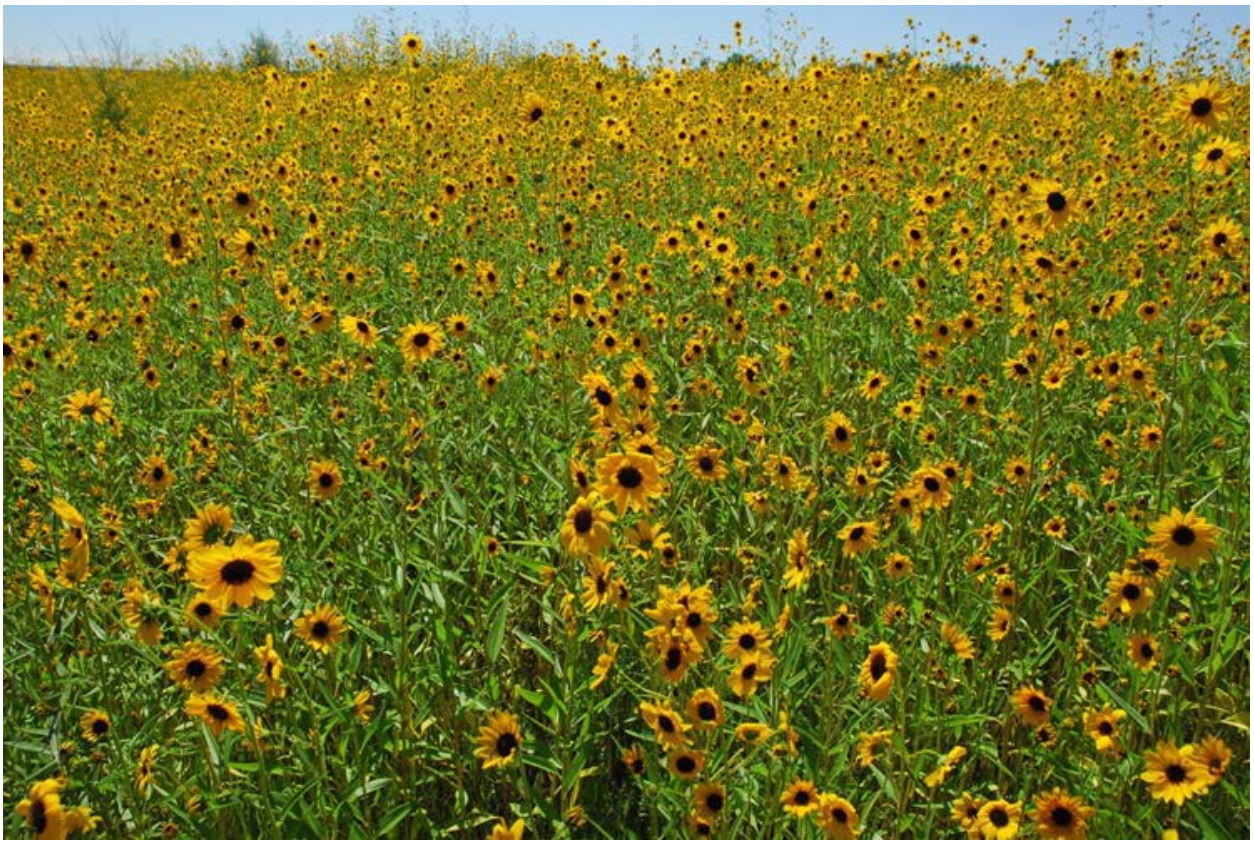
Pecos Sunflower
(*Helianthus paradoxus*)

5-Year Review:
Summary and Evaluation



Pecos Sunflowers at Blue Hole Cienega in Santa Rosa, New Mexico
September 2009 (Photograph by Robert Sivinski, New Mexico Forestry Division)

U.S. Fish and Wildlife Service
New Mexico Ecological Services Field Office
Albuquerque, New Mexico

August 2015

5-YEAR REVIEW
Pecos Sunflower / *Helianthus paradoxus*

1.0 GENERAL INFORMATION

1.1 Reviewers

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1.2 Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species once every 5 years. The purpose of this 5-year review is to ensure that the Pecos sunflower has the appropriate level of protection under the Act. This review documents a determination by the Service whether the status of the species has changed since the time of its listing. This review also provides updated information on the current threats, ongoing conservation efforts, and the priority needs for future conservation actions. Based on the 5-year review, we recommend whether the species status should remain unchanged, or whether the species should be removed from the list of endangered and threatened species, or be changed in status from threatened to endangered. Our original listing as threatened was based on the species' status considering the five threat factors described in section 4(a)(1) of the Act. These same five factors are considered in any subsequent reclassification or delisting decisions. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process including public review and comment.

1.3 Methodology used to complete the review

The Federal Register (FR) notice (72 FR 20134) announcing this review solicited new information about species biology, habitat conditions, conservation measures implemented, threats, trends, and other new information from other agencies, both Federal and State, non-governmental organizations, academia, and the general public. No new information was

received from this solicitation. This review considers the best scientific and commercial data that has become available since the current listing determination or most recent status review of the Pecos sunflower. This 5-year review of the Pecos sunflower was a collaborative effort comprised of biologists from the New Mexico Forestry Division and the Service's New Mexico Ecological Services Field Office (NMESFO). Robert Sivinski, previously State Botanist for the Forestry Division, was contracted through a section 6 grant to gather relevant information and prepare a preliminary draft of the review. Additional information, synthesis, recommendations, and the final review were prepared by the NMESFO.

1.4 Background:

1.4.1 FR Notice citation announcing initiation of this review:

72 FR 20134-20136; April 23, 2007. No comments were received in response to this notice.

1.4.2 Listing history

Original Listing
FR notice: 64 FR 56582
Date listed: October 20, 1999
Entity listed: Species
Classification: Threatened, without critical habitat

1.4.3 Associated rulemakings:

U.S. Fish and Wildlife Service. 2008. Designation of Critical Habitat for *Helianthus paradoxus* (Pecos sunflower). Federal Register, Vol. 73. No. 63:17762-17807.

1.4.4 Review History

Sivinski, R. 1995. New Mexico status of *Helianthus paradoxus*. Progress Report, Section 6, Segment 10, Submitted to U.S. Fish and Wildlife Service, Region 2, Albuquerque, New Mexico.

U.S. Fish and Wildlife Service. 1998. Proposed threatened status for the plant "*Helianthus paradoxus*" (Pecos sunflower). Federal Register Vol. 63, No. 62:15808-15813.

U.S. Fish and Wildlife Service. 2005. Pecos sunflower (*Helianthus paradoxus*) Recovery Plan. Albuquerque, New Mexico.

U.S. Fish and Wildlife Service. 2007. Proposed Designation of Critical Habitat for the Pecos Sunflower (*Helianthus paradoxus*) Federal Register, Vol. 72, No. 58: 14328-14366.

U.S. Fish and Wildlife Service. 2008. Environmental assessment for designation of critical habitat for Pecos sunflower. New Mexico Ecological Services Field Office, Albuquerque, New Mexico.

1.4.5 Species' Recovery Priority Number at start of 5-year review: 8

The recovery priority number is 8, indicating a species with a moderate degree of threat and a high recovery potential (U.S. Fish and Wildlife Service 2012).

Most recent status in biennial Recovery Report to Congress:

Increasing (U.S. Fish and Wildlife Service 2012).

1.4.6 Recovery Plan or Outline

Name of plan or outline: Pecos sunflower (*Helianthus paradoxus*) Recovery Plan
Date issued: September 2005

Dates of previous revisions, if applicable: The recovery plan has not been revised.

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy:

The Distinct Population Segment policy does not apply to the Pecos sunflower because it is not a vertebrate animal.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

_X_ Yes
____ No

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

___Yes
_X_ No. The recovery criteria in the Pecos Sunflower Recovery Plan (U.S. Fish and Wildlife Service 2005) should be collectively re-evaluated to determine if they constitute the most effective strategy for conservation and recovery of the species. Of most significance, the actual size of existing core populations is between 50 and 100 times, or even higher

multiples in some years of, the minimum number required in the recovery plan. The current recovery criteria may not have considered this much higher number of plants extant throughout the range of the species.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?

_X_ Yes
____ No

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.

The recovery plan contains the following criteria for removing Pecos sunflower from the list of threatened species:

1. Identify and establish at least one core conservation area for Pecos sunflower in each of the four distinct recovery regions that would collectively, if protected, ensure the long-term survival of the species. Each core habitat must occur on wetlands that are not threatened by depletion of the contributing aquifer and have demonstrated a self-perpetuating stand of Pecos sunflowers of greater than 5,000 individuals for a minimum of 7 out of 10 years. In addition to the core conservation area, each region should have at minimum one isolated stand of protected Pecos sunflowers with greater than 1,600 individuals for at least 7 out of 10 years to protect against catastrophic loss of the regional population.

2. Assure long-term protection of designated core conservation areas and designated isolated stands in perpetuity through the implementation of appropriate management plans, conservation easements, or land acquisitions.

Both criteria address the following three listing factors: Factor 1 – Present or threatened destruction, modification, or curtailment of its habitat or range; Factor 4 – Inadequacy of existing regulatory mechanisms; and Factor 5 – Other natural or manmade factors affecting its continued existence.

The remaining two listing factors are not relevant to Pecos sunflower at this time. These are: Factor 2 – Overutilization for commercial, recreational, scientific, or educational purposes; and Factor 3 – Disease or predation.

Progress toward Attainment of Recovery Criteria

Pecos sunflowers occur in four disjunct regions, which currently encompass the entire genetic variability and ecological characteristics of the species. The West-central New Mexico Recovery Region contains populations along the Rio San Jose and the middle Rio Grande. Two distinct regions on the Pecos River in eastern New Mexico include

populations in the Santa Rosa Recovery Region and further south, the Roswell/Dexter Recovery Region encompasses populations on Bitter Lake National Wildlife Refuge (Bitter Lake NWR) and nearby areas. Pecos sunflowers in the West Texas Recovery Region occur on two desert springs within the Pecos Plain region. The general strategy in the recovery plan is to protect and manage a significant, sustainable portion of each of the four regions' Pecos sunflower habitats, or core conservation areas, against the threat of future habitat loss and degradation, and as needed, from any other threats to Pecos sunflower. Land uses within these protected areas would be prescribed by management plans or voluntary deed restrictions that are designed to conserve Pecos sunflowers.

The Pecos sunflower faces a moderate degree of threat. This species is associated with spring seeps and desert cienegas, or wet meadows, which are very rare in the dry regions of New Mexico and Texas. Little is known about the historical distribution of the Pecos sunflower, but there is evidence that these habitats have historically, and are presently being reduced or eliminated by aquifer depletion or severely impacted by agricultural activities and encroachment by exotic plants (Poole 1992; Sivinski and Tonne 2011).

Recovery Criterion 1. One very large and persistent core population of Pecos sunflowers occurs within each of the four designated recovery regions. These core populations each consist of several hundred thousand plants or many more in most years, far exceeding the requirement in the Pecos Sunflower Recovery Plan of greater than 5,000 individuals for a minimum of 7 out of 10 years. However, only two of these populations, Bitter Lake NWR and Blue Hole Cienega, have guaranteed water sources. Regarding isolated stands, only the Pueblo of Laguna in the West-central New Mexico Recovery Region meets the requirements of 1,600 plants or more during at least 7 out of 10 years.

Recovery Criterion 2. Each of the four core populations is protected and managed to benefit the species in perpetuity. For isolated stands, only the Pueblo of Laguna in the West-central New Mexico Recovery Region is protected and managed to benefit the species in perpetuity at this time.

The recovery criteria from the Pecos Sunflower Recovery Plan (2005) have been partially attained. At least one core Pecos sunflower population is protected within all four of the designated recovery regions. All of these core populations are at least 50 to 100 times, or even higher multiples in some years of, the minimum size recommended in the recovery plan. Three recovery regions presently lack additional protected populations that fit the definition of 'isolated stand' in the Pecos Sunflower Recovery Plan. To meet the delisting criteria, two of the large core populations located within the four designated recovery regions still require guaranteed water sources in perpetuity. Of the four isolated stands, three of these still need to meet the requirements of 1,600 plants or more during at least 7 out of 10 years, and two still require protection and management to benefit the species in perpetuity (Table 1).

Table 1. Status of Pecos sunflower core populations and isolated stands.

