5-YEAR REVIEW
Missouri bladderpod (*Physaria filiformis*)

GENERAL INFORMATION:

Species: Missouri bladderpod (*Physaria filiformis*)
Date listed: January 8, 1987
Federal Register (FR) citation(s): 84 FR 28850
Classification: Threatened (Reclassified as Threatened - USFWS 2003, pp. 59337-59345)

Lead Field Office: Missouri Ecological Services (ES) Field Office, Columbia, Missouri, John Weber, 573-825-6048. John_S_Weber@fws.gov

Lead Region: Midwest Regional Office (Region 3), Bloomington, Minnesota, Laura Ragan, 612-713-5157, laura_ragan@fws.gov; and Karen Herrington, 612-713-5334, karen_herrington@fws.gov

Cooperating Field Offices: Arkansas ES Field Office, Conway, Arkansas, Rebecca Peak, 501-513-4475, rebecca_peak@fws.gov

BACKGROUND:

The Missouri bladderpod (*Physaria filiformis*) (Rollins) O'Kane & Al-Shehbaz is a small annual plant that occurs in Missouri and Arkansas (see Figures 1 and 2 from Edwards et al. 2021). The main threats to Missouri bladderpod are the lack of preservation and management of glade habitats on which this species depends, residential and commercial development, quarrying, spread of exotic species, encroachment by eastern red cedar (*Juniperus virginiana*), fire suppression, and climate change (Nelson 2005, Yatskievych 2006, U.S. Fish and Wildlife Service (USFWS) 2015, USFWS 2020, Edwards et al. 2021, Soteropoulos 2023). Botanical nomenclature of *Physaria* sp. follows Al-Shehbaz and O'Kane (2002).

FR Notice citation announcing this status review: 89 FR 804. Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews of 16 Listed Animal and Plant Species. January 5, 2024 (USFWS 2024).

ASSESSMENT:

The USFWS' Missouri ES Field Office conducted this 5-year review. We solicited data for this review from interested parties through a FR notice announcing this review on January 5, 2024. We also contacted the following species experts: Christine Edwards, Stephen and Camilla Brauer Conservation Geneticist with Missouri Botanical Garden (MOBOT); Ben Benton, Botanist for the Arkansas Natural Heritage Commission (ANHC) in Little Rock, Arkansas; Rhonda Rimer, Regional Natural History Biologist for the Southwest Region of Missouri, Missouri Department of Conservation (MDC); Chris Crabtree, Ecologist for the Missouri Department of Natural Resources-Division of State Parks; and Sherry Leis, Plant Ecologist for the Heartland Inventory and Monitoring Network of the National Park Service (NPS). The review also consisted of an

evaluation of MDC Natural Heritage data, reports produced since the last review (see Literature Reviewed), and information provided by Ben Benton of the ANHC.

Information acquired since the last status review:

1. *New information on the species' biology and life history:*

   Recent genetic analyses indicate that portions of the Missouri bladderpod in Arkansas may no longer be appropriately categorized as *P. filiformis*. When initially discovered on shale glades in the Arkansas Ouachita Mountains (Garland and Hot Spring counties), populations of Missouri bladderpod were considered to be *P. filiformis* (USFWS 2008; Witsell 2008). Subsequent genetic analyses by Edwards et al. (2021, 2023), however, revealed that bladderpod from this habitat potentially represented a new cryptic species. Edwards et al. (2023) concluded that the new species was more closely related to *Physaria globosa* than any other species in the genus *Physaria*. Kallison et al. (submitted for publication August 2024) proposed naming the new bladderpod as *Physaria ouachitensis,* E.R. Kallison and C.E. Edwards, sp. nov[1].

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

   For purposes of this analysis, the terms "sites," "occurrences," and "populations" have been used interchangeably in Arkansas and Missouri natural heritage databases or in published literature.

