Status Report

Amsonia tharpii (Tharp's bluestar)

on

NM State Trust Lands

(Section 6, Segment 27)

2013

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

INTRODUCTION

Amsonia tharpii is only known from a few populations in Eddy County, New Mexico, and in adjacent Pecos County, Texas. It was originally collected in 1943 by B.C. Tharp near Ft. Stockton, Texas, and described in 1948 by R.E. Woodson. In 1989, it was discovered by Bill Dunmire of The Nature Conservancy on Bureau of Land Management (BLM) lands in New Mexico at Cedar Canyon (Figure 1). Two additional locations were documented in 1995 by Bob Sivinski (former Botanist, NM State Forestry) in the Yeso Hills area southwest of Carlsbad (Ben Slaughter/Yeso Hills population), and the Red Lake area, northeast of Artesia (Red Lake population) (Figure 1). No new populations have been found since. Additional surveys by the BLM and USFWS in 2006 and 2010 expanded and mapped the perimeters of the known populations (Howard 2007, NHNM 2013).

Oil and gas development on BLM and State Trust lands have already impacted two of the three populations in New Mexico (Sivinski *et al.* 2013). Continued and increasing mineral leases, exploration and development increase the likelihood of further impacts to the habitats of known populations and similar potentially occupied habitats. The U.S. Fish and Wildlife is currently assessing the status of *Amsonia tharpii* and will prepare a 12-month finding to determine whether listing the species is warranted under the Endangered Species Act (74 FR 66866). Current and accurate information on the status, distribution, habitat requirements, and population abundance were needed to support the development of conservation measures to avoid or minimize threats and possibly preclude the need for listing as threatened or endangered.

The New Mexico sites are predominantly on BLM lands, but also extend into adjacent State Trust lands. It is estimated that approximately 20% of potential *Amsonia tharpii* habitat occurs on State Trust Land. Prior to 2013 information on the habitat requirements of *Amsonia tharpii* and its status and distribution were limited because no comprehensive surveys were completed for the species. Because of the relative large distances between populations and the heterogeneity of their habitat it was thought that there was significant potential to locate new populations on BLM and State Trust lands.

The BLM conducted field surveys in 2013 of known populations on BLM managed lands and is developing a habitat model in coordination with Natural Heritage New Mexico (NHNM) (Sivinski *et al.* 2013). The purpose of this study was of complete surveys on NM State Trust lands to compliment efforts on BLM lands and develop a habitat model to identify and prioritize survey areas, and to provide a more accurate assessment of the distribution, abundance and status of the species throughout its range in New Mexico.

Plant Description

Amsonia tharpii is a perennial suffrutescent herb up to 30 cm tall. It forms a strong woody rootstock. Leaves are dimorphic, those on the lower half of the stem elliptic-lanceolate and those above linear to linear-lanceolate; flowers are pale-blue or greenish-white and salverform; the fruit is composed of two short, thick follicles, 25-35 mm long. It flowers from April to May.

Distribution

Amsonia tharpii is only known to occur in Eddy County, NM, and Pecos County, TX. In New Mexico plants are distributed in three distinct meta-populations in the vicinity of Carlsbad and Artesia (Figure 1) (Red Lake, Cedar Canyon, Ben Slaughter/Yeso Hills). In Texas the species is known from one small population near Ft. Stockton (Poole *et al.* 2007, Sivinski 1992). A meta-population is a population of plants composed of one to several sites of occupation where genetic exchange is likely through pollination and dispersal. A site represents an occupied patch of habitat separated by a minimum distance of approximately 100 ft between individual plants.