Recovery Region	**Core Population**	**Isolated Stand**	**Size Criterion Met**	**Secure Water Source Criterion Met**	**Protection Criterion Met**
West-Central New Mexico					
	La Joya Waterfowl MA		yes	no	yes
		Pueblo of Laguna	yes	n/a*	yes
		Rhodes Property	yes	n/a	no
West Texas					
	Diamond Y Preserve		yes	no	yes
		East Sandia Spring	no	n/a	yes
Roswell/Dexter New Mexico					
	Bitter Lake NWR		yes	yes	yes
		Lea Lake Bottomless Lakes State Park	no	n/a	no
		Overflow Wetlands	no	n/a	no
		State Land Office Sink Hole	no	n/a	no
		BLM North Dexter Cienega	no	n/a	no
		Oasis Dairy	no	n/a	no
		Dexter Cienega	no access	n/a	no
Santa Rosa New Mexico					
	Blue Hole Cienega		yes	yes	yes
		City Cienega Restoration Site	no	n/a	no

*n/a (not applicable): The Pecos Sunflower Recovery Plan does not require a secure water source for isolated stands.

Figure 1. Distribution of known Pecos sunflower populations from the recovery plan (2005).

West-Central New Mexico Recovery Region

La Joya Waterfowl Management Area. The West-Central New Mexico Recovery Region contains a very large, protected core population at La Joya Waterfowl Management Area (La Joya WMA), managed by the New Mexico Department of Game and Fish. This population consists of several hundred thousand plants, has persisted since at least 2003, when it was discovered, and is managed under a plan specifically to benefit the Pecos sunflower.

The largest stands of Pecos sunflower on La Joya WMA are in relatively natural cienega habitats that are not directly affected by the man-made impoundments and their management (Sivinski 2008). The habitats are impacted by non-native weeds, and a management plan has been developed to control salt cedar (*Tamarix chinensis*), Russian olive (*Elaeagnus angustifolia*), and perennial pepperweed (*Lepidium latifolium*), and restore native habitat. This plan also includes mapping and monitoring Pecos sunflower stands at La Joya WMA and protecting spring features from motorized vehicles and heavy equipment (New Mexico Department of Game and Fish 2007). The habitat management plan supports conservation of the species on La Joya WMA by:

1. Annually controlling invasive species;
2. Protecting the natural spring from motorized vehicles and heavy equipment;
3. Monitoring core populations by digitizing these areas annually;
4. Conserving Pecos sunflower by adjusting invasive species treatment area boundaries; and
5. Restoring native habitat through re-vegetation.

The acreage of Pecos sunflower on La Joya WMA has varied, but has remained greater than 200 acres (ac) (80.94 hectares) (ha) since 2008. The water source for this population is partially provided through existing drains that supply La Joya WMA. This population of Pecos sunflowers exists along La Joya Drain. Water from the drain augments the wetlands on the wildlife area from direct irrigation and possibly from seepage (Bureau of Reclamation 2015). This water supply is not guaranteed, as it is a voluntary agreement contingent on water availability (New Mexico Department of Game and Fish 2007). The water right at La Joya WMA is owned by the Middle Rio Grande Conservancy District. The State of New Mexico has a written agreement from 1960 with the District that allows them to replenish the water in six ponds from the return flow during the non-irrigation season, approximately October 1 to February 1, to provide resting places for migratory waterfowl (New Mexico Department of Game and Fish 2007). During this period, the District will allow the diversion of water from the return flow to the extent that such water is available. This water is used to inundate wetland areas within La Joya WMA at a time of the year when other water demands are at their lowest. To date, there have been no conflicts associated with competing demands for this water (U.S. Fish and Wildlife Service 2008a).

The wetlands occupied by Pecos sunflower at this site are also supported by natural seeps and springs along the west side of the valley (U.S. Fish and Wildlife Service 2008a) and a

high water table associated with the river stage of the Rio Grande (New Mexico Department of Game and Fish 2007). The relative importance of the various water sources, i.e., diversions from the drain, springs, and a high water table associated with the river, in maintaining suitable habitat for Pecos sunflowers at La Joya WMA is unknown (New Mexico Department of Game and Fish, 2007). La Joya WMA is bounded on the west by Sevilleta National Wildlife Refuge. There are no substantial groundwater wells in the vicinity that potentially draw water from the same aquifer that supplies the springs and seeps on La Joya WMA.

Pueblo of Laguna. An isolated stand of Pecos sunflowers is managed to benefit the species on the Pueblo of Laguna. This population consists of several thousand plants, has persisted for at least 7 out of 10 years, and is managed under a plan specifically to protect and benefit Pecos sunflowers (U.S. Fish and Wildlife Service 2008b; Marek 2012a, b). This site is on undeveloped land along the Rio San Jose near the Valencia-Bernalillo County line and does not appear to be at risk for aquifer depletion, because there do not appear to be any groundwater wells in the area (New Mexico Office of the State Engineer 2007, U.S. Fish and Wildlife Service 2008a). The Pueblo of Laguna has also developed a management plan to preserve Pecos sunflower stands along the Rio San Jose on the Laguna Reservation (U.S. Fish and Wildlife Service 2008b). This plan was adopted by the Pueblo of Laguna in 2008 (Resolution # 01-08) and prescribes the following conservation measures:

1. Surveys and monitoring of Pecos sunflower,
2. Monitoring of spring and stream flow near habitats of Pecos sunflower,
3. Control of non-native plants and riparian restoration,
4. Limiting access into stands of Pecos sunflower through a recently adopted trespass ordinance, and
5. Appropriate management of livestock grazing to minimize impacts to Pecos sunflowers.

Under this management plan, Pecos sunflower will benefit from monitoring, restoration, enhancement, and survey efforts.

Rhodes Property. The Rhodes Property population is located on private property on the Middle Rio Grande near Socorro. Pecos sunflower seeds from La Joya State WMA were collected by the New Mexico Forestry Division and used to re-seed an area of this land in 2009. This area recently burned and also had non-native trees removed through a cooperative inter-agency project (Save our Bosque Task Force 2010). Funds from the Service were added to contributions from the Natural Resources Conservation Service, Save our Bosque Task Force, the New Mexico Forestry Division, and the New Mexico Department of Game and Fish to improve and restore habitats by treating and removing exotic vegetation and restoring native vegetation. Thousands of Pecos sunflowers resulted in the planted area, and this appears to be a new self-perpetuating population. The Pecos sunflower patches are becoming dense, and individuals are spreading to areas where they were not planted. This re-seeding was successful in producing a large population of Pecos sunflowers that has persisted and, in some years, contains tens of

thousands of plants. The size of these stands will be monitored in the future. This is currently the farthest south known Pecos sunflower population on the Rio Grande.

West Texas Recovery Region

Diamond Y Preserve. The large protected core population of Pecos sunflowers on the Diamond Y Preserve in the West Texas Recovery Region is designated as critical habitat for the Pecos sunflower and is owned and managed by The Nature Conservancy (TNC) to benefit this and other rare species that occur at the site (The Nature Conservancy 2008). This population was first described in 1946, and consists of several hundred thousand plants in most years (Texas Natural Diversity Database 2015). Management is conducted through cooperative partnerships with academic and agency researchers, oil and gas companies, and local ranchers. Active management that benefits conservation of Pecos sunflower includes control of salt cedar and prescribed burning. Livestock grazing is not currently allowed on the preserve, and TNC works cooperatively with oil and gas companies with leases on the preserve to abate threats from energy exploration, production and transportation (The Nature Conservancy 2008; U.S. Fish and Wildlife Service 2008a).

The water source supporting this important population is not guaranteed, as it is susceptible to adverse impacts by current and future ground water withdrawals and potentially to contamination from oil and gas operations (U.S. Fish and Wildlife Service 2008a; U.S. Fish and Wildlife Service 2010). Although TNC owns and manages the property surrounding the Diamond Y Preserve, it has no control over groundwater use that affects spring flow. One significant factor that influences flows at the spring is the large groundwater withdrawals for agricultural irrigation of farms to the southwest in the Belding and Fort Stockton areas (U.S. Fish and Wildlife Service 2010). This core population of Pecos sunflowers is 7 miles (mi) (11 kilometers) (km) west of Fort Stockton where the type specimen was collected in 1947. This location was reported to still have a remnant population of Pecos sunflowers in 1980 (U.S. Fish and Wildlife Service 1999), but since that time there are no reported findings. Several Pecos sunflower specimens collected in Pecos County, Texas, strongly indicate Pecos sunflower once grew in places where it no longer occurs. A specimen from ‘‘Fort Stockton’’ collected in 1943, is thought to be from around Comanche Springs, which is now dry and incapable of supporting Pecos sunflower. Although there is a reported collection from Escondido Creek occurring in the 1800s, the springs feeding this creek have been dry for many years, are no longer suitable habitat, and are no longer marked on topographic maps (U.S. Fish and Wildlife Service 1999).

East Sandia Spring. An isolated stand of Pecos sunflowers at East Sandia Spring is similarly owned and managed by TNC to benefit this and other rare species on the 240-ac (97-ha) Sandia Springs Nature Preserve. This population currently consists of more than 2,000 plants, although the size of this stand has not consistently been this large (U.S. Fish and Wildlife Service 2007; Marek 2012a, b). The water source for this Preserve is also susceptible to adverse impacts by current and future ground water withdrawals (U.S. Fish and Wildlife Service 2008a). East and West Sandia Springs are at the base of the Davis

Mountains just east of Balmorhea, Texas, and are part of the San Solomon and Balmorhea Spring Complex. Brune (1981) noted that flows from Sandia Springs were declining. East Sandia may be very susceptible to over pumping in the area of the local aquifer that supports the spring. The Texas Water Development Board agreed with this conclusion (U.S. Fish and Wildlife Service 2005b). Because of the regional scale of the base flow, slow travel time, and the age of the waters issuing from the spring system, it is anticipated that any substantial pumping in the regional flow system will cause a decline in the spring flow in the San Solomon Springs system, which includes Phantom Lake, San Solomon, Giffin, and East Sandia springs (U.S. Fish and Wildlife Service 2005b). This stand of Pecos sunflowers needs further study to see if it persists at this number of plants to qualify as an isolated stand under the recovery plan.

New Mexico-Roswell/Dexter Recovery Region

Bitter Lake NWR. The cienega on Bitter Lake NWR supports the largest population of Pecos sunflowers to date. This population is nearly continuous throughout the spring run and impoundments on the Refuge and in some years consists of a few million plants (Sivinski and Tonne 2011). This protected population inhabits an area designated as critical habitat for the Pecos sunflower and has persisted for over 25 years. It is managed under a plan that benefits the Pecos sunflower (U.S. Fish and Wildlife Service 2008b). Bitter Lake NWR has adjudicated water rights for wetland habitat maintenance (Sivinski 2008); therefore, the water supply for the Pecos sunflowers here is protected.

The natural cienega at Bitter Lake NWR supports the greatest biological diversity of any cienega in New Mexico (Sivinski and Tonne 2011). The total current area of cienega habitat on Bitter Lake NWR is about 567 ac (229.46 ha). The Refuge and adjacent Bottomless Lakes in the Roswell Artesian Basin were designated a Ramsar Site, or Internationally Important Wetland, in 2010 (Sivinski and Tonne 2011). The Convention on Wetlands of International Importance, also called the Ramsar Convention, is an inter-governmental treaty that provides a framework for local and national action and international cooperation for the conservation and wise use of wetlands and their resources. Bitter Lake NWR has received recognition from the State of New Mexico for their federally reserved water right. This right allows the Refuge to manage wetlands on the Middle Tract of the Refuge and protects spring resources from impairment.

The Pecos sunflower was recognized as occurring at Bitter Lake NWR in 1991. Management on the Refuge is credited with increasing the population size of Pecos sunflowers by an estimated 300 percent since 1993, when a new water-level management plan was implemented (U.S. Fish and Wildlife Service 2008a). This water-level management strategy has created conditions that are ideal for germination of Pecos sunflower seeds and growth of seedlings. Formerly, water levels in these wetlands were kept high year-round. Now, levels are left low during the summer when evaporation is highest and are allowed to rise during the colder months. While the primary reason for this change was to mimic natural conditions and improve wetland habitat, it may have also reduced losses due to evaporation. These actions protect groundwater levels of the Roswell Basin in the vicinity of the Refuge and help preserve Pecos River flows.

Additionally, other habitat management measures, including removal and control of non-native invasive plants, such as salt cedar and Russian knapweed *(Rhaponticum repens)*, and prescribed burning in presently unoccupied habitat have benefitted Pecos sunflowers on the Refuge (U.S. Fish and Wildlife Service 2008a). Two large restoration projects are currently underway on the Rio Hondo and Bitter Creek, which should further enhance Pecos sunflower populations on the Refuge (Sanchez 2015).

