U.S. Fish & Wildlife Service

Arizona Eryngo (*Eryngium sparganophyllum*) Draft Recovery Plan

Eryngium sparganophyllum in flower. United States Fish and Wildlife Service photo.

Arizona Eryngo (*Eryngium sparganophyllum*)
Draft Recovery Plan

Southwest Region
U.S. Fish and Wildlife Service
Tucson, Arizona

Approved: _____

Regional Director, Southwest Region
U.S. Fish and Wildlife Service

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Lead Authors:
Erin Fernandez, Fish and Wildlife Biologist, and Julie Crawford, Plant Ecologist, Arizona Ecological Services, Fish and Wildlife Service

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https://ecos.fws.gov/ecp/species/10705

ARIZONA ERYNGO (*ERYNGIUM SPARGANOPHYLLUM*) DRAFT RECOVERY PLAN

BACKGROUND

Recovery Plan Overview

This document presents the U.S. Fish and Wildlife Service (USFWS) plan for the conservation and recovery of the Arizona eryngo (*Eryngium sparganophyllum*). Arizona eryngo is a member of the Apiaceae, or carrot family, and was listed as endangered with designated critical habitat under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.; ESA), on June 10, 2022 (U.S. Fish and Wildlife Service 2022a). The recovery priority number for Arizona eryngo is 5c, indicating that this species faces a high degree of threat and has a low recovery potential; there is a potential conflict with groundwater withdrawal at all population locations (U.S. Fish and Wildlife Service 1983). Recovery priorities for listed species range from 1 to 18, with species ranking 1 having the highest recovery priority (U.S. Fish and Wildlife Service 1983). Pursuant to section 4(f) of the ESA, a recovery plan must, to the maximum extent practicable, include (1) a description of site-specific management actions as may be necessary to achieve the plan's goals for the conservation and survival of the species; (2) objective, measurable criteria which, when met, would support a determination under section 4(a)(1) that the species be removed from the List of Endangered and Threatened Species; and (3) estimates of the time and costs required to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

In 2016, the USFWS adopted a new recovery planning process called "Recovery Planning and Implementation" (RPI). This is a streamlined approach to recovery planning and is intended to reduce the time needed to develop recovery plans, increase the relevancy of recovery plans over a longer timeframe, and add flexibility to recovery plans so they can be adjusted to new information or circumstances. Under the RPI framework, a recovery plan includes the statutorily required elements pursuant to section 4(f) of the ESA, along with a concise introduction and explanation of our strategy to achieve species recovery. This recovery plan is based on a separate Species Status Assessment (SSA) report for the Arizona eryngo (U.S. Fish and Wildlife Service 2022b), which describes the life history and biology of the species, the current and plausible future status of the species, and the threats that impact the species. The SSA report is briefly summarized below. Additionally, under the RPI process, a separate working document called the Recovery Implementation Strategy (RIS) is developed, providing a stepped-down schedule of activities from the more general description of the recovery actions described in the recovery plan. The RIS describes in detail specific activities necessary for implementing this plan's recovery actions. The RIS will be adaptable by incorporating new information as needed without revising the recovery plan, unless there is a need to also change statutory elements. Both the Species Status Assessment report and the Recovery Implementation Strategy will be updated as necessary and are available at: https://ecos.fws.gov/ecp/species/10705.

Species Status Assessment Report Overview and Updated Information

The following overview summarizes life history information, habitat needs, distribution and abundance, and threats to Arizona eryngo. For a more thorough review of these topics, see the SSA report (U.S. Fish and Wildlife Service 2022b). Arizona eryngo is an herbaceous perennial flowering plant in the Apiaceae, or carrot family. Plants flower from June to September (Stromberg et al. 2020, p. 179; New Mexico Rare Plants 2013, p 1), and dry fruits ripen in September and October (Li 2020, p. 2; AGFD 2019, p. 2; Stromberg et al. 2020, p. 179). Aboveground, plants die back partially or completely in the winter months, such that almost no green or very little green aboveground structure can be seen (Li 2020, p. 9). The lifespan of Arizona eryngo is unknown (AGFD 2019, p. 1; Stromberg et al. 2020, p. 179); however, the species is hypothesized to be a long-lived perennial that can live well over 10 years (S. Blackwell, Desert Botanical Garden, personal communication December 10, 2019). While little is known about the reproductive strategy of Arizona eryngo, it is likely that pollinators are required for cross-pollination in this species. The species also reproduces vegetatively via rhizomes (underground stems), thus producing ramets (clones) (Stromberg et al. 2020, p. 179). Each clone has a unique basal stem, and multiple clones can form a clustered aggregate that resembles an individual plant (Li 2020, p. 2).

The species is a habitat specialist and occurs in open, sunny, spring-fed cienega wetlands where soils are organic, alkali, and perennially moist. Plants grow best in full sun in areas with few nonnative plant species, limited woody vegetation, and other vegetation that may shade or otherwise outcompete them.

Arizona eryngo is known historically from six sites in Arizona, New Mexico (now extirpated), Sonora, and Chihuahua at elevations ranging from 825 to 1,492 m (Table 1, Figure 1). Four of six of the spring-fed cienegas were/are thermal springs (Agua Caliente, Arizona; Las Playas, New Mexico; Rancho Agua Caliente, Sonora; and Ojo Vareleño, Chihuahua). The species was extirpated from two known sites (one site in Arizona [Agua Caliente] and one site in New Mexico [Las Playas]) but remains extant at the other four sites (two in Arizona [Lewis Springs and La Cebadilla], one in Sonora [Rancho Agua Caliente], and one in Chihuahua [Ojo Vareleño]). The remaining populations are isolated from one another, and as of 2018 to 2020, estimates indicate there is a range of 56 to 31,467 individuals per population (Table 1). In the SSA, we consider a population to have high resiliency if it has more than 1,840 plants, moderate resiliency if it has between 800 and 1,840 plants, and low resiliency if it has between 50 and 799 plants. A population with fewer than 50 plants is considered functionally extirpated.