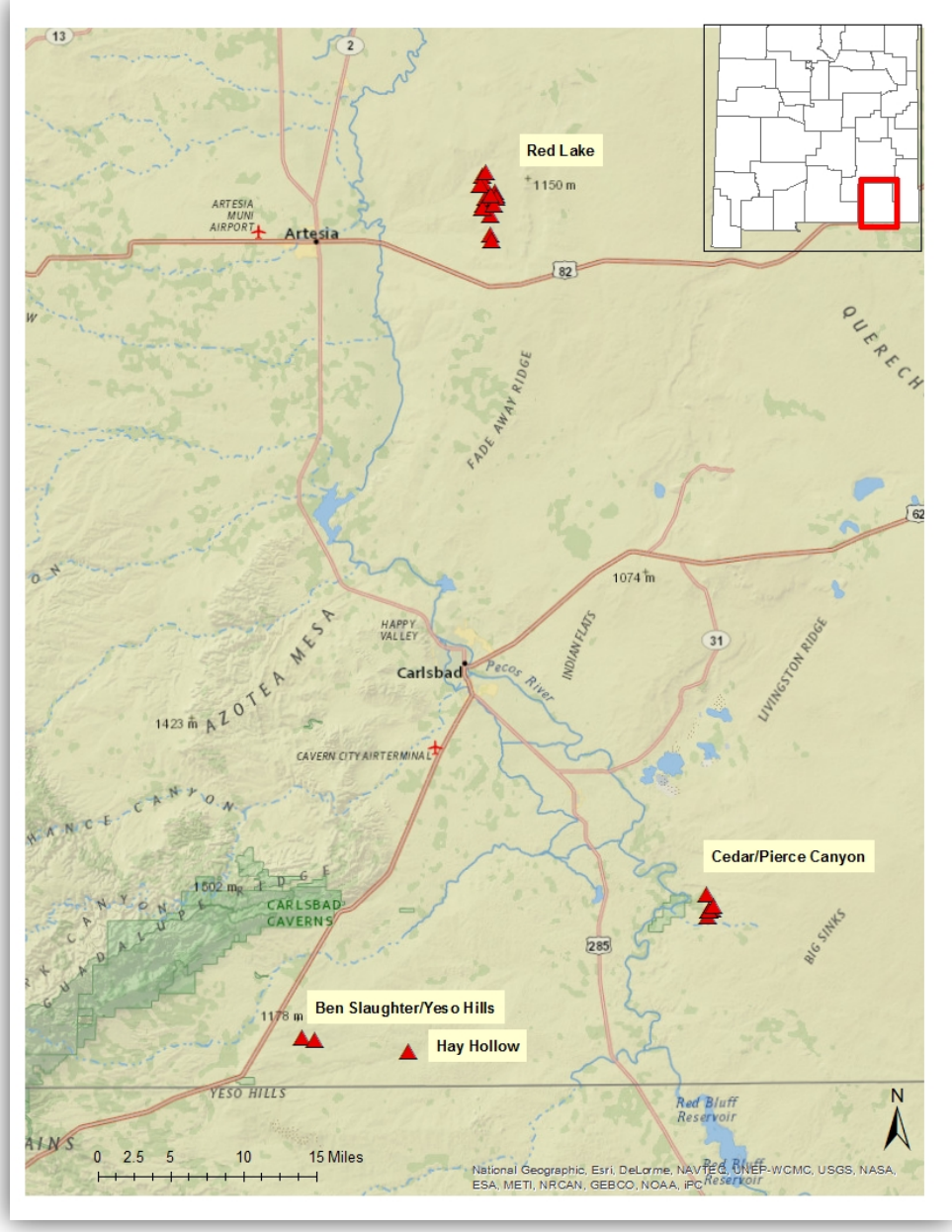

Figure 1. Overview of the 2013 distribution of *Amsonia tharpii* in Eddy County, NM.

Habitat

The habitat of *Amsonia tharpii* is characterized by rolling hills and shallow drainages composed of sandy soils with a limestone, gypsum, or dolomite component derived from the Rustler, Gatuña, and Castille formations (Howard 2007, *Sivinski et al*. 2013). All three formations contain various concentrations of gypsum, which appears to be an important component of the substrate in which the species is found (Howard 2007). It occurs within Chihuahuan desert shrub communities between 3,060 and 3,760 ft in elevation. The average annual precipitation for Carlsbad is 12.84 inches and 11.88 inches for the Artesia area (WRCC 2014).

Status

Amsonia tharpii is listed as NM State Endangered and is a BLM Sensitive Species. It is also a Federal Species of Concern and is currently being evaluated for listing under the Endangered Species Act, following a 90-day finding indicating that listing as threatened or endangered may be warranted for the species (74 FR 66866; NMRPTC 1999).

NatureServe lists the species critically imperiled (G1/S1) globally and statewide in New Mexico and Texas due to the low number of documented populations and threats caused by prevalent land uses. The NM Rare Plant Technical Committee has assigned a RED code of 2-2-2, indicating that the occurrence of the species is confined to several populations (Rarity), is endangered in a portion of its range (Endangerment), and is considered rare outside of New Mexico (Distribution) (NMRPTC 1999).

Threats

The primary threats to *Amsonia tharpii* are direct impacts caused by the construction and maintenance of oil well pads and associated infrastructure, including road construction, pipelines, storage facilities, and waste water pits. Many sites occur in the immediate vicinity or in close proximity of existing oil well pads and associated access roads. Several sites have been impacted by oil & gas development in the past (Sivinski *et al.* 2013). Occupied sites are often very small (< 0.5 acres), often smaller than the standard size of a single oil well pad (> 1 acre). Additional threats may include herbicide treatments (BLM Restore NM Program), habitat fragmentation, livestock grazing, OHV use, small population size, and climate change. Indirect impacts caused by habitat fragmentation, dust deposition, and impacts to pollinators and their habitat have not been studied and are unknown.

METHODS

Objectives

- Conduct field surveys to determine the distribution and abundance of known *Amsonia tharpii* population on State Trust lands.
- Conduct surveys for new populations in potential habitats identified by the GIS model developed by Natural Heritage NM in 2012.

- Record positive and negative findings of field surveys in GIS format and assess habitat requirements, distribution, abundance, and status of known and new populations on State Trust lands.

Inventories were begun by reviewing existing descriptions of habitat characteristics and locations. Herbarium records were queried on-line and transferred into GIS files (SEINet 2013). Additional site specific information, maps and GIS shapefiles of known populations and potential habitat were provided by Natural Heritage New Mexico (2013).

A one year delay in the rollout of the draft NHNM model preempted the use of this model for the 2013 habitat analysis as a means to prioritize and target potential habitat for on the ground surveys. Therefore potential habitat was identified from satellite imagery, and the 2006 BLM model (Howard 2007, NHNM 2013). Surveys on State lands coincided with initial surveys to support the draft NHNM model on BLM lands (Sivinski *et al.* 2013).

In general, *Amsonia tharpii* grows on sedimentary outcrops or alluvium derived from Upper Permian beds containing gypsum or Ogallala-like caliche fragments (Howard 2007). These soil types were targeted to identify potential habitat for the 2006 BLM model, as well as to identify potential habitat from satellite imagery for the initial NHNM draft model surveys (Sivinski *et al.* 2013). The 2006 BLM habitat model results used for this surveys used habitat information derived from the 3 known populations, including elevation, slope, aspect, and geology (Howard 2007).

Intensive surveys were conducted on foot in the vicinity of known sites to better define populations and their habitat for use of the NHNM model. Focus areas were sites adjacent to areas mapped during the 2006 and 2010 surveys by the BLM and USFWS and areas not mapped since 1995. In addition, a 10-mile radius around each of the three known population was mapped and survey sites were selected based on land ownership and targeting geologic outcrops visible on color aerial imagery, and by identifying potential habitat from on the ground observations. Additional areas outside the 10-mile focus area were surveyed based on the 2006 BLM model (Howard 2007). Survey areas were chosen based on the highest potential of species occurrence on State Trust Lands. Habitat assessments outside the 10-mile focus area were conducted via vehicle combined with walking surveys whenever suitable habitat was located. Surveys were conducted during flowering season from April 9 through May 15, 2013.

