

**Price's potato-bean
(*Apios priceana*)**

**5-Year Review:
Summary and Evaluation**



**U.S. Fish and Wildlife Service
Southeast Region
Tennessee Ecological Services Field Office
Cookeville, Tennessee**

5-YEAR REVIEW
Price's potato-bean/*Apios priceana*

I. GENERAL INFORMATION

A. Methodology used to complete the review -- In conducting this 5-year review, we relied on the best available information pertaining to historic and current distributions, life history, and habitat of this species. Our sources include the final rule listing this species under the Endangered Species Act; the recovery plan; unpublished field observations by Service, State, US Forest Service, and other experienced biologists; unpublished survey reports; and notes and communications from other qualified biologists or experts. We published an announcement of this review in the *Federal Register* and requested information about this species on July 6, 2009 (74 FR 31972), and a 60-day comment period was opened. Comments received and suggestions from peer reviewers were evaluated and incorporated as appropriate (see Appendix A). No part of this review was contracted to an outside party. This review was completed by the Service's lead Recovery biologist in the Tennessee Ecological Services Field Office, Cookeville, Tennessee.

B. Reviewers

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C. Background

1. **Federal Register Notice citation announcing initiation of this review:** July 6, 2009, 74 FR 31972
2. **Species status:** Stable. Many new populations of *Apios priceana* have been discovered since the species' recovery plan (USFWS 1993) was published. Of the 25 populations included in the recovery plan, 20 are still extant, and available data indicate that population sizes have remained stable in those locations. Twenty-three

populations are located on public lands or privately owned conservation lands. However, populations are small at most locations.

3. **Recovery achieved:** 3 (3 = 50-75% species recovery objectives achieved)
4. **Listing history:**
Original Listing
FR notice: 55 FR 429
Date listed: January 5, 1990
Entity listed: species
Classification: threatened
5. **Associated rulemakings:** n/a
6. **Review History:**
Recovery Data Call: 1998 – 2011
Recovery Plan for Price's Potato-Bean (*Apios priceana*), February 1993
7. **Species' Recovery Priority Number at start of review (48 FR 43098):** 8
(moderate degree of threat; high recovery potential)
8. **Recovery Plan**
Name of plan: Recovery Plan for Price's Potato-Bean (*Apios priceana*)
Date issued: February 10, 1993

II. REVIEW ANALYSIS

- A. **Is the species under review listed as a DPS?** *Apios priceana* is a plant; therefore, the DPS policy does not apply. The Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPS to only vertebrate species of fish and wildlife.
- B. **Recovery Criteria**
 1. **Does the species have a final, approved recovery plan containing objective, measurable criteria?** Yes.
 2. **Adequacy of recovery criteria.**
 - a. **Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?** Yes

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria? No, there is new information summarized below related to conservation efforts to reduce threats.

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.

Recovery Criteria:

Apios priceana will be considered for delisting when 25 geographically distinct, self-sustaining populations are adequately protected and they have been maintained for 10 years. A population will be considered to be adequately protected when it is legally protected and actively managed. A population will be considered to be self-sustaining if it is observed to be successfully reproducing and the size is stable or increasing. The minimum population size necessary for a self-sustaining population should be determined in future demographic studies. The requirements for delisting are preliminary and may change as more information about the biology of the species is discovered.

The recovery criteria for *A. priceana* have not been met. Many new populations have been discovered since the recovery plan was completed, as discussed below; however, fewer than 25 populations are adequately protected (i.e., legally protected and actively managed).

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends, demographic features or demographic trends:

When the Recovery Plan for Price's Potato-bean was published in 1993, there were 25 known extant populations distributed among 15 counties and four states: Autauga (2), Madison (1), and Marshall (1) counties, Alabama; Livingston (1), Lyon (1), and Trigg (2) counties, Kentucky; Clay (1), Lee (1), and Oktibbeha (2) counties, Mississippi; and DeKalb (1), Hickman (6), Marion (1), Maury (1), Montgomery (1), and Williamson (3) counties, Tennessee. There were 11 other populations considered extirpated in 1993 (2 in Illinois, 6 in Kentucky, and 3 in Tennessee), bringing the total number of known populations of the species at that time to 36. The species is considered extirpated from the State of Illinois (Ebinger et al. 2010), as no populations have been discovered since the recovery plan was published.

