Amsonia kearneyana
Kearney bluestar

5-Year Review:
Summary and Evaluation

Photo by Dan Austin 4-25-12

U.S. Fish and Wildlife Service
Arizona Ecological Services Tucson Sub-Office
Tucson, Arizona

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5-YEAR REVIEW
Kearney bluestar (*Amsonia kearneyana*)

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Field Office: Arizona Ecological Services Office
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1.2 Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species status should remain unchanged, or whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing as endangered or threatened is based on the species' status considering the five threat factors described in section 4(a)(1) of the Act. These same five factors are considered in any subsequent reclassification or delisting decisions. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process including public review and comment.

1.3 Methodology used to complete the review:

The U. S. Fish and Wildlife Service (Service) conducts status reviews of species on the List of Endangered and Threatened Wildlife and Plants (50 CRF 17.12) as required by section 4(c)(2)(A) of the Endangered Species Act (Act) (16 U.S.C. 1531 *et seq*.). We provided notice of this status review via the Federal Register on March 20, 2008 (73 FR 14995) requesting information on the status of *Amsonia kearneyana* (Kearney bluestar). No comments from the public were received. This 5-year review was completed by the lead biologist for the species from the Arizona Ecological Services Tucson Sub-Office. This review was conducted through a comprehensive review of all documents pertaining to *A. kearneyana* on file at the Arizona Ecological Services Field Office (AESFO). Interviews with individuals familiar with *A. kearneyana* were conducted by the AESFO, as needed, to clarify or obtain specific information. Additional sources of information included the Kearney bluestar Recovery Plan (1993), section 7

consultations, telephone conversation records, letters from researchers providing anecdotal field observations, unpublished field surveys and notes, monitoring reports, peer reviewed publications, reports of research projects, and various documents published by the Bureau of Land Management (BLM) and their contractors. Information regarding the status of the species on Tohono O'odham Nation lands was reviewed by the Tohono O'odham Nation biologist, and updates were incorporated into this document.

1.4 Background

1.4.1 FR Notice citation announcing initiation of this review:

73 FR 14995, March 20, 2008

1.4.2 Listing history:

On July 1, 1975, the Service published a notice in the Federal Register (40 FR 27823) of its acceptance of a report prepared by the Secretary of the Smithsonian Institution to consider the *A. kearneyana* to be endangered, threatened, or extinct. In 1980, the species was listed as a candidate in the Federal Register (45 FR 82486). In October 1982, the Act was amended (Section 2(b)(1)) and *A. kearneyana*, as well as all other pending species were treated as newly submitted. In 1982, 1983, and 1984, the Service determined the petition to list this species was warranted, but precluded by other listing actions of higher priority. *Amsonia kearneyana* was ultimately listed as an endangered species without designated critical habitat on January 19, 1989 (54 FR 2131). A draft Recovery Plan was sent for review on July 9, 1992, and was finalized on May 24, 1993.

1.4.3 Associated rulemakings: None.

1.4.4 Review History: A 5-year review was initiated on November 6, 1991 (56 FR 56882) for all species listed before 1991, but no document was prepared for *A. kearneyana*.

1.4.5 Species' Recovery Priority Number at start of 5-year review: *Amsonia kearneyana* recovery priority number is 2, meaning that the level of threat is high, the recovery potential is high, and the listed entity is a species.

1.4.6 Recovery Plan or Outline

Name of plan or outline: Kearny bluestar (*Amsonia kearneyana*) Recovery Plan
Date issued: May 24, 1993
Dates of previous revisions, if applicable: Not applicable.

2.0 REVIEW ANALYSIS

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

2.1.1 Is the species under review a vertebrate? No.

2.2 Recovery Criteria

2.2.1 Does the species have a final approved Recovery Plan? Yes.

2.2.1.1 Does the Recovery Plan contain objective, measurable criteria? Yes.
While the Recovery Plan does have measurable criteria, the definition of a population is lacking, as is the definition of a geographically distinct area or distance. In addition, the geographic range and genetic variability of the species are unknown.

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat? No.
The recovery criteria are still pertinent in a broad sense, but are lacking in updated specifics. However, for the reasons explained above in 2.2.1.1, more recent information may help us better describe whether we should use populations as the appropriate recovery level, or some other species unit that is more clearly defined and objective. Additional survey efforts indicate that we may not know what the total geographic range of this species is, and what constitutes geographic distinctness. However, the second recovery criterion is broad with regard to ensuring the continued protection of populations from human and natural threats. This criterion could be interpreted to include the more recent concerns to the species' survival from high severity wildfire and subsequent vegetation community type conversion, as well as extended drought and climate change. Therefore, this recovery criterion may still represent the direction that the current and best available information suggests.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? No.
While no detailed five factor analysis was conducted in the Recovery Plan, reasons for listing, such as limited distribution and declining numbers and habitat, are discussed. Also discussed are some of the major recognized threats of the time, such as insect damage, grazing, and flooding. The additional threats of high severity fire, extended drought and climate change, and vegetation community type conversion are not discussed, as these are newly determined threats.

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

The Kearney Bluestar Recovery Plan includes two criteria for downlisting the species from endangered to threatened:

1) Establish or maintain 10 self-sustaining, native populations of *A. kearneyana*,
2) Establish procedures to ensure continued protection of these populations from human and natural threats on tribal, private, and public lands.

There are no criteria provided in the Recovery Plan for delisting the species, stating instead that delisting objectives will be established once downlisting is accomplished.

For the first downlisting criterion, each of the 10 *A. kearneyana* populations must be geographically distinct, contain at least 200 reproducing individuals, and show recruitment that equals or exceeds mortality. These populations must represent the geographic range and genetic variability of the species. At least seven of the populations must be natural populations and up to three may be reintroduced populations. As of May 2012 there were 19 known locations supporting *A. kearneyana*, of which 18 are natural and 1 is an *ex situ* transplanted population placed on Service lands in Buenos Aires National Wildlife Refuge (Phillips and Brian 1982; Reichenbacher *et al*. 1994; Donovan 1998; Austin 2010b; University of Arizona Herbarium 2011; AZGF Heritage 2011). These locations occur in three canyons in the Baboquivari Mountain Range of southern Arizona in an area of approximately 130 hectares (ha) (321 acres [ac]); no single location is currently known to support over 130 individuals (Service 2012; Donovan 1998). No seedlings have been recorded in any subpopulation since 1982 (Phillips and Brian 1982).

