

Virginia Spiraea
(*Spiraea virginiana* Britton)

5-Year Review:
Summary and Evaluation

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

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5-YEAR REVIEW

Virginia spiraea (*Spiraea virginiana*)

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5-YEAR REVIEW

Virginia spiraea (*Spiraea virginiana*)

1.0 GENERAL INFORMATION

1.1 Reviewers

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Technical Reviewers/Experts:

See Appendix A (Coordination List of Partners and Experts) for list of technical reviewers and experts.

1.2 Methodology Used to Complete This Review:

This 5-year review, conducted primarily by the lead recovery biologist for Virginia spiraea, summarizes and evaluates new information relevant to the listing status of the species. New data and information regarding the species' population status and habitat used in this report were based on: peer reviewed literature; information and occurrence data from state natural resource agencies, federal agencies (National Park Service, U.S. Forest Service [USFS]), and researchers; and information provided in the biological status review conducted by Ogle (2008). In 2007, the U.S. Fish and Wildlife Service (Service) funded a scientific assessment (Ogle 2008) to comprehensively review research regarding the ecology, conservation, and status of this species and to provide the most up-to-date information on Virginia spiraea. Ogle (2008) requested information about Virginia spiraea from various management agencies and/or species experts in

states of known or potential occurrences. The Ogle (2008) report was the basis for the Service's 2008 draft 5-year review, which was not finalized. In 2019, Service Field Offices, state natural resource agencies, federal agencies, and researchers were contacted for up-to-date information on species' occurrences, threats, and recovery activities (see Appendix A for list of partners and experts contacted). Since the 2008 5-year review was not finalized, this review provides the first comprehensive status review of the species since the 1992 recovery plan was written (Service 1992). All pertinent literature and documents on file at the Virginia Field Office were used for this review.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review: 84 FR 46562-46563 (September 4, 2019)

1.3.2 Listing history:

FR notice: 55 FR 24241-24247

Date listed: June 15, 1990

Entity listed: species

Classification: threatened

1.3.3 Associated rulemakings: None

1.3.4 Review history:

Previous 5-Year Review

Initiated: 73 FR 3991-3993

Date Finalized: review drafted but not finalized and signed

Results: not applicable

1.3.5 Species' Recovery Priority Number at start of review: 8. This designation corresponds to a species experiencing a moderate degree of threat and a high recovery potential.

1.3.6. Recovery Plan:

Name of plan: Virginia Spiraea (*Spiraea virginiana* Britton) Recovery Plan

Date issued: November 13, 1992

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. Because Virginia spiraea is a plant, the 1996 DPS policy does not apply.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes, the species has an approved plan containing objective, measurable criteria; however, two criteria merit clarification to support consistent, objective evaluation.

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, recovery criteria 1 and 2 do not reflect current information because state natural resource agencies do not track populations in the same manner as in the recovery criteria (e.g., waterbody and clones) and the definition for drainage system was not clearly defined.

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)? Yes.

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 criteria for delisting are:

1. Any existing or, if possible, a minimum of three stable populations are permanently protected in each drainage system where populations are currently known.

It is difficult to determine abundance and population trends for Virginia spiraea due to different monitoring approaches for abundance (e.g., stem counts, areal coverage, clumps) and definitions for populations (clones, population, element occurrence [EO], and sub-EOs) over time and among the states in Virginia spiraea's current range. See Section 2.3.1.2 for additional information. In addition, drainage system was not sufficiently defined in this criterion. Recognizing the ambiguity in this criterion, we made an assessment based on assumptions that an EO is a population, stable populations are those with an A or B rank, and drainage system is a minor drainage basin based on hydrologic unit code (HUC) 4 basins. Based on these assumptions, the criterion has not been met because only 4 of the 9 minor drainage basins with known populations (i.e., based on 1992 recovery plan) have 3 or more A- or B-ranked EOs on public or permanently managed/protected lands. For the 5

minor drainage basins that do not meet the criterion, 4 have no A- or B-ranked EOs on public or permanently managed/protected lands and 1 has 1 A- or B-ranked EO on public or permanently managed/protected lands. Section 2.3.1.5 provides additional details on the distribution of EOs throughout the current range, based on various geographic scales of drainage systems.

2. A minimum of three stable populations are established or found in drainages where documented vouchers have been collected, and that the species is not currently known. These populations must also be permanently protected.

This criterion is ambiguous for the same reasons discussed above for the first criterion. If we make the same assumptions as for criterion 1, there is only 1 minor drainage basin where documented vouchers have been collected and the species was not known at the time of the 1992 recovery plan, which is the Middle-Tennessee-Elk. This basin contained a historical occurrence in Cypress Creek, AL. This criterion has not been met because no *Virginia spiraea* occurrences have been documented in this basin since the 1890s. Section 2.3.1.5 provides information about this occurrence.

3. Potential habitat in all states with present or past collections has been searched for other populations.

This criterion has not been met as stated. Ogle (2008) estimated that approximately 60% of potential habitat in states with present or past collections, specifically in the Blue Ridge and Appalachian Plateau physiographic provinces, had been surveyed for additional populations by 2007. Since then, additional surveys in known drainages (as defined by state natural resource agencies) have found 12 new EOs across the range in North Carolina, Ohio, Tennessee, and West Virginia, as well as rediscovered an EO in the Buckhannon River, WV, in 2019, which was thought to be extirpated in 2007. It would be difficult to provide an updated percent of potential habitat surveyed in states with any collections, but it is expected to be more than 60% but less than 100%. State natural resource agencies expect to find new EOs/sub-EOs with additional comprehensive surveys of potential habitat in known drainages. Also, there is the possibility of additional areas of suitable habitat based on a species distribution model. See Sections 2.3.1.5 and 2.3.1.6 for additional information.

4. Representative genotypes are cultivated in permanent collections with adequate locality information.

This criterion has not been met. Collections of living *Virginia spiraea* plants from 26 of 72 extant EOs (36.1%) and 2 of 7 historical/extirpated EOs (28.6%) across the range are maintained at multiple gardens. Efforts to conduct genetic analyses to determine genotypes across the range and within the collections are needed to determine which localities should be added to cultivated collections to provide genetic representation. Genetic analyses are ongoing. See Sections 2.3.1.2 and 2.3.1.3 for additional information.

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:

Since 1992, research has been conducted on multiple topics associated with Virginia spiraea's biology and life history. See Section 2.3.1.3 for research related to character variation between populations, genetic structure, and reproduction (e.g., seed viability, pollinators, self-incompatibility) and Section 2.3.1.6 for research about habitat characterization and management of populations. Below is new research on biology of the species related to identification.

The survey season in West Virginia is June 1 to September 30, during peak flowering when it is easiest to identify Virginia spiraea. The West Virginia Division of Natural Resources (WVDNR) studied the feasibility of conducting winter surveys to detect Virginia spiraea and distinguish it from other *Spiraea* species (e.g., shinyleaf meadowsweet [*Spiraea betulifolia* var. *corymbosa*]) (K. O'Malley and P.J. Harmon, WVDNR, letter to J. Stanhope, Service, January 23, 2020). Virginia spiraea can be identified if vestigial inflorescences are still on the plants, but WVDNR biologists observed that stems and inflorescences regularly fell off because they were fragile and very brittle during the winter. Therefore, Virginia spiraea were more difficult to identify. If inflorescences were present and plants were 1-2 meters tall with multiple stems, researchers could identify Virginia spiraea. In addition, researchers were not able to find young Virginia spiraea, in particular small plants with single stems (about 0.3-0.5 meters tall) that had not flowered, when they visited a site on the Bluestone River with previously documented plants. Based on these results, WVDNR determined that winter surveys are not recommended.

2.3.1.2 Abundance, population trends, demographic features, or demographic trends:

Abundance and populations

It is challenging to assess abundance and determine population trends for Virginia spiraea due to different approaches for monitoring abundance (e.g., stem counts, areal coverage, clumps) and defining populations. Abundance has been estimated in several different ways and most methods have generally been a source of confusion and inconsistency for field workers and researchers (Ogle 2008). Generally, for smaller populations, upright stem counts or "clumps" counts are used. For larger populations, "clumps" counts or area/percent cover estimates are used. In some cases, all methods are used at a site. Methods have also changed over time at the same population, making it difficult to assess trends. There have been several attempts to use other methods, including line intercept and segmental "pie" sectioning procedures to estimate number of clones in a 360-degree matrix (Ogle 2008). Without exception, these have proven difficult to apply for several reasons. The number of upright stems can vary drastically within a season and

over time at one location due to hydrologic variation. There are currently no standardized methods to estimate abundance that will accurately reflect numbers or relative abundance (in terms of spatial extent or percent cover) of individuals in the field. Because the plant is clonal, most abundance estimates are likely an estimate of plant size rather than actual abundance or population size.

Determination of “N” (the number of genetically different plants) versus “n” (the number of genetically identical nodules or clones that are part of a single plant) would address this problem. The actual number of genetically different plants in the wild is not known but is currently being assessed (see Section 2.3.1.3).

Regarding definitions of populations, terms such as clone, population, EO, and sub-EO are used to refer to an occurrence of one or more Virginia spiraea stems found in a given location. Clone was used in the recovery plan (Service 1992) and not specifically defined, but appeared to be used interchangeably with population. An EO is the spatial representation of a species or ecological community at a specific location. The EO concept originated within the state Natural Heritage Programs (NHP) and was not in general use in 1992 when the species’ recovery plan was completed. EO and/or sub-EO was used in Ogle (2008), but was not reported consistently. For this 2021 assessment, states reported data by EO, but they utilized different definitions. As defined by NatureServe (2002, 2020a), the recommended default EO minimum separation distance for plants (i.e., considered to be part of a different EO or population) is 0.62 mile (1 kilometer [km]). States may use this standard, but may also use other separation distances (i.e., less than 0.62 miles) or further refine this separation distance based on NatureServe’s (2020a) guidance, which considers if there is continuous suitable habitat, such as flowing water (as described below). There is no standard conversion factor between population/clone counts and EO counts and no consistent EO definition across the range, and as a result, there is a lack of clarity about the relative abundance and population trends of this species.

Table 1 provides a summary of the numbers of extant clones reported in 1992 (Service 1992) and extant EOs/sub-EOs in 2007 (Ogle 2008). To attempt to compare and assess abundance/population trends, occurrence data provided by state natural resource agencies are summarized by EO (Table 2), based on their own EO definition. We did not change their EO definition to be consistent across states because we are relying on the state natural resource agencies’ expertise and experience with the species. Also, it will allow comparison of data in the future, if they maintain their EO definitions. We also summarized the number of sub-EOs (or sub-populations) by state. It appears that the following states applied the default 0.62-mile separation distance or less for defining EOs: Georgia, Kentucky, Ohio, and Tennessee. Virginia, West Virginia, and North Carolina used greater separation distances based on continuous suitable habitat; therefore, they have lower number of EOs and greater number of sub-EOs than other states. Most states did not specifically define sub-EO (except North Carolina), and we based the number of sub-EOs on various sources of information, including: EO description indicating sub-populations, number of source features in the GIS

shapefile, and state agency expert opinion. North Carolina NHP (NCNHP) provided their occurrence data as parent EOs and EOs. For this assessment, we considered EOs nested within parent EOs as sub-EOs because NCNHP defined EO to be within the same parent EO when it “is less than 10 km from the next nearest conspecific EO, shares linear water-current flow in the same riparian system, and is not separated by an area of persistently unsuitable habitat greater than 3km long (NatureServe 2020a).” We therefore considered parent EOs as EOs in North Carolina.

Tables 1 and 2 illustrate the difficulty in trying to analyze trends in populations when using information from different sources. Differences in the number of populations across years, as reported in clones, EOs, and sub-EOs, should not be assumed to be a direct increase or decrease in abundance or populations but may be an artifact of different monitoring methods and population definitions. In addition, due to the predominantly clonal nature of reproduction (i.e., asexual), the actual number of genetically distinct populations in the wild is not known and currently being assessed.

To evaluate the current status of the EOs, Tables 2 and 3 also provide a summary of EO by rank in 2019. As defined by NatureServe (2002), “EO ranks provide a succinct assessment of ESTIMATED VIABILITY, or PROBABILITY OF PERSISTENCE (based on condition, size, and landscape context) of occurrences of a given Element [i.e., species or taxon]. In other words, EO ranks provide an assessment of the likelihood that if current conditions prevail an occurrence will persist for a defined period of time, typically 20-100 years.” State natural resource agencies assign ranks to their EOs. Based on the definitions, EOs with A or B ranks have excellent or good viability, respectively, and are very likely or likely to persist for the foreseeable future (i.e., at least 20-30 years), respectively, if current conditions prevail ([NatureServe 2020b, see Appendix B](#)). EOs with C rank have fair viability; the definition for this rank includes EOs that have uncertain persistence under current conditions, may persist with appropriate protection or management, or are likely to persist but may decrease in size or condition. For the purposes of this review, we assumed that EOs with ranks of F (failed to find), H (historical), and X (extirpated) are not currently extant. NatureServe provides additional specifications for the EO ranks for Virginia spiraea that take into account areal coverage, occurrence at multiple locations within a river, and/or habitat conditions, as defined by D. White on January 25, 2005 (see Appendix B). Virginia Department of Conservation and Recreation – Division of Natural Heritage (VDCR-DNH) and Tennessee Department of Environment and Conservation, Division of Natural Areas (TDEC-DNA) indicated that their EO ranks are based on the January 25, 2005 specifications and the Office of Kentucky of Nature Preserves (OKNP) applied these specifications to some of their EOs; the other states did not indicate the exact specifications or criteria used for assessing EO ranks. It should also be noted that some extant EOs have not been observed or surveyed for more than 15 years, providing some uncertainty about the current status and ranks of these extant EOs (Table 2). In

most cases for extant EOs, year last observed is the same as year last surveyed (e.g., monitored for abundance, such as stem counts, areal coverage, clumps; assessed habitat); however, for a small number of EOs (e.g., all EOs in Virginia, 1 EO in Ohio), the presence of the plant was noted, but information to support assessment of viability was not collected.

As of 2019, of 89 total EOs across the range, 72 are extant (80.9%), 32 have an A or B rank (36.0% of historically known EOs) and 23 have a C rank (25.8% of historically known EOs) (Tables 2 and 3). Fifteen EOs (16.9% of historically known EOs) have a D rank (poor condition) and NatureServe (2020b) indicates that “if current conditions prevail, occurrence has a high risk of extirpation.” For the 17 EOs that are not extant, 11 EOs became presumed extirpated (F or X rank) since 1992, when the species’ recovery plan was completed. Of the extant EOs, 36 (40.4% of historically known EOs) are located on public or permanently managed/protected property, and of those, 20 have an A or B rank (22.5% of historically known EOs). A greater proportion of the A or B ranked EOs are located on public or permanently managed/protected property (20 EOs) versus not (12 EOs) (62.5% vs. 37.5%), suggesting a potential conservation benefit from being located on such lands. When considering C ranked EOs, a lower proportion are located on public or permanently managed/protected property (9 EOs) vs. not (14 EOs) (39.1% vs. 60.9%). However, it should be noted that 6 of the 11 EOs that became presumed extirpated since 1992 were located on public or permanently managed/protected property.

