Shale Barren Rock Cress
(Boechera serotina)

5-Year Review:
Summary and Evaluation

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U.S. Fish and Wildlife Service
Virginia Field Office
Gloucester, Virginia

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5-YEAR REVIEW
Shale Barren Rock Cress (*Boechera serotina*)

1.0 GENERAL INFORMATION

1.1 Reviewers

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1.2 Methodology used to complete the review:

This 5-year review was conducted by the U.S. Fish and Wildlife Service's (Service) Virginia Field Office. Data for this review were solicited from interested parties through a Federal Register notice announcing this review on October 13, 2020. We also contacted State agencies, species experts, and nongovernment organizations to request any data or information we should consider in our review. State agency botanists reviewed draft sections of the document and provided comments. Additionally, we conducted a literature search and a review of information in our files.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review: October 13, 2020 (85 FR 64527-64529).

1.3.2 Listing history

Original Listing
FR notice: 54 FR 29655-29658
Date listed: July 13, 1989
Entity listed: species
Classification: endangered

1.3.3 Associated rulemakings:

FR Notice: 86 FR 57373-57376
Date: October 15, 2021
Action: Technical correction that changed the genus from *Arabis* to *Boechera*.

1.3.4 Review History:
The recovery plan for *B. serotina* was completed in August 1991, and *B. serotina* was included in a cursory 5-year review of all species listed prior to 1991 (56 FR 56882, November 6, 1991). The most recent 5-year review was finalized on November 18, 2010 (Service 2010, entire).

1.3.5 Species' Recovery Priority Number at start of 5-year review: 11

1.3.6 Recovery Plan:

Name of plan: Shale barren rock cress (*Arabis serotina* Steele) Recovery Plan
Date issued: August 15, 1991

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?

_____**Yes,** go to section 2.1.2.
__**X**__**No,** go to section 2.2.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria? The criteria are objective. The recovery plan stated that guidelines would be developed to determine what constitutes a self-maintaining population (Task 4.3). Although these guidelines have not been developed, persistence through time in the absence of management has provided empirical evidence that most populations are self-maintaining. See discussion in section 2.2.3.

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? The recovery criteria in the recovery plan were developed in 1991. New element occurrences (EOs) and source features (SFs) have been documented, and additional information on the species' life history has been discovered since 1991. Additional EOs and SFs have also been discovered since the 2010 status review. Therefore, the criteria were not developed based on our current understanding of the species biology, abundance, and distribution. However, the criteria are still a valid reflection of a recovered condition for the species.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? The recovery criteria do not speak to specific threats, but rather a more general requirement that habitat for extant populations be "protected," defined as under Federal, State, or private ownership with special conservation designation or easement. The recovery criteria

include demographic criteria (# of self-sustaining populations), which are intended to identify the level of resiliency and redundancy needed to address threats associated with small population size and number (demographic and environmental stochasticity and risk of catastrophic events).

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.

The recovery objective for *B. serotina* is to downlist the species by meeting the following criteria:

1. Twenty demonstrably self-maintaining populations are distributed throughout the species' range. Guidelines for determining what constitutes a self-maintaining population will be developed as part of the recovery program.

   Guidelines for what constitutes a self-maintaining population have not been developed for *B. serotina*. Using available literature on the subject, Scott *et al*. (2005, p. 386) define the term "self-sustaining" in the context of Endangered Species Act (ESA) listed species as those with the ability to "remain stable or increase over time without human assistance to reproduction or dispersal in the wild." Rohlf *et al*. (2014, p. 601) propose a biology-based definition of conservation-reliant, which is arguably the inverse of self-sustaining in terms of ESA listed species. They propose conservation-reliance is best expressed as a spectrum "based on the degree to which a species needs direct and ongoing human manipulation of its life cycle or environment in order to persist in the wild" (Rohlf *et al*. 2014, p. 601). In the case of *B. serotina,* the number of known EOs throughout the species' range has increased from 34 to 62 in the 34 years since the time of listing, with 1 EO in WV not relocated and 4 EOs in VA not revisited since the 1990s. In terms of EO viability for the remaining 57 EOs, 4 have been downranked, 5 have not been assessed, and 48 have not changed. The viability/status of these EOs is a result of additional field surveys, not specific targeted assistance to reproduction or dispersal or other significant human manipulation of the species' life cycle or environment. As such, the available information implies a level of self-sustainment for as many as 48 EOs. Therefore, the intent of this criterion has been met.