Lea Lake at Bottomless Lakes State Park. The New Mexico State Parks Division currently protects habitat occupied by Pecos sunflower and designated as critical habitat on the perimeter of Lea Lake, at Bottomless Lakes State Park, by not mowing the area (U.S. Fish and Wildlife Service 2008a). Pecos sunflowers occur along the margins of Lea Lake in the State Park and are abundant on the banks of the constructed spring run that flows from Lea Lake. Additionally, the State Parks Division entered into a cost-share agreement with the U.S. Army Corps of Engineers under Section 206 of the Water Resources Development Act to restore wetland habitat at Lea Lake Marsh. This project has created additional suitable habitat into which this population of Pecos sunflower has expanded (O. Hummel, Corps of Engineers, pers. comm., May 28, 2015). In 2012, there were more than 1,600 Pecos sunflower plants present, but this population has not always been this numerous (Marek 2012a, b). This stand needs further study to see if it is large enough, persistent, and adequately protected in perpetuity to qualify as an isolated stand under the recovery plan.

Overflow Wetlands. The Overflow Wetlands are also in the Roswell Artesian Basin south of Bottomless Lakes State Park. These wetlands spread across the east side of the Pecos River valley from the overflow of Lea Lake, a large sink hole, and other springs and seeps to the south. They extend 2.4 mi (3.86 km) from Lea Lake to the Pecos River, mostly on Bureau of Land Management (BLM) land. The Overflow Wetlands contracted and became more salty as regional irrigation pumping drew down the aquifer and the Pecos River. State monitoring of agricultural water use is allowing most of the aquifer to recover and stabilize, which is increasing discharge from the Bottomless Lakes springs and expanding the Overflow Wetland (Sivinski and Tonne 2011).

This extensive wetland has a few large patches of Pecos sunflowers in its southern half, which numbered approximately 2,000 plants in 2012 (Marek 2012). The current Resource Management Plan directs the Roswell District Office of BLM to implement special-status species habitat management (Bureau of Land Management 1997). In addition, site-specific plans have been developed, including the Overflow Wetlands Area of Critical of Environmental Concern (ACEC) Implementation Plan and grazing allotment management plans that incorporate objectives to protect Pecos sunflower habitat. The 7,000-ac (2832.80-ha) Overflow Wetlands ACEC is about 16 mi (25.75 km) east of Roswell and supports a significant riparian wetland community. Projects within the ACEC include noxious and invasive weed control, including salt cedar removal, and limiting the use of off-highway vehicles to designated roads and trails within the ACEC. No specific plan has yet been developed for the long-term management of Pecos sunflower at the Overflow Wetlands. This stand needs further study to see if it is large

enough, persistent, and adequately protected in perpetuity to qualify as an isolated stand under the recovery plan.

State Land Office Sink Hole. In the mid-1990s a new sink hole located on State Trust Land opened in a small cienega on the east side of the Pecos River and south of Bottomless Lakes State Park. The State Land Office and New Mexico Forestry Division obtained Pecos sunflower seed from the Oasis Dairy population and introduced it to the Sink Hole Cienega. This is a relatively small habitat, but by the summer of 2010, there were a few thousand Pecos sunflowers at this location. The number of plants at this site has varied from year to year, and there is a need for weed control to create more habitat for Pecos sunflowers (D. Baggao, Bureau of Land Management, pers. comm. 2012). This stand needs further study to see if it is large enough, persistent, and adequately protected in perpetuity to qualify as an isolated stand under the recovery plan.

BLM North Dexter Cienega. Approximately 5 mi (8.05 km) north of the town of Dexter, a spring at the head of a broad valley created a cienega more than 1 mi (1.61 km) long. Several decades ago, a new well dried the cienega. A 1994 survey of this valley found only two Pecos sunflowers among the salt cedars in the impounded area (Sivinski 1995). BLM purchased the land with the impoundment and began removing salt cedars. The remnant cienega below the impoundment is sometimes relatively dry and marginal for Pecos sunflower. In 2010, however, several hundred sunflowers flowered and set seed, indicating that the remnant cienega is viable Pecos sunflower habitat. In 2012, there were more than 2,000 Pecos sunflower plants present, following more salt cedar removal (Marek 2012a, b). This stand needs further study to see if it is large enough, persistent, and adequately protected in perpetuity to qualify as an isolated stand under the recovery plan.

Oasis Dairy. An unnamed spring and associated large cienega opposite Bottomless Lakes State Park west of the Pecos River had so many thousands of Pecos sunflowers in the mid-1990s they were visible in flower from the bluff above Lea Lake more 2 miles distant (Sivinski and Tonne 2011). This Oasis Dairy population is designated critical habitat for the Pecos sunflower. Although 2010 was a wetter than normal precipitation year, the southern part of the Oasis Dairy cienega was abnormally dry. The spring had ceased flowing and the vast stand of Pecos sunflowers had been replaced by non-native kochia (*Kochia scoparia*). Dry meadows of saltgrass were littered with thousands of dead sunflower stems that were at least 2 years old. Only a few hundred Pecos sunflowers survived in the valley, widely scattered among kochia and salt cedars. Agricultural irrigation pumping may have drawn down the aquifer in this area, and this once-large cienega may no longer be viable to support a persistent population of Pecos sunflowers (Sivinski and Tonne 2011).

Dexter Cienega. An unnamed spring seep 2.8 mi (4.51 km) north of Dexter crosses beneath the Hagerman Canal and makes a 0.8 mi- (1.29 km-) long cienega in the bottom of a narrow valley. This cienega is designated critical habitat for the Pecos sunflower. Larger patches of Pecos sunflowers are visible in this valley from a distance, but this cienega has not been accessible for detailed study (Sivinski and Tonne 2011).

New Mexico-Santa Rosa Recovery Region

Santa Rosa sits within much of the best arid land spring cienega habitat in New Mexico (Sivinski and Tonne 2011). Relatively large expanses of State, municipal, and private property in Santa Rosa consist of permanent cienegas, and sinkhole lakes that are ringed with excellent examples of fresh water and alkaline marshlands. The groundwater of this regional sink usually comes up in broad-area seeps that cause most of the soils to be saturated to the surface or root-zone. The cienegas of the Santa Rosa sink are among the most botanically diverse wetlands in the Southwest (Sivinski and Tonne 2011). Some parts of the Santa Rosa sink cienegas have either dense or sparse patches of Pecos sunflowers.

The spring waters of the Santa Rosa sink are very high in the dissolved solids, sulfate and carbonate salts, and are unsuitable for municipal use. The City of Santa Rosa gets its municipal water from a different aquifer, miles to the west, and does not threaten the aquifer that creates the Santa Rosa cienegas. However, there have been, and still are, serious impacts to these cienegas that reduce or destroy them. Nearly all of the cienega immediately adjacent to Blue Hole Spring has been replaced by roads, parking lots, buildings, playing fields, and fishing ponds. Many acres of cienega below Perch Lake and a few acres of Blue Hole Cienega have been plowed and planted with non-native pasture grass, meadow fescue (*Festuca pratensis*), before those cienegas were acquired by the City and the State, respectively. This tenacious non-native grass is persisting as a dense cover to the exclusion of native cienega plants, and the disturbed soils of planted pastures are more susceptible to non-native tree infestation (Sivinski and Tonne 2011). The Santa Rosa cienegas have been over-grazed by livestock for more than a century. Many spring runs have been damaged in order to drain bogs and spread water to drier areas. These actions have changed parts of cienega hydrology and encouraged proliferation of non-native trees on the disturbed soils (Sivinski and Tonne 2011).

Blue Hole Cienega Nature Preserve. The 116-ac (46.94-ha) Blue Hole Cienega Nature Preserve has the largest stand of sunflowers in the Santa Rosa area. Blue Hole Cienega is owned by the New Mexico Forestry Division and is designated as critical habitat for the Pecos sunflower. The Division purchased the Pecos sunflower habitat at Blue Hole Cienega in Santa Rosa in 2005, with funding from the New Mexico Department of Transportation and a Recovery Lands Acquisition Grant from the Service. The warranty deed for Blue Hole Cienega designates this tract of land as a nature preserve with the purpose of protecting threatened and endangered plant habitat. Approximately 40 ac (16.19 ha) of the Blue Hole Cienega Preserve are occupied by a large Pecos sunflower population of several hundred thousand plants. New Mexico Forestry Division cut and herbicide-treated a Russian olive/salt cedar forest occupying about 25 percent of the preserve and burned the entire cienega in 2007, during the dormant season for Pecos sunflower. The size and number of Pecos sunflowers on the preserve dramatically increased in 2008 (New Mexico Forestry Division 2008).

Blue Hole Cienega is managed specifically for the protection and management of this large core population of the New Mexico-Santa Rosa Recovery Region. Management of

the cienega consists of maintaining the boundary fence and removing non-native Russian olive (New Mexico Forestry Division 2008). Several hundred thousand Pecos sunflowers have persisted at this level for at least 7 out of 10 years (Sivinski and Tonne 2011). Wetland habitat at Blue Hole Cienega is maintained by high water tables associated with numerous small springs and seeps. The aquifer associated with Blue Hole Cienega should not be in danger of depletion, because its water is unsuitable for irrigation or municipal water use (Sivinski 2008). The Santa Rosa Water Supply system serves approximately 2,500 people and comes from two wells that draw from a deeper aquifer (U.S. Fish and Wildlife Service 2008a). However, there are four domestic wells in the vicinity of Blue Hole Cienega that draw up to 3 ac-ft per year and one larger irrigation supply well that draws up to 45 ac-ft per year (U.S. Fish and Wildlife Service 2008a).

City Cienega Restoration Site. There are several other smaller patches of Pecos sunflowers in Santa Rosa cienegas. The municipal fishing ponds, or fish hatchery, and an un-named spring on the west side of the Pecos River are also designated as critical habitat. There are several smaller stands of Pecos sunflowers in the Santa Rosa Recovery Region that could potentially be restored and developed to conform to the recovery plan criteria for an isolated stand. At present, the most likely population for this designation is located at the City Cienega Restoration Site, part of a 119-ac (48.16-ha) parcel of land owned by the City of Santa Rosa. It contains one of the last remaining intact wetlands in the Santa Rosa area and thousands of Pecos sunflowers (Roth 2014). In 2014, non-native trees were removed during the dormant season for Pecos sunflower, and a gate was purchased and installed on the north site of the property to limit vehicle access. The City of Santa Rosa installed a lock to secure the site. Eleven permanent photo monitoring points were established within the fenced area to documented habitat and population changes over time. The primary area of Pecos sunflower occupation is approximately 5 ac (2.02 ha) and is largely contained within the fenced area. The site requires additional habitat restoration and monitoring to determine the size and persistence of this population, and it currently lacks long-term protection.

2.3 Updated Information and Current Species Status

The Pecos sunflower was listed as a threatened species under the Endangered Species Act (Act), on October 20, 1999 (64 FR 56582-56590). The State of New Mexico lists Pecos sunflower as endangered under the regulations of the New Mexico Endangered Plant Species Act (19 NMAC 21.2). This species is also listed as threatened by the State of Texas (31 TAC 2.69[A]).

A final recovery plan for the Pecos sunflower was completed in 2005. Recovery actions include identifying and securing core conservation habitats essential for the long-term survival of this species, and continuing to study its life history, population, and habitat, and ensuring compliance with existing regulations. While some land management activities, such as grazing and mowing, are not necessarily incompatible with the species' conservation, the timing and duration of these activities is important.

2.3.1 Biology and Habitat

The Pecos sunflower is a wetland plant that was known from only a single population near Fort Stockton, Pecos County, Texas, when it was proposed as a candidate for listing as endangered under the Act on December 15, 1980 (45 FR 82480). Subsequent field surveys for this species found additional populations in New Mexico and Texas. Until 1990, the Pecos sunflower was known from only three extant sites. Two sites were in Pecos County, Texas, and one site was in Chaves County, New Mexico (U.S. Fish and Wildlife Service 1999). Searches of suitable habitats in Pecos, Reeves, and Culbertson counties, Texas, during 1991 failed to locate any new sites (Poole 1992). However, searches in New Mexico from 1991 through 1994 located a significant number of new sites (Sivinski 1995). In Texas, one new site was reported in 1998 (U.S. Fish and Wildlife Service 1999). At the time of listing, Pecos sunflower was known from 25 sites that occurred in five general areas. These areas were Pecos and Reeves counties, Texas, in the vicinity of Fort Stockton and Balmorhea; Chaves County, New Mexico, from Dexter to just north of Roswell; Guadalupe County, New Mexico, in the vicinity of Santa Rosa; Valencia County, New Mexico, along the lower part of the Rio San Jose; and Cibola County, New Mexico, in the vicinity of Grants. There were three sites in the Fort Stockton to Balmorhea area, 11 in the Dexter to Roswell area, eight in the Santa Rosa area, one along the lower Rio San Jose, and two in the Grants area. In addition, since listing, two new large sites on the middle Rio Grande have been added and several new sites have been discovered in the Santa Rosa area.