   Seven new populations of Missouri bladderpod have been discovered in Missouri and one in Arkansas since the last 5-year review (Rimer, pers. comm. 5 Sep. 2024). Currently, there are 75 sites of Missouri bladderpod in Missouri and 8 in Arkansas (Soteropoulos 2023). One of the sites in Missouri at the Nathan Boone State Historic Site was a result of seed dispersal from an adjacent site in 2020-2021 (Crabtree, pers. comm. 28 Sep. 2024). Of the 75 naturally occurring, known sites in Missouri, 24 (32%) of these sites are extirpated or likely extirpated (Rimer, pers. comm. 5 Sep. 2024). Since the last 5-year review, approximately 21 of the known sites in Missouri were monitored (~ 28%).

   Leis (2023) monitored sites on the Wilson Creek National Battlefield and used a grid-based survey approach (Young et al. 2008) to monitor 10 known Missouri bladderpod sites and established a midpoint of population estimates. Leis noted that bladderpod numbers increased following dormant season burns.

   Soteropoulos (2023) monitored all known sites of Missouri bladderpod in Arkansas and noted that some populations were the largest ever recorded in the state, and some of the increases were due to clearing of competing vegetation or prescribed fires (Soteropoulos 2023; Benton, pers. comm. 20 Sep. 2024).

[1] Submitted to Systematic Botany for potential publication 26 Aug. 2024; note- this document is proprietary information of the authors. Any reference to this document must have authorized permission from C.E. Edwards.

Based on Edwards et al. (2021), Edwards et al. (2023), and Kallison et al. (submitted for publication August 2024), populations of *Physaria* sp. on shale glades in the Ouachita Mountains represent a new species. A manuscript on the new species (*Physaria ouachitensis* E.R. Hallison & C.E. Edwards) was submitted to Systematic Botany and is currently under review (Edwards, pers. comm. Sep. 19, 2024). Given probable approval, the new species in the Ouachita Mountains would remove four populations from the overall range of the species (see further discussion in section 4). Prior to 2023 it would have been three sites, but Benton discovered one new site in Garland County in 2023 on a shale substrate (Benton, pers. comm. 20 Sep. 2024). Approval of the new species would also remove one natural community from the range of *P. filiformis*.

Of the 51 extant sites in Missouri, 23 (45%) are in public ownership (Rimer, pers. comm. 9 Sep. 2024). Assuming the bladderpod that occurs on shale glades in the Ouachita Mountains is accepted as a new species, only two sites with Missouri bladderpod in Arkansas would be in public ownership [Blue Springs Recreation Area in Northwest Arkansas- Beaver Lake North and Beaver Lake South (Soteropoulos 2023)]. Therefore, 25 of the currently known 55 (~45%) sites for *P. filiformis* rangewide are in public ownership.

While some of the currently known Missouri 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 would increase if various management actions were undertaken [e.g., removal of woody vegetation, especially red cedar; control of invasive brome (*Bromus* spp.) grasses] but the original recovery goal of one-half acre of size was based on limited data on only 11 sites when the recovery plan was completed in 1988. Recovery criteria could be updated and revised to address the current knowledge of the species' life history requirements, distribution, and new information on management actions that can benefit the species and address known threats. Given information obtained since the recovery plan was approved in 1988 regarding variations in areal coverage of some bladderpod sites, the habitat size criterion may not benefit recovery.

3. *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), or demographic trends:*

While some populations of Missouri bladderpod are stable or increasing on well-managed sites in Missouri and Arkansas, others are decreasing due to lack of ongoing management (Rimer, pers. comm. 5 Sep. 2024). Nelson (2005) noted that fire suppression, overgrazing, drought, and introduction of invasive species negatively impact Missouri glades.

To date, 75 (one the result of seed planting) populations have been documented in Missouri, mostly on private land in the southwest part of the state. Since the last 5-year review in 2020, MDC surveyed 39 of these populations on both private and public lands.

A large population of Missouri bladderpod within the NPS' Wilson's Creek National Battlefield remains stable due to dedicated glade management (Leis 2023). In 2019, approximately 60,000 plants (USFWS 2020) were documented at the site and in 2023 an estimate of between 32,078 and 87,431 were calculated for the location (Leis 2023).