To further help evaluate the status of the EOs, state natural resource agencies were asked for their assessment of population stability in their state in 2007 (Ogle 2008) and 2019. In 2007, populations were assessed as: stable in Georgia, North Carolina, West Virginia, and Ohio; increasing in Tennessee; decreasing to stable in Virginia; and decreasing in Kentucky (Ogle 2008) (Table 1). At that time, most experts cautioned that assessments were based on anecdotal or casual observation and little, if any quantitative data were available for those determinations. Kentucky State Nature Preserves Commission (now OKNP) was considering raising their state listing status from threatened to endangered, and Tennessee officials were considering lowering their state status from endangered to threatened (Ogle 2008). In 2019, some state natural resource agencies and federal agencies indicated that they conduct periodic monitoring of their EOs (Ohio Department of Natural Resources, Division of Natural Areas and Preserves [ODNR-DNAP]; TDEC-DNA; WVDNR; National Park Service [NPS] at Big South Fork National River and Recreation Area/Obed Wild and Scenic River [BSFNRR/OWSR]) or have conducted status surveys of their EOs recently (e.g., OKNP in 2018, NPS at Great Smoky Mountains National Park [GSMNP] in 2020). Populations are currently assessed as stable in Georgia, Kentucky, North Carolina, Ohio, Tennessee, and Virginia and stable to decreasing in West Virginia (Table 2). State listing status has not changed (see Section 2.3.2.4).

Table 1. Number of extant clones reported in 1992 (Service 1992). Number of element occurrences (EOs) and sub-EOs reported in 2007 and related information (Ogle 2008). N/A = not applicable.

State	Number of extant clones in 1992	Number of extant EOs in 2007	Number of extant sub-EOs in 2007	Were EOs located on public property as of 2007?	Population stability as assessed by survey respondents in 2007
Alabama	0 (historical record prior to 1992)	0	N/A	N/A	N/A
Georgia	7	3	8	Partial	Stable
Kentucky	20	17	not reported	Yes (7), No (10)	Decreasing
Louisiana	misidentification	N/A	N/A	N/A	N/A
North Carolina	12	not reported	36	Partial	Stable
Ohio	3	not reported	5	Partial	Stable
Pennsylvania	0 (historical record prior to 1992)	0	N/A	N/A	N/A
Tennessee	20	32+	not reported	Partial	Increasing
Virginia	18	not reported	24 ¹	Partial (at least 3 clones)	Decreasing to Stable
West Virginia	27	not reported	109 ²	Partial but primarily on private lands	Stable
All States	107	52+	182	Partial	

¹ Four sub-EOs with propagated/outplanted stems not included because these sites are not tracked in VDCR-DNH database.

² Reported as 109 EOs and sub-EOs in Ogle (2008). Placed in sub-EO column due to unknown number of EOs vs. sub-EOs.

Table 2. Number of element occurrences (EOs) and sub-EOs in 2019, and number of extant EOs located in managed/protected land and their EO rank (i.e., estimated viability by state natural resource agency). Extant EOs are those with A, B, C, D, or E rank (see Table 3). N/A = not applicable.

State	Number of extant EOs in 2019	Number of extant sub-EOs in 2019 (of total sub-EOs)	Total Number of EOs (all ranks)	Number of extant EOs located on public or permanently managed/protected land			Range of years for when extant EOs last observed	Population stability as assessed by survey respondents in 2019/2020
				A or B rank ¹	C rank ¹	Total extant (all ranks)		
Alabama	0	N/A	1	N/A	N/A	N/A	N/A	N/A
Georgia	3	6+ (of 8+) ²	3	3	0	3	2010-2015	Stable
Kentucky	13	15+ (of 37) ³	16	1	3	7	2018, except 1 in 1996 and 1 in 2013	Stable
North Carolina	14 ⁴	46 (of 55) ⁵	16	2	0	3	2011-2019	Stable
Ohio	6	9 (of 9) ^{2,6,7}	6	0	1	1	2015-2018	Stable
Pennsylvania	0	N/A	1	N/A	N/A	N/A	N/A	N/A
Tennessee	22 ⁸	57 (of 67) ^{3,6}	28	9	5	16 (3 partial)	2007-2019, except 2 in 1995	Stable
Virginia	4 ⁹	24 (of 25) ^{3,10}	5	2	0	3	2017 ¹¹	Stable
West Virginia	10 ¹²	126 (of 136) ⁶	13	3	0	3	2015-2020 ¹² , except 1 in 2002	Stable to Decreasing
All States	72	283+ (of 337+)	89	20	9	36		

¹ A or B rank (excellent or good viability) includes B?, BC-ranked occurrences, though there is uncertainty regarding the rank. C rank (fair viability) includes BCD and CD-ranked occurrences (D indicates poor viability). See the NatureServe Element Occurrence Data Standard (2002) for more details on ranking methodology and Appendix B for ranking definitions.

² Number of sub-EOs based on EO description.

³ Number of sub-EOs based on number of source features.

⁴ Number of EOs based on number of parent EOs and standalone EOs (e.g., EOs that are not nested within a parent EO)

⁵ Number of sub-EOs based on number of EOs nested within a parent EO (i.e., each sub-EO had a separate record) and standalone EOs.

⁶ Number of sub-EOs based on state agency expert opinion or provided in occurrence table.

⁷ Historical number of sub-EOs not provided and assumed to be the same as current.

⁸ Two EO rankings updated to failed to find based on EO descriptions of not finding plants when last surveyed (C. Elam, TDEC, email to J. Stanhope, Service, March 11, 2021).

⁹ One EO on the North Fork Pound River is assumed to be failed to find because it was last observed in 2002 and not found during 3 searches in recent years (J. Rhode Ward, University of North Carolina at Asheville [UNCA], email to J. Stanhope, Service, January 24, 2020). Ogle (2008) also suggested that an EO on the North Fork Pound River was based on a misidentified specimen and should be deleted from the database. It is not clear if this is the same EO.

¹⁰ Three sub-EOs with propagated/outplanted stems not included because they are not tracked in VDCR-DNH database and status is unknown. They were last observed to be extant 10 years ago (D. Ogle, formerly Virginia Highlands Community College, email to J. Stanhope, Service, March 4, 2021).

¹¹ Although the 4 extant EOs were last observed by Appalachian State University researchers in 2017, they were last surveyed in 1992, 1993, 2007, and 2014 and their EO ranks may not be current.

¹² Includes new EO found in 2020.

Table 3. Number of element occurrences (EOs) by rank (i.e., estimated viability by state natural resource agency) in 2019. N/A = not applicable.

State	Number of EOs by ranks ¹						Total (all ranks)
	Excellent or Good (A or B rank)	Fair (C rank)	Poor (D rank)	Verified Extant (E rank)	Failed to Find (F rank)	Historical/Extirpated (H or X rank)	
Alabama	0	0	0	0	0	1	1
Georgia	3	0	0	0	0	0	3
Kentucky	3	4	6	0	3	0	16
North Carolina	8	3	3	0	1	1	16
Ohio	0	5	0	1	0	0	6
Pennsylvania	0	0	0	0	0	1	1
Tennessee	10	9	3	0	5 ²	1	28
Virginia	2	0	2	0	1 ³	0	5
West Virginia	6	2	1	1	0	3	13
All States	32	23	15	2	10	7	89

¹ A or B rank includes B? and BC-ranked occurrences, though there is uncertainty regarding the rank. C rank includes CD and BCD-ranked occurrences. E rank are EOs that have been recently verified as extant, but insufficient information to estimate viability. See the NatureServe Element Occurrence Data Standard (2002) for more details on ranking methodology and Appendix B for ranking definitions.

² Two EO rankings updated to failed to find based on EO descriptions of not finding plants when last surveyed (C. Elam, TN Department of Environment and Conservation, email to J. Stanhope, Service, March 11, 2021).

³ One EO on the North Fork Pound River (VA EO#7) is assumed to be failed to find because it was last observed in 2002 and not found during 3 searches in recent years (J. Rhode Ward, University of North Carolina at Asheville [UNCA], email to J. Stanhope, Service, January 24, 2020). Ogle (2008) also suggested that an EO on the North Fork Pound River was based on a misidentified specimen and should be deleted from the database. It is not clear if this is the same EO.

Propagation for reintroduction and rescue efforts

There have been multiple efforts to propagate *Virginia spiraea*, either to reintroduce the species to new areas within its range or to rescue/safeguard them from anthropogenic threats. Plants were propagated from a sub-EO of VA EO#3 in the Pound River, VA, downstream of John Flannagan Reservoir (Ogle 2003). The reintroduction effort originally established 4 sub-populations on the Pound and Cranesnest rivers, VA, by 2007 (Ogle 2008). Three of the outplanted sub-populations were extant about 10 years ago but have not been visited since then (D. Ogle, formerly Virginia Highlands Community College [VHCC], email to J. Stanhope, Service, March 4, 2021). These sub-populations were not included in VDCR-DNH's database.

In North Carolina, whole plants were removed in Lakey Creek (NC EO#61), in advance of bridge construction by the North Carolina Department of Transportation (NCDOT). Whole plant stems and cuttings were held or propagated, respectively, in pots and reintroduced to near original plant locations in March and November 2015 within a NCDOT permanent right-of-way (NCDOT 2016). Transplants were reported as surviving as of February 2018 (NCNHP 2020). In the Cheoah River in the Nantahala National Forest (NC EO#25, sub-EO of parent NC EO#57), 100-150 cuttings were collected, in case herbicide application to remove invasive species (kudzu [*Pueraria montana*]) harmed the plants, and grown in 10- to 20-gallon nursery pots at the Service's Asheville Field Office (NC Department of Agriculture and Consumer Services [NCDACS] 2015; J. Mizzi, Service, letter to A. Punsalan, Nantahala National Forest, March 25, 2015). Some of the cuttings did not take root and grow. Thirty-three pots of propagated plants were outplanted to 4 sites within 3 sub-EOs (NC EO#25, 27, and 53 within parent NC EO#57) along the Cheoah River in March

2018 and of those, only 9 plants (i.e., pots) have survived (NCDACS 2018; G. Kauffman, USFS, Service, emails to J. Stanhope, Service, August 8, 2021 and August 16, 2021). Re-establishment of most of the plants was limited primarily by heavy competition from non-native, invasive plants, primarily kudzu, but also from native, invasive plants at 1 site. The surviving 9 plants are also threatened by the invasive plants and being managed to reduce this threat.

In Georgia, stems were collected from 2 EOs in Rock Creek (GA EO#1, 3) and grown and currently maintained at the Atlanta Botanical Gardens (ABG) (Georgia Plant Conservation Alliance 2019). In 2009 as part of a restoration project, 64 of these propagated plants were outplanted to the edge of a limestone spring in Crockford-Pigeon Wildlife Management Area, which is a protected area but appears to be outside of the Tennessee River basin and *Virginia spiraea*'s historical and occupied range (ABG 2012). Beaver activities impacted the plants by both inundation and use of the planted material to make their dams. As of 2011, approximately 17% of the plants had survived (Georgia Plant Conservation Alliance 2019).

Abundance in living collections

There are collections of living plants of this species in multiple gardens. The Arnold Arboretum of Harvard University's collection includes 39 plants from 24 EOs in 20 counties in Georgia, Kentucky, North Carolina, Tennessee, Virginia, and West Virginia (<https://arboretum.harvard.edu/explorer/>; accessed December 7, 2020). Most of the plants were grown from cuttings, divisions, or a plant, except for 3 grown from seed (K. Richardson, Arnold Arboretum, email to J. Stanhope, Service, January 21, 2021). Several of the plants originated from EOs that are now thought to be extirpated including Hominy Creek, Buncombe County, NC, and Little River, Blount County, TN. The plants are located in 3 main areas of the Arboretum, but are kept as individual plants (i.e., not planted close together), labeled accurately, and not allowed to grow together. Each plant is monitored and maintained by each horticulturist managing the zone in which each individual plant resides. However, specific precautions are not taken on a routine basis to prevent cross pollination (K. Richardson, Arnold Arboretum, email to J. Stanhope, Service, August 16, 2021).

In addition to the stems propagated and grown from 2 EOs in Georgia (described above), ABG collected 6 stem cuttings from a single clump with a single branched stem in 2020 from White Oak Creek in Nantahala National Forest, NC, for vegetative propagation and are growing them in their greenhouse (Duke Energy Carolinas, LLC et al. 2015, ABG 2020). Cuttings taken to ABG had a 69.8% success rate in rooting. Propagated plants may be reintroduced into the source location pending permits.

At Appalachian State University (ASU) and University of North Carolina at Asheville (UNCA), plants from stem cuttings are being grown in protected gardens and in greenhouses/growth chambers. The cuttings were collected from 4

EOs, consisting of at least 7 sub-EOs, in the Lower and Upper South Fork New Rivers, Little Tennessee River, and Cheoah River (J. Rhode Ward, UNCA, email to J. Stanhope, Service, January 24, 2020; M. Estep, ASU, email to J. Stanhope, Service, January 5, 2021). They recently acquired a cutting of the extirpated Hominy Creek EO from Harvard University's Arnold Arboretum and the plant is being maintained at UNCA. Cuttings were also collected from 4 EOs in Virginia, however, they were not successful in rooting.

There are less than 6 plants (clumps) of *Virginia spiraea* at VHCC in Abingdon, VA, grown from 1 cutting collected from an undocumented location in 2016 (B.L. Casteel, VHCC, emails to J. Stanhope, Service, December 7 and 8, 2020). There were previously multiple plants from various locations throughout the species range grown at VHCC, but the caretaker of the collection retired and the plants were mistakenly mowed by grounds workers.

The Holden Arboretum in Kirtland, OH, has 1 *Virginia spiraea* plant from Scioto Brush Creek, Scioto County, OH (E. Johnson, Holden Arboretum, email to J. Stanhope, Service, February 22, 2021).

Efforts are currently proposed or planned to collect stems from additional EOs for cultivation and propagation in gardens and to augment/reintroduce *Virginia spiraea* in several states. In West Virginia, the NPS is planning to collect stems for propagation and safeguarding at Mt. Cuba Center, DE, from EOs in the Gauley and Meadow Rivers in the Gauley River National Recreation Area (GRNRA) and Bluestone River within WVDNR-managed lands (D. Manning, NPS, email to J. Stanhope and J. Norris, June 11, 2021). They are proposing to utilize the propagated plants to augment declining sub-populations. In Tennessee, the NPS is proposing to augment the EO in Abrams Creek within the GSMNP with propagated stems, potentially from Cheoah River, NC, being grown at ASU and UNCA gardens (Estep and Rhode Ward 2021). In June 2021, the Georgia Department of Natural Resources received funding from the Service's Recovery Challenge Grant for a 5-year project to implement safeguarding actions for 14 federally listed plant species. Specifically for *Virginia spiraea* in Georgia, they propose to: "secure the one occurrence that is not in living collection; seed bank both natural occurrences; [and] introduce and monitor 2 in-situ safeguarded populations in suitable habitat on protected land" (J. Moffett, Service, email to J. Stanhope, M. Elmore, and A. Protus, Service, July 1, 2021).

Seed collections

The North Carolina Botanical Garden collected wild-produced seeds from plants in Bluestone River and Gauley River, WV, and Abrams Creek in GSMNP, TN, in 2006 to 2007 and the seeds are being stored at their facility or at the National Laboratory for Genetic Resource Preservation (NLGRP) in Fort Collins, CO (M. Kunz, North Carolina Botanical Garden, email to J. Stanhope, Service, December 8, 2020). The Missouri Botanical Garden collected wild-produced seeds from the Obed River and Big South Fork Cumberland River, TN, in 2005 and these are

stored at NLGRP (<https://www.livingcollections.org/mobot/Home.aspx>, accessed December 8, 2020).