Pecos sunflower populations occur on State, Federal, tribal, and several private land holdings. Many of these sites on spring seeps or cienega habitats were also determined to have a moderate degree of threat from aquifer depletion, agricultural activities, or encroachment by alien plants (Poole 1992; Sivinski 1995). The cienega climax community has been described as mid-elevation, 3280.84 to 6561.68 feet (ft) (1000 to 2000 meters (m)) freshwater wetlands with permanently saturated, highly organic, reducing soils occupied by a low-growing herbaceous cover of mostly sedges and rushes. Few woody plants occur in the cienega flora and often only as riparian tree species around the drier margins. Cienegas occur in arid landscapes with high rates of evaporation, so the soils at the drying wetland margins usually have surface crusts of alkali or salts that are the deposited dissolved solids of evaporated or transpired soil solutions (Hendrickson and Minckley 1984).

The southwestern United States has been experiencing a period of prolonged drought that is exacerbating habitat degradation of cienegas (Sivinski and Tonne 2011). The trend of decreasing habitat availability and suitability caused by drying of wetlands from groundwater depletion, alteration of wetlands (e.g., wetland fills, draining, impoundment construction), competition from nonnative plant species, poorly managed livestock grazing, mowing, and highway maintenance were threats identified in listing the Pecos sunflower as a threatened species. Recovery actions to reverse or stabilize this trend and ensure the long-term sustainability of this species include identifying the ecological parameters of Pecos sunflower habitat and enlisting the cooperation of managers and

owners of suitable habitat in the long-term conservation of the species. Pursuing voluntary conservation opportunities with landowners and managers is a high priority.

Critical Habitat

The Service designated approximately 1,305 ac (528.11 ha) of critical habitat for Pecos sunflower in April 2008 (Service 2008b). Areas of critical habitat include the Diamond Y Spring in Pecos County, Texas; Dexter Cienega, Lea Lake, Oasis Dairy, and Bitter Lake National Wildlife Refuge with adjacent City of Roswell land in Chaves County, New Mexico; Blue Hole Cienega and fishing ponds, and West Side Spring in Guadalupe County, New Mexico; and the Grants salt flat and Rancho del Padre Spring in Cibola County, New Mexico. The west-central New Mexico Pecos sunflower populations at Laguna Pueblo and La Joya were determined to be adequately protected by management plans and excluded from critical habitat designation (U.S. Fish and Wildlife Service 2008b).

Critical habitat is a term in the Act that identifies geographic areas containing features essential for the conservation of a threatened or endangered species and which may require special management considerations or protection. Pursuant to the Act and its implementing regulations, the Service is required to identify the physical and biological features within the geographical area occupied by Pecos sunflower at the time of listing that are essential to the conservation of the species and which may require special management considerations or protections. The physical and biological features (PBFs) are those primary constituent elements that exist in a specific spatial arrangement and quantity to be essential to the conservation of the species. All areas designated as critical habitat for Pecos sunflower are currently occupied, within the species' historical geographic range, and contain all the PBFs.

Based on knowledge of the life history, biology, and ecology of the Pecos sunflower and the habitat requirements for sustaining the essential life history functions of the species, the PBFs for Pecos sunflower are the desert wetland or riparian habitat components that provide: (1) Silty clay or fine sand soils that contain high organic content, are saline or alkaline, are permanently saturated within the root zone in the top 19.69 inches (in) (50 centimeters (cm)) of the soil profile, and have salinity levels ranging from 10 to 40 parts per thousand; and (2) low proportion (less than 10 percent) of woody shrub or canopy cover directly around the plant (U.S. Fish and Wildlife Service 2008b).

2.3.1.1 New information on the species' biology and life history:

The Pecos sunflower is an annual plant that must re-establish each population by seeds produced during preceding years. Seed germination does not occur during approximately the first 3 months after ripening. This dormancy period prevents seeds from germinating during the early winter when soil and temperature conditions may occasionally be suitable, but killing frosts have a high probability of occurring. Seeds may remain dormant for longer periods and ensure the soil seed bank is viable for future germination events (Van Auken 2001). The

longevity of Pecos sunflower seed has not been studied. However, observational information from Bitter Lake NWR suggests that many seeds may remain viable in the soil for at least 5 years. It was observed that Pecos sunflowers germinated in a wet year in areas where drought conditions had resulted in no germination for 5 years (J. Sanchez, Bitter Lake NWR, pers. comm., 2015).

The Pecos sunflower differs from other annual sunflowers in the high soil salinity of its habitats (Welch and Rieseberg 2002). This salt marsh species also differs from related annual sunflowers by using sodium to replace potassium, sodium and magnesium to supplement osmotic pressure in its tissues and increasing leaf succulence to reduce the toxic effects of sodium (Lexer et al. 2003; Karrenberg et al. 2006).

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Demographic trends in Pecos sunflower populations have not been scientifically studied. There is observational evidence that population numbers fluctuate from year-to-year in response to environmental factors (U.S. Fish and Wildlife Service 2005; Hirsch 2012). For example, Grunstra and Van Auken (2007) identified 2002 as a year of low sunflower density at the Diamond Y Preserve population in Texas because a period of drought had decreased ground water levels and increased the soil surface pH and salinity.

During the last decade, large-scale projects have been implemented in the Southwest to reduce or remove exotic trees from riparian areas. Extensive removal of salt cedar and Russian olive has opened the canopy and increased water availability. These changes have resulted in increased numbers and extent of Pecos sunflowers in suitable habitat at several sites, including Blue Hole Cienega (Sivinski 2007), La Joya WMA (New Mexico Department of Game and Fish 2007), and Lloyd's Draw (D. Baggao, Bureau of Land Management, pers. comm., 2012; Marek 2012a, b), among others.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

The Pecos sunflower, *Helianthus paradoxus*, was derived from hybridization between *H. petiolaris* and *H. annuus* that occurred between 60,000 and 200,000 years ago (Welch and Rieseberg 2002). It is a homoploid species, meaning there has been no change in chromosome number from its parent species (Baack et al. 2005). All three species are diploids, containing two complete sets of chromosomes, one from each parent. However, *H. paradoxus* is karyotypically differentiated from its progenitors and strongly reproductively isolated (Lai et al. 2005). *H. paradoxus* also diverged from its progenitors by having 50 percent more nuclear deoxyribonucleic acid, or DNA, than its parental species through the

amplification of repetitive elements that may have been indirectly favored by selection (Baack et al. 2005). Genomic redundancy provides a means to reduce the initial fitness costs of genetic rearrangements. There may have been strong selection for early-generation hybrids that carried large-scale chromosomal duplications. Currently, obvious hybrids between sympatric *H. annuus* and *H. paradoxus* are rare and do not phenotypically appear to be influencing dense stands of Pecos sunflower (U.S. Fish and Wildlife Service 2005). No researchers have reported low reproductive vigor that might indicate inbreeding depression (Sivinski 2008). Research in evolutionary genetics is exploring this rare and unique sunflower for insights into genomic activation, expansion, and restructuring, which are evolutionary processes for all plants and animals.

The Pecos sunflower is also being studied to see if it has a genetic component that could possibly increase salt tolerance of commercial sunflower species (Marek 2011). Because germplasm from wild relatives has provided a source of genes for crop improvement for many domesticated crops, including sunflowers, there has been increased screening of wild germplasm for disease resistance, oil composition, and tolerance to biotic stresses such as drought and salinity (Marek 2011).

2.3.1.4 Taxonomic classification or changes in nomenclature:

The location of the 1851 paratype specimen cited as “Nay Camp” in the 1958 description of *Helianthus paradoxus* was a transcription error of “Hay Camp”. The subsequent 1853 Whipple Expedition places “Hay Camp” at the modern day location of Grants in Cibola County, New Mexico (Sivinski 2003).

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species’ within its historic range, etc.):

In 2003, a new Pecos sunflower population was discovered at the La Joya WMA in the Rio Grande valley of Socorro County, New Mexico. The spring seep habitats at this location are highly alkaline, saltgrass cienegas that are typical for the species. This is a very large population, exceeding several hundred thousand plants on over 200 ac (80.94 ha) of habitat (New Mexico Department of Game and Fish 2007; U.S. Fish and Wildlife Service 2008b).

Pecos sunflower seeds from the La Joya State WMA were collected by the New Mexico Forestry Division and used to re-seed an area on private land along the Middle Rio Grande near Brown Arroyo in 2009, where non-native trees had recently been removed and a wildfire had occurred (Save Our Bosque Task Force 2010). This re-seeding was successful in producing a large population of Pecos sunflowers on the restored property. In some years, there are tens of thousands of

plants. These stands will continue to be monitored. This is currently the furthest south known Pecos sunflower population on the Rio Grande.

A planting program was adopted by the State of New Mexico in 2001 to reintroduce Pecos sunflower to suitable habitats within its historic range (New Mexico State Land Office 2001). Seedlings were planted in 2002 at a spring seep wetland near south of Fort Sumner in De Baca County and around a sinkhole wetland between the Roswell and Dexter populations in Chaves County. These seedlings failed to become established, so the sinkhole location was directly planted with Pecos sunflower seeds in 2003. About 150 sunflowers germinated, flowered and produced seed that year. This sink hole wetland population has consistently produced between 500 and 1,000 plants during subsequent years (Sivinski 2008). This new population occurs 2 miles south of the natural Lea Lake population within the Roswell/Dexter Recovery Region and does not extend the distribution of Pecos sunflower.

In 2008, Pecos sunflower seeds were also planted by the Forestry Division on La Jencia Ranch, at locations near La Jencia Creek and the town of Magdalena, in Socorro County, New Mexico. These plants have persisted since then in small numbers and are located within the West-Central New Mexico Recovery Region.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

The most abundant perennial plant cover in alkaline cienega habitats is inland saltgrass (*Distichlis spicata*). Greenhouse experiments show that saltgrass competition does not diminish the growth of Pecos sunflower (Van Auken and Bush 2006, 2007). Although saltgrass is not a significant competitor, the vegetation cover and thatch produced over several years of productive growth can diminish habitat suitability for germination and establishment of Pecos sunflower seedlings. Disturbance regimes, such as fire or tillage, which eliminate vegetation thatch and expose bare ground surface tend to increase Pecos sunflower cover and productivity (Van Auken and Bush 2004; New Mexico Forestry Division 2008). In conjunction with removal of non-native trees, these techniques have been successfully used during late fall and early winter months to increase or restore Pecos sunflowers to Blue Hole Cienega, La Joya WMA, and on the Rhodes private property near Brown Arroyo on the Rio Grande.

The Pecos sunflower is intolerant of habitats that are too wet at the surface and prefers soils that are relatively dry at the surface and wet in the lower root zone (Bush 2006). For example, habitats with significant Pecos sunflower cover around Diamond Y Spring in west Texas tend to be at locations with depth to ground water greater than 9.84 in (25 cm), soil salinity between 7 and 12 g/kg, and soil pH between 8.3 and 8.5 (Grunstra and Van Auken 2007).

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

The primary threat to Pecos sunflower is destruction or modification of wetland habitats from filling, groundwater pumping, aquifer depletion, and surface water diversion. Other threats include competition from non-native plant species, excessive livestock grazing, mowing, and highway maintenance (U.S. Fish and Wildlife Service 1999).

2.3.2.1 Present or threatened destruction, modification, or curtailment of its habitat or range:

Most southwestern cienegas are in private ownership because the spring features associated with them are valuable assets in an arid region. Nevertheless, some remnant southwestern cienegas have been acquired by Federal and State governments and TNC as natural preserves or wildlife refuges. These have usually been protected because of the rare or endangered animals inhabiting the actual spring features, but the rare cienega plants also need to be considered in preserve management. Restoration, protection and management of these rare and unique habitats are costly and require perpetual effort. A protective fence or hands-off approach for preserve management may only yield a cienega that is overgrown, thatchy, drying, and pest-ridden (Kodric-Brown and Brown 2007; Unmack and Minckley 2008). Needs for grazing or fire prescriptions, aquifer protection or restoration, and weed control require active management (Sivinski and Tonne 2011).

Restoration and management of cienegas affected by arroyo cuts that have lowered the water table of adjacent springs and seeps require the difficult task of raising their elevation through deposit of detritus or sediment. (Minckley and Brunelle 2007; Turner and Fonseca 2008). The ground water of a dead or damaged cienega may still be close to the surface, but requires significant sedimentation and restoration of sheet flow to bring the water table back to ground level and re-establish the cienega. On the other hand, former cienegas supported by spring aquifers that have been depleted by groundwater pumping are unlikely to resume surface flow for the foreseeable future (Sivinski and Tonne 2011).