New sites discovered in 2013 were delineated with a Garmin Montana 650 GPS by walking tracks 2-3 meters on the outside of individual plants along the periphery of a site. New site polygons were established where ever there was a 100 ft or greater gap between plants. In addition, negative survey results were tracked with a GPS or on maps when no plants were found.

Plant numbers were visually estimated. An actual count of plant numbers was difficult because more than one clump of aerial branches can originate from one long underground stem or root. Also assessed was the overall vigor and phenology of plants within a site, associated species, and observed and potential threats to the site.

RESULTS

Summary

Only one additional population of *Amsonia tharpii* was located during the 2013 surveys, on private lands (Hay Hollow - Ben Slaughter/Yeso Hills meta-population). Known populations at Red Lake, Cedar/Pierce Canyon, and Ben Slaughter/Yeso Hills were partially resurveyed and expanded on BLM and State lands (Sivinski *et al.* 2013). A total of 11 occupied sites were mapped on State Trust lands, containing between 50 and 1,000 individuals distributed over total area of approximately 70 acres (Table 1). Plants were largely found in poor condition and were not reproductive (Table 1).

Based on the 2006 BLM habitat model, approximately 6,742 acres of State Trust lands were evaluated on the ground for potential habitat and new occurrences of *Amsonia tharpii* within Eddy County, without success. Although targeted were areas mapped to contain the highest potential for suitable habitat, no new sites were found on NM State Trust Lands.

Table 1. 2013 positive survey results for *Amsonia tharpii* on NM State Trust lands.

Population	**Est. number of plants (site number)**	**Plant Vigor**	**Approximate acres of occupied habitat**
Red Lake	50 (1) Hundreds (2) 150-200(3) 700 – 1000(4) 200-250 (5) 1000 (6)	Poor, 95% senescent	3.42 20.50 3.78 14.81 1.52 17.5
Cedar/Pierce Canyon	30 (9), 50(10), 25(11), 1000(12)	Good, 80 – 95% flowering	0.17 0.28 0.05 7.89
Ben Slaughter/Yeso Hills	50 (7)	Poor, 80 – 90% senescent	0.50
TOTAL			**70.42 acres**

1. Red Lake

The Red Lake population located northeast of Artesia is the largest of the four known meta-populations (including Texas) of *Amsonia tharpii*. This population was originally discovered by Sivinski in 1995 and partially mapped by the BLM in 2006, including population sites located on state lands (Figure 2; Howard 2007; Sivinski 1995). Population sites are largely located on BLM lands (Sivinski *et al.* 2013). On State Trust lands in the Red Lake area *Amsonia tharpii* was found in 6 sites ranging in size from 1.52 acres to 20.5 acres of occupied habitat (Table 1). Sites contained from 50 to 1,000 individual plants. Three of these sites were previously undocumented. Approximately 95% of plants were senescent and not flowering. They were rated in poor condition.

Potential habitat was surveyed on state lands within 10 miles of the known Red Lake population including the existing site located by Sivinski in 1995. No additional populations were found. A total of 6 occupied sites were located within T16S R28E S32 and T17S R 28E S8, including sites delineated in 2006 and 2010 (Figure 2; NHNM 2013). The population mapped along the eastern edge of Section 32 was not resurveyed but all other sites on State Trust lands (Sites 3 – 6) were relocated or expanded and mapped within that Section (Figure 2).

The geology of the area has been described as dolomite derived from the Rustler Formation, although the area has not been mapped in detail (Sivinski *et al.* 2013, Howard 2007). *Amsonia tharpii* was found among rolling hills in red sandy soils among grey dolomite cobble and outcrops (Figure 3). Plants occupied all aspects and shallow drainages, with the majority occurring on N-facing slopes. Slopes range from 0 – 20%. Elevation ranges between 3,540 and 3,630ft. Associated species include *Berberis trifoliata, Prosopis glandulosa, Ephedra torreyana, Allionia incarnata, Thymophylla acerosa, Vachellia vernicosa, Bouteloua eriopoda, Pleuraphis mutica,* and *Dalea formosa*.

The largest threat to the Red Lake population of *Amsonia tharpii* are direct impacts caused by the construction and maintenance of well pads and associated facilities, including road construction, pipelines, storage facilities, and waste water pits (Figure 2). Direct impacts associated with oil and gas development within the Red Lake population and its habitat have been documented from BLM and State Trust lands (Sivinski *et al.* 2013). In addition, the presence of numerous dirt roads in this area is making the population sites vulnerable to impacts from off-highway vehicle (OHV) traffic, dust deposition, habitat fragmentation, and the possible invasion from exotic species.