For the purposes of this review, we consider each distinct element occurrence tracked by a Natural Heritage Program to constitute a separate population. The data provided by Natural Heritage Programs follow the NatureServe Natural Heritage methodology, in which the fundamental unit of information is the

element occurrence (EO), defined as “an area of land and/or water in which a species or natural community is, or was present” (NatureServe 2004). One question that often arises in developing botanical EO data is what the separation distance should be for two or more observations in different but nearby places to be considered different EOs. Unless custom EO specifications exist for a species, Heritage programs are advised to follow NatureServe (2004) guidance for habitat-based delimitation of EOs for plants, which generally advises that occurrences located less than one kilometer apart be combined into a single EO.

Based on data in unpublished reports and data from Natural Heritage Programs in Alabama, Kentucky, Mississippi, and Tennessee, there are now 59 known extant populations, distributed among 26 counties in four states. Twenty-three of these populations are located entirely or in part on public lands or privately owned conservation lands; however, not all of these populations on protected lands receive adequate management to ensure they persist.

Alabama

There currently are 16 known extant populations of *A. priceana* in Alabama, distributed among nine counties: Autauga (2), Butler (1), Dallas (2), Jackson (2), Lawrence (1), Madison (5), Marshall (1), Monroe (1), and Wilcox (1) (Alabama Natural Heritage Program (ANHP) 2014, Barger et al. 2014). Ten of these populations are located on publicly owned lands or private conservation lands (Table 1). Land owners of these sites include Alabama Department of Conservation and Natural Resources (ADCNR), Department of Defense (DOD), Land Trust of North Alabama (LTNA), U.S. Army Corps of Engineers (COE), and U.S. Fish and Wildlife Service (USFWS). The remaining populations are located on private lands, including two on privately owned timber lands. These 15 extant populations totaled at least 2,266 *A. priceana* plants, as reported by ANHP (2014). During a 2011 population census a total of 2,158 plants were counted at Redstone Arsenal alone, half of which had stems 2 mm or less in diameter and were considered to be juveniles, providing evidence of recent successful recruitment (Boyd 2014) (Figure 1).

Two extant Alabama populations that were included in the recovery plan have remained stable (Table 2). Based on available data, we are unable to determine the status of the other two Alabama populations that were included in the recovery plan.

Kentucky

There currently are seven known extant populations of *A. priceana* in Kentucky, distributed among three counties: Livingston (2), Lyon (3), and Trigg (2) (Kentucky State Nature Preserves Commission (KSNPC) 2015). Of these seven populations, three were included in the species’ recovery plan – one in Lyon County and the two in Trigg County (USFWS 1993). A fourth population, at the Carrsville Bluff site in Livingston County that was included in the recovery

Table 1. Price's potato-bean sites on protected lands (TDEC 2015, ANHP 2014, Boyd 2014, KSNPC 2015, USFS 2015)

State	County	Site (EO Number)	Land Ownership	Last Observation
AL	Autauga	Jones Bluff (6)	COE	21 vines – 2010
	Jackson	Little Coon Creek (8)	ADCNR	5 vines – 2012
		Sauta Cave (13)	USFWS	152 vines – 2011
	Madison	Blevins Gap (11)	ADCNR, LTNA	32 vines – 2011
		Monte Sano State Park (19)	ADCNR	27 vines – 2011
		Redstone Arsenal (7)	DOD	2158 vines – 2011
		Rainbow Mountain (20)	LTNA	42 vines – 2011
		Hale Mountain (24)	ADCNR	6 vines – 2011
KY	Livingston	Corley Farm (12)	Private	4 vines - 2014
		Livingston Co. WMA (13)	Livingston County	41 vines - 2013
	Lyon	Mammoth Furnace (15)	USFS	9 vines, 7 flowers, 1 legume – 2014
		Pisgah Bay (16)	USFS	3 vines – 2011 (no plants found in 2013 or 2014)
	Trigg	Hematite Lake (3)	USFS	23 vines, 401 flowers – 2014
		Laura Furnace (5)	USFS	42 vines, 611 flowers, 53 legumes – 2014
MS	Lee	Coonewah (n/a)	NMLT	> 500 vines – 2012
		Natchez Trace (n/a)	NPS	53 vines – 2014
TN	DeKalb	Center Hill Bluffs	COE	44 vines, 5 flowering – 2011
	Franklin	Bear Hollow Mtn. WMA (36)	TWRA	100s of vines – 2012
		Bear Hollow Mtn. WMA (37)	TWRA	1 vine – 2011
	Hardin	Ross Forest SNA	Private	10 vines – 2014
	Montgomery	Barnett's Woods SNA	TDEC	96 vines, 17 flowering – 2011
	Stewart	Neville Creek	USFS	48 vines, 14 flowers – 2014
Ft. Donelson NB		NPS	14 vines, 3 flowering – 2014	

plan, has since been extirpated. *Apios priceana* has not been observed at this location since 1992, despite several searches, most recently in 2008. However *A. americana* was found at this site in 1996, raising a question about the accuracy of the original record's identification as *A. priceana*. The three extant populations that were included in the recovery plan have remained stable (Table 2).

