DRAFT
KEARNEY'S BLUE STAR (*Amsonia kearneyana*)
RECOVERY PLAN

First Revision - August 2019

Amsonia kearneyana –Photo credit Bill Radke, U.S. Fish and Wildlife Service

Original Plan Approved: May 24, 1993

Southwest Region (Region 2)
U.S. Fish and Wildlife Service
Albuquerque, New Mexico

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

Date: ____

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In memory of Daniel F. Austin, who loved the Baboquivari Mountains, their flora, and *Amsonia*.

LITERATURE CITATION AND AVAILABILITY

Literature citation should read as follows:

U.S. Fish and Wildlife Service. 2019. Kearney's Blue Star (*Amsonia kearneyana*) Draft Recovery Plan, First Revision. Southwest Region, Tucson, Arizona, USA. 56 pp.

An electronic copy of this draft Recovery Plan will be made available at:
https://www.fws.gov/southwest/es/arizona/Kearney.htm and

https://ecos.fws.gov/ecp0/profile/speciesProfile?sId=7485

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

Current Species Status

Amsonia kearneyana (Kearney's blue star) was listed as Endangered without designated critical habitat on January 19, 1989, under the Endangered Species Act of 1973, as amended (54 FR 2131). In the United States, the taxon occurs in southern Arizona in the Baboquivari Mountains on lands administered by the Tohono O'odham Nation, the Arizona State Land Department, the Bureau of Land Management, and the U.S. Fish and Wildlife Service. It may also occur in portions of Sonora, Mexico, where there is one reference to the species occurrence, but this has not been verified. It is not fully understood what constitutes a population of *A. kearneyana*, therefore we use the terms site (areas supporting *A. kearneyana* including a 1,000-meter (m; 0.63-mile [mi]) radius surrounding individuals that provides habitat for pollinators of *A. kearneyana*) and subsite (areas within sites supporting *A. kearneyana* individuals that likely share pollinators) to describe the current distribution of the species. In Arizona, the distribution of *A. kearneyana* is limited to one naturally occurring site, as well as one site where the species has been introduced. The naturally occurring plants are separated into 8 subsites. As of 2019, we are aware of approximately 326 individuals in both natural and introduced sites, as well as some seed and plants at various botanical institutions. Comparing recent and historical survey efforts of *A. kearneyana* at subsites to which we had access, the number of individuals has declined by about 48 percent over the past three decades.

Habitat Requirements and Ecology

Amsonia kearneyana occurs in steep, dry, open woodland slopes and coarse alluvium along dry canyon bottoms. The taxon may require shade from overstory *Quercus* sp. (oaks) and *Pinus* sp. (pines), as well as intermittent periods of above average precipitation to enable successful germination. The species is capable of reproducing both through seed (sexually) and vegetatively (asexually, through roots). Sexual reproduction of this species requires pollinators which include butterflies, bees, beetles, moths, and hummingbirds. *A. kearneyana* pollinators may spread pollen up to 1,000 meters (0.63 mile) from individual plants. Therefore, pollinator habitat requirements also need to be considered for the conservation of *A. kearneyana*.

Threats

The 1989 listing rule identified the following threats to *A. kearneyana*: (1) cattle grazing that modifies the habitat, (2) probable seed predation by *Chlorochroa ligulata*, and (3) low numbers and limited distribution. At this time, we recognize the following threats to the continued existence of the species are (for a description of listing factors, see Reasons for Listing/Threats Assessment below): Factor A: poorly managed livestock grazing, nonnative plant presence and spread, altered wildfire regime, and border activities; Factor C: seed predation; Factor E: low numbers and limited distribution, drought and climate change, and trampling by livestock. Research is needed to verify and quantify the impacts of these threats on the species.

Recovery Priority

The recovery priority number for *A. kearneyana* is 2, meaning it is a full species with a high degree of threat but also a high potential for recovery. Recovery priorities for listed species range from 1 to 18, with species ranking 1 having the highest recovery priority (48 FR 43098).

Recovery Goal and Vision

The recovery goal is to ensure the long-term viability of *A. kearneyana* through increasing and conserving individuals, conserving habitat, and reducing the threats and stressors to the species, thus allowing for removal of *A. kearneyana* from the list of threatened and endangered species.

For the species to be recovered, we envision that *A. kearney*ana will demonstrate: 1) resiliency, by having sufficient naturally occurring and successfully introduced plants; and 2) redundancy and representation, by being distributed in multiple locations throughout its narrow range. Threats relevant to long-term viability will be reduced and habitat conserved and managed such that sufficient habitat quantity and quality is maintained to support the long-term survival of the species and its pollinators.

Recovery Strategy

Our recovery strategy for *A. kearneyana* addresses the resiliency, representation, and redundancy, as well as a reduction of threats, needed to downlist and delist the species.

Our recovery strategy for *A. kearneyana*, is to:

1. Maintain a sufficient and stable or increasing number (i.e., recruitment equals or exceeds mortality) of plants at multiple subsites throughout the species' narrow range for an adequate time-period. Initial numbers may be reached through augmentation or discovery at existing subsites and/or introduction or discovery at new subsites; however, plants will need to be self-sustaining over time. This promotes resiliency (number of plants), redundancy (number of subsites), and representation (subsites across the species' range, including a variety of ecological settings) of the species.

2. Implement cooperative efforts to identify and reduce threats and to conserve and manage habitat in sufficient quantity and quality to promote the long-term survival of the species and its pollinators.

Recovery Objectives

Recovery objectives identify outcomes that will lead to achieving the goal of recovery and delisting. Recovery objectives for *A. kearneyana* are:

> Population-based Objective: Conserve existing, newly discovered, and introduced *A. kearneyana* individuals and their seedbanks (approximately 10 meter [32.8 feet] radius from plants) throughout the species' narrow range to ensure the long-term survival of the taxon.

<u>Habitat and Threat-based Objective</u>: Conserve, restore, and properly manage the quantity and quality of habitat needed for the long-term survival of *A. kearneyana* and its pollinators (habitat is approximately 1,000-meter [0.63 mile] radius from plants). This includes reducing or preventing habitat degradation as a result of poorly managed livestock grazing, spread of nonnative plant species; alteration of natural fire regimes, and other stressors, such as drought caused by climate change, and border activities.

Recovery Criteria

Note: please see Section IV, RECOVERY GOAL AND VISION, STRATEGY, OBJECTIVES, AND CRITERIA (pp. 34-42) for justifications and definitions of specific terms used in the recovery criteria below.

Amsonia kearneyana will be considered for **downlisting** when all of the following criteria are met:

1) <u>Population-based Criterion</u>:
A minimum of 1,225 *A. kearneyana* throughout the species' known range are stable or increasing over 15 years of a 20-year period, with the number of individuals ≥1,225 at the last two monitoring events. This is measured by monitoring every 3-5 years, using a standardized protocol. In order to address the expected yearly fluctuations in plant abundance due to changes in precipitation, fire, or other causes, we anticipate and allow for the fact that two monitoring events during the 20-year time-period may not meet these targets; therefore, the 15 years do not need to be consecutive (e.g. Year 0: 1,225 individuals; Year 5: 1,000 individuals; Year 10: 1,000 individuals; Year 15: 1,225 individuals; Year 20: 1,225 individuals). *Amsonia kearneyana* individuals are distributed among ≥ 5 known, discovered, or established Subsites, each containing ≥100 individuals. The minimum 1,225 individuals may be attained naturally or through introduction. Augmented or established Subsites will have successfully introduced plants (reproducing and at least 10 years old). The ≥ 5 Subsites can be distributed within one or more Sites.

2) <u>Habitat-based Criteria:</u>
   a) At least 60 percent or 1,239 hectares (3,061 acres) of the 2,064 total hectares (5,101 acres) of habitat across the currently known range (i.e., within sites or nearby) supports *A. kearneyana* or its pollinators. Of the 1,239 hectares (3,061 acres), at least 65 percent (805 hectares; 1,990 acres) must be in optimal condition and 35 percent (434 hectares; 1,071 acres) must be in good condition (see Explanation of Concepts and Rationale for Recovery Criteria below for a description of habitat quality terms).
   b) At least 25 percent of the *remaining* habitat across the currently known range supports *A. kearneyana* or its pollinators (Remaining habitat = Total habitat minus Optimal Quality Habitat minus Good Quality Habitat) although this habitat may be of lesser quality.
   c) Cooperative programs are being developed and partially implemented to conserve habitat, seedbank, and pollinator habitat in perpetuity to ensure continued existence of *A. kearneyana*. These efforts include sharing of collected data between land managers and researchers, as well as development and partial implementation of land management

plans that effectively manage nonnative plants, restore a more natural fire regime, and promote pollinator diversity and habitat,

Amsonia kearneyana will be considered for **delisting** when all of the following are met:

1) Population-based Criteria:
   a) A minimum of 1,225 *A. kearneyana* throughout the species' known range are stable or increasing over 25 years of a 30-year period (an additional 10 years from downlisting), with the number of individuals ≥1,225 at the last two monitoring events. This is measured by monitoring every 3-5 years, using a standardized protocol. In order to address the expected yearly fluctuations in plant abundance due to changes in precipitation, fire, or other causes, we anticipate and allow for the fact that two monitoring events during the 30-year time-period may not meet these targets; therefore, the 25 years do not need to be consecutive (e.g. Year 0: 1,225 individuals; Year 5: 1,000 individuals; Year 10: 1,000 individuals; Year 15: 1,225 individuals; Year 20: 1,225 individuals; Year 25: 1,225 individuals; Year 30: 1,225 individuals). These are distributed among ≥ 5 known, discovered, or established subsites, each containing ≥ 100 individuals. The minimum 1,225 individuals may be attained naturally or through introduction. Augmented or established subsites will have successfully introduced plants (reproducing and at least 10 years old). The ≥ 5 subsites can be distributed within one or more sites.

2) Habitat-based Criteria:
   a) At least 75 percent of habitat (1,548 ha; 3,826 ac) of the 2,064 total ha (5,101 ac) of habitat across the currently known range (i.e., within sites or nearby) supports *A. kearneyana* or its pollinators. Of the 1,548 ha (3,826 ac), at least 65 percent (1,006 ha or 2,486 ac) must be in optimal condition and 35 percent (542 ha or 1,339 ac) must be in good condition.
   b) At least 40 percent of the *remaining* habitat across the currently known range supports *A. kearneyana* or its pollinators (Remaining habitat = Total habitat minus Optimal Quality Habitat minus Good Quality Habitat) although this habitat may be of lesser quality. There is potential for habitat improvement with land management practices.
   c) Cooperative efforts are being fully implemented to conserve habitat, seedbank, and pollinator habitat to ensure continued existence of *A. kearneyana*. These efforts include sharing of collected data between land managers and researchers, as well as implementation of land management plans that effectively manage nonnative plants, restore a more natural fire regime, and promote pollinator diversity and habitat.

Recovery Actions Needed

1) Census of known *A. kearneyana* subsites
2) Monitor *A. kearneyana* individuals and their habitat (e.g. quality)
3) Survey for new *A. kearneyana* individuals and subsites
4) Augment the number of *A. kearneyana* individuals at existing subsites
5) Establish new *A. kearneyana* subsites
6) Acquire or protect *A. kearneyana* subsites

7) Establish and maintain *A. kearneyana* seeds and plants in botanical institutions
8) Conduct research relating to *A. kearneyana* biology, ecology, threats, management, etc.
9) Monitor threats to *A. kearneyana*
10) Reduce threats to *A. kearneyana* and manage habitat quality
11) Conduct outreach, education, and coordination relating to *A. kearneyana* conservation and recovery

Estimated Timing and Cost of Recovery

We expect the status of *A. kearneyana* to improve such that we can achieve downlisting criteria in approximately 25 years (this includes 20 years to meet the Period for Stability plus 5 years to discover or establish more plants). We expect to achieve recovery in approximately 40 years (this includes 30 years to meet the Period for Stability plus 10 years to discover or establish more plants). In other words, **2059** is the approximate date to reach the goal of recovery for *A. kearneyana*. The time to recovery is based on the expectation of full funding, implementation as provided for in the recovery plan and implementation schedule, and full cooperation of partners.

The <u>total</u> estimated cost of recovery is $**5,743,650**. This cost includes those borne by Federal and State governmental agencies and the Tohono O'odham Nation, as well as other institutions, universities, and organizations with an interest in recovering *A. kearneyana*.

Annual cost estimates to implement recovery actions for the first 5 years are as follows:
Year 1 = $220,854
Year 2 = $179,281
Year 3 = $305,439
Year 4 = $210,348
Year 5 = $409,784

The estimated cost to implement the first 5 years of recovery actions (i.e., intermediate steps toward the goal of recovery) is $1,325,706. The calculation of the total estimated cost to recovery is included in the Recovery Action Table below. The cost of implementing the first 5 years of recovery is detailed in the Implementation Schedule Table included in a separate Recovery Implementation Strategy.

SÍNTESIS DE ACCIÓN

Estado actual de la especie

La especie *Amsonia kearneyana* (estrella azul de Kearney) fue catalogada en peligro, sin hábitat crítico designado, el 19 de enero de 1989, en virtud de la Ley de Especies en Peligro de Extinción de 1973 y sus enmiendas (54 FR 2131). En los Estados Unidos, el taxón se encuentra en el sur de Arizona, en las montañas Baboquivari, sobre tierras administradas por la nación Tohono O'odham, el Departamento de Tierras del Estado de Arizona, la Oficina de Administración de Tierras y el Servicio de Pesca y Vida Silvestre de los EE. UU. También puede estar presente en regiones de Sonora, México, donde hay una referencia a la presencia de la especie, pero esto no se ha verificado. No se dispone de un conocimiento cabal de lo que constituye una población de *A. kearneyana*, por lo tanto, empleamos los términos sitio (zonas que admiten un radio de 1000 metros [m; 0,63 millas, mi] de *A. kearneyana* alrededor de ejemplares que proporcionan un hábitat para los polinizadores de *A. kearneyana*) y subsitio (zonas dentro de los sitios que admiten ejemplares de *A. kearneyana* que probablemente compartan polinizadores) para describir la distribución actual de la especie. En Arizona, la distribución de *A. kearneyana* se limita a un sitio donde se presenta de forma natural, así como a un sitio donde se ha introducido la especie. Las plantas que nacen de manera natural se separan en 8 subsitios. A partir de 2019, conocimos aproximadamente 326 ejemplares en sitios tanto autóctonos como introducidos, así como algunas semillas y plantas en varias instituciones botánicas. Al comparar sondeos históricos y recientes sobre *A. kearneyana* en los subsitios a los que teníamos acceso, la cantidad de ejemplares ha disminuido en un 48 por ciento en las últimas tres décadas.

Requisitos de hábitat y ecología

La especie *Amsonia kearneyana* nace en laderas empinadas, secas, en el bosque abierto y en amplios aluviones a lo largo de las bases secas de los cañones. Es posible que el taxón necesite la sombra del follaje de especies como *Quercus sp.* (robles) y *Pinus sp.* (pinos), así como períodos intermitentes de precipitación por encima del promedio para lograr una germinación exitosa. La especie es capaz de reproducirse tanto a través de semillas (sexualmente) como de manera vegetativa (asexualmente, a través de las raíces). La reproducción sexual de esta especie requiere polinizadores que incluyen mariposas, abejas, escarabajos, polillas y colibríes. Los polinizadores de *A. kearneyana* pueden diseminar el polen hasta a 1000 metros (0,63 millas) de los ejemplares. Por lo tanto, los requisitos del hábitat de los polinizadores también se deben tener en cuenta para la conservación de *A. kearneyana*.

Amenazas

La regla de inclusión de 1989 identificó las siguientes amenazas para *A. kearneyana*: (1) pastoreo de ganado que modifica el hábitat, (2) posible depredación de semillas por parte de *Chlorochroa ligulata*, y (3) cifras bajas y distribución limitada. En este momento, reconocemos las siguientes amenazas para la existencia continua de la especie (para conocer una descripción de los factores de inclusión, consulte la sección Motivos para la inclusión/Evaluación de las amenazas a continuación): Factor A: pastoreo de ganado mal gestionado, presencia y propagación de plantas no autóctonas, régimen alterado de incendios forestales y actividades fronterizas; Factor C: depredación de semillas; Factor E: cifras bajas y distribución limitada, sequía y cambio climático, y pisoteo por parte del ganado. Se requiere investigación para verificar y cuantificar el impacto de estas amenazas en la especie.

Prioridad de recuperación

El número de prioridad de recuperación para *A. kearneyana* es 2, lo que significa que es una especie completa con un alto grado de amenaza, pero también un alto potencial de recuperación. Las prioridades de recuperación para las especies incluidas en la lista varían de 1 a 18, y la clasificación 1 de las especies tiene la mayor prioridad de recuperación (48 FR 43098).

Meta de recuperación y visión

La meta de recuperación consiste en garantizar la viabilidad a largo plazo de *A. kearneyana* a través del aumento y la conservación de sus ejemplares, la conservación del hábitat y la reducción de las amenazas y de los factores de estrés para la especie, lo que eliminaría a *A. kearneyana* de la lista de especies amenazadas y en peligro de extinción.

Para lograr la recuperación de la especie, visualizamos que *A. kearneyana* demostrará: 1) capacidad de recuperación, al tener suficientes plantas que se presenten de manera natural y se introduzcan con éxito; y 2) redundancia y representación, al distribuirse en múltiples ubicaciones a lo largo de su estrecho rango. Las amenazas relevantes para la viabilidad a largo plazo se reducirán y el hábitat se conservará y administrará de manera tal que se mantenga una cantidad y calidad de hábitat suficientes para admitir la supervivencia a largo plazo de la especie y sus polinizadores.

Estrategia de recuperación

Nuestra estrategia de recuperación para *A. kearneyana* aborda la capacidad de recuperación, la representación y la redundancia, así como la reducción de las amenazas, factores necesarios para reducir y excluir a la especie de la lista.