Summary of abundance, population trends, demographic features, or demographic trend

Data gathered since the listing and recovery plan provide additional information on the abundance and number of populations of *Virginia spiraea* throughout its range, but it is difficult to assess population trends due to different monitoring approaches for abundance and definitions for populations over time and among the states. Although population trends and accurate counts of populations cannot be determined, the current data suggest that at least 72 of the 89 historically known EOs (80.9%) are extant, and 32 EOs (36.0% of historically known EOs) are considered to have excellent or good viability (A or B rank) and are very likely or likely to persist, respectively, if current conditions prevail. However, 23 EOs (25.8% of historically known EOs) have an uncertain probability of persisting (fair viability; C rank) and 15 EOs (16.9% of historically known EOs) have a poor probability of persisting (D rank) and a high risk of extirpation, if current conditions prevail. For the 17 EOs that are not extant, 11 EOs became presumed extirpated (F or X rank) since 1992 when the species' recovery plan was completed. Of the extant EOs, 36 (40.4% of historically known EOs) are located on public or permanently managed/protected lands, and 20 of these 36 EOs (22.5% of historically known EOs) are considered to have excellent or good viability. Populations are currently estimated by the state natural resources agencies as stable (Georgia, Kentucky, North Carolina, Ohio, Tennessee, and Virginia) or stable to decreasing (West Virginia). Propagation efforts have been successful in reintroducing *Virginia spiraea* to new or known rivers and rescuing them from construction and herbicide application; new propagation efforts are proposed or recently funded in Georgia, West Virginia, and Tennessee. Collections of living *Virginia spiraea* are maintained at multiple gardens, including plants from 26 of 72 extant EOs (36.1%) and 2 of 7 historical/extirpated EOs (28.6%), across the species range. Seeds collected from 5 EOs in the wild are stored at NLGRP.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation:

Anders and Murrell (2001) examined leaf morphological differences within sub-drainage basins and across the range; their analyses indicated no clear differences of leaf shape and size among sub-drainage basins, but some general patterns emerged in 3 of the sub-drainage basins (Cumberland, Ohio, and Tennessee River basins) and suggested gene flow occurred across drainage boundaries. Randomly Amplified Polymorphic DNA techniques were also used to examine within species variation; cluster analysis identified 4 molecular phenotypes located in the southern part of the range in the southern portions of both the Blue Ridge and Cumberland Plateau (i.e., the southern part of the Appalachian Plateau). Their results also suggest that the ancestral population likely originated in the southern part of the range and used 3 different migratory paths out of the Cumberland and southern Blue Ridge Mountains refugia via an initial southward path then

northward recolonization during and after glaciation, respectively. Williams (2003) continued analysis of their samples using Inter-Simple Sequence Repeat variation and supported Anders and Murrell's (2001) conclusions that along short reaches among the Cumberland, Ohio, and Tennessee Rivers sub-drainage basins, there is a greater degree of similarity and that *Virginia spiraea* likely originated in the southern part of the range.

Bryzski (2010) developed genetic microsatellite markers based on 11 primers for *Virginia spiraea* and results indicated a moderate level of genetic variation for 3 populations (1 in Ohio, 2 in Tennessee). Brzyski and Culley (2011) continued the genetic microsatellite markers work on plants from 8 populations (or watersheds) and 43 sub-populations (or groupings of plants) in Ohio, Kentucky, and Tennessee and found low genetic diversity within populations with greater variability among populations and no relationship between genetic and geographic distance. The genetic results were representative of high clonal reproduction. However, they also found that reproduction for 4 populations may not be strictly asexual based on inbreeding coefficient values closer to 0; sub-populations within these populations demonstrated high differentiation from each other and most of them had unique genotypes.

UNCA and ASU researchers are conducting genetic analysis of diversity across all states in the geographic range of *Virginia spiraea* using microsatellite markers (Estep and Rhode Ward 2021). Preliminary analyses of plant samples collected at multiple populations (EOs and sub-EOs) in the New River and Cheoah River, NC, indicate low genetic diversity; most variation occurs within river basins (sub-EOs within the New River) vs. between river basins, and some of the genetic diversity patterns suggest downstream dispersal of propagules (Clark 2017, Estep and Rhode Ward 2021). Analyses also did not support high population differentiation, but further study of additional populations across the range is ongoing. Estep and Rhode Ward (2021) have observed tetraploid and triploid genotypes (4 or 3 alleles per locus, respectively) in some markers in the North Carolina sites and are planning more work to assess ploidy throughout the range using flow cytometry. Understanding ploidy is important because a common trait of triploids is sterility. In addition, knowing ploidy numbers makes accurate calculations of heterozygosity possible and will help to guide potential propagation efforts.

Because seedlings have not been observed in the wild rangewide, Bryzski and Culley (2013) conducted a study on conditions to promote germination of seeds from a population in Scioto County, OH. They found that pollen viability was high (approximately 90%) and seed germination was low (10%) overall, and made recommendations for substrate and cold treatment of the seeds to increase potential germination for propagation efforts. Bryzski et al. (2014) conducted controlled breeding experiments at a garden and results indicated that sexual reproduction may occur, but is rare with 13-15% of the hand pollinations producing seed and greater seed production for outcrossed treatments. The percentage of seeds that were viable (tetrazolium assays) by treatment varied from

43 to 100%. They also found low diversity at the self-incompatibility (SI)-locus and that it did not relate directly to the pollination results, but this specific SI-locus may not be the gene responsible for preventing self-fertilization. UNCA and ASU researchers are currently assessing the prevalence of s-alleles, which are self-sterility genes that prevent self-fertilization and inbreeding depression.

UNCA and ASU researchers have also been assessing potential barriers to sexual reproduction for Virginia spiraea. Wise (2018) analyzed pollen viability for plants in the North Fork of the New River, North Carolina, and found high viability ratios of almost 90%. Pate (2010) conducted pollination studies in a garden and in the wild and results suggested that Virginia spiraea can reproduce sexually. Emery et al. (2014) collected reproductive data from 3 North Carolina river systems (Cheoah, Little Tennessee, and New Rivers) and found lower pollen production in the Cheoah River, possibly due to light limitation, but seed production was not lower; these results suggest that seed production may not be limited by pollen. In this study, they also conducted controlled breeding experiments in the wild and analysis indicated no significant differences in seed production under 4 treatments: open (unassisted self-pollination), self (hand-assisted pollination using pollen from neighboring corymb in same clump), inbreeding within populations (hand-assisted pollination using pollen from different clump in same EO), and outbreeding among populations (hand-assisted pollination using pollen from different EO). Their analysis of seed viability (tetrazolium assays) indicated that seeds were not viable from the Little Tennessee and Cheoah Rivers and 28 of 6,314 seeds from the New River were viable. There was no germination of planted seeds after 4 weeks. They are planning further controlled breeding experiments using plants in UNCA and ASU gardens. Rhode Ward and Estep (2019) collected reproductive data in the summers of 2017 to 2019 at North Carolina sites and analysis of 2017 and 2018 data indicated no differences in reproductive effort (pollen and seed production) across sites; analysis of 2019 data and seed viability and germination tests are ongoing. To further understand potential barriers to sexual reproduction, Rhode Ward and Estep (2019) conducted studies to survey floral insect visitors of Virginia spiraea corymbs and assessed pollen on the insects to determine which of the insects could be effective pollinators; preliminary data analyses suggest that bee species carried higher percentages of Virginia spiraea pollen. Their research has also shown that Virginia spiraea and Japanese spiraea (*Spiraea japonica*) do not appear to cross-fertilize under field conditions (J. Rhode Ward, UNCA, email to J. Stanhope, Service, January 24, 2020).

Regarding seed dispersal, Ogle (2009) observed that Virginia spiraea produce very small, slightly winged seeds that may facilitate upstream seed dispersal via wind.

Summary of genetics, genetic variation, or trends in genetic variation

Results of studies conducted thus far suggest low genetic diversity, but differ in where most variation occurs. Brzyski and Culley (2011) found greater variability

among populations (or watersheds) and no relationship between genetic and geographic distance, but UNCA and ASU researchers observed most variation occurs within river basins vs. between river basins and some of the genetic diversity patterns suggest downstream dispersal of propagules. Research related to genetic diversity and reproduction is currently ongoing at UNCA and ASU and will include additional populations across the range. Research supports that reproduction is primarily asexual, with some sexual reproduction occurring. Availability and viability of pollen do not appear to be barriers to sexual reproduction, but seed viability and germination are very low. Other potential genetic barriers to reproduction are being investigated by UNCA and ASU, including assessing polyploidy in the populations and prevalence of s-alleles. Knowing ploidy numbers makes accurate calculations of heterozygosity possible and will help to guide potential propagation efforts.

2.3.1.4 Taxonomic classification or changes in nomenclature:

No taxonomic changes or revisions of nomenclature have been published for this species since the recovery plan (Service 1992) was completed.

2.3.1.5 Spatial distribution, trends in spatial distribution, or historic range:

The historical distribution of Virginia spiraea is well known. Specimens have been deposited in herbaria collections and the species occurrence has been vouchered since the initial description in 1890. Virginia spiraea is widely scattered within 7 states (Georgia, Kentucky, North Carolina, Ohio, Tennessee, Virginia, West Virginia) and recorded from historical locations in Pennsylvania and Alabama (Youghiogheny River and Cypress Creek, respectively). Historical records from both states have been examined and verified and periodic searches have occurred in both locations, but the species is not currently known from either state (Ogle 1991; Ogle 2008; R. Anderson, Service, email to J. Stanhope, Service, December 17, 2019; A. Schotz, Auburn University, email to J. Stanhope, Service, January 17, 2021). There is currently a question to the validity of the location of the historical Alabama collection in Cypress Creek (last verified observation in 1890s [Service 1992, p. 9]), because the stream is “fairly pristine” and may not have “conditions favorable to the species,” based on observations of the species at other sites and its habitat in Georgia, West Virginia, and Virginia (A. Schotz, Auburn University, email to J. Stanhope, Service, January 17, 2021). However, Ogle visited that the historical site and believes that it was likely flooded by backwaters of the Tennessee River/Wilson Lake and there continues to be suitable habitat for the species nearby and in adjacent drainages (D. Ogle, formerly VHCC, email to J. Stanhope, Service, July 15, 2021). A specimen reported from Louisiana (Thomas and Allen 1998 *in* Ogle 2008) was determined to be a misidentified specimen of a cultivated spiraea.

Since the recovery plan was published in 1992, 1 EO with historic documentation has been rediscovered (Cheoah River, North Carolina) and 38 additional EOs (32 extant as of 2019) and 74+ sub-EOs have been discovered across the range due to searches of rivers/streams with suitable habitat in known drainages, surveys of

rivers/streams with known occurrences, and incidental finds when surveying for other species (Table 4, Figure 1) (Stine 1993; Wofford 2003; Gardner and Moser 2007; Ogle 2008; Shaw and C. Elam, TDEC-DNA, email to J. Stanhope, January 21, 2020; J. Rhode Ward, UNCA, email to J. Stanhope, January 24, 2020). However, as noted in section 2.3.1.2, 11 EOs have become presumed extirpated (F or X rank) since 1992, which include 6 EOs discovered since 1992.

Table 4. Number of element occurrences (EOs), extant EOs, and sub-EOs discovered since recovery plan was published in 1992. N/A = not applicable.

State	Number of EOs ¹	Number of extant EOs in 2019	Number of extant Sub-EOs in 2019	New extant rivers/creeks ²
Georgia	0	N/A	N/A	
Kentucky ³	4	3	3+	Laurel River, Marsh Creek
North Carolina	8	7	35	French Broad River, Lackey Creek, North Toe River, White Oak Creek
Ohio	3	3	3	
Tennessee ³	17	14	26	North Chickamauga Creek, Emory River, Obed River, Big South Fork Cumberland River, Caney Fork River, White Oak Creek, White Creek, Piney Creek
Virginia	1	0	0	
West Virginia	5	5	7	Camp Branch
All States	38	32	74+	

¹ Number includes new EOs discovered since 1992 and includes EOs that are now F rank (failed to find), which are presumed to not be extant. For example, Kentucky had 4 total EOs discovered since 1992, but only 3 EOs are extant as of 2019.

² If new EOs or sub-EOs were discovered in the same rivers/creeks that were documented in 1992, then the river/creek name is not provided in this column.

³ Does not include 4 new locations of Virginia spiraea found at BSFNRR/OWSR, which may be in Tennessee or Kentucky, in 2016 because they could not provide any location information or if the new locations would be considered EOs or sub-EOs (M. Tackett, BSFNRR/OWSR, email to J. Stanhope, February 19, 2020). We could not verify if these locations are included in EO databases from OKNP or TDEC-DNA.

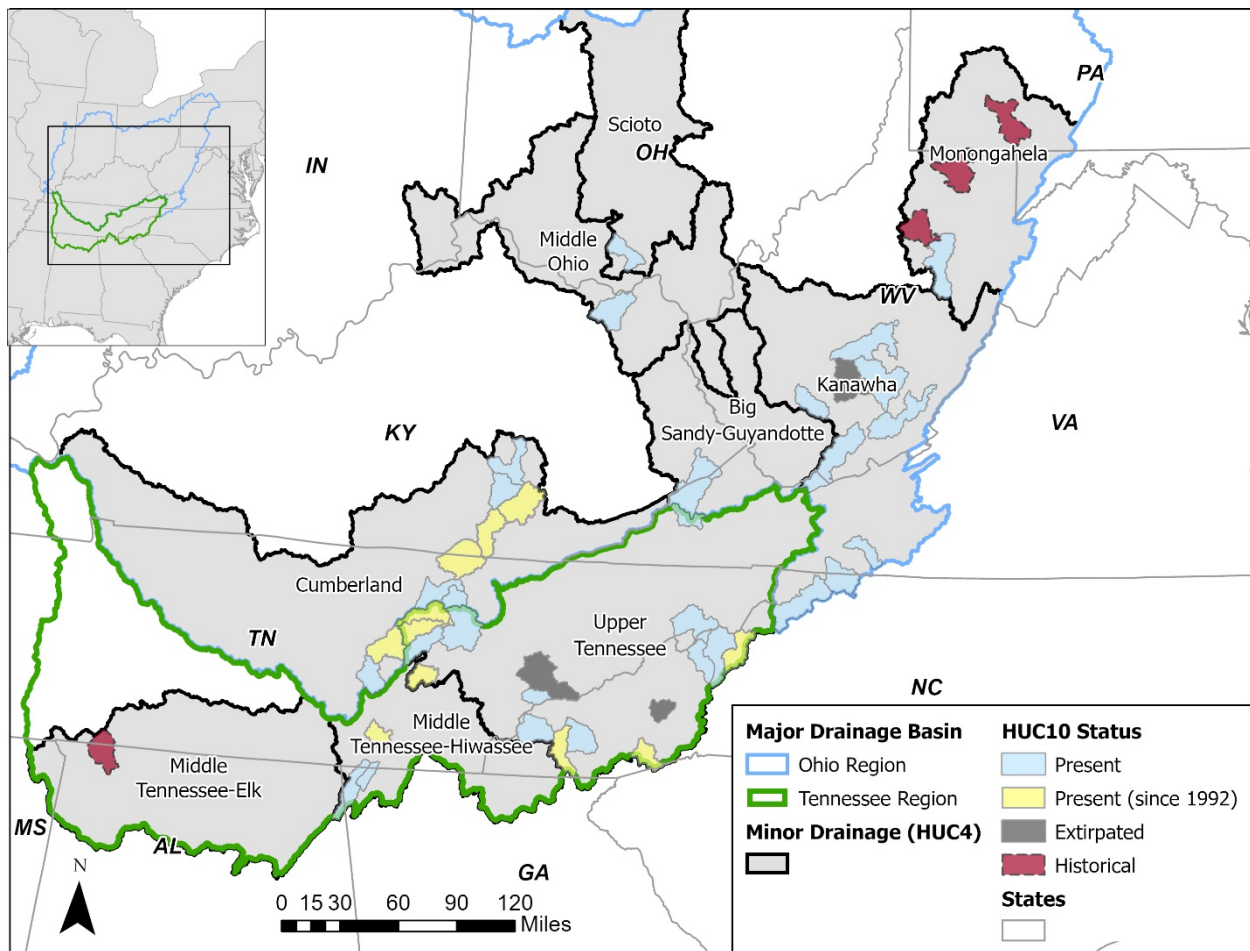


Figure 1. Historical and current range of *Virginia spiraea* as shown by HUC10 watersheds in major and minor drainage basins. Minor drainage basins are labeled. HUC10s with extant element occurrences (EOs) as of 2019 have “Present” status (e.g., discovered 1992 and earlier). HUC10s with EOs discovered since 1992 and still extant in 2019 are labeled as “Present (since 1992).” HUC10s with “Extirpated” or “Historical” status are based on the EO ranks assigned by the state natural resource agencies. Note: All EOs with F rank (“failed to find”) occurred in HUC10s that also had EOs that are present (e.g., A, B, C, D, or E ranks).