Eight to 12 populations of Missouri bladderpod occur in Arkansas. This range is based on uncertainty associated with the proposed new species on the Ouachita Mountains shale glades. All Arkansas sites were surveyed in 2023 (Soteropoulos 2023; Benton, pers. comm. 20 Sep. 2024). The two populations of Missouri bladderpod at Blue Springs Conservation Area have increased due to management activities (Soteropoulos 2023) but a genetic bottleneck has occurred in the populations, see description in Section 4, below (Edwards et al. 2021). Some of the largest population numbers were reported for several Arkansas sites in 2023. Private landowners at one site in Izard County actively manage their property for Missouri bladderpod and over 5,000 plants were observed in 2023 (Soteropoulos 2023). Healthy populations exist on roadside and utility right-of-way locations in Izard and Sharp counties but plants are at risk from cedar encroachment, spread of invasive species, and ground debris (Soteropoulos 2023).

In the USFWS's Recovery Plan for Missouri bladderpod (USFWS 1988), the agency noted that a minimum of 30 "self-sustaining" populations that persisted for a period of seven years were needed before the species could be removed from the Federal list of Endangered and Threatened species. The USFWS did not attempt to further define "self-sustaining" and the term has continually been debated since the passage of the Endangered Species Act (ESA) of 1973. In the broadest sense, a "self-sustained" population would be one that would be able to persist in the wild without any human assistance, or one that would be able to continue in a healthy state without outside assistance. In the overwhelming majority of cases, however, ongoing conservation measures would be necessary for a species to meet the statutory requirement that protections under the ESA were no longer needed (Dormeus 2000; Scott et al. 2005; Scott et al. 2010).

Scott et al. (2005) established criteria to determine if a species met the definition of being "conservation-reliant." Many authors now agree that most federally listed species are "conservation-reliant" and some suggested revisions to the definition so that it satisfied relevant legal and policy considerations (Rohlf et al. 2014). Scott et al. (2005), Scott et al. (2010), Goble et al. (2012) estimated that 84% of species listed through 2010 were conservation-reliant species. Without the ability to completely remove threats to a species, Doremus and Pagel (2001) noted that few species have been delisted and actually recovered to the point that they were able to persist in the wild without ongoing conservation actions. It is unlikely that Missouri bladderpod will persist in the wild without active management of its habitat. Consequently, the species meets the definition of a "conservation-reliant" species.

4. *Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding):*

Missouri bladderpod occurs in three disjunct geographic areas across Missouri and Arkansas: limestone glades in southwest Missouri and northwest Arkansas, and dolomite glades in northcentral Arkansas (Edwards et al. 2021). In 2015 and 2016, researchers with MOBOT collected genetic data from populations within each of the three geographic areas and analyzed the genetic structure of each geographic area. The results demonstrated that the three geographic areas can be divided into six distinct genetic groups, and that each group has high levels of genetic diversity (Fig. 1 and 2) (Edwards et al. 2021). Edwards et al. (2021) conducted genetic analysis of *P. filiformis* at 14 sites in Missouri and three in Arkansas. Of these, seven sites in Missouri (representing four of the genetic cluster subunits, Fig. 2) and one in Arkansas (representing one of the distinct genetic clusters, Fig. 2) were on public land. Although two sites in northcentral Arkansas were on private land (representing one of the distinct genetic clusters, Fig. 2), a new site within the same genetic cluster is owned by a private landowner who actively manages their property for Missouri bladderpod (Soteropoulos 2023). Protection of populations of all genetic clusters identified by Edwards et al. (2021,) (Fig. 1) within Missouri and Arkansas is critical for conservation of genetic diversity in this plant species.