It is unclear if each of these individual locations containing *A. kearneyana* represents a unique population or even a unique individual, given the clonal nature of the species. Many of the locations contain a single individual or a group of less than 10 plants, and many are separated by less than 100 meters. The original 1928 description of the species states that several "colonies" have been found in the same general vicinity (Woodson 1928). Phillips and Brian (1982) refer to groups of 1 to 3 *A. kearneyana* plants in 12 "population areas." The idea of colonies or subpopulations may be more appropriate in describing the *A. kearneyana* than populations, making this downlisting criterion outdated and difficult to apply.

Amsonia kearneyana plants are separated geographically; however, they may interact at some level, such as through shared pollinators. For example, *A. kearneyana* is known to be pollinated by a wide range of insect and hummingbird pollinators (Reichenbacher *et al*. 1994; Service 2012). Many of these pollinators may travel hundreds of meters between individual *A. kearneyana* plants and may be utilizing associated plant species with overlapping bloom periods that occur geographically between *A. kearneyana* plants. In this manner, most, if not all known naturally occurring plants may be interconnected. For this reason, for the remainder of this document, we will refer to all locations containing *A. kearneyana* plants as subpopulations. We suggest further research on the

connectivity of these subpopulations and possible future revision of the population-level downlisting criteria stated in the Recovery Plan.

For the second downlisting criterion, legal protection for *A. kearneyana* remains unchanged since the Recovery Plan was completed in 1993. Arizona Native Plant Law (Arizona Revised Statutes, Chapter 7, 1993) provides for the protection of *A. kearneyana* as a Highly Safeguarded Species. This status makes it unlawful for any person to destroy, dig up, cut, collect, mutilate, harvest or take, and place into possession this plant on public lands. Arizona Native Plant Law does not prohibit landowners from removing or destroying protected plants on their property though they are required to notify the Arizona Department of Agriculture prior to destruction; there are no *A. kearneyana* plants known to occur on private lands. The Arizona Native Plant Law does not afford protection to the habitat of *A. kearneyana*, nor does it apply on Native American Reservations.

The Service and the BLM have taken steps toward meeting the downlisting criteria on Federal lands by completing the following identified recovery actions:

1. In 1996, the BLM placed the Baboquivari range allotment into a non-use status (BLM 1997), thereby removing all but approximately 10 trespass cattle from the area directly associated with known subpopulations of *A. kearneyana*. As this species is not directly eaten by cattle due to toxins, the impact of removing cattle lies in both reduction of direct trampling of plants (Phillips and Brian in 1982; Reichenbacher April 3, 1988 field notes) and in overall habitat quality improvement due to increased understory cover and reduction in erosion (Loftin *et al.* 2000). The removal of cattle from the Baboquivari allotment continue in 2013; and there are no plans to reintroduce grazing (Tersey 2012, pers. comm.). Trespass cattle have not been seen in Brown Canyon in the past five years (Austin 2012a, pers. comm.).

2. In 1997, the BLM stopped all range improvements, chemical or mechanical vegetation management, or planting/seeding of non-native plants within the Brown Canyon watershed (Service 1997). The area burned in the 2009 Elkhorn Fire, which includes much of *A. kearneyana* habitat, was not seeded (Wilson 2012, pers. comm.). Pre-fire, the 20 to 30 degree north-facing slopes, where a majority of plants have been located within Brown Canyon, were part of the Madrean evergreen woodland – interior chaparral transition zone (Arizona Rare Plant Guide Committee 2001), dominated by stands of oak, pinyon, and juniper and interspersed with patches of grassland (Donovan 1998). This area is now recovering well, but has shifted dominance to a suite of native grasses, herbs, and re-sprouting chaparral and grassland shrub species; the woodland component is greatly reduced (Service 2012).

3. Prescribed fire is only allowed on BLM lands following development of a mitigation plan approved by the Service (Service 1997). A prescribed fire plan was being developed in June of 2009, when the human-caused Elkhorn Fire was ignited. This fire burned through many *A. kearneyana* subpopulations at moderate or high severity and the transplant population at moderate severity (Wilson 2012, pers. comm.).

In upper Brown Canyon, the Elkhorn Fire burned at high severity through the largest known naturally occurring subpopulation of *A. kearneyana*; where approximately 300 individuals were recorded in 1996, 2001, and 2002 (Donovan 1998; Donovan and Topinka 2004). In 2012, 43 confirmed individuals were found; a reduction of more than 85 percent from the 2002 monitoring (Yost and Stromberg 2013). This subpopulation was noted previously to be critical to the survival of the species (Service 1997).

In 2002, 38 *A. kearneyana* plants were counted within the transplant population (Donovan and Topinka 2004). The Elkhorn Fire burned at lower severity through this population. A 2009 post-fire survey located 21 individuals, representing a 45 percent loss of plants in this population. In both the previously mentioned naturally occurring subpopulation in upper Brown Canyon and in the transplant population, post-fire plants were robust, nearly doubling in size from pre-fire measurements (Reichenbacher *et al.* 1994; Service 2012; Donovan and Topinka 2004; Cohan 2011a, pers. comm.).

Because seven years had passed between monitoring visits in both the upper Brown Canyon subpopulation and the transplant population, it is unknown if the fire itself reduced the number of plants in these two areas. It is possible that there was die-off due to some other factor prior to the fire event. It is also possible that the fire, in combination with long-term drought and habitat alteration, was responsible for these losses. The upper Brown Canyon subpopulation had a greater percentage loss of plants than the transplant population; it is unknown if this increased loss was related to differing fire severity levels experienced at the two sites. Nor do we know if disturbance related to fire enhances or reduces survival, reproduction, and seed germination of *A. kearneyana*, and, thus, we do not know the long term effects or benefits of fire with regard to the ecology of this species.