Figure 1 provides the historical and current range of *Virginia spiraea* within major drainage basins (or regions) in the United States, which are the Ohio River basin (HUC2 #05) and Tennessee River basin (HUC2 #06) (<https://water.usgs.gov/GIS/regions.html>; accessed March 27, 2020). The major drainage basins may be further divided into HUC4 minor drainage basins (or subregions), HUC8 sub-basins (or cataloguing units), and HUC10 watersheds. Figure 1 also shows new *Virginia spiraea* locations in HUC10 watersheds discovered since the recovery plan was completed (Service 1992) and are still extant; Figure 1 does not show HUC8 sub-basin, but no new *Virginia spiraea* HUC8 sub-basin has been discovered. Within the Ohio River basin, all 6 historically occupied minor drainages have HUC10s with present status, but the Monongahela minor drainage basin only has 25% of its historically occupied HUC10s present. Within the Tennessee River basin, 2 of 3 of historically occupied minor drainages have HUC10s with present status, with the Middle Tennessee-Elk minor drainage basin continuing to be historical with the only

occurrence found in Alabama. Overall, *Virginia spiraea* lost redundancy in the northern and southern portions of the historical range prior to 1992, but since then the species has increased redundancy in the middle part of the range with 11 new HUC10s due to increased searches for the species; however, the species has become presumed extirpated in 1 HUC10 in this area since 1992.

To better understand the distribution of EOs and attempt to address delisting criteria 1 and 2, Tables 5 and 6 provide a summary of HUC10s and extant EOs by sub-basin (HUC8) within the major and minor drainage basins, and their status in terms of A, B, or C rank and land management. In the Ohio River basin, 13 of 17 historically occupied HUC8 sub-basins (76.5%) have extant EOs. Fourteen of the 52 historically known EOs (26.9%) have an A or B rank and 8 of these 14 EOs (15.4% of historically known EOs) are on public or permanently managed/protected land. Assuming an EO represents a population (see Section 2.2.3), 2 of the 6 minor drainage basins (33.3%) have 3 or more EOs on public or permanently managed/protected land with A or B rank. There are also 16 C-ranked EOs (15.4% of historically known EOs), 8 of which are on public or permanently managed/protected land.

Table 5. Number of HUC10s with element occurrences (EOs) and EOs (total, extant, A, B, or C rank, land management) by minor drainage and watersheds in the Ohio River basin. Gray shaded rows are extirpated or historical watersheds.

Major/Minor Drainage	Sub-basin (HUC8)	Number of HUC10s with EOs (any status)		Number of EOs (all ranks)	Number of Extant EOs in 2019			Number of extant EOs located on public or permanently managed/protected land		
		Total ¹	Present		Total	A or B rank ²	C rank ²	Total	A or B rank ²	C rank ²
Ohio River										
Cumberland	Rockcastle	2	2	7	6	2	2	4	1	2
	Upper Cumberland	2	2	4	3	0	1	3	0	1
	Caney	2	2	2	2	2	0	2	2	0
	South Fork Cumberland	3	3	8	7	1	4	6	1	4
Kanawha	Upper New	3	3	4	4	1	1	1	0	0
	Greenbrier	1	1	2	2	1	1	0	0	0
	Lower New	1 (X)	0	1	0	0	0	0	0	0
	Coal	1	1	2	2	0	1	0	0	0
	Gauley	2	2	4	4	3	0	2	2	0
Middle Ohio	Middle New	1	1	1	1	1	0	1	1	0
	Ohio Brush-Whiteoak	1	1	5	4	1	1	0	0	0
Scioto	Lower Scioto	1	1	6	6	0	5	1	0	1
Monongahela	Tygart Valley	1	1	1	1	1	0	0	0	0
	West Fork	1 (H)	0	1	0	0	0	0	0	0
	Upper Monongahela	1 (H)	0	1	0	0	0	0	0	0
	Youghiogheny	1 (H)	0	1	0	0	0	0	0	0
Big Sandy-Guyandotte	Upper Levisa	2	2	2	1	1	0	1	1	0
	Total	26	22	52	43	14	16	21	8	8

¹ If the HUC10 is historical or extirpated, it is noted in parenthesis.

² A or B rank includes B?- and BC-ranked occurrences, though there is uncertainty regarding the rank. C rank includes CD- and BCD-ranked occurrences. See the NatureServe Element Occurrence Data Standard (2002) for more details on ranking methodology.

Table 6. Number of HUC10s with element occurrences (EOs) and EOs (total, extant, A, B, or C rank, land management) by minor drainage and watersheds in the Tennessee River basin. Gray shaded rows are extirpated or historical watersheds.

Major/Minor Drainage	Sub-basin (HUC8)	Number of HUC10s with EOs (any status)		Number of EOs (all ranks)	Number of Extant EOs in 2019			Number of extant EOs located on public property or permanently managed/protected land		
		Total ¹	Present		Total	A or B rank ²	C rank ²	Total	A or B rank ²	C rank ²
Tennessee River										
Middle Tennessee-Elk	Pickwick Lake	1 (H)	0	1	0	0	0	0	0	0
Middle Tennessee-Hiwassee	Middle Tennessee-Chickamauga	3	3	5	5	4	1	5	4	1
Upper Tennessee	Lower Little Tennessee	2	2	2	2	2	0	2	2	0
	Nolichucky	4	4	7	5	3	1	1	1	0
	Upper French Broad	2 (1 X)	1	2	1	1	0	0	0	0
	Upper Little Tennessee	2	2	5	5	2	1	1	0	0
	Emory	4	4	12	9	5	3	5	4	0
	Watts Bar Lake	2 (1 X)	1	2	1	0	1	0	0	0
	Upper Clinch	1	1	1	1	1	0	1	1	0
	Total	21	18	37	29	18	7	15	12	1

¹ If the HUC10 is historical or extirpated, it is noted in parenthesis.

² A or B rank includes B?- and BC-ranked occurrences, though there is uncertainty regarding the rank. C rank includes CD- and BCD-ranked occurrences. See the NatureServe Element Occurrence Data Standard (2002) for more details on ranking methodology

In the Tennessee River basin, 8 of 9 historically occupied HUC8 sub-basins (88.9%) have extant EOs. Eighteen of the 37 historically known EOs (48.6%) have an A or B rank and 12 of these 18 EOs (32.4% of historically known EOs) are on public or permanently managed/protected land. Two of the 3 minor drainage basins (66.6%) have 3 or more EOs on public property or permanently managed/protected land with A or B rank. The minor drainage basin (Middle Tennessee-Elk) that does not meet this criterion had 1 historical occurrence in Alabama from the 1890s, as discussed above.

If we consider EOs with A or B rank as populations that are sufficiently healthy and have adequate habitat to likely persist for the foreseeable future, based on the detailed EO rank definitions (NatureServe 2020b), Figure 2 provides a map of the percentage and number of healthy EOs within HUC8 sub-basins. Healthy EOs are found throughout the range, but are not evenly distributed in some areas. There are fewer healthy EOs in specific areas of the middle portion of the range and northern and southern extents of range. The number of C-ranked EOs are also included in Figure 2. Although their probability of persistence is uncertain under current conditions, they may persist for the foreseeable future if managed or protected.

In terms of distribution of *Virginia spiraea* across physiographic province, almost all historical and present HUC10 watersheds occur in the Appalachian Plateau and Blue Ridge (Figure 3). There are 2 exceptions, the historical occurrence in Alabama in the Interior Low Plateaus and 1 extant EO in Virginia in the Valley and Ridge.

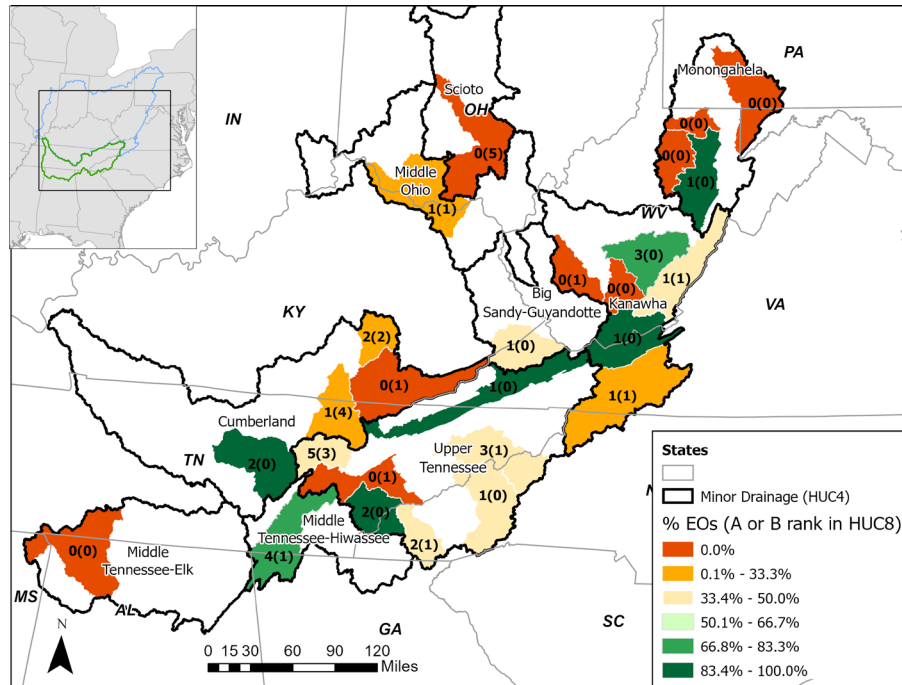


Figure 2. Percentage of element occurrences (EOs) that have A or B rank (i.e., considered healthy) within the HUC8 sub-basin. Minor drainage basins are labeled. Numbers denote number of A or B-ranked EOs with C-ranked EOs in parenthesis within HUC8 sub-basin.

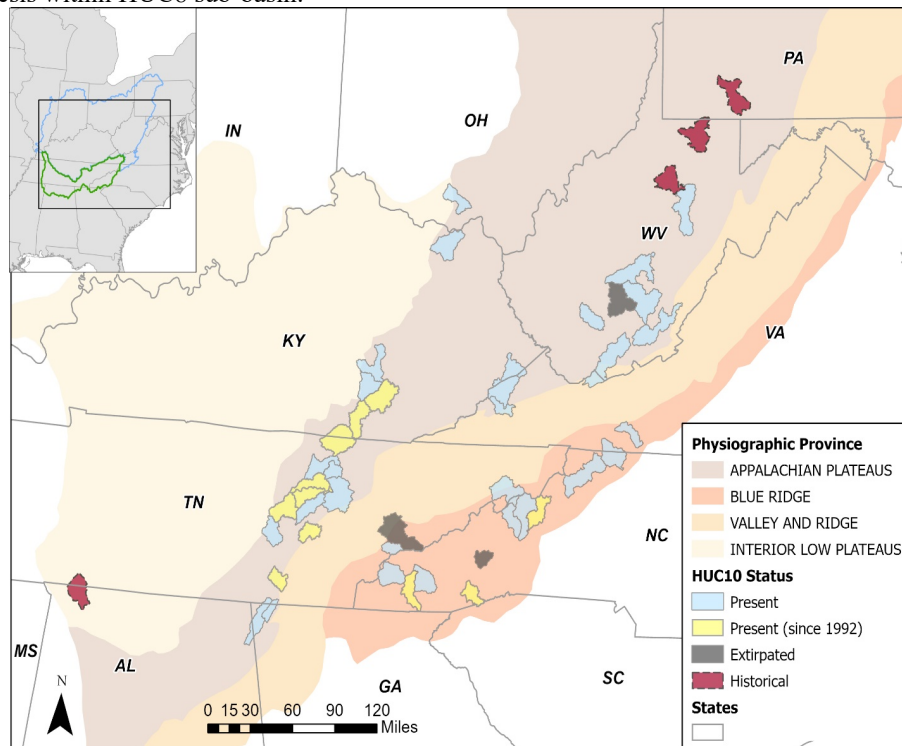


Figure 3. Historical and current range of *Virginia spiraea* as shown by HUC10 watersheds in physiographic provinces. HUC10s with extant element occurrences (EOs) as of 2019 have “Present” status (e.g., discovered 1992 and earlier). HUC10s with EOs discovered since 1992 and still extant in 2019 are labeled as “Present (since 1992).” HUC10s with “Extirpated” or “Historical” status are based on the EO ranks assigned by the state natural resource agencies. Note: All EOs with F rank (“failed to find”) occurred in HUC10s that also had EOs that are present (e.g., A, B, C, D, or E ranks).

Ogle (2008) estimated that approximately 60% of potential habitat in states with present or past collections, specifically in the Blue Ridge and Appalachian Plateau physiographic provinces, had been surveyed for additional populations by 2007. Since then, additional surveys in HUC8 sub-basins where the species is known to occur have found 12 new EOs and 3 new HUC10s, as well as re-discovered an EO in the Buckhannon River, WV, in 2019, which was thought to have been extirpated in 2007 (A. Silvis, WVDNR, email to J. Stanhope, Service, January 24, 2021). If not for the discoveries of EOs in 2 new HUC10s, the Upper French Broad and Watts Bar Lake HUC8 sub-basins, in the Upper Tennessee minor drainage basin would have been considered extirpated. WVDNR noted that they have not found new populations during additional minimal searches of drainages not known to have occurrences (A. Silvis, WVDNR, email to J. Stanhope, Service, January 24, 2021). State natural resource agencies, federal agencies, and researchers anticipate finding more EOs and sub-EOs with additional comprehensive surveys of potential habitat in known drainages (M. Tackett, BSFNRR/OWSR, email to J. Stanhope, Service, February 19, 2020; R. Gardner, ODNR-DNAP, email to J. Stanhope, Service, January 17, 2020; J. Amoroso, NCNHP, email to J. Stanhope, Service, February 25, 2020; C. Elam, TDEC-DNA, email to J. Stanhope, Service, January 21, 2020; A. Silvis, WVDNR, email to J. Stanhope, Service, January 24, 2021; J. Rhode Ward, UNCA, email to J. Stanhope, Service, January 24, 2020). However, with the possible exception of some Blue Ridge areas of South Carolina, it is unlikely the species range will expand to more states (Ogle 2008). It would be difficult to provide an updated percent of potential habitat surveyed in states with any collections, but we expect it is more than 60% given the new occurrences found. In addition, there is the potential for additional suitable habitat, based on the species distribution model, as described below in Section 2.3.1.6 (Habitat or Ecosystem Conditions).