<u>Reduction of water in springs</u>

Loss or alteration of spring habitat continues to be the main threat to Pecos sunflower. The typically scattered distribution of springs makes these aquatic islands unique habitat for many rare species in an arid-land matrix (Myers and Resh 1999). The Pecos sunflower is susceptible to extirpation because it depends on isolated desert springs for its survival (U.S. Fish and Wildlife Service 2005a). Curtailment of the range and habitat of the Pecos sunflower has likely occurred primarily through the loss of suitable spring habitat. This species was likely more widely distributed throughout its historic habitat during wetter climatic periods.

As the climate became warmer and drier, the Pecos sunflower was restricted to remaining free-flowing springs. For example, in the 1880s, irrigated agriculture in the Roswell and Artesia Basins was limited to a few small farms (Fielder and Nye 1933). By the end of 1905, 485 artesian wells had been drilled, and by 1927, 1,424 wells were pumping water (Fiedler and Nye 1933). One well, drilled for the Oasis Cotton Company, is estimated to have produced 20 cubic feet per second (cfs) (0.57 cubic meters per second (cms) (Fiedler and Nye 1933; Jones and Balleau 1996). As a result of extensive groundwater pumping, the artesian head in the basin declined (Fiedler and Nye 1933). The amount of decline depended on the location within the basin and ranged from 32 to 204 ft (9.7 to 62.2 m) from original levels by 1927, and led to a decrease in area within the basin that had artesian flow (Fiedler and Nye 1933). Groundwater depletion continued until the mid-1970s, when it reached its maximum (McCord et al. 2005).

Lowering water tables from aquifer withdrawals for irrigation and municipal use has degraded many desert spring habitats. The primary threat to the Pecos sunflower in west Texas is the potential failure of spring flow due to excessive groundwater pumping or drought or both, which would result in total habitat loss for the species. There is evidence that spring habitats have been historically reduced or eliminated by aquifer depletion on the Bitter Lake NWR (Jones and Balleau 1996). In addition, recent drought years may have impacted the size of Pecos sunflower populations on La Joya WMA (Hirsch 2012). Here, the total number of acres occupied by Pecos sunflower fell from 261 ac (105.622 ha) in 2010, to 224 ac (90.65 ha) in 2011, to 200 ac (80.94 ha) in 2012, as the drought in New Mexico intensified.

Diamond Y Spring. Diamond Y Spring, which supports the core population of Pecos sunflowers for the West Texas Recovery Region, is the last major spring still flowing in Pecos County, Texas (Veni 1991). There have been no continuous records of spring flow discharge at Diamond Y Spring by which to determine trends in flow. Studies by Veni (1991) and Boghici (1997) indicate that the spring flow at Diamond Y Spring may come from the Rustler aquifers located west of the spring outlets. One significant factor that influences flows at the spring is the large groundwater withdrawals for agricultural irrigation of farms to the southwest in the Belding through Fort Stockton areas. Although TNC owns and manages the property surrounding the Diamond Y Springs Complex, it has no control over the groundwater use that affects spring flow.

East and West Sandia Springs. East Sandia Spring in Reeves County, Texas, supports an important stand of Pecos sunflowers in the West Texas Recovery Region. It discharges at an elevation of 3,205 ft (977 m) from alluvial sand and gravel (Schuster 1997). Brune (1981) noted that flows from East Sandia Spring were declining. East Sandia Spring may be very susceptible to over-pumping in the area of the local aquifer that supports the spring. Measured discharges in 1995 and 1996 ranged from 0.45 to 4.07 cfs (0.013 to 0.11 cms) (Schuster 1997). The small outflow channel from East Sandia Spring has not been significantly

modified and water flows into an irrigation system approximately 328 to 656 ft (100 to 200 m) after surfacing. West Sandia Spring also occurs on the TNC Preserve, but it ceased flowing in the past 10 years (Schuster 1997). Pumping of the regional aquifer system for agricultural production of crops has resulted in the drying of most other springs in this region (Brune 1981).

Comanche Springs. Other springs that have already failed include Comanche Springs, which was once a large spring in Fort Stockton, Texas, about 18 mi (29.0 km) from Diamond Y Spring. Comanche Springs flowed at more than 142 cfs (4.0 cms) (Scudday 1977; Brune 1981) and undoubtedly provided habitat for rare species of fish, invertebrates, and plants. The spring ceased flowing by 1962 (Brune 1981), except for brief periods (Small and Ozuna 1993).

Leon Springs. Leon Springs, located upstream of Diamond Y Spring in the Leon Creek watershed, was measured at 18 cfs (0.5 cms) in the 1930s and was also known to contain rare fish, but ceased flowing in the 1950s, following significant irrigation pumping (Brune 1981). In the 1930s, Leon Springs, located upstream of Diamond Y in the Leon Creek watershed was measured at 18 cfs (0.5 cms) and was also known to contain rare fish. This spring ceased flowing in the 1950s, following significant irrigation pumping (Brune 1981). East and West Sandia Springs are at the base of the Davis Mountains just east of Balmorhea, Texas, and are part of the San Solomon-Balmorhea Spring Complex. The springs are included in a 240-ac (97-ha) preserve owned and managed by TNC (Karges 2003).

Phantom Lake Spring. Phantom Lake Spring, another spring near the Sandia Springs, has experienced a long-term, consistent decline in flow. Discharge data have been recorded from the spring six to eight times per year since the 1940s by the U.S. Geological Survey (Schuster 1997). The record shows a steady decline of flows, from greater than 10 cfs (0.28 cms) in the 1940s to 0 cfs in 2000. The exact causes for the decline in flow from Phantom Lake Spring are unknown. Some possible reasons are groundwater pumping of the supporting aquifer and decreased recharge of the aquifer from drought (Sharp et al. 1999, 2003). The Texas Water Development Board (2005) concluded that because of the uncertainties of the regional flow system, it is difficult to assess why spring flow in Phantom Lake Spring has declined. Ashworth et al. (1997) noted the improper placement of new wells could have a detrimental effect on the springs. The Texas Water Development Board (2005) agreed with this conclusion. Because of the regional scale of the base flow, slow travel time, and the age of the waters issuing from the spring system, it is anticipated that any substantial pumping in the regional flow system will cause a decline in the spring flow in the San Solomon Springs system, which includes Phantom Lake, San Solomon, Giffin, and East Sandia springs (Texas Water Development Board 2005).

Roswell Artesian Basin Cienégas, Chaves County, New Mexico

The Pecos River valley from Bitter Lake south approximately 21 mi (33.8 ha) to the town of Dexter was a complex series of sinkhole lakes, resurgent creeks, spring runs and vast spring seeps that combined to make one of the largest areas of aridland spring cienega in the Southwest. Most of the seeping ground has been on the west side of the valley, discharging from the regional aquifer of the Roswell artesian basin draining the west slope, including the Sacramento Mountains (Land and Huff 2010). More than one-half of the cienegas on the west side of the valley have been eliminated or severely diminished by conversion to farmland, agricultural drains, and aquifer depletion by intensive irrigation water withdrawals. However, the northern Salt Creek portion of this regional aquifer passes through gypsum strata, becoming less suitable for agriculture, and emerging as Bitter Creek, a continuous spring run and cienega nearly 4 mi (33.80 km) in length and 300 ft (91.44 m) to 1,200 ft (365.76 m) in width through Bitter Lake NWR.

Bitter Lake National Wildlife Refuge. Surface flow at Bitter Lake NWR was also diminished by artesian pumping. Springs adjacent to Salt Creek no longer flow, and surface flow from the Middle Tract of Bitter Lake NWR, including flow in upper Bitter Creek and Middle Tract springs) was 15 cfs (0.4 cms) in 1937 and 5 cfs (0.14 cms) in 1995 (Jones and Balleau 1996). Aerial photographs that show a larger, meandering channel for Bitter Creek also provide evidence that discharge from Bitter Creek was greater in the past. Groundwater pumping in the Roswell Basin led to the drying of several springs. It is not possible to determine the extent of the loss of Pecos sunflower populations, because many springs went dry long before surveys were conducted. In addition, loss cannot be measured simply by the number of artesian springs that are no longer flowing. Many of these springs were large enough to form rivers that flowed for several miles, and creeks, such as Bitter Creek, while still flowing, are reduced in length. Most likely there was suitable habitat available for the Pecos sunflower throughout the length of the streams.

Groundwater pumping in the Roswell Basin increased through the 1950s, when approximately 450,000 ac ft per year were extracted (McCord et al. 2007). Rates remained fairly stable through 1966 (McCord et al. 2007). In 1967, water rights were adjudicated in the Roswell Basin, wells were metered, and pumping rates administered by the Office of the State Engineer. Currently, any proposed change in use of water, either underground or surface depletion, in the Roswell Basin will undergo analysis by the State Engineer to determine if there would be impairment to existing water rights (McCord et al. 2007). The State Engineer would not allow such change, if it impairs the Federal water right in any aspect. Thus, the spring flows on Bitter Lake NWR should be protected from any changes in groundwater pumping near the Refuge in the future. A drought in the 1950s most likely affected the recharge of the groundwater in the Roswell Basin. In spite of controls on pumping initiated in 1968, and increased precipitation near Roswell in

the 1960s and 1970s, artesian groundwater levels continued to decline until 1975 (McCord et al. 2007). Therefore, it appears there was a lag time of many years between the time of the drought and recovery of the artesian groundwater.

Competition from non-native plant species

Exotic plants have potential to seriously impact the native plant community composition and ecological integrity of arid land springs and cienegas. Exotic trees, especially salt cedar and Russian olive can almost completely convert a treeless cienega to a dense woodland with little understory vegetation. Aggressive, rhizomatous non-native grasses and forbs compete with, and replace, native cienega plants, especially in areas of soil disturbance. Herbaceous exotics that are currently degrading some arid land springs and cienegas include Persoon (Johnsongrass) (*Sorghum halepense*), Hudson meadow fescue and perennial pepperweed.

Exotic Russian olive and, to a lesser extent, salt cedar trees are the most negative influence on the Santa Rosa cienegas. Tall, dense forests of Russian olive have invaded large areas of cienega during the past 40 years and would convert most of the Santa Rosa sink to woodland in the absence of costly restoration. For the last 5 years, the State of New Mexico, City of Santa Rosa, and private landowners have been clearing dense stands of Russian olive to restore the cienega to its natural, treeless condition. These exotic trees are very difficult to kill. Follow-up treatments of crown and root sprouts must occur for several years and active elimination of new seedlings must be perpetual. On the Blue Hole Cienega Nature Preserve, restoration costs during the past 4 years have almost equaled the purchase price of the property. Institutional dedication and long-term commitment will be required to ensure this cienega does not revert to a non-native woodland (Sivinski and Tonne 2011).

Water Contamination

Water contamination, particularly from oil and gas operations, could be a potential threat for Pecos sunflower, but the effects on this species have not been studied. In order to assess the potential for contamination, a study was completed in September 1999 to delineate the area that serves as sources of water for the springs on Bitter Lake NWR (Balleau Groundwater, Inc. 1999). This study reported that the sources of water that will reach Bitter Lake NWR's springs include a broad area beginning west of Roswell near Eightmile Draw, extending to the northeast to Salt Creek, and southeast to Bitter Lake NWR. This area represents possible pathways from which contaminants may enter the groundwater that feeds the springs on the Refuge. This broad area is located within a portion of the Roswell Basin and contains a mosaic of Federal, State, City, and private lands with multiple land uses, including expanding urban development. There are 378 natural gas and oil wells in the 12-township area

encompassing the source-water capture zone for the Middle Tract of Bitter Lake NWR that are potential sources of contamination (Go-Tech 2010).

The BLM designated an area for protection of habitat from potential groundwater contamination by oil and gas well-drilling operations (Bureau of Land Management 2002). This area, referred to as the habitat protection zone, includes a portion of the source-water capture area for the springs in the northern part of the Middle Tract of Bitter Lake NWR, where the Pecos sunflower occurs. There are 17 oil and gas leases currently within this habitat protection zone. A lease does not necessarily represent a well; a lease may have approval for drilling, but no wells, or it may have one or more wells. This habitat protection zone encompasses 12,585 ac (5,093 ha) of the Federal mineral estate within the water resource area for the Refuge (U.S. Fish and Wildlife Service 2005b). Twenty natural gas wells currently exist on these leases. The BLM has estimated a maximum potential development of 66 additional wells within the habitat protection zone, according to well spacing requirements established by the New Mexico Oil Conservation Division (New Mexico Statutes Annotated 1978, Chapter 70, Article 2).