Summary

Significant efforts have been made to protect the habitat of *A. kearneyana* on BLM land. More surveys and studies are needed throughout the range to determine the relationship of the subpopulations to one another and to better understand the impacts of fire, climate change, and resultant vegetation community changes. The single subpopulation on State Trust Lands (see section 2.3.1.2) which contained 130 plants prior to burning (Donovan 1998) and which has not been revisited since discovery in 1998, may be the largest remaining subpopulation of *A. kearneyana*, but we have no recent information of the status of this subpopulation. Most subpopulations contain fewer than 30 individuals and are inadequate to meet the downlisting goal of 10 self-sustaining populations containing at least 200 reproducing individuals each.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

Amsonia kearneyana is a herbaceous perennial in the Dogbane family (Apocynaceae). A subshrub with a thickened woody root, the plants' many pubescent (hairy) stems rarely branch and are up to 1 meter (m) (3 feet [ft] 3 inches [in]) tall. 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. The leaves are 3.8-6.9 cm (1.5-2.7 in) long, 1.5 cm (0.6 in) broad and are soft and bright green with short petioles. White flowers form a terminal inflorescence in late April and May. 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. Seeds are cylindrical, corky, and large, spanning 8-11 mm x 3-4 mm (0.31-0.43 in x 0.12-0.16 in). The species is capable of reproducing both sexually and asexually and the lifespan of plants is speculated to be many decades (Topinka *et al*. 2004).

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

Habitat

Since the Recovery Plan was finalized in 1993, a great deal of information has been attained regarding *A. kearneyana* biology, life history, and habitat. For example, once thought to only occupy canyon bottoms, we now know that this is secondary habitat for the species, with most subpopulations being located on steep, dry, and open woodland-dominated slopes (Donovan 1998; Arizona Rare Plant Guide Committee 2001).

Pollinators

The long, tubular, early-blooming 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; Service 2012). 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, long-winged black Coleoptera, mordellid and various other beetles, broad-tailed hummingbird (*Selasphorus platycercus*) (Reichenbacher's hand field notes from April 13, 1990; Reichenbacher *et al*. 1994); bee flies (Bombyliidae); and Arizona metalmarks (Riodinidae) (Service 2012). Long-distance pollinators, such as larger butterflies and hummingbirds (Schmitt 1980), may be capable of cross-pollinating plants from across subpopulations of *A. kearneyana*. McLaughlin (2011, pers. comm.) suspects moths may be the primary pollinator though suggests a number of generalist pollinators may be effective.

Precipitation

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 (Phillips and Brian 1982; Reichenbacher *et al*. 1991; Reichenbacher *et al*. 1994; Donovan 1988). 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 (McLaughlin 1982), may have contributed to the lack of recruitment recorded for this species (Phillips and Brian 1982; Donovan 1998; Service 2012). Donovan (1998) likens *A. kearneyana* to other arid adapted plants which may go long intervals with no establishment punctuated by successful recruitment when rainfall is suitable.

Disturbance

The role of disturbance in *A. kearneyana* life history remains unclear, though based on unconsolidated steep slope habitat and clonal reproduction, Donovan (1998) suggests it may require some disturbance to establish and colonize new areas. Open habitat created by fire may benefit *A. kearneyana*, as Reichenbacher noted that plants in shadier locations tend to be further behind in growth than those growing in the open (Reichenbacher 1988-1990 field notes). Similarly, Donovan (1998) reported this plant appears to do best in open habitat. Alternatively, the Recovery Plan states that loss of shade plants may be preventing seedling establishment. It is unclear from these reports if associated vegetation is helpful to *A. kearneyana* (*e.g*. nurse plant) or harmful (*e.g.* competition). The newly created and more open habitat in the wild subpopulations is greatly changed from the pre-fire woodland, and research will be needed to determine *A. kearneyana* response.

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

Natural subpopulations of *A. kearneyana* are divided between steep, dry, open woodland slopes and coarse alluvium along dry canyon bottoms (Arizona Rare Plant Guide Committee 2001). These subpopulations occur on lands administered by the Tohono O'odham Nation, the Arizona State Land Department, and the BLM. An *ex situ* population was created in 1988 on land now administered by the Service as part of the Buenos Aires National Wildlife Refuge.

Tohono O'odham Nation subpopulations

Initial investigations by Phillips and Brian in 1982 noted 25 individuals from 12 small "population areas" in South Canyon, each containing 1 to 3 plants. One seedling was reported at this time. The number was reduced to 8 individuals by 1986; speculations on the decline involve overgrazing and alteration of hydrologic characteristics, impacts from bruchid beetle infestations, or other unknown factors (Reichenbacher *et al.*1994). The current number of living plants from South

Canyon is unknown, as this subpopulation resides on Tohono O'odham lands and researchers outside of the Tribe are limited. No information is available on plants noted through historical herbarium collections from Baboquivari Canyon or Sycamore Canyon on the Tohono O'odham Nation. These subpopulations may be extant and other subpopulations may occur on Tribal lands; further surveys by Tribal biologists are needed, preferably during the flowering period or late fall when leaves have yellowed, increasing the probability of relocation.

BLM Wilderness locations

In 1996, a new subpopulation of approximately 300 individual *A. kearneyana* clustered together on an east facing hillside was discovered in upper Brown Canyon (Donovan 1998). Two years later, Donovan found 11 additional new subpopulations on BLM lands, each containing fewer than 40 individuals and totaling roughly 260 additional individuals (Donovan 1998). Nine of the 11 subpopulations were clustered within a 30 ha (74 ac) area. Due to the rugged terrain and steep topography in which these new subpopulations were discovered, other small subpopulations likely exist in the Baboquivari Mountains that have not been discovered (Donovan 1998).

In 2001, a 20-m long transect intersecting 13 individuals was established on the lower slopes of the upper Brown Canyon site with 300 *A. kearneyana* individuals (henceforth referred to as subpopulation 300). This transect was re-read in June 2002 (Donovan and Topinka 2004). Data from 2001 were not available; however comments in the notes following the second reading indicated that plants were much smaller during 2002 than in 2001. Subpopulation 300 was not revisited again until April 2012, when a group of nine biologists located 33 verified *A. kearneyana* plants on the upper and mid slopes of this subpopulation; the transect was not relocated, however a metal tag was found (Service 2012). Subpopulation 300 was revisited in November 2012 when plants had turned yellow and were easier to see. At this time, 43 individuals were located and georeferenced. The researchers noted more plants could be seen but not reached due to steep terrain and others may have been missed (Yost and Stromberg 2013). They conclude however that this population currently contains far fewer than the previously recorded 300 individuals (Yost and Stromberg 2013).