Summary of spatial distribution, trends in spatial distribution, or historic range

The current range of *Virginia spiraea* is generally unchanged since the recovery plan was completed (Service 1992), occurring in 7 states (Georgia, Kentucky, North Carolina, Ohio, Tennessee, Virginia, West Virginia) within the Ohio and Tennessee River basins; the species remains extirpated from Pennsylvania and Alabama. One EO with historic documentation has been rediscovered (Cheoah River, North Carolina) and 38 additional EOs (32 of them extant as of 2019) and 74+ sub-EOs have been discovered due to searches of rivers/streams with suitable habitat in known drainages, surveys of rivers/streams with known occurrences, and incidental finds when surveying for other species. Prior to 1992, *Virginia spiraea* had lost redundancy in the northern and southern portions of the historical range. Since 1992, however, the species has increased redundancy in the middle part of the range with extant EOs/sub-EOs in 10 new HUC10 watersheds due to increased searches for the species but also has 1 HUC10 become presumed extirpated in this area. In the Ohio River basin, 13 of the 17 historically occupied HUC8 sub-basins (76%) have extant EOs and 2 of the 6 minor drainage basins (33.3%) have 3 or more EOs on public or permanently managed/protected land

with A or B rank. In addition, 14 of the 52 historically known EOs (26.9%) have an A or B rank. In the Tennessee River basin, 8 of the 9 historically occupied HUC8 sub-basins (89%) have extant EOs and 2 of the 3 minor drainage basins (66.6%) have 3 or more EOs on public or permanently managed/protected land with A or B rank. In addition, 18 of the 37 historically known EOs (48.6%) have an A or B rank. Although more than 60% of potential habitat in states with present or past collections, specifically in the Blue Ridge and Appalachian Plateau physiographic provinces, has been surveyed for additional populations, many biologists anticipate finding more EOs and sub-EOs with additional comprehensive surveys.

2.3.1.6 Habitat or ecosystem conditions:

Horton et al. (2015) found that Virginia spiraea in western North Carolina occurred on steep, south-facing slopes with “higher percentage of large substrate, lower herbaceous and vine cover, higher non-[Virginia spiraea] shrub density, lower tree influence, and higher visible sky than” areas without the species. Analysis of Virginia spiraea data suggested that the species had greater growth in area and height when there were fewer competing trees, shrubs, vines, and herbs and increasing light availability.

Studies have been conducted to help manage and increase growth and flowering of Virginia spiraea populations. Clarke et al. (2014) examined the effects of long-arm mowing (during the dormant season) on a population along a road on the Cheoah River, North Carolina, and observed greater survival rates of tagged stems in the treatment group (mowed; 55% of stems alive) vs. the control group (not mowed; 29% of stems alive) 2 years after treatment. They also observed that there were no significant differences in stem lengths between treatments at the beginning and end of the study. The results suggested that Virginia spiraea growing along roadsides may benefit from dormant season mowing every other year due to increased survival rates, as well as benefit from cutting of trees and shrubs shading Virginia spiraea to increase light availability; however, the researchers cautioned that the results were based on a short-term study and limited sample size and recommended a longer duration study and using genets instead of stems. There was also a potential confounding factor of beaver (*Castor canadensis*) grazing in the study.

At a sub-EO in the Pound River, Ogle (2003) removed above-ground biomass of non-native, invasive species, mostly multiflora rose (*Rosa multiflora*) and honeysuckle (*Lonicera* spp.) by hand, to reduce arboreal competition and applied fertilizer/nutrients to mimic deposition by normal riverine processes in April 2003. When the site was revisited in September 2003, the original colony had increased vertical growth and vigor, with the following observations: wider and more numerous leaves; longer/thicker canes; and more maturing follicles for seed production on the corymbs, but not more corymbs.

This summer (2021), UNCA is conducting a light physiology study in their common gardens to assess effects of shade on photosynthetic rates.

A species distribution model for *Virginia spiraea* for the entire range was developed by Dr. Crystal Krause (Davis & Elkins College and WVDNR staff) using Maximum Entropy modelling that predicts potential suitable habitat for the species at a 90-meter pixel resolution based on occurrence data (Krause and Harmon 2018 *in* Tessel 2018, pp. 3-4; K. O'Malley and P.J. Harmon, WVDNR, letter to J. Stanhope, Service, January 23, 2020). The model variables most important in predicting suitable habitat were: distance to water, elevation, temperature seasonality, solar radiation, geology, canopy cover, temperature, and precipitation (Krause and Harmon 2018 *in* Tessel 2018). This model showed new potential areas for suitable habitat throughout *Virginia spiraea*'s current and historical range within the Appalachian Plateau and Blue Ridge physiographic provinces. It also includes areas in the Interior Low Plateaus and Valley and Ridge physiographic provinces where few *Virginia spiraea* EOs have been located, which are 1 historical occurrence in Alabama in the Interior Low Plateaus and 1 extant EO in Virginia in the Valley and Ridge. WVDNR shared the model with state agencies and federal agencies to review its accuracy and no comments/responses were received (K. O'Malley and P.J. Harmon, WVDNR, letter to J. Stanhope, Service, January 23, 2020). WVDNR is refining the model for West Virginia to a higher resolution of 30-meter pixel and to include the rediscovered Buckhannon River EO (A. Silvis, WVDNR, email to J. Stanhope, Service, January 24, 2021).

Summary of habitat or ecosystem conditions

New research supports that *Virginia spiraea* habitat is improved when there are fewer competing trees and invasive plant species (non-native and native) and greater light availability. Prior to alteration of flow regimes at some sites, reduction in competition occurred naturally during high-volume scouring floods. A species distribution model that predicts potential suitable habitat shows new potential areas throughout *Virginia spiraea*'s current and historical range within the Appalachian Plateau and Blue Ridge physiographic provinces, but also includes areas in the Interior Low Plateaus and Valley and Ridge physiographic provinces where only 2 EOs are located. Efforts to solicit review of the model by state and federal agencies were unsuccessful and have been discontinued, but WVDNR is continuing to refine the model for West Virginia.

2.3.2 Five-Factor Analysis:

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

The final listing rule described threats to Virginia spiraea to include competition by both native and non-native species and anthropogenic disturbances to habitat (e.g., development, railroads, roads, clearing, mowing, recreational use of rivers, dam construction). In particular, loss of suitable habitat due to dam construction was listed as a threat due to flooding of populations in the upstream impoundment and stabilization of flows, which would eliminate or reduce scouring action necessary to maintain downstream open habitat for the species (55 FR 24241-24247). At the time of listing, hydroelectric facilities were proposed at the Summersville Dam on the Gauley River in West Virginia and John Flanagan Dam on the Pound River in Virginia; both dams upstream of Virginia spiraea populations (additional information about these dams are discussed further below under subsection “Anthropogenic disturbance and habitat modification”). Recent information shows that most of the threats described in the final listing remain ongoing and occur throughout the species range, in particular invasive plant species, habitat loss due to land disturbances, and changes in hydrologic flow regime, and that they are expected to continue in the future.

Invasive, native and non-native plant species: Invasive non-native plant species, such as Japanese knotweed (*Polygonum cuspidatum*), purple loosestrife (*Lythrum salicaria*), Japanese spiraea, multiflora rose, honeysuckle, and bamboo are significant threats to Virginia spiraea by competing with the species, in particular by shading and reducing light. Native plant species, such as poison ivy (*Toxicodendron radicans*), may also compete with Virginia spiraea, as noted in the final listing (55 FR 24241-24247). When state natural resource agencies, federal agencies, and researchers were surveyed in 2019 by the Service, the majority of the respondents listed invasive species as a primary threat in their region. Of 38 EO records where threats were noted or described in the occurrence data provided, 21 indicated competing vegetation or invasive species as one of their threats (note: many EO records noted multiple threats). For example, competition from invasive plant species is the primary reason for decline of the EO in White Oak Creek, North Carolina, from 50-75 stems (number of plants not provided) to 1 plant with 1 stem (G. Kauffman, USFS, email to J. Stanhope, Service, July 30, 2021). In addition, this threat was noted for 3 EOs that became presumed extirpated since the 1992 recovery plan was written. In many cases, the agencies have been focused on reducing invasive plant species when managing a Virginia spiraea population, including the NPS (Gauley River, Meadow River, Abrams Creek) and USFS (Cheoah River, White Oak Creek). However, herbicide (triclopyr 3A) applied to manage invasive Japanese knotweed has been observed to spread and impact a few adjacent Virginia spiraea stems across 3 populations in

the Little Tennessee River, White Oak Creek, and Nolichucky River (G. Kauffman, USFS, email to J. Stanhope, Service, July 30, 2021). As noted below, this threat is also related to flood control and reduction of normal hydrologic flows that would scour competing invasive plants and allow for colonization by *Virginia spiraea*. The threat of invasive plant species may increase with global climate change due to increasing air temperature and atmospheric carbon dioxide (Liu et al. 2017), but there is large uncertainty about the scale of effects of climate change on invasive plants (<https://www.fs.usda.gov/ccrc/topics/invasive-plants>; accessed March 23, 2021).

Anthropogenic disturbance and habitat modification: Anthropogenic factors include many types of development such as construction and maintenance of roads, railroads, sewer systems, electric and gas lines, dams, and watershed flow control systems. Land disturbance due to development of streamside habitat, such as clearing, mowing, filling, or herbicide application, can directly kill or crush plants and alter habitat by creating conditions conducive to invasive plants. Under some circumstances, roadside mowing may benefit the species by controlling woody competitors and promoting asexual production. Of 38 EO records where threats were noted or described in the occurrence data provided, 11 EOs records indicated land disturbance activities as one of their threats. For 1 EO that became presumed extirpated since the 1992 recovery plan was written, the plants were removed in association with the replacement of a bridge.

Changes in hydrologic flow regime was the second most frequently listed threat by respondents when surveyed in 2019. Dams, constructed for flood control and/or generating power, limit downstream dispersal of *Virginia spiraea* through the alteration of pre-impoundment hydrologic regimes. Since the species is dependent on scour, regulating the flow of water below a dam has the effect of eliminating normal erosion and deposition cycles upon which the plant depends for maintenance, reduction of arboreal/invasive species competition, and possibly any reproduction that may be associated with dispersal. At the time of final listing, hydroelectric facilities were proposed at the John Flanagan Dam and Summersville Dam. Construction of a hydroelectric facility was completed at the Summersville Dam in 2001, but construction has not started at John Flanagan Dam, although it has been licensed by the Federal Energy Regulatory Commission (FERC). For the sub-EO downstream of the John Flanagan Dam on the Pound River in Virginia, *Virginia spiraea* was observed to be negatively affected by invasive, non-native plants due to competition, likely as a result of the regulation of flow (Ogle 2003). However, in the Gauley River, Summersville Dam may potentially reduce seasonal streamflow fluctuations and provide some stability for plants (i.e., ameliorate severe flooding events that may wash *Virginia spiraea* from habitat; see below for additional discussion) (K. O'Malley and P.J. Harmon, WVDNR, letter to J. Stanhope, Service, January 23, 2020).

For the EO downstream of the Nantahala Hydroelectric Project on White Oak Creek in North Carolina, Duke Energy, as part of its *Virginia Spiraea*

Management Plan, is required to monitor and manage the population, which is currently a single plant, and continue recreational, high flow releases, which likely incidentally help maintain Virginia spiraea habitat and control the growth of invasive plants (Duke Energy Carolinas, LLC et al. 2015) (see Section 2.3.2.4 for additional information about FERC regulation of hydroelectric projects). For 2 sub-EOs on the Cheoah River, downstream of the Santeetlah Dam in North Carolina, occurrence data indicate Virginia spiraea habitat may have been impacted by the dam (e.g., lack of substrate, increased non-native species and arboreal competition). As a result of FERC relicensing in 2005, the Tapoco Hydroelectric Project is required to maintain minimum flows with periodic recreational, flow increases in the Cheoah River. Monitoring is on-going to determine if the increased flows are improving streamside habitat, but more sub-EOs have been discovered in this river (Kauffman 2021). There may be additional EOs affected by dams that are not documented in occurrence data or that the Service is not aware of (e.g., EO on Laurel River downstream of Laurel Dam in Kentucky). While construction of new dams is unlikely a current threat, flow regulation for flood control and/or generating power continues to be a threat. It is unknown what level and frequency of high flow events would be sufficient to maintain Virginia spiraea habitat but not cause long-term adverse effects to populations. As discussed below, flow events that are too high and/or frequent are also a threat to Virginia spiraea.

For multiple EOs throughout the range, severe and repeated flooding events were noted as a threat due to extreme scour and erosion of the habitat, washing away plants, or large debris piles accumulating on the habitat (i.e., exceeding the unknown threshold of beneficial scour that removes competing vegetation). Of 38 EO records where threats were noted or described in the occurrence data provided, 16 EO records indicated scour and flooding as one of their threats. For 3 EOs that became presumed extirpated since the 1992 recovery plan was written, scouring and flooding were noted as one of their primary threats. Although these flooding events are natural, land use changes, in particular increased development and impervious surface in watersheds, alter flow regimes and contribute to greater frequency and intensity of severe flood events (<https://www.usgs.gov/special-topic/water-science-school/science/impervious-surfaces-and-flooding>; accessed May 5, 2021). Development in the southeastern United States is predicted to increase, thus a greater percentage of impervious surface in watersheds and more severe flood events are likely. Terando et al. (2014) projected urban sprawl changes for the next 50 years for the southeastern United States and the extent of urbanization in the region is projected to increase 101 to 192%. Climate change is also predicted to contribute to greater flooding events (see Section 2.3.2.5).

Another concern is the increasing number of river access locations for recreational boating (e.g., fishing, rafting) as well as other outdoor recreation activities (e.g., ATV, hiking) disturbing habitat and/or crushing plants. Possible effects have been noted in Kentucky, North Carolina, Tennessee, West Virginia, and Virginia in the 2019 survey responses or occurrence data. Of 38 EO records

where threats were noted or described in the occurrence data provided, 3 EO records indicated recreational activities as one of their threats. In one specific case, it is suspected that a fence placed around a Virginia spiraea plant was removed and the plant was cut to the ground to provide quicker access to the river to fish (G. Kauffman, USFS, email to J. Stanhope, Service, July 30, 2021).

Water quality is a threat to the species only as it relates to acid mine drainage and water release temperatures below dams (Ogle 2008). Water temperatures often decrease at dam outflows and 2 populations located in Kentucky and Virginia may have been negatively affected by this habitat modification.

2.3.2.2 Factor B. Overutilization for commercial, recreational, scientific, or educational purposes:

At the time of listing there was no specific information available to suggest that this factor presented a threat to Virginia spiraea (55 FR 24241-24247). This continues to be accurate. There is no new relevant information regarding overutilization.

2.3.2.3 Factor C. Disease or predation:

The final listing rule described aphid and caterpillar herbivory at several Virginia spiraea populations, but effects were unknown (55 FR 24241-24247). The recovery plan (Service 1992) concluded that “there is little evidence of anything other than local damage by insect pest.” Dr. Rhode Ward has observed aphid infestations on Virginia spiraea in the UNCA common gardens and in the field, but they did not appear to cause long-term consequences (J. Rhode Ward, UNCA, email to J. Stanhope, Service, July 26, 2021); therefore, this new information does not change the conclusion in the recovery plan.