2. The habitat of these 20 populations is permanently protected. Habitat will be considered permanently protected if it is:

   a) in Federal ownership and protected through special designation such as an ecological reserve or research natural area,
   b) in ownership by a State agency or private conservation organization that considers maintenance of the *A. serotina* population to be the predominating management objective for the site, or,
   c) in private ownership and safeguarded through a long-term cooperative agreement, deeded conservation easement, or covenant that effectively commits present and future landowners to protecting the site.

A total of 52 of the 62 EOs (84 percent) occur partially or entirely on public lands including U.S. Forest Service (USFS), U.S. Department of the Navy (Navy), Virginia Department of Conservation and Recreation-Division of Natural Heritage (VDCR-DNH), and Virginia Department of Wildlife Resources (VDWR) lands. In VA, one site is designated as a Natural Area Preserve (owned and managed by VDCR-DNH). In WV, the Navy Information and Operations Command at Sugar Grove is cooperatively working with the Service to protect one EO on their property, including control of invasives. The remaining EOs on public lands do not have special designations. However, the 49 EOs (79 percent of total EOs) that occur partially or entirely on USFS lands are under the relevant forest management plans. These 52 EOs are protected from destruction due to development, primarily because Federal and State partners are vested in the protection of the species under their management plans. As such, the intent of this criterion has been met.

3. Seeds are stored to prevent extinction in case of disastrous loss of natural populations.

In 2012 the VDCR-DNH received a permit from the Service to collect shale barren rock cress seeds. Seeds were collected from a total of eight EOs at eight sites across four counties in VA. Along with seeds already in storage from WV, the seeds collected from VA are in storage at the North Carolina Botanical Gardens. The genetic material held in the North Carolina Botanical Gardens represents the range of the species. In addition to addressing a recommendation in the 2010 status review, the collection and storage of seeds from VA and WV at North Carolina Botanical Gardens fulfills this recovery criterion.

Delisting will be considered when, in addition to the above conditions, the following is met:

Fifteen additional self-maintaining populations and their habitat are permanently protected.

As noted above, 52 of the 62 EOs (84 percent) occur partially or entirely on public lands owned and managed by the USFS, Navy, VDCR-DNH, or VDWR. These EOs are protected from destruction due to development, primarily because Federal and State partners are vested in the protection of the species under their management plans. As such, the intent of this criterion has been met.

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:

A 2016 cooperative agreement between the Navy and West Virginia Department of Natural Resources (WVDNR) funded research on the natural history and reproductive biology of the

shale barren rock cress (Harmon and McMullen 2016, entire). As recommended in the 2010 status review, research conducted by WVDNR and Dr. McMullen resulted in identifying two primary candidates as reliable pollinators for the shale barren rock cress. The insects have not been identified to species but appeared to the researchers to be "sweat bees." Additionally, results from the pollinator aspect of this work indicated that the species can produce fruits and seeds by "selfing." Damage to the species from white-tailed deer (*Odocoileus virginianus*) browse and insects was the same as noted in other reports (e.g., Stanley 2015, p. 15; Van Alstine 2019, p. 22). This study was the first to note an insect larva, the large-spotted Evergestis moth (*Evergestis unimacula*), using shale barren rock cress as a food plant.

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:

In 2014, VDCR-DNH developed a Predicted Suitable Habitat (PSH) layer for the shale barren rock cress in VA that has been updated as new EOs and SFs are found. The VDCR-DNH uses this layer to help select sites to survey for the species. Site selection focuses on areas delineated in the model as having a high probability of supporting habitat suitable for the species. New survey areas identified using the PSH have coincided with new SF discoveries. WVDNR, in collaboration with Dr. Crystal Krause of Davis & Elkins College, has also developed a Habitat Suitability Model for shale barren rock cress (J. Burkhart, WVDNR, email to K. Maison, Service, October 24, 2022). The model was developed using the maximum entropy methodology ('MaxEnt'). WVDNR began field assessing this model for reliability and predictive power in 2022. Preliminary results suggest that this model is a useful tool for prioritizing remaining areas to be surveyed.