We have defined four representation areas based on river basin boundaries and geographic separation of known historical populations (Figure 1). The four populations and river basins of representation are: 1) the La Cebadilla population in the Santa Cruz River Basin, 2) the Lewis Springs population in the San Pedro River Basin, 3) the Rancho Agua Caliente population in the Rio Bavispe River Basin, and 4) the Ojo Vareleño population in the Rio Casas Grandes (Mimbres) Basin. Recovery criteria are based on populations within these four representation areas.

Reintroduction efforts of Arizona eryngo began in 2017 at Agua Caliente using plants grown in a nursery with seeds collected from La Cebadilla (Fonseca 2018, entire; Stromberg et al. 2020, p. 182). Furthermore, introduction efforts have been made at five sites in Arizona: Canoa Ranch,

Las Cienegas National Conservation Area (LCNCA, within various wetlands), Saint David Cienega (within the San Pedro Riparian National Conservation Area; SPRNCA), Bar V Ranch (at Mescal Spring), and Sweetwater Wetlands (Table 2, Figure 1). Because these populations are still in the establishment phase, estimates at these sites are variable, ranging from tens to over two hundred individuals, and are expected to fluctuate or may even become extirpated. As we increase our understanding of Arizona eryngo microhabitat needs, and our methodology for introduction improves, establishment success will increase (Table 2). The species has been successfully grown from seed at the Desert Botanical Garden, Pima County Native Plant Nursery, and the Arizona-Sonora Desert Museum where plants continue to be in cultivation and/or at display at these facilities. Seeds are banked at the Desert Botanical Garden.

Table 1. Historical and current Arizona eryngo populations in the United States and Mexico (created with data from Condo 2023, p. 2; Li et al. 2023, p. 6, Li 2020, p. 1; Stromberg et al. 2020, pp. 175-179, 14; and Sanchez 2019, p. 17).

Name of population	**River Basin**	**County, State and Country**	**Elevation (m)**	**Status (date last documented)**	**Land ownership**	**Year, estimated population size, and spatial extent, if known**
Las Playas Springs	Playas (a closed basin)	Hidalgo, New Mexico, U.S.	1,420	Extirpated, unknown extirpation date	Private	NA
Agua Caliente	Santa Cruz	Pima, Arizona, U.S.	884	Extirpated, unknown extirpation date, but reintroduced	Pima County Natural Resources, Parks, and Recreation (PCNRPR); Agua Caliente Regional Park	Some plants were reintroduced in 2016-2020. As of 2023, about 20 seedlings were documented on the south shore of the pond. The wildlife island may still support the species, but has not been revisited since plants were introduced
La Cebadilla Cienega	Santa Cruz	Pima, Arizona, U.S.	825	Extant (2024)	La Cebadilla Estates; and Pima County Regional Flood Control District	**2020**: 31,467 (Li et al. 2023); 4,488 m^2

Lewis Springs	San Pedro	Cochise Arizona, U.S.	1,219	Extant (2024)	Bureau of Land Management (BLM) San Pedro Riparian National Conservation Area	**2020**: 2,111 (Li et al. 2023, p. 6); 438 m^2 **2021**: 1,579 (Condo 2023) **2022**: 1,399 (Condo 2023) **2023**: 1,193 (Condo 2023)
Rancho Agua Caliente	Rio Bavispe	Nacozari de García, Sonora, Mexico	940	Extant (2018)	Private	**2018**: 100s of plants; 9,000 m^2 (Sanchez 2019, p. 17)
Ojo Vareleño	Rio Casas Grandes (Mimbres)	Casas Grandes, Chihuahua, Mexico	1,492	Extant (2018)	Private	**2019**: 56 adult plants; 750 m^2 (Sanchez 2019, p. 17)

Table 2. Introduced Arizona eryngo populations in the U.S.

Name of population	**River Basin**	**County, State and Country**	**Elevation (m)**	**Year first introduced and seed source**	**Land ownership**	**Year and estimated population size**
Canoa Ranch	Santa Cruz	Pima, Arizona, U.S.	~910	2020 (La Cebadilla)	PCNRPR, Historic Canoa Ranch	**2023**: 27
Bar V Ranch (Mescal Spring)	Santa Cruz	Pima, Arizona, U.S.	~ 1,490	2022 (La Cebadilla)	PCNRPR, Bar V Ranch	**2023**: 57 adult plants, 59 seedlings
Las Cienegas (various sub-populations located in different wetlands)	Cienega Creek Watershed within the Santa Cruz River Basin	Pima and Santa Cruz, Arizona, U.S.	Varies by wetland, but ~ 1,400	2020 (La Cebadilla)	BLM Las Cienegas National Conservation Area	**2023**: 221 (in various wetlands)
Sweetwater Wetlands	Santa Cruz	Pima County, Arizona, U.S.	~690	2022 (La Cebadilla)	City of Tucson, Sweetwater Wetlands	**2024**: Few adults, many seedlings

St. David Cienega (Donlavy Wetlands)	San Pedro	Cochise Arizona, U.S.	1,125	2022 (Lewis Springs)	BLM SPRNCA	**2022**: 71 **2023**: 0

