

**Spreading avens
(*Geum radiatum*)**

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



**U.S. Fish and Wildlife Service
Southeast Region
Asheville Ecological Services Field Office
Asheville, North Carolina**

*Please see Addendum 1 at the end of this, our original 5-year review, document. The Addendum provides the limited new information we have gathered for our second 5-year review for this endangered plant that was initiated in the Federal Register (April 11, 2019; 84 FR 14669) and the analysis we have shared to explain the basis for continuing to recommend no change in status for this species.

5-YEAR REVIEW
Spreading avens (*Geum radiatum*)

LIST OF ABBREVIATIONS

AFO	Asheville Field Office, U.S. Fish and Wildlife Service
EO	Element Occurrence (a mapping unit commonly used by Natural Heritage Programs)
NCNHP	North Carolina Natural Heritage Program
NPS	National Park Service
TNC	The Nature Conservancy
TNNHP	Tennessee Natural Heritage Program
USFWS	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service

5-YEAR REVIEW
Spreading avens/*Geum radiatum*

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Region: Southeast Region:

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Lead Field Office: Asheville Ecological Services Field Office, Asheville, NC
Carolyn Wells, (originating author; moved to a new office and position, Mara
Alexander new species lead), phone 828.258.3939 ext. 238

Cooperating Field Office(s): Tennessee Ecological Services Field Office,
Cookeville, TN, Geoff Call, phone 931.528.6481 ext. 213

1.2 Methodology used to complete the review:

We announced initiation of this 5-year review in the *Federal Register* on July 29, 2008 (73 FR 43947) and opened a 60 day comment period. During the comment period, we did not receive any additional information about *Geum radiatum* in response to the *Federal Register* notice. However, the USFWS did receive additional information about the species in response to requests for peer review that were made (by the USFWS) directly to biologists familiar with the species. Once all data was obtained, the review was completed by the USFWS's lead recovery biologist for the species in Asheville, North Carolina (Carolyn Wells). A draft of the 5-year review was peer reviewed by several experts familiar with the plant (See Appendix A). No part of the review was contracted to an outside party. Comments received on this review were evaluated and incorporated as appropriate.

1.3 Background:

- 1. Federal Register Notice citation announcing initiation of this review:**
July 29, 2008 (73 FR 43947)
- 2. Species Status:** Stable. Eleven of the 15 extant populations occur on publicly owned lands or lands otherwise managed for conservation. Threats persist like trampling, vegetation succession, but overall the species appears stable.
- 3. Recovery Achieved:** 2 (2 = 26-50% species recovery objectives achieved)

4. Listing history

Original Listing

FR notice: 55 FR 12793

Date listed: April 5, 1990

Entity listed: species

Classification: endangered

5. Associated rulemakings: n/a

6. Review History:

Recovery Plan: 1993

Recovery Data Call: 1998-2011

FWS conducted a 5-year review for this plant in 1991 (56 FR 56882). In this review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors or threats as they pertain to the individual species. The notice stated that FWS was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notice indicated that if significant data were available warranting a change in a species' classification, the Service would consider proposing a rule to modify the species' status. No change in this plant's listing classification was found to be warranted.

Additional review type documents consulted in the preparation of this review, are cited accordingly throughout, and a complete list of works consulted (and on file with the USFWS's AFO) follows the list of literature cited.

7. Species' Recovery Priority Number at start of 5-year review (48 FR 43098):

This species has a recovery priority number of 2, which indicates a high degree of threat and a high potential for recovery.

8. Recovery Plan

Name of plan:

Recovery Plan for Spreading Avens (*Geum radiatum*) Rafinesque

Date issued: April 28, 1993

2.0 REVIEW ANALYSIS

1. Application of the 1996 Distinct Population Segment (DPS) policy

The Act defines species as including any subspecies of fish or wildlife or plant, and any distinct population segment (DPS) of any vertebrate wildlife. Therefore, the DPS policy applies to only vertebrate species of fish and wildlife. Because *G. radiatum* is a plant, the DPS policy is not applicable.

2. Recovery Criteria

2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

The species has a final, approved recovery plan with recovery criteria. The recovery criteria are not objective and measurable, beyond establishing a minimum number of populations to be protected (16). The recovery criteria do not specify the number of individuals or the quantity and quality of habitat needed for the species' recovery, due to a lack of knowledge of the species' biology. The recovery criteria in the 1993 plan were regarded as interim goals to be modified upon acquiring additional information (specific actions intended to address these information needs are identified among the recovery tasks).

