

Missouri Bladderpod
(Physaria filiformis)

5-Year Review:
Summary and Evaluation

March 2015

U.S. Fish and Wildlife Service
Columbia, Missouri Ecological Services Field Office
Columbia, Missouri

5-YEAR REVIEW

Missouri bladderpod/*Physaria filiformis*

1.0 GENERAL INFORMATION

1.1 Reviewers

U.S. Fish and Wildlife biologists in the offices listed below provided valuable additional information and corrections to a draft of this Review.

Lead Regional Office: Jessica Hogrefe, Midwest Regional Office; 612-713-5346

Lead Field Office: Paul McKenzie, Columbia, Missouri Ecological Services Field Office, MO; 573-234-2132, ext. 107

Cooperating Field Offices: Mitch Wine, Conway, Arkansas Ecological Services Field Office, AR; 501-513-4488

1.2 Methodology used to complete the review:

The U.S. Fish and Wildlife Service's (USFWS) Columbia, Missouri Ecological Services Field Office (Columbia, Missouri Field Office) completed this review. In the September 14, 2010, *Federal Register* notice initiating this 5-year review (75 FR 55820), the U.S. Fish and Wildlife Service requested new scientific or commercial data and information that may have a bearing on the Missouri bladderpod (*Physaria filiformis*) classification of threatened. New information considered in this review includes relevant information generated since the January 14, 2008 approved 5-year review (available at http://www.fws.gov/midwest/endangered/recovery/5yr_rev/MoBladderpod2008.html), published reports in peer-reviewed literature, gray literature (e.g., various state and Federal Aid grant reports, theses and dissertations by graduate students) and data received from various state personnel through personal communication involving electronic mail and letters. All literature and documents used for this review are on file at the USFWS's Columbia, Missouri Field Office. In January 2015, the Columbia, Missouri Field Office solicited peer review of this draft 5-year review from four recognized Missouri bladderpod experts: Dr. George Yatskievych, Flora of Missouri Project, Missouri Botanical Garden, St. Louis, Missouri, Theo Witsell, Botanist for the Arkansas Natural Heritage Commission in Little Rock, Arkansas; Rhonda Rimer, Regional Natural History Biologist for the Southwest Region of Missouri, Missouri Department of Conservation, Springfield, Missouri, and Craig Young, Biologist, National Park Service, Heartland Inventory and Monitoring Program, Republic, Missouri. We received comments from all peer reviewers and Mitch Wine of the Conway, Arkansas Field Office. All reviewers' comments and edits have been addressed and incorporated into the current draft of this document.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review:

September 14, 2010 (75 FR 55820): Notice of Endangered and Threatened Wildlife and Plants; 5-Year Review of Seven Midwestern Species.

1.3.2 Listing history

Original Listing

FR notice: 52FR 679

Date listed: January 8, 1987

Entity listed: Species

Classification: Endangered

Revised Listing

FR notice: 68FR 59337

Date listed: October 15, 2003

Entity listed: Species

Classification: Threatened

1.3.3 Associated rulemakings: NA

1.3.4 Review History:

The first formal review for this species was associated with the proposed and final rules involving the reclassification of the species from endangered to threatened [June 10, 2003 (68 FR 34569); October 13, 2003 (68 FR 59337)]. An initial 5-year review by McKenzie (2008, pp. 1-6) was approved on January 14, 2008. Witsell (2008, pp. 1-18; Witsell and Baker 2011, pp. 1-77) provided a review of sites recently discovered in Arkansas and Young (2013, pp.1-16) summarized changes in population levels of *Physaria filiformis* at seven glades on the Wilson Creek National Battlefield in Greene County, Missouri between 2008 and 2013. Other than published literature on various ecological parameters and management recommendations for *Physaria filiformis* outlined in this 5-year review, no other formal reviews are known for this species.

1.3.5 Species' Recovery Priority Number at start of 5-year review:

The recovery priority number for the Missouri bladderpod is 8. This is indicative of a species with a moderate degree of threat but one with a high recovery potential.

1.3.6 Recovery Plan

Missouri Bladderpod Recovery Plan

Date issued: April 7, 1988

Dates of previous revisions, if applicable: N/A

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

2.1.2 Is the species under review listed as a DPS? N/A

2.1.4 Is there relevant new information for this species regarding the application of the DPS policy? N/A

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes.

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.