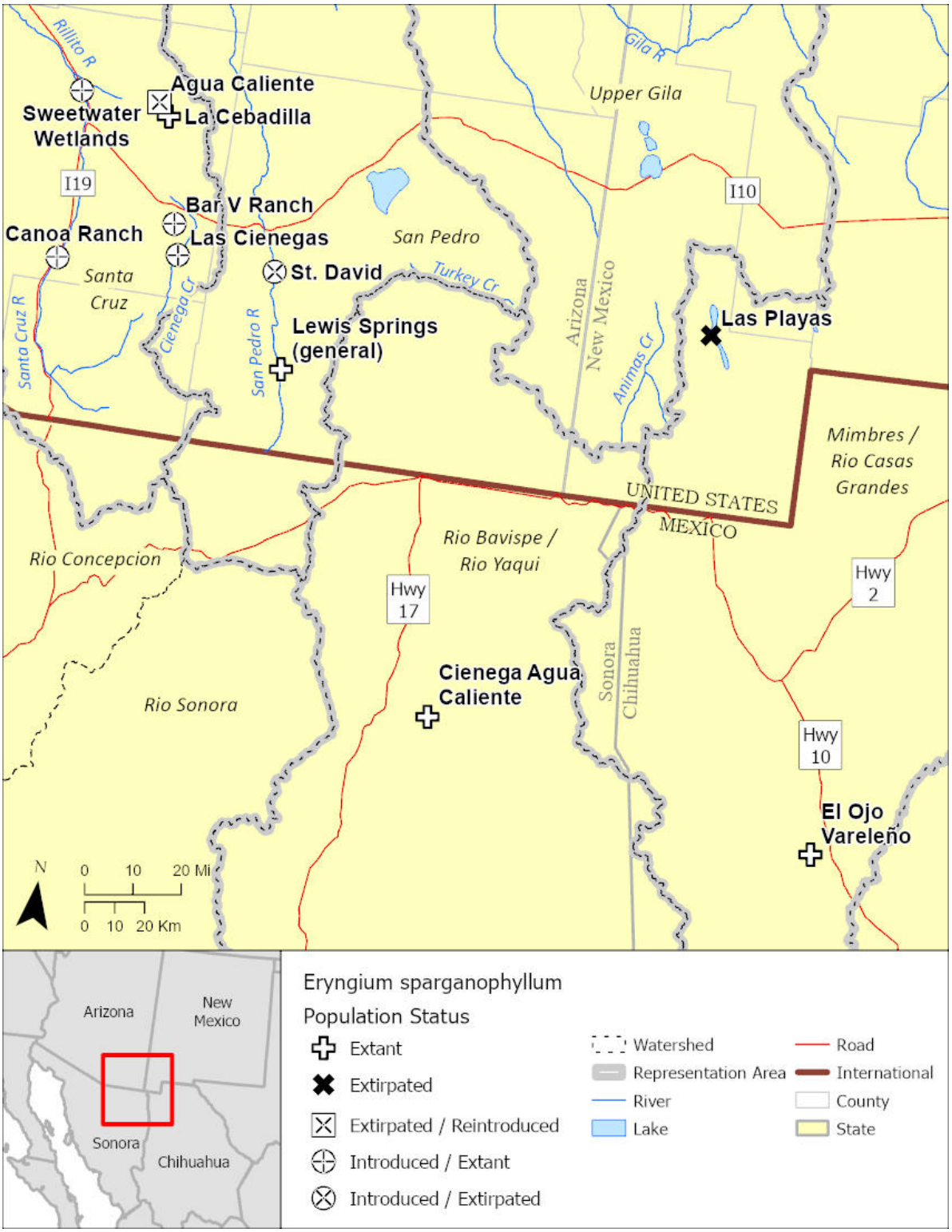

Figure 1. Historical extant, historical extirpated, and introduced populations of Arizona eryngo in the United States and Mexico, with representation areas (watershed boundaries are at the HUC-6 level).

Section 4(a) of the ESA describes five factors that may lead to endangered or threatened status for a species. These include A) the present or threatened destruction, modification, or curtailment of its habitat or range; B) overutilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; or E) other natural or manmade factors affecting its continued existence. The primary threats to Arizona eryngo are: (1) loss and physical alteration of cienegas (e.g., from intensive grazing of domestic livestock, removal of beaver, agricultural recontouring) (Factor A), (2) water loss from cienegas (e.g., from groundwater pumping/withdrawal, spring modification, water diversion, drought caused by climate change) (Factor A), and (3) changes in co-occurring vegetation (e.g., from fire suppression, introduction of nonnative plant species, decreased flood events, and changes in hydrology and climate) (Factor A). These factors are exacerbated by the ongoing and expected effects of climate change. Direct harm or mortality due to herbivory or trampling (Factor C) may also affect individuals and the seedbank, but possibly not at levels likely to affect species viability. See the SSA report (U.S. Fish and Wildlife Service 2022b) for a discussion of these threats.

RECOVERY STRATEGY, OBJECTIVES, AND CRITERIA

The recovery goal is to ensure the long-term persistence of Arizona eryngo in the wild over time (viability) through increasing and conserving individuals and populations; restoring and conserving habitat; and reducing the threats to the species, thus allowing for removal of Arizona eryngo from the list of threatened and endangered species.

For the species to be recovered, we envision that Arizona eryngo will demonstrate: 1) resiliency, by having naturally occurring and successfully introduced viable populations; and 2) redundancy and representation, by having genetically and ecologically diverse populations distributed in multiple locations throughout the species' range. Threats relevant to long-term viability will be reduced and habitat restored and conserved such that sufficient habitat quantity and quality is maintained to support the long-term survival of the species and its pollinators.

Recovery Strategy

The USFWS uses the conservation biology principles of resiliency, redundancy, and representation (collectively known as the "3Rs") as a lens to evaluate the current and future condition of a species. Resiliency describes the ability of populations to withstand stochastic events (arising from random factors). Representation describes the ability of a species to adapt to changing environmental conditions. Redundancy describes the ability of a species to withstand catastrophic events. To ensure viability, Arizona eryngo requires multiple resilient populations distributed throughout its geographic range. The recovery strategy includes: 1) increasing resiliency by establishment and management of sufficiently large populations to withstand stochastic events, 2) providing representation of the genetic and ecological diversity of the species throughout its geographic range, and 3) increasing redundancy by establishment of a sufficiently large number of populations to provide a safety margin to withstand catastrophic events.

Recovery of the species will require the discovery or establishment of multiple self-sustaining populations throughout the geographic range of the species in areas with suitable habitat. It likely will require the augmentation of some existing populations to increase the number of individuals in each population. This increase in numbers of populations and individuals within populations is essential to protect the species against extinction. Because the main cause of the decline of the species is the physical alteration of and water loss from its cienega habitat and changes in co-occurring vegetation, all of which are exacerbated by climate change, the recovery strategy focuses upon amelioration of these threats. However, it will be challenging to remove or ameliorate all threats to the species as they are difficult to reduce or control. Threats to the species in introduction or potential introduction sites must also be ameliorated to achieve recovery.