The Lyon County population that was included in the species' recovery plan is on privately owned land. While the current land owner is cooperative with KSNPC conservation efforts for *A. priceana*, there is no protection agreement in place and the landowner has expressed interest in selling this property. Two of the three populations in Lyon County are on U.S. Forest Service (USFS) property at Land Between the Lakes National Recreation Area (LBL), as are the two Trigg County populations included in the recovery plan (Table 1).

The two extant populations in Livingston County both are protected. One is located on the privately owned Corley Farm State Natural Area (SNA), which receives voluntary protection from the landowner under a natural area registry established in 2006. The second population is located on a site owned by

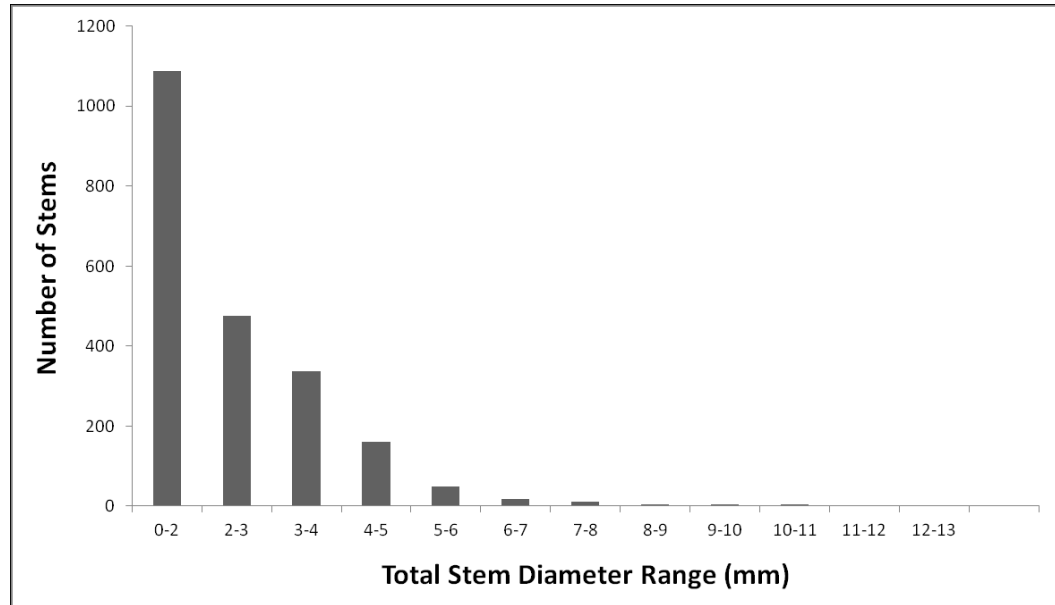


Figure 1. Size class distribution of *Apios priceana* stems at Redstone Arsenal, measured 5/23/2011 - 7/14/2011, from Boyd (2014).

Table 2. Status of extant *Apios priceana* populations in Alabama, Kentucky, Mississippi, and Tennessee (ANHP 2014, KSNPC 2015, TDEC 2015) that were included in the recovery plan (USFWS 1993).

State	County	EO Number	Number of Vines - Date	
			Recovery Plan	Last Observation
AL	Autauga	6	6 – 1988	21 – 2010
	Marshall	1	5 or less - 1991	7 – 2010
KY	Lyon	1	7 – 1990	10 (50 legumes) – 8/12/2013
	Trigg	3	<25 – 1989	23 (401 flowers) – 7/18/2014
		5	30-50 – 1989	42 (611 flowers, 53 legumes) – 7/18/2014
MS	Lee	n/a	1,000 – 1983	> 500 - 2012
	Oktibbeha	n/a	10-16 – 1988	11 - 2012
TN	DeKalb	5	25-50 – 1990	44 (5 flowering vines) – 2011
	Hickman	6	25 – 1990	22 (7 flowering vines) – 2011
		12	4 – 1991	4 – 2011
		11	7-10 – 1991	7 – 2011
		14	12 – 1991	3 – 2011
		13	6 – 1991	71 (16 flowering vines) – 2011
		10	1-2 – 1991	1 – 2010
	Marion	3	100-200 – 1990	> 100 (> 50 vines flowering) – 2011
	Maury	25	24 – 1990	2 (2 fruiting vines) – 2010
	Montgomery	2	30-40 – 1990	96 (17 flowering vines) – 2011
	Williamson	4	18 – 1990	9 – 2011
7		45 – 1990	> 20 – 2010	
8		7 – 1990	22 (1 flowering vine) – 2006	