The Diamond Y Springs Complex is within an active oil and gas extraction field. At this time, there are still many active wells and pipelines located within approximately 330 ft (100 m) of the surface waters at the springs. In addition, a natural gas refinery is located within 0.5 mi (0.8 km) upstream of Diamond Y Spring. There are also old brine pits associated with previous drilling that can contribute salt and other mineral pollutants to the groundwater and are near surface waters. In addition, oil and gas pipelines cross the spring outflow channels and marshes where the species occurs, creating a constant potential for contamination by pollutants from leaks or spills. These activities pose a potential threat to the habitat of the Pecos sunflower by creating the possibility for pollutants to enter underground aquifers that contribute to spring flow or by point sources from spills and leaks of petroleum products on the surface (U.S. Fish and Wildlife Service 2010).

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

There are no commercial uses for Pecos sunflower at this time. A few scientific collections Pecos sunflower seeds have been conducted under Federal and State permits for genetic experiments and to attempt to establish populations in new locations. Therefore, overutilization for commercial, recreational, scientific, or educational purposes is not considered to be a threat to the Pecos sunflower at this time.

2.3.2.3 Disease or predation:

Several insect herbivores use Pecos sunflower stems, leaves and flowers, but their prevalence and identities have not been studied. Bitter Lake NWR reported a large mortality event caused by grasshoppers before seed dispersal in 2010 (J. Sanchez, Bitter Lake NWR, pers. comm, 2015). No other insects or diseases that cause mortality have been reported in Pecos sunflower populations (U.S. Fish and Wildlife Service 2005; Sivinski 2008).
Well-managed livestock grazing during non-growing months may have a beneficial effect on Pecos sunflower populations by decreasing the density and biomass thatch covering the habitat soils (U.S. Fish and Wildlife Service 2005a). Continuous grazing during growing and flowering seasons greatly diminishes the productivity of Pecos sunflower and may even eliminate it from its habitat (Van Auken and Bush 2004; U.S. Fish and Wildlife Service 2008a). Of the total area considered critical habitat for Pecos sunflower, only about 5 percent is subject to livestock grazing. Therefore, disease and predation is not considered to be a threat to the Pecos sunflower at this time.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

Section 9. Section 9 of the Federal Endangered Species Act (Act) does not protect threatened and endangered plant species from ‘take’ as it does threatened and endangered animal species. Although there are no prohibitions of "take" for plant species under section 9(a)(1) of the Act, pursuant to section 9(a)(2) of the Act, listed plants such as Pecos sunflower do receive protection from removal and malicious damage or destruction on areas under Federal jurisdiction and from removing, cutting, digging up, damaging or destroying plants on any other areas in knowing violation of any State law or regulation or in the course of any violation of a State criminal trespass law. Pecos sunflowers on tribal, State, or private land may be destroyed by their landowners without consulting the Service.

Section 7. Section 7 of the Act prohibits Federal agencies carrying out, funding, or authorizing activities that adversely affect a listed species or destroy critical habitat. This prohibition is not extended to non-Federal landowners of Pecos sunflower habitats if their activities do not use Federal funding or require Federal permits. All of the areas designated as critical habitat are currently occupied by Pecos sunflower. Therefore, Federal actions that may affect groundwater levels or wetland hydrology in occupied habitats would trigger section 7 consultation under the jeopardy standard, because such impacts could adversely affect reproduction, growth, or survival of Pecos sunflower plants. Section 7 has resulted in numerous informal and two formal consultations for Federal activities on Bitter Lake NWR, one consultation with the Army Corps of Engineers for federally permitted and funded activities at Lea Lake on Bottomless Lakes State Park, and a few with the Federal Highway Administration. None of these consultations produced biological opinions that concluded with findings of jeopardy for the Pecos sunflower.

Clean Water Act. The Federal Clean Water Act requires the Army Corps of Engineers to permit filling or draining of wetlands that contribute to the navigable water of the United States. Private and state landowners of wetlands are often unaware of this permitting requirement and may fill or drain their lands without requesting determination of wetland status or a permit.

New Mexico Law(s). New Mexico State Law Section 75-6-1 NMSA 1978 directs the Energy, Minerals and Natural Resources Department (Department) to investigate all plant species in the State for the purpose of establishing a list of endangered plant species. It also authorizes the Department to prohibit the taking of endangered species, with the exception of permitted scientific collections or propagation and transplantation activities that enhance the survival of endangered species. Listed in the State of New Mexico as endangered, the Pecos sunflower is protected from unauthorized collection, transport, or sale by the New Mexico Endangered Plant Species Act, 9-10-10 NMSA, the Federal Lacey Act Amendments of 1981, and National Forest regulations - e.g. 36 CFR 261.9(b). New Mexico State Law prohibits taking of listed plants, which includes Pecos sunflower, without a permit from the State (New Mexico Administrative Code §19.21.2.15), where taking is defined as "removal, with the intent to possess, transport, sell, or offer for sale any ...[listed plant]... from places in the State of New Mexico where they naturally grow" (New Mexico Administrative Code §19.21.2.7.C). The law does not apply to tribal lands in the State or to Federal employees working on lands within their jurisdiction. The State Forester of the Forestry and Resources Conservation Division is the designated representative of the Department Secretary for the purposes of endangered plant investigations and for issuing collection and transplantation permits (10-29-85, 12-23-91, 8-31-95).

Texas Law(s). In 1988, the Texas legislature authorized Texas Parks and Wildlife Department to establish a list of threatened and endangered plant species for the State. The Pecos sunflower is listed as threatened by the State of Texas (31 TAC 2.69(A)). State laws and regulations prohibit commerce in threatened and endangered plants and the collection of listed plant species from public land without a permit issued by Texas Parks and Wildlife Department. Texas State law specifies that no person may "take, possess, transport or sell an endangered, threatened, or protected native plant" from public lands in the State without a valid scientific plant permit that authorizes such activity (Texas Administrative Code §31.2.69.A.1). Removal or destruction of plants on private lands in Texas would not violate State law, and therefore, would not be prohibited by the Act, unless it is associated with violation of State criminal trespass law.

Even with these existing regulatory mechanisms, for some extant populations, the Pecos sunflower requires additional protection of the water sources upon which it depends, and management plans and conservation easements to protect, conserve, and recover this species. Without these, the inadequacy of existing regulatory mechanisms is a significant threat to the Pecos sunflower into the foreseeable future.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Hybridization

Pecos sunflower hybridization with common sunflower and plains sunflower is not a threat to this species. Genetic research has determined these three species to be strongly reproductively isolated with hybridization sterility barriers and obvious hybrids are very rare or not existent in sympatric populations (Lai et al. 2005; Sivinski 2008).

Weed Control

Mowing and highway maintenance of Pecos sunflowers during the growing season in the right-of-way of Highway 91 in Santa Rosa has been reduced by placement of permanent signs that prohibit mowing from April through October (Sivinski 2008; Parametrix 2013). The New Mexico Department of Transportation now cooperates by conducting weed control almost entirely during the non-growing season, and the frequency of adverse impacts has been reduced. Additional coordination to further curtail this threat is ongoing.

Climate Change

The effect climate change will have on springs in New Mexico is unknown. Since 1999, New Mexico has been in a drought (Piechota et al. 2004). The current drought may also affect groundwater recharge, but there may be a lag before the effect of the current drought is seen. However, through the drought of the 1950s, when pumping was at a maximum, several of the springs on Bitter Lake NWR continued to flow (McCord et al. 2005). Groundwater pumping is currently about 100,000 ac ft/yr less than it was during the drought of the 1950s, and artesian groundwater levels have recovered to the levels of the 1950s (McCord et al. 2005). Consequently, we expect that there is some added margin of protection for the springs through this current drought with pumping at reduced volume. However, the length or severity of the current drought cycle is not known, and the Southwest may be entering a period of prolonged drought (MaCabe et al. 2004). Droughts of the twentieth century were eclipsed in severity by droughts in the last 2,000 years, with some characterized by longer duration and greater spatial extent (Woodhouse and Overpeck 1998; Piechota et al. 2004). The evidence suggests that the springs at Bitter Lake NWR will flow in spite of relatively intense drought comparable to the drought of the 1950s (McCord et al. 2005).

It is unknown how the springs in Texas would respond to extended drought and the current level of groundwater pumping. Drought could affect the springs through decreased flow. The springs do not have to dry out completely to have an adverse effect on Pecos sunflower populations. The impact of drought on both surface and groundwater resources can lead to diminished water quantity, quality, and disturbed riparian habitats (Woodhouse and Overpeck 1998; MacRae et al.

2001). Decreased flow could lead to a reduction in habitat availability and an increase in salinity (MacRae et al. 2001). Any of these factors, alone or in combination, could lead either to the reduction or extirpation of a Pecos sunflower population.

The seeps and springs currently occupied by Pecos sunflower have been perennial even through times of drought and increased groundwater pumping, such as in the 1970s, suggesting that these springs are relatively resilient to drought. However, climate change may test that resiliency. Seager et al. (2007) show that there is a broad consensus among climate models that the Southwest will get drier in the twenty-first century and that the transition to a more arid climate is already under way. Only 1 of 19 models examined showed a trend toward a wetter climate in the Southwest (Seager et al. 2007). An increase in average mean air temperature of just under 1˚C (1.8 ˚F) has already been documented in New Mexico since 1976 (Lenart et al. 2007). Udall and Bates (2007) found that multiple independent data sets confirm widespread warming in the West. In consultation with leading scientists from the Southwest, the New Mexico Office of the State Engineer prepared a report for the Governor (New Mexico Office of the State Engineer 2006) which made the following observations about the impact of climate change in New Mexico:

1. Warming trends in the American Southwest exceed global averages by about 50 percent;
2. Models suggest that even moderate increases in precipitation would not offset the negative impacts to the water supply caused by increased temperature;
3. Temperature increases in the Southwest are predicted to continue to be greater than the global average; and
4. The intensity, frequency, and duration of drought may increase.

Increased air temperatures lead to higher evaporation rates, which may reduce the amount of runoff, groundwater recharge, and consequently spring discharge. Increased temperatures across the Southwest may also increase the extent of area influenced by drought (Lenart 2003), decreasing groundwater recharge regionally, and thereby reducing spring discharge. Prolonged drought leading to diminishment or drying of springs would have a negative impact on Pecos sunflower. Springs would not have to dry out completely to have an adverse effect. In addition, as water becomes increasingly scarce, conflict over its use becomes more intense. The proportion of human and livestock consumption of water would be expected to increase during drought. Any of these factors, alone or in combination, could lead to either the reduction or extirpation of Pecos sunflower populations. Therefore, climate change is a significant threat to the Pecos sunflower into the foreseeable future.

2.4 Synthesis

Several biological traits of a population have been identified as putting a species at risk of extinction. Some of these characteristics include having a localized range, limited mobility, and fragmented habitat (McKinney 1997; O'Grady et al. 2004). The Pecos sunflower has a small, localized range, such that either a natural (e.g., drought) or anthropogenic (e.g., water withdrawal) perturbation can eliminate many or all of the existing populations. Even having a large number of individuals at a site provides little protection against these threats. Limited seed mobility restricts the ability of the Pecos sunflower to disperse to other suitable habitats or away from habitat that becomes unsuitable. Consequently, the range of the Pecos sunflower remains restricted, and it is unable to avoid dewatering or other unfavorable changes to its habitat. Fragmented, or unconnected, habitat restricts gene flow among populations and limits the ability of the species to recolonize habitats that have been disturbed, but then recover. In the currently fragmented habitats, adequate seed dispersal is unlikely, and if a population is extirpated, the habitat probably will not be recolonized, further restricting the range. In addition to the characteristics listed above that may put Pecos sunflower at greater risk of endangerment, habitat loss, introduced non-native species, and habitat degradation can also lead to endangerment (Meffe et al. 1994; Frankham et al. 2002).

Pecos sunflower was described as *Helianthus paradoxus* in 1958 from two collections: one from near Fort Stockton, Texas and another from Grants, New Mexico. It is an ancient hybrid species that evolved from a cross between the common sunflower (*Helianthus annuus*) and plains sunflower (*Helianthus petiolaris*). Pecos sunflower differs most notably from its progenitors by its more succulent leaves and salt marsh habitats. It is annual plant that germinates in the spring, and flowers and makes seed from late August through October.