Nuestra estrategia de recuperación para *A. kearneyana* consiste en:

3. Mantener una cantidad suficiente y estable o creciente (es decir, que la recuperación iguale o supere la mortalidad) de plantas en múltiples subsitios en todo el estrecho rango de la especie durante un período adecuado. Los números iniciales se pueden alcanzar mediante el aumento o el descubrimiento de subsitios existentes y/o la introducción o el descubrimiento de nuevos subsitios; sin embargo, las plantas deberán ser autosuficientes con el tiempo. Esto promueve la capacidad de recuperación (cantidad de plantas), la redundancia (cantidad de subsitios) y la representación (subsitios en todo el rango de la especie, incluida una variedad de entornos ecológicos) de la especie.

4. Implementar esfuerzos cooperativos para identificar y reducir las amenazas y conservar y administrar el hábitat en cantidad y calidad suficientes para promover la supervivencia a largo plazo de la especie y sus polinizadores.

Objetivos de recuperación

Los objetivos de la recuperación identifican resultados que conducirán a alcanzar la meta de la recuperación y la exclusión de la lista. Los objetivos de la recuperación para *A. kearneyana* son:

> <u>Objetivo basado en la población</u>: Conservar ejemplares existentes, recientemente descubiertos e introducidos de *A. kearneyana* y sus semillas (en un radio de aproximadamente 10 metros [32,8 pies] de las plantas) en todo el estrecho rango de la especie para garantizar la supervivencia a largo plazo del taxón.
>
> <u>Objetivo basado en el hábitat y la amenaza</u>: Conservar, restaurar y administrar de manera adecuada la cantidad y calidad del hábitat necesario para la supervivencia a largo plazo de *A. kearneyana* y sus polinizadores (el hábitat es un radio de aproximadamente 1000 metros [0,63 millas] alrededor de las plantas). Esto incluye reducir o prevenir la degradación del hábitat como resultado del pastoreo de ganado mal gestionado, la propagación de especies de plantas no autóctonas; la alteración de los regímenes de incendios naturales y otros factores de estrés, como la sequía causada por el cambio climático y las actividades fronterizas.

Criterios de recuperación

Nota: consulte la Sección IV, META DE RECUPERACIÓN Y VISIÓN, ESTRATEGIA, OBJETIVOS, Y CRITERIOS (págs. 34-42) para conocer las justificaciones y definiciones de los términos específicos utilizados en los criterios de recuperación a continuación.

La especie *Amsonia kearneyana* será tenida en cuenta para ser **excluida de la lista** cuando se cumplan todos los criterios siguientes:

2) <u>Criterio basado en la población</u>:
   Un mínimo de 1225 ejemplares de *A. kearneyana* en todo el rango conocido de la especie es estable o aumenta durante 15 años dentro de un período de 20 años, con una cantidad de ejemplares ≥ 1225 en los últimos dos eventos de monitoreo. Esto se mide monitoreando cada 3-5 años, utilizando un protocolo estandarizado. Con el fin de abordar las fluctuaciones anuales esperadas en la abundancia de las plantas debido a cambios en las precipitaciones, los incendios u otras causas, anticipamos y permitimos el hecho de que dos eventos de monitoreo durante el período de 20 años puedan no cumplir con estos objetivos; por lo tanto, los 15 años no necesariamente deben ser consecutivos (por ejemplo, Año 0: 1225 ejemplares; Año 5: 1000 ejemplares; Año 10: 1000 ejemplares; Año 15: 1225 ejemplares; Año 20: 1225 ejemplares). Los ejemplares de *Amsonia kearneyana* se distribuyen entre ≥ 5 subsitios conocidos, descubiertos o establecidos, y cada uno contiene ≥ 100 ejemplares. El mínimo de 1225 ejemplares se puede alcanzar de manera natural o mediante la introducción. Los Subsitios aumentados o establecidos habrán introducido con éxito las plantas (que se reproducen y tienen, al menos, 10 años). Los ≥ 5 Subsitios se pueden distribuir en uno o más Sitios.

3) Criterios basados en el hábitat:
   b) Al menos el 60 por ciento, o 1239 hectáreas (3061 acres), del total de 2064 hectáreas (5101 acres) de hábitat en el rango actualmente conocido (es decir, dentro de los sitios o cerca de ellos) admite la especie *A. kearneyana* o sus polinizadores. De las 1239 hectáreas (3061 acres), al menos el 65 por ciento (805 hectáreas; 1990 acres) debe estar en condiciones óptimas, y el 35 por ciento (434 hectáreas; 1071 acres) debe estar en buenas condiciones (consulte la sección Explicación de los conceptos y Justificación de los criterios de recuperación a continuación para obtener una descripción de los términos de calidad del hábitat).
   d) Al menos el 25 por ciento del hábitat *restante* en el rango actualmente conocido admite la especie *A. kearneyana* o sus polinizadores (Hábitat restante = Hábitat total menos Hábitat de calidad óptima menos Hábitat de buena calidad), si bien este hábitat puede ser de menor calidad.
   e) Se están desarrollando e implementando de manera parcial programas cooperativos para conservar el hábitat, las semillas y el hábitat de los polinizadores en perpetuidad para garantizar la existencia continua de *A. kearneyana*. Estos esfuerzos incluyen el intercambio de datos recopilados entre los administradores e investigadores de la tierra, así como el desarrollo y la implementación parcial de planes de gestión de la tierra que gestionen de manera efectiva las plantas no autóctonas, restauren un régimen de incendios más natural y promuevan la diversidad y el hábitat de los polinizadores.

La especie *Amsonia kearneyana* será tenida en cuenta para ser **quitada de la lista** cuando se cumpla todo lo siguiente:

2) Criterios basados en la población:
   b) Un mínimo de 1225 ejemplares de *A. kearneyana* en todo el rango conocido de la especie es estable o aumenta durante 25 años dentro de un período de 30 años (10 años más que para la exclusión de la lista), con una cantidad de ejemplares ≥ 1225 en los últimos dos eventos de monitoreo. Esto se mide monitoreando cada 3-5 años, utilizando un protocolo estandarizado. Con el fin de abordar las fluctuaciones anuales esperadas en la abundancia de las plantas debido a cambios en las precipitaciones, los incendios u otras causas, anticipamos y permitimos el hecho de que dos eventos de monitoreo durante el período de 30 años puedan no cumplir con estos objetivos; por lo tanto, los 25 años no necesariamente deben ser consecutivos (por ejemplo, Año 0: 1225 ejemplares; Año 5: 1000 ejemplares; Año 10: 1000 ejemplares; Año 15: 1225 ejemplares; Año 20: 1225 ejemplares; Año 25: 1225 ejemplares; Año 30: 1225 ejemplares).Estos ejemplares se distribuyen entre ≥ 5 subsitios conocidos, descubiertos o establecidos, y cada uno contiene ≥ 100 ejemplares. El mínimo de 1225 ejemplares se puede alcanzar de manera natural o mediante la introducción. Los subsitios aumentados o establecidos habrán introducido con éxito las plantas (que se reproducen y tienen, al menos, 10 años). Los ≥ 5 subsitios se pueden distribuir en uno o más sitios.

3) Criterios basados en el hábitat:
   d) Al menos el 75 por ciento de hábitat (1548 ha; 3826 acres) del total de 2064 ha (5101 acres) de hábitat en el rango actualmente conocido (es decir, dentro de los sitios o

cerca de ellos) admite la especie *A. kearneyana* o sus polinizadores. De las 1548 ha (3826 acres), al menos el 65 por ciento (1006 ha o 2486 acres) debe estar en condiciones óptimas y el 35 por ciento (542 ha o 1339 acres) debe estar en buenas condiciones.

e) Al menos el 40 por ciento del hábitat *restante* en el rango actualmente conocido admite la especie *A. kearneyana* o sus polinizadores (Hábitat restante = Hábitat total menos Hábitat de calidad óptima menos Hábitat de buena calidad), si bien este hábitat puede ser de menor calidad. Existe la posibilidad de mejorar el hábitat con las prácticas de gestión de la tierra.
f) Se están implementando de manera total esfuerzos cooperativos para conservar el hábitat, las semillas y el hábitat de los polinizadores para garantizar la existencia continua de *A. kearneyana*. Estos esfuerzos incluyen el intercambio de datos recopilados entre los administradores e investigadores de la tierra, así como la implementación de planes de gestión de la tierra que gestionen de manera efectiva las plantas no autóctonas, restauren un régimen de incendios más natural y promuevan la diversidad y el hábitat de los polinizadores.

Acciones de recuperación necesarias

12) Censo de subsitios conocidos de *A. kearneyana*
13) Supervisión de los ejemplares de *A. kearneyana* y su hábitat (por ejemplo, la calidad)
14) Sondeo de nuevos ejemplares y subsitios de *A. kearneyana*
15) Aumento en la cantidad de ejemplares de *A. kearneyana* en subsitios existentes
16) Establecimiento de nuevos subsitios de *A. kearneyana*
17) Adquisición o protección de los subsitios de *A. kearneyana*
18) Establecimiento y mantenimiento de semillas y plantas de *A. kearneyana* en instituciones botánicas
19) Elaboración de investigaciones relacionadas con la biología, ecología, amenazas, gestión, etc. de *A. kearneyana*
20) Supervisión de las amenazas para *A. kearneyana*
21) Reducción de las amenazas para *A. kearneyana* y gestión de la calidad del hábitat
22) Organización de actividades de divulgación, educación y coordinación relacionadas con la conservación y recuperación de *A. kearneyana*

Tiempo estimado y costo de la recuperación

Esperamos que el estado de *A. kearneyana* mejore de manera tal que podamos alcanzar los criterios para excluir a la especie de la lista en aproximadamente 25 años (esto incluye 20 años hasta alcanzar el Período de estabilidad más 5 años para descubrir o establecer más plantas). Anticipamos lograr la recuperación en aproximadamente 40 años (esto incluye 30 años hasta alcanzar el Período de estabilidad más 10 años para descubrir o establecer más plantas). En otras palabras, **2059** es la fecha aproximada para alcanzar la meta de recuperación de *A. kearneyana*. El tiempo de recuperación se basa en la expectativa de una financiación total, la implementación según lo previsto en el plan de recuperación y el cronograma de implementación, y la plena cooperación de los colaboradores.

El costo total estimado de la recuperación es de $5 743 650. Este costo incluye aquellos a cargo de organismos gubernamentales federales y estatales y de la nación Tohono O'odham, así como de otras instituciones, universidades y organizaciones interesadas en recuperar la especie *A. kearneyana*.

Los costos anuales estimados para implementar las acciones de recuperación durante los primeros 5 años son los siguientes:
Año 1 = $220 854
Año 2 = $179 281
Año 3 = $305 439
Año 4 = $210 348
Año 5 = $409 784

El costo estimado para implementar los primeros 5 años de acciones de recuperación (es decir, pasos intermedios hacia la meta de recuperación) es de $1 325 706. El cálculo del costo total estimado para la recuperación se incluye en la siguiente Tabla de acción de recuperación. El costo de la implementación de los primeros 5 años de recuperación se detalla en la Tabla del cronograma de implementación incluida aparte en la Estrategia de implementación de recuperación.

II. BACKGROUND

a. Brief Overview, Legal Status of the Species, and Recovery Planning

Amsonia kearneyana (Kearney's blue star) is a long-lived sub-shrub with clusters of white flowers that grow on dry, open, woodland slopes and canyon bottoms of southern Arizona. The species was listed as Endangered without designated critical habitat on January 19, 1989, under the Endangered Species Act (ESA) of 1973, as amended (54 FR 2131). The species is protected by the Arizona Native Plants Law as a highly safeguarded protected native plant (Arizona Revised Statutes, Chapter 7, 2007, entire).

The original Kearney's blue star (*Amsonia kearneyana*) Recovery Plan was finalized in 1993 (Service 1993, entire). Since that time, the species has been in decline and new information has been gathered over the last 25 years on the species' biology, distribution, and threats (e.g. Hazelton 2018, entire; Franklin and Aslan 2016, entire; Yost and Stromberg 2016, entire; Yost 2015, entire; and Donovan 1998, entire), therefore warranting a recovery plan revision. This information has allowed us to develop new downlisting criteria, as well as new objective and measurable delisting criteria which, when met, would result in recovery of the species.

In 2016, the Service 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 statutorily required elements (objective, measurable criteria; site-specific management actions; and estimates of time and costs), along with a concise introduction and explanation of our strategy to achieve species recovery. The RPI recovery plan is supported by a separate Species Status Assessment or similar species background document define what an SSA is. Additionally under the RPI process, a separate working document called the Recovery Implementation Strategy (RIS) is developed that provides a stepped-down schedule from the more general description of the recovery actions described in the recovery plan. The RIS describes in detail the near-term, specific activities needed to implement the 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.

Due to time constraints, for the Kearney's Blue Star (*Amsonia kearneyana*) Recovery Plan, First Revision (Recovery Plan), we used an approach to recovery planning where we combined the background species document (with life-history, threat assessment information, etc.) and the abbreviated Recovery Plan into a single document, and developed a separate RIS (Service 2019). While we did not utilize the standard three-document approach of the RPI process, our approach is streamlined and meets the statutorily required elements for recovery planning.

To help develop this Recovery Plan, we looked at the currently known range and ecology of *A. kearneyana*, the maximum distance its pollinators travel, and historical and recent survey data. We invited species experts from two Arizona universities, a private botanical firm, the Bureau of Land Management (BLM), and the Service's Buenos Aires National Wildlife Refuge (BANWR) to provide additional information on the species range, biology, and ecology and provided review of an earlier draft. We contacted the Tohono O'odham Nation (TON) and the ASLD for additional information and access to locations to gather current information on the status of the species. The data available to us from TON and ASLD is from 2013 and 2012, respectively. We relied heavily on the Phillips et al. (1982, entire), Donovan (1998, entire), and several recent reports funded through section 6 of the Endangered Species Act (Hazelton 2018a and b, entire; Franklin and Aslan 2016, entire; Yost and Stromberg 2016, entire; and Yost 2015, entire).

b. Species' Description, Life History, and Taxonomy

Description

Amsonia kearneyana is a perennial plant in the Dogbane family (Apocynaceae; McLaughlin 1982, p. 347). A subshrub with a thickened woody root, the plants' many pubescent (hairy) stems rarely branch and are up to 90 centimeters (cm; 35.4 inches [in]) tall (Service 1989, p. 2131; McLaughlin 1982, p. 347). Mature plants are nearly as wide as they are tall (Service 2012, p. 4; Service 1989, p. 2131). A mature adult may have more than 50 stems that are erect to ascending, with alternate, oblong-lanceolate (longer than broad and lance-shaped) to lanceolate (lance-shaped) leaves (Service 1989, p. 2131). The lower leaves are 1.1- 1.7 cm broad (0.4-0.7 in) with the upper leaves 3-8 mm (0.1-0.3 in) broad; all are bright green, short petioled, and soft with pubescence (Service 1989, p. 2131; McLaughlin 1982, p.347l). Leaves turn yellow in the fall making the plants easy to recognize at this time of year (Hazelton 2018a, p. 1; Yost et al. 2013, p. 3).

Large white flowers (corolla tube 1.2-1.5 cm [0.5- 0.6 in] long) tinged with blue at the base form a terminal inflorescence (define) in late April and May, also making the plants easy to recognize at this time of year (Figures 1 and 2; Donovan 1998, p. 2; Service 1989, p. 2131; McLaughlin 1982, p. 3471). Flowers are tubular in shape with a narrow corolla throat, and deeply inserted stigma and anthers (Reichenbacher pers. com. February 24, 2019). Although this prevents ready access to larger bees, it is likely that smaller bees, bombyliid flies, and other insects may access the throat to get to the nectar pool and possibly move pollen (Aslan pers. comm. March 3, 2019). In addition, hummingbirds are likely accessing nectar in the day and moving pollen (Aslan pers. comm. March 3, 2019). Hummingbirds have been noted visiting *A. kearneyana* previously (Aslan pers. comm. February 8, 2019; Reichenbacher et al. 1994, p. 27). The fruit is a follicle (dry fruit that opens along one side) born singly or in pairs at the end of stems, and develops from June through August (Service 1989, p. 2131). The follicles are terminal and extend above the foliage, making the plant also easy to recognize when fruiting (Service 1989, p. 2131). Seeds are cylindrical, corky (for water transport), and large, spanning 8-11 mm x 3-4 mm (0.3-0.4 in x 0.1-0.2 in; McLaughlin 1982 p. 347).

Figures 1 and 2. *Amsonia kearneyana* flower illustrating long corolla tube tinged with blue. Photo credit Bill Radke, U.S. Fish and Wildlife Service.

Life History

The species is capable of reproducing both through seed (sexually) and vegetatively (asexually, through roots) (Topinka et al. 2004). Sexual reproduction of this species requires pollinators. It is unknown if the species is able to self-pollinate and produce viable seed. This species exhibits limited recruitment through sexual reproduction (Phillips and Brian 1982, p. 5). The reasons behind this limited recruitment are unknown; however, seed production does not seem to be the limiting factor contributing to the limited number of seedlings in populations of *A. kearneyana* that have been visited, with seed set reported on numerous occasions (e.g. McLaughlin pers. comm. May 10, 2019; Hazelton pers. comm. May 24, 2018; B. Radke pers. comm. November 9, 2018; Yost and Stromberg 2016, p. 12; Yost 2015, p. 24-25). Germination is reported to occur easily under greenhouse conditions, especially when shade reaches 60-66 percent (Yost 2015, p. 56; Donovan and Topinka 2004, p. 3; Desert Botanical Garden 1995, p. 15; Phillips and Brian 1982, p. 6). Seed may persist for long periods of time, at least under artificial conditions (Montgomery pers. comm. June 13, 2012). Donovan (1998, p. 5) suggests *A. kearneyana* requires water for both dispersal and germination, thus reductions in precipitation in recent decades may be the limiting factor in sexual reproduction in this species (See Climate Change and Drought section below).