In May 2010, researchers found five new plants discovered within upper Brown Canyon, approximately 360 m (1,181 ft) south and upslope from subpopulation 300 (Austin 2010b). Counts of stems and fruits were taken from four plants and one plant, occurring in two closely separated subpopulations. Stems ranged from 11 to 81 per plant and fruits from 7 to 76, including some that were only partially developed (Radke 2011, pers. comm.). It was noted that the four plants in one of the subpopulations were close enough together that they may have shared a single root system. Measurements were taken on these same five plants during a 2012 site visit. Stems ranged from 32 to 105 per plant, all of which were in flower. In addition, a single *A. kearneyana* was located in 2012 between these five plants and subpopulation 300. This individual had 54 stems, all of which supported

flowers (Service 2012). All of these plants are located in areas that completely burned in the 2009 Elkhorn Fire and are roughly twice the size of measures taken from various *A. kearneyana* plants before the fire (Reichenbacher *et al.* 1994; Service 2012; Donovan and Topinka 2004; Cohan 2011a, pers. comm.).

State Trust Lands locations

During Donovan's 1998 survey of BLM lands, three adjacent subpopulations containing more than 130 total individuals (comprised of 8 plus 2 nearby individuals, approximately 80 individuals, and more than 50 individuals) were found in Thomas Canyon on State Trust land near the border with BLM land (Donovan 1998). The 2009 Elkhorn Fire burned through this area at an unknown level of severity; the fire edge occurred roughly 140 m (459 ft) from these subpopulations to the west. These subpopulations have not been revisited since 1998; therefore the impact of the fire to these individuals and the current subpopulation sizes are unknown.

Buenos Aires National Wildlife Refuge *ex situ* location

The *ex situ* population in Brown Canyon is located on land now managed by the Service. This population was established in 1988 and originally consisted of 76 container-grown individuals from wild seed stock collected in South Canyon (Reichenbacher *et al.* 1991). Due to poor survival, an additional 105 individuals were planted in January 1989. Flooding in June 1990 eliminated roughly 75% of the population and a third planting was initiated in January 1992 (Reichenbacher *et al.* 1994). Additional floods in July 1992 and January 1993 resulted in further loss. Between March 29, 1988, and November 16, 1993, the *ex situ* population was visited 70 times to monitor growth and reproduction and to artificially water the plants when necessary (Reichenbacher *et al.* 1994). 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 (Reichenbacher *et al.* 1994). Reichenbacher *et al.* (1994) reported that by November 1993, just 64 of the 245 total transplanted individuals had survived. In 2002, Donovan noted 38 plants were tagged and monitored on an annual basis from this population. It is not known if monitoring occurred again until 2009 when plants were counted following the Elkhorn Fire, which burned at moderate severity through this population. At that time, 21 plants had resprouted and were reported to be robust (Cohan 2011a, pers. comm.).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation:

Topinka *et al.* (2004) state that fewer than 1,000 *A. kearneyana* plants are distributed into very small groups that "contain fewer individuals than are necessary for the long-term maintenance of genetic diversity." Due to small sample size, we encourage additional genetics work to increase our knowledge of *A. kearneyana* genetic diversity and subpopulation relationships. A species that has always been rare, yet continues to survive, could be well-equipped to continue to exist into the future (Brigham 2003). Many naturally rare species have

persisted for long periods within small geographic areas, and many exhibit traits that allow them to persist despite their small population sizes.

Butterflies, bee flies, mordellid beetles, hawkmoths, moths, and even broad-tailed hummingbirds have been seen visiting the plants and flowers (Reichenbacher *et al*. 1994; Service 2012). Such long-distance pollinators as larger butterflies and hummingbirds (Schmitt 1980) may be capable of cross-pollinating plants from across subpopulations of *A. kearneyana*. As larger pollinators in particular may be capable of traveling greater distances, it is entirely possible that pollinators may be providing genetic exchange between most, if not all, subpopulations of *A. kearneyana*. Such pollen flow contributes to the preservation of genetic variation, as the exchange of a single grain of pollen or a single seed between populations per generation may maintain genetic variation (Kwak *et al*. 1988). For example, butterflies typically do not return to specific flower clumps and often maintain pollen on their probosces for more than two days, allowing transfer of pollen longer distances between clumps (Schmitt 1980; Courtney *et al*. 1982) thus reducing the chance of genetic drift within *A. kearneyana* subpopulations.

It is possible that other plant species in the vicinity of *A. kearneyana* plants such as beargrass (*Nolina microcarpa*) in the steep slope habitat or doctorbush (*Plumbago scandens*) in the canyon bottom habitat may contribute to successful pollination for the species. Both of these associates have overlapping bloom periods with *A. kearneyana* and may jointly attract and maintain pollinators, thus providing a benefit to both species and "stepping stones" (Kwak *et al*. 1998; Moeller 2004) between *A. kearneyana* subpopulations.

It is generally thought that small insect-pollinated plant populations may have reduced or halted seed set, possibly due to low flower density making pollinators less effective (Kwak *et al*. 1998). This is a less likely scenario for *A. kearneyana* because: a) a single plant averages more than 50 stems, b) each stem contains an average of 16 flowers (Service 2012), c) the plants are known to be pollinated by a wide range of insect and bird species, and d) seed set has been reported on numerous occasions (McLaughlin 1982; Phillips and Brian 1982; Reichenbacher *et al*. 1994; Donovan 1998; Cohan 2011b, pers. comm.). Donovan and Topinka (2004) note that the seeds are highly viable and easy to cultivate.

2.3.1.4 Taxonomic classification or changes in nomenclature:

The taxonomy and nomenclature of *A. kearneyana* have not changed since the 1993 Recovery Plan was written. There is no disagreement in the scientific literature regarding the taxonomy of this species; thus we consider *Amsonia kearneyana* to be a valid taxon and a listable entity.