2.2 Adequacy of recovery criteria.

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?

Yes. While additional information has been obtained regarding the species and its habitat, this information would not yet necessitate revision of the recovery criteria. This updated information is summarized in Section 2.3 (Updated Information).

2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?

Yes. The existing recovery criteria could not be met without addressing the three listing factors still identified as significantly affecting the status of the species in the listing rule (habitat loss, the inadequacy of existing regulatory mechanisms, and other natural or manmade factors). One listing factor (over utilization for commercial, recreational, scientific, or educational purposes) is no longer considered a significant threat to the species. There are no new threats affecting the species beyond those mentioned in the listing rule and the recovery plan. However, accelerated global climate change may exacerbate those threats already identified; this is discussed in Section 2.3.2 (Five-Factor Analysis).

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:

Criterion 1: It has been documented that at least 16 self-sustaining populations exist and that necessary management actions have been undertaken by the landowners or cooperating agencies to ensure their continued survival.

As of 2013, the global distribution of *G. radiatum* consists of 15 extant (and three extirpated) populations within the states of North Carolina and Tennessee (NCNHP 2013 and TNNHP 2012) (Appendix B, Table B.1). Completion of Recovery Task 2 (determine and implement management necessary for long-term reproduction, establishment, maintenance, and vigor) and its associated subtasks would provide for the creation of objective criteria for self-sustaining populations. However, these tasks (particularly tasks 2.1, 2.3 and 2.5) have only recently been initiated in earnest (as recently as 2003). As a result, objective criteria for self-sustaining populations do not yet exist.

Completion of Recovery Task 2 and its associated subtasks would also provide for an improved understanding of the necessary management actions needed to ensure the species' continued survival. Some progress has been made in evaluating the efficacy of management techniques to control trampling and vegetation succession (NPS 2004, Donaldson 2002a, -- 2002b, -- 1999a, -- 1999b, Johnson 1995). However, it is presently unknown how many sites require active management to address these threats, due in large part to a lack of monitoring data and objective characterization of the scope, magnitude, immediacy and severity of these and other threats.

Therefore, this criterion has not been met.

Criterion 2: All of the above populations and their habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations.

Of the 15 extant populations of *G. radiatum*, 11 occur on publicly owned lands or lands otherwise managed for conservation. The remaining four grow on private, unconserved land. Although species-specific management agreements do not exist for the majority of these populations, every land owner is cooperative and has expressed willingness to work with the USFWS and its partners toward the management and recovery of this species. Therefore, we have made progress in protecting populations but as stated above additional work needs to be conducted in terms of monitoring and management.

3. Updated Information and Current Species Status

3.1 Biology and Habitat

3.1.1 New information on the species' biology and life history:

There is no new information on the species' biology and life history.

3.1.2 Abundance, population trends, demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

G. radiatum is a rhizomatous, herbaceous perennial that forms basal rosettes arising from a buried horizontal rhizome. Rosettes (called "crowns" by some) each bear 1-2 leaves and may produce 1-2 flowering stems. This complex growth form has led different observers to define (and count) "plants" differently, with some observers reporting counts in terms of individual rosettes and others counting aggregations of rosettes (clusters, clumps, or more recently, patches) separated from one other by a significant distance or by a mass of solid rock. Until fairly recently, there was no consistent separation distance for defining an aggregation of rosettes as a "patch", "clump", or "cluster." Johnson suggested a basal separation distance of 25 cm in the early 1990s, although he later argued the merits of both basal and foliar separation distances. The 25 cm basal separation rule has been adopted by most and is in greatest use today (Ulrey 2008, Donaldson 2002a, 2002b, 1999a, 1999b, TNC 1996). However, when reviewing available observation data spanning the past several decades, one will find various operational definitions of a "plant", with some observers not being explicit as to whether they were counting (or estimating) rosettes or aggregations of rosettes (clumps, clusters, or patches) (NCNHP

2013, TNNHP 2012). This significantly impedes the ability to compare observations and infer trends.

Inferring patterns in overall abundance and population trends is further complicated by different levels of survey effort applied at a given subpopulation or population. In some instances, the level of survey effort and/or the spatial extent of a given search are not specified, making inferences of trends all the more difficult.