2.2.2.2 Are all of the five 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.

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 recovery goal listed for Missouri bladderpod when the recovery plan was approved in 1988 was: To prevent the extinction and enhance the status of *Physaria filiformis* by protecting, restoring, and managing populations so that the species may be removed from the Federal list of endangered and threatened species (U.S. Fish and Wildlife Service 1988, p. i). Although the approved recovery plan did not have reclassification criteria, the U.S. Fish and Wildlife Service reclassified Missouri bladderpod from endangered to threatened with a final rule published in the *Federal Register* on Oct. 15, 2003 (68 FR 59337). Missouri bladderpod was reclassified based on the increased knowledge of known populations since the species was listed in 1987 (9 vs. 63 in 2003: U.S. Fish and Wildlife Service 2003, p. 59337), the protection or management of a minimum of 15 sites under public ownership, the positive response of *Physaria filiformis* to limited disturbance, especially prescribed fire, an increased understanding of the species' life history requirements, and the discovery of two new populations in two counties in Arkansas (U.S. Fish and Wildlife Service 2003, pp. 59337-59343; Cindy Osborne, pers. comm. Aug. 13, 2014). Of the 67 extant populations in Missouri (Rhonda Rimer,

Missouri Department of Conservation, pers. comm. Mar. 10, 2014), one new population was discovered in Greene County, Missouri by Linda Ellis and Bob Kipfer on May 2, 2013 (Rhonda Rimer, pers. comm. May 2, 2013).

Four recovery criteria were listed (U.S. Fish and Wildlife Service 1998, p. ii) for the Missouri bladderpod and the species could be proposed for removal from the Federal list of endangered and threatened species when each of the following stipulations was met:

- Criterion 1.** The protection of 30 scattered, self-sustaining populations.
- Criterion 2.** Of the 30 populations, 15 must be in public ownership.
- Criterion 3.** Each population must occupy a minimum of one-half acre of habitat.
- Criterion 4.** Each population must be self-sustaining populations for at least seven years.

When the criteria were developed for the Missouri bladderpod recovery plan, the species was not yet known from Arkansas and there were only 11 known populations in Missouri (U.S. Fish and Wildlife Service 2003, p. 59337). Currently, the species is known from 66 sites in Missouri and 10 sites in Arkansas (U.S. Fish and Wildlife Service 2003, p. 59337, 59340; Rhonda Rimer, pers. comm. Mar.10, 2014, Jan. 14, 2015; Cindy Osborne, pers. comm., Aug. 13, 2014). Missouri bladderpod currently occurs in four counties in Missouri and five counties in Arkansas and the species is distributed on limestone glades in Southwest Missouri, dolomite glades in northern Arkansas (a report for Missouri on a dolomitic glade has not been confirmed, George Yatskievych, pers. comm. Aug. 11, 2014), and shale glades in the Ouachita Mountains in central Arkansas (Witsell 2008, pp. 7-8, 14-15). While the total number of populations now far exceeds the first criterion, an assessment as to whether or not they are self-sustaining is problematic because populations of *Physaria filiformis* can vary widely from year to year depending on different climatic and edaphic factors and in response to various management practices. On Bloody Hill Glade on the National Park Service's Wilson Creek National Battlefield (WCNB), Young (2013, p. 5) noted that the annual population size for the species ranged from 261,837 plants in 1991, to 2,070 plants in 2002, to zero in 1993 and 1994. Similar population fluctuations were reported for six other glades on the WCNB (Young 2013, pp. 6-15).

Of the currently known 76 sites, 10 in Missouri and four in Arkansas are under public ownership or managed by a conservation organization (i.e., The Nature Conservancy in Missouri). One additional site on private property in Arkansas is managed to benefit and conserve Missouri bladderpod (Theo Witsell, pers. comm. Aug. 11, 2014).

Based on new information obtained since the recovery plan was approved in 1988, the first criterion does not reflect the total current range of Missouri bladderpod and the knowledge that the species now occurs on three different soil substrates. Additionally, the phrase "self-sustaining populations" in the first and fourth criteria needs to be changed to reflect the annual fluctuations in numbers. While recovery efforts and the discovery of new populations, including some in public ownership have, in principle, met most of the

elements of the first two criteria, they are inadequate as currently written and should be amended to reflect new information.