Livingston County government. The Nature Conservancy transferred this site to the local government, and the KSNPC has entered into an agreement with Livingston County to assist in managing *A. priceana* at the site.

Mississippi

There are currently four known extant populations of *A. priceana* in Mississippi, distributed among the following counties: Kemper (1), Lee (2), and Oktibbeha (1) (H. Sullivan pers. comm. 2010, ANHP 2014, J. Burton pers. comm. 2014).

One Lee County population is located in the North Mississippi Land Trust's (NMLT) Coonewah Nature Preserve, and another population was discovered in 2014 on National Park Service lands along the Natchez Trace Parkway. There were more than 500 plants estimated in the population at Coonewah Nature Preserve in 2012 (ANHP 2014) and 53 plants at the Natchez Trace Parkway site (J. Burton pers. comm.). The Kemper County population, consisting of only 6 plants as of 2012, and the Oktibbeha County population, with 11 plants in 2012, are both on privately owned lands (ANHP 2014). The Lee and Oktibbeha County populations were both included in the recovery plan and, based on numbers reported in the recovery plan and in ANHP (2014), appear to have remained stable (Table 2).

Two of the four populations that were known to exist in Mississippi at the time the recovery plan was completed have since been extirpated: the Rock Hill population in Oktibbeha County and the Clay County population. The Rock Hill population was lost to incompatible land uses, including timber harvest and gravel mining. The Clay County population was apparently destroyed by a habitat improvement project funded by the Natural Resources Conservation Service (H. Sullivan pers. comm. 2010).

Tennessee

There currently are 32 known extant *A. priceana* populations in Tennessee, distributed among 11 counties: Dekalb (1), Franklin (2), Giles (2), Hardin (3), Hickman (10), Marion (1), Maury (2), Montgomery (1), Stewart (2), Wayne (4), and Williamson (4) (TDEC 2015). Of these occurrences, 13 were included in the species' recovery plan – one each in Dekalb, Marion, Maury, and Montgomery counties, six in Hickman County, and three in Williamson County. Most of these occurrences included in the recovery plan have remained stable (Table 2).

There are seven populations on protected lands in Tennessee (Table 1). One Stewart County population is located at LBL and the other at Fort Donelson National Battlefield, a NPS unit. The Montgomery County population is located at Barnett's Woods Designated State Natural Area (SNA), owned by the Tennessee Department of Environment and Conservation (TDEC), and one of the Hardin County populations discovered in 2009 is located on a privately owned, Registered SNA. The two Franklin County populations are located on Tennessee Wildlife Resources Agency's Bear Hollow Mountain Wildlife Management Area

(WMA). In addition to these sites, there are reports of two sites on NPS lands along the Natchez Trace Parkway, in Tennessee, supporting plants suspected to be *A. priceana*, but positive identification of these plants has not been confirmed (Phillips 2006, Hatch and Kruse 2008).

b. Genetics, genetic variation, or trends in genetic variation:

We have no new information.

c. Taxonomic classification or changes in nomenclature:

Woods (2005) revised the taxonomy of the North American species of *Apios* (Fabaceae). In doing so, he maintained recognition of Price's potato-bean as *Apios priceana* Robinson, as originally published. A phylogenetic analysis indicated that the genus *Apios* originated in Southeast Asia, and that the North American species (*A. americana* and *A. priceana*) are more closely related to one another than to any of the Asian species (Li et al. 2014). The parent species of these two taxa likely migrated to North America via the Bering land bridge and have diverged into separate species as a response to ecological or biological pressures or physical barriers (Li et al. 2014).

d. Spatial distribution, trends in spatial distribution, or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

See section 1.a above.

e. Habitat conditions:

We have no new information.

f. Reproductive biology:

The DOD funded a study of the reproductive biology of the *A. priceana* population at Redstone Arsenal in Alabama, which took place during 2010 through 2014 (Boyd 2014), and is the source of the information in this section. This study quantified the population structure, demonstrating that the majority (63 percent) of the population occurred within one of five subpopulations¹ at the installation and that half of the individuals counted were classified as juveniles (i.e., plants with basal stem diameter less than 2 mm) (Figure 1). Basal stem diameter was used as an indicator of demographic status and was positively related with total stem length in regression analyses (i.e., longer stems had greater stem diameters). No plants with stem diameters less than 2 mm (i.e., juveniles) were found in reproductive condition. Survival and growth rates of small (i.e.,

¹ Subpopulations are spatially discrete patches of plants growing in close enough proximity to be considered a single population in aggregate, in this case within the one kilometer separation distance used by NatureServe to warrant mapping as separate occurrences.

stems ≤ 30 cm long and ≤ 3 nodes) and large (i.e., stems > 30 cm long and > 3 nodes) juveniles over two years of observation were not statistically different, with 82 percent of small juveniles and 68 percent of large juveniles surviving.

To investigate reproductive attrition (i.e., loss of reproductive potential at each stage of flower and fruit development), Boyd (2014) quantified for a sample of 10 plants the proportion of flower buds initiated that subsequently produced flowers, initiated fruit development, produced mature fruits, and the number of seeds that resulted. Reproductive attrition was high, with mature fruits and seeds produced only in two of four years. Furthermore, less than 1 percent of reproductive attempts (i.e., flower buds) during these two years successfully produced mature fruits. During 2013, when reproductive output was the highest observed during the study, 10,752 flower buds were initiated, from which 2,550 flowers were produced, resulting in 97 mature fruits bearing a total of 234 seeds. Reproductive output was lower during 2010, when a sample of five plants that generated 4,299 flower buds ultimately produced only 7 mature fruits, yielding a total of 51 seeds. Greater reproductive success observed in 2013 occurred during a year of abundant rainfall distributed through the growing season. These data from Redstone Arsenal suggest that *A. priceana* exhibits low rates of reproductive output.

Results of a field-based study of the species' breeding system indicated that *A. priceana* is not self-compatible (Boyd 2014). However, production of viable seeds by a lone plant at Missouri Botanical Garden indicates that self-compatibility is possible (M. Albrecht pers. comm. 2008). At least four species of medium (~ 1 -1.5 cm length; *Bombus pennsylvanicus*, *Bombus* sp.) to large bees (> 1.5 cm; *Bombus bimaculatus*, *Megachile sculpturalis*) were relatively efficient pollinators in the breeding system study (Boyd 2014). Pollen supplementation by hand from an out-crossed source increased rates of fruit initiation and produced a statistically non-significant trend towards greater numbers of seeds per legume, demonstrating some pollen limitation. However, pollinators provided adequate pollen loads for sexual reproduction, and any limitation by pollen in this population was minor in comparison to the influence of rainfall during the reproductive season (Boyd 2014).

Apios priceana apparently experiences low levels of seed predation and did not demonstrate potential for forming a long-term persistent soil seed bank, due to germination of most seeds in the spring following dispersal and mortality of others (Boyd 2014). However, the species exhibits strong physical dormancy [i.e., has a water-impermeable seed coat; Baskin et al. (2000)], suggesting that formation of a long-term persistent soil seed bank should be possible (M. Albrecht pers. comm. 2008). Seed production is sporadic and it is not known whether seedling establishment is a limiting factor for this species, but the large numbers of seedlings that were present and their high survival rates suggest that it is not limiting for this large population (Boyd 2014). Moreover, given the long-lived nature of this species and the numbers of individuals in larger size classes capable of reproduction, the Redstone Arsenal population appears to be stable at present time.

2. Five-Factor Analysis

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

The recovery plan for *A. priceana* discussed several threats to the species' habitat, including incompatible logging (i.e., clearcutting or heavy logging), excessive shading by canopy trees, right-of-way maintenance for roads and utilities, and competition with non-native, invasive plants. A monitoring report based on site visits during 2010 – 2011 indicates that most Tennessee populations still face one or more of these threats (TDEC 2012). Similarly, seven of the 15 Alabama populations and one Mississippi population are exposed to one or more of these threats (ANHP 2014). We do not have current information on threats to populations in Kentucky, other than those on USFS lands at LBL. While these threats still affect many populations across the species' range, conservation efforts (discussed below) have been undertaken to reduce their effects on some populations.