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

At the time of listing (1989) *A. kearneyana* was only known from a single location at the mouth of South Canyon in the Baboquivari Mountains on lands administered by the Tohono O'odham Nation. When the Recovery Plan was completed (1993), a second population had been created by transplanting plants propagated from South Canyon seed collection into lower Brown Canyon on private land that was later sold and is currently owned and administered by the Buenos Aires National Wildlife Refuge. Since then, discovery of new subpopulations on lands administered by the BLM and Arizona State Land Department 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 Tohono O'odham lands in drainages to the north and west of Baboquivari Peak. Donovan (1998) states the species does not appear to be habitat limited and that there is a high possibility that more (sub)populations occur in the vicinity. A map showing general locations of *A. kearneyana* is found in Figure 1.

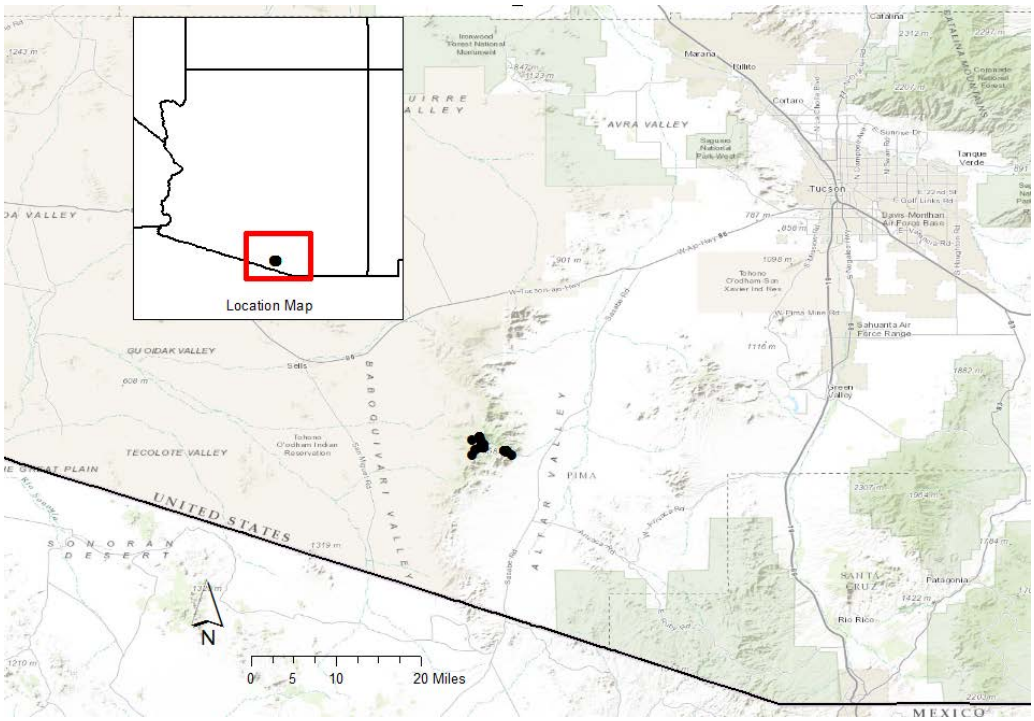

Figure 1. General location of *Amsonia kearneyana* in Pima County, AZ.

While suitable habitat is abundant on the slopes and associated drainages of the Baboquivari Mountains, the plant remains rare. Intensive surveys for this species to date have yielded the following limited results: 1) in 1981 Phillips and Brian (1982) found just 25 individual plants in South Canyon; 2) in 1987, while surveying major canyons on the east slope of the Baboquivari Mountains for suitable habitat to locate an *ex situ* population, Howell found no additional plants (Reichenbacher *et al.* 1994); 3) Donovan's 1996 and 1998 surveys of 5 canyons yielded 11 new *A. kearneyana* subpopulations from Brown Canyon and 1 from Thomas Canyon, totaling 690 individuals (Donovan 1998); 4) Austin *et al.* in 2009 located a new subpopulation of 6 individuals in upper Brown Canyon (Austin 2010b); and 5) in 2012 a single previously unrecorded individual was located in route to the subpopulation Austin had found in 2010 (Service 2012). Many of the plants found by Donovan have not been relocated in recent years (Austin 2010b; Service 2012; Yost 2012, pers. comm.). In both April (during flowering) and July (during fruiting) of 2013, researchers from the University of Arizona, funded through a Service section-6 grant, collected data from eight known *A. kearneyana* subpopulations within Brown Canyon. All newly encountered subpopulations located while traversing between the eight known subpopulations were mapped during this effort, but data were not available at the time of writing this document. The habitat of *A. kearneyana* is remote and plants are easily missed when traversing the steep slopes; much of the suitable habitat remains unsurveyed.

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

Amsonia kearneyana occurs in two distinct habitats: open woodland on unconsolidated slopes of over 20 degrees, and canyon bottoms in full sun to partial shade (Arizona Rare Plant Guide Committee 2001). This species is known only from the slopes and canyons of the Baboquivari range of Pima County in southern Arizona at elevations from 1,095 to 1,830 meters (3,600 to 6,000 feet). The Baboquivari Mountains are a granitic outcrop containing a mixture of species from four distinct floras, making this a very diverse region floristically (Austin 2010a). Donovan (1998) 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 Emory and Mexican blue oaks (*Quercus emoryi* and *obolngifolia*), Mexican pinyon pine (*Pinus cembroides*), catclaw acacia (*Acacia greggii*), sotol (*Dasylirion wheeleri*), shindagger agave (*Agave schottii*), Wright's silktassel (*Garrya wrightii*), squawbush (*Rhus trilobata*), and beargrass (*Nolina microcarpa*). Associated species of the canyon bottom habitat include netleaf hackberry (*Celtus reticulata*), Arizona walnut (*Juglans major*), catclaw acacia, Mexican blue oak, sotol, and doctorbush (*Plumbago scandens*) (Phillips and Brian 1982; Donovan 1998). These habitats are changing due to a combination of high severity fire and drought, and are becoming more desertified with fewer trees and more grassland species associates (Service 2012). Although

much suitable habitat occurs within the Baboquivari Mountains region, merely a few plants have been found, growing in small scattered groups.