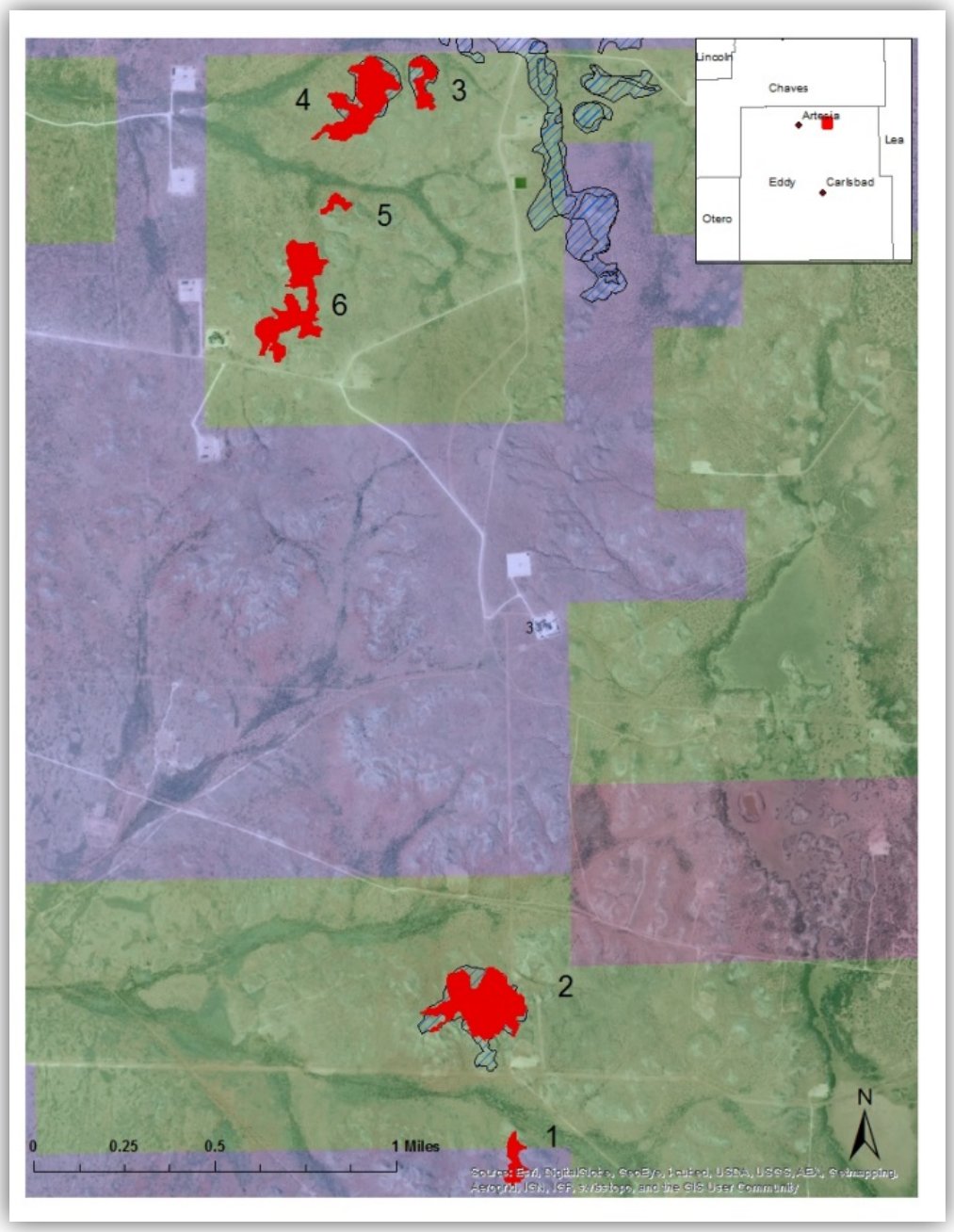

Figure 2. Red Lake population sites of *Amsonia tharpii* on NM State Trust lands (green shading). Blue hatched areas represent previous surveys (NHNM 2013).

Figure 3. Occupied habitat, Red Lake population of *Amsonia tharpii*, April 2013.

2. Cedar/Pierce Canyon

The Cedar/Pierce Canyon population was the first population of *Amsonia tharpii* found in New Mexico. The majority of sites within this meta-population occur on NM State Trust lands and it represents the largest population on Trust lands. Following the initial discovery of the species and several survey efforts, populations were delineated and GIS mapped in 2006 (BLM 2007). Overall this meta-population is estimated to contain several thousand plants distributed on BLM and State Trust lands (Sivinski *et al.* 2013). State land surveys in 2013 documented over 1,000 plants from 4 sites, ranging from 0.05 to 7.89 acres in size (Table 1).

Potential habitat was surveyed on state lands within 10 miles of the known Cedar/Pierce Canyon population. No additional populations were found. A total of 4 occupied sites were located within T24S R 29E S36, including one site previously mapped in 2006 (Figure 4). The population mapped by the BLM in 2006 was partly resurveyed (Site 12) and additional sites (Sites 9 – 11) were located and mapped within that Section (Figure 4).

The geology of the Cedar Canyon area is described as limestone derived from the Gatuña Formation (Sivinski *et al.* 2013, Howard 2007). Plants were found among rolling hills capped with grey limestone in pinkish sandy limy soils among grey limestone cobble (Figure 5). Plants occupied all aspects including flat areas and shallow drainages, with the majority

occurring on N and NW-facing slopes. Slopes range from 0 – 20%. Elevation ranges around 3,100 ft. Between 80 and 95 % of plants were flowering and rated in good condition. Associated species include *Berberis trifoliata, Prosopis glandulosa, Ephedra aspera, Thymophylla acerosa, Tiquilia hispidissima, Tiquilia canescens, Nerisyrenia camporum, Condalia ericoides, Vachellia vernicosa, Bouteloua eriopoda,* Aristida pupurea, *Rhus microphylla, Parthenium incanum, Bouteloua breviseta, Euphorbia acuta,* and *Dalea formosa*.

There is active oil & gas development on State Trust lands, in the immediate vicinity of *Amsonia tharpii* sites, including one site (10) that is bisected by an access road leading to active oil well pads (Figure 4). Numerous dirt roads run through this area making the population sites vulnerable to impacts from OHV traffic, dust deposition, habitat fragmentation, and the possible invasion from exotic species.