In cooperation with KSNPC, TDEC, and the Service's Ecological Services Field Office in Frankfort, Kentucky (KYFO), the USFS drafted a management plan in 2008 for sites where *A. priceana* occurs at LBL (USFS 2009). This plan summarized management measures that Tennessee Valley Authority (TVA) had taken at LBL during the mid-1990s, before transferring management authority at LBL to the USFS in 2004, and provides direction for future management and protection by USFS. TVA established a no-mowing zone along the road at the Laura Furnace site in Kentucky to prevent routine mowing at that location, rerouted a trail away from the Hematite Lake population, and removed selected canopy trees at both sites to increase light levels. While short term positive responses occurred, shading and canopy closure resumed and all LBL populations remained stable or declined in years that followed. KSNPC (2001) recommended shade reduction at all but one (i.e., Pisgah Bay) of the five LBL sites.

The USFS has undertaken efforts to reduce forest canopy cover at all LBL sites. While short term positive responses have been observed at most of these sites (USFS 2015), it is not yet known whether these responses will be sustained. Additional management may be necessary at these sites to minimize encroachment of woody species resulting from increased light exposure. In addition, USFS, KSNPC, and KYFO have collected and planted seeds within the Laura Furnace and Hematite Lake sites at LBL, but this effort has produced few recruits into these populations, as yet, despite emergence of some seedlings which later died (USFS 2015).

In 2015, the Service and TVA began managing habitat at Sauta Cave National Wildlife Refuge (NWR) and on adjacent TVA land to benefit *A. priceana*, Indiana bat (*Myotis sodalis*), and northern long-eared bat (*M. septentrionalis*) (USFWS

2015). These efforts include careful use of herbicides to control invasive, exotic plant species in both occupied and suitable, but currently unoccupied, *A. priceana* habitat. In addition, mechanical and chemical methods will be used to reduce forest canopy cover, including removal of all trees in an area less than one-half acre in size. The intent of this management is to increase the spatial extent of the *A. priceana* population and increase light exposure in an attempt to improve population vigor and stimulate greater reproductive output.

In an effort to manage threats associated with road right-of-way maintenance, TDEC undertook a project in 2004 to work cooperatively with local county governments and highway officials (TDEC 2005). TDEC personnel met separately with highway officials from each county to inform them about *A. priceana*, encourage development of a cooperative agreement, and to show them the species in their counties. As a result of this effort, signs containing the message “Do Not Mow or Spray” were posted in the vicinity of nine populations distributed among Giles, Hickman, Maury, and Williamson counties and the City of Centerville. None of these local governments chose to enroll in cooperative agreements.

A previously unrecognized threat to *A. priceana* occurred in the form of a 100-year flood event in middle Tennessee during May 2010, which severely disturbed habitat at nine populations in Hickman, Maury, and Williamson counties (TDEC 2012). Many of the affected populations occur on steep slopes along the sides of roads that were severely damaged by the floods, due to their locations near streams in narrow valleys. As a result, further disturbance to the slopes where *A. priceana* is located occurred at some of these sites during the process of clearing and grading the roadbeds for emergency repairs to restore traffic flow.

b. Overutilization for commercial, recreational, scientific, or educational purposes:

We have no new information concerning this factor.

c. Disease or predation:

Boyd (2014) observed a large number of flowers at Redstone Arsenal with cavities created in the style of the flowers by a small herbivore. Leaf and flower bud herbivory were observed on many plants at the Fiery Gizzard Gorge site in Marion County, Tennessee (A. Bishop pers. comm. 2010). The bean leaf beetle (*Certoma trifurcate*) was observed eating leaves and flower buds, causing the formation of holes in the leaves and interrupting development of flowers and fruits. A second species of beetle, *Chalepus scapularis*, was collected from an *A. priceana* plant, but its feeding behavior was not observed. The extent to which these observations of insect herbivory indicate a threat to *A. priceana* is not known, but monitoring efforts for the species should include assessments of the extent of insect herbivory when observed and collection of specimens to identify potentially threatening species.

d. Inadequacy of existing regulatory mechanisms:

We have no new information concerning this threat.

e. Other natural or manmade factors affecting its continued existence:

The recovery plan for *A. priceana* discussed threats related to small population size and apparent low reproductive vigor, including potential for diminished genetic variation within the species. Despite the fact that 23 *A. priceana* populations are on protected lands, recent observations indicate that low numbers of plants are present in most of these populations (Table 1) (ANHP 2014, KSNPC 2015, USFS 2015, TDEC 2015). And, evidence of sufficient recruitment of seedlings into larger size classes capable of reproduction is generally lacking, with the exception of the large population at Redstone Arsenal (Boyd 2014).