While some of the currently known bladderpod sites exceed one-half acre in size, many are much smaller and the distributions of some populations are limited due to the availability of suitable glade habitat. There are populations that could be expanded if various management actions are undertaken [e.g. removal of woody vegetation, especially eastern red cedar (*Juniperus virginiana*); control of invasive brome (*Bromus* spp.) grasses] but the original recovery goal of one-half acre in size was based on limited data on only 11 sites when the recovery plan was completed. Recovery criteria need to be updated and revised to address the current knowledge of the life history requirements, distribution, and new information of management actions that can benefit the species and address known threats.

Finally, the fourth criterion in the 1988 approved recovery plan does not reflect the yearly fluctuations in population levels due to changes in climatic and edaphic factors and in response to management actions that stimulate seed germination, plant growth, and flowering. Depending on habitat suitability, populations can crash but then rebound and exhibit a significant increase in the numbers of plants. For example, Young (2013, pp. 15-16) monitored populations of *Physaria filiformis* over a 25-year period on the largest bladderpod site on the WCNB in Missouri and demonstrated that plants fluctuated from a few thousand in 1990, to 261,000+ in 1991, to a few thousand in 1992, to zero in 1993 and 1994, and then rebounded to highs of between 30,000+ and 137,000+ in 1995, and between 42,000+ and 114,000+ in 2011. Similar results have been noted at the Missouri Department of Conservation's Rocky Barrens Conservation Area (U.S. Fish and Wildlife Service 2003, p. 59338). Consequently, the original criterion of "self-sustaining for seven years" does not reflect our current knowledge of Missouri bladderpod and delisting criteria that address all new information related to the life history and management requirements of the species should be developed in the future.

New discoveries of Missouri bladderpod sites have increased the number of known populations of the species by more than eight times since the species was listed in 1987. Nonetheless, the species' habitat is threatened by overgrazing, development, woody encroachment, invasive species, and likely projected climate change(s). As noted in U.S. Fish and Wildlife Service (2003, p. 59342) there is no evidence of over-collecting. Consequently the recovery criteria provided in the 1988 recovery plan do not sufficiently address these threats or are no relevant to the first three listing factors: A) the present or threatened destruction, modification, or curtailment of the its habitat or range, B) overutilization for commercial, recreational, scientific, or educational purposes, and C) disease or predation. Finally, none of the recovery criteria outlined above address factors D) the inadequacy of existing regulatory mechanisms, or E) other natural or manmade factors affecting its continued existence. Despite the increase in known populations, Missouri bladderpod is still subject to various threats and revised delisting criteria should address any remaining risks.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history: The life history requirements of this species were summarized in the reclassification rule completed in 2003 (U.S. Fish and Wildlife Service 2003, pp. 59337-59343). Edens-Meier et al. (2011, pp. 287-297) investigated the pollination biology of *Physaria filiformis* and determined that, as with many other members of the genus *Physaria*, Missouri bladderpod is self-incompatible and is dependent upon several species of pollinators for pollination and fruit set. The authors documented that no less than 38 species of insects, representing four insect orders, visited Missouri bladderpod plants (Edens-Meier et al. 2011, pp. 287, 293-294). Other aspects related to the distribution, abundance, and response to management actions have been published since the initial 5-year review (McKenzie 2008, pp. 1-6) and will be covered in appropriate sections below.

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:

There have been limited population trend analyses conducted at most localities and ones that provide long term demographic data sets [e.g., Wilson Creek National Battlefield: Eulinger and Skinner (2007, p. 17) and Young (2013, pp. 15-16)] indicate that populations vary significantly from year to year due to edaphic and environmental factors. Eulinger and Skinner (2007, pp. 14) observed Missouri bladderpod at 36 of 51 sites visited and discovered one new population during the survey. A total of 207,664 plants were estimated at the 37 sites.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.): There have been multiple genetic analyses on *Physaria filiformis* in Missouri (Graham 1994, pp. 1-61; Smart 1996, pp. 1-48; Westrich 1997, pp. 1-8; Keene 2009, pp. 1-59) but the species would benefit from additional genetic analyses across the range of the species, especially populations on different limestone, dolomite, and shale substrates; and disjunct populations between southwestern Missouri, the northern Arkansas Ozarks, and the Ouachita Mountains sites in central Arkansas. The southern-most populations in the northern Arkansas Ozarks in Washington County are approximately 111 air miles from the eastern most population in the Ouachitas in Garland County (Brent Baker, pers. comm., Aug. 14,

2014), the southern-most populations in Christian County, Missouri are approximately 74 air miles from the northern-most location in the Arkansas Ozarks in Sharp County, and the eastern-most and western-most populations in northern Arkansas (Sharp and Washington Counties, respectively) are separated by approximately 129 air miles (Brent Baker, pers. comm., Aug. 14, 2014). Given the distances between populations across the species' range and different soil substrates, an analysis of genetic diversity and gene flow would help direct revised delisting criteria.