Recovery Objectives

Recovery objectives identify outcomes that will lead to achieving the goal of recovery and delisting. Recovery objectives for Arizona eryngo are:

1. Increase the size and number of populations (i.e., improve resiliency and redundancy) through Arizona eryngo augmentation and introduction success.
2. Ensure long-term Arizona eryngo conservation through the establishment of ex-situ plants and seed collections housed at multiple Center for Plant Conservation approved botanical institutions and seed banks.
3. Improve our understanding of the status and conservation needs of Arizona eryngo and its habitat through monitoring and research, and practice adaptive management in which recovery is monitored and recovery activities are updated by the USFWS in coordination with partners as new information becomes available.
4. Reduce threats of loss and alteration of cienegas and water loss from cienegas through the protection, restoration, and proper management of adequate quantity and quality of functional cienega habitat within existing, newly discovered, and introduced Arizona eryngo populations.
5. Reduce threats from changes in co-occurring vegetation to Arizona eryngo habitat within existing, newly discovered, and introduced Arizona eryngo populations.
6. Identify and reduce other threats (e.g., unsustainable levels or timing of predation or herbivory, trampling, pollinator loss), as needed, to ensure Arizona eryngo growth, reproduction, and recruitment within existing, newly discovered, and introduced Arizona eryngo populations.
7. Ensure long-term Arizona eryngo conservation through adequate funding, public education and outreach, and partnerships.

Recovery Criteria

An endangered species is defined in the ESA as a species that is in danger of extinction throughout all or a significant portion of its range (section 3(6)). A threatened species is one that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (section 3(20)). When we evaluate whether or not a species warrants downlisting (reclassification from endangered to a threatened status) or delisting (removal from the list of threatened and endangered species), we consider whether the species meets either of these statutory definitions. A recovered species is one that no longer meets the ESA definitions of threatened or endangered due to the species' condition and amelioration of threats. Determining whether a species should be downlisted or delisted requires consideration of the same five factors that were considered when the species was listed (as discussed above) and which are specified in section 4(a)(1) of the ESA and at 50 C.F.R. 402.02.

Recovery criteria are conditions that, when met, indicate that a species may warrant downlisting or delisting. Thus, recovery criteria are mileposts that measure progress toward recovery. Because the appropriateness of delisting is assessed by evaluating the five factors identified in the ESA, the recovery criteria below pertain to and are organized by these factors. These recovery criteria are our best assessment at this time of what the species needs to be downlisted from endangered to threatened, and delisted. Because we cannot envision the exact course that recovery may take, and because our understanding of the vulnerability of a species to threats is likely to change as more is learned about the species and the threats, it is possible that a status review may indicate that downlisting or delisting is warranted even if not all recovery criteria are met. Conversely, it is possible that the recovery criteria could be met, and a status review may

indicate that downlisting or delisting is not warranted. For example, a new threat may emerge that is not addressed by the current recovery criteria.

The downlisting criteria for Arizona eryngo consist of a combination of conditions that, when met, indicate the species may warrant reclassification from endangered to a threatened status. These criteria are described in detail in the Downlisting Criteria section of this document. Full recovery of the species to the point that protections of the ESA are no longer necessary (delisting) involves similar criteria as that of Downlisting, but are sustained for a longer period, and are described in detail in the Delisting Criteria section of this document.

Note: please see below for justifications and definitions of specific terms used in the recovery criteria.

Downlisting Criteria

The following are objective, measurable criteria which, when met, would result in a determination that Arizona eryngo will be considered for reclassification as a threatened species:

1. Fourteen or more populations of Arizona eryngo are viable throughout the species' geographic range in the U.S. and Mexico, including populations in the four representation areas as follows:
    a. Santa Cruz River Basin: at least four populations, including La Cebadilla and three additional populations that are newly discovered or introduced (these may include Agua Caliente, Canoa, Bar V, and LCNCA).
    b. San Pedro River Basin: at least two populations, including Lewis Springs and one additional population that is newly discovered or introduced.
    c. Rio Bavispe River Basin: at least two populations, including Rancho Agua Caliente and one additional population that is newly discovered or introduced, or two populations that are newly discovered or introduced.
    d. Rio Casas Grandes Basin (Mimbres): at least four populations, including Ojo Vareleño and three additional populations that are newly discovered or introduced, or four populations that are newly discovered or introduced.
    e. Two additional populations that are newly discovered or introduced in any existing or new representation area.

    Introduced populations are created using appropriate genetic stock and are placed in suitable habitat and microhabitat.

    Of the 14 populations referenced above, at least:
    a. One population supports more than 30,000 adult individuals (i.e., genets),
    b. One population supports more than 1,840 adult individuals (i.e., genets),
    c. Six populations support more than 800 adult individuals (i.e., genets),
    d. Six populations support more than 100 adult individuals (i.e., genets).

    The total number of adult individuals may be spatially distributed in subpopulations within a population (i.e., the subpopulations must be close enough to interact via pollination).

These population numbers will be maintained (natural recruitment is greater than or equal to documented plant loss) for a total of at least 5 years over the last 10-years of the period prior to downlisting (20 years), as indicated by monitoring every 1 to 3 years, including during the three most recent monitoring events. This allows for some fluctuation in population abundance due to drought or other threats.

2. A collection of seed representing the geographical, morphological, and genetic diversity of Arizona eryngo is started within 5 years of the finalization of this recovery plan, with regular supplemental collections, and maintained in at least one Center for Plant Conservation partner botanical or seed storage institution for conservation purposes.

3. A living collection of plants representing the geographical, morphological, and genetic diversity of Arizona eryngo is started within 5 years of the finalization of this recovery plan, with needed supplemental collections, and maintained long-term in at least one botanical institution for educational and conservation purposes.

4. Lands supporting 10 of 14 populations of Arizona eryngo are protected in perpetuity through a conservation easement, habitat conservation plan, or other conservation mechanism appropriate to the land status.