One measure to safeguard against the loss of small, isolated populations of plants is to establish a conservation seed bank that could be used to propagate plants for reintroductions or population augmentation, should such measures become necessary. The Missouri Botanical Garden has collected *A. priceana* seed from populations in Alabama, Kentucky, Mississippi, and Tennessee (Albrecht 2009, Long and Albrecht 2012). Seed accessions from the Redstone Arsenal population in Alabama have been provided to Georgia Tech for cryogenic storage and to the Missouri Botanical Garden (Boyd 2014). And, the Atlanta Botanical Garden has successfully produced plants from stem cuttings, with no significant effects to the donor plants at Redstone Arsenal from which cuttings were taken (Boyd 2014), providing another alternative for *ex situ* conservation efforts.

Davenport (2007) included *A. priceana* in an analysis of potential effects of climate change on Alabama's plant life. The analysis was based on best professional judgment of how various habitat types and associated species would respond to climate changes that models predict Alabama will experience. Davenport (2007) concluded that "species demanding shady ravines and stream banks will constrict in distribution", including the hardwood forests inhabited by *A. priceana*.

D. Synthesis

While many additional populations of *Apios priceana* have been discovered since the species' recovery plan was published in 1993, the recovery criteria have not been met. The species' known geographic range includes 59 extant populations, distributed among 26 counties in four states: Alabama, Kentucky, Mississippi, and Tennessee. Twenty-three of these populations occur entirely or in part on public lands or privately owned conservation lands; though, most of these populations are small and many are likely not self-sustaining (Table 1). And, few of these populations on public lands or privately owned conservation lands receive adequate management to ensure their persistence. The five populations on USFS land at LBL, in Kentucky and Tennessee, and the population at

Sauta Cave NWR in Alabama receive active management for the purpose of improving habitat conditions for *A. priceana*. TDEC has worked with local highway departments to reduce threats associated with roadside vegetation management at nine populations. However, no formal management agreements have been established with local governments to ensure that conservation measures for these populations will continue in the future. None of these management activities have been ongoing for a sufficient period of time to allow conclusions about their long term effectiveness; though, monitoring at LBL suggests that canopy reductions produced desired initial responses from the managed populations.

Threats documented in the recovery plan, including excessive shading by canopy trees, right-of-way maintenance for roads and utilities, and competition with non-native, invasive plants still affect many populations. A monitoring report based on site visits during 2010 – 2011 in indicates that most Tennessee populations still face one or more of these threats (TDEC 2012). Similarly, seven of the 15 Alabama populations and one Mississippi population are exposed to one or more of these threats (ANHP 2014). We do not have current information on threats to populations in Kentucky, other than those on USFS lands at LBL.

Therefore, based on the information in our files, we believe that *A. priceana* still meets the definition of a threatened species, and that neither reclassification to endangered, nor removal from the list of Threatened and Endangered Plant Species, is warranted at this time. The species recovery priority number should remain at 8, reflecting the moderate threats and high recovery potential.

III. RESULTS

A. Recommended Classification:

 X **No change is needed**

B. New Recovery Priority Number – no change recommended

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- A.** Continue efforts to work with local governments and highway officials to reduce threats associated with roadside maintenance, including establishing cooperative agreements when possible.
- B.** Continue management at LBL and Sauta Cave NWR to reduce canopy cover and invasive species encroachment and promote flowering, seed production, and population growth. Encourage similar management efforts at other protected sites.
- C.** Work with Natural Heritage Programs, NPS, USFS, and others to establish consistent range wide monitoring program.

- D. Work cooperatively with Redstone Arsenal, Alabama, to manage and monitor population on Department of Defense lands.
- E. Work cooperatively with ADCNR to manage and monitor population at Old Cahawba Forever Wild Tract in Alabama.
- F. Work cooperatively with NPS to develop conservation strategies for populations at Fort Donelson National Battlefield, in Tennessee, and Natchez Trace Parkway, in Mississippi.
- G. Work with landowners of protected sites to develop conservation agreements that establish biological goals for *A. priceana*, identify management strategies to achieve those goals, and include a monitoring plan for measuring effectiveness of conservation efforts as relates to the species' status.
- H. Ensure that *ex situ* accession information and propagation protocols are maintained and curated in the Center for Plant Conservation National Collection of Endangered Plants centralized database.
- I. Conduct experimental studies that examine the species' habitat needs in order to develop management protocols that bolster population size and fitness. While it has been assumed that *A. priceana* will respond favorably to opening forest canopies, current monitoring protocols are not adequately designed to compare population responses across light gradients. Future work should include design of experiments to examine the response of natural or experimental populations to fire, canopy thinning, and other management tools. Greenhouse studies to explore effects of varying levels of shade, soil moisture, and soil fertility could also improve understanding of factors that regulate growth of *A. priceana* individuals and populations.