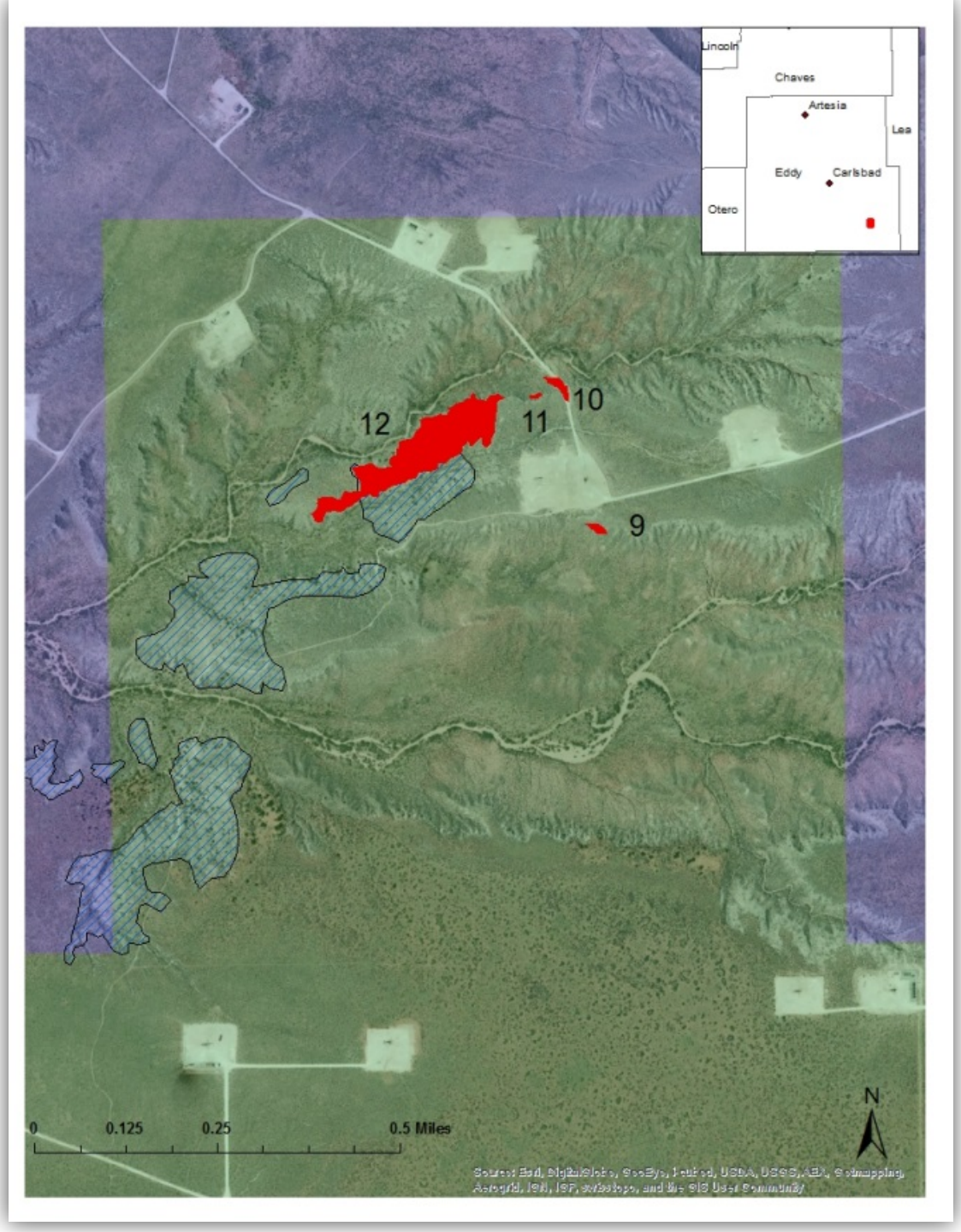

Figure 4. Cedar/Pierce Canyon population sites of *Amsonia tharpii* on NM State Trust lands (green shading). Blue hatched areas represent previous surveys (Howard 2007, NHNM 2013).

Figure 5. Occupied habitat, Cedar/Pierce Canyon population of *Amsonia tharpii*, April 2013.

Ben Slaughter/Yeso Hills

The Ben Slaughter/Yeso Hills population is the smallest population of *Amsonia tharpii* on State Trust lands in New Mexico (Table 1). It consist of four small sites (< 1.5 acres), including three on BLM lands and one located on Trust lands (Figure 6). The population on State Trust lands was originally found by Sivinski in 1995, but had not been documented since.

Potential habitat was surveyed on state lands within 10 miles of the known Ben Slaughter/Yeso Hills population, with a focus on suitable habitat in the immediate vicinity of the known population and in suitable habitats surrounding Ben Slaughter Draw. One additional population was found approximately 7 miles east of the Ben Slaughter/Yeso Hills population (Hay Hollow). The Hay Hollow population is located on private lands, immediately south of State Trust lands (Figure 8).

In 2013 the Ben Slaughter/Yeso Hills population site on State Trust lands was estimated to contain 50 plants distributed over a small hillside (0.5 acres) overlooking Ben Slaughter

Draw. Approximately 80 - 90% of plants were senescent and not flowering. They were rated in poor condition. An estimated 100 -150 plants were found at the Hay Hollow site, 90 % were found flowering and rated in good condition. Plants were growing on similar substrate and contained similar associated plant species as found within the Ben Slaughter/Yeso Hills population. Suitable habitats were surveyed in the vicinity of the Hay Hollow population on State Trust lands to the north, without success. Plants in this area are highly localized and both populations are distributed over very small areas. This is consistent with the Ben Slaughter/Hay Hollow sites found on BLM lands (Sivinski *et al.* 2013).