There is new information to indicate beaver herbivory as a potential threat to Virginia spiraea (Ogle 2008). Continuous beaver herbivory may kill less established, smaller populations. Grazing by beavers led to an outplanted plant in the Cranesnest River to be in very poor condition and it was moved to a new location (Ogle 2006; D. Ogle, formerly VHCC, email to J. Stanhope, Service, March 5, 2021). Rossell et al. (2013, 2014) found that Virginia spiraea was a preferred food source for beaver, but overall browsing levels along the Cheoah River, North Carolina, were relatively low due to this river being turbulent and high gradient. They also observed that beaver herbivory may promote asexual production by causing rhizomatous growth and dispersing stem cuttings. Beaver population numbers could not be found to determine if this could be an increasing threat.

Herbivory by other animals, such as white-tailed deer (*Odocoileus virginianus*), has also been observed. At several outplanted sites in the Pound and Cranesnest rivers, stems were observed to be cut or browsed, but plants were still alive (Ogle 2006). White-tailed deer population have been decreasing in some areas in the southeastern United States due to disease and hunting, but also increasing in

suburban and urban areas where hunting is more limited (Webster et al. 2005; Hanberry and Hanberry 2020; <https://www.ncwildlife.org/Learning/Species/Mammals/Whitetail-Deer>, accessed August 20, 2021). White-tailed deer herbivory may be a potential, increasing threat in the future for Virginia spiraea in these areas.

In summary, herbivory by animals is currently a minor and localized threat to Virginia spiraea.

2.3.2.4 Factor D. Inadequacy of existing regulatory mechanisms:

The final listing rule indicated that the species was state listed as endangered in Tennessee, North Carolina, and Virginia and described limited protections provided by these designations within each state (55 FR 24241-24247). Since final listing, states with extant Virginia spiraea EOs have listed the species as endangered (Ohio) or threatened (Georgia, Kentucky, North Carolina), except West Virginia, which does not have a state endangered species law. Kentucky's Rare Plant Recognition Act provides no protection to state listed plant species. The laws in the other states provide varying levels of limited protections, with some states prohibiting some activities (e.g., digging, removing, collecting, transporting, or selling) only on public lands until receiving approval from their designated state agency. None of the states endangered plant laws regulate destruction or alteration of habitat. If this species is delisted, removing state protections might occur after independent state review, but would not automatically change with Federal status.

FERC regulates hydropower activities, including building, maintenance, and operation of hydroelectric dams. Pursuant to the ESA, FERC is required to consult with the Service on new or amended hydropower activities that may affect federally listed species, including Virginia spiraea. If a hydroelectric dam was licensed prior to listing of the species, FERC will consider the effects of the hydropower operations during the relicensing process. For example, as part of relicensing for the Franklin and Nantahala Hydroelectric Projects, Duke Energy was required to prepare and implement Virginia Spiraea Management Plans on the Little Tennessee River and White Oak Creek, respectively (i.e., through Memorandum of Agreements with the Service and other stakeholders), which include measures to remove invasive and competing plants. Without ESA protection for Virginia spiraea, FERC would likely approve activities without requiring measures to avoid or minimize impacts to the species and there would likely be a further reduction in Virginia spiraea habitat quality and quantity and a resultant decrease in number of EOs and sub-EOs downstream of hydroelectric dams. FERC regulates a small number of large dams in the United States (approximately 1,700 non-federal dams that affect navigable waters) (<https://www.ferc.gov/industries-data/hydropower>, accessed March 24, 2021). There are approximately 91,500 large dams tracked in the U.S. Army Corps of Engineers' National Inventory of Dams and the majority (63%) are privately owned and 4.2% are federally owned (Gonzales and Walls 2020). Therefore, most

existing large dams (i.e., those expected to affect Virginia spiraea) are not regulated by FERC or federally owned (i.e., does not undergo ESA consultation) and Virginia spiraea does not receive any regulatory protections for these dams.

There are other regulations and policies that protect plants on USFS property. USFS regulation 36 CFR 261.9 prohibits removing or damaging any plant that is classified as a threatened, endangered, sensitive, rare, or unique species. Additionally, Forest Service Manual 2673 establishes policy that prohibits the removal and collection of any threatened or endangered plants on lands under Federal jurisdiction except when authorized by permits. Although these regulations and policies should protect Virginia spiraea on USFS property (e.g., from recreational activities, as described in Section 2.3.2.1), lack of resources prevents monitoring of compliance and enforcement. If this species is delisted, removing USFS protections might occur after independent USFS review, but would not automatically change with Federal status. The USFS has additional categories of regional forester sensitive species, forest concern species (i.e., locally rare), and species of conservation concern that offer protections.

As described above, removal of ESA protections would likely exacerbate the extent of the primary threats of invasive plant species and habitat loss or degradation due to changes in flow regime.

2.3.2.5 Factor E. Other natural or manmade factors affecting its continued existence:

The final listing rule described threats to Virginia spiraea to include biological factors limiting the establishment and colonization of new sites because of very low sexual reproduction (based on observations of low seed production, lack of seedlings, low germination rates, and very old plants with well-established root systems) and low genetic variability (e.g., 1 genotype per population) (55 FR 24241-24247). In addition, severe floods could potentially eliminate populations, in particular those that are small- to moderate-sized (less than 10 clumps and 10-50 clumps, respectively, as defined in the final listing rule); at the time of listing 88% of known populations were small to moderate in size. Recent information shows that low sexual reproduction and low genetic diversity likely remain ongoing sources of inherent vulnerability and occur throughout the species range, and asexual reproduction may be the dominant mechanisms for maintenance and establishment of sites. There is insufficient information to determine if the new EOs or sub-EOs found since 1992 is due to increased survey effort or due to new sites being establish via asexual reproduction. In addition, the threat of severe floods will likely remain ongoing and occur throughout the species range and is predicted to increase in the future with climate change.

Reproduction and low diversity

As described in Sections 2.3.1.3, reproduction for Virginia spiraea is primarily asexual (e.g., when clumps or stems break off and lodge themselves in a downstream, suitable location favorable for establishment), which is likely

contributing to *Virginia spiraea*'s low genetic diversity. Although new populations have been found since 1992, it may be due to additional searches of suitable habitat vs. establishment of new sites via asexual reproduction; there is not sufficient data to make that assessment. Low genetic diversity is well documented as a threat to a species because it decreases the ability of the species to adapt to short- and long-term changes in physical and biological environments. This ability to adapt to new environments—referred to as adaptive capacity—is essential for viability, as species need to continually adapt to their continuously changing environments (Nicotra et al. 2015). *Virginia spiraea* may not be able to adapt to changes, such as those caused by climate change, as discussed below. The genetic analyses of *Virginia spiraea* populations have been conducted in a subset of the populations across the range and are ongoing in additional populations.

Climate change

Since the 1950s, the North American climate trends demonstrate an increase in overall temperature and an increase in the number of heavy precipitation events (IPCC 2014, Wuebbles et al. 2017). Temperatures are expected to continue rising, and heat waves and extreme precipitation events are predicted to become more frequent, last longer, and become more intense by the mid-21st century (IPCC 2014, Wuebbles et al. 2017). Climate projections downscaled to the Ohio Valley region, which overlaps with the *Virginia spiraea* range and are based on 11 global climate models, indicate that the following climate variables will increase during the 2011-2050 period when compared to 1981-2005: average annual temperature (median of about 1.4°C), number of extreme hot days (median of about 12 days), percent change of annual precipitation (median of about 2.5%), and percent change of number of precipitation extremes (mean of about 10%; precipitation extreme is when “daily precipitation magnitude exceeds the climatological value of the 95th percentile of the baseline precipitation”) (Ashfaq et al. 2016). With a warming climate, some studies predict an increase in the frequency of more intense hurricanes (e.g., category 4 and 5) by the end of the 21st century, in particular in the western Atlantic Ocean north of 20°N latitude (i.e., Cuba and north), which would likely cause periodic, extreme inland flooding events, potentially resulting in loss of *Virginia spiraea* habitat and populations through extreme scouring events (Bender et al. 2010, Knutson et al. 2010). The projected periods of extreme drought may negatively affect *Virginia spiraea* by reducing river flow and decreasing beneficial scouring of habitat that removes competing vegetation and disperses propagules. *Virginia spiraea* may also be stressed by drought and temperature increases, although we are unaware of information about their drought or temperature tolerances. As discussed in Section 2.3.2.1, increasing temperatures and atmospheric carbon dioxide associated with the global change may increase the spread and growth of invasive plant species (Liu et al. 2017).

Other

Feral hogs have been observed along a few riparian areas in the BSFNRRRA, but

their potential impact to *Virginia spiraea* is unknown (M. Tackett, BSFNRRA/OWSR, email to J. Stanhope, Service, February 19, 2020).

2.4 Synthesis

The current range of *Virginia spiraea* is generally unchanged since the 1992 recovery plan, occurring in 7 states (Georgia, Kentucky, North Carolina, Ohio, Tennessee, Virginia, West Virginia) within the Ohio and Tennessee River basins; the species remains extirpated from Pennsylvania and Alabama. One EO with historic documentation has been rediscovered (Cheoah River, North Carolina) and 38 additional EOs (32 of them extant as of 2019) and 74+ sub-EOs have been discovered due to searches of rivers/streams with suitable habitat in known drainages, surveys of rivers/streams with known occurrences, and incidental finds when surveying for other species. However, 11 EOs became presumed extirpated (F or X rank) since 1992 when the species' recovery plan was completed.

Data gathered since the 1992 recovery plan provide additional information on the abundance and number of populations of *Virginia spiraea* throughout its range, but it is difficult to assess population trends due to different monitoring approaches for abundance and definitions for populations over time and among the states. Although population trends and accurate counts of populations cannot be determined, the current data suggest that at least 72 of the 89 historically known EOs (81%) are extant, and 32 EOs (36.0% of historically known EOs) have an A or B rank, which indicates that the EO has excellent or good viability and are very likely or likely to persist, respectively, if current conditions prevail. However, 23 EOs (25.8% of historically known EOs) have an uncertain probability of persisting (fair viability; C rank) and 15 EOs (16.9% of historically known EOs) have a poor probability of persisting (D rank) and a high risk of extirpation, if current conditions prevail. Of the extant EOs, 36 (40.4% of historically known EOs) are located on public or permanently managed/protected lands and 20 of these 36 EOs (22.5% of historically known EOs) have an A or B rank. Populations are currently assessed by the state natural resources agencies as stable (Georgia, Kentucky, North Carolina, Ohio, Tennessee, and Virginia) or stable to decreasing (West Virginia). Propagation efforts have been successful in reintroducing *Virginia spiraea* to new or known rivers and rescuing them from construction and herbicide application; new propagation efforts are proposed or recently funded in Georgia, West Virginia, and Tennessee. Collections of living *Virginia spiraea* are maintained at multiple gardens, including plants from 26 of 72 extant EOs (36.1%) and 2 of 7 historical/extirpated EOs (28.6%), across the species range. Seeds collected from 5 EOs in the wild are stored at NLGRP.

Prior to 1992, *Virginia spiraea* had lost redundancy in the northern and southern portions of the historical range. Since 1992, however, the species has increased redundancy in the middle part of the range with extant EOs/sub-EOs in 10 new HUC10 watersheds due to increased searches for the species but also has 1 HUC10 become presumed extirpated in this area. In the Ohio River basin, 13 of the 17 historically occupied HUC8 sub-basins (76.5%) have extant EOs and 2 of the 6 minor drainage basins (33.3%) have 3 or more EOs on public or permanently managed/protected land with A or B rank. In addition, 14 of the 52 historically known EOs (26.9%) have an A or B rank and 8 of these 14 EOs (15.4% of historically known EOs) are on public or permanently managed/protected land. In the Tennessee River basin, 8 of the 9

historically occupied HUC8 sub-basins (88.9%) have extant EOs and 2 of the 3 minor drainage basins (66.7%) have 3 or more EOs on public or permanently managed/protected land with A or B rank. In addition, 18 of the 37 historically known EOs (48.6%) have an A or B rank and 12 of these 18 EOs (32.4% of historically known EOs) are on public or permanently managed/protected land. Although more than 60% of potential habitat in states with present or past collections, specifically in the Blue Ridge and Appalachian Plateau physiographic provinces, has been surveyed for additional populations, many biologists anticipate finding more EOs and sub-EOs with additional comprehensive surveys.

New research supports that Virginia spiraea habitat is improved when there are less vegetation competition and increased light availability. Prior to alteration of flow regimes at some sites, reduction in competition occurred naturally during high-volume scouring floods. A species distribution model that predicts potential suitable habitat shows new potential areas throughout Virginia spiraea's current and historical range within the Appalachian Plateau and Blue Ridge physiographic provinces, and includes areas in the Interior Low Plateaus and Valley and Ridge physiographic provinces, where only 2 EOs are located.

Results of genetics studies conducted thus far suggest low genetic diversity in the populations sampled, but differ in where most variation occurs. Brzyski and Culley (2011) found greater variability among populations (or watersheds) and no relationship between genetic and geographic distance, but UNCA and ASU researchers observed most variation occurs within river basins vs. between river basins and some of the genetic diversity patterns suggest downstream dispersal of propagules. Research related to genetic diversity and reproduction is currently ongoing at UNCA and ASU and will include additional populations across the range. Research supports that reproduction is primarily asexual, with some sexual reproduction occurring. Availability and viability of pollen do not appear to be barriers to sexual reproduction, but seed viability and germination are very low. Other potential genetic barriers to reproduction are being investigated by UNCA and ASU, including assessing polyploidy in the populations and prevalence of s-alleles. Understanding ploidy is important because a common trait of triploids is sterility. In addition, knowing ploidy numbers makes accurate calculations of heterozygosity possible and will help to guide potential propagation efforts.

The final listing rule described threats to Virginia spiraea to include competition by both native and non-native plant species, anthropogenic disturbances to habitat (e.g., development, railroads, roads, clearing, mowing, recreational use of rivers, dam construction), and changes in hydrologic regime. These threats remain ongoing, occur throughout the species range, and are expected to continue in the future. Although 38 additional EOs (32 extant as of 2019) have been found since 1992 due to searches/surveys, 11 EOs have become presumed extirpated since then as a result of these threats. When state natural resource agencies, federal agencies, and researchers were surveyed in 2019 by the Service, the majority of the respondents listed invasive species as a primary threat in their region. Of 38 EO records where threats were noted or described in the occurrence data provided, the following are the number of EO records indicating one of the above described threats (note: many EO records noted multiple threats): 21 (55%) indicated competing vegetation or invasive species; 11 (29%) indicated land disturbance activities; 16 (42%) indicated scour and flooding. Efforts to manage competing vegetation or invasive species are occurring for some EOs. The threat of invasive plant species may increase in the future with

increased anthropogenic disturbances and global climate change due to increasing air temperature and atmospheric carbon dioxide (Liu et al. 2017), but there is large uncertainty about the scale of effects of climate change on invasive plants. The threats of land disturbance activities are likely to increase in the future with the extent of urban sprawl projected to increase 101 to 192% in the next 50 years for the southeastern United States. Scour and flooding are potentially exacerbated by increased development and impervious surfaces in watersheds and global climate change, with extreme precipitation events predicted to increase. New dam construction, which will alter flow regimes and cause habitat loss, is not expected across the species range. Minor threats to the species that are not widespread are recreational activities disturbing habitat and/or crushing plants (3 (8%) EO records indicated this as a threat) and herbivory by beavers and white-tailed deer. Existing regulatory mechanisms without ESA protections continue to be inadequate to protect Virginia spiraea from the primary threats of invasive plant species and habitat loss or degradation due to changes in flow regime.