Graham examined genetic diversity of Missouri bladderpod from sites in four counties in southwest Missouri and determined that genetic diversity was surprisingly high (p. 26) for a species that at the time was known to be a narrow endemic (1994, pp. v, 23-36). This was prior to the discovery of populations in two different regions of Arkansas.

Smart (1996, pp. 11, 24) analyzed the breeding system of *Physaria filiformis* (then *Lesquerella filiformis*) and concluded that this was primarily an obligate outcrossing species and that it exhibited what was likely stable levels of high genetic diversity, but this was under the assumption that the species did not occur anywhere outside of its then known range in southwest Missouri. Again, this predates the discovery of the species in Arkansas.

The genetic structure of Missouri bladderpod was studied on the National Park Service's Bloody Hill Glade in Greene County by Westrich (1997). This is one of the largest known sites for this species in Missouri with populations at times exceeding 100,000-200,000 plants (Eulinger and Skinner 2007, p. 63; Young 2013, p. 5). Westrich (1997, pp. 27-28) reported that there was high genetic diversity at the site and postulated that gene flow was likely facilitated by a healthy population of pollinators present in the area. She recommended, however, (Westrich 1997, p. 34) that gene flow continue be monitored, especially for such a large population.

High genetic diversity for populations of *Physaria filiformis* due to extensive gene flow was also concluded by Keene (2009, p. 26) who examined genetic diversity from two sites in southwestern Missouri. Edens-Meier et al. (2011, pp. 293-295) suggested that Missouri bladderpod was an efficient obligate out-crossing species because it was not pollen-limited and was visited by a wide array of pollinator generalists. Smart (1996, pp. 16-17) also suggested that large population sizes and the presence of an extensive seed bank for Missouri bladderpod will contribute to the maintenance of high genetic diversity. Whether similar trends in genetic diversity of *Physaria filiformis* will be exhibited among and between populations in Missouri and Arkansas has yet to be

determined, especially for populations, as noted above, that are separated by as much as 74-129 miles.

2.3.1.4 Taxonomic classification or changes in nomenclature: As noted in McKenzie (2008, p. 2), Yatskievych (2006, p. 714), U.S. Fish and Wildlife Service (2010, pp. 55686-55688), and Witsell and Baker (2011, p. 1), the scientific name *Lesquerella filiformis* Rollins was changed to *Physaris filiformis* (Rollins) O’Kane & Al-Shehbaz by Al-Shehbaz and O’Kane (2002, pp. 319-329).

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 historic range, etc.): The currently known extant populations of Missouri bladderpod have significantly expanded since the species’ listing in 1987. At the time of listing the species was known solely from nine sites in four counties in southwest Missouri. The species is now known from 76 sites across its range. Missouri bladderpod occurs at 66 sites in four counties in Missouri and 10 sites but scattered across five counties in Arkansas. To our knowledge, none of these sites have been destroyed. Bowe (2008, pp. 9, 16), however, reported that four respondents of a land owner questionnaire indicated that construction or cultivation was planned for sites currently occupied by the species. Additionally, Witsell (2008, p. 9) and Eulinger and Skinner (2007, p. 17) noted that encroachment by Eastern red cedar onto glades causes habitat degradation and this threat will need to be continually monitored. At the time of listing and completion of the recovery plan (1987 and 1988, respectively) *Physaria filiformis* was only known to occur on Burlington Limestone in southwestern Missouri. The species now occurs on three different soil substrates: limestone glades in Missouri and limestone, dolomite, and shale glades in Arkansas. A report of the species on a dolomitic glade in Missouri cannot be verified (George Yatskievych, pers. comm. Aug. 11, 2014). Nonetheless, there is clear evidence that our knowledge of the distribution has increased significantly in the last 25+ years compared to what occurred historically as new populations have been discovered in Arkansas. Additionally, there are yet suitable habitats that have not been surveyed that could potentially yield additional populations as well as sites that would benefit from management activities that have proven to benefit the species (e.g., cedar tree removal, prescribed fire, exotic species control).