5. Conservation and management programs and plans address the threats to Arizona eryngo, including cienega habitat loss, drying, and alteration; changes in co-occurring vegetation; and direct harm to Arizona eryngo. The following must be met:

   a. site-specific plans are developed and at least partially implemented, such that:
      i. competing native and nonnative vegetation is reduced to a level that ensures Arizona eryngo is not shaded and their vigor is not negatively affected (Factor A),
      ii. a more natural fire or other disturbance regime is promoted (Factor A),
      iii. natural spring flow supporting cienegas is increased by reducing water loss (from groundwater pumping, etc.) and increasing water conservation and recharge (Factor A),
      iv. moist soil cienega habitat is increased (Factor A),
      v. herbivory and trampling are minimized (Factor C), and
      vi. native plant diversity is maintained or increased, thus promoting native pollinators; and

   b. data on the conservation and management of Arizona eryngo are collected and shared among landowners, managers, and researchers.

<u>Delisting Criteria</u>

The following are objective, measurable criteria which, when met, would result in a determination that Arizona eryngo will be considered for removal from the endangered species list:

1. Fourteen or more populations of Arizona eryngo are viable throughout the species' geographic range in the U.S. and Mexico, including populations in the four representation areas as follows:

a. Santa Cruz River Basin: at least four populations, including La Cebadilla and three additional populations that are newly discovered or introduced (these may include Agua Caliente, Canoa, Bar V, and LCNCA).
b. San Pedro River Basin: at least two populations, including Lewis Springs and one additional population that is newly discovered or introduced.
c. Rio Bavispe River Basin: at least two populations, including Rancho Agua Caliente and one additional population that is newly discovered or introduced, or two populations that are newly discovered or introduced.
d. Rio Casas Grandes River Basin: at least four populations, including Ojo Vareleño and three additional populations that are newly discovered or introduced, or four populations that are newly discovered or introduced.
e. Two additional populations that are newly discovered or introduced in any existing or new representation area.

Introduced populations are created using appropriate genetic stock and are placed in suitable habitat and microhabitat.

Of the 14 populations reference above, at least:
a. One population supports more than 30,000 adult individuals (i.e., genets),
b. One population supports more than 1,840 adult individuals (i.e., genets),
c. Six populations support at more than 800 adult individuals (i.e., genets),
d. Six populations support more than 100 adult individuals (i.e., genets).

The total number of adult individuals may be spatially distributed in subpopulations within a population (i.e., the subpopulations must be close enough to interact via pollination).

These population numbers will be maintained (natural recruitment is greater than or equal to documented plant loss) for a total of at least 5 years over the last 10-years of the period prior to delisting (30 years), as indicated by monitoring every 1 to 3 years, including during the three most recent monitoring events. This allows for some fluctuation in abundance due to drought or other threats.

To count toward achieving this criterion, existing or introduced populations that are used to evaluate this criterion may be augmented for the first 20 years of recovery to achieve population numbers. To show that populations are viable, no augmentation can occur within populations being evaluated under this criterion in the last 10 years for populations considered as contributing to possible delisting.

2. A collection of seed representing the geographical, morphological, and genetic diversity of Arizona eryngo is started within 5 years of the finalization of this recovery plan, with regular supplemental collections, and maintained in at least one Center for Plant Conservation partner botanical or seed storage institution for conservation purposes.

3. A living collection of plants representing the geographical, morphological, and genetic diversity of Arizona eryngo is started within 5 years of the finalization of this recovery plan,

with needed supplemental collections, and maintained in long-term in at least one botanical institution for educational and conservation purposes.

4. Lands supporting 12 of 14 populations of Arizona eryngo are protected in perpetuity through a conservation easement, habitat conservation plan, or other conservation mechanism appropriate to the land status.

5. Conservation and management programs and plans address the threats to Arizona eryngo, including cienega habitat loss, drying, and alteration; changes in co-occurring vegetation; and direct harm to Arizona eryngo. The following must be met:

   a. site-specific plans are developed and fully implemented, such that:
      vii. competing native and nonnative vegetation is reduced to a level that ensures Arizona eryngo is not shaded and their vigor is not negatively affected (Factor A),
      viii. a more natural fire or other disturbance regime is promoted (Factor A),
      ix. natural spring flow supporting cienegas is increased by reducing water loss (from groundwater pumping, etc.) and increasing water conservation and recharge (Factor A),
      x. moist soil cienega habitat is increased (Factor A),
      xi. herbivory and trampling are minimized (Factor C), and
      xii. native plant diversity is maintained or increased, thus promoting native pollinators; and

   b. data on the conservation and management of Arizona eryngo are collected and shared among landowners, managers, and researchers.

Justification for Recovery Criteria

Justification for recovery criteria consists of an explanation of concepts, definitions, and rationale for recovery criteria in the context of the species viability (resiliency, redundancy, and representation), and amelioration of threats, as described below.

Explanation of Concepts

- **Representation Area** – Definition: An area representing the groupings of populations, based on river basin boundaries and geographic separation of known historical populations (Figure 1). These representation areas are: 1) the Santa Cruz River Basin, 2) the San Pedro River Basin, 3) the Rio Bavispe River Basin, and 4) the Rio Casas Grandes (Mimbres) Basin.