Historically, five populations of what was initially identified as *P. filiformis* occurred on shale glades in the Ouachita Mountains (three populations in Cedar Fourche Glade complex and one in Jack Mountain Wildlife Management Area). Edwards et al. (2021) conducted a thorough genetic analysis of individuals from these populations as well as those from across the known range of *P. filiformis* in Missouri and Arkansas and determined that bladderpod from the Ouachita Mountains are genetically divergent from the other populations, and likely represent a new, extremely rare, endemic, cryptic species. Edwards et al. (2021) concluded that a morphological comparison between populations in the Ouachita Mountains and the remaining geographical areas was needed to further support these findings.

Edwards et al. (2021) also sampled a population of a closely related congener (*Physaria gracilis)* from Texas to compare genetic diversity of that species with that of the Ouachita plants. Edwards et al. (2021) suggested that the Ouachita Mountain *Physaria* were possibly closer genetically to *P. gracilis* than *P. filiformis.* As a follow up, Edwards et al. (2023) conducted a population genetic comparison of the bladderpod from the Ouachita Mountains with *P. filiformis, P. gracilis,* and *P. globosa*, a geographically proximal federally listed species found in Kentucky, Indiana, and Tennessee (O'Kane 2010). Edwards et al. (2023) determined that the Ouachita Mountain *Physaria* was sister to *P. globosa* while *P. filiformis* was more closely related to *P. gracilis.*

Kallison et al. (manuscript submitted in 2024) conducted a morphological comparison of flowers and fruit of the Ouachita Mountain *Physaria* with *P. filiformis* and determined that the Ouachita populations had smaller flowers, larger fruits, and a distinct petal morphology. Additionally, these authors conducted a phylogenomic analysis to determine the placement of Ouachita Mountain *Physaria* compared to *P. filiformis, P. globosa, P. gracilis,* 14 other species of *Physaria* in eastern North America, and *Paysonia* (O'Kane and Al Shehbaz 2002) as a sister outgroup. Kallison et al. (Manuscript submitted in 2024) concluded that Ouachita Mountain *Physaria* were most closely related genetically to *P.*

globosa. Phylogenomic analyses of the Ouachita Mountain bladderpod (Edwards et al. 2021; Edwards et al. 2023; and Kallison et al (Manuscript submitted in 2024) provide strong evidence that this *Physaria* is a sister species to *P. globosa*) and should be treated as a new species. Based on this information, the authors proposed describing the Ouachita Mountain *Physaria* as *P. ouachitensis,* E.R. Kallison and C.E. Edwards, sp. nov. As noted elsewhere, this unpublished scientific name is proprietary information of the authors and further reference to the name should be limited until the new species is formally accepted.

If accepted as a new species to science, the recognition of *Physaria ouachitensis* would result in the reduction of four populations of *P. filiformis* in Arkansas and would reduce the range-wide distribution of Missouri bladderpod by four populations. Given that there are currently about 51 extant populations of *P. filiformis* in Missouri (Rimer, pers. comm. 9 Sep. 2024), the total number of populations in Missouri and Arkansas would then be approximately 59 populations (51 in Missouri and 8 in Arkansas).

As previously reported by others, Edwards et al. (2021) concluded that *P. filiformis* had high genetic diversity across its range. The sole site in northwest Arkansas, however, revealed a likely genetic bottleneck compared to populations in northcentral Arkansas and southwest Missouri (Edwards et al. 2021). While numbers of *P. filiformis* at the northwest Arkansas site increased substantially following management of the site, genetic diversity was low due to the replication of the few alleles that were duplicated following the genetic bottleneck (Edwards et al. 2021; Edwards, pers. comm. 18 Sep. 2024). In *situ* and *ex situ* conservation efforts may be necessary to increase the genetic diversity of Missouri bladderpod in northwest Arkansas. See notes below on recommendations for future actions.

5. *Taxonomic classification or changes in nomenclature:*

   There are no changes in taxonomic classification or nomenclature for Missouri bladderpod, but see genetics above on a proposal to treat the *Physaria* sp. in the Ouachita Mountains of central Arkansas as a new species to science.