Long-term monitoring of habitat conditions within the Baboquivari Mountains is lacking, therefore we are unaware of changes in habitat due to the removal of livestock. Perhaps the biggest changes in habitat in recent years are due to the above-mentioned high severity fire in combination with prolonged drought. In addition to habitat change, the past, current, and projected future drought throughout the southwest impacts natural recruitment of *A. kearneyana*. Although canyon bottoms seem to be secondary habitat for *A. kearneyana*, the additional water available periodically therein may have aided in the continued survival of at least some individuals of the transplant population. Supplemental water provided by researchers during and following the transplant operation also undoubtedly aided in initial survival of many of these individuals. Any future transplant operations would likely also require supplemental water for establishment.

2.3.1.7 Other:

Donovan (1998) recommends further surveys for *A. kearneyana* in the Coyote Mountain Range to the northeast; no surveys for this species have been conducted there to date. It is recommended that biologists with the Tohono O'odham Nation conduct surveys for this species in both historical and nearby locations and that they extend their searches up slope to incorporate both types of habitat. 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; Yost 2012, pers. comm.). The presence of *Nolina microcarpa* in upslope populations may be also an indicator of the species that could aid in discovery of *A. kearneyana* (Austin 2010b). It should be noted that while new surveys are needed to locate previously unrecorded plants, it is also very important to revisit known sites, especially following the Elkhorn Fire, to determine the current status of these subpopulations, and potential effects of the fire on this species.

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

Threats to the species identified in the Recovery Plan that could potentially impact *A. kearneyana* include: catastrophic flooding and soil erosion accelerated by losses in plant cover and vigor due to livestock grazing (Factor A); seed predation by insects (Factor C); and low numbers, few populations, and apparently insufficient reproduction (Factor E). Since the Recovery Plan was written, the additional threats to *A. kearneyana* of climate change, fire impacts, and border activity have been identified.

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

Livestock grazing

Although cattle do not eat *A. kearneyana*, trampling of individual plants has been noted (Reichenbacher 1988; Reichenbacher *et al*. 1994) and cattle trailing could result in erosion on slope subpopulations, especially during severe weather events (Service 1997).

Tohono O'odham lands

According to Phillips and Brian (1982), the area of *A. kearneyana* in South Canyon of the Tohono O'odham Nation was severely overgrazed by domestic livestock and resulted in the reduction of understory cover and the trampling of plants. They noted that the lack of seedlings and small plants and overall low number of plants could be partially attributable to the heavy use of the habitat. Currently, there is no information available with regard to the health of habitat or *A. kearneyana* individuals in locations on Tohono O'odham lands. The Recovery Plan (Service 1993) states the Tohono O'odham habitat had been overgrazed resulting in erosion, flooding, and general habitat degradation. A 1997 Biological Opinion (Service 1997) stated that no change in the grazing regime on Tohono O'odham lands is expected.

Since the 1997 Biological Opinion, the current grazing regime has slowly decreased in the area where *A. kearneyana* had been found due to several different factors, including an overall decrease in organized cattle ranching although individual ranchers with smaller herds still utilize the area but primarily on lower slopes (Howe 2013, pers. comm.). Because of this and other reasons, the area has undergone some recovery to see an increase in grassland and chaparral species (Howe 2013, pers. comm.).

BLM and Service lands

The Brown Canyon area is known to have had cattle ranching operations since the late 1800s (Kirkpatrick 2011, pers. comm.). In the late 1980s and early 1990s, Reichenbacher noted cattle trampling of transplanted individual *A. kearneyana* plants in the lower Brown Canyon *ex situ* colony (Reichenbacher 1988; Reichenbacher *et al*. 1994). In 1993, the Service purchased property in Brown Canyon, including the *ex situ* colony site, which became part of the Buenos Aires National Wildlife Refuge. The Service let the grazing lease on the property expire, and in 1996 the BLM placed the Baboquivari allotment into non-use status (Service 1997). Approximately 10 "wild" cattle remained on this allotment at that time (Service 1997). Cattle sign (bones, fresh dung, and trailing by deer and possibly cattle) were present in upper Brown Canyon in July 1997 (Service 1997). Donovan reported seeing feral bulls on a few occasions during his 1996 and 1998 work in upper Brown Canyon (Donovan 2012, pers. comm.). Annual BLM reports from 1997 through 2001 note there may be one or two stray cattle remaining in the canyon and that this could be a yearly event due to fenceline issues; however, trespass livestock do not appear to be a threat to *A. kearneyana* on this allotment (BLM 1998; BLM 1999; BLM 2000; BLM 2001). At present, trespass cattle have not been noted in Brown Canyon in at least five years (Cohan

2011c, pers. comm.; Anderson 2011, pers. comm.; Service 2012). Potential for trespass cattle from neighboring lands remains a possibility.

State of Arizona lands
The upper Thomas Canyon subpopulation occurs on land owned by the State of Arizona that is leased for livestock grazing. The lease is for a total of 161 ha (400 ac) and is rated for 5 Animal Units. The lessee is currently grazing from December through April each year (Sommers 2012, pers. comm.).

In summary, on lands where *A. kearneyana* is known to occur, the BLM and the Service have rested livestock grazing, the State permits grazing on a limited basis, and the Tohono O'odham Nation lands likely remain impacted by livestock grazing.

Wildfire
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; TNC 2006). The historical fire regime of the Madrean pine-oak woodland is one of frequent low intensity surface fires in the early spring and summer that moved through areas spanning elevations from semi-desert grasslands through montane conifer systems (TNC 2006). Based on the size and growth rate of pine trees in Brown Canyon, it is estimated that fire has been absent from this area for more than 100 years (Wilson 2012, pers. comm.). Austin (2012b, pers. com.) noted that long-time ranchers who were interviewed by him have not seen fire in this canyon in their memory. This timeframe coincides with the history of cattle grazing in the canyon (Kirkpatrick 2011, pers. comm.). In general, the lack of fine fuels available for fire has been attributed to cattle grazing (TNC 2006).