The geology of the area is described as gypsum derived from the Castille Formation (Sivinski *et al.* 2013, Howard 2007). *Amsonia tharpii* was found on a low hill in light colored gypsum soils with a hard grey colored crust (Figure 7). The majority of plants occurred on the top of the hill with some individual occurring on sparsely vegetated south and east-facing slopes at 3,700 ft. Slopes range from 0 – 20%. Associated species include *Juniperus pinchotii, Berberis trifoliata, Yucca elata, Ephedra torreyana, Bouteloua breviseta, Aristida purpurea, Tiquilia hispidissima,* and *Castilleja sp.*

Habitats within the Ben Slaughter and Hay Hollow populations are actively grazed; livestock and horses were observed in the immediate vicinity of both populations. Active oil and gas development occurs in the area, specifically on State Trust lands in the vicinity of the Hay Hollow population (Figure 8). In addition, a profusion of dirt roads provide access to OHV use, impacts of which were documented near the Hay Hollow population on State Trust lands. Dirt roads are making the population sites vulnerable to impacts from OHV traffic, dust deposition, habitat fragmentation, and the possible invasion from exotic species.

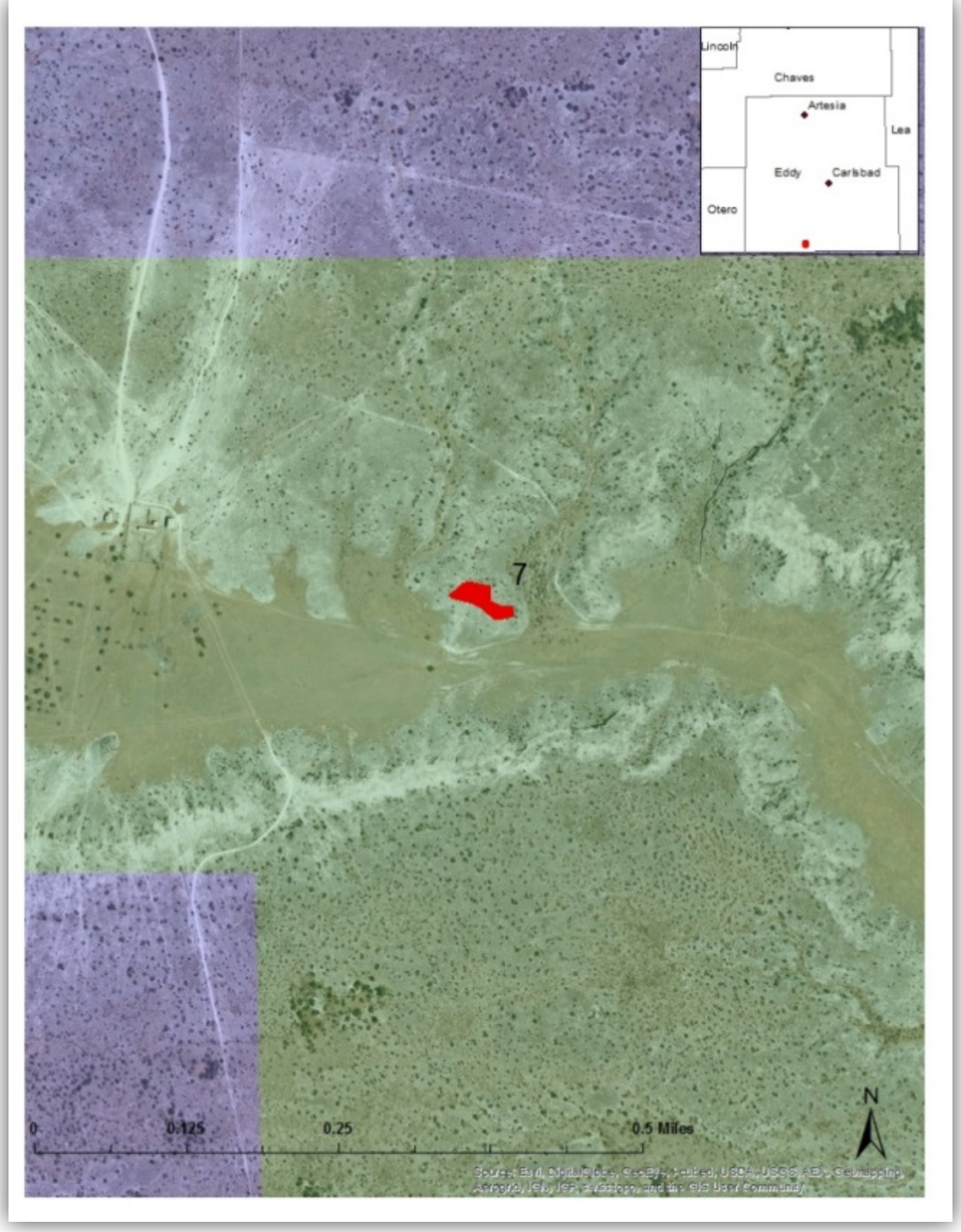

Figure 6. Ben Slaughter/Yeso Hills population site of *Amsonia tharpii* on NM State Trust lands (green shading).

Figure 7. Occupied habitat, Ben Slaughter/Yeso Hills population of *Amsonia tharpii*, April 2013.