6. *Habitat or ecosystem conditions (e.g., amount, distribution, and sustainability of the habitat or ecosystem):*

   Consistent glade management maintains suitable habitat for Missouri bladderpod and is considered vital to the survival and recovery of populations in Arkansas and Missouri. Removal of eastern red cedar, prescribed fire, and control of exotic species allow for the persistence and expansion of populations (Nelson 2005; Young et al. 2009; Edwards et al. 2021; Leis 2023; Soteropoulos 2023; and Crabtree, pers. comm. 2 Oct. 2024).

   Most privately owned glades in Missouri are not being managed to promote the persistence of this plant species, and surveys indicate generally low numbers of Missouri bladderpod (Edwards et al. 2021). The potential loss of 32% of known sites in Missouri is primarily due to the lack of suitable management on private property (Rimer, pers.

comm. 5 Sep. 2024). The lack of management on private land at Arkansas sites is also a major threat to the species (Soteropoulos 2023). With a few exceptions, glades on private lands are over-shaded by encroaching eastern red cedar, intensively grazed, densely covered by grasses and forbs, and not managed with fire (Edwards, pers. comm. 12 Nov. 2019). Although restoration efforts increase abundance of Missouri bladderpod, implementation of those efforts on privately-owned glades is challenging (Edwards, pers. comm. 12 Nov. 2019). Similar to Missouri, glade habitat in Arkansas has become degraded at several locations due to lack of suitable management, but restoration efforts on the Army Corps of Engineers (COE) properties in northwest Arkansas and one property under private ownership in northcentral Arkansas have provided positive results (Soteropoulos 2023).

Summary:

We received survey data and monitoring reports from MDC, ANHC, MODNR-DSP, and NPS with updated information regarding the species' status and current threats in the time since we conducted the last 5-year review. Three new sites have been documented since the last review. Results of these efforts indicate that managed populations in Missouri and Arkansas are stable and that unmanaged populations may be declining rapidly. No new threats have been documented since the last 5-year review but Nelson (2005) and Yatskievych (2006) identified quarrying as a new threat to the species since it was listed.

Conclusion:

As noted above, Missouri bladderpod does not meet the definition of being "self-sustained" and is a "conservation-reliant" species. While some sites in Missouri and Arkansas are managed to benefit the species, it will not persist into the future without human assistance and intervention. 68% of known Missouri bladderpod sites in Missouri remain extant as of the writing of this document. 45% of the known Missouri bladderpod sites in Missouri are under public ownership but require ongoing management to maintain stable populations. That management is not currently happening at most sites and measure are not in place to assure such management would continue if the species were delisted. Possibly as much as 32% of historically known populations on private land have been extirpated since the species was reclassified from endangered to threatened in 2003. As a consequence of the differential management of the species across Missouri and Arkansas, protection under the ESA is still necessary for the species.

Appropriate and measurable delisting criteria are recommended to better guide recovery for this species. A more detailed recovery implementation strategy that follows the principles outlined in the USFWS Species Status Assessment (SSA) process (USFWS 2016; Smith et al. 2018) could provide more appropriate delisting criteria. If still considered appropriate, the term "self-sustained" should be clarified in a revised recovery plan.

Based on the current status and distribution of Missouri bladderpod populations, and the continuing threats to the species and its habitat, the species remains likely to be in danger of extinction throughout all or a significant portion of its range in the foreseeable future, and therefore, continues to meet the definition of a threatened species.

RECOMMENDATIONS FOR FUTURE ACTIONS:

The Service provides the following recommendations:

1. Edwards et al. (2021) recommended the collection of seed from genetic clusters they identified. A threatened and endangered species seed bank proposal has been submitted to MDC's Science Branch by the Missouri Botanical Garden that will help ensure that the range-wide genetic diversity is represented in ex-situ conservation (Malissa Briggler, State Botanist, MDC, pers. comm. 10 Oct. 2024).