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

As noted above, glade habitat for Missouri bladderpod ranges from the Ozark Plateau in southwestern Missouri, northwestern and northern

Arkansas to the Ouachita Mountains in central Arkansas (McKenzie 2008, pp. 2-3; Witsell 2008, pp. 7-8). Numerous glades that provide seemingly suitable habitat in southern Missouri and northern Arkansas have been surveyed for the species without the documentation of additional populations other than the 76 that are currently known. Consequently, there is an abundance of habitat for this species that exists that could allow for an expansion of populations. Additional habitat could also be provided if various management actions were undertaken such as cedar tree removal, prescribed fire and exotic species control (Eulinger and Skinner 2007, p. 43; Witsell 2008, pp. 9-11; Young et al. 2009, pp. 233-241; Young 2013, p. 13). Missouri bladderpod responds favorably to active management and best management practices have been recommended to benefit the species (Eulinger and Skinner 2007, p. 43; Witsell 2008, pp. 9-11; Young et al. 2009, pp. 233-241; Young 2013, p. 13).

2.3.1.7 Other: NA

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

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

Since the species was listed in 1987 and the recovery plan approved in 1988, our knowledge of the overall range of Missouri bladderpod has expanded significantly as noted above. Due to the discovery of Missouri bladderpod on dolomite and shale glades in Arkansas, occupied habitat for this species has increased in the total number of sites and total areal coverage. Nonetheless, the species still faces various threats to its habitat that include development, spread of exotic species, lack of management, and climate change(s).

There have been various recovery actions that have been implemented to benefit Missouri bladderpod. These include:

1. Conducting extensive surveys for new populations in Arkansas,
2. Monitoring of many sites to determine presence/absence in Missouri and Arkansas,
3. The development of a management plan for the species in Arkansas (Witsell 2008, pp. 1-18),
4. The development of best management practices for the species in Missouri (Eulinger and Skinner 2007, pp. 42-45),
5. Ongoing management actions to enhance bladderpod populations at Beaver Lake in northwestern Arkansas,
6. Some successful efforts in contacting private landowners who have extant sites in Missouri and Arkansas,

7. The completion of a pollination biology of Missouri bladderpod by Edens-Meier et al. (2011, pp. 287-297),
8. Long term monitoring at some sites, particularly research undertaken at the Wilson's Creek National Battlefield (Young et al. 2008, pp. 370-378; Young 2013, pp. 1-15.),
9. Completion of initial genetic analyses (Graham 1994; Smart 1996; Westrich 1997; Keene 2009),
10. Implementation of various management actions that have demonstrated that the species responds well to such operations (e.g., cedar tree removal, prescribed fire, control of exotics), and
11. The development of suggested monitoring protocols (Young et al. (2008, pp. 370-378); Morrison et al. (2008, pp. 417-425).

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

There is no indication that any commercial, recreational, scientific, or education activities have adversely impacted Missouri bladderpod. Given that populations in some years can number in the hundreds of thousands, voucher specimens taken at new sites associated with scientific collecting would not negatively impact bladderpod populations. At the time of listing wildflower collectors were considered a threat to the species (U.S. Fish and Wildlife Service, 1987, p. 681), but this was postulated at a time when only nine populations were known (U.S. Fish and Wildlife Service, 1987, p. 679) and a few of the extant sites were easily accessible along highway right-of-ways. There is no evidence of overutilization of any bladderpod population. Based on the large number of plants present during some years at many sites, especially following the implementation of various management actions that benefit the species, scientific collecting associated with research activities should be considered miniscule.

2.3.2.3 Disease or predation:

At the time of listing in 1987, seed predation and fungal infection of developing capsules were noted from an earlier study (U.S. Fish and Wildlife Service, 1987, p. 680). Edens-Meier et al (2011, pp. 287-297) conducted a pollination biology study on *Physaria filiformis* but did not report any evidence of disease or predation on bladderpod flowers or seeds. Given the current large number of populations, it is unlikely that disease or predation is a present threat to the range-wide distribution of the species.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