The final listing rule described natural threats to include biological factors of low sexual reproduction and low genetic variability. Recent information shows that these risk factors likely remain ongoing and occur throughout the species range, and asexual reproduction may be the dominant mechanism for maintenance and establishment of sites. Low genetic diversity is well documented as a threat to a species because it decreases the ability of the species to adapt to short- and long-term changes in physical and biological environments. This ability to adapt to new environments—referred to as adaptive capacity—is essential for viability, as species need to continually adapt to their continuously changing environments (Nicotra et al. 2015). Virginia spiraea may not be able to adapt to changes, such as those caused by climate change.

The Service established a framework in which we consider what a species needs to maintain viability over time by characterizing the biological status of the species in terms of its Resiliency, Redundancy, and Representation (“the 3 Rs”; Smith et al. 2018). **Resiliency** means having sufficiently healthy populations for the species to withstand stochastic events (arising from random factors). We can measure resiliency based on metrics of population health; for example, population size, if that information exists. Resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of human activities. **Redundancy** means having a sufficient number of populations for the species to withstand catastrophic events (such as a rare destructive natural event or episode involving many populations). Redundancy is about spreading the risk and can be measured through the duplication and distribution of populations across the range of the species. Generally, the greater the number of populations a species has distributed over a larger landscape, the better it can withstand catastrophic events.

Representation means having the breadth of genetic makeup of the species to adapt to changing environmental conditions. Representation can be measured through the genetic diversity within and among populations and the ecological diversity (also called environmental variation or diversity) of populations across the species range. The more representation, or diversity, a species has, the more it is capable of adapting to changes (natural or human caused) in its environment. Table 7 summarizes the information provided in this report in terms of the 3 Rs.

Table 7. Resiliency, redundancy, and representation (3Rs) for *Virginia spiraea* and its current condition.

3Rs	Requisites	Description	Current Condition
Resiliency (ability to withstand stochastic events)	Healthy populations and habitat.	Populations with: • High gradient streams/rivers with scoured banks, meander scrolls, point bars, natural levees, or other braided features; • Normal hydrologic flows to maintain habitat integrity and reduce competing arboreal and invasive vegetation; • Connectivity — waterways without impoundments and significant barriers to allow dispersal.	Each population or EO with excellent or good (A or B rank) current condition is thought to be healthy and have adequate habitat, thus has high or moderate resiliency, respectively. • 72 of 89 EOs (80.9%) are known to be extant. • EO status: – 32 EOs (36.0%) excellent/good condition – 23 EOs (25.8%) fair condition (C rank) – 15 EOs (16.9%) poor condition (D rank) – 2 EOs (2.2%) unknown condition (E rank) – 17 EOs (19.1%) presumed extirpated (F or X rank) or historical
Redundancy (ability to withstand catastrophic events)	Sufficient distribution of healthy populations.	Sufficient distribution of healthy populations to prevent catastrophic losses of species' adaptive capacity due to severe flood events. Multiple healthy populations and occupied HUC10s (watersheds) distributed within the species range are important for the species' redundancy.	• Healthy EOs (good to excellent condition) throughout range, but not evenly distributed in some areas: fewer healthy EOs in specific areas of middle portion of the range and northern and southern extents of range. • Loss of occupied HUC10s in the northern and southern extents of the range (historically; prior to 1992) • Increase in occupied HUC10s in the middle portion of the range due to increased searches for the species.
	Sufficient number of healthy populations.	Sufficient number of healthy populations and occupied HUC10s to prevent catastrophic losses of adaptive capacity.	• 32 of 89 EOs (36.0%) are good to excellent condition across the range. – Ohio basin: 14 of 52 (26.9%) are good to excellent condition. 16 of 52 (30.8%) are fair condition. – Tennessee basin: 18 of 37 (48.6%) are good to excellent condition. 7 of 29 (24.1%) are fair condition. • 40 of 47 HUC10 watersheds (85%) currently occupied.
Representation (ability to adapt)	Sufficient capacity to adapt to new, continually changing environments.	Genetic diversity within and among populations contribute to and maintain adaptive capacity. Occupied HUC10s distributed across the range, including the ecological diversity of river basins and physiographic provinces that contribute to and maintain adaptive capacity. Adequate dispersal ability for the species to migrate to suitable habitat and climate over time.	Low genetic diversity documented among populations analyzed thus far, but able to reproduce asexually. Connected, occupied HUC10s found in both river basins and physiographic provinces. River basin: • Ohio – 22 of 26 HUC10s (84.6%) occupied. • Tennessee – 18 of 21 HUC10s (85.7%) occupied. Physiographic province: • Appalachian Plateau – 28 of 32 HUC10s (87.5%) occupied. • Blue Ridge – 12 of 14 HUC10s (85.7%) occupied. • Interior Low Plateau – 0 of 1 HUC10 (0%) occupied.

Overall, *Virginia spiraea* is facing ongoing and likely increasing threats to its continued existence throughout its range. We are unable to assess trends in abundance and number of populations or EOs since the recovery plan, but based on the assumptions that an EO is a population, stable populations are those with an A or B rank, and drainage system is a minor drainage basin based on HUC4 basins, none of the recovery criteria have been met. When assessing the 3 Rs, 36.0% of historically known EOs are considered healthy (e.g., moderately to highly resilient) and 22.5% of historically known EOs are both considered healthy and located on public or permanently managed/protected lands. However, 25.8% of historically known EOs have an uncertain probability of persisting (fairly resilient) and 16.9% of historically known EOs have a high risk of extirpation (poorly resilient), if current conditions prevail. If we predict that approximately half of the EOs with an uncertain probability and all the EOs with a high risk of extirpation will not persist in the future, there is a potential for 48.3% of historically known EOs to become extirpated in the future when including EOs that are currently presumed extirpated or historical. Although redundancy has increased in the middle portion of the range, *Virginia spiraea* continues

to have reduced redundancy in the northern and southern portions of the historical range. In addition, there are fewer healthy EOs in specific areas of middle portion of the range. Research is ongoing to assess genetic diversity and genetic barriers to reproduction and results will help inform recovery options, including the planned/proposed propagation efforts. When evaluating the status of the species and current and future threats, we conclude that the Virginia spiraea continues to meet the definition of a threatened species under the ESA.

3.0 RESULTS

3.1 Recommended Classification:

- ☐ **Downlist to Threatened**
- ☐ **Uplist to Endangered**
- ☐ **Delist** (*Indicate reasons for delisting per 50 CFR 424.11*):
 - ☐ *Extinction*
 - ☐ *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: No change; retain priority 8

Brief Rationale: The species continues to experience a moderate degree of threat and has a high recovery potential, if recommendations for future actions are implemented.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Clarify recovery criteria 1 and 2 to support consistent evaluation and to reflect current information. Specifically, both recovery criteria should be clarified in terms of population assessment measures (e.g., what factors determine a “stable” population) and definition of “population.” In addition, the definition of “drainage system” should be clarified as it relates to this species’ recovery and definition of a population.

Recommendations for specific recovery actions and priority number (1-3, based on priority number definitions in the Virginia spiraea recovery plan [Service 1992]):

1. Continue genetic analysis of Virginia spiraea across its range and within collections to determine genotypes and ploidy numbers, which will help guide potential propagation efforts and determine which localities/genotypes should be added to cultivated collections to provide genetic representation [Priority 1].
2. Develop specific guidance on the treatment of invasive species that threaten this species and recommendations for habitat management to increase viability of the populations, in particular EOs with C or D ranks. Include invasive species specialists and encourage practical application of invasive species and habitat management in populations across the range [Priority 1].
3. If deemed necessary based on the genetic analysis, develop a rangewide propagation and reintroduction plan [Priority 2].
4. Coordinate with natural resource agencies to complete rangewide review and revision, if needed, of the Virginia spiraea species distribution model to help identify potential suitable habitat [Priority 2].
5. Conduct comprehensive surveys of potential habitat in streams/rivers with known occurrences and no known occurrences, but identified in a species distribution model, to find

new populations. Efforts should focus within the Blue Ridge and Appalachian Plateau physiographic provinces, where almost all EOs occur [Priority 2].

6. Conduct surveys of extant EOs that have not been surveyed for more than 10 years to verify presence and update their EO ranks [Priority 2].
7. Determine if there is suitable habitat in areas where the species has been historically documented or extirpated and search these areas. Some areas that should receive priority ranking for survey work include, but are not limited to: Cypress Creek, AL; Youghiogheny River, MD and PA; Little River, TN; Hominy Creek, NC; Monongahela River, WV; and New River, WV [Priority 3].
8. Coordinate with natural resources agencies and Service Field Offices to develop methods and resolve nomenclature for accurately counting/measuring individual plants, population size, and populations to provide consistency and allow objective assessment of populations. Also coordinate to define appropriate ecological units (e.g., HUC units) to assist with organizing populations as it relates to species' recovery [Priority 3].
9. Coordinate with natural resource agencies and NatureServe to utilize consistent definitions of EO and EO rank for *Virginia spiraea* across the range to allow analysis of population trends and consistent assessment of status [Priority 3].
10. Develop educational materials for local government and public use aimed at increasing public awareness of the species, in particular in areas where development and recreational activities may impact *Virginia spiraea* [Priority 3].

5.0 REFERENCES

Data and references are located within the U.S. Fish and Wildlife Service's Virginia Field Office, 6669 Short Lane, Gloucester, VA 23061.

Anders, C.M., and Z.E. Murrell. 2001. Morphological, molecular, and biogeographical variation within the imperiled Virginia spiraea. *Castanea* 66:24-41.

Ashfaq, M., D. Rastogi, R. Mei, S.-C. Kao, S. Gangrade, B.S. Naz, and D. Touma. 2016. High-resolution ensemble projections of near-term regional climate over the continental United States. *Journal of Geophysical Research: Atmospheres* 121:9943–9963.

Atlanta Botanical Garden. 2012. Northwest Georgia Wetland Restoration and Rare Species Recovery. Five Star Restoration and NRT 2009 - Final Programmatic Report. Report to National Fish and Wildlife Foundation, Washington, D.C.

Atlanta Botanical Gardens. 2020. Reporting for 2020 TE 02200B-2. Report to Southeast Region, U.S. Fish and Wildlife, Atlanta, GA.

Bender, M.A., T.R. Knutson, R.E. Tuleya, J.J. Sirutis, G.A. Vecchi, S.T. Garner, and I.M. Held. 2010. Modeled impact of anthropogenic warming on the frequency of intense Atlantic hurricanes. *Science* 327(5964):454-458.

Brzyski, J.R. 2010. Isolation and characterization of microsatellite markers in the rare clonal plant, *Spiraea virginiana* (Rosaceae). *American Journal of Botany Primer Notes & Protocols* 97: e20-e22.

Brzyski, J.R. and T.M. Culley. 2011. Genetic variation and clonal structure of the rare shrub *Spiraea virginiana* (Rosaceae). *Conservation Genetics* 12:1323-1332.

Brzyski J.R. and T.M. Culley. 2013. Seed germination in the riparian zone: the case of the rare shrub, *Spiraea virginiana* (Rosaceae). *Castanea* 78:87-94.

Brzyski J.R., T.M. Culley, and A. Hird. 2014. Does sexual reproduction matter for a rare clonal species in frequently disturbed habitats? *Journal of the Torrey Botanical Society* 141(4):294–301.

Clarke, H.D., C.R. Rossell, Jr., J. Rhode, and J. Horton. 2014. Final Report: Evaluating the Effects of Long-arm Mowing on Virginia Spiraea along US 129 in the Cheoah River Corridor. Report to North Carolina Department of Transportation, Raleigh, NC.

Clark, L. 2017. Identifying Evolutionary Significant Units in *Spiraea virginiana*. Unpublished Honors Thesis. Appalachian State University, Boone, NC.

Duke Energy Carolinas, LLC, U.S. Fish and Wildlife Service, and U.S. Forest Service. 2015. Nantahala Hydroelectric Project (FERC No. 2692) Virginia Spiraea Management, Memorandum of Agreement between Duke Energy Carolinas, LLC, U.S. Fish and Wildlife Service, and U.S. Forest Service.

Emery, K., J. Rhode Ward, and H.D. Clarke. 2014. Effects of Open Pollination, Selfing, Inbreeding, and Outbreeding on Seed Set and Viability in *Spiraea virginiana* Britton (Rosaceae). University of North Carolina at Asheville Journal of Undergraduate Research Asheville, NC. May 2014: 400-409.

Estep, M. and J. Rhode Ward. 2021. *Spiraea virginiana* genetics – Planning for augmentation. Powerpoint presentation to the U.S. Fish and Wildlife Service, Gloucester, VA.

Gardner, R.L., and M. Moser. 2007. Surveys for Virginia Sneezeweed (*Helenium virginicum*) and New Populations of Virginia Spiraea (*Spiraea virginiana*) in Ohio. Ohio Department of Natural Resources Ohio Division of Natural Areas and Preserves, Columbus, OH.

Georgia Plant Conservation Alliance. 2019. Safeguarding Database Reports for *Spiraea virginiana*. Accessed September 13, 2019 by Carrie Radcliffe, Atlanta Botanical Garden, Atlanta, GA.

Gonzales, V. and M. Walls. 2020. Dams and dam removals in the United States. Resources for the Future, Washington, D.C. Report 20-12.

Hanberry, B.B. and P. Hanberry. 2020. Regaining the history of deer populations and densities in the southeastern United States. Wildlife Society Bulletin 44(3):512–518.

Horton, J.L., J. McKenna, C.R. Rossell, Jr., H.D. Clarke, J. Rhode Ward, and S.C. Patch. 2015. Habitat Characteristics of *Spiraea virginiana* Britton, a Federally Threatened Riparian Shrub, in North Carolina. Castanea 80(2):122-129.

Intergovernmental Panel on Climate Change. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.

Kauffman, G. 2021. Status of Virginia Spiraea along the Cheoah River in NC from Santeetlah Dam to NC border. Report to Brookfield Renewable US, New York City, NY.

Knutson, T.R., J.L. McBride, J. Chan, K. Emanuel, G. Holland, C. Landsea, I. Held, J.P. Kossin, A.K. Srivastava, and M. Sugi. 2010. Tropical cyclones and climate change. Nature Geoscience 3:157-163.

Liu, Y., A.M.O. Oduor, Z. Zhang, A. Manea, I.M. Tooth, M.R. Leishman, X. Xu, and M. Van Kleunen. 2017. Do invasive alien plants benefit more from global environmental change than native plants? *Global Change Biology* 23:3363-3370.

NatureServe. 2002. Element Occurrence Data Standard. Arlington, VA. Available from: http://downloads.natureserve.org/conservation_tools/element_occurrence_data_standard.pdf

NatureServe. 2020a. Habitat-based Plant Element Occurrence Delimitation Guidance. Arlington, VA. Available from: https://www.natureserve.org/sites/default/files/eo_specs-habitat-based_plant_delimitation_guidance_may2020.pdf

NatureServe. 2020b. Ranking species occurrences: generic guidelines and decision key. Arlington, VA. Available from: https://www.natureserve.org/sites/default/files/eo_rank_specifications-generic_guidelines_and_decision_key_may2020.pdf

Nicotra, A.B., E.A. Beever, A.L. Robertson, G.E. Hofmann, and J. O'Leary. 2015. Assessing the components of adaptive capacity to improve conservation and management efforts under global change. *Conservation Biology* 29:1268-1278.

North Carolina Department of Agriculture and Consumer Services. 2015. Protected Plant Permit 424. Raleigh, NC.

North Carolina Department of Agriculture and Consumer Services. 2018. Protected Plant Permit 629. Raleigh, NC.

North Carolina Department of Transportation. 2016. Final Report – Rescue and reintroduction of Virginia spiraea (*Spiraea virginiana* EO #61) for NCDOT Bridge No. 321 replacement – Lakey Creek/Clark Road (SR 1424), Macon Co. Report to North Carolina Department of Agriculture and Consumer Services, Raleigh, NC.