2. Based on genetics results outlined by Edwards et al. (2021), ongoing monitoring should be undertaken at a minimum of the six genetic clusters identified in Arkansas and Missouri. Due to the number of extant sites in Missouri and Arkansas, and a general lack of personnel, there will likely be a need to prioritize what sites are monitored. Simple presence/absence monitoring may be insufficient to assess the status of Missouri bladderpod in Arkansas and Missouri, especially sites with high genetic diversity as determined by Edwards et al. (2021). Monitoring as outlined by Young et al. (2008) and Leis (2023), or a program supported and coordinated among Federal and State agencies in Missouri and Arkansas, should be implemented. The need for an increased level of monitoring at priority sites notwithstanding, only 28% of known sites in Missouri were surveyed between 2020 and 2024 (Rimer, pers. comm. 5 Sep. 2024). At least presence/absence monitoring should be conducted on Missouri sites that have not been visited in several years.

3. In Arkansas, Soteropoulos (2023) determined that there was "considerable habitat in Arkansas suitable for the species that remains under-surveyed and under-inventoried," and Benton (pers. comm. 20 Sep. 2024) reported that surveys in un-inventoried habitat are planned for the spring of 2025. Consequently, we recommended enhanced survey effort in suitable habitat in Arkansas.

4. Because Missouri bladderpod is a conservation-reliant species as described above, private land-owner incentive programs could be investigated that ensure long-term conservation of Missouri bladderpod while providing financial benefits to landowners. Possible landowner incentive programs include: a Recovery Credit System and a Conservation Award System (Wilkins et al. 2009; Kreuter 2017); conservation management agreements (Scott et al. 2005; Bocetti et al. 2012); credit marketing (Wolfe et al. 2017); and conservation banking for multiple species (Evans et al. 2016). One of the more innovative approaches has been the development of a Covenant Program for Environmentally Endangered Lands in Florida that provided as much as a 90% reduction in property taxes for private landowners who signed up in the program (Giannini and Heinen 2014).

5. Conduct an analysis of the projected impact of future residential and commercial development on existing bladderpod habitat. In Missouri, populations in Christian and Greene counties are projected to significantly increase between 2000 and 2030 (Missouri

Economic and Resource Report 2024). Because some of our largest populations have historically occurred in these two counties (MDC Natural Heritage Database 2024), residential and commercial development on private property could eliminate bladderpod habitat.

6. Conduct an analysis on changes in suitability of glade habitat in Missouri and Arkansas. Young et al. (2009) provided startling photos depicting changes in bladderpod habitat on Bloody Hill Glade of Wilson's Creek National Battlefield between 1936 and 2003. Similar analyses of potential bladderpod habitat may reveal that areas now completely enclosed due to canopy closure from red cedar encroachment were historically more open as noted by Nelson (2005). The identification of such areas could be identified as priority areas for restoration efforts using clearing and prescribed fire.

7. Conduct outreach efforts with private landowners in Missouri and Arkansas regarding best management practices to maintain, and where necessary, restore habitat for Missouri bladderpod. Provide technical assistance and cooperatively work with private landowners in restoration efforts.

8. Evaluate whether herbicide spraying along rights of way and roadways in Missouri and Arkansas negatively affects Missouri bladderpod.

9. Continue to protect and manage at least one population within each distinct genetic group and two populations from the genetically distinct group that occur in Sharp and Izard Counties, Arkansas as recommended by Edwards et al. (2021).

10. Based on genetic analyses of Edwards et al. (2021), Missouri bladderpod on COE land in northwest Arkansas is experiencing a genetic bottleneck. Consideration should be given to the possibility of increasing the genetic diversity of northwest Arkansas plants by supplementing existing populations with seeds from the most geographically proximal site in Arkansas or Missouri. Such augmentations will require close coordination among Missouri and Arkansas natural heritage botanists, U.S. Army Corps of Engineers personnel, USFWS staff, and geneticists from the Missouri Botanical Garden.

11. Conduct an analysis on which environmental variables affect yearly demographic trends in Missouri bladderpod and incorporate that information into a future SSA.