- **Number of individuals –** The minimum number of Arizona eryngo required for recovery was derived from the literature and estimates of Arizona eryngo population abundance.
  - For rare plants, a minimum population size of 100 is suggested to prevent inbreeding depression, and more than 1,000 individuals may be required to maintain evolutionary potential (Jamieson & Allendorf 2012 p. 580; Maschinski & Albrecht 2017 p. 392). Based on our analysis of current population condition in the Arizona eryngo SSA, a known abundance of 50 to 799 individuals is defined as a low condition for this demographic factor (U.S. Fish and Wildlife Service 2022b p. 53). Our recovery criteria require at least six populations with more than 100 adult individuals to meet this minimum suggested population size, as well as six populations with more than 800 adult

individuals to meet the moderate condition category for population abundance described in the SSA.
  - The largest Arizona eryngo population recorded was 31,467 individuals at La Cebadilla, and the second highest population count for any location was 2,111 individuals at Lewis Springs. We use an abundance of greater than 1,840 individuals as defined in the Arizona eryngo SSA as a threshold for high condition for this demographic factor (U.S. Fish and Wildlife Service 2022b p. 53). Our recovery criteria require at least one population with more than 1,840 adult individuals and one population with more than 30,000 adult individuals to meet the high condition category for population abundance, as well as to retain the current resiliency for the La Cebadilla population, the largest population documented. Ideally, populations in the low condition category would increase over time to reach the moderate or high condition category; however, limited spring-fed cienega habitat may make this difficult to achieve. If new information indicates that such small populations, particularly those on the low end of the low condition category, are not viable, this recovery criterion will be revisited in the future.

- **Subpopulation** – Pollinators of Arizona eryngo have not been identified; however, many insect visitors have been observed on their flowers, including bees, wasps, beetles, and butterflies, which may be pollinators (Li et al. 2023 p. 2). Foraging flight distance of the Sonoran bumblebee (*Bombus sonorus*), a species regularly observed on Arizona eryngo, is unknown, but other bumblebees are capable of flying at least 1,000 m to forage (Wolf & Moritz 2008; Osborne et al. 2008; Hagen et al. 2011). Therefore, we assume subpopulations within 1000 m of one another interact via pollination and form a population; however, future research may reveal a more accurate distance.

- **Time Period –** The period required to meet Recovery Criterion 1.
  - **The 20-Year** period is based on longevity of individual Arizona eryngo (at least 10 years) coupled with recovery actions that will take time, funding, and personnel commitment to fully implement.
  - **The 30-year** period includes 20 years to achieve population numbers and 10 years to demonstrate stability, and it assures that target numbers of Arizona eryngo are maintained through fluctuations in drought and other disturbances, thus demonstrating that the species is resilient. The additional time (10 years) necessary to achieve delisting allows land managers to continue the progress made toward Arizona eryngo threats reduction during downlisting and track the long-term effectiveness of management activities.

- **Successfully introduced plants** (from transplanted individuals or seeds sown on site) – Is defined as introduced plants (augmented at existing populations or established at new populations) that are fully functioning (reproducing) in their environment as indicated by post-introduction monitoring. Introduced plants may experience mortality after introduction, and additional introductions may be necessary to help achieve Recovery Criterion 1.

- **Natural recruitment** – Is defined as juveniles that survive the first year of life in Arizona eryngo populations.

- **Suitable habitat** – A cienega or cienega-like habitat that provides the resource needs of Arizona eryngo as outlined in the SSA and is protected from dewatering and other threats.

- **Geographic range –** Is defined as an area within Arizona, New Mexico, Sonora, and Chihuahua that historically supported cienega habitat appropriate to Arizona eryngo. If evidence suggests that climate change (or other factors) is causing suitable habitat to shift in location, introducing new populations into suitable habitat outside of the historical geographic range of the species may be warranted.

- **Partially vs. Fully Implemented** (Downlisting vs. Delisting Criterion 6) – Is defined as the degree to which management plans are implemented such that the impacts of threats are reduced (partially implemented) versus no longer an imminent concern (fully implemented). Reduction of threats will be determined by baseline measurement and repeated measurements following treatment. We recognize that it will take commitments of time, funding, and personnel to fully implement these plans; therefore, downlisting requires only partial implementation.

Rationale for Recovery Criteria – Achieving Species Viability (3Rs), and Ameliorating Threats

Below we justify our recovery criteria in the context of the 3Rs (resiliency, redundancy, and representation) used to assess the species' long-term viability and describe how our recovery criteria address threats to Arizona eryngo.

3Rs:
Resiliency is met by having enough individuals within populations to withstand disturbances such as random fluctuations in germination rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities. Little is known regarding the numbers of plants required to achieve resilient Arizona eryngo populations; however, in general, having more individuals across populations will provide greater resiliency. Greater resiliency will enable the species to better withstand the effects of its various threats and increases the likelihood of species viability. Our current understanding of the species, as well as minimum rare plant population sizes called for in the literature, suggest that the number of individuals called for in Recovery Criterion 1 (minimum of one population with more than 30,000, one population with more than 1,840, six populations with more than 800, and six populations with more than 100 adult individuals) is sufficient to achieve resilient Arizona eryngo populations.

Redundancy is met by having multiple populations distributed across the species' range. Because plants in populations are separated spatially from plants in other populations, they are less likely to be simultaneously affected by catastrophic events (e.g., high severity fire) or locally important events (e.g., intense flooding). Therefore, the species will be more likely to withstand such events, reducing the risk of extinction. The recovery criteria require a minimum of 14 populations distributed across the geographic range of the species.

Representation is met by maintaining sufficient genetic diversity across the geographic range of Arizona eryngo. We do not have genetic information about Arizona eryngo, and additional

research into genetic isolation is warranted. Ecological diversity can potentially be increased through the introduction of new populations in suitable habitat that have slightly different elevations, temperatures, precipitation, water sources, soils, vegetation community, etc. If evidence suggests that climate change is causing suitable habitat to shift in location, introducing new populations into suitable habitat outside of the historical geographic range of the species may be warranted.

Viability:
In summary, viability of Arizona eryngo, or persistence in the wild over the long-term, is achieved by improving population resiliency, increasing species redundancy, and maintaining or improving its representation. Resiliency is improved by successful augmentation and/or discovering new individuals. Redundancy is increased by the introduction or discovery of new populations. Representation is maintained or improved by ensuring sufficient genetic and ecological diversity across, or possibly outside of, the current geographic distribution of Arizona eryngo. Additionally, primary threats to the species and its habitat, such as loss and physical alteration of cienegas, water loss from cienegas, and changes in co-occurring vegetation, must be addressed to ensure Arizona eryngo viability.

Threats:
Table 3 below indicates how the primary threats to Arizona eryngo, in the context of the five listing factors, are addressed in the recovery criteria.

