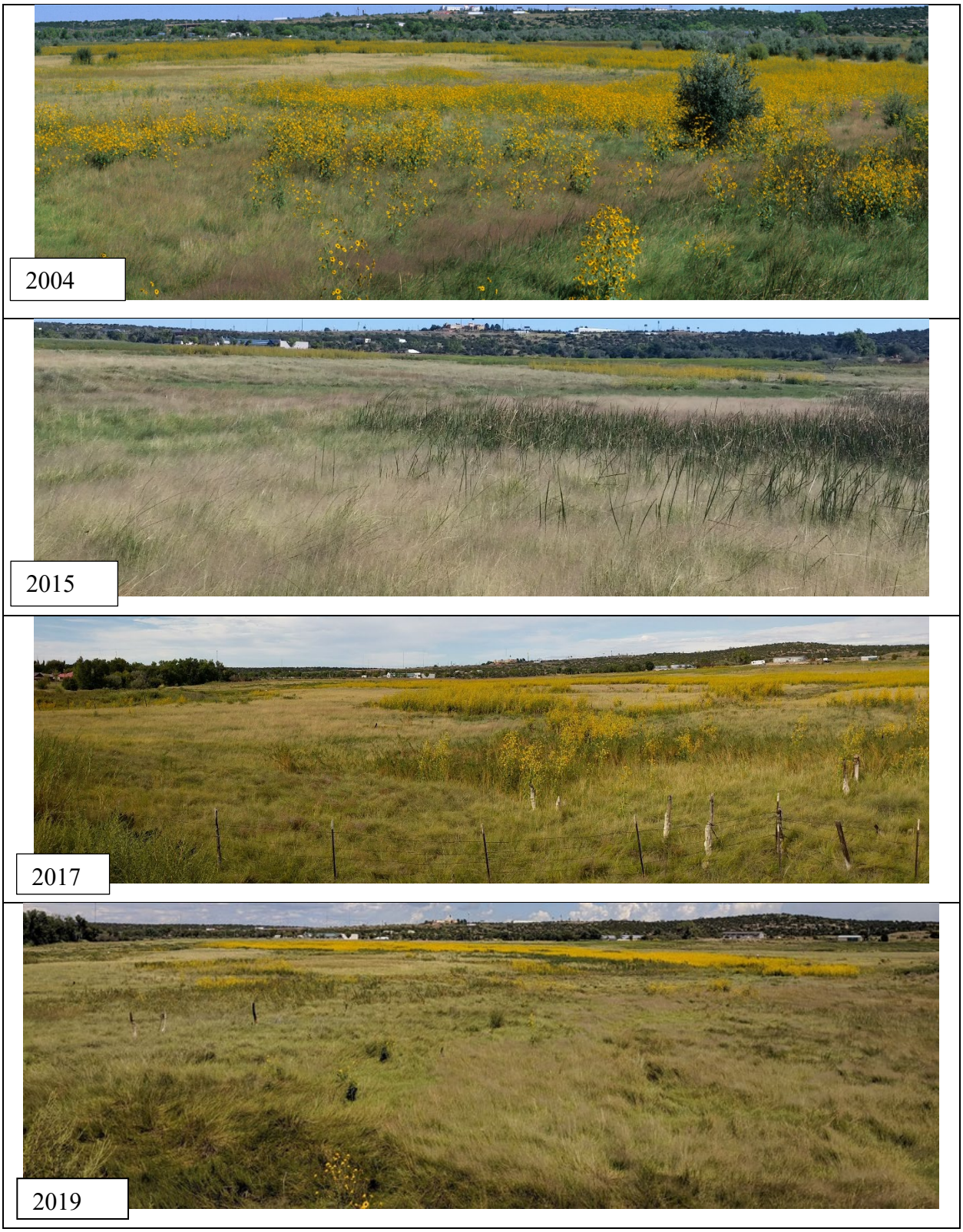

Figure 9. Sunflower abundance at Blue Hole Ciénega Nature Preserve in Santa Rosa, NM, before treatments (2004), after treatments (2015), after a prescribed fire (2017), and in 2019.

Seedlings

The first seedlings were found on March 6, 2019 (Figure 10). However, germination continued through the beginning of April. Monitoring took place on April 18, 2019 and April 15, 2020. A total of 2,115 seedlings were counted in 2019 and 741 seedlings were found in 2020 in 55 subplots along the 11 monitoring transects (Table 2). The 2020 lower count of seedlings is supported by lower counts of adult plants later in the season. In 2019 the number of seedlings varied widely between sampling plots along the 30 m transects, ranging by as a much as 132 to 340 seedlings per subplot along the same transect and 0 to 974 seedlings between transects. In 2020 the number of seedlings ranged from as 0 to 358 seedlings per subplot along the same transect and 0 to 401 seedlings between transects. Hence extrapolating of the number of adults found later in the season along the entire transects is not feasible. However, after 2 years of data collection it appears that adult plant numbers collected along the entire transects are approximately three times higher than the seedling counts from the subplots for both years. Two transects where no seedlings were found also had no adults during the October counts during both years. Percent cover of associated species (mostly saltgrass) was documented in 2019. Cover 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 10).