North Carolina Natural Heritage Program. 2020. Geographic Information System (GIS) data. NCDNCR, Raleigh, NC. Available at www.ncnhp.org. (Accessed: February 21, 2020).

Ogle, D.W. 1991. *Spiraea virginiana* Britton: I. Delineation and Distribution. *Castanea* 56(4): 287-296.

Ogle, D.W. 2003. Summary of Recovery Activity for *Spiraea virginiana* Britton at John Flannagan Reservoir, U.S. Army Corps of Engineers. Phase II. Contract # DACW69-03-P-0126. Report to U.S. Army Corps of Engineers, Haysi, VA.

Ogle, D.W. 2006. 2006 Status Assessment for *Spiraea virginiana* at John Flannagan Reservoir. Report to the U.S. Army Corps of Engineers, Haysi, VA.

Ogle, D.W. 2008. Scientific assessment for the federally listed plant *Spiraea virginiana* Britton. Report to the U.S. Fish and Wildlife Service, Gloucester, VA.

Ogle, D.W. 2009. Interactions Between Weather and Landforms Important to Phytogeography. Pages 435-440 in S. M. Roble and J. C. Mitchell, eds. A Lifetime of Contributions to Myriapodology and the Natural History of Virginia: A Festschrift in Honor of Richard L. Hoffman's 80th Birthday. Virginia Museum of Natural History Special Publication No. 16, Martinsville, VA.

Pate, S.J. 2010. Phylogeography and mating system of *Spiraea virginiana* britton: a multi-scale exploration of the biology of a threatened species. M.S. Thesis. Appalachian State University.

Rhode Ward, J. and M. Estep. 2019. Grant Agreement F16AP00773: Interim Performance and Financial Report, November 2019. Report to U.S. Fish and Wildlife Service, Raleigh, NC.

Rossell, Jr. C.R., K. Selm, J.D. Clarke, J.L. Horton, J. Rhode Ward, and S.C. Patch 2013. Impacts of Beaver Foraging on the Federally Threatened Virginia Spiraea (*Spiraea virginiana*) along the Cheoah River, NC. Southeastern Naturalist 12(2):439-447.

Rossell, Jr. C.R., S. Arico, H.D. Clarke, J.L. Horton, J. Rhode Ward, and S.C. Patch. 2014. Forage Selection of Native and Nonnative Woody Plants by Beaver in a Rare-Shrub Community in the Appalachian Mountains of North Carolina. Southeastern Naturalist 13(4):649-662.

Shaw, J. and B.W. Wofford. 2003. Woody plants of Big South Fork National River and Recreation Area, Tennessee and Kentucky and floristic comparison of selected Southern Appalachian woody floras. Castanea 68:119-134.

Smith, D., N.L. Allan, C.P. McGowan, J. Szymanski, S.R. Oetker, and H.M. Bell. 2018. Development of a species status assessment process for decisions under the U.S. Endangered Species Act. Journal of Fish and Wildlife Management 9(1):1-19.

Stine, S.J., Jr. 1993. Inventory for Virginia Spiraea (*Spiraea virginiana* Britton) in Ohio, Project No. E-2-1, Study No. 204. Report to the U.S. Fish & Wildlife Service, Ft. Snelling, MN.

Terando, A.J., J. Constanza, C. Belyea, R.R. Dunn, A. McKerrow, and J.A. Collazo. 2014. The Southern Megalopolis: Using the Past to Predict the Future of Urban Sprawl in the Southeast U.S.. PLoS ONE 9(7):e102261. <https://doi.org/10.1371/journal.pone.0102261>

Tessel, S.M. 2018. Management guidance for sensitive species forest stewardship program, *Spiraea virginiana*, Britton. Report to U.S. Forest Service, Forest Stewardship Program, Raleigh, NC.

U.S. Fish and Wildlife Service. 1992. Virginia spiraea (*Spiraea virginiana* Britton) recovery plan. U.S. Fish and Wildlife Service, Newton Corner, MA.

Webster, C.R., M.A. Jenkins, and J.H. Rock. 2005. Long-term response of spring flora to chronic herbivory and deer exclusion in Great Smoky Mountains National Park, USA. Biological Conservation 125:297-307.

Williams, F. 2003. Examination of variation among populations of *Spiraea virginiana* Britton based on multiple molecular methods. Senior Honors Thesis, Appalachian State University, Boone, NC.

Wise, J. 2018. Assessing reproductive potential in a federally listed species: differential staining for pollen viability in *Spiraea virginiana*. Unpublished Honors Thesis. Appalachian State University, Boone, NC.

Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, B. DeAngelo, S. Doherty, K. Hayhoe, R. Horton, J.P. Kossin, P.C. Taylor, A.M. Waple, and C.P. Weaver. 2017. Executive summary. In: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 12– 34.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of the Virginia spiraea, *Spiraea virginiana*

Current classification: Threatened

Recommendation resulting from the 5-Year Review:

☐ Downlist to Threatened
☐ Uplist to Endangered
☐ Delist
☒ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable:

Review Conducted By: Jennifer Stanhope, Virginia Field Office

LEAD REGIONAL OFFICE APPROVAL

Assistant Regional Director, Fish and Wildlife Service

Approve SHARON MARINO Digitally signed by SHARON MARINO
Date: 2021.12.20 11:52:23 -05'00' Date _____

APPENDIX A: COORDINATION LIST OF PARTNERS AND EXPERTS

The following partners and experts were contacted for information to support the 5-year review and provided responses, in addition to those listed in Section 1.1 (Reviewers):

Federal agencies

- National Park Service, Big South Fork National River and Recreation Area (KY & TN) & Obed Wild & Scenic River (TN) (Marie Tackett [Kerr])
- National Park Service, Great Smoky Mountains National Park (Kristine Johnson*, Joshua Albritton*)
- National Park Service, New River Gorge National Park and Preserve, Gauley River National Recreation Area, Bluestone National Scenic River (Doug Manning*, Bryan Wender)
- US Forest Service, George Washington and Jefferson National Forest (Tom Brumbelow)
- U.S. Forest Service, National Forests in North Carolina (Gary Kauffman*)

State agencies

- Alabama Department of Conservation and Natural Resources, States Land Division, Natural Heritage Section (Wayne Barger)
- Georgia Department of Natural Resources, Wildlife Resources Division (Laci Pattavina, Lisa Kruse, Nathan Thomas)
- Kentucky Energy and Environment Cabinet, Office of Kentucky Nature Preserves (Tara Littlefield, Nour Salam, Elizabeth Mason)
- North Carolina Natural Heritage Program (Jame Amoroso, Suzanne Mason*)
- North Carolina Department of Agriculture and Consumer Services (Lesley Starke*)
- Ohio Department of Natural Resources, Division of Natural Areas and Preserves (Richard Gardner)
- Tennessee Department of Environment and Conservation, Division of Natural Areas (Caitlin Elam)
- Virginia Department of Conservation and Recreation, Division of National Heritage (Rene' Hypes*, Johnny Townsend)
- West Virginia Division of Natural Resources (Kieran O'Malley*, Alexander Silvis)

Other

- Atlanta Botanical Garden (Carrie Radcliffe)
- University of North Carolina – Asheville (Jennifer Rhode Ward*)
- Appalachian State University (Matt Estep*)
- Seton Hill University (Jessica Bryzski*)
- Holden Living Collections (Ethan Johnson)
- Harvard Arnold Arboretum (Kathryn Richardson)
- Auburn University (Alfred Schotz)
- North Carolina Botanical Garden (Michael Kunz)
- Virginia Highlands Community College (Doug Ogle* [retired]; Ben Casteel)

*All federal and state partners and most “other” partners were provided the opportunity to review a draft 5-year review document. Those with an * reviewed the draft 5-year review and provided comments.

APPENDIX B: SPECIFIC AND GENERAL EO RANKS DEFINITIONS

Specific EO Rank Definitions for Virginia spiraea

(from

https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.135631/Spiraea_virginiana;
accessed June 21, 2021)

Excellent Viability:

Colonies of plants totaling ca 100 sq. m in areal coverage and occurring at several locations along 2 or more river miles, river bank communities stable and mostly dominated by native vegetation.

Good Viability:

Colonies of plants totaling ca 50 sq m in areal coverage and occurring at several locations along 1-2 river miles, river bank communities stable and mostly dominated by native vegetation.

Fair Viability:

Colonies of plants averaging smaller than 5 sq m in size and occurring at fewer than 5 locations along a water course, much of the river bank is native vegetation but may be disrupted by cleared areas or disturbance.

Poor Viability:

Any occurrence where the total coverage of all colonies is less than 15 sq m.

Justification:

Based on a review of occurrences and habitat rangewide.

Date:

January 25, 2005

Author:

White, D.

General Element Occurrence Rank Definitions
(from NatureServe 2020b)

A: Excellent viability

Occurrence exhibits optimal or at least exceptionally favorable characteristics with respect to population size and/or quality and quantity of occupied habitat; and, if current conditions prevail, the occurrence is very likely to persist for the foreseeable future (i.e., at least 20-30 years) in its current condition or better. These occurrences have characteristics (e.g., size, condition, landscape context) that make them relatively invulnerable to extirpation or sustained population declines, even if they have declined somewhat relative to historical levels. For species associated with habitat patches or ephemeral or particularly dynamic habitats, occurrences warranting an A rank generally consist of metapopulations rather than single demes (unless exceptionally large and robust). Occurrences of this rank typically include at least 1,000 mature individuals but may be smaller (100s) or might require larger populations (10,000s), depending on the species and its demographic characteristics. However, occurrences can be ranked A even if population size is not known. For example, for occurrences lacking information on population size, an A rank may be appropriate under the following circumstances: the population is clearly very large but it is not known how large; the area of occupied habitat is exceptionally large; or the occurrence has excellent condition and landscape context and a long history of occurrence persistence. Occurrences with excellent estimated viability are ranked A even if one or more other occurrences have a much larger population size and/or much greater quantity of occupied habitat. In most cases, occurrences ranked A will occupy natural habitats. However, "natural" is an ambiguous concept, and occurrences in "unnatural" conditions (e.g., somewhat modified by human actions) may still be assigned a rank of A if they otherwise meet the criteria.

B: Good viability

Occurrence exhibits favorable characteristics with respect to population size and/or quality and quantity of occupied habitat; and, if current conditions prevail, the occurrence is likely to persist for the foreseeable future (i.e., at least 20-30 years) in its current condition or better. B-ranked occurrences have good estimated viability and, if protected, contribute importantly to maintaining or improving the conservation status of threatened or declining species. For species associated with habitat patches or ephemeral or particularly dynamic habitats, a high-quality occurrence may warrant a B rank if it consists of a single deme rather than a metapopulation (unless the single deme is exceptionally large and robust, in which case an A rank may be appropriate).

C: Fair viability

Occurrence characteristics (size, condition, and landscape context) are non-optimal such that occurrence persistence is uncertain under current conditions, or the occurrence does not meet A or B criteria but may persist for the foreseeable future with appropriate protection or management, or the occurrence is likely to persist but not necessarily maintain current or historical levels of population size or genetic variability. This rank may be applied to relatively low-quality occurrences with respect to size, condition, and/or landscape context if they still appear to have reasonable prospects for persistence for the foreseeable future (at least 20-30 years). Examples include very small non-degraded relict occurrences as well as some remnant

occurrences of former landscape-level species such as many extant occurrences of tall-grass prairie insects. These occurrences represent the lower bound of occurrences worthy of protection.

D: Poor viability

If current conditions prevail, occurrence has a high risk of extirpation (because of small population size or area of occupancy, deteriorated habitat, poor conditions for reproduction, ongoing inappropriate management that is unlikely to change, or other factors). Questionably viable occurrences that could be restored to at least fair viability should not be ranked D if restoration is deemed feasible and plausible; in most such cases CD should be used. Very small occurrences that may be vulnerable to deleterious stochastic events may be ranked as follows: If the stochastic event is highly theoretical or of very low probability in the appropriate time frame (e.g., 20-30 years), then a C or CD rank may be appropriate. If a minority of other similar occurrences have disappeared as a result of, say, disease or inbreeding, then perhaps CD is best. If most of these small occurrences have been extirpated or are disappearing due to such events, then D is probably appropriate. The D rank also applies if the population is so small that there will inevitably be a year (or generation) in the near future in which by chance all adults will be the same gender.

E: Verified extant

Occurrence recently has been verified as still existing, but sufficient information on the factors used to estimate viability of the occurrence has not yet been obtained. Use of the E rank should be reserved for those situations in which the occurrence is thought to be extant, but an A, B, C, D, or combination rank cannot be assigned.

H: Historical

Recent field information verifying the continued existence of the occurrence is lacking. Examples of this rank include occurrences based only on historical collection data, or occurrences that previously were ranked A, B, C, D, or E but that are now, without field survey work, considered to be possibly extirpated due to general habitat loss or degradation of the environment in the area. H may be applied to recently verified occurrences if two or more competent subsequent efforts that should have found the species did not, or if there has been a known major disturbance since the last observation such that continued existence of the occurrence is in doubt (for example, an isolated Lepidoptera occurrence that was sprayed with Dimilin®).

In the absence of known disturbance and with the habitat still extant, H is generally recommended for occurrences that have not been reconfirmed for 20 or more years, but for many short-lived insects a shorter interval may be appropriate, and for unusually stable habitats (like undisturbed caves), or for certain plants whose seeds may persist and remain viable in the soil for decades, a longer interval, up to 40 years, may be used. With very few exceptions, occurrences are to be regarded as H after 40 years without confirmation, even with no effort to locate the species. The time frame for H occurrences is necessarily arbitrary, and the values specified here should be regarded as generally appropriate but somewhat flexible rules. The professional judgment of the assessor should determine when resurveys with negative results have been sufficient in quantity and quality to warrant updating an occurrence rank from F to H or from H

to X. Deviations from the suggested time frame should be explained in the EO RANK Comment field.

In some cases, H may indicate occurrences with imprecise locational information such that it may be difficult or impossible to determine whether subsequent observations are of the same occurrence; many of these occurrences may remain H indefinitely. Nevertheless, occurrences with imprecise locational information sometimes may be mapped using an appropriate and reasonable indication of the degree of locational uncertainty.

F: Failed to find

Occurrence has not been found despite a search by an experienced observer at a time and under conditions appropriate for the Element at a location where it was previously reported, but the occurrence still might be confirmed to exist at that location with additional field survey efforts. For occurrences with vague locational information, the search must include areas of appropriate habitat within the range of locational uncertainty.

X: Extirpated

Adequate surveys by one or more experienced observers at times and under conditions appropriate for the species at the occurrence location, or other persuasive evidence, indicate that the species no longer exists there or that the habitat or environment of the occurrence has been destroyed to such an extent that it can no longer support the species.

Unrankable

An occurrence rank (including E) cannot be assigned due to lack of sufficient information on the occurrence. As currently defined, this category is not clearly distinguishable from H, and use of U is discouraged until this issue is resolved (perhaps by elimination of the U category).

Occurrences that currently cannot be surveyed because of access issues (e.g., a cave entrance has been permanently sealed, or an uncooperative landowner denies access) may be ranked A, B, C, D, E, F, H, or X if the rank is based on recent survey data obtained when access was still possible. Currently inaccessible occurrences that are based only on old (historical) information should be ranked H. Note that access issues often are temporary and may be overcome by negotiation, change in ownership, use of novel survey techniques, or other methods. The U code sometimes has been used to indicate occurrences with "unknown" viability, but such occurrences generally should be coded as H, F, or NR, depending on the circumstances.