The lifespan of the species is unknown; however, individuals at the introduction site have been documented to persist a minimum of 30 years (Yost and Stromberg 2015, p. 21; Reichenbacher et al. 1994, p. 1). Therefore, the lifespan of *A. kearneyana* may be many decades (Topinka et al. 2004).

Taxonomy

Amsonia kearneyana was first collected by F. Thackery on May 24, 1926 (Woodson 1928, p. 415). Robert Peebles, G. Harrison, and Thomas Kearney collected it on March 29, 1927, and, on April 9, 1928, Thackery collected it again (Service 1989, p. 2131). Robert E. Woodson, Jr. described the new species in 1928, naming it in honor of Kearney who brought it to Woodson's attention (Phillips and Brian 1982, p. 1; Woodson 1928, p. 416). Woodson believed *A. kearneyana* was a hybrid between *A. standleyi* or *A. palmeri* and *A. brevifolia* or *A. tomentosa*, because of its geographic location and because seeds from the specimens provided him were sterile (Service 1989, p. 2131; Phillips and Brian 1982, p. 1; Woodson 1928, pp. 390, 416). He thought this indicated some form of reproductive incompatibility between the putative parent species. Woodson later reduced *A. kearneyana* to synonymy under *A. palmeri* (Phillips and Brian 1982, p. 2). Because Kearney and Peebles (1964, p. 653), the authors of the Arizona Flora, considered *A. kearneyana* fruits to be distinct from other species, the species was included under the original name. Woodson's conclusion that *A. kearneyana* is a recent sterile hybrid was disproved when McLaughlin (1982, p. 339) relocated the original collection locality, collected *A. kearneyana* seed, and observed 66 percent germination. McLaughlin believed that the seeds available to Woodson had been destroyed by stink bugs (*Chlorochroa ligulata*), which attack and destroy the seed embryos (Figure 3). McLaughlin (1982, p. 340) recognized *A. kearneyana* as a valid taxon and its taxonomy has not been changed since. Little work has been done on the genetics of the species; however, research supports the continued recognition of *A. kearneyana* as a distinct species (Topinka et al. 2005, p. 2).

Figure 3. *Amsonia kearneyana* seed pod with seed destroyed by *Chlorochroa ligulata*. Photo credit Bill Radke, U.S. Fish and Wildlife Service.

c. Species' Distribution

Distribution and survey efforts

Amsonia kearneyana is a narrow endemic species known from a single mountain range in Pima County of southern Arizona (Figure 4). At the time *A. kearneyana* was being considered for listing, it was only known from a single location in the riparian area of South Canyon in the Baboquivari Mountains on lands administered by the TON. From 1988 to 1992, *A. kearneyana* was established at a second location by outplanting plants propagated from South Canyon seed collection. These plants were put into lower Brown Canyon on private land that was later sold and is currently owned and administered by BANWR. Since then, discovery of new plants on lands administered by BLM and the Arizona State Land Department (ASLD) has increased the known spatial distribution of the species to include ridges in Brown Canyon, Jaguar Canyon, and Thomas Canyon.

Discovery of historical documentation from herbarium records indicates additional nearby locations on TON lands in drainages to the north and west of Baboquivari Peak. For example, L. Gooding collected a plant from Sycamore Canyon on the TON. The GIS information available to us indicates a plant locality closer to "Mundo Perdido" than Sycamore Canyon; however, we are considering this the same location at this time. NatureServe (Accessed 5-9-2018) indicates *A. kearneyana* was discovered in Sonora in 1996, citing a personal communication between R. Paredes to M. Martinez in January of 1997. As there are no known herbarium collections from this discovery, the claim requires further investigation.

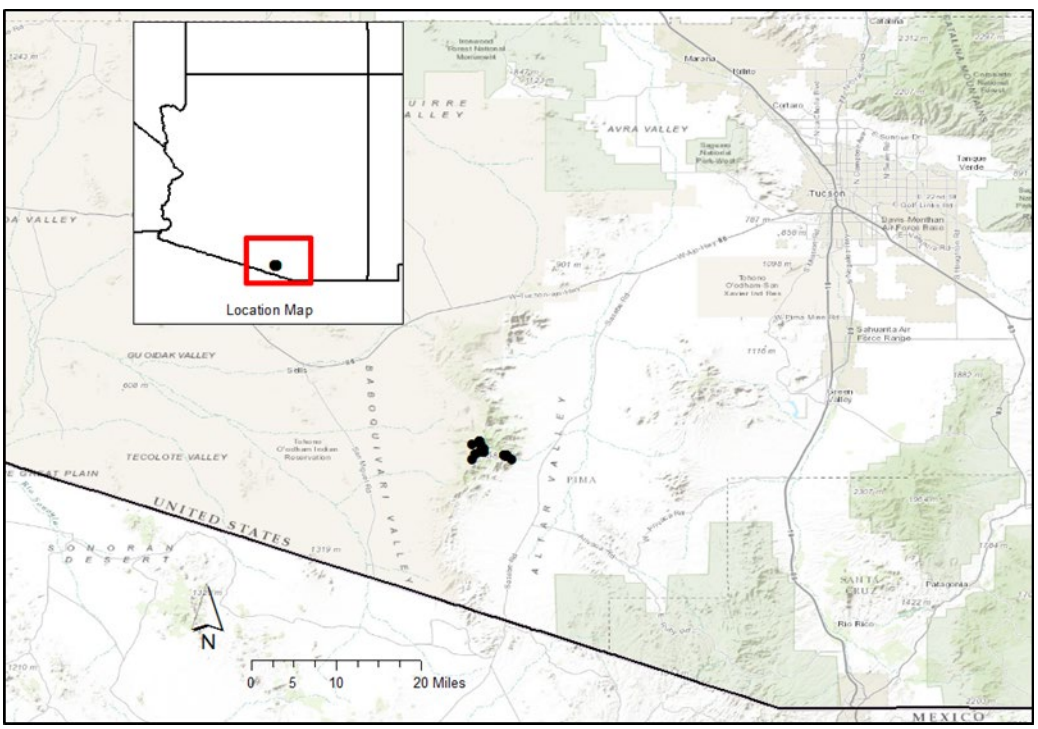

Figure 4. General location of *Amsonia kearneyana* in Pima County, AZ.

While suitable habitat is abundant on the slopes and associated drainages of the Baboquivari Mountains, *A. kearneyana* remains rare. Surveys for this species to date have yielded the following results:

- **1927**: F. Thackery collected type specimen (Woodson 1928, p. 415);
- **1927**: R. Peebles; G. Harrison, T. Kearney – herbarium collection from South Canyon (SEINet);
- **1928**: F. Thackery – herbarium collection; location undisclosed (SEINet);
- **1931**: G. Harrison and T. Swift - herbarium collection from the base of the Baboquivari Mountains (SEINet);
- **1931**: R. Peebles – herbarium collection from South Canyon (SEINet);
- **1932**: G. Harrison & T. Kearney Jr. – herbarium collection from near Baboquivari Peak (SEINet);
- **1935**: L. Goodding – herbarium collections from the Baboquivari Mountains (SEINet);
- **1941**: L. Goodding – herbarium collection from Sycamore Canyon (SEINet);
- **1979**: S. McLaughlin – herbarium collection from South Canyon (SEINet);
- **1979**: S. McLaughlin; J. Bowers, S. Sutherland – herbarium collection from South Canyon (SEINet);
- **1981**: Phillips and Brian (1982, p. 5) found 25 individual plants in South Canyon and collected a herbarium specimen; they also surveyed Baboquivari and Sycamore Canyons with no plants found;
- **1986**: Resurveys of South Canyon conducted in 1986 by U.S. Fish and Wildlife Service botanists, Bureau of Indian Affairs biologists, and others found 8 plants (Reichenbacher et al. 1994, p. 5);
- **1987**: While surveying major canyons on the east slope of the Baboquivari Mountains for suitable habitat to establish an *ex situ* population, Howell found no additional plants (Reichenbacher et al. 1994);
- **1995**: T. Ulen – herbarium collection from Brown Canyon (SEINet);
- **1996 and 1998**: Donovan's surveys of 5 canyons yielded 11 new *A. kearneyana* locations from Brown Canyon and 1 from Thomas Canyon, totaling 690 individuals (Donovan 1998);
- **2010**: Austin and other biologists documented a new location of 6 individuals in Upper Brown Canyon Middle Slope (Austin 2010b, p. 1);
- **2012**: A single previously unrecorded individual was located in route to the plants Austin had found in 2010 (Service 2012, p. 4);
- **2012 and 2013**: Yost et al., during 6 separate field visits, found only previously known groups of *A. kearneyana* in upper and lower Brown Canyon (Yost et al. 2013, pp. 4-5; Yost 2015, p. 12); they also surveyed the Thomas Canyon area, but did not reach the exact locality and found no *A. kearneyana*;
- **2016**: Franklin and Aslan made pollinator observations within the Upper and Lower Brown Canyon *A. kearneyana* locations on 14 separate dates; no new plant locations were noted during these visits;
- **2017**: Hazelton and West revisited known locations in Upper Brown Canyon, Jaguar Canyon, and Thomas Canyon on BLM lands only (Hazelton 2018a, p.1, Hazelton 2018b, entire). Due to access issues, they were not able to revisit Thomas Canyon on State lands or

any locations on the TON. They were able to locate many, but not all locations first located by Donovan in the late 1990s (Hazelton 2018a, pp. 9-11); and

- **2018**: Hazelton (2018b, entire) surveyed three southern BLM parcels ("Three Peaks", "South of La Jolla Peak", and "West of Mildred Peak") for three days, as well as the Coyote Mountains for two days and Sabino / Elkhorn Canyon for one day. No new *A. kearneyana* were confirmed, though a group of likely *A. kearneyana* were seen through binoculars in a nearby side canyon of Jaguar Canyon. Technical climbing equipment or drones would be necessary to access these plants.
- **2019**: Radke (pers. comm. April 22, 2019) conducted preliminary drone surveys in Brown Canyon, determining that the drone could detect *A. kearneyana* while in flower. However, the drone was limited to a ¼ mile and 15-minute range, suggesting a larger drone is necessary for future attempts. In addition, 9 transplanted individuals were found in a cursory search. The search team noted the area was more channelized and flashy.

Current Distribution – Sites and Subsites

Amsonia kearneyana occurs in steep, dry, open woodland slopes and coarse alluvium along dry canyon bottoms (Arizona Rare Plant Guide Committee 2001, unpaginated) and, as of 2019, on lands administered by the TON, the ASLD, BLM, and the Service (BANWR). Previous documents (e.g., the 1993 recovery plan, entire, Hazelton 2018a, entire) have referred to groups of *A. kearneyana* plants as populations or subpopulations. However, it is not fully understood what constitutes a population of *A. kearneyana* because little genetics work has been done on this subject. Therefore, to describe the current distribution of the species, herein, we use the terms site and subsite, as explained below, to describe groupings of *A. kearneyana* plants. A map showing general locations of *A. kearneyana* sites and subsites in Arizona is found in Figure 5. As future research illuminates what constitutes *A. kearneyana* populations and/or subpopulations, these terms may be utilized in place of sites and subsites.

- **Sites**:
    - Areas supporting *A. kearneyana* including a 1,000-meter (m; 0.63-mile [mi]) radius surrounding individuals that provides habitat for pollinators of *A. kearneyana*.
        - Many *A. kearneyana* pollinators (i.e., bees, butterflies, and hummingbirds) can travel 1,000 m (e.g., Aslan pers. comm., August 13, 2018; Zurbuchen et al. 2010, p. 669; Courtney et al. 1982, p. 262), therefore we use the distance of 1,000 m bounding the area around known *A. kearneyana* plants to differentiate sites herein.
        - We presume plants <u>within</u> sites interact through pollen exchange and propagule dispersal.
    - The distance between sites may vary, but we presume plants in <u>separate</u> sites do not interact through pollen exchange and propagule dispersal due to the distance between sites.
    - A site may support one or more subsites.
    - We identify two known sites: 1) Baboquivari Mountain and 2) Lower Brown Canyon Introduction (Table 1, Figure 5), the closest distance between site boundaries is approximately 1,500 m (0.93 mi).

- **Subsite:**
  - Areas within sites supporting *A. kearneyana* plants that likely share pollinators, based on groupings recognized in previous studies (Hazelton 2018a, entire; Donovan 1998, p. 8; Phillips and Brian 1982, p. 5).
    - We presume plants within and among subsites in the same site interact through pollen exchange and propagule dispersal.
  - The perimeter for each subsite is determined by bounding an area of habitat for pollinators around known *A. kearneyana* plants by 1,000 m, based on plant groupings recognized in previous studies. These groupings are based on assemblages of plants located in separate areas; the distance between the groupings varies.
  - The perimeters of subsites may overlap, but the plants within each subsite are assembled such that the groups are separated from one another, by distances that vary from 175 to 1,675 m (1.0 mi; distance measured in a straight line, not taking into account topography).
  - One or more subsites may occur within a site.
  - Plants growing within subsites can occur in different ecological settings (e.g., canyon bottom and slope; unburned and burned; xeric and mesic; open and closed canopy).
  - We identify 9 known subsites, 8 of which are within the Baboquivari Mountain Site and 1 is in the Lower Brown Canyon Introduction Site (Table 1, Figure 5). The Lower Brown Canyon Introduction Subsite and Site currently have the same boundary, but additional subsites may be established (through plant introduction) in the future within the Lower Brown Canyon Introduction Site.

Table 1. Land ownership of *Amsonia kearneyana* sites and subsites in Arizona.

Land Ownership	Site	Subsite Number	Subsite
BLM	Baboquivari Mountains	1	Upper Brown Canyon – Upper Slope
BLM	Baboquivari Mountains	2	Upper Brown Canyon – Middle Slope
BLM	Baboquivari Mountains	3	Upper Brown Canyon – Lower Slope
BLM	Baboquivari Mountains	4	Jaguar Canyon
TON	Baboquivari Mountains	5	South Canyon
TON	Baboquivari Mountains	6	Sycamore Canyon
TON	Baboquivari Mountains	7	Baboquivari Canyon
ASLD	Baboquivari Mountains	8	Thomas Canyon
BANWR	Lower Brown Canyon Introduction	9	Lower Brown Canyon Introduction

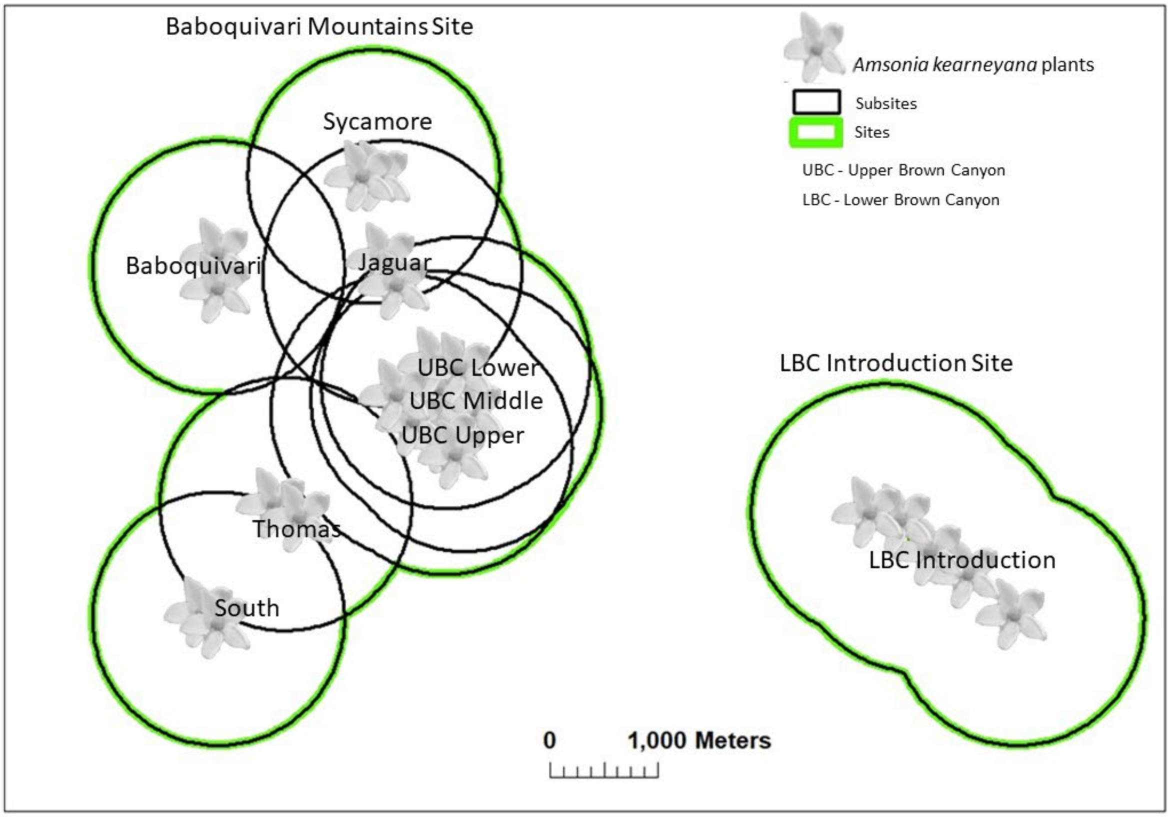

Figure 5. *Amsonia kearneyana* sites and subsites in Pima County, Arizona.