Table 3. How significant threats to Arizona eryngo (*Eryngium sparganophyllum*) are addressed in the recovery criteria.

Factor Addressed	Threat Addressed	Criterion Number and Explanation and
Factor A – Present or threatened destruction, modification, or curtailment of its habitat or range	Loss and physical alteration of cienegas (e.g., from intensive grazing of domestic livestock, removal of beaver, agricultural recontouring)	**Criterion 5** addresses the need to help repair damage to landscapes from intensive grazing of domestic livestock and land recontouring, as well as to promote introduction and maintenance of beaver in historically occupied habitats.

Factor Addressed	Threat Addressed	Criterion Number and Explanation and
	Water loss from cienegas (e.g., from groundwater pumping/withdrawal, spring modification, water diversion, drought caused by climate change)	**Criterion 5** addresses the need to help repair damage to cienegas from historical and current modification and aquifer depletion.
Factor A – Present or threatened destruction, modification, or curtailment of its habitat or range	Changes in co-occurring vegetation (e.g., from fire suppression, introduction of nonnative plant species, decreased flood events, and changes in hydrology and climate)	**Criterion 5** addresses the need to reduce competing native and nonnative vegetation and help restore more natural fire regimes in and around cienega habitat.
Factor A – Present or threatened destruction, modification, or curtailment of its habitat or range	Climate change	**Criterion 5** address the need to promote natural spring flow and moist soil cienega habitat.
Factor C – Disease or predation	Direct harm or mortality due to herbivory or trampling	**Criterion 5** addresses the need to help ensure flowering and fruiting individuals reach seed production and dispersal.

RECOVERY ACTIONS NEEDED

Recovery of Arizona eryngo will be accomplished through implementation of the site-specific recovery actions provided in Table 4 below. In general, implementation of the recovery actions will involve participation from local, state, and federal agencies, local communities, private landowners, nongovernmental organizations, academia, and the public. Recovery actions, organized by recovery objective, are accompanied by estimates of the time and cost required to achieve the plan's goal to recover Arizona eryngo. The site-specificity of the recovery actions is provided primarily at the geographic scale of the population (see Figure 1). We assign priorities to each action; note that actions within an action group may have different priorities. Priority 1 actions must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future. Priority 2 actions must be taken to prevent a significant decline in population size or habitat quality, or some other significant negative impact. Priority 3 actions are all other actions that are necessary for the species' full recovery. The assignment of priorities does not imply that some recovery actions are of low importance, but instead implies that lower priority items may be deferred while higher priority items are being implemented.

The separate RIS for Arizona eryngo provides additional detailed, site-specific near-term activities needed to implement the actions identified here. We intend to update the implementation strategy as frequently as needed by incorporating new information, including the findings of future 5-year status reviews. The RIS will provide activities that will be continually updated as recovery implementation progresses. Therefore, we anticipate being able to provide a greater degree of site-specificity in the implementation strategy than for the recovery actions in the recovery plan. For example, introduction locations will be determined based on present-year circumstances. We will revise the recovery actions in this recovery plan only if there are needed changes based upon the findings of future 5-year status reviews or other information.

As stated in the Disclaimer, recovery plans are advisory documents, not regulatory documents. A recovery plan does not commit any entity to implement the recommended strategies or actions contained within it for a particular species, but rather provides guidance for ameliorating threats and implementing proactive conservation measures, as well as providing context for implementation of other sections of the ESA, such as section 7(a)(2) consultations on federal agency activities or development of Habitat Conservation Plans.

Estimated time and cost of recovery

We expect the status of Arizona eryngo to improve such that we can achieve downlisting criteria in approximately 20 years (i.e., 2045). We expect to achieve recovery (delisting) in approximately 30 years (i.e., 2055) for a total estimated cost of $54,093,300. This is the estimated cost of completing the recovery actions such that the recovery criteria have been met and includes those costs borne by all responsible parties. The calculation of the total estimated cost to recovery is included in the Recovery Action Table (Table 4) below. The actions identified in the Recovery Action Table are those that, based on the best available science, the USFWS thinks are necessary to achieve recovery of Arizona eryngo. Time to recovery is based on the expectation of full funding, implementation as provided for in the recovery plan and implementation strategy, and full cooperation of partners. The estimated cost to implement the first 20 years of recovery actions is $41,990,500 (i.e., intermediate cost). Note that actions taken

to improve cienega habitats for this species will benefit many other listed plant and animal species, and costs incurred for improving habitat of any other listed or rare species found within these cienega habitats will reduce the recovery cost of this species.

Table 4.a-g. Recovery Action Table: Estimated Cost, Time, and Priority for Recovery Actions for Arizona eryngo (*Eryngium sparganophyllum*). These actions apply to the sites of all current Arizona eryngo populations; in some cases, as in introductions, they apply to future currently unknown Arizona eryngo sites. The threats we have identified for Arizona eryngo, and which are addressed below, include Factors A (the present or threatened destruction, modification, or curtailment of its habitat or range) and C (disease or predation).

4.a. Objective 1. Increase the size and number of populations (i.e., improve resiliency and redundancy) through Arizona eryngo augmentation and introduction success.

Priority #	Action #	Site-Specific Action	Recovery Criteria Addressed	Action Duration (years)	Estimated Total Cost ($)	Addresses Threat
1	1a	Survey for and locate potential sites for Arizona eryngo introduction with suitable habitat.	1	15	45,000	Factor A
1	1b	Work with landowners, managers, and researchers to complete all necessary compliance, permits, and approvals for augmentation and introduction.	1	15	10,000	Factor A
1	1c	Augment existing Arizona eryngo populations and establish new Arizona eryngo populations in strategic sites using appropriate genetic stock to increase the redundancy (number of populations) and resiliency (size of populations) of the taxon.	1	20	186,500	Factor A

4.b. Objective 2. Ensure long-term Arizona eryngo conservation through the establishment of ex-situ plant and seed collections housed at multiple Center for Plant Conservation approved botanical institutions and seed banks.