Pecos sunflower habitats are saline-alkaline soils that are irrigated in the lower root-zone by ground water in desert wetlands at elevations between 3,300 and 6,600 feet. These wetlands are always associated with springs and seeps that often produce cienegas of inland saltgrass (*Distichlis spicata*), Baltic rush (*Juncus balticus*), alkali sacaton (*Sporobolus airoides*), chairmaker's bulrush (*Schoenoplectus americanus*) and other salt-tolerant wetland plants. Pecos sunflowers often occur in the saltgrass zone between the water saturated soils occupied by bulrush and the relatively drier soils occupied by alkali sacaton. Periods of drought may temporarily render some habitats unsuitable as soils become drier and soil surface alkalinity increases. Periodic fire in these habitats removes vegetation thatch, which may constrict the number and size of Pecos sunflowers.

Most Pecos sunflower habitats are limited to less than 5 ac (2 ha) of wetland. Some are only a small fraction of a hectare. However, populations near Fort Stockton, Texas, and Bitter Lake NWR and La Joya WMA in New Mexico, are considerably larger. The number of sunflowers per site varies from less than 100 to several hundred thousand. Because Pecos sunflower is an annual, the number of plants per site can fluctuate greatly from year to year with changes in precipitation and depth to ground water. This sunflower is completely dependent on soils that are water saturated in the lower root zone. If a wetland habitat dries out permanently, even a large population of Pecos sunflower would disappear. The most significant threats to Pecos

sunflower are the filling or drying of its wetland habitats and adverse modification of habitats by infestations of non-native plants, especially salt cedar and Russian olive trees.

Pecos sunflower populations occur at alkaline wetlands in the arid regions of west Texas, lower Pecos River of eastern New Mexico, and the Rio Grande and Rio San Jose of west-central New Mexico. There is a large west Texas population at Diamond Y Spring in Pecos County and a small population at Sandia Spring near Balmorhea in Reeves County. Both of these habitats are owned by TNC. The Roswell/Dexter area of Chaves County, New Mexico has eleven Pecos sunflower locations on private lands, City of Roswell land, Bottomless Lakes State Park, State Trust land, Bitter Lake NWR, and BLM land. Three of these, Bitter Lake NWR, Oasis Dairy, and Dexter Cienega, currently have, or had in the past, very large populations. However, the other eight locations contain smaller populations. Springs and cienegas within the Guadalupe County City of Santa Rosa have eight wetland locations with Pecos sunflower. These are mostly small stands of sunflowers on private lands and in Santa Rosa municipal parks. A single large population at Blue Hole Cienega is owned by the New Mexico Forestry Division and managed as a nature preserve. Two widely separated areas of spring seeps and cienegas in the Rio San Jose valley of western New Mexico each support a population of Pecos sunflower. One occurs on the Pueblo of Laguna in the lower Rio San Jose in Valencia County and the other is in Cibola County on private land and Acoma Pueblo land near Grants. Another larger population on the Rio Grande at state-owned La Joya WMA in Socorro County occurs near confluence of the Rio Puerco, which has the Rio San Jose as a tributary stream.

The Service designated approximately 1,305 ac (528.12 ha) of critical habitat for Pecos sunflower in April 2008. Areas of critical habitat include the Diamond Y Spring in Pecos County, Texas; Dexter Cienega, Lea Lake, Oasis Dairy, and Bitter Lake NWR with adjacent City of Roswell land in Chaves County, New Mexico; Blue Hole Cienega and fishing ponds, and West Side Spring in Guadalupe County, New Mexico; and the Grants salt flat and Rancho del Padre Spring in Cibola County, New Mexico. The west-central New Mexico Pecos sunflower populations at Laguna Pueblo and La Joya were determined to be adequately protected by management plans and excluded from critical habitat designation.

The recovery criteria from the Pecos Sunflower Recovery Plan have been partially attained. At least one core Pecos sunflower population is protected within all four of the designated recovery regions. The Diamond Y Preserve in the West Texas Recovery Region is owned and managed by TNC. Bitter Lake NWR manages habitat for a large population of Pecos sunflower in the New Mexico-Roswell/Dexter Recovery Region. Blue Hole Cienega Nature Preserve was purchased by the New Mexico Forestry Division, specifically for the protection and management of a large Pecos sunflower population in the New Mexico-Santa Rosa Recovery Region. Finally, the West-Central New Mexico Recovery Region has a large core population protected at the La Joya WMA and an isolated population protected on the Pueblo of Laguna. All of these core populations are at least 50 to 100 times, or even higher multiples in some years of, the minimum size recommended in the recovery plan. The first three recovery regions presently lack additional protected populations that fit the definition of ‘isolated stand’ in the Pecos Sunflower Recovery Plan.

Management plans and actions to control non-native plants in Pecos sunflower habitats have been adopted and implemented at Bitter Lake NWR, Blue Hole Cienega Nature Preserve, La Joya WMA, and Laguna Pueblo. The aquifers supporting Pecos sunflower habitat springs at these locations have also been determined to be relatively safe from depletion by ground water pumping, although part of the water source for the population at La Joya WMA is contingent on water availability. The water source for the Diamond Y Preserve Pecos sunflower core population is subject to possible aquifer depletion.

The Pecos sunflower is susceptible to extirpation because it depends on isolated desert springs for its survival (U.S. Fish and Wildlife Service 2005). For some extant populations, the species currently requires additional protection for the water sources upon which it depends and additional management plans and conservation easements for recovery. Because the recovery criteria are not fully met and the threat of water reduction or elimination may be exacerbated by climate change, the status of the Pecos sunflower remains threatened and in danger of becoming an endangered species under the Act.

3.0 RESULTS

3.1 Recommended Classification

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
  ____ *Extinction*
  ____ *Recovery*
  ____ *Original data for classification in error*
_X_ **No change is needed in classification.**

3.2 Recovery Priority Number: No change, remains at 8

Brief Rationale: The Pecos sunflower was listed as threatened on October 20, 1999, with a recovery priority of 8, indicating it is a full species, with a moderate degree of threat, and a high potential for recovery. At this time, the recovery priority conditions remain the same. As a wetland obligate species, the Pecos sunflower still faces threats of development of wetlands and reduction or elimination of water sources, which may be exacerbated by climate change. When the threat of diminished water availability is not present, Pecos sunflowers can be re-seeded and thrive in densely occupied areas of suitable habitat if invasion of non-native tree species can be controlled. We have learned a great deal about restoring suitable habitat for this species.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Protect Habitat. Habitat protection through land acquisition or conservation agreements with landowners is the most important remaining recovery task. The development of management plans for the different agencies, as outlined in the recovery plan, should continue to be pursued. Government programs that acquire cienegas or assist landowners with their management are greatly needed.

Restore and Re-seed Habitat; Consider Opportunities for Public Education. Non-native tree species and thatch should continue to be removed in occupied and potential Pecos sunflower habitats. Pecos sunflowers should be re-seeded in suitable areas with willing land owners or managers within the range of the species to expand occupied habitats. The Pecos sunflower would also make an excellent focal species for public education and awareness of the importance of wetlands and the recovery of listed species. These opportunities should be explored and implemented where appropriate.

Re-evaluate Recovery Criteria. The recovery criteria in the Pecos Sunflower Recovery Plan (U.S. Fish and Wildlife Service 2005) should be collectively re-evaluated to determine if they constitute the most effective strategy for conservation and recovery of the species. Of most significance, the actual size of existing core populations is between 50 and 100 times, or even higher multiples in some years of, the minimum number required in the recovery plan. The current recovery criteria may not have considered this much higher number of plants extant throughout the range of the species.

Standardize and Conduct Surveys. Survey efforts in occupied and potential habitats should be increased and improved, and surveys should employ an agreed-upon standardized protocol. Surveys should cover the entire range of the species and be repeated at least every 3 years. Existing populations should be monitored to document population trends in response to habitat restoration and maintenance.

5.0 REFERENCES

Ashworth, J.B., D.B. Coker, and W. Tschirhart. 1997. Evaluation of diminished spring flows in the Toyah Creek Valley, Texas. Open File Report 97-03. Texas Water Development Board, Austin, Texas. 12 pp.

Baack, E.J., K.D. Whitney and L.H. Rieseberg. 2005. Hybridization and genome size evolution: Timing and magnitude of nuclear DNA content increases in *Helianthus* homoploid hybrid species. New Phytologist 167:623-630.

Balleau Groundwater, Inc. 1999. Source-water protection zones for Bitter Lake National Wildlife Refuge. Prepared for U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Boghici, R. 1997. Hydrogeological investigations at Diamond Y Springs and surrounding area, Pecos County, Texas. Unpublished Master's Thesis, University of Texas at Austin. 120 pp.

Brune, G. 1981. Springs of Texas (Vol. 1). Branch-Smith, Inc., Fort Worth, Texas. 566 pp.

Bureau of Land Management. 1997. Roswell approved resource management plan and record of decision, Roswell, New Mexico. 71 pp. plus appendices.

Bureau of Land Management. 2002. Habitat protection zone environmental assessment, EA-NM-060-00- 030. Bureau of Land Management, Roswell Field Office, Roswell, New Mexico.

Bureau of Reclamation. 2015. Joint biological assessment – draft: Bureau of Reclamation, Bureau of Indian Affairs, and non-Federal water management and maintenance activities on the Middle Rio Grande, New Mexico. Albuquerque, New Mexico. 476 pp.

Bush, J.K. 2006. Abiotic edaphic factors affecting the growth of a threatened North American sunflower, *Helianthus paradoxus* (Asteraceae). Plant Ecology 183:215-225.

Fiedler, A.G. and S.S. Nye. 1933. Geology and Ground-Water Resources of the Roswell Artesian Basin, New Mexico, Water Supply Paper 639. U.S. Geological Survey, prepared in cooperation with the New Mexico State Engineer and Chaves and Eddy Counties. 436 pp.

Frankham, R., D. A. Briscoe, and J. D. Ballou. 2002. Introduction to conservation genetics. Cambridge University Press, New York, New York.

Go-Tech. 2010. Active oil and gas wells in the 12-township area encompassing the Bitter Lake National Wildlife Refuge source-water capture zone. *http://mapserve.nmt.edu/Website/NMOG/viewer.htm* Accessed 4/29/2010.

Grunstra, M. and O.W. Van Auken. 2007. Factors that influence the distribution and cover of *Helianthus paradoxus* in a west Texas salt marsh. Phytologia 89(1):24-42.

Hendrickson, D.A., and W.L. Minckley. 1984. Cienegas – vanishing climax communities of the American Southwest. Desert Plants 6:131-175.

Hirsch, J. 2012. Email to Patricia Zenone, New Mexico Ecological Services Field Office. La Joya Pecos sunflower, New Mexico Department of Game and Fish, Conservation Services Division. Santa Fe, New Mexico. 1p. w attachment.

Jones, M. A. and W. P. Balleau. 1996. Interrelation of groundwater and surface water at Bitter Lake National Wildlife Refuge. Balleau Groundwater, Inc. Report to U. S. Department of Justice. 16 pp.

Karges, J. 2003. Aquatic conservation and The Nature Conservancy in West Texas. Pages 151–150, in G.P. Garrett and N.L. Allan, eds. Aquatic Fauna of the Northern Chihuahuan Desert. Museum of Texas Tech University, Special Publications 46.

Karrenberg, S., C. Edelist, C. Lexer and L. Rieseberg. 2006. Response to salinity in the homoploid hybrid species *Helianthus paradoxus* and its progenitors *H. annuus* and *H. petiolaris*. New Phytologist 170:615-629.

Kodric-Brown, A. and J.H. Brown. 2007. Native fishes, exotic mammals, and the conservation of desert springs. Frontiers in Ecology and the Environment 5(10): 549-553. http://www.frontiersinecology.org

Lai, Z., T. Nakazato, M. Salmaso, J.M. Burke, S. Tang, S.J. Knapp, and L.H. Rieseberg. 2005. Extensive chromosomal re-patterning and the evolution of sterility barriers in hybrid sunflower species. Genetics 171:291-303.

Land, L. and G.F. Huff. 2010. Multi-tracer investigation of groundwater residence time in a karstic aquifer: Bitter Lakes National Wildlife Refuge, New Mexico. New Mexico Bureau of Geology and Mineral Resources, New Mexico Tech, Socorro. Open-file Report 521.

Lenart, M. 2003. Southwestern drought regimes might worsen with climate change. CLIMAS, Southwest Climate Outlook. December 2003.

Lenart, M., G. Garfin, B. Colby, T. Swetnam, B. J. Morehouse, S. Doster, and H. Hartmann. 2007. Global warming in the Southwest: Projections, observations, and impacts. Climate Assessment for the Southwest, University of Arizona. 88 pp.

Lexer, C., M.E. Welch, O. Raymond, and L.H. Rieseberg. 2003. The origin of ecological divergence in *Helianthus paradoxus* (Asteraceae): Selection on transgressive characters in a novel hybrid habitat. Evolution 57(9):1989-2000.