Surveys Needed

As habitat is not considered limited for this species (Donovan 1998, p. 4), additional surveys are needed to locate previously unrecorded plants and better understand the distribution of the species. Future surveys would benefit by being conducted during the period of flowering (April-May) or late season when leaves have turned yellow (November) to better aid in discovery (Donovan 1998, p. 4; Yost 2015, p. 17). In addition, the use of drones may be useful to access areas of extremely steep terrain. The presence of *Nolina microcarpa* (beargrass) in upslope populations may also be an indicator of the species that could aid in discovery of *A. kearneyana* (Austin 2010b, p. 1). It is also very important to revisit known sites, especially following the Elkhorn Fire in 2009 and Brown Fire of 2016, to determine the current status of these plants, and potential effects of fire on this species.

d. Abundance and Trends

Amsonia kearneyana is a rare, narrow endemic species. Since it was listed as Endangered in 1993, *A. kearneyana* has been discovered at new locations; however, overall the number of *A. kearneyana* individuals has decreased (Table 2) and documentation of reproduction is limited. Comparing recent and historical survey results of *A. kearneyana* at subsites to which we had access, the number of individuals has declined by about 48 percent.

Table 2. *Amsonia kearneyana* locations and numbers of individuals within the currently known range in Arizona.

Land Ownership	Site	Subsite	Historical (# of individuals; date of survey)	Recent (# of individuals; date of recount)
BLM	Baboquivari Mountains	Upper Brown Canyon – Upper Slope	190 in 1998	58 in 2017
BLM	Baboquivari Mountains	Upper Brown Canyon – Middle Slope	26 plants between 1998 and 2012	14 in 2017
BLM	Baboquivari Mountains	Upper Brown Canyon – Lower Slope	~300 plants in 1998; 43 plants in partial survey in 2012	201 in 2017
BLM	Baboquivari Mountains	Jaguar Canyon	50 in 1998	38
TON	Baboquivari Mountains	South Canyon	25 in 1981	No access granted in 2017
TON	Baboquivari Mountains	Sycamore Canyon	unknown	No access granted in 2017
TON	Baboquivari Mountains	Baboquivari Canyon	unknown	No access granted in 2017
ASLD	Baboquivari Mountains	Thomas Canyon	130 in 1998	No access granted in 2017
BANWR	Lower Brown Canyon Introduction	Lower Brown Canyon Introduction	245 in 1988-1992; 64* in 1994; 50 in 1998	15 in 2013; 0 in partial survey in 2017
Minimum Total			785	326**

*We used the 1994 survey result at the Lower Brown Canyon Introduction Site to estimate the Minimum total of historical *A. kearneyana* because this was the first survey following the period of introduction and flooding events that occurred at this site.
**The recent Minimum Total likely underestimates the number of individuals at all subsites due to lack of access in 2017 to some historically occupied subsites.

Possible reasons for declines include poorly managed livestock grazing, nonnative plant (e.g., *Bromus rubens* [red brome], *Eragrostis lehmanniana* [Lehmann lovegrass], *Melinis repens* [Natal grass]) presence and spread, altered wildfire regime, border activities, seed predation, low numbers and limited distribution, and drought and climate change (Reichenbacher 2018, p. 2; Service 2013, p. 16; Reichenbacher et al.1994, p. 5; see Section f below for more information on potential threats to the species). However, research is needed to verify and quantify the impacts of these threats on *A. kearneyana*. All of these possible reasons for decline may be contributing to seeds not germinating, and therefore lack of recruitment. While smaller plants have been found (e.g. Hazelton pers. comm. May 24, 2018), thus indicating reproduction (sexual or vegetative) has occurred, seedlings (sexual reproduction) are rare in the Baboquivari Mountains Site (Philips and Brian 1982, p. 5). In 1981, Philips and Brian (1982, p. 5) located a single *A. kearneyana* seedling among 24 adult plants in the South Canyon Subsite on TON land. In 2003, at the Upper Brown Canyon Lower Slope Subsite, while no seedlings were found, Donovan and Topinka (2004, p. 4) measured individual *A. kearneyana* plants with 4 to 70 stems per plant, indicating a range of plant sizes present and therefore reproduction in the past. Most recently, no seedlings were noted by researchers in the Upper Brown Canyon Upper, Middle and Lower Slope Subsites in 2012 (Service 2012, p. 5) or in 2017 (Hazelton 2018a, p. 6). No seedlings have been documented at the Lower Brown Canyon Introduction Site (Service 2012, p. 5; Service 2011a, entire; Reichenbacher et al. 1994, p. 29).

e. Habitat and Ecology

<u>Habitat</u>

The habitat of *A. kearneyana* lies at the lower elevation transition of the Madrean pine-oak woodland and the semi-desert grassland (The Nature Conservancy [TNC] 2006, p. 5-1; Arizona Rare Plant Guide Committee 2001, unpaginated). Within this habitat, *Amsonia kearneyana* occurs in both open woodland on unconsolidated slopes of over 20 degrees, and canyon bottoms in full sun to partial shade (Figures 6-8; Arizona Rare Plant Guide Committee 2001, unpaginated). This species is known only from the slopes and canyons of the Baboquivari Mountains of Pima County in southern Arizona at elevations from 1,095 to 1,830 m (3,600 to 6,000 feet [ft]). The Baboquivari Mountains are a granitic outcrop containing a mixture of species from four distinct floras, making this a very diverse region floristically (Austin 2009, p. 1). Donovan (1998, p. 4) states that drainage bottoms support some individuals, but most *A. kearneyana* occur on 20-30 degree slopes. Associated species in the upslope locations include sparse *Quercus emoryi* and *obolngifolia* (Emory and Mexican blue oaks), *Pinus cembroides* (Mexican pinyon pine), *Acacia greggii* (catclaw acacia), *Dasylirion wheeleri* (sotol), *Agave schottii* (shindagger agave), *Garrya wrightii* (Wright's silktassel), *Rhus trilobata* (squawbush), and *Nolina microcarpa* (beargrass). Associated species of the canyon bottom habitat include *Celtus reticulata* (netleaf hackberry), *Juglans major* (Arizona walnut), *A. greggii*, *Q. obolngifolia*, *D. wheeleri*, and *Plumbago scandens* (doctorbush) (Donovan 1998, p. 8; Ulen 1995, herbarium specimen; Phillips and Brian 1982, p. 5).

Amsonia kearneyana habitat quantity does not appear to have decreased since the time of listing, yet, despite recent surveys, only 326 individuals have been documented as of 2019. We estimate that that the known habitat for *A. kearneyana* and its pollinators is 2,064 hectares (ha; 5,101 acres [ac]); this represents the total area within both sites (Baboquivari Mountains and Lower Brown Canyon Introduction) (Table 3). Because the species is declining in number and limited in distribution, conservation of this habitat is likely key to its recovery. Currently, 756 ha (1,872 ac) of *A. kearneyana* habitat are conserved through Federal protections.

Table 3. Acres and hectares of habitat, by landowner and conservation status, within the currently known range of *Amsonia kearneyana* in Arizona.

Landowner	**Acres**	**Hectares**	**% of Total Habitat Area**
Conservation Lands			
BLM wilderness	928	375.5	18.2
BANWR	944	382	18.5
Total Conservation Lands	**1,872**	**758**	**36.7**
Other Lands			
Private	212	85.8	4.2
ASLD	1,201	486	23.5
TON	1,817	735.3	35.6
Total Other Lands	**3,230**	**1,307**	**63.3**
Total Sites Habitat Area	**5,101**	**2,064.3**	**100**

A full discussion of threats is included in the section below (Reasons for Listing/Threats Assessment); however, in summary habitat quality for the species is changing due to a combination of factors likely including poorly managed livestock grazing, nonnative plant presence and spread, and altered wildfire regime, border activities, and drought and climate change. As a result, woodland habitats, such as those that support *A. kearneyana*, are becoming more desertified with fewer trees and more grassland species associates (Service 2012, p. 1). In addition, although there are no major nonnative plant infestations known to occur within near proximity to *A. kearneyana* individuals, such infestations have been documented nearby (Radke 2019, p. 6). Changes in habitat quality have not been quantified due to lack of long-term habitat monitoring, however, such monitoring should occur. Maintaining or improving habitat quality (e.g., ensuring nonnative plants do not infest sites) is likely needed for *A. kearneyana* recovery.

Figure 6. *Amsonia kearneyana* in Upper Brown Canyon showing steep slope, unconsolidated soils, and previous associated overstory of *Quercus* sp. (here shown burned post Elkhorn Fire). U.S. Fish and Wildlife Service photo.

Figure 7. *Amsonia kearneyana* with fall foliage at the introduction site in Lower Brown Canyon. Photo credit Tyna Yost.

Figure 8. Illustrating *Amsonia kearneyana* habitat in upper Brown Canyon. U.S. Fish and Wildlife Service photo.

Pollinators

The long, tubular, early-blooming *A. kearneyana* flowers have a wide variety of pollinators. Butterflies, bee flies, mordellid beetles, hawkmoths, moths, and even broad-tailed hummingbirds have been seen visiting the plants and flowers (Reichenbacher et al. 1994, p. 25; Service 2012, p. 5). Specifically the pollinators noted visiting *A. kearneyana* plants include: skipper butterfly (Hesperidae), pipevine swallowtail (Papilionidae), gossamer-winged butterfly (Lycaenidae), sphinx moth (Sphingidae), tiger moth (Arctiidae), snout moth (Lasiocampidae), thrips (Thysanoptera), long-winged black Coleoptera, mordellid and various other beetles, broad-tailed hummingbird (*Selasphorus platycercus*) (Figure 9; Reichenbacher et al. 1994, p. 25; Reichenbacher's hand field notes from April 13, 1990, pp. 1-2); bee flies (Bombyliidae); and Arizona metalmarks (Riodinidae) (Service 2012, p. 5). Long-distance pollinators, such as larger butterflies, hummingbirds, and hawkmoths (Raguso and Willis 2003, p. 44; Schmitt 1980, p. 936), may be capable of cross-pollinating plants from between *A. kearneyana* subsites. McLaughlin (pers. comm. May 8, 2011) suspects moths may be the primary pollinator though suggests a number of generalist pollinators may be effective.

Figure 9. *Amsonia kearneyana* in pots at the Arizona Sonora Desert Museum with hummingbird pollinator. Photo credit Dr. Clare Aslan.

Climate

Amsonia kearneyana is very dependent on adequate winter precipitation for flower and seed production, seed dispersal (it has corky seeds which float in water), as well as germination and establishment (Donovan 1998, p. 5; Reichenbacher et al. 1994, pp. 32-33; Reichenbacher et al. 1991, p. 6). The lack of high winter and spring precipitation in recent decades, in combination with individual years of above average winter precipitation and associated increased insect damage to seeds (Western Regional Climate Center 2019, entire; McLaughlin 1982, p. 339), may have contributed to the lack of recruitment recorded for this species (Service 2012, p. 2; Phillips and Brian 1982, p. 7). *Amsonia kearneyana* may be similar to other arid adapted plants which may go long intervals with no establishment, punctuated by successful recruitment when rainfall is suitable (Reichenbacher 2018, p. 5; Donovan 1998, p. 5). Additional research is necessary to understand the requirements for and necessity of germination from seed in the wild.

Disturbance

The role of disturbance in *A. kearneyana* life history remains unclear, though based on unconsolidated steep slope habitat and clonal reproduction, Donovan (1998, p. 5) suggests it may require some disturbance to establish and colonize new areas. Reichenbacher (2018, p. 5) noted light to moderate disturbance by fire or grazing may be beneficial to *A. kearneyana*. Open habitat created by fire may benefit *A. kearneyana*, as plants in shadier locations tend to be further behind in growth than those growing in the open (Reichenbacher 1988-1990 field notes). Alternatively, the loss of shade plants may be preventing seedling establishment. As associated vegetation may be helpful to *A. kearneyana* (e.g., nurse plant, increase in shade and humidity) or harmful (e.g., competition). The altered, more open habitat, is greatly changed from the pre-severe fire woodland, and research will be needed to determine temperature, moisture, humidity and other environmental changes post-severe fire, as well as *A. kearneyana* response. In addition, research is needed to determine best management practices for restoration of a more natural fire regime.

f. Reasons for Listing/Threats Assessment

A number of potential threats to the species have been identified since the time the species was listed, as described below.

- The 1989 listing rule (Service 1989, p. 2132) identified the following threats to *A. kearneyana*: (1) cattle grazing that modifies the habitat (e.g., disturbs topsoil, increases erosion and flooding, decreases pollinator numbers and diversity, reduces seedling establishment, and potentially kills seedlings by trampling), (2) probable seed predation by *C. ligulata*, and (3) low numbers and limited distribution.
- The 1993 recovery plan (Service 1993, entire) reaffirmed the threats identified in the 1989 listing rule and identified catastrophic floods as an additional concern.
- The 2013 5-year review (Service 2013, pp. 5, 14-22) reaffirmed the threats identified in the listing rule and recovery plan, and identified the following additional threats: (1) alteration of fire severity and frequency, and border activity (e.g., fire starts, soil disturbance, and nonnative plant spread); and (2) climate change and drought.
- Since the 2013 five-year review, we have identified the importance of eliminating nonnative plants or reducing them to low levels, particularly grasses that increase fire severity and frequency. In addition, we also recognize the significant role of fire suppression over the last 100 years in this landscape.

In summary, we currently recognize all of the previously mentioned potential threats to *A. kearneyana*. These threats are: Factor A: poorly managed livestock grazing, nonnative plant presence and spread, altered wildfire regime, and border activities; Factor C: seed predation; Factor E: low numbers and limited distribution, drought and climate change, and trampling by livestock. However, research is needed to verify and quantify the impacts of these threats on the species. The following is a more detailed description of the listing factors.

Factor A - Present or threatened destruction, modification, or curtailment of its habitat or range:

Habitat modification is considered one of the primary threats to *A. kearneyana*. The main causes of habitat modification (livestock grazing, nonnative plants, wildfire, drought and climate change, and border activities) are discussed below.

<u>Poorly managed livestock grazing</u>
Livestock can modify *A. kearneyana* habitat in a number of ways. High levels of livestock use/grazing can impact the habitat detrimentally. For example, livestock (e.g., livestock trailing and gathering) can trample vegetation and expose and compact soil which can result in habitat erosion and alter hydrological characteristics, particularly on slopes, supporting *A. kearneyana*,

especially during severe weather events (e.g. Service 1997, p. 68). In addition, livestock grazing has the potential to reduce pollinator numbers and diversity, reduce plant cover (through herbivory and trampling), and disturb topsoil (e.g., Fleischner 1994, entire). On the other hand, low to moderate levels of livestock grazing may aid in counteracting the effects of years of fire suppression by reducing fine fuels. More research and monitoring is needed to understand the effects of livestock grazing on *A. kearneyana* habitat and to develop grazing management recommendations to benefit the species.

Below livestock grazing is discussed by landownership, however, in summary, on lands where *A. kearneyana* is known to occur, there is no current grazing on BLM and Service lands, however, livestock grazing continues on TON and State lands.

Tohono O'odham Nation lands
In South Canyon on the TON in the 1980s, domestic livestock grazing was documented showing erosion, flooding, general habitat degradation, and the reduction of understory plant cover (Figure 10; Service 1997, p. 69; Service 1993, p. 7; Phillips and Brian 1982, pp. 5, 7, 8). The current status of grazing in Baboquivari, South, and Sycamore Canyons is unknown, but the amount of grazing may have decreased in recent years (Howe pers. comm. July 31, 2013).

Figure 10. Livestock impact in South Canyon, April, 1986. U.S. Fish and Wildlife Service file photo.

BLM and Service lands
The Brown Canyon area (Upper, Middle, and Lower Slopes, Upper Brown Canyon Subsites and Jaguar Canyon Subsite) on BLM and Service lands is known to have had cattle ranching operations since the late 1800s (Kirkpatrick pers. comm. May 11, 2011). No grazing has occurred on the Service (BANWR) and BLM portions of Brown Canyon since 1993 and 1996, respectively (Service 2013, p. 15). Other BLM lands outside of Brown Canyon but within the possible range of *A. kearneyana* are still grazed (M. Radke pers. com. November 29, 2018). Historically, there have been trespass cattle noted in Brown Canyon (Donovan pers. comm. April 12, 2012; Service 1997, p. 68), however, between 2006 and 2018, no cattle were documented

(Hazelton 2018a, p. 7; M. Radke pers. comm. November 29, 2018; B. Radke pers. comm. November 29, 2018; Service 2012, p. 5; Anderson, pers. comm. May 10, 2011; Cohan, pers. comm., May 10, 2011). Potential for trespass cattle from neighboring lands remains a possibility.

Arizona State Land Department lands
Thomas Canyon on ASLD lands is leased for livestock grazing. As of 2012, the lease is for a total of 161 ha (400 ac) and is rated for 5 Animal Unit Months (Sommers pers. comm. September 9, 2012).

Nonnative plants presence and spread
Nonnative plant invasion threatens many native plant species. We have not documented the specific impacts of nonnatives on *A. kearneyan*a; however, adverse effects of nonnative plant invasion on native plants and plant communities in general are well documented. Adverse effects include increased competition for space, nutrients, and water; alteration in vegetation structure and species composition; increased fire severity and frequency; and, changes in soil chemistry, stabilization, and erosion (e.g., Crimmins and Comrie 2004, p. 464; VanDevender et al. 1997, p. 1; McPherson 1995, p. 145; Anable et al. 1992, p. 186; D'Antonio and Vitousek 1992, entire).

Although the impacts from nonnative plant invasion on *A. kearneyana* have not been documented, it is nonetheless important to prevent nonnative plant invasion, or if present, reduce or eliminate nonnative plants, particularly grasses that increase fire severity and frequency. Nonnatives such as *B. rubens* and *E. lehmanniana*, both of which occur in Brown Canyon (Radke 2019, p. 6; Austin 2010, p. 298-299), are known to alter natural fire regimes (e.g., Pyke et al. 2016, p. 310; Anable et al. 1992, p. 186). While nonnative *M. repens* does not yet appear to occur in the exact location occupied by *A. kearneyana* within Brown Canyon, its expansion within Brown Canyon is of concern (Radke 2019, p. 6). *Melinis repens* may impact soil characteristics and increase fire spread and frequency and subsequent soil erosion (B. Radke pers. comm., November 9, 2018; Center for Agriculture and Biosciences International 2017, entire; Romo et al. 2012, p. 35). Higher severity fires can remove the overstory canopy, which results in higher evaporation, loss of soil moisture, and a shift in species composition from a dominance of *Quercus* (oak) spp. to dominance of smaller drought and fire tolerant shrubs. It is presumed that the resultant reduction in soil moisture and shade may impact *A. kearneyana* germination and survival (Yost and Stromberg 2016, pp. 21, 35).