Based on review of VA survey reports from 2013 to 2021 (Van Alstine and Heffernan 2013, entire; Van Alstine 2017, entire; Van Alstine 2019, entire; Stanley 2019, entire; Stanley 2021, entire) the previous 5-year review, and communications with State botanists, the use of phrases such as "colony" or "population" has added confusion when trying to interpret the survey reports. The terms SF and EO are defined by NatureServe. A SF "results from the translation of a conceptual feature (an observed feature) to a tangible form and serves as the initial mapped spatial component developed from a discrete unit of observation data. Creation of the SF requires an interpretive process. The likely location and extent of an observation is determined through consideration of the nature of any uncertainty associated with the location of the observation data. In most cases, the SF is delineated to encompass locational uncertainty" (NatureServe 2002, p. 91). An EO is defined as "an area of land and/or water in which a species or natural community is or was present" (NatureServe, 2002, p. 10). Element Occurrence designation follows a flow chart devised by NatureServe. In general, for terrestrial species, an EO can include multiple SFs if they are approximately 2 kilometers, or less, apart. As such, an EO could comprise many SFs across a long distance (i.e., many ridges), and the resulting EO could cover an extensive area, which might encompass SFs yet to be discovered. Additionally, the number of EOs might decrease over time, but that does not necessarily reflect a declining species status, rather it could reflect multiple EOs merging into one EO if new SFs were found in between. See figure 1 for an example of EOs and SFs.

Figure 1: From Stanley 2021. Natural Heritage Element Mapping and Associated Terminology. An example of an EO comprised of multiple SFs (based on NatureServe 2002).