Under chapter four of the Missouri Wildlife Code (<http://www.sos.mo.gov/adrules/csr/current/3csr/3csr.asp>) “the exportation, transportation or sale of any endangered species of plant or parts thereof, or the sale of or possession with intent to sell any product in

whole or in part from any parts of any endangered species of plant is prohibited” (3 CSR 10-4.111 Endangered Species, p. 4). In the State of Missouri, Missouri bladderpod is considered an endangered species under the Wildlife Code (3 CSR 10-4.111 Endangered Species, p. 4). Populations of *Physaria filiformis* that occur on Federal land, are under Federal jurisdiction, or where a Federal permit is required, or Federal funding of projects or activities that may involve or affect the species, receive some protection under Sections 2 (c)(1), 7(a)(1) and 7(a)(2) of the Endangered Species Act (50 Code of Federal Regulations, Chapter 4, Part 402- Interagency Cooperation- Endangered Species Act of 1973, As Amended, Subpart B- Consultation Procedures- Sections 402.10-402.16, pp. 880-891). Although plants receive no protection on private lands, multiple outreach programs to private entities in Missouri and Arkansas have been successful in establishing commitments from landowners to properly maintain and manage bladderpod habitat. In Missouri, Eulinger and Skinner (2007, pp. 15; Appendix 1, p. 36; Appendix 4, pp. 42) developed a Landowner Consent Form to enable monitoring of bladderpod on private land and best management practices to reduce potential impacts and recommendations to enhance the species’ habitat. Bowe (2008, pp. 9, 16) contacted private landowners via a questionnaire in southwest Missouri to assess future development threats and reported that most individuals had no plans to initiate projects that could impact bladderpod habitat. Four respondents, however, noted that they would either construct a structure on bladderpod habitat or cultivate areas currently occupied by the species. In Arkansas, one private entity in Hot Springs County has worked closely with the Arkansas Natural Heritage Commission in maintaining and managing bladderpod habitat, and outreach to other private landowners who have extant sites is planned in the near future (Theo Witsell, pers. comm. Sep. 10, 2014). Active monitoring and habitat enhancement, restoration, or management continues on Federal land in Missouri (National Park Service), and Arkansas (Army Corps of Engineers and U.S. Forest Service) (Witsell 2008, pp. 1-8), (Young 2013, pp. 1-15) as well as state-owned land in Missouri (Eulinger and Skinner 2007, pp. 42-45).

2.3.2.5 Other natural or manmade factors affecting its continued existence: There has been an increased awareness of the potential impact of climate change on federally listed species. Some authors have predicted that climate change threatens plant diversity, species phenology and distribution, and increases extinction risk (Iverson and Prasad 2002, pp. 465-484; McLaughlin et al. 2002, pp. 6070-6074; Thuiller et al. 2005, pp. 8245-8249; Bertin 2008, pp. 126-142; Maclean and Wilson 2011, pp. 12337-12341). Climate change may lead to increased frequency and duration of droughts (Rind *et al.* 1990, p. 9983; Seager *et al.* 2007, pp. 1181-1184; Rahel and Olden 2008, p. 526). Climate warming may increase the virulence of nonnative parasites and increased drought

conditions may favor the establishment and spread of nonnative species (Rahel and Olden 2008, pp. 525-526, 529-530). Extended droughts and an increase in soil and air temperatures could negatively impact seed set, germination, and overall fitness of *Physaria filiformis*. The potential impacts of climate change to Missouri bladderpod should be evaluated.

2.4 Synthesis

Despite ongoing threats to this species, knowledge of the overall range of Missouri bladderpod continues to improve and this species responds well to management. With the development of recovery criteria outlined in an updated recovery plan that address ongoing and future threats to *Physaria filiformis*, and the protection and proper maintenance of populations throughout its range, Missouri bladderpod is on the road to recovery and possible delisting in the near future. Nonetheless, monitoring of a subset of populations and the establishment of measurable recovery criteria that address threats to the species should be developed and implemented before such actions are recommended. Consequently, no change in the classification of the species is warranted.

3.0 RESULTS

3.1 Recommended Classification:

Downlist to Threatened

Uplist to Endangered

Delist (*Indicate reasons for delisting per 50 CFR 424.11*):

Extinction

Recovery

Original data for classification in error

No change is needed

3.2 New Recovery Priority Number : N/A

Brief Rationale: N/A

3.3 Listing and Reclassification Priority Number: N/A

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS –

During the next five years, it is recommended that the following actions be undertaken for the reasons given below:

1. A revision of the 1998 Missouri Bladderpod Recovery Plan is needed to develop measurable delisting criteria that reflect remaining threats to the species and to incorporate new information that has been obtained in the last 26 years. Development of such a plan should be done in cooperation with the appropriate experts and stakeholders in Missouri and Arkansas.
2. Missouri bladderpod numbers and the results of ongoing conservation efforts need to be regularly monitored to assess recovery and ongoing management efforts. Suggested recommendations should be outlined in an adaptive management framework and adjustments made as necessary. Experimental design in monitoring and revisions to approaches should consider guidelines found in Young et al. (2008, pp. 370-378) or procedures evaluated by Morrison et al. (2008, pp. 417-425). Given the large number of populations scattered across the range of the species, it may be appropriate to identify priority populations in Missouri and Arkansas for monitoring. Monitoring efforts should include populations that occur on the three different substrate types. It is highly unlikely that agencies will have sufficient funds or personnel to conduct detailed demographic monitoring of all populations so an identified subset is recommended. It will be necessary to develop criteria that reflect annual fluctuations in population numbers due to changes in environmental and edaphic variables. One suggested approach has been to establish a criterion where x number of populations exhibit a stable trend over x number of years (George Yatskievych, pers. comm. August 11, 2014). This could be reflected in some measure of persistence over time. Another could reflect the need to maintain and manage habitat by using prescribed fire, cedar tree removal, and the control of exotics.
3. Studies need to be initiated on the potential impacts of climate change on the Missouri bladderpod and its habitat. The species could be impacted from droughts and accompanying problems associated with climate change and further research is warranted.
4. *Physaria filiformis* would benefit from additional genetic studies that evaluate genetic diversity across the range of the species, especially given the now known large geographic gaps between populations in southwest Missouri and scattered populations in Arkansas and the occurrence on three different soil substrates.
5. Outreach efforts need to be made to private landowners in Missouri and Arkansas regarding best management practices that will maintain, and where necessary restore bladderpod habitat.

6. Ongoing survey efforts should continue to search for new populations, especially in Arkansas.
7. Viable sites should be protected and properly managed in all the outlying clusters within the species' range.

5.0 REFERENCES

- Al-Shehbaz, I.A. and S.L. O'Kane, Jr. 2002. *Lesquerella* is united with *Physaria* (Brassicaceae). *Novon*. 12:319-329.
- Bertin, R.I. 2008. Plant phenology and distribution in relation to recent climate change. *J. of the Torrey Bot. Soc.* 135(1):126-146.
- Bowe, M. 2008. Preservation of Missouri Bladderpod through landowner cooperation and the control of brome grass. Unpub. Rep. Grant No. 33410-1113-0000. Missouri State University, Springfield, Missouri. 19pp.
- Edens-Meier, R., M. Joseph, M. Arduser, E. Westhus, and P. Bernhardt. 2011. The pollination biology of an annual endemic Ozarks following controlled burns. *J. of the Torrey Bot. Soc.* 138(3): 287-297.
- Eulinger, K. and M. Skinner. A survey of three federally listed plant species in southwest Missouri. Missouri Department of Conservation Unpubl. Report. Section 6 Grant E-1-43. Springfield, Missouri. 67pp.
- Graham, M. 1994. Genetic population structure of a glade endemic, the Missouri bladderpod (*Lesquerella filiformis*; Brassicaceae). MS thesis, Northeast Missouri State University, Kirksville, Missouri. 61pp.
- Keene, J. 2009. Genetic and ecological aspects of conserving the federally threatened Missouri Bladderpod. M.S. Thesis. Missouri State University, Springfield, Missouri. 59pp.
- Iverson, L.R. and A.M. Prasad. 1998. Predicting abundance of 80 tree species following climate change in the eastern United States. *Ecol. Monogr.* 68(4): 465-485.
- Maclean, I.M.D and R. J. Wilson. 2011. Recent ecological responses to climate change support predictions of high extinction risk. *PNAS* 108(30):12337-12342.
- McKenzie, P.M. 2008. 5-year review for Missouri Bladderpod. U.S. Fish and Wildlife Service Unpubl. Report. Columbia, Missouri. 6pp.
- McLaughlin, J.F., J.J. Hellmann, C.L. Boggs, and P.R. Ehrlich. 2002. Climate change hastens population extinctions. *PNAS* 99(9): 6070-6074.