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). The species has a creeping rhizome which can recover from disturbance, and other species in this genus and family are known to respond positively from the effects of fire (Duncan *et al.* 2008; Chapman and Crow 1981). The benefit of the nitrogen pulse and reduced competition following fire can be seen in the increased plant size and general vigor of *A. kearneyana* individuals seen following the 2009 Elkhorn Fire (Reichenbacher *et al.* 1994; Service 2012; Donovan and Topinka 2004; Cohan 2011a, pers. comm.). Despite increased vigor, there was also a loss of *A. kearneyana* plants documented following the fire. We do not know if competition, drought, increased fire severity, other unknown causes, or a combination of these factors resulted in the loss of roughly 242 *A. kearneyana* plants from one upper Brown Canyon subpopulation between 2002 and 2012. It is impossible to draw conclusions about fire severity impacts to *A. kearneyana* without intermittent data available. High severity fire, which is outside of the normal fire regime for this species and which did occur in upper Brown Canyon at the site of this loss in individuals, may

have negatively impacted *A. kearneyana*. Research into fire severity impacts on this plant is needed.

Border Activity

The southern portion of *A. kearneyana* habitat is located approximately 34 kilometers (21 miles) 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 2011a). This illegal activity is often followed with a law enforcement response by Customs and Border Protection (CBP) 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). *Amsonia kearneyana* is located in rugged habitat that precludes driving off road; therefore any impact incurred by these activities would be primarily on foot.

A 2007 Biological Opinion regarding Buenos Aires National Wildlife Area, which incorporates a portion of the *A. kearneyana* population, notes that some illegal traffic occurs near known populations of *A. kearneyana* (Service 2007). 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; Donovan 1998). 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.

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

With regard to the production of glucose and ethanol, Punnapayak and Hoffmann (1994) suggest that *A. kearneyana* would be a good crop candidate for arid lands. Growing *A. kearneyana* for biofuels has not been attempted. The species has reportedly been used medicinally by the Tohono O'odham Nation (Desert Botanical Garden 1992). There are currently no known issues with overutilization for either of these uses.

Amsonia kearneyana is a very attractive plant; however, due to the inaccessibility of habitat, collection is unlikely and has never been reported. As the plant did well in previous transplanting efforts, we know this species survives both in pots and transplanting.

The Recovery Plan calls for the establishment of a garden population and seed bank at a botanic garden. In 2011, the Sonoran Desert Museum propagated seed collected in South Canyon between 1986 and 1988. Germination rates varied from zero to 64 percent (Montgomery 2012, pers. comm.). The Museum currently maintains 39 one-gallon potted *A. kearneyana* individuals and there are plans to collect seeds from these individuals should they become available (Montgomery 2012, pers. comm.).

2.3.2.3 Disease or predation:

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 stinkbug (*Chlorochora ligata*: Pentatomidae) predation (McLaughlin 1982). Donovan noted no infestation or abnormally appearing predation during 1998 surveys following a dry winter (Donovan 1998; Western Regional Climate Center 2011).

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). Twice the recorded average precipitation was recorded in 1978 (Western Regional Climate Center 2011).

The region is predicted to become drier and hotter as a result of climate change (Karl *et al.* 2009), and it is possible that stinkbug predation will pose less of a threat to *A. kearneyana* in the future. Another possibility, however, includes reduced health of *A. kearneyana* plants due to drought and an increase in susceptibility to predation and disease. The latex within the plant stems and leaves, which deters cattle from eating the plant, may preclude some predation by insects. Research into predation impacts on this plant, given changing climate, is needed. There are no known diseases impacting *A. kearneyana*.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

On State of Arizona, BLM, and Service lands, *A. kearneyana* is protected by the Arizona Native Plants Law as a highly safeguarded protected native plant (Arizona Revised Statutes, Chapter 7, 2007). This law prohibits collection without obtaining a permit on all public lands, but does not protect habitat. No cases of unauthorized collection of *A. kearneyana* have been documented.

There are no regulations in place that address threats to *A. kearneyana* and its habitat from drought and the effects of climate change.

With respect to threats to the species caused by activities along the U.S.–Mexico border, there is a Memorandum of Understanding (U.S. Department of Homeland Security *et al*. 2006) and a Biological Opinion (Service 2007) that include measures aimed at reducing effects to resources in the border region from U.S. Border Patrol activities. These documents provide some relief to the species from the threats caused from cross-border violators and CBP law enforcement activities. In general, CBP 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 issues, 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.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Low numbers, few populations, and apparently insufficient reproduction
Amsonia kearneyana has a very restricted geographic range with a small number of known subpopulations ranging in size from a single plant to roughly 130 individuals (Donovan 1998; Service 2012). Additionally, seedlings are rare in both wild subpopulations and in the transplant population.

In 1981, Philips and Brian located a single *A. kearneyana* seedling among 24 adult plants in South Canyon on Tohono O'odham land. In 1994, Reichenbacher *et al.* noted no seedlings were present in the transplant population during any year of study to that point. Donovan and Topinka (2004) measured individual *A. kearneyana* plants with 4 to 70 stems per plant, indicating a range of plant sizes present. No seedlings were noted by researchers in the transplant population in 2011 or in 3 upper Brown Canyon subpopulations (including subpopulation 300) in 2012 (Service 2011b, Service 2012). Five individuals were noted to be smaller in height with fewer stems during a November 2012 site visit to subpopulation 300 in upper Brown Canyon (Yost 2012, pers. comm.). These are presumed to be younger individuals (Yost 2012, pers. comm.).

Seed production does not seem to be the limiting factor contributing to the lack of seedlings in populations of *A. kearneyana* that have been visited, with seed set reported on numerous occasions (McLaughlin 1982; Phillips and Brian 1982; Reichenbacher *et al.* 1994; Donovan 1998; Donovan and Topinka 2004; Cohan 2011b, pers. comm.; Service 2011b). Germination is reported to occur easily under greenhouse conditions (Donovan and Topinka 2004) and seed is known to persist for long periods of time, at least under artificial conditions (Montgomery 2012, pers. comm.).

Donovan (1988) 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).