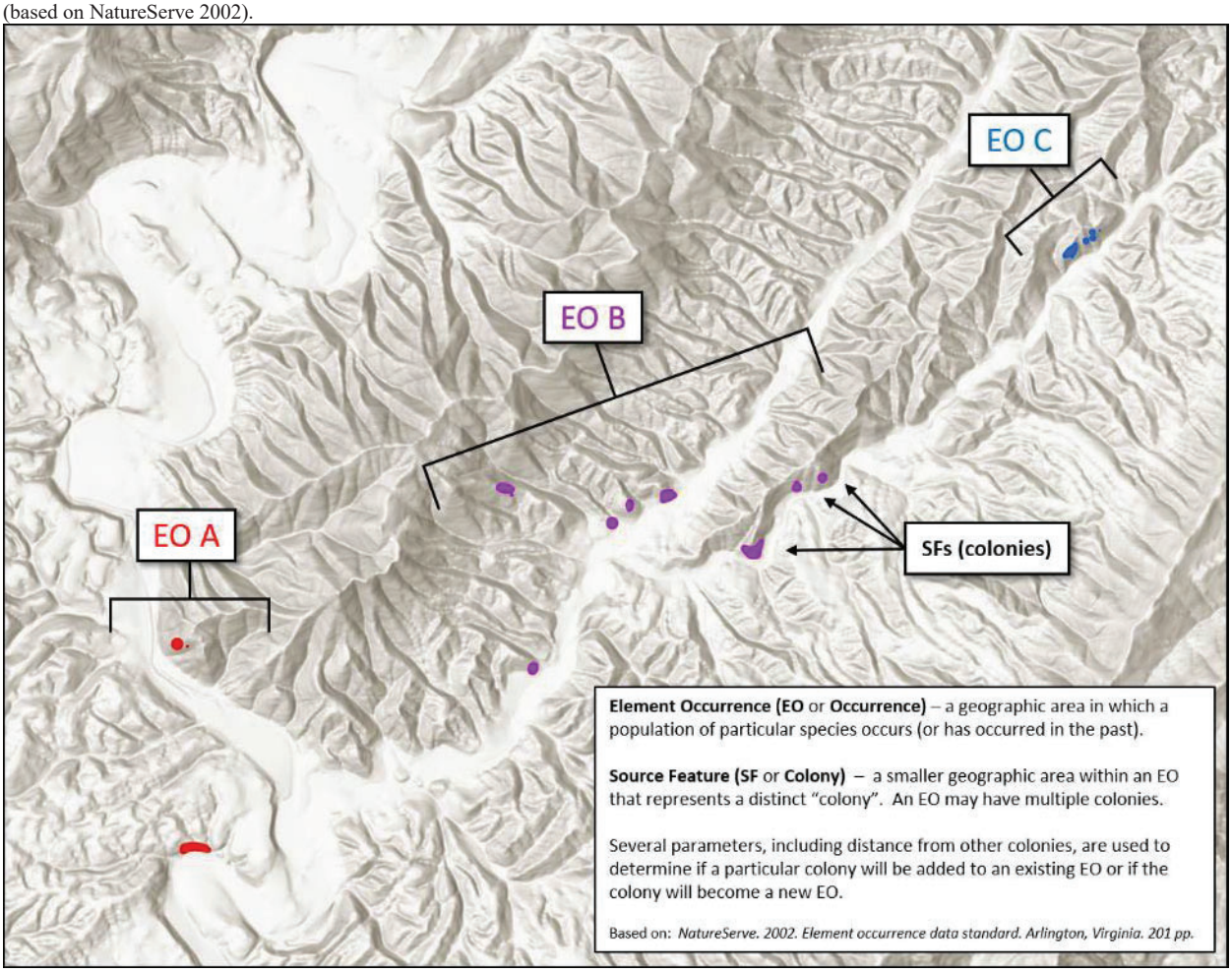

Table 1 provides a summary of the shale barren rock cress EO status for VA and WV, and the following paragraphs are a synopsis of the EOs in each State. It is important to note that, in terms of overall species viability, EO ranks at face value are not necessarily the best indicator; rather, how they change over time is more informative of trends contributing to the current and future status of the species. For *B. serotina*, 29 EOs in VA and 22 EOs in WV have been assessed since 2010. Of these 51 EOs, 4 have been downranked and 47 have had no change in status since their original discovery.

Table 1. Shale barren rock cress EO status summary.

EO Status	Number of EOs in WV	Number of EOs in VA	Total Number of EOs
A - Excellent estimated viability	3	4	7
AB - Excellent or good estimated viability	1	1	2
B - Good estimated viability	1	2	3
BC - Good or fair estimated viability/ecological integrity	0	8	8
C - Fair estimated viability	11	4	15

CD - Fair or poor estimated viability/ecological integrity	0	5	5
D - Poor estimated viability	6	9	15
D? - Possibly poor estimated viability/ecological integrity	0	1	1
E - Verified extant (viability not assessed)	5	0	5
F - Failed to find	1	0	1
H – Historical	0	4	4

Since the 2010 status review, VDCR-DNH conducted shale barren rock cress surveys in 2013 (Van Alstine and Heffernan 2013, entire), 2017 (Van Alstine 2017, entire), 2018 (Van Alstine 2019, entire), 2019 (Stanley 2019, entire), and 2020 (Stanley 2021, entire). At the time of the 2010 status review, more than half of the known occurrences in VA had not been revisited since the 1990s. As of this review, approximately 30 (of 34) previously known EOs in VA have been revisited/monitored, and several new EOs and SFs within existing EOs have been identified. Of the 30 EOs that were revisited, 4 were downranked, and the remainder had no change in rank. The four downrankings were a result of either finding lower numbers of SFs than previous counts or finding other site conditions or reproductive conditions that lowered the EO rank. For this status review, VDCR-DNH staff botanist John Townsend reviewed the VA reports written since the 2010 status review to clarify the findings in terms of EOs and SFs. A total of 3 new EOs (comprising a total of 7 new SFs) were recorded during the 2017-2020 surveys, as well as a total of 31 new SFs that were grouped into existing EOs due to proximity to known SFs (J. Townsend, VDCR-DNH, email to S. Hoskin, Service, August 27, 2021).