U.S. FISH AND WILDLIFE SERVICE
STATUS REVIEW of MISSOURI BLADDERPOD

Current Classification: Threatened

Status Recommendation resulting from Status Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (Indicate reasons for delisting per 50 CFR 424.11):
____ The species is extinct
____The species does not meet the definition of an endangered or threatened species
____The listed entity does not meet the statutory definition of a species
_X_ No change needed

Lead Field Supervisor, Fish and Wildlife Service

Approve JOHN WEBER Digitally signed by JOHN WEBER Date: 2025.04.03 15:58:37 -05'00' Date _____

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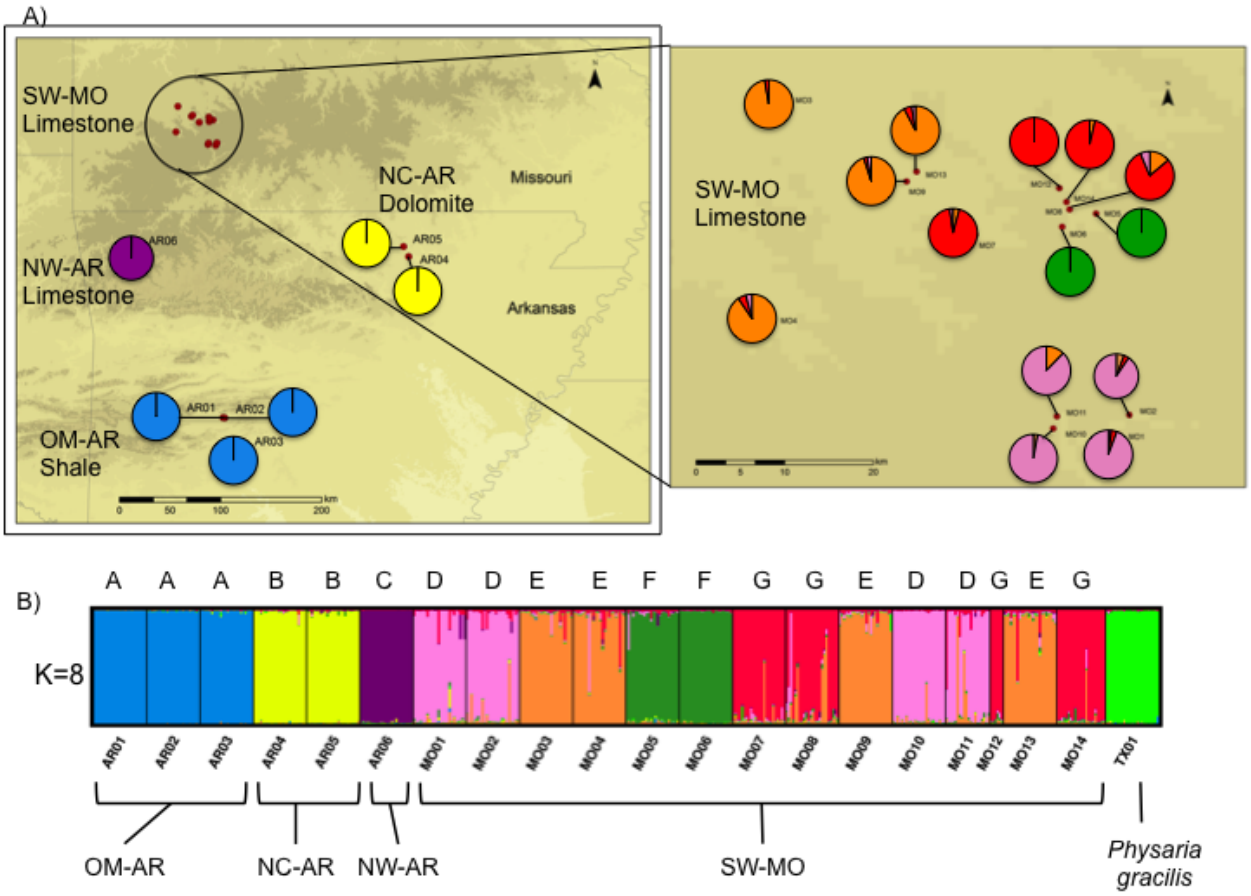

Figure. 1. Collection sites and genetic clusters of Missouri bladderpod in Missouri and Arkansas (from Edwards et al. 2012).