V. REFERENCES

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Apios priceana*

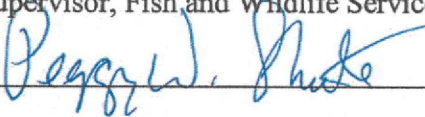
Current Classification: **Threatened**
Recommendation resulting from the 5-Year Review

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change is needed

Review Conducted By: Geoff Call, Tennessee Ecological Services Field Office

FIELD OFFICE APPROVAL:

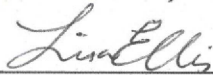
Lead Field Supervisor, Fish and Wildlife Service

Approve  Date 8/31/15

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

for **Lead Regional Director, Fish and Wildlife Service**

Approve  Date 7/13/16

Cooperating Regional Director, Fish and Wildlife Service

Concur Do Not Concur

Signature  Date 9/2/14

APPENDIX A: Summary of peer review for the 5-year review of Price's potato-bean (*Apios priceana*)

A. Peer Review Method: A draft of this review was sent to the following individuals to solicit peer review:

Matthew Albrecht, Missouri Botanical Garden
Andrea Bishop, Tennessee Department of Environment and Conservation
Bob Boyd, Ph.D., Auburn University
Mike Floyd, U.S. Fish and Wildlife Service, Kentucky ES Field Office
Shannon Holbrook, U.S. Fish and Wildlife Service, Alabama ES Field Office
Tara Littlefield, Kentucky State Nature Preserves Commission
Andy Radomski, U.S. Fish and Wildlife Service, Kentucky ES Field Office
Elizabeth Raikes, U.S. Forest Service, Land Between the Lakes
Al Schotz, Alabama Natural Heritage Program
Heather Sullivan, Mississippi Museum of Natural Science
Scott Wiggers, U.S. Fish and Wildlife Service, Mississippi ES Field Office

B. Peer Review Charge: The Service's lead recovery biologist sent an email to the individuals listed above, requesting that they review the draft document and provide comment on the information it contained and to request any relevant information that had been omitted.

C. Summary of Peer Review Comments/Report – We received comments from four reviewers: Matthew Albrecht, Andrea Bishop, Bob Boyd, and Scott Wiggers.

Mr. Albrecht suggested including all observation data available in Table 2 of the document, rather than including only data from observations made prior to Recovery Plan preparation and the most recent observation data available. Mr. Albrecht recommended that other data from years intervening these two endpoints be included, to allow for interpretation of population trends. In addition, Mr. Albrecht suggested actions to include in Section IV. Recommendations for Future Actions.

Ms. Bishop provided corrections to data for populations in Tennessee.

Dr. Boyd provided supportive comments for the review, but suggested no edits.

Mr. Wiggers provided corrections to data for populations in Alabama and suggested the need for additional information or clarifying text in several sections, especially Section C.1.f. Reproductive Biology. Additionally, Mr. Wiggers provided literature citations to support edits that he suggested in some places.

D. Response to Peer Review – We have incorporated most of the suggestions and corrections we received from peer reviewers. We did not follow Mr. Albrecht's suggestion that we include additional data for years intervening the data points that are presented in Table 2, because

availability of data and methods used for collecting them varies widely among populations. Rather, we used data from the most recent observations available to compare to reported abundance for each population that was included in the species' recovery plan to judge the populations' persistence and determine whether the species abundance had changed substantially during that time. Mr. Wiggers requested that information in Section C.1.f. be synthesized to provide a greater understanding of reproductive biology and ecology for *A. priceana* rangewide, rather than limiting it to Redstone Arsenal. The only data that we are aware of that relate to the reproductive biology of *A. priceana* are from a study at Redstone Arsenal by Nathan Paris and Dr. Bob Boyd at Auburn University. Lacking data from other locations, we are unable to provide a synthesized overview of the species' reproductive biology across its geographic range. We have included other additional information – e.g., explained the relationship between populations and subpopulations, added names of known pollinators, included a citation on potential effects of climate change based on a report from Alabama – which Mr. Wiggers specifically requested be included in this review.