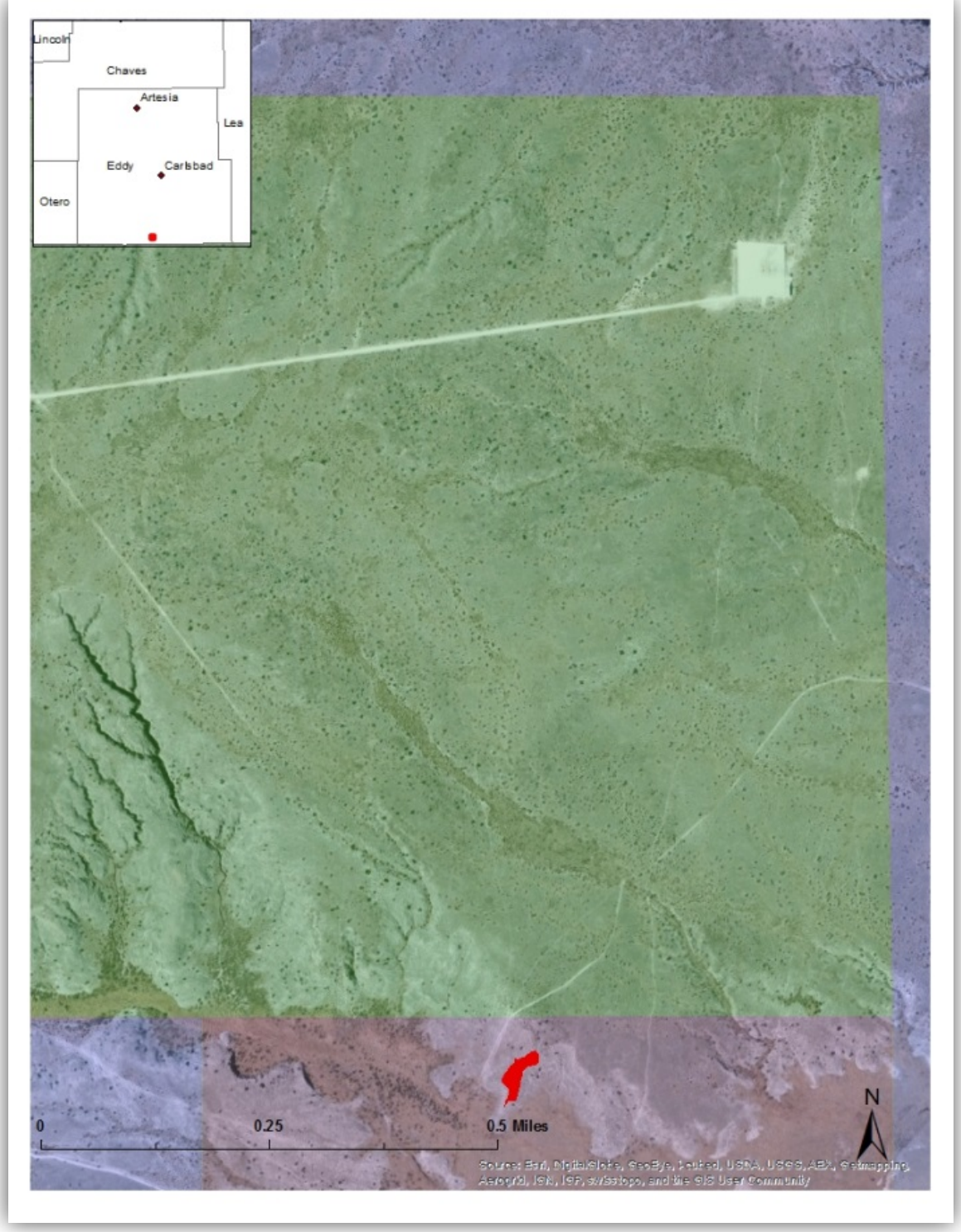

Figure 8. Hay Hollow population site of *Amsonia tharpii* immediately south of NM State Trust lands (green shading).

CONCLUSION

Amsonia tharpii occurs on a variety of substrates and exposures within Eddy County, NM. This somewhat non-specific habitat preference was the primary reason for estimating a high potential for additional populations to be found. However, despite extensive survey efforts on State Trust lands and BLM lands in 2013, only one small additional population was found. Existing populations were expanded and have the potential to be further expanded to a limited extent. Range wide surveys in adjacent Texas have not been successful in finding additional populations (Poole *et al.* 2007). Only a small fraction of the available suitable habitat is occupied by the species, for unknown reasons. However, this is not unusual for many rare plant species. Therefore *Amsonia tharpii* remains a very rare plant with a very limited distribution.

Unfortunately the 2006 BLM habitat model was not successful in helping to locate additional populations of *Amsonia tharpii*. Only one new population was found (Hay Hollow). The habitat potential for this site was mapped by the model as unlikely to somewhat likely. The site was chosen for surveys after evaluating satellite imagery for the presence of suitable habitat defined by gypsum outcrops. Perhaps the completion of a refined habitat model by NHNM in 2014 will lead to additional populations to be found within previously unsurveyed areas.

The Hay Hollow population was found incidentally during surveys on Trust lands 200 ft to the north. The general area just north of the Texas border in Eddy County contains little State Trust lands. Potential habitat is largely found on BLM lands. Due to the contiguity of the habitat and the likeliness for additional populations to be found in between the Hay Hollow and the Ben Slaughter/Yeso Hills population, it is currently mapped as part of the Ben Slaughter/Yeso Hills meta-population. From aerial photography the habitat appears more or less contiguous between these two populations, with all known sites being located on gypsum hills bordering the north side of Ben Slaughter Draw.

Surveys on habitats with a high potential to contain suitable habitat on State Trust lands between the Ben Slaughter/Hay Hollow and the Cedar Canyon populations were unsuccessful. Although surveys in 2013 and in the past have not located other occupied habitat except for the Hay Hollow site, considering the small size of the known sites in this area, there is a good potential for additional sites to be found in suitable habitat on BLM lands between the known sites and possible the State Trust lands section to the north of the Hay Hollow site. Additional surveys planned on BLM lands in 2014 may shed a better light on the overall distribution of *Amsonia tharpii* on gypsum outcrops in the area.

Although individual sites of occupied habitat were added to the known populations of *Amsonia tharpii* in 2013, the total number of meta-populations in New Mexico remains three. The three meta-populations occur on similar topography (low, rolling hills, 3100 – 3700 ft elevation), but on different geological formations (Rustler, Gatuña, Castille). Plants occur on all aspects, including flat areas, but appear to prefer N-facing slopes in most sites. Additional surveys in 2014 based on the draft habitat model developed by the NHNM from 2013 survey data may further refine habitat requirements for this species.