Priority #	Action #	Site-Specific Action	Recovery Criteria Addressed	Action Duration (years)	Estimated Total Cost ($)	Addresses Threat
1	2a	Grow out Arizona eryngo propagules from appropriate genetic stock.	1 & 2	30	5,000	Factor A
1	2b	Regularly collect Arizona eryngo seed representing the geographical, morphological, and genetic diversity of the species using Center for Plant Conservation guidelines (Center for Plant Conservation 2019).	2	30	54,000	Factor A
1	2c	Conserve the Arizona eryngo seed in Center for Plant Conservation approved facilities and periodically test the seed to estimate the rate of viability loss during seed storage.	2	30	70,000	Factor A
1	2d	Maintain Arizona eryngo plants in captivity at botanical gardens and other USFWS approved facilities for educational purposes, seed amplification, and introduction.	2 & 3	30	120,000	Factor A

4.c. Objective 3. Improve our understanding of the status and conservation needs of Arizona eryngo and its habitat through monitoring and research and practice adaptive management in which recovery is monitored and recovery tasks are revised by the USFWS in coordination with partners as new information becomes available.

Priority #	Action #	Site-Specific Action	Recovery Criteria Addressed	Action Duration (years)	Estimated Total Cost ($)	Addresses Threat
1	3a	Monitor natural and augmented Arizona eryngo populations every 1 to 3 years.	1	30	620,500	Factor A & C
1	3b	Monitor response of Arizona eryngo and its habitat to recovery actions and practice adaptive management to improve actions as needed.	5	30	Cost included in 3a	Factor A & C
1	3c	Monitor water availability (including groundwater levels and soil moisture) through time including water availability response to conservation efforts and hydrological and geomorphological restoration work.	5	30	1,634,100	Factor A
2	3d	Work with land managers, owners, and planners to develop, update, and implement site specific management plans to protect, manage, and monitor Arizona eryngo, its habitat, and its pollinators.	5	30	90,000	Factor A & C

Priority #	Action #	Site-Specific Action	Recovery Criteria Addressed	Action Duration (years)	Estimated Total Cost ($)	Addresses Threat
2	3e	Identify research needs and conduct scientific studies on the geography, ecology, biology, viability, and genetics of the species and share results among land managers and researchers.	5	20	165,000	Factor A & C
2	3f	Identify research needs and conduct scientific studies on threats, compatible land uses, and habitat restoration not identified above, and share results among land managers and researchers.	1 & 5	10	40,000	Factor A & C
2	3g	Review the status of Arizona eryngo periodically.	All	30	12,000	Factor A & C
3	3h	Compile and discuss Arizona eryngo recovery accomplishments and updates with the recovery partners at least once per year.	All	30	90,000	Factor A & C

4.d. Objective 4. Reduce threats of loss and alteration of cienegas and water loss from cienegas through the protection, restoration, and proper management of adequate quantity and quality of functional cienega habitat within existing, newly discovered, and introduced Arizona eryngo populations.

Priority #	Action #	Site-Specific Action	Recovery Criteria Addressed	Action Duration (years)	Estimated Total Cost ($)	Addresses Threat
1	4a	Protect through acquisition, conservation easements, habitat conservation plan, or other conservation mechanism appropriate to the land status, land supporting Arizona eryngo populations, as well as sites supporting suitable functional cienega habitat where Arizona eryngo could be introduced.	4	30	15,815,000	Factor A
1	4b	Enhance natural spring flow supporting cienegas by reducing water loss (e.g., from groundwater pumping and diversion) and increasing water conservation and recharge.	5	30	32,440,000	Factor A
1	4c	Increase moist soil cienega habitat through the removal of invading woody species, restoration of historical water flow paths, and introduction and maintenance of beaver populations.	5	30	360,000	Factor A

4.e. Objective 5. Reduce threats from changes in co-occurring vegetation to Arizona eryngo habitat within existing, newly discovered, and introduced Arizona eryngo populations.

Priority #	Action #	Site-Specific Action	Recovery Criteria Addressed	Action Duration (years)	Estimated Total Cost ($)	Addresses Threat
1	5a	Reduce competing native and nonnative vegetation to a level that ensures Arizona eryngo is not negatively affected by reduced light, water, space, or nutrients.	5	30	1,540,000	Factor A
1	5b	Restore and maintain low to moderate intensity disturbance regimes that reduce competing vegetation and allow for Arizona eryngo establishment and growth.	5	30	350,000	Factor A

4.f. Objective 6. Identify and reduce other threats (e.g., unsustainable levels or timing of predation or herbivory, trampling, pollinator loss), as needed, to Arizona eryngo growth, reproduction, and recruitment within existing, newly discovered, and introduced Arizona eryngo populations.

Priority #	Action #	Site-Specific Action	Recovery Criteria Addressed	Action Duration (years)	Estimated Total Cost ($)	Addresses Threat
1	6a	Ensure grazing of Arizona eryngo does not occur during the flowering and fruiting seasons and that grazing levels, methods, and infrastructure are compatible with, or enhance, Arizona eryngo conservation.	5	30	5,000	Factor C
2	6b	Check for insect outbreaks that could impact seed production and treat accordingly as needed with approved biocontrol or insecticide.	5	30	12,000	Factor C
2	6c	Increase native plant diversity thus promoting native pollinators.	5	30	148,000	Factor C
2	6d	Reduce other threats that are identified through research.	5	30	None	Factor A & C

4.g. Objective 7. Ensure long-term Arizona eryngo conservation through adequate funding, public education and outreach, and partnerships.

Priority #	Action #	Site-Specific Action	Recovery Criteria Addressed	Action Duration (years)	Estimated Total Cost ($)	Addresses Threat
2	7a	Secure funding for the conservation of Arizona eryngo and its habitat.	All	30	96,000	Factor A & C
3	7b	Conduct education and outreach programs to increase awareness of the value and status of Arizona eryngo and its habitat.	All	30	41,200	Factor A & C
3	7c	Develop and maintain partnerships with agencies, organizations, and citizens to conserve Arizona eryngo and its habitat.	All	30	140,000	Factor A & C

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