In 2011, WVDNR botanists reduced shale barren rock cress monitoring frequency to every 5 years due to concerns that shale barrens might be negatively impacted by people traversing the barrens during surveys. Depending on funding and staffing, EOs are monitored every 5 years. In 2017, WVDNR botanists clarified that a plant identified as shale barren rock cress was smooth rock cress (*Arabis laevigata var. burkii*) (WVDNR 2018, unpaginated). In 2019, WVDNR staff assisted in investigating a report of a new occurrence of shale barren rock cress in the path of a proposed Federal highway. After examining seeds under a dissecting microscope, sharing plant photos and a summary of characteristics with experts in VA and WV, and examining known shale barren rock cress plants, they determined the plants in question were a different species (WVDNR 2019). Overall, the status and trends in WV have been stable, but many of the EOs have fair or worse viability, which increases their risk to stochastic events (A. Silvis, WVDNR, letter to S. Hoskin, Service, January 25, 2021).

In summary, the number of known EOs throughout the species range has increased from 34 to 62 in the 34 years since the time of listing, with 1 EO in WV not relocated and 4 EOs in VA not revisited since the 1990s. Twenty-nine EOs in VA and 22 EOs in WV have been assessed since 2010. Of these 51 EOs, 4 have been downranked and 47 have had no change in status since their original discovery.

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

No new genetic information has become available since the 2010 status review for *B. serotina.*

2.3.1.4 Taxonomic classification or changes in nomenclature:

As recommended in the 2010 status review, the nomenclature in the scientific literature has changed. The scientific name change of *Boechera serotina* (shale barren rock cress) from *Arabis serotina* is supported by molecular, cytological, and morphological analyses. Al-Shehbaz (2003, entire) found that 32 of the North American species of *Arabis* (Brassicaceae) should be recognized as members of the genus *Boechera* based on morphological differences between the two genera. Extensive molecular studies on members of the North American *Arabis* indicate that the genus is polyphyletic and represents a heterogeneous assemblage of four genera: *Arabidopsis, Boechera, Pennellia*, and *Turritis* (Al-Shehbaz 2003, p. 381). *Boechera serotina* was not transferred to *Boechera* by Al-Shehbaz (2003) pending further study; however, a published diploid chromosome count of 2*n*=14 (Wieboldt 1987, p. 381) and recent molecular investigations have determined that this taxon belongs to a clade of eastern North American species now assigned to *Boechera* (Windham and Al-Shehbaz 2007, p. 236). *Boechera serotina* is the accepted scientific name of shale barren rock cress in the Integrated Taxonomic Information System, which incorporates the naming principles established by the *International Code of Nomenclature for algae, fungi, and plants*. The Service found that shale barren rock cress should be recognized as *Boechera serotina* and is a valid species. The Service published a technical correction rule on October 15, 2021 (86 FR 57373-57376) to address the name change.

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.):

No significant new information is available on spatial distribution for *B. serotina*. The new EOs and SFs identified in surveys since 2017 are within/among the known occurrences and range for the species. However, VDCR-DNH notes that potential habitat for *B. serotina* in VA is extensive and many more SFs will likely be discovered with additional field work (J. Townsend, VDCR-DNH, email to S. Hoskin, Service, August 27, 2021). WVDNR botanists note that a consistent challenge is gaining access to private lands to conduct inventories for the species. For example, in Pendleton County, WV, a number of unsurveyed areas identified as highly suitable by the WVDNR habitat suitability model are on private lands, and similar barrens that have been surveyed have known populations of *B. serotina* (J. Burkhart, WVDNR, email to K. Maison, Service, October 24, 202).

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

As noted above, in 2014, the VDCR-DNH developed a PSH layer for the shale barren rock cress in VA that has been updated as new EOs are found. The VDCR-DNH uses this layer to help select sites to survey. Site selection focuses on areas delineated in the model as having a high

probability of supporting habitat suitable for the species. New survey areas identified using the PSH have coincided with new SF discoveries. While the exact percentage hasn't been calculated, VDCR-DNH estimates that over 90 percent of suitable habitat identified by the 2014 PSH model has not yet been surveyed. VDCR-DNH thinks more SFs will be found with additional field work, potentially expanding the amount and distribution of known occupied habitat. WVDNR, in collaboration with Dr. Crystal Krause of Davis & Elkins College, has developed a Habitat Suitability Model for shale barren rock cress (J. Burkhart, WVDNR, email to K. Maison, Service, October 24, 202). The model was developed using the maximum entropy methodology ('MaxEnt'). WVDNR began field assessing this model for reliability and predictive power in 2022. Preliminary results suggest that this model is a useful tool for prioritizing remaining areas to be surveyed. As noted above, a challenge during field vetting of this model is that a high proportion of the areas predicted as suitable habitat is on private lands. WVDNR is working to communicate with landowners to gain access to these properties to conduct surveys.