In conclusion, nonnative species have been documented within and near areas supporting *A. kearneyana*; however, as of 2019, we do not know the distribution and abundance of nonnatives in these areas and do not know if they are affecting species viability. Because nonnatives have many impacts on native plant communities, they should be carefully monitored and managed within *A. kearneyana* sites and nearby areas.

Altered wildfire regime
Wildfire likely has mixed effects on *A. kearneyana*. The species evolved with frequent, low severity fires, which remove fine fuels thus benefitting the *A. kearneyana* in a number of ways (e.g., increased in nitrogen, reduced competition). However, high severity fires may be

detrimental to the species and its habitat. For example, indirect impact of high severity fire may include hydrophobic soil, increased runoff of floodwaters, post-fire flooding, deposition of debris and sediment originating in the burned area, erosion, changes in vegetation community composition and structure, increased presence of nonnative plants, alterations in the hydrologic and nutrient cycles, and loss of overstory canopy shade essential for maintaining microhabitat of the species (Stephens et al. 2014, p. 42; Hart et al. 2005, p. 167; Smithwick et al. 2005, p. 165; Crawford et al. 2001, p. 265; Griffis et al. 2000, p. 243). Years of fire suppression, coupled with nonnative plant occurrence, removal of livestock in recent decades, drought and climate change, and illegal border activities (see Factor E) that result in increased fire starts, have resulted in more frequent, severe fires in the Baboquivari Mountains. More research into the impacts of high severity fire on *A. kearneyana* and its habitat is needed, as well as, how to move toward a more natural fire cycle.

The habitat of *A. kearneyana* lies at the lower elevation transition of the Madrean pine-oak woodland and the semi-desert grassland (Arizona Rare Plant Guide Committee 2001, unpaginated; TNC 2006, p. 5-1). Pre-1880 Madrean pine-oak woodlands had widely spaced pines and oaks, with pines dominating the overstory and abundant perennial bunch grasses covering the ground (Barton et al. 2001, p. 366; Fulé and Covington 1998, p. 197; Swetnam et al. 1992, p. 166). The historical fire regime of the Madrean pine-oak woodland is one of frequent low severity surface fires in the early spring and summer that moved through areas spanning elevations from semi-desert grasslands through montane conifer systems (TNC 2006, p. 5-4). Based on the size and growth rate of pine trees in Brown Canyon, it is estimated that fire had been absent from this area for more than 100 years due to fire suppression (Reichenbacher pers. comm. February 24, 2019, p. 2; Wilson pers. comm. May 22, 2012) until recent fires occurred in 2009 (the Elkhorn Fire) and 2016 (the Brown Fire). Austin noted that long-time ranchers who were interviewed by him have not seen fire in this canyon in their memory (Service 2012, p. 5.). The 100-year timeframe coincides with the history of cattle grazing in the canyon (Kirkpatrick pers. comm. May 11, 2011). Austin (2010, p. 8) also notes significant tree harvesting in the Baboquivari Mountains historically, which likely altered forest structure, fire regimes, and understory diversity.

Because *A. kearneyana* apparently evolved with this frequent, low severity fire regime, it may rely on such fire to reduce competition and allow for colonization of new sites (Service 2009, p. 7; Reichenbacher pers. comm. February 24, 2019, pp. 4-5). The species has a creeping rhizome that can recover from disturbance, and other species in this genus and family are known to respond positively from the effects of fire (i.e. Duncan et al. 2008, p. 44). The benefit of the nitrogen pulse and/or reduced competition following fire is shown in the increased plant size and general vigor of *A. kearneyana* individuals following the 2009 Elkhorn Fire, which affected areas including Upper Brown Canyon Upper Slope, Middle Slope, and Lower Slope Subsites, South Canyon, and Jaguar Canyon Subsites in the Baboquivari Mountains Site and Lower Brown Canyon Introduction Site (Service 2012, p. 4; Cohan pers. comm. April 27, 2011, p. 2; Donovan and Topinka 2004, p. 4; Reichenbacher et al. 1994, p. 23).

The Brown Fire of 2016 burned through the Upper Brown Canyon Upper Slope, Middle Slope, and Lower Slope Subsites, South Canyon, Thomas Canyon, and Jaguar Canyon Subsites in the Baboquivari Mountains Site and Lower Brown Canyon Introduction Site; however, we do not know how this has affected plants at these subsites. Between 1994 and 2017, there was nearly a 48 percent loss of *A. kearneyana* individuals across subsites (Table 2). We do not know if the Elkhorn or Brown fires, historical fire suppression, competition, drought, or other unknown causes, or a combination of these factors resulted in this loss. It is impossible to draw conclusions about fire frequency and severity impacts to *A. kearneyana* without intermittent and post-fire survey data available.

Research into fire severity impacts on *A. kearneyana* is needed. For example, following recent high severity fires, there has been a documented loss of *Quercus* and *Pinus* shade trees in the immediate vicinity of this plant (Figure 11). This loss of shade likely impacts microhabitat through higher evaporation, temperature, and loss of soil moisture, changes in mycorrhizae, and a shift in species composition from a dominance of *Quercus* spp. and *Pinus* spp. to dominance of smaller drought and fire tolerant shrubs. The Desert Botanical Garden noted in captivity this species does best with 60 percent shade and recommended planting within the gardens in areas with shade (Desert Botanical Garden 1995, p. 15). Similarly, Yost (2015, p. 56) noted that 66 percent shade was most conducive to seedling survival in her *A. kearneyana* experiments. Therefore, it is important to gain an understanding of how the post-high severity fire shift in vegetation community to a drier and hotter microenvironment impacts *A. kearneyana* reproduction and survival.

Figure 11. Habitat of *Amsonia kearneyana* in Upper Brown Canyon following the 2009 Elkhorn Fire. Illustrating loss of native *Quercus* species. Service photo April 2012.

<u>Border Activities</u>
The southern portion of *A. kearneyana* habitat is located approximately 34 kilometers (km; 21 mi) from the U.S.-Mexico border. Over the past decade or more, tens of thousands of people, known as cross-border violators, have illegally attempted crossings of the border into Arizona annually (Service 2011b, p. 14). With respect to threats to *A. kearneyana* caused by activities along the border, there is a Memorandum of Understanding (U.S. Department of Homeland Security et al. 2006, entire) and a Biological Opinion (Service 2007, entire) that include measures aimed at reducing effects to resources in the border region from border activities. These documents provide some relief to the species from the threats caused from cross-border violators and United States Border Patrol (USBP) law enforcement activities. In general, Customs and Border Protection and USBP efforts to stop cross-border violators in recent years by means of traffic barriers and other infrastructure have greatly reduced cross-border violator activities and afforded some protection to habitat, especially in the lower grassland areas to the east of the *A. kearneyana* populations. However, due to the difficulty and ever-changing status of border activities, compliance with these agreements has been difficult. The cross-border violator activities are, by their very nature, in violation of the law and regulations, and often occur in remote, unseen areas. Therefore, we believe that regulations designed to protect the species and its habitat will be generally of little impact to alleviate the threats caused by border activities.

This illegal activity is often followed with a law enforcement response by USBP and other Federal agencies. Both the crossings and the respondent law enforcement activity may cause adverse effects to listed species through direct mortality or the degradation of habitat by creating new roads and trails, disturbing vegetation and soils, and moving exotic plant seeds or plant parts, which may lead to their spread into unoccupied areas (Duncan et al. 2010, p. 124). *Amsonia kearneyana* is located in rugged habitat that precludes driving off road; therefore any impact incurred by these activities would be primarily on foot. In addition, cross-border violator warming and cooking fires may spread out of control causing damage to *A. kearneyana* habitat.

A 2007 Biological Opinion regarding BANWR, which incorporates a portion of the *A. kearneyana* population, notes that some illegal traffic occurs near known populations of *A. kearneyana* (Service 2007, p. 41). To date however, no *A. kearneyana* plants have been reported to be impacted by this activity, though reporting is inconsistent. Because of the frail nature of the steep slopes on which *A. kearneyana* grow, foot traffic through any subpopulation could cause damage to individual plants and habitat. *Amsonia kearneyana* has the ability to re-sprout from low to moderate levels of disturbance and may require such disturbance to establish and colonize new areas (Service 2012, p. 5; Donovan 1998, p. 5). Disturbance of soil, however, may lead to erosion in the unconsolidated steep slope habitat of *A. kearneyana*. Research into erosion impacts on this plant is needed.

Factor B - Overutilization for commercial, recreational, scientific, or educational purposes:

Amsonia kearneyana has reportedly been used medicinally by the TON (Desert Botanical Garden 1991, p. 1). However, there are currently no known concerns with overutilization of this species and therefore it is not considered a threat to the species.

Factor C - Disease or predation:

Currently, disease and predation are not considered primary threats to *A. kearneyana*. Disease has not been documented in the species; however, predation has been documented and remains a potential concern that requires monitoring and research. In 1926, 1927, and 1928, herbarium collections were made of *A. kearneyana* in South Canyon of the Baboquivari Range. Robert Woodson, who described the species, determined from these specimens that the plants were a sterile hybrid based on sterile seeds. Steve McLaughlin, in 1978 made observations of increased insect activity following wet winters in 1978 and 1979 and suggested the earlier specimens were not sterile, but had been hindered by *C. ligulata*: Pentatomidae) predation (McLaughlin 1982, p. 339). *Chlorochroa ligulata* is a native insect predator. Predation by *C. ligulata* was reported again in 2016, when researchers suggested roughly one tenth of *A. kearneyana* seeds produced were predated (Yost and Stromberg 2016, p. 12), and by Radke in 2018 (B. Radke pers. comm. November 9, 2018).

As suggested above, increased insect predation activity on *A. kearneyana* appears to be correlated with wet years. Although no data are available from nearby weather stations for the 1926-1928 time period, these three years were wetter than average at Cochise Stronghold to the east and two of the years were wetter than average at the Yuma Date Orchard weather station to the northwest (Western Regional Climate Center 2011, entire). In 1978, at the nearby Kitt Peak Weather Station, more than double the average precipitation was recorded (43.7 inches vs. 22.2 inches average from 1961-2018) (Western Regional Climate Center 2019, entire). In 2016, also at Kitt Peak Weather Station, the annual precipitation was below average (19.11 inches vs. 22.2 inches average; Western Regional Climate Center 2019, entire). In 2018, annual precipitation was slightly higher than average (23.3 vs. 22.2; Western Regional Climate Center 2019, entire).

While livestock grazing may potentially impact *A. kearneyana* habitat, as discussed under Factor A above, evidence of browsing of *A. kearneyana* has not been documented, likely because the plant produces toxic latex (McLaughlin pers. comm. May 10, 2018; McLaughlin pers. comm. May 8, 2011; Juárez-Jaimes et al. 2007, p. 460; Phillips and Brian 1982, p. 9; Woodson 1928, p. 384).

Factor D - Inadequacy of existing regulatory mechanisms:

Currently, the inadequacy of existing regulatory mechanisms is not considered a primary threat to *A. kearneyana*; however, some concerns with the strength of these mechanisms remain. Existing regulatory mechanisms may be adequate for protection of this plant on BLM and BANWR lands; however, it is uncertain if regulatory mechanisms are strong enough to protect plants on the ASLD, private, and TON lands. Additionally, the lack of funding and personnel to implement and enforce the regulatory mechanisms (e.g., ESA, Arizona Native Plants Law) is a concern.

Factor E - Other natural or manmade factors affecting its continued existence:

<u>Low numbers and limited distribution</u>
Amsonia kearneyana has a very restricted geographic range with a small number of known subsites ranging in size from a 14 to 201 individuals (Figure 12; Hazelton 2018a, p. 4; Yost et al. 2013, p. 5) and limited recruitment through sexual reproduction. Small, reproductively isolated populations are susceptible to the loss of genetic diversity, genetic drift (a change in the frequencies of alleles in a population over time), and inbreeding depression (the loss of fitness among offspring of closely related individuals). The loss of genetic diversity may reduce the ability of a species or population to resist pathogens and parasites, to adapt to changing environmental conditions, or to colonize new habitats. The net result of the loss of genetic diversity is likely to be a loss of fitness and lower chance of survival of populations and of the species. Genetic drift can arise from random differences in founder populations and the random loss of rare alleles in small isolated populations. Genetic drift may have a neutral effect on fitness, but is also a cause of the loss of genetic diversity in small populations. While most animal species are susceptible to inbreeding depression, plant species vary greatly in response to inbreeding.

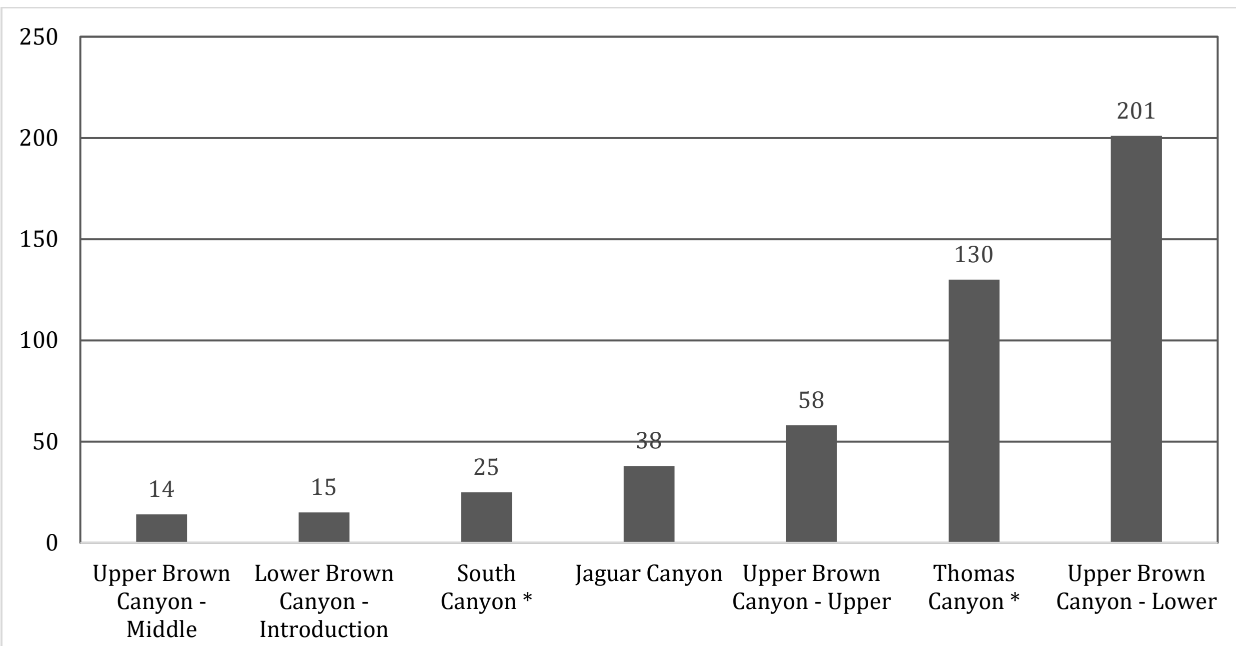

Figure 12. Number of *Amsonia kearneyana i*ndividuals at subsites. Note that a) *South Canyon and Thomas Canyon numbers were derived in 1990s surveys and b) the Baboquivari and Sycamore Canyons Subsites have never been counted and therefore are not included here. Per recent surveys, we can only confirm the 326 individuals from Upper Brown Canyon Upper, Middle, and Lower Slopes, Jaguar Canyon, and the Lower Brown Canyon Introduction Subsite.

Small populations are less able to recover from losses caused by random environmental changes (Shaffer and Stein 2000, pp. 308-310), such as fluctuations in reproduction (demographic stochasticity), variations in rainfall (environmental stochasticity), or changes in the frequency or severity of disturbances, such as wildfires. Levels of loss of genetic diversity, genetic drift, and inbreeding depression for *A. kearneyana* are unknown, but it is known that small population size exacerbates these population genetics issues. Additionally, *A. kearneyana* exhibits limited recruitment through sexual reproduction, while this species is not the only plant in south-central Arizona that produces apparently adequate numbers of propagules but few or no progeny (Reichenbacher pers. comm. February 24, 2019, p. 3-4), limited recruitment (via seed) could also affect its genetic diversity. To adapt to rapid human induced environmental changes, sexual reproduction may become more important than it was in the past (Fehlberg pers. comm. February 28, 2019).

The limited distribution of *A. kearneyana* makes the species more susceptible to extinction due to catastrophic events (e.g., wildfire or severe drought). Furthermore, while some stressors (e.g., trampling, erosion, creation of firebreaks, maintenance of recreational trails, freezing and flooding events) may not necessarily have large effects by themselves, in combination with small population size and limited distribution, they have the potential to lead to extirpation of plants at sites or subsites.