Figure 10. Seedlings of *Helianthus paradoxus* emerging from a thick cover of saltgrass (*Distichlis spicata*) and other grasses**.**

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

Transect No	2019 No of Seedlings	2019 No of Adults	2020 No of Seedlings	2020 No of Adults
1	8	19	0	1
2	123	287	19	323
3	5	24	1	33
4	0	15	2	10
5	5	250	2	53
6	330	1131	210	0
7	974	2293	401	1522
8	16	305	4	103
9	0	0	0	0
10	654	1683	103	544
11	0	0	0	0
Total	**2,115**	**6,007**	**742**	**2,589**

Water Wells

Groundwater fluctuations were originally documented from 10 water monitoring wells outfitted with automated data loggers from 2014 to 2017 (LeJeune 2018; Figure 11). 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). Data collection ended in 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 10). 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 half of the 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 Nos 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 (0 plants since 2018).

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 12). Overall depth to groundwater levels and ground water fluctuation do not appear to be influenced by rainfall amounts since 2016 for unknown reasons.

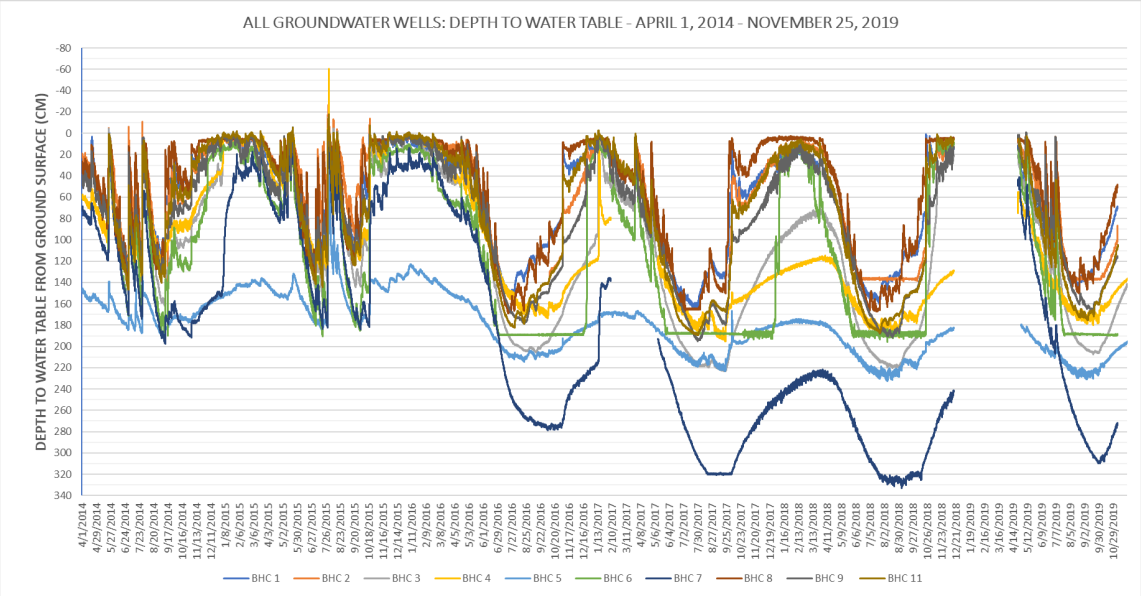

Figure 11. Ground water fluctuations at 10 monitoring wells on Blue Hole Ciénega in Santa Rosa, NM.