The total annual precipitation was well below averages for the past 3 years prior to this study, with somewhat of a recovery following the monsoons of 2013 (WRCC 2014). Drought conditions were especially severe in the 6 month period prior to the 2013 surveys, causing many plants to stall or reduce their vegetative and reproductive output, especially in the Red Lake area, east of Artesia, and the Ben Slaughter Draw area, southwest of Carlsbad. There, the majority of plants appeared dead with no green stems, leaves, or flowers. Plants were identified by the previous year's growth. Additional surveys on BLM lands following a strong 2013 monsoon season revealed that all of these plants were alive and had resprouted (Sivinski *et al*. 2013).

The largest threat to all *Amsonia tharpii* populations in New Mexico remains oil and gas exploration and development, including associated infrastructure development, such as roads, water waste pits, storage facilities and distribution centers. Oil and gas development in southeastern New Mexico has been experiencing a boom for the past 6 years and a lot more growth is projected for the future (Robinson-Avila 2013). Direct impacts on plants and their habitat from these activities have been documented in the past and are expected to continue unless conservation measures are implemented to protect known sites. Many of the population sites are small in area and may contain only very few plants (Table 1, Sivinski *et al.* 2013). Small populations are inherently more vulnerable to stochastic events, habitat destruction and disturbances, as well as inbreeding depression and pollination failure. Indirect impacts associated with oil and gas developments such as habitat fragmentation, pollinator availability and pollination success, dust deposition, and exotic species invasions have not been studied.

Amsonia tharpii appears to be drought tolerant and can remain largely dormant during long spells of drought conditions. However, prolonged drought conditions stretching over several years may ultimately be detrimental to these small isolated populations which are more vulnerable to regional droughts and global climate change than widespread species.

The spring of 2013 was an extremely dry spring in southeastern New Mexico and few if any annual invasive species were found within the populations or habitat of *Amsonia tharpii*. However, the potential for their presence is high due to the degree of disturbances associated with their habitat, but could not be evaluated due to drought conditions. High densities of invasive plants may result in increased fine fuel loads and therefore increased fire frequency, as well as increased resource competition, which may impact seedling germination and establishment during wet periods. Further evaluation of the extent of invasive species and their impacts on *Amsonia tharpii* are needed.

The impacts of grazing on *Amsonia tharpii* are unclear. Many members of the dogbane family (Apocynaceae) are considered toxic to livestock, including some species of *Amsonia* (Howard 2007). Palatability and toxicity of *Amsonia tharpii* have not been studied. Although some plants have been reported to be browsed, none were observed to be browsed during the 2013 surveys. However, impacts on the habitat caused by trampling were observed at the State Trust Land site within the Ben Slaughter/Yeso Hills population and the Hay Hollow population. Trampling by livestock will cause direct impacts to plants and also impacts fragile soil crusts associated with the gypsum habitat in these areas. This could result in reduced germination and establishment of new plants.

No good population trend information is available for *Amsonia tharpii* due to the lack of monitoring at any of the known populations since their discovery. However, the Ben Slaughter/Yeso Hills population on State Trust lands was estimated at 200 plants at the time of discovery in 1995 (Sivinski 1995). In 2013 only 50 plants were found within the same small area (0.5 acres). Reasons for this apparent decline are unknown, but may be drought related, caused by habitat disturbance by livestock, or be the results reproductive failure due to inbreeding depression. Regular monitoring of *Amsonia tharpii* is needed to inform on long term trends of this species.

The 2013 surveys for *Amsonia tharpii* on NM State Trusts lands and BLM lands have increased our knowledge of the status and distribution of this species in New Mexico substantially. It remains a rare species with a limited distribution and a significant amount of threats to all of the known occupied sites and the habitat.

ACKNOWLEDGEMENTS
Funding for this project has been provided by the U.S. Fish and Wildlife Service, Region 2, Albuquerque, NM, through a Section 6 Endangered Species Grant.

LITERATURE CITED

Howard, M. 2007. Inventory of Tharp's bluestar in the Carlsbad Area: Report on 2006 field survey. May 11, 2007 memorandum, report, and GIS habitat model to the Bureau of Land Management, Carlsbad Field Office.

Natural Heritage New Mexico. 2013. NM Biotics Database. Museum of Southwestern Biology, University of New Mexico, Albuquerque, NM.

New Mexico Rare Plant Technical Council. 1999. New Mexico Rare Plants. Albuquerque, NM: New Mexico Rare Plants Home Page. http://nmrareplants.unm.edu (Latest update: 30 March 2012). Accessed in April 2013.

Poole, J.M, W.R. Carr, D.M. Price, and J.R Singhurst. 2007. Rare Plants of Texas. Texas University Press, College Station. 640pp.

Robinson-Avila, K. 2013. New Mexico's gusher of good news. Albuquerque Journal – Business, November 25, 2013.

Southwest Environmental Information Network (SEINet). 2013. http//:swbiodiversity.org/seinet/index.php. Accessed in April.

Sivinski, R.C., 1992. *Amsonia tharpii*. Section 6, Segment 6 report to USDI-Fish and Wildlife Service, Region 2, Albuquerque, New Mexico.

Sivinski, R.C. 1995. Tharp's Blue Star on State Trust Land. Memorandum to David Deardorff, State Land Office, Santa Fe, NM.

Sivinski, R.C., T.B. Neville, E. Muldavin, and H. Hulse. 2013. Tharp's bluestar in the Carlsbad, NM area. 2013 field survey and habitat model. Interim progress report prepared for the BLM NM State Office, Santa Fe, NM.

Western Regional Climate Center. 2014. Cooperative Climatological Data Summaries. http://www.wrcc.dri.edu/climatedata/climsum/. Accessed January.

Woodson, R.E. 1948. Miscellaneous New Apocynaceae and Asclepiadaceae. Ann. Miss. Bot. Garden. 35(3):237-238.