<u>Climate change and drought</u>
Climate change is likely to adversely affect the long-term survival and distribution of native plant species, including *A. kearneyana*, through changes in temperature and precipitation. The Southwestern United States is warming and experiencing severe droughts of extended duration, decreased stream flows, changes in amount and timing of snow melt, and changes in timing and severity of precipitation and flooding (CLIMAS 2014, entire). Southeastern Arizona and much of the American Southwest have experienced serious drought in recent decades (CLIMAS 2014, entire; Garfin et al. 2013, p. 3; Bowers 2005, p. 421). Precipitation is projected to decrease in the future with climate change, although it is expected to be more intense when it does occur (Karl et al. 2009, pp. 24, 33; Seager et al. 2007, p. 1181). Continuing drought, increased temperatures, and increased evapotranspiration may lead to loss of vegetation cover and shade through the dying of overstory trees stressed from the reduction of available water or from insect predation or wildfire, both of which may increase under these circumstances.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as anthropogenic process, to evaluate observed and project future changes in climate conditions (i.e. temperature, sea level, etc.). However, there is uncertainty in these natural and anthropogenic processes and possible trajectories in the future. Consequently, a multi-model approach with a range of assumptions about the magnitude and pace of future emissions helps scientists develop different emission scenarios. Some projections suggest an overall similar amount of precipitation in the Southwest, but that it will be distributed differently in timing and intensity (Zhang et al. 2012, p. 390). Most climate change scenarios predict that the American Southwest will also become warmer during the 21st century (Overpeck et al. 2012, p. 5; Karl et al. 2009, p. 129). A map of past and projected mean daily maximum temperature was created using Climate Explorer for Pima County, where *A. kearneyana* occurs (Figure 13).

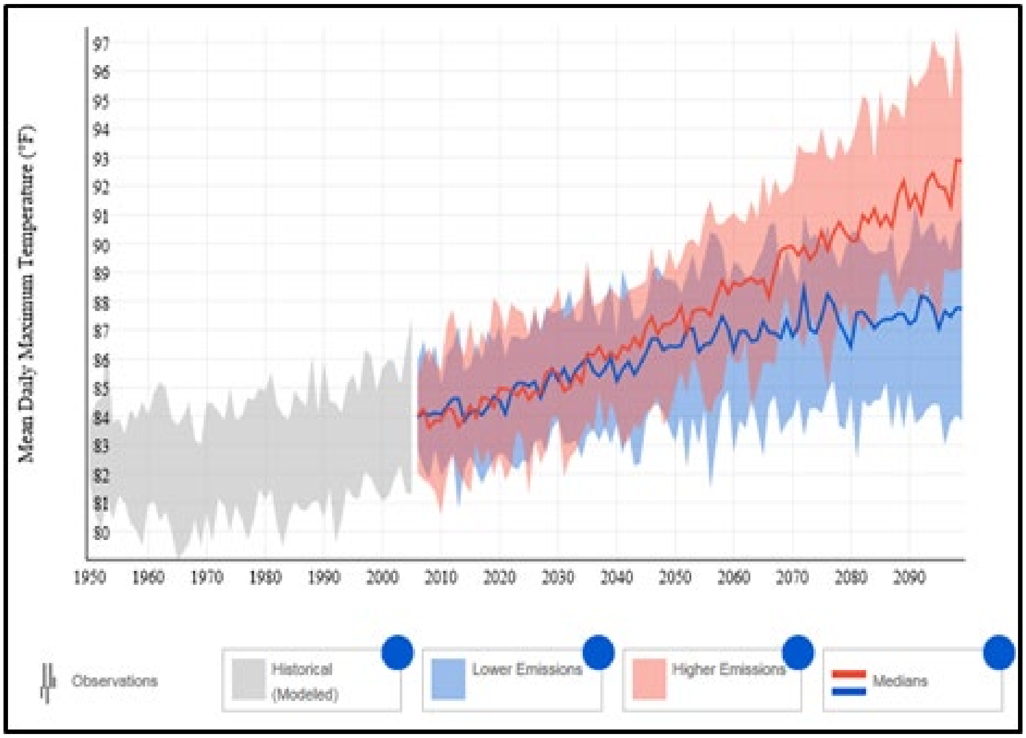

Figure 13. Past and projected mean daily maximum temperature in Pima County, Arizona under RCP4.5 (lower) and RCP8.5 (higher) emissions scenarios.

With experienced and predicted climate change come several possible impacts to *A. kearneyana* including:

1) **Earlier and more frequent freezes in the spring.** Spring onset has important consequences for plant phenology, as well as variability in streamflow, drought, and wildfire activity (Ault et al. 2011, p. 4003). In the western United States, as in other areas of the world, spring onset has been advancing every decade for the past 50 plus years (Cayan et al. 2005, p. 3; Ault et al. 2011, p. 4003). Although studies are hesitant to make a direct correlation with global climate change, it is possible this trend will continue in the future. If leaf or flower buds are initiated earlier, they will be more vulnerable when frost occurs (Inouye 2008, p. 354). Many plant species have frost-sensitive buds, ovaries, and leaves, and can produce fewer flowers and seeds due to frost damage during times of the year when frost is unusual (Inouye 2000, p. 457).

   Amsonia kearneyana is one of the earliest flowering species in Brown Canyon (Austin pers. comm. January 23, 2013). Unusual frost events experienced in the spring of 2011 and 2013 negatively affected *A. kearneyana* observed in the Lower Brown Canyon Introduction Site (Cohan pers. comm. February 22, 2013; Cohan pers. comm. May 16, 2011). There was also evidence of the 2011 frost damage in plants at the Baboquivari Site visited in April 2012 (Service 2012, p. 6). These frost events occurred during January, before flowering commenced. While *A. kearneyana* is frost intolerant, plants recovered from these documented losses of all spring foliage by re-growing new stems and leaves from a large rootstalk (Cohan pers. comm. May 16, 2011). The impact remains unknown of more frequent or later season freezes on the specie's ability to re-sprout or produce flowers or seeds.

2) **Increased intensity of storm events.** In the past 50 years, the intensity of springtime storm events in the southwestern United States has increased (Groisman et al. 2004, p. 77). Climatic projections for the southwestern United States indicate both increased summer drought coupled with more intense periodic rainfall events (Zhang et al. 2012, p. 390; Karl et al. 2009, p. 24). Such extreme rainfall is projected to increase runoff and soil erosion (Zhang et al. 2012, p. 390). Fire can also increase hydrophobicity of soil in the first few years following fire (DeBano 1990, p. 6; Campbell et al. 1977, p. 3); this may also increase runoff in the Brown Canyon area.

   The severity of storm disturbance greatly influences severity of impact to plant species. *Amsonia kearneyana* is known to be impacted by flooding, as evidenced by the loss of roughly 75 percent of the plants in the Lower Brown Canyon Introduction Site due to extreme flood events during the early 1990s (Reichenbacher et al. 1994, p. 2). In addition, in April, 2019, it was reported this area is now more channelized and flashy (M. Reichenbacher pers. comm. April 22, 2019). An increase in the intensity of seasonal flooding could reduce or even remove subpopulations growing in canyon bottoms and severely damaged slope-side subpopulations due to erosion of their associated friable soils.

3) **Increased probability of summer drought**. The southwestern region of the United States has experienced drought conditions since 1998 (Bowers 2005, p. 421; CLIMAS 2017, p. 1). Annual mean precipitation levels are expected to decrease in western North America and especially the southwestern states by midcentury (IPCC 2013, p. 45; Seager et al. 2007, p. 1181). Drought negatively impacts *A. kearneyana* flower and seed development, germination, and seedling survival. Reichenbacher et al. (1994, p. 18) noted that aridity and record daytime maximum temperatures caused flower abortion in the *A. kearneyana* Introduction Site in the spring of 1989. Radke, in her 2010 observations of 5 Baboquivari Site *A. kearneyana* plants, noted 42 whole and 33 partial fruits that, for unknown reasons, were not fully developed (M. Radke, pers. comm. May 10, 2011). No other mentions of flower or fruit abortion were found in the records; however, there is mention of few or no seedlings present in several reports (Service 2012, pp. 2-3; Service 2011b, entire; Reichenbacher et al. 1994, p. 29; Phillips and Brian 1982, p. 6). Donovan (1998, p. 5) notes the necessity of adequate precipitation for establishment.

4) **Increased potential for fire with increased drought**. Warming and drying in the southwestern United States over the past 50 years have led to increased fire potential (Groisman et al. 2004, p. 81). The impacts of fire of varying severity have not been studied in *A. kearneyana*. From visiting two sites following the 2009 Elkhorn Fire, we know that this species can resprout vigorously following at least some level of fire severity. The decrease in plant numbers within populations visited more than once may or may not have been related to fire. Fire coupled with drought can lead to vegetation community type conversion, as is taking place in the Baboquivari Site following the Elkhorn burn. Fire coupled with severe storms can lead to flooding and erosion of unstable slopes, either of which can negatively impact *A. kearneyana* plants. Fire has

also been associated with increases in invasive exotic plant species abundance (Ford et al. 2012, p. 82; Brooks and Pyke 2001, p. 5). Should any invasive exotic grass species, for example, become established in the Brown Canyon area post-burn, these could impact *A. kearneyana* plants through direct competition for resources, as well as perpetuating a rapid return fire cycle. To date, no exotic plants have been reported near *A. kearneyana* plants.

Livestock trampling
In addition to potential livestock grazing impacts to *A. kearneyana* habitat discussed under Factor A above, livestock or javelina trampling of individual plants has also been noted (Reichenbacher 1988, p. 1). However, this may not have long-term impacts to the species due to vegetative reproduction and resprouting potential.

g. Conservation Efforts

Laws and Land Protection
The species is protected by various laws, including the ESA (e.g., section 7 consultation when there is a Federal nexus), as well as, the Arizona Native Plants Law, under which the species is listed as a highly safeguarded protected native plant (Arizona Revised Statutes, Chapter 7, 2007, entire). The Arizona Native Plants Law prohibits collection without obtaining a permit on all public lands, but does not protect habitat. The species is included on BLM's sensitive species list which requires BLM to promote the conservation of such species, similar to section 7(a)(1) of the ESA. In addition, the species occurs partially on federally-managed lands that provide protection as wilderness (BLM) and wildlife refuge (BANWR); these lands are not grazed by domestic livestock.

Botanical Gardens and Outplanting
Recovery actions listed in the 1993 Recovery Plan include the establishment of *A. kearneyana* plants in botanical institutions, outplanting in appropriate habitat, and the preservation of seed for future conservation efforts. Many efforts have been made to implement these actions. Table 4 provides a history of seed collection, germination, outplanting, and storage of either seed or plants at Botanical Institutions.

Table 4. History of *Amsonia kearneyana* seed collection and storage, germination, and outplanting.

Year	Event	Citation
1979 - 1981	Steve McLaughlin of the University of Arizona collected *A. kearneyana* seed from South Canyon on the TON.	Desert Botanical Gardens note card scans
1980s	Steve McLaughlin used both field beds and greenhouses at the University's Natural Products Center (formerly Sunnyside Junior High School) to grow *A. kearneyana* seed into plants, reporting a 66 percent germination rate.	McLaughlin 1982, p. 339; McLaughlin pers. comm. May 10, 2018
1980s	As plants grown at the Natural Products Center from wild collected seed "seemed true to wild *A. kearneyana* in all diagnostic features", when these	McLaughlin pers. comm. May 10, 2018; McLaughlin 1986, entire

Year	Event	Citation
	plants set seed, the seed was collected and distributed to Arizona Sonora Desert Museum and the Desert Botanical Garden, as well as was kept at the Natural Products Center.	
1986	The Arizona Sonora Desert Museum reported 50 percent *A. kearneyana* germination rate.	McLaughlin 1986, entire
March, 1988	Seventy-six one-year-old *A. kearneyana* plants in one-gallon pots grown at the Arizona Sonora Desert Museum were used in the initial outplanting in Lower Brown Canyon. Between March 29, 1988, and November 16, 1993, the Introduction Site was visited 70 times to: monitor growth and reproduction, artificially water (Figure 14), add fertilizer, and add pesticide to the plants when necessary. Each plant was marked with an aluminum tag and measures of height, diameter, and reproductive status taken on 41 occasions during the 5-year period (Figure 15).	Reichenbacher et al. 1994, pp. 13, 21, 22; Reichenbacher et al. 1991, p. 9 Reichenbacher 2019, p. 1
January 1989	Due to poor survival at the Introduction Site, an additional 105 *A. kearneyana* individuals were planted.	Reichenbacher 2019, p. 1; Reichenbacher et al. 1994, p. 2
June 1990	Flooding eliminated roughly 75 percent of the *A. kearneyana* at the Introduction Site.	Reichenbacher et al. 1994, p. 2
1991	The Desert Botanical Garden Reports having 34 living *A. kearneyana* and 459 seed represented from the South Canyon collection. Researchers there underwent freezing and pollination experiments this year. Planning for additional pollination experiments and seed viability testing on 5-year old frozen seeds in 1992.	Desert Botanical Garden 1991, entire
January 1992	A third planting of 69 *A. kearneyana* individuals was undertaken at the Introduction Site.	Reichenbacher 2019, p. 1
July 1992 & January 1993	Additional floods resulted in further loss of plants at the *A. kearneyana* Introduction Site.	Reichenbacher et al. 1994, p. 2
1993	The Desert Botanical Garden cultivated *A. kearneyana* from seed collected from plants grown at the University's Natural Products Center. They have in possession 439 field collected seed, 642 seeds produced in cultivation, 46 plants from field collected seeds, and 7 cutting from 5 individuals. They also attempted to produce plants via cuttings using various hormone levels. In addition, crosses between *A. kearneyana* and *A. grandiflora* were attempted with minimal seed produced.	Desert Botanical Garden 1993, pp. 16-17
November 1993	Searches revealed 64 of the 245 total introduced individuals survived.	Reichenbacher et al. 1994, p. 19
1994	The Desert Botanical Garden reports adequate seed from known populations of *A. kearneyana* are in	Desert Botanical Gardens 1994, unpaginated

Year	Event	Citation
	standard long-term storage, that seed can be easily propagated, ad that propagation from cutting is poor.	
June 1996	The Desert Botanical Garden requested an amendment to their permit from the Service to collect seed from the Brown Canyon Lower Slope *A. kearneyana*.	Desert Botanical Garden 1996, entire
2002	Thirty-eight *A. kearneyana* plants were still tagged and monitored on an annual basis at the Introduction Site.	Donovan and Topinka 2004, p. 4
2009	Monitoring occurred at the Introduction Site following the Elkhorn Fire, which burned at low to moderate severity through this location. 21 *A. kearneyana* plants had resprouted and were reported to be robust.	Franklin and Aslan 2016, p. 15; Cohan pers. comm. April 27, 2011;
2011	The Arizona Sonora Desert Museum tested *A. kearneyana* seeds from 26 different seed accessions (1986-1988), with germination rates varying from 0 to 64 percent, and an average of 7.3 percent. Note that McLaughlin suspected with the porous seed coat, seed would be susceptible to fungal pathogens and short-lived.	McLaughlin pers. comm. May 10, 2018; Montgomery pers. comm. June 13, 2012; Wilson pers. comm. May 22, 2012
June 2012	The Arizona Sonora Desert Museum has 39 one-gallon potted *A. kearneyana* individuals grown from both wild collected and first-generation collected seed. There are plans to collect seeds from these individuals should they become available.	Montgomery pers. comm. June 13, 2012
August 2013	M.S. student, Tyna Yost, collected one or two fruits per *A. kearneyana* plant in each year to determine number of seeds per fruit and thus per plant. These and other seed were used in later germination trials.	Yost 2015, p. 16
November 2013	The Desert Botanical Garden tested 36 *A. kearneyana* seeds collected by Tyna Yost in August 2013, reporting an 11 percent germination rate.	Blackwell pers. comm. April 1, 2019
2014	Additional *A. kearneyana* seeds were collected, air dried, and planted in September 2014. Germination tests revealed the following results: experiments using freshly collected seeds produced a 36 percent germination rate (24 percent of these survived to 20 weeks), while experiments using 18 17-year-old seed achieved 61 percent germination rate. Germination was highest in seeds sewn on the surface indicating seed buried by erosion, rain events, etc. in the wild may not germinate.	Yost 2015, p. 55
2016	The Arizona Sonora Desert Museum has 9 *A. kearneyana* plants growing on the grounds and 40 plants in the nursery.	Arizona Sonora Desert Museum 2016, p. 44
2018	The Desert Botanical Garden has 3 *A. kearneyana* plants growing from 1986 collected seed that were propagated sometime between 1986 and 1992.	Blackwell pers. comm. May 9, 2018

From this work, we have learned much from previous attempts at germination and outplanting. Supplemental water provided by researchers during and following the introduction undoubtedly aided in initial survival of many of these individuals (Figures 14 and 15). Any future outplanting would likely also require supplemental water for establishment of potted plants. In addition, trials of direct seeding (e.g. with protective fine mesh caging) should be attempted to augment subsites and create new sites at reduced cost and commitment of botanists. Reichenbacher (2018, p. 6) noted that future outplanting should focus on selecting areas on north and east-facing margins of the canyon bottom, above the inundation zone, that are slightly more mesic than the slopes.

Figures 14 and 15. Images from the March 1988 outplanting at the Lower Brown Canyon Introduction Site. Photo credit Frank Reichenbacher.

<u>Survey Efforts</u>
Recovery actions listed in the 1993 Recovery Plan include additional survey efforts. As described in Section c above, survey efforts have yielded discovery of additional groups of *A. kearneyana* on both sides of Baboquivari Peak. Despite multiple survey efforts and new locations, the species remains very isolated and in very small numbers.

<u>Research</u>
Recovery actions listed in the 1993 Recovery Plan include gathering biological information needed to describe habitat requirement and determine management decisions. In this regard, several recent studies have investigated pollination and seedling establishment (e.g. Yost 2015, entire; Franklin and Aslan 2016, entire). Many more questions remain (see Biological Constraints and Needs - Research Needs).

h. Biological Constraints and Needs

The following biological constraints of *A. kearneyana* are the synthesis of information presented above. The species has:

- a limited distribution: two sites verified from a single area, the Baboquivari Mountains, in southern Arizona;
- a small number of known subsites;
- a limited number of individuals per subsite;
- limited seedling germination and survival;
- many of the known plant locations are on tribal and State lands that have limited accessibility.