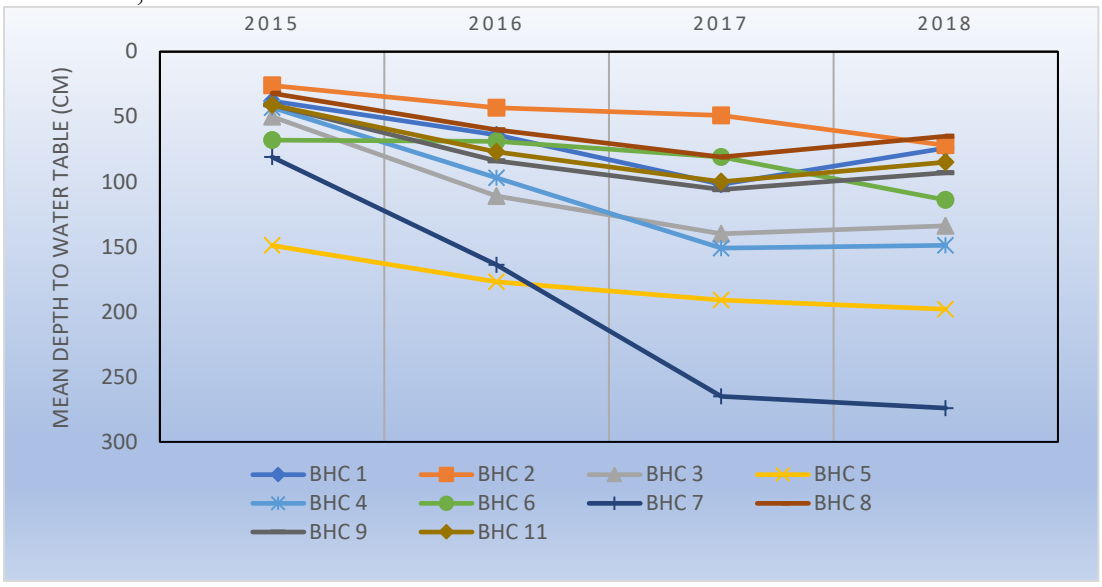

Figure 12. Mean ground water table to surface levels at 10 monitoring wells on Blue Hole Ciénega in Santa Rosa, NM.

DISCUSSION

Although Pecos sunflowers can be locally abundant, they are nationally and globally extremely 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 hailstorms and prescribed fires. Reduced competition in combination with increased availability of soil nutrients following the fire contributed to the germination and establishment of seedlings in the spring following the fire of 2017. Above average rainfall during key periods for germination, establishment and growth increased the survival of 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. Despite groundwater levels barely rising to the surface, 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 0.39 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). However, winter rainfall was abundant in 2019/2020 (7.51 inches between November and April), but seedling counts and adult plant counts were low in 2020.

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. Although 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), low numbers of plants in 2020 remain unexplained by rainfall amounts. No ground water data is available for the winter of 2019/2020, but it is possible that groundwater levels did not reach the surface, or only for a small time period. What drives ground water levels at the Ciénega remains a mystery, but rainfall amounts appear to be only a marginal component. Population trend data from the adjacent Robinson Ciénega also documented a decline in the abundance of sunflowers from the previous years' observations, however, the decline was significantly lower (24% vs. 67% at Blue Hole Ciénega), despite the year-round presence of livestock. The Robinson Ciénega is irrigated and grazed throughout the flowering season. 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. Grazing impacts may depend on the type of livestock present. The impacts of seasonal grazing, grazing animal types, 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 2020). 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 cut and 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. Unfortunately, we have no data associated with the impacts of the 2008 prescribed burn. 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. Yet, monitoring results show only a moderate number of sunflowers in 2015, which is reflected 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 2017. Significantly more sunflowers were recorded in the 11 monitoring transect in 2017 over any of the previously recorded years. This was clearly the response to the prescribed burn in early February of 2017, approximately 1 month before sunflowers germinate. Significant increases in plant numbers were reported after a prescribed burn and additional fencing were completed at the nearby Milagro Ciénega in 2020. Plant numbers increased from 9,982 to 34,385 in the 8 monitoring transects inside the fenced area at Milagro Ciénega (71%). Fire clearly benefits Pecos sunflowers. 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.

After 8 years of monitoring and active management prescriptions, the overall population trend of Pecos sunflowers at Blue Hole Ciénega is up, despite significant annual population fluctuations. However, the overall upward trend is heavily influenced by the effects of the prescribed fire. Continued long-term monitoring is needed to further evaluate the impacts of management actions on the sunflowers and understand long term population trends in a changing climate. Continued monitoring of the groundwater table is highly recommended to help interpret population trends. Unfortunately funding for this project was lost in 2020. Additional monitoring transects established at Milagro and Robinson ciénegas will help to improve our understanding of grazing impacts on the species. Milagro Ciénega may be grazed during the winter months, the Robinson Ciénega is grazed year-round.

ACKNOWLEDGEMENTS

Funding for this project has been provided by the U.S. Fish and Wildlife Service, Region 2, Albuquerque, NM, through Section 6 Endangered Species grants, received from 2017 through 2020.

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. 2020. Monthly precipitation totals, Santa Rosa, NM. Accessed online on 012/29/2020 at https://wrcc.dri.edu/summary/Climsmnm.html