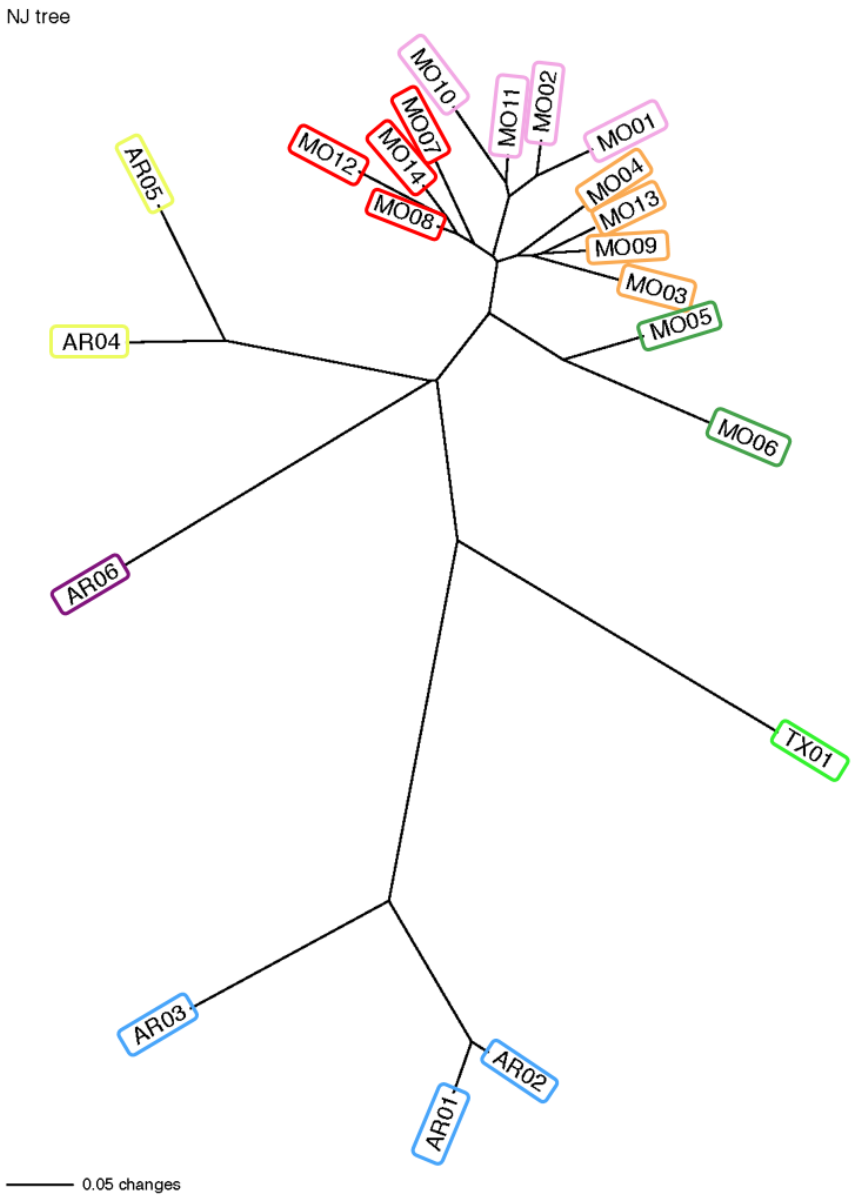

Figure. 2. Genetic phylogram for Missouri bladderpod in Missouri and Arkansas (from Edwards et al. 2021).