While some of the species biological needs (e.g., requirement for adequate precipitation for germination and seedling development) are known, some are not well understood and research to better understand these is needed. These are further discussed below.

Research Needs

The status of the species is still precarious and *A. kearneyana* continues to have many informational gaps that, if known, could aid in its recovery. The following is a list of known information gaps and research needs for *A. kearneyana*.

i. *Surveys* - Additional *A. kearneyana* surveys in Arizona and Mexico are needed to determine distribution and status across the entire range. Donovan (1998, p. 4) states the species does not appear to be habitat limited and that there is a high possibility that more plants occur on the TON. Difficulty, however, lies in the inaccessibility of both the remote and rugged terrain, as well as, in attaining permission to access to lands administered by the ASLD, the TON, and possibly sites in Mexico. It is possible that the use of drones, scent detection dogs, or other innovative methods may assist in this endeavor, given landowner permissions are attained.

ii. *Biology* - Basic *A. kearneyana* biology studies are needed. For example, what is the lifespan of *A. kearneyana*? Are flowers self-compatible, obligate outcrosser, or facultative (e.g. greenhouse studies to see if selfing produces viable seed)? Also, a map the daily production of nectar, the receptivity of stigmatic surfaces, and the dehiscence of anthers, would be useful in determining pollinator effectiveness. How do populations of known pollinators vary across habitat types and conditions in the site?

iii. *Genetics* - Studies of *A. kearneyana* genetics within and between subsites are needed to determine the functioning and structure of populations, the level of genetic diversity, if inbreeding depression is occurring, and how frequently sexual vs. vegetative reproduction is required to maintain or improve genetic diversity. Given human induced changes that occur more rapidly, sexual reproduction may become more important than it was in the past in order to adapt more rapidly (Fehlberg pers. comm. February 28, 2019).

iv. *Threats* - Studies on the effects to *A. kearneyana* from nonnative plant competition, livestock use of habitat, shade and nurse tree reduction, and fire frequency and severity shifts are necessary to better understand how these impact *A. kearneyana* germination, growth, and reproduction. For example, how does regular low severity fire vs. irregular high severity fire impact the species? Does the loss of shade trees to fire and drought impact moisture, humidity, and *A. kearneyana* germination and survival?

v. *Introductions* - Studies of the best methods for *A. kearneyana* introduction are needed to create new viable populations. For example, what is the best introduction location for this species? Can plants be grown in the field with direct seeding under protective wire mesh? How can seed germination be improved when seed availability must coincide with wet years for germination and initial seedling survival?

vi. *Management* – Determine the best management practices for habitat and pollinator health.

i. Resiliency, Redundancy, Representation, and Species Viability

The Service uses the concepts of resiliency, redundancy, and representation (the "3Rs") to assess species viability, defined as the likelihood of persistence over the long-term. If we consider what a species needs to maintain viability, we are better able to identify the conditions needed for species recovery. The concepts of resiliency, redundancy, and representation are (Service 2016):

Resiliency describes the ability of the species to withstand stochastic disturbance events, which is associated with population size, growth rate, and habitat quality.

Redundancy describes the ability of a species to withstand catastrophic events, which is related to the number, distribution, and resilience of populations.

Representation describes the ability of a species to adapt to changing environmental conditions, which is related to distribution within the species' ecological settings.

In combination with the identification of threats to the species (section f above), our assessment of the resiliency, redundancy, and representation of the species below serves as the foundation for the recovery section of this recovery plan.

Resiliency

Resiliency of *A. kearneyana* will be achieved by having enough individuals across the species' range 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 *A. kearneyana* required to achieve resiliency, however, in general having more individuals across the range of the species will provide greater resiliency. Greater resiliency will enable the species to better withstand the effects of its various threats and increase the likelihood of species viability.

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 (Machinski and Albrecht 2017, p. 392; Jameison and Allendorf 2012, p. 580). One thousand individuals is also the cutoff used by Nature Serve to differentiate between critically imperiled and imperiled species (NatureServe 2019, entire). Pavlik (1996, p. 137) recommends Minimum Viable Population sizes ranging from 50 individuals to 2,500 individuals for the conservation of rare plants, depending on various life-history characteristics of the taxon. Minimum viable population size is the smallest number of individuals required for 95 percent survival of the species over 100 years.

In looking at Pavlik's Figure 6.3, *A. kearneyana* meets criteria for both the upper and lower ends of this spectrum. On the low end of the spectrum, *A. kearneyana* is a perennial and has common ramet production. However, although the species has a woody root, it does die back to the ground each year and then resprouts, therefore, it may more closely be considered herbaceous. The other criteria are unknown for *A. kearneyana*. Therefore, based on our current understanding of the species, as well as minimum rare plant population sizes called for in the literature, a minimum viable population (MVP) of 1,225 may be needed to achieve resiliency for *A. kearneyana*. An MVP of 1,225 is derived from the following calculation: 2500-50 / 2 = 1,225, where *A. kearneyan*a's life history characteristics indicate that the species falls somewhere around Pavlik's (1996, p. 137) half-way mark of the MVP scale. There are still many life history characteristics and other variables that we need to more fully understand to best determine MVP size to achieve resiliency.

As of 2019, *A. kearneyana* are likely not resilient and require more individuals. The total known plants have declined from previous counts of 785 conducted between 1994 and 2012 (Table 2). The current number of known *A. kearneyana* individuals is 326, but this does not include two previously censused groups on TON, which historically contained 155 plants in total and have not been revisited since the 1980s. To meet resiliency, the number of plants in the wild must increase through augmentation or discovery of new *A. kearneyana* individuals.

Redundancy

Amsonia kearneyana redundancy will be achieved by having multiple subsites distributed broadly across the species' range. Because groups of plants in subsites are separated from groups of plants in other subsites (by distances that vary from 175 to 1,675 meters, measured in a straight line), they are less likely to be simultaneously affected by catastrophic events (e.g., high severity fire) or locally important events (e.g., rockslide, intense flooding), both of which are common in *A. kearneyana* habitat. Therefore, the species will be more likely to withstand such events, reducing the risk of extinction.

The number of subsites needed for redundancy could vary depending on how many plants are within each subsite. In general, more subsites with an adequate number of plants will provide for greater redundancy and increase the likelihood of species viability. While we do not currently know what an adequate number of plants per subsite is, it is important that each subsite have a sufficient number of individuals such that if plants at one subsite are destroyed, the other subsites would still contain enough plants to meet or achieve species resiliency, as described above.

Examples of combinations of the number of subsites and number of plants per subsite to achieve redundancy and resiliency could be: 5 subsites with 245 plants each; 10 subsite with 122 plants each, etc. Too few subsites (e.g., 2 subsites with 612 plants each) could decrease the likelihood of species viability if plants are destroyed by a catastrophic event at one of the subsites. The current number of subsites (9) could provide for redundancy; however, as of 2019, the total number of plants at these subsites is not adequate for resiliency and the number of plants at many of the subsites have too few individuals to provide for security against extinction from catastrophic events.

While the number of subsites needed for redundancy could vary, based on 1) our current understanding of the species, 2) the number of subsites that are most likely to support more than 100 plants (Upper Brown Canyon Upper and Lower Slopes, Jaguar Canyon, and Thomas Canyon), and 3) the amount of likely potential habitat in the species range in which new subsites could be discovered or established, we believe that an adequate level of redundancy would be a minimum of 5 subsites supporting at least 100 plants each.

Furthermore, when research illuminates what constitutes a population of *A. kearneyana*, we may need to re-evaluate the number of subsites needed for adequate redundancy. For example, research could show that plants at some subsites are separate populations, such that we have more redundancy than currently assumed.

Representation

Representation will be achieved by maintaining the numbers and geographic distribution of *A. kearneyana* throughout its narrow range. Although we have limited genetic information about *A. kearneyana*, we do know that the species occurs in a range of habitats, including canyon bottoms and steep oak woodlands. We assume that plants occurring in these distinct ecological settings have genetic variation that have enabled them to adapt to their local environment. Therefore, it will be important to conserve plants occurring in a variety of ecological settings across the species' range.

More research on the genetic diversity of this species, as well as more surveys for *A. kearneyana* at new sites, will help us better understand the full breadth of its genetic and ecological diversity across its range. Such diversity is important to conserve as it may contribute to the species capacity to adapt over time.

Viability

In summary, to achieve viability of *A. kearneyana*, or persistence over the long-term, resiliency and redundancy need to be improved and representation needs to be maintained. Resiliency can be improved by discovering new individuals and/or introduction into the wild. Redundancy can be improved by establishment of new subsites. Additionally primary threats to the species and its habitat, such as nonnative plant invasion and altered fire regime, must be addressed.

III. RECOVERY GOAL AND VISION, STRATEGY, OBJECTIVES, AND CRITERIA

a. Recovery Goal and Vision

The recovery goal is to ensure the long-term viability of *A. kearneyana* through increasing and conserving individuals, conserving habitat, and reducing the threats and stressors to the species, thus allowing for removal of *A. kearneyana* from the list of threatened and endangered species.

For the species to be recovered, we envision that *A. kearney*ana will demonstrate: 1) resiliency, by having sufficient naturally occurring and successfully introduced plants; and 2) redundancy and representation, by being distributed in multiple locations throughout its narrow range. Threats relevant to long-term viability will be reduced and habitat conserved and managed such that sufficient habitat quantity and quality is maintained to support the long-term survival of the species and its pollinators.

b. Recovery Strategy

Our recovery strategy (i.e., how we will achieve our recovery goal and vision) for *A. kearneyana* addresses the resiliency, representation, and redundancy, as well as a reduction of threats, needed to downlist and delist the species.

Our recovery strategy for *A. kearneyana*, is to:

1) Maintain a sufficient and stable or increasing number (i.e., recruitment equals or exceeds mortality) of plants at multiple subsites throughout the species' narrow range for an adequate time-period. Initial numbers may be reached through augmentation or discovery at existing subsites and/or introduction or discovery at new subsites; however, plants will need to be self-sustaining over time. This component of the strategy promotes resiliency (number of plants), redundancy (number of subsites), and representation (subsites across the species' range, including a variety of ecological settings) of the species.

2) Implement cooperative efforts to identify and reduce threats relevant to long-term viability and to conserve and manage habitat in sufficient quantity and quality to promote the long-term survival of the species and its pollinators. *A. kearneyana* species reproduces both vegetatively (asexual) and through seed (sexual). Sexual reproduction, via pollinators, is required to maintain genetic diversity. *A. kearneyana* is pollinated by an array of insects and birds, including several of which are capable of dispersal up to 1,000 meters or more. Therefore, we assume that all plants that occur within 1,000 meters of one another are capable of genetic exchange. Maintaining habitat for these pollinators is a necessary component of *A. kearneyana* recovery. This component of the strategy promotes resiliency, redundancy, and representation of the species.

c. Recovery Objectives

Recovery objectives identify outcomes that will lead to achieving the goal of recovery and delisting. Recovery objectives for *A. kearneyana* are:

1) <u>Population-based objective</u>: Conserve existing, newly discovered, and introduced *A. kearneyana* individuals and their seedbanks (approximately 10 meter [32.8 feet] radius from plants) throughout the species' narrow range to ensure the long-term survival of the taxon.

2) <u>Habitat and Threat-based objective</u>: Conserve, restore, and properly manage the quantity and quality of habitat needed for the long-term survival of *A. kearneyana* and its pollinators

(habitat is approximately 1,000-meter radius from plants). This includes reducing or preventing habitat degradation as a result of poorly managed livestock grazing, spread of nonnative plant species, alteration of natural fire regimes, and other stressors, such as drought and climate change, and border activities.

d. Recovery Criteria

Recovery criteria serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the protections afforded by the Act are no longer necessary and *A. kearneyana* may be delisted. Delisting is the removal of a species from the Federal Lists of Endangered and Threatened Wildlife and Plants. Downlisting is the reclassification of a species from Endangered to Threatened. The term "endangered species" means any species (species, sub-species, or distinct population segment) which is in danger of extinction throughout all or a significant portion of its range. The term "threatened species" means any species that is likely to become an endangered species within the foreseeable future throughout all or a signification portion of its range.

All classification decisions consider the following five factors: (A) is there a present or threatened destruction, modification, or curtailment of the species' habitat or range, (B) is the species subject to overutilization for commercial, recreational scientific or educational purposes, (C) is disease or predation a factor, (D) are there inadequate existing regulatory mechanisms in place outside the Act (taking into account the efforts by states and other organizations to protect the species or habitat), and (E) are other natural or manmade factors affecting its continued existence. When delisting or downlisting a species, we first propose the action in the *Federal Register* and seek public comment and peer review. Our final decision is announced in the *Federal Register*.

Below we provide downlisting and delisting criteria for *A. kearneyana*, as well as explanation of concepts and justification:

Downlisting Recovery Criteria

Note: please see Explanation of Concepts and Rationale below for definitions of specific terms used in and justification for the recovery criteria below.

Amsonia kearneyana will be considered for **downlisting** when all of the following criteria are met:

1) Population-based Criterion:
   A minimum of 1,225 *A. kearneyana* throughout the species' known range are stable or increasing over 15 years of a 20-year period, with the number of individuals ≥1,225 at the last two monitoring events. This is measured by monitoring every 3-5 years, using a standardized protocol. In order to address the expected yearly fluctuations in plant abundance due to changes in precipitation, fire, or other causes, we anticipate and allow for the fact that two monitoring events during the 20-year time-period may not meet these targets; therefore, the 15 years do not need to be consecutive (e.g. Year 0: 1,225 individuals;

Year 5: 1,000 individuals; Year 10: 1,000 individuals; Year 15: 1,225 individuals; Year 20: 1,225 individuals). *Amsonia kearneyana* individuals are distributed among ≥ 5 known, discovered, or established Subsites, each containing ≥100 individuals. The minimum 1,225 individuals may be attained naturally or through introduction. Augmented or established Subsites will have successfully introduced plants (reproducing and at least 10 years old). The ≥ 5 Subsites can be distributed within one or more Sites.

2) Habitat-based Criteria:
   a) At least 60 percent or 1,239 ha (3,061 acres [ac]) of the 2,064 total ha (5,101 ac; Table 3) of habitat across the currently known range (i.e., within Sites or nearby) supports *A. kearneyana* or its pollinators. Of the 1,239 ha (3,061 ac), at least 65% (805 ha; 1,990 ac) must be in optimal condition and 35% (434 ha; 1,071 ac) must be in good condition (Table 5).
   b) At least 25 percent of the *remaining* habitat across the currently known range supports *A. kearneyana* or its pollinators (Remaining habitat = Total habitat minus Optimal Quality Habitat minus Good Quality Habitat) although this habitat may be of lesser quality.
   c) Cooperative programs are being developed and partially implemented to conserve habitat, seedbank, and pollinator habitat to ensure continued existence of *A. kearneyana*. These efforts include sharing of collected data between land managers and researchers, as well as development and partial implementation of land management plans that effectively manage nonnative plants, restore a more natural fire regime, and promote pollinator diversity and habitat.

Delisting Recovery Criteria

Amsonia kearneyana will be considered for **delisting** when all of the following are met:

1) Population-based Criterion:
   A minimum of 1,225 *A. kearneyana* throughout the species' known range are stable or increasing over 25 years of a 30-year period (an additional 10 years from downlisting), with the number of individuals ≥1,225 at the last two monitoring events. This is measured by monitoring every 3-5 years, using a standardized protocol. In order to address the expected yearly fluctuations in plant abundance due to changes in precipitation, fire, or other causes, we anticipate and allow for the fact that two monitoring events during the 30-year time-period may not meet these targets; therefore,the 25 years do not need to be consecutive (e.g. Year 0: 1,225 individuals; Year 5: 1,000 individuals; Year 10: 1,000 individuals; Year 15: 1,225 individuals; Year 20: 1,225 individuals; Year 25: 1,225 individuals; Year 30: 1,225 individuals). These are distributed among ≥ 5 known, discovered, or established Subsites, each containing ≥100 individuals. The minimum 1,225 individuals may be attained naturally or through introduction. Augmented or established Subsites will have successfully introduced plants (reproducing and at least 10 years old). The ≥ 5 Subsites can be distributed within one or more Sites.

2) Habitat-based Criteria:
   a) At least 75 percent of habitat (1,548 ha; 3,826 ac) of the 2,064 total ha (5,101 ac; Table 3) of habitat across the currently known range (i.e., within Sites or nearby) supports *A.*

kearneyana or its pollinators. Of the 1,548 ha (3,826 ac), at least 65% (1,006 ha or 2,486 ac) must be in optimal condition and 35% (542 ha or 1,339 ac) must be in good condition (Table 5).

b) At least 40 percent of the *remaining* habitat across the currently known range supports *A. kearneyana* or its pollinators (Remaining habitat = Total habitat minus Optimal Quality Habitat minus Good Quality Habitat) although this habitat may be of lesser quality. There is potential for habitat improvement with land management practices.

c) Cooperative efforts are being fully implemented to conserve habitat, seedbank, and pollinator habitat in perpetuity to ensure continued existence of *A. kearneyana*. These efforts include sharing of collected data between land managers and researchers, as well as implementation of land management plans that effectively manage nonnative plants, restore a more natural fire regime, and promote pollinator diversity and habitat.

Justification for Recovery Criteria

Justification for recovery criteria consists of an Explanation of Concepts and Rationale for Recovery Criteria in the context of the 3 "R"s, Species Viability, and Threats, as described below.

<u>Explanation of Concepts</u>
Below, we explain and justify concepts used in the recovery criteria:

- **Minimum number of individuals –** The minimum number of *Amsonia kearneyana* required for down- and delisting.
  - Based on our current understanding of the species, as well as minimum rare plant population sizes called for in the literature (e.g., NatureServe 2019, entire; Machinski and Albrecht 2017, p. 392; Pavlik 1996, p. 137) it is likely that viability of *A. kearneyana* can be achieved by having a minimum of 1,225 individuals.