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

The purpose of a 5-Year Review is to recommend whether a listed taxon continues to warrant protection under the ESA and, if so, whether it should be reclassified (from threatened to endangered or from endangered to threatened). This task requires that the analysis of the threats to the species be performed while assuming that the species is not receiving the regulatory protections, funding, recognition, and other benefits of ESA listing. Summaries of ongoing applications of ESA protections may shed light on some future activities that constitute threats to the species. However, the analysis under Factor D (Inadequacy of Existing Regulatory Mechanisms) focuses on the adequacy of existing alternative (i.e., non-ESA) mechanisms to address the continuing and foreseeable threats.

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

The final listing rule (54 FR 29655-29658) cited habitat destruction as a result of recent road/railroad construction as one of the primary influencing factors for the species. The recovery plan developed 2 years later (Service 1991, entire) noted that no new construction had taken place since the final listing. The 2010 review noted Norris and Sullivan (2002, p. 35) indicated that large groups of people visiting shale barrens for scientific and educational purposes may cause damage by displacement of the substrate and plants from pedestrian traffic. There was no evidence in 2010 to suggest that any *B. serotina* have been impacted from further construction activities or pedestrian traffic and there continues to be no such evidence.

In 2013 VA surveys, Van Alstine and Heffernan (2013, p. 65-66) noted invasive species as a potential habitat-related threat but did not observe evidence of the threat acting on any populations. In 2017 VA surveys, no threats related to habitat destruction were observed (Van Alstine 2017, p. v). In 2019 VA surveys, no imminent threats were observed, but the potential for colonization of invasive plants was noted as a possible future threat to the species (Stanley 2019, p. iv). In 2020 VA surveys, Stanley (2021, p. 7) noted that no imminent threats to *B. serotina* were observed, but several factors that may ultimately negatively impact the species and its habitat were noted, including fire suppression and white-tailed deer browse, which are

discussed below under Factor E. Surveyors in WV noted road building/maintenance as a potential habitat-related concern but reported no evidence of those activities.

Given the lack of evidence of habitat destruction as an active threat to *B. serotina*, we have determined that the likelihood of habitat destruction being an influencing factor on the viability of the species has been low historically and is currently low.

The lack of marketable timber occurring naturally in shale barrens precludes commercial logging activities, and the treacherous, sloped, and unstable terrain often results in livestock being fenced out by private landowners (Anderson *et al*. 1999, p. 95). As noted previously, 84 percent of shale barren rock cress sites in VA and WV are owned by Federal or State land management agencies. Management practices at these sites will likely continue regardless of whether the species is listed under the Federal ESA, primarily because the active management benefits the overall habitat and meets the management objectives of the landowner. These EOs are protected on Federal and State lands from destruction due to development, primarily because Federal and State partners are vested in the protection of the species under their management plans. Based on these considerations, we consider it unlikely that *B. serotina* will experience habitat alterations throughout all or a significant portion of its range in the foreseeable future that would rise to the level of negative influence on the species' viability.

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

Overcollection by botanists was identified as a threat in the recovery plan (Service 1991); however, there is no evidence that this activity is a threat to *B. serotina*. The Service is not aware of impacts to *B. serotina* from other forms of overutilization currently, and we have no information indicating a risk of collection in the future at a rate that would jeopardize the viability of individual EOs or the species.