Climate Change and Drought

Climate change is likely to affect the long-term survival and distribution of native plant species, including *A. kearneyana*, through changes in temperature and precipitation. Over the past 40 to 50 years, the United States has experienced more extreme weather events, heat waves, and regional droughts than in previous decades (Karl *et al.* 2009). The southwestern U.S. has experienced the greatest temperature increase in the continental United States; average temperatures increased approximately 0.8 degrees Celsius (°C) (1.5 degrees Fahrenheit (°F)) compared to a 1960 to 1979 baseline (Karl *et al.* 2009). By the end of this century, temperatures in the southwest region are expected to warm a total of 2 to 5 °C (4 to 10 °F) (Karl *et al.* 2009). The frequency and intensity of high temperature extremes will increase, and heat waves currently considered rare will become more common (Karl *et al.* 2009).

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). 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 (Ault *et al*. 2011; Cayan *et al*. 2005). 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). 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).

   Amsonia kearneyana is one of the earliest flowering species in Brown Canyon (Austin 2013, pers. comm.). Unusual frost events experienced in the spring of 2011 and 2013 negatively affected *A. kearneyana* observed in the lower Brown Canyon *ex situ* colony (Cohan 2011b, pers. comm.; Cohan 2013, pers. comm.). There was also evidence of the 2011 frost damage in the upper canyon subpopulations visited in April 2012 (Service 2012). 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 2011b, pers. comm.). 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). In addition, over a 63 year period, Karl *et al*. (2009) found an increase in high intensity rainfall events during the summer monsoon in the nearby desert of northwestern Mexico. Climatic projections for the southwestern United States indicate both increased summer drought coupled with more intense periodic rainfall events (Karl *et al*. 2009; Zhang *et al*. 2012). Such extreme rainfall is projected to increase runoff and soil erosion (Zhang *et al*. 2012). Fire can also increase hydrophobicity of soil in the first few years following fire (Campbell *et al*. 1977; DeBano 1990); 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 74 percent of the plants in the lower Brown Canyon *ex situ* colony due to extreme flood events during the early 1990s (Reichenbacher *et al.* 1994). 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; Western Region Climate Center (WRCC) 2012). Annual mean precipitation levels are expected to decrease in western North America and especially the southwestern states by midcentury (IPCC 2007; Seager *et al.* 2007). Drought negatively impacts *A. kearneyana* flower and seed development and germination. Reichenbacher *et al*. (1994) noted that aridity and record daytime maximum temperatures caused flower abortion in the *A. kearneyana ex situ* colony in the spring of 1989. Radke, in her 2010 observations of 5 upper Brown Canyon *A. kearneyana* plants, noted 42 whole and 33 partial fruits that, for unknown reasons, were not fully developed (Radke 2011, pers. comm.). 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, the last two of these during drought periods (Phillips and Brian 1982; Reichenbacher *et al*. 1994; Service 2011b; Service 2012). Donovan (1988) 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). 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 upper Brown Canyon 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 (Brooks and Pyke 2001; Ford *et al*. 2012). 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.

2.4 Synthesis

Amsonia kearneyana is a plant that occurs in two disturbance-prone environments: open unconsolidated slopes and intermittent stream beds. Although plants have been lost to flooding and likely to erosion, the species' ability to persist in these habitats and the evidence of resprouting following frost or fire indicate the species is likely adapted to at least some level of disturbance. Although more small subpopulations of *A. kearneyana* have been found in recent years, populations and subpopulations visited more than once show declines, and this species is still very limited both in numbers and in distribution. The ongoing and projected drought of the region may add to the uncertainty of this species' future given that it requires adequate rainfall for sexual reproduction. In addition, drought coupled with a recent large-scale fire has resulted in changes in vegetation community characteristics in the plant's habitat; we do not know what impact this may have on *A. kearneyana*. The species reproduces both sexually and asexually, and is long-lived; these characteristics may aid in survival. Research is lacking in areas of genetics, disturbance and drought impacts, seed dispersal and germination, dynamics of the metapopulation, and many basic biology and ecology questions. In addition, more surveys and monitoring are needed.

3.0 RESULTS

3.1 Recommended Classification: Remain as endangered.

Amsonia kearneyana is a species with limited range and a small number of individuals. There is a great deal of uncertainty about the relationship of individuals, subpopulations, and populations, and about the species' ability to respond to disturbances such as fire and drought. Although new populations of *A. kearneyana* have been located in the past decade, following the Elkhorn Fire at least two of these populations have declined in number, but increased in stature. The vegetation community surrounding at least one large population changed significantly following the fire; implications of this change to *A. kearneyana* remain unknown. As most subpopulations of *A. kearneyana* contain fewer than 30 individuals, the recovery goal of 10 self-sustaining populations containing at least 200 reproducing individuals is far from being met. The species continues to be in danger of extinction throughout its narrow range for the foreseeable future, and thus meets the definition of endangered at this time.

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

3.2 New Recovery Priority Number: No change is needed. The recovery priority number should remain as a 2, given that the level of threat continues to be high, the recovery potential is high, and the listed entity is a species.

3.3 Listing and Reclassification Priority Number: Not Applicable.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- The 1993 Recovery Plan should be updated with recovery criteria that reflect current threats to *A. kearneyana*. Updated objective, measurable criteria for downlisting and delisting should be established.
- Studies should be conducted to evaluate impacts of climate and long-term drought on this species. Studies should focus on site specific climate changes such as precipitation, snowfall, and temperature that influence flower and seed production, and seed germination.
- Studies should be conducted to evaluate the impacts of fire of varying severity on this species. Comparisons to non-burned subpopulations on Tohono O'odham lands would be very helpful.
- Studies should be conducted to evaluate the pollination ecology of *A. kearneyana* and evaluate if pollinators are connecting all subpopulations, thereby maintaining genetic diversity.
- Establish monitoring within several subpopulations that allows comparison of data over time and across various disturbance regimes.
- Studies specific to genetics or trends in genetic variation should be completed.

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Additional Contacts for this report:

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Karen Howe, Ecologist, Tohono O'odham Nation, Natural Resources Department

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Amsonia kearneyana*

Current Classification: Endangered without critical habitat

Recommendation resulting from the 5-Year Review:

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

Appropriate Listing/Reclassification Priority Number, if applicable: Not applicable.

Review Conducted By: Julie Crawford

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service, Tucson Ecological Services Field Office

Approve Debra T. Bills Date 8/2/13

REGIONAL OFFICE APPROVAL:

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

Approve Michelle Shaffney Date 8/15/13

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