- Morrison, L.W., D.R. Smith, C.C. Young, D.W. Nichols. 2008. Evaluating sampling designs by computer simulation: a case study with the Missouri bladderpod. *Pop. Ecol.* 50:417-425.
- Rahel, F.J. and J.D. Olden. 2008. Assessing the effects of climate change on aquatic invasive species. *Conserv. Biol.* 22(3): 521-533.
- Schlinder, D.W. 2001. The cumulative effects of climate warming and other human stresses on Canadian freshwaters in the new millennium. *Can. J. Aquat. Sci.* 58:18-29.
- Smart, M.B.S. 1996. Breeding system, heterozygosity, and seed germination in a population of Missouri bladder-pod, *Lesquerella filiformis*. M.S. Thesis. Southwest Missouri State University, Springfield, Missouri. 48pp.
- Thuiller, W. S. Lavorel, M. B. Araujo, M.T. Sykes, and I. C. Prentice. 2005. Climate change threats to plant diversity in Europe. *PNAS* 102(23): 8245-8250.
- U.S. Fish and Wildlife Service. 2003. Endangered and Threatened Wildlife and Plants; Reclassification of *Lesquerella filiformis* (Missouri Bladderpod) From Endangered to Threatened. *Fed. Reg.* 68(199): 59337-59345).
- U.S. Fish and Wildlife Service. 2010. Endangered and Threatened Wildlife and Plants; Technical Corrections for Three Midwest Region Plant Species. *Fed. Reg.* 77(177): 55686-55689.
- Westrich, J.L. 1997. Genetic population substructure of the rare *Lesquerella filiformis*: consequences of the factors which affect gene flow within a site. M.S. Thesis. Truman State University, Kirksville, Missouri. 48pp.
- Witsell, T. 2008. Management Plan for Missouri Bladderpod (*Physaria filiformis*) in Arkansas and Recently Discovered New Populations in Arkansas. Arkansas Natural Heritage Commission Unpubl. Report. Little Rock, Arkansas. 18 pp.
- Witsell, T. 2011. Final report on *Physaria filiformis* (Rollins) O’Kane & Al-Shehbaz [Missouri bladderpod] survey work in Arkansas, 2010. Arkansas Natural Heritage Commission Unpubl. Report. Section 6 Grant E-31-R. Little Rock, Arkansas. 77 pp.
- Young, C.C. 2013. Annual Status Report: Missouri bladderpod monitoring for Wilson’s Creek National Battlefield. National Park Service Natural Resources Data Series Report: NPS/HTLN/NRDS-2013. 15pp.
- Young, C.C., L.W. Morrison, and J.L. Haack. Habitat relationships and management implications for *Lesquerella filiormis* Rollis (Missouri bladderpod) on a xeric limestone prairie. *J. of the Torrey Bot. Soc.* 136(2): 233-241.

Young, C.C., L.W. Morrison, M.J. Kelrick, M.D. DeBacker. 2008. Monitoring *Lesquerella filiformis* Rollins (Missouri bladderpod): Application and Evaluation of a Grid-based Survey Approach. *Nat. Areas J.* 28(4):370-378.

Personal Communications

Baker, Brent- Aug. 14, 2014, Arkansas Natural Heritage Commission, Little Rock, AR

Osborne, Cindy- Aug. 13, 2014, Arkansas Natural Heritage Commission, Little Rock, AR

Rimer, Rhonda- May 2, 2013; March 10, 2014; Jan. 14, 2015, Missouri Department of Conservation, Springfield, MO

Witsell, Theo- Aug. 11, 2014; Sep. 10, 2014, Arkansas Natural Heritage Commission, Little Rock, AR

Yatskievych, George- Aug. 11, 2014, Missouri Botanical Garden, St. Louis, MO

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Missouri Bladderpod*

Current Classification:

Recommendation resulting from the 5-Year Review:

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

Appropriate Listing/Reclassification Priority Number, if applicable: 8 (no change)

Review Conducted By: Dr. Paul McKenzie, Fish and Wildlife Biologist, Columbia, Missouri Ecological Services Field Office

FIELD OFFICE APPROVAL:
Lead Field Supervisor, Fish and Wildlife Service

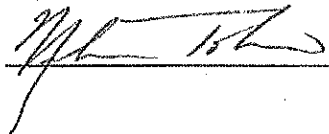
Approve AMY SALVETER Digitally signed by AMY SALVETER
DN: cn=AMY SALVETER, o=U.S. Fish and Wildlife Service, ou=FIELD OFFICE Date _____

REGIONAL OFFICE APPROVAL:
Assistant Regional Director, Fish and Wildlife Service, Midwest Region

Approve LYNN LEWIS Digitally signed by LYNN LEWIS
DN: cn=LYNN LEWIS, o=U.S. Government, ou=Department of the Interior, ou=U.S. Fish and Wildlife Service, ou=WSM Date _____

Cooperating Assistant Regional Director, Fish and Wildlife Service, Southeast Region

Concur Do Not Concur

Signature  Date 9/15/2015