2.3.2.3 Disease or predation:

Evidence of browse by white-tailed deer on shale barren rock cress plants in VA EOs was first discussed in the final listing rule and noted in every subsequent Service document and VDCR-DNH survey report since 1989. Surveyors in WV also report evidence of white-tailed deer browse at some EOs. The Recovery Plan notes that spring herbivory may increase branching and seed production, although further assessment is needed to understand the positive and negative impacts of herbivory overall. The 2010 status review reported that white-tailed deer browse had been noted in WV, but WVDNR found no significant differences in flowers or seed capsules on browsed vs. unbrowsed bolts; however, it is unknown if later season browsing affects seed production. Over the 33 years since the species was listed, the number of known EOs has increased from 34 to 62, with 4 EOs reduced in EO rank and 11 EOs not revisited recently, not relocated, or not assessed. The persistence of 47 EOs over multiple decades with stable viability (as indicated by EO rank) despite recurring instances of white-tailed deer browse indicates that this does not rise to a level of concern for the viability of EOs or the species. We have no information indicating a risk of increase in the rate of white-tailed deer browse in the future. As noted above, Harmon and McMullen (2016, p. 16) observed an insect larva, the large-spotted Evergestis moth (*Evergestis unimacula*), using shale barren rock cress as a food plant. This is the

first documentation of predation by an insect larva. However, there is no evidence to suggest that predation by moth larvae may be adversely affecting individuals or populations of shale barren rock cress.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

Shale barren rock cress is listed as an endangered species by the Commonwealth of Virginia under the Virginia Endangered Plant and Insect Species Act (Chapter 10 §3.2-1000 through 1011 of the Code of Virginia, as amended). This law protects listed plant and insect species from take in the form of collection or translocation, except by the landowner, unless landowner permission and a State permit are obtained. Virginia statutes primarily regulate collection and trade in state-listed species and do not prohibit landowners from neglecting or otherwise impacting such species (e.g., destruction or alteration of habitat) on their own properties or in conjunction with otherwise legal activities. If Federal ESA protections were to be removed, the species may be removed from the State list as well, however there are several species that remain on the State list without Federal protection in place, so State botanists may be able to lobby to maintain the species on the State list. In WV, no State legislation has been enacted to designate or protect State-listed species.

Of the 62 total EOs, 50 (81 percent) occur partially or entirely on USFS lands. Forest management plans are sufficient to avoid impacts to the species. Two EOs in VA occur on State land managed by VDCR-DNH and VDWR. Management practices at these sites will likely continue regardless of whether the species is listed under the Federal ESA, primarily because active management benefits the overall habitat and meets the management objectives of the landowner. These EOs are protected on Federal and State lands from destruction due to development, primarily because Federal and State partners are vested in the protection of the species under their management plans.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Fire suppression: There has been little research conducted on the role of fire in shale barrens. In Illinois, Heikens *et al*. (1994, p. 279) found no increase in herbaceous understory plants at a shale barren in the short term, 7 months after a prescribed burn. The authors note that more research is necessary to understand the best ways to restore and maintain shale barren habitats. WVDNR reported that prescribed fire may pose a threat to populations, but the impacts of prescribed fire currently are poorly understood, and it is possible that prescribed fire, under certain management prescriptions and implementations, may be beneficial for the species (WVDNR email to Sumalee Hoskin, Service, January 25, 2021). Stanley (2021, p. 7) noted that lack of fire is likely a potential threat to *B. serotina*, although again noting the role of fire historically in shale barrens is poorly understood. One source indicates that shale barrens were historically prone to regular burning (Aldrich *et al*. 2010, p. 36). A prescribed burn of a shale barren adjacent to a population of *B. serotina* resulted in the species occurring in the burned area where it was not previously known to occur (Fred Huber, pers. comm.). Although the 2010 status review referred to prescribed fires as "a newly identified threat to this species" it further stated that there is "limited information in the scientific literature about the impact of fire and/or prescribed burns to shale barrens and specifically to *A. serotina*." To date there has not been

targeted research to understand whether fire is ultimately beneficial or harmful to shale barren rock cress. However, as stated earlier, this species occurs in fire-prone areas that may have a history of fire, which is indicative that it has adapted to periodic fire. Without fire, the woodland landscapes surrounding the barrens may begin to encroach. While fire may have short-term negative impacts to individuals, it is unclear whether a frequent fire regime may have long-term beneficial impacts to the species.