- **Periods for Stability –** The period required to meet the population-based recovery criteria.
  - **The 20-Year** period for stability or increase required to meet population-based <u>downlisting</u> Criterion 1 is based on 2/3 of the minimum documented lifespan of *A. kearneyana*.
  - **The 30-year** period for stability or increase required to meet population-based <u>delisting</u> Criterion 1 is based on the minimum documented lifespan of the species (per monitored individuals in the Reintroduction Site; Yost and Stromberg 2015, p. 21; Reichenbacher et al. 1994, p. 1). This period also assures that target numbers are maintained through fluctuations in drought, fire, and other disturbances, thus demonstrating that the species is resilient.
  - The additional time (10 years) necessary to achieve delisting, rather than downlisting, ensures continued species viability. Additionally, it will allow land managers to continue to reduce threats to *A. kearneyana* from nonnative species invasion, fire, and small population size achieved during downlisting and track the long-term effectiveness of management. The additional time will also allow land managers to develop methods to reduce anticipated cost and effort needed to maintain habitat and species viability absent the protections of the Act.

- **Monitoring Frequency –** The frequency with which subsites are monitored to meet the population based recovery criteria.
    - Monitoring will likely occur more frequently (e.g., every 3 years) in more accessible subsites (e.g., the Upper Brown Canyon Lower Slope Subsite, Lower Brown Canyon Subsite). Monitoring will likely occur less frequently (e.g., every 5 years) in less accessible (due to topography and landowner permission) subsites (e.g., Jaguar Canyon, Thomas Canyon, etc.).

- **Successfully introduced plants** – Post-introduction monitoring indicates introduced plants (augmented at existing subsites or established at new subsites) are fully functioning (reproducing and at least 10 years old) in their environment. Introduced plants may experience mortality after outplanting and additional outplanting may be necessary to help achieve population-based criteria..

- **Currently known range –** Area within Arizona containing *A. kearneyana* and its pollinators within the Baboquivari Peak Site and Lower Brown Canyon Introduction Site on BLM, BANWR, ASLD, and the TON lands.

- **Habitat Quantity**
    - **Minimum habitat quantity required to achieve habitat based <u>downlisting</u> criteria –** the number of hectares needed to achieve downlisting criteria 2a and 2b was calculated by requiring that at least 60 percent (1,239 ha; 3,061 ac) of the total habitat acreage (2,064 ha; 5,101 ac; Table 3) of both known sites be in optimal (≥ 65 percent) or good (≥ 35 percent) condition (Table 5).
    - **Minimum habitat quantity required to achieve habitat based <u>delisting</u> criteria –** the number of hectares needed to achieve delisting criteria 2a and 2b was calculated by requiring that at least 75 percent (1,548 ha; 3,826 ac) of the total habitat acreage (2,064 ha; 5,101 ac; Table 3) of both known sites, be in optimal (≥ 65 percent) or good (≥ 35 percent) condition (Table 5).
    - **For both down- and delisting –**
        - While we calculated the total habitat (2,064 ha; 5,101 ac; Table 3) based on the area of <u>current</u> sites; however, achieving the criteria (both quantity and quality) could also be met by the inclusion of some nearby habitat outside of these sites. For example, this would be appropriate should additional plants be discovered or introduced outside of current sites.
        - To recover *A. kearneyana*, a narrow endemic (occurring within a relatively small area), with fewer than 330 individuals known at this time, protection and/or management of a large portion of habitat supporting the species and its pollinators is necessary. The quantity of habitat required for delisting is larger than for downlisting to ensure long-term stability of the species. This amount of habitat is anticipated to be capable of supporting a minimum of 1,225 individuals (as called for in the population-based criteria). Should monitoring indicate that more habitat is needed, this criteria will be revisited.

- **Habitat Quality**

- **Optimal quality habitat –** habitat is protected for conservation purposes in perpetuity; is managed in a manner that promotes the long-term survival of *A. kearneyana*; has less than 20 percent cover of *Cenchrus ciliaris* (buffelgrass), *E. lehmanniana*, or other invasive nonnative plant species that alter ecosystem function; and contains contiguous habitat and corridors for pollinators, which include a diversity of native plant species.
- **Good quality habitat –** habitat that is managed in such a way that promotes the continued existence or expansion of long-term survival of *A. kearneyana* and its pollinators; has less than 35 percent cover of *C. ciliaris*, *E. lehmanniana*, or other nonnative plants that alter ecosystem function; and contains contiguous habitat and corridors for pollinators, which include a diversity of native plant species. We do not currently know the number of acres managed in such a way that promotes the continued existence or expansion of long-term survival of *A. kearneyana* and its pollinators. Table 5 shows the total area of land in good status required to meet habitat based down- and delisting criteria for *A. kearneyana*.
- **Lesser quality habitat –** habitat within the currently known range of the species that is not considered optimal or good, but that still supports *A. kearneyana* or its pollinators. There is potential for this habitat to be improved with land management practices. The species requires this lesser quality habitat because it provides protection from the impacts of human developments and other similar threats and may contain suitable microhabitats needed for recovery given the threats of drought and climate change. For example, in a hotter, drier future, microhabitats with greater shade may better support the species. Conserving these distinct ecological settings will allow opportunities for the species to endure into the future.
- We do not currently know the number of acres of optimal, good, or lesser quality habitat, because we do not know the cover of nonnative plants within *A. kearneyana* habitat. However, there are no major nonnative plant infestations known to occur within near proximity to *A. kearneyana* individuals. In addition, we know the number of acres (756 ha; 1,872 ac, or 36.7 percent of all *A. kearneyana* habitat) protected for conservation purposes within the currently known range of *A. kearneyana* and its pollinators (See Table 3). Table 5 shows the total area of land in optimal status required to meet habitat-based down- and delisting criteria for *A. kearneyana*.
- Habitat quality will be determined through monitoring of habitat conditions (e.g., nonnative plant cover).

Table 5. Acres and hectares of habitat in optimal and good status required to meet habitat based down- and delisting criteria for *Amsonia kearneyana*.

Habitat Based Recovery Criteria	Acres	Hectares	Percent of Total Site Area
Total Sites Habitat Area (outlined in green in Figure 5)	5,101	2,064.3	100 (provided here as reference, from Table 3)
Downlisting			
Optimal	1,990	805	65% of 60%
Good	1,071	434	35% of 60%
Total optimal and good habitat required for downlisting	3,061	1,239	60
Delisting			

Habitat Based Recovery Criteria	Acres	Hectares	Percent of Total Site Area
Optimal	2,486	1,006	65% of 75%
Good	1,339	542	35% of 75%
Total optimal and good habitat required for delisting	3,826	1,548	75

<u>Rationale for Recovery Criteria – 3Rs, Species Viability, and Threats</u>

Below we justify our recovery criteria in the context of the 3Rs, resiliency, redundancy, and representation (as explained in the Background – Resiliency, Redundancy, and Representation section), used to assess the species' long-term viability, and threats (as explained in the Background – Reasons for Listing/Threats Assessment, which when combined with the explanations above, provide for a complete rationale for the criteria.

3Rs:
Resiliency
Resiliency is met by having enough individuals (≥1,225) at subsites 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 required to achieve resiliency *of A. kearneyana*, however, in general having more individuals across sites and subsites will provide greater resiliency. Greater resiliency will enable the species to better withstand the effects of its various threats and increase the likelihood of species viability. Based on our current understanding of the species, as well as minimum rare plant population sizes called for in the literature, it is likely that resiliency of *A. kearneyana* can be achieved by having a minimum of 1,225 individuals for the time-period indicated in population-based criteria. Should more information become available on the number of plants required for resiliency and viability, we will revisit this topic.

Redundancy
Redundancy is met by having multiple subsites distributed across the species' range. Because plants in subsites are separated from plants in other subsites, they are less likely to be simultaneously affected by catastrophic events (e.g., high severity fire) or locally important events (e.g., rockslide, intense flooding), both of which are common in *A. kearneyana* habitat. Therefore, the species will be more likely to withstand such events, reducing the risk of extinction. The population-based recovery criteria (down- and delisting criteria) require a minimum of 5 subsites distributed within one or more sites. If future research indicates that more redundancy is needed for species viability, then we will revisit this topic.

Representation
Representation is met by maintaining the numbers and geographic distribution of *A. kearneyana* throughout its narrow range. Although we do not have genetic information about *A. kearneyana*, we do know that the species occurs in a range of habitats, including canyon bottoms and steep oak woodlands. We assume that plants occurring in these different ecological settings have genetic variation that have enabled them to adapt to their environment. Protecting subsites with different ecological settings is beneficial for maintaining genetic diversity of the species via gene

flow among plants within and between subsites. Therefore, the population-based criteria are designed to ensure conservation of plants occurring in a variety of ecological settings across the species' range.

Viability:
In summary, viability of *A. kearneyana*, or persistence over the long-term, is achieved by improving resiliency and redundancy of the species and maintaining its representation. Resiliency is improved by discovering new individuals and/or introduction into the wild. Redundancy is improved by establishment of new subsites. Additionally primary threats to the species and its habitat, such as nonnative plant invasion and altered fire regime, are addressed.

Threats:
Table 6 below indicates how the primary threats to the species, in the context of the five listing factors, are addressed in the recovery criteria.

Table 6. How significant threats to *Amsonia kearneyana* are addressed in the recovery criteria.

Factor	Threat	Criteria	Explanation
Factor A - Present or threatened destruction, modification, or curtailment of its habitat or range	Poorly managed livestock	1, 2 a-c	Criterion 1 promotes species resiliency and should ensure that the species is abundant enough to withstand some grazing pressure. Criteria 2a-c require *A. kearneyana* habitat to be protected and/or managed to promote the long-term survival of the species.
	Nonnative plant presence and spread	1, 2 a-c	Criterion 1 promotes species resiliency and should ensure that the species is abundant enough to withstand some nonnative presence. Criteria 2a-c require that at least 75 percent of habitat across the currently known range of *A. kearneyana* has less than either 20 percent (for optimal quality habitat) or 35 percent (for good quality habitat) cover of *C. ciliaris*, *E. lehmanniana*, *M. repens*, or other invasive nonnative plant species that alter ecosystem function.
	Altered wildfire regime	1, 2 a-c	Criterion 1 promotes species resiliency and redundancy, ensuring that the species is abundant and well-distributed enough to withstand some high severity wildfire activity. Criteria 2a-c require *A. kearneyana* habitat to be protected and/or managed to promote the long-term survival of the species.
	Border activities	1, 2 a-c	These criteria require *A. kearneyana* habitat to be protected and/or managed to promote the long-term survival of the species.
Factor C – Disease or predation	Seed predation	1	Criterion 1 promotes species resiliency and should ensure that the species is abundant enough to withstand natural seed predation.
Factor E – Other Natural or Manmade Factors Affecting its Continued existence	Low numbers and limited distribution	1	Criterion 1 promotes species resiliency (increased numbers) and representation (subsites distributed across the species range). Maintaining an adequate amount of *A. kearneyana* in multiple subsites throughout

Factor	Threat	Criteria	Explanation
			the range of *A. kearneyana* helps retain its genetic variation and demographic stability.
	Drought and climate change	1	Criterion 1 promotes species resiliency, redundancy, and representation. Maintaining an adequate amount of *A. kearneyana* in multiple locations with different ecological settings helps improve the species' ability to withstand the effects of drought and climate change.

IV. ACTIONS NEEDED

Recovery actions guide site-specific activities to address threats and achieve the recovery criteria; they are provided in Table 7 below. Implementation of the recovery actions will involve participation from the ASLD, Federal agencies, the TON, non-governmental organizations, academia, and the public in Arizona. Recovery actions are accompanied by estimates of the cost and time required to achieve the plan's goal to recover *A. kearneyana*.

A separate Recovery Implementation Strategy provides additional detailed, site-specific near-term activities needed to implement the actions identified in the recovery plan (Service 2019). 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 implementation strategy will provide near-term (e.g., 1-5 years) 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 the recovery actions in the recovery plan. We will only revise the recovery actions in this recovery plan if there are needed changes based upon the findings of future 5-year status reviews.

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, development of Habitat Conservation Plans, or the creation of experimental populations under section 10(j).

Estimated Timing and Cost of Recovery

We expect the status of *A. kearneyana* to improve such that we can achieve downlisting criteria in approximately 25 years (this includes 20 years to meet the Period for Stability plus 5 years to discover or establish more plants). We expect to achieve recovery in approximately 40 years (this includes 30 years to meet the Period for Stability plus 10 years to discover or establish more plants). In other words, **2059** is the approximate date to reach the goal of recovery for *A. kearneyana*. The time to recovery is based on the expectation of full funding, implementation as provided for in the recovery plan and implementation schedule, and full cooperation of partners.

The <u>total</u> estimated cost of recovery is $**5,743,650**. This cost includes those borne by Federal and State governmental agencies and the TON, as well as other institutions, universities, and organizations with an interest in recovering *A. kearneyana*.

Annual cost estimates to implement recovery actions for the first 5 years are as follows:
Year 1 = $220,854
Year 2 = $179,281
Year 3 = $305,439
Year 4 = $210,348
Year 5 = $409,784
The estimated cost to implement the first 5 years of recovery actions (i.e., intermediate steps toward the goal of recovery) is $1,325,706. . The calculation of the total estimated cost to recovery is included in the Recovery Action Table below. The cost of implementing the first 5 years of recovery, as well as a description of the costs for all years, is detailed in the Implementation Schedule Table of the Recovery Implementation Strategy.

Recovery actions are assigned numerical priorities, as defined below, to highlight the relative contribution they may make toward species recovery.

<u>Key to priorities used in the Recovery Action Table</u>

Priority 1 - An action that must be taken to prevent extinction; or to prevent the species from declining irreversibly in the foreseeable future.
Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other negative impact short of extinction.
Priority 3 - All other actions necessary to meet recovery objectives.

<u>Key to acronyms used in the Recovery Action Table</u>

Acronym	Institution
APTPL	All public, tribal, and private landowners (ASLD, BLM, BANWR, TON, private)
ASDM	Arizona Sonoran Desert Museum
ASLD	Arizona State Land Department
AZESFO	Arizona Ecological Services Field Office
BANWR	Buenos Aires National Wildlife Refuge
BLM	Bureau of Land Management
DBG	Desert Botanical Garden
TON	Tohono O'odham Nation
UNIV	University
USBP	U.S. Border Patrol

Table 7. Recovery Action Table

Priority #	Action #	Site-Specific Action	Recovery Criteria Addressed	Action Duration	Responsible Parties	Total Estimated Cost ($)	Threat(s) Addressed
1	1	Census of known *A. kearneyana* subsites	1	Every 3 - 5 years over 40 years	APTPL, ASDM, DBG, AZESFO, TON, UNIV	348,000	Low numbers and limited distribution (Factor E)
1	2	Monitor *A. kearneyana* individuals and their habitat (e.g. quality)	1	Every 3 - 5 years over 40 years	APTPL, ASDM, DBG, AZESFO, TON, UNIV	348,000	Poorly managed livestock grazing, nonnative plant presence and spread, altered wildfire regime, border activities, seed predation, low numbers and limited distribution, and drought and climate change (Factors A, C, E)
1	3	Survey for new *A. kearneyana* individuals and subsites	1	Every 3 - 5 years over 40 years	APTPL, ASDM, DBG, AZESFO, TON, UNIV	388,000	Low numbers and limited distribution (Factor E)
1	4	Augment the number of *A. kearneyana* individuals at existing subsites	1	10 years	APTPL, ASDM, DBG, AZESFO, TON, UNIV	390,600	Low numbers and limited distribution (Factor E)
1	5	Establish new *A. kearneyana* subsites	1	10 years	APTPL, ASDM, DBG, AZESFO, TON, UNIV	390,600	Low numbers and limited distribution (Factor E)
3	6	Acquire *A. kearneyana* habitat within existing and new subsites and protect *A. kearneyana* subsites	2	Periodically	APTPL, TON	1,782,650	Poorly managed livestock grazing, nonnative plant presence and spread, altered wildfire regime, border activities, low numbers and limited distribution, and drought and climate change (Factors A, E)

Priority #	Action #	Site-Specific Action	Recovery Criteria Addressed	Action Duration	Responsible Parties	Total Estimated Cost ($)	Threat(s) Addressed
1	7	Establish and maintain *A. kearneyana* seeds and plants in botanical institutions	1	40 years	ASDM, DBG, AZESFO, UNIV	100,000	Low numbers and limited distribution (Factor E)
1	8	Conduct research relating to *A. kearneyana* biology, ecology, threats, management, etc.	All	Periodically over 40 years	APTPL, ASDM, DBG, AZESFO, TON, UNIV	508,000	Poorly managed livestock grazing, nonnative plant presence and spread, altered wildfire regime, border activities, seed predation, low numbers and limited distribution, and drought and climate change (Factors A, C, E)
1	9	Monitor threats to *A. kearneyana*	All	40 years	APTPL, ASDM, DBG, AZESFO, TON, UNIV	348,000	Poorly managed livestock grazing, nonnative plant presence and spread, altered wildfire regime, border activities, seed predation, low numbers and limited distribution, and drought and climate change (Factors A, C, E)
2	10	Reduce threats to *A. kearneyana* and manage habitat quality	All	Periodically over 40 years	APTPL, ASDM, USBP, DBG, AZESFO, TON, UNIV	511,800	Poorly managed livestock grazing, nonnative plant presence and spread, altered wildfire regime, border activities (Factor A)
2	11	Conduct outreach, education, and coordination relating to *A. kearneyana* conservation and recovery	All	40 years	APTPL, ASDM, DBG, AZESFO, TON, UNIV	628,000	Poorly managed livestock grazing, nonnative plant presence and spread, altered wildfire regime, drought and climate change (Factors A, E)

Total Cost to recovery 5,743,650

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