Marek, L.F. 2011. Plant exploration in the southwestern United States to collect sunflower germplasm for crop improvement. Project summary, Iowa State University, Ames, Iowa. 12pp.

Marek, L.F. 2012a. Plant exploration in the southwestern United States to collect sunflower germplasm for crop improvement. Iowa State University, Ames, Iowa. 18 pp.

Marek, L.F. 2012b. USFWS permit data template for Pecos sunflower locations. Iowa State University, Ames, Iowa. 1p.

MacRae, R.K., J.D. Lusk, and W.R. Radke. 2001. Investigation of the role of environmental contaminants upon ecological sentinel species and their habitats at Bitter Lake National Wildlife Refuge, New Mexico. Report prepared by the New Mexico Ecological Services Field Office, Environmental Contaminants Program, Project Identification 2N27 9620001A.

McCord, J.T., J.A. Clark, and J.L. Smith. 2007. Review of groundwater hydrology associated with spring flows at Bitter Lake National Wildlife Refuge, New Mexico. Report to the New Mexico Interstate Stream Commission. 27 pp.

McKinney, M.L. 1997. Extinction vulnerability and selectivity: Combining ecological and paleontological views. Annual Review of Ecology and Systematics 28:495-516.

Meffe, G.K., C.R. Carroll, and S.L. Pimm. 1994. Community-level conservation: Species interactions, disturbance regimes, and invading species. Pp. 209-236 *in* Principles of Conservation Biology (G. Meffe and C.R. Carroll, eds). Sinauer Associates, Inc. Sunderland, Massachusetts.

Minckley, T.A. and A. Brunelle. 2007. Paleohydrology and growth of a desert cienega. Journal of Arid Environments 69: 420-431.

Myers, M.J. and V.H. Resh. 1999. Spring-formed wetlands of the arid west. In: Invertebrates in Freshwater Wetlands of North America: Ecology and Management (D.P. Batzer, R.B. Rader, and S.A. Wissinger, eds.). John Wiley and Sons, New York. Pp. 811-828.

New Mexico Department of Game and Fish. 2007. Pecos sunflower (*Helianthus paradoxus*) habitat management plan for the La Joya Waterfowl Management Area. Conservation Services Division, Santa Fe. 15 pp. plus appendix.

New Mexico Forestry Division. 2008. Blue Hole Cienéga. Energy, Minerals and Natural Resources Department, Santa Fe.

New Mexico Office of the State Engineer. 2006. The impact of climate change on New Mexico's water supply and ability to manage water resources. 69 pp.

New Mexico Office of the State Engineer. 2007. iWaters, the Internet Waters Database System. http://iwaters.ose.state.nm.us:7001/ iWATERS/

New Mexico State Land Office. 2001. Agreement signed to grow sunflowers. Agricultural Issues Brief 2(1):3.

O'Grady, J.J., D.H. Reed, B.W. Brook, and R. Frankham. 2004. What are the best correlates of predicted extinction risk? Biological Conservation 118:513-520.

Parametrix. 2013. Blue Hole Cienega Pecos Sunflower Monitoring Project. Prepared by Parametrix, Albuquerque, New Mexico, for the New Mexico Ecological Services Field Office, Albuquerque. December 2013. 23 pp.

Piechota, Y.T., J. Timilsena, G. Tootle, and H. Hidalgo. 2004. The Western U.S. Drought: How Bad Is It? Eos, Transactions, American Geophysical Union, Vol. 85(32):301–308.

Poole, J.M. 1992. Puzzle sunflower (*Helianthus paradoxus*), a status report update. Performance Report for Section 6 Grant No. E-1-3, Job No. 2.3, Texas Parks and Wildlife Department, Austin, 48 pp.

Roth, D. 2014. Pecos sunflower restoration and protection project, Santa Rosa, New Mexico. Energy, Minerals, and Natural Resources Department, Forestry Division, Santa Fe, New Mexico. 17 pp.

Sanchez, J. 2015. Email to Patricia Zenone, New Mexico Ecological Services Field Office, August 13, 2015. Restoration presentation-wetland roundtable.pptx, Bitter Lake National Wildlife Refuge, New Mexico. 1p. with attachment.

Save our Bosque Task Force. 2010. Rhodes Ranch Habitat Restoration Project, Socorro, New Mexico. 15 pp.

Schuster, S.K. 1997. Hydrogeology and local recharge analysis in the Toyah Basin Aquifer. M.S. Thesis, University of Texas at Austin. 130 pp.

Scudday, J.F. 1977. Some recent changes in the herpetofauna of the northern Chihuahuan Desert. In: Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region (R.H. Wauer and D.H. Riskin, eds.). U.S. National Park Service, Transactions and Procedures Series, No. 3. Pp. 513-522.

Seager, R., M.F. Ting, I.M. Held, Y. Kushnir, J. Lu, G. Vecchi, H.-P. Huang, N. Harnik, A. Leetmaa, N.-C. Lau, C. Li, J. Velez, and N. Naik. 2007. Model projections of an imminent transition to a more arid climate in southwestern North America. Science, Vol. 316(5828):1181–1184. DOI: 10.1126/science.1139601.

Sharp, J.M., Jr., M.M. Uliana, and R. Boghici. 1999. Fracture controls on regional groundwater flow in a semiarid environment and implications for long-term maintenance of spring flows. Water 99 Joint Congress, Institute of Engineers, Brisbane, Australia. 2:1212–1217.

Sharp, J.M., Jr., R. Boghici, and M.M. Uliana. 2003. Groundwater systems feeding the springs of West Texas. Pages 1–12, in G.P. Garrett and N.L. Allan, eds. Aquatic fauna of the northern Chihuahuan Desert. Museum of Texas Tech University, Special Publications 46.

Sivinski, R.C. 1995. Section 6, segment 10, progress report on the status of *Helianthus paradoxus* for the New Mexico Ecological Services Field Office, Albuquerque, New Mexico. New Mexico Forestry Division, Santa Fe, New Mexico.

Sivinski, R. 2003. On the trail of John Bigelow: A clarification of some New Mexico type localities. The New Mexico Botanist 26:6-7.

Sivinski, R.C. 2007. Monitoring report for Pecos sunflower for the New Mexico Environment Department, Santa Fe, New Mexico, 3 pp.

Sivinski, R.C. 2008. Section 6 draft of Pecos sunflower 5-year review for the New Mexico Ecological Services Field Office, New Mexico Forestry Division, Santa Fe, New Mexico. 17 pp.

Sivinski, R. and P. Tonne. 2011. Survey and assessment of aridland spring cienegas in the Southwest Region. Section 6 report submitted to the U.S. Fish and Wildlife Service, Region 2, Albuquerque, New Mexico. New Mexico Energy, Minerals and Natural Resources Department, Santa Fe. 139 pp.

Small, T.A. and G.B. Ozuna. 1993. Ground-water conditions in Pecos County, Texas, 1987. U.S. Geological Survey Water-Resources Investigations Report 92-4190. Austin, Texas.

Texas Natural Diversity Database. 2015. Element occurrence record for Pecos sunflower in Texas, Texas Parks and Wildlife Department, Austin, Texas. 9 pp.

Texas Water Development Board. 2005. Diminished spring flows in the San Solomon Springs System, Trans-Pecos, Texas. Unpublished report, May 2005. Texas Water Development Board, Austin, Texas. 131 pp.

The Nature Conservancy. 2008. Diamond Y Preserve. http://www.nature.org/wherewework/northamerica/states/texas/preserves/art13316.html

Turner, D. and J. Fonseca. 2008. What is a cienega? (and why do we care?). Restoring Connections, Newsletter of the Sky Island Alliance 11(2): 1-4. http://www.skyislandalliance.org/newsletter/08_Summer-Water.pdf.

Udall, B. and G. Bates. 2007. Climatic and hydrologic trends in the Western U.S.: A review of recent peer reviewed research. The Intermountain West Climate Summary. January 2007. Pp. 1-8.

Unmack, P.J. and W.L. Minckley. 2008. The demise of desert springs. In: L.E. Stevens and V.J. Meretsky (eds.), Aridland Springs in North America: Ecology and Conservation. The University of Arizona Press and the Arizona-Sonora Desert Museum, Tucson. Pp. 11-34.

U.S. Fish and Wildlife Service. 1999. Threatened status for the plant "*Helianthus paradoxus*" (Pecos sunflower). Federal Register Vol. 63, No. 62:15808-15813.

U.S. Fish and Wildlife Service. 2005a. Pecos sunflower (*Helianthus paradoxus*) recovery plan. Albuquerque, New Mexico.

U.S. Fish and Wildlife Service. 2005b. Endangered and Threatened Wildlife and Plants; Listing Roswell springsnail, Koster's springsnail, Noel's amphipod, and Pecos assiminea as Endangered with Critical Habitat. Federal Register, Vol. 70(152): 46304- 46333.

U.S. Fish and Wildlife Service. 2007. Endangered and threatened wildlife and plants; proposed designation of critical habitat for the Pecos sunflower (*Helianthus paradoxus*). 72 Federal Register 14328-14366.

U.S. Fish and Wildlife Service. 2008a. Environmental assessment for designation of critical habitat for Pecos sunflower. Region 2, Albuquerque, New Mexico. 69 pp.

U.S. Fish and Wildlife Service. 2008b. Designation of Critical Habitat for *Helianthus paradoxus* (Pecos sunflower). Federal Register 73(63):17762-17807.

U.S. Fish and Wildlife Service. 2010. Roswell springsnail (*Pyrgulopsis roswellensis*), Koster's springsnail (*Juturnia kosteri*), Noel's amphipod (*Gammarus desperatus*), Pecos assiminea (*Assiminea pecos*) 5-year review, New Mexico Ecological Services Field Office, Albuquerque, New Mexico. 25 pp.

U.S. Fish and Wildlife Service. 2012. Report to Congress on the Recovery of Threatened and Endangered Species Fiscal Years 2009-2010. U.S. Fish & Wildlife Service Endangered Species Program, www. fws.gov/endangered, Arlington, Va. 47 pp.

Van Auken, O.W. 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. 2004. Growth of *Helianthus paradoxus*, the puzzle or Pecos sunflower (Asteraceae), in response to disturbances. In: Delmatier, C., F. Oxley, K. Clary, and J. Poole (eds.), Texas Plant Conference – 2002 Proceedings, Austin, Texas: Lady Bird Johnson Wildflower Center Texas and U.S Fish and Wildlife Service. Pp. 1-21.

Van Auken, O.W. and J.K. Bush. 2006. Competition between *Helianthus paradoxus* (Asteraceae) and *Distichlis spicata* (Poaceae). Phytologia 88(1):17-37.

Van Auken, O.W. and J.K. Bush. 2007. The importance of competition in the isolation and establishment of *Helianthus paradoxus* (Asteraceae). In: P. Barlow-Irick, J. Anderson and C. McDonald, tech. eds., Southwestern Rare and Endangered Plants: Proceedings of the Fourth Conference, March 22-26, 2004, Las Cruces, New Mexico. RMRS-P-48CD. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado. Pp. 122-135.

Veni, G. 1991. Delineation and preliminary hydrogeologic investigations of the Diamond Y Spring, Pecos County, Texas. Report to the Nature Conservancy of Texas. 110 pp.

Welch, M.E. and L.H. Rieseberg. 2002. Habitat divergence between a homoploid hybrid sunflower species, *Helianthus paradoxus* (Asteraceae), and its progenitors. American Journal of Botany 89(3):472-478.

Woodhouse, C.A. and J.T. Overpeck. 1998. 2000 years of drought variability in the central United States. Bulletin of the American Meteorological Society, Vol. 79(12): 2693- 2714.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
Pecos Sunflower / *Helianthus paradoxus*

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: 8

Review Conducted By: Patricia G. Zenone, Senior Fish and Wildlife Biologist
New Mexico Ecological Services Field Office, Albuquerque

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service
New Mexico Ecological Services Field Office, Albuquerque

Approve WALLY MURPHY Digitally signed by WALLY MURPHY DN: c=US, o=U.S. Government, ou=Department of the Interior, ou=U.S. Fish and Wildlife Service, cn=WALLY MURPHY, 0.9.2342.19200300.100.1.1=1400100258970 Date: 2015.08.28 14:49:34 -06'00' Date _____
Wally J. Murphy, Field Office Supervisor

REGIONAL OFFICE APPROVAL:

Assistant Regional Director, Ecological Services, Fish and Wildlife Service, Region 2

Approve Michelle Shaughnessy Date 8/25/15
Michelle Shaughnessy, Assistant Regional Director