Climate change: Shale barrens and their associated species have a naturally patchy distribution as they occur in spatially isolated outcroppings across the landscape. Shale barrens are also considered xeric (low moisture) habitats, and the species that occur there are adapted to those conditions. There is little available information specific to the potential impacts of climate change to shale barren habitats or associated species. Anderson *et al*. (1999, p. 95) made the assumption that shale barren endemics are likely to have the capacity to tolerate temperature extremes given the high summer temperatures often experienced on shale barrens. Damschen *et al*. (2012) conducted a literature review of the responses of plant communities on "special soils," specifically serpentine communities, and found that the limited amount of research available seems to indicate that these communities may be less sensitive to climatic changes than their "normal soil" counterparts (p. 1127); however, they noted that application to other "special soil" communities like shale barrens can be challenging given the differences in specific stressful conditions, functional traits, and stress-tolerance adaptations of the different plant communities (i.e., low moisture vs. acidic soils vs. nutrient limited, etc.; p. 1127). In summary there is high uncertainty associated with the potential effects of future climatic changes to shale barrens in general and *B. serotina* specifically. However, the currently available information, albeit limited, does not indicate a mechanism for impacts to the species from changing climate.

2.4 Synthesis

The number of known EOs for *B. serotina* has increased from 34 at the time the Recovery Plan was issued in 1991 to 62 currently. As noted above, the EO numbers do not entirely reflect the overall increase for the species given that at least 31 new SFs have also been observed and attributed to existing EOs in VA. These numbers (62 EOs) represent a significant increase in redundancy compared to the time of listing. In addition, only a small proportion of the 600+ shale barrens with suitable habitat have been surveyed, and state botanists have noted that additional EOs and SFs are likely to be found with more surveys directed to areas identified by the existing PSH model.

Discussion of threats over time has been largely speculative and not verified. Evidence of impacts to individuals is anecdotally noted by surveyors, but there has been no assessment or confirmation that those noted (white-tailed deer browse, invasive species, human activities) rise to a level of concern for individual EOs or the species overall, and the persistence of 47 EOs with stable EO ranks, many over several decades, indicates the same. Service records indicate a total of 758 consultations under Section 7 of the ESA for Federal agency activities that may affect *B. serotina* among other species, and in all cases the Service concurred that the activities in question were not likely to adversely affect *B. serotina*. A total of 84 percent of known EOs occur partially or entirely on Federal or State lands with management plans in place to preserve

the integrity of unique habitats and species. The most uncertainty is associated with the effects of fire suppression and climate change in the future.

Given the increased redundancy, largely stable resilience as measured by EO ranks, existing management of 84 percent of known EOs on Federal/State lands, lack of evidence of active or imminent threats under any of the 5 listing factors, the expanse of unsurveyed suitable habitat that is likely to yield continued discovery of new SFs and EOs, and that the intent of all recovery criteria for both downlisting and delisting have been met, we find that the species no longer meets the definition of Threatened or Endangered as provided under the ESA and is therefore recommended for delisting.

3.0 RESULTS

3.1 Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
_X_ Delist (*Indicate reasons for delisting per 50 CFR 424.11):*
____ Extinction
__X_ No longer meets the definition of threatened or endangered
____ No longer meets the definition of a species
____ No change is needed

3.2 New Recovery Priority Number: N/A

3.3 Listing and Reclassification Priority Number:

Reclassification (from Threatened to Endangered) Priority Number: ____
Reclassification (from Endangered to Threatened) Priority Number: ____
Delisting Priority Number: _6__

Brief Rationale: There is a low management burden associated with the current listed status of *B. serotina*; as noted above, none of the 758 ESA Section 7 consultations in the Service's records required formal consultation on *B. serotina*. The recommendation to delist is not a result of a petitioned action.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Complete process for removal of ESA protections
- Develop post-delisting monitoring plan in collaboration with state agencies

While not a requirement for delisting the species, research using prescribed fire to restore the historical fire regime of shale barrens would ascertain its impact on native species including *B. serotina*. This activity would address an area of uncertainty that has been frequently noted by state biologists and the results would be informative for habitat restoration purposes for species associated with rare and unique shale barren habitats.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Boechera serotina*

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

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

Appropriate Delisting Priority Number: 6

LEAD REGIONAL OFFICE APPROVAL:

Approve SHARON MARINO Digitally signed by SHARON MARINO Date: 2023.06.16 11:49:39 -04'00' _____

Assistant Regional Director, Ecological Services