The rugged, high elevation (4500 to 6000 ft. above sea level) rock outcrops and vertical to near-vertical cliffs occupied by this species present numerous survey challenges. Within these habitats, a single *G. radiatum* population (or subpopulation) may span several hundred feet in elevation, with only a fraction of the plants accessible without rappelling equipment or at the very least a precarious scramble over slick, steep and at times complexly fractured rock. As a result, it can be difficult to distinguish varying levels of survey effort from actual trends in the plant population (or subpopulation).

While conducting this five year review, we have undertaken great effort to verify the unit of measurement (rosettes, clusters, patches) and the spatial extent of all estimates used in inferring trends, and restrict inferences to those observations which we are reasonably confident can be meaningfully compared. We have noted limitations in available data where appropriate.

The 1993 recovery plan recognized 11 extant and five extirpated populations (USFWS 1993). Six of the extant populations were described as having fewer than 50 plants each; three of these six were thought to contain fewer than 10 plants each (p. 9).¹ The 1993 recovery plan assessed four of the 11 extant populations as having undergone significant population declines, ranging from 67 to 96 percent (p. 9).² However, available information indicates that these apparent trends were often exaggerated by discrepancies in units of observation among earlier observers, as detailed above. As a result, estimates of population size dating to this time period (the 1970s to early 1990s) do not usually exist in units which can be directly compared. Therefore, the trends stated in the species' recovery plan should no longer be regarded as accurate.

As of 2013, there are 15 extant and three extirpated populations of *G. radiatum* (Appendix B, Table B.1). Of the five populations regarded as extirpated in the recovery plan (USFWS 1993), two have been rediscovered and confirmed extant.³ Seven of the 15 extant populations consist of more than one subpopulation, with these seven populations

¹ These six populations (along with the estimate of population size used by the Service during the preparation of the recovery plan) are as follows: Cliff Top (9 blooming clumps), Bluff Mountain (34 (units unknown)), Hanging Rock (< 50 (units unknown)), Mt. Craig (48 crowns), Three Top (3 (units unknown)), Craggy Pinnacle (11 (units unknown)), and Devils Courthouse (7 plants).

² These four populations (along with the percentage population decline calculated by the USFWS during the preparation of the recovery plan) are as follows: Cliff Top (67% decline), Roan Mountain (81% decline at Cloudland Trail, 96% at Tollhouse Gap, 14% decline at Grassy Ridge), Bluff Mountain (90% decline), Hanging Rock (92% decline).

³ Populations previously thought to be extirpated (and now confirmed extant) are The Peak and Bald Mountain (a.k.a. Yellow Mountain, Raven Cliffs), both in North Carolina. The species continues to be regarded extirpated at Linville Falls and Green Mountain in North Carolina and Gregory Bald in Tennessee.

containing a collective total of 36 subpopulations. Of the 15 extant populations, five (and possibly six) are currently thought to contain fewer than 50 patches.⁴

Due primarily to the issues noted above (observations reported in inconsistent units, or else representing different portions of a given population or subpopulation), population trends are lacking for most occurrences of *G. radiatum*. However, beginning in 2003, the NPS began initiating demographic level monitoring at populations within the Blue Ridge Parkway management unit (two populations of the species). Since that time, NPS and USFWS have been working with other land owners to extend this monitoring effort to other populations across the species' range. Wherever possible, this monitoring consists of a complete, or nearly complete, census of all plants present – using rappelling equipment to access plants on vertical faces or otherwise inaccessible areas. As of 2009, five populations of *G. radiatum* are receiving annual monitoring via a complete (or nearly complete) census and significant portions of four other populations are similarly receiving annual monitoring in conjunction with this effort (Ulrey 2008). Data accumulated will ultimately be analyzed in conjunction with a Population Viability Analysis (PVA).⁵

Three of the nine populations receiving demographic level monitoring are characterized by too few years of data to suggest meaningful trends (Ulrey 2008). The remaining six populations (or portions of these) characterized by multiple years of data have exhibited little turnover (adult mortality or seedling recruitment) in the *G. radiatum* present. Thus these locations appear to be stable over the short term (the past two to five years). However, the exceedingly low rates of seedling recruitment are troubling and do not bode well for the long term viability of these populations (Ulrey 2008). One of the populations shown to be stable by these short term data has declined by as much as 58% from historical estimates, and another population at which demographic monitoring was initiated in 2009 also appears to have declined by more than 90% from historical levels.⁶ Both of these populations are in protective ownership (the former owned by the State of North Carolina and managed as a part of the State Park system, the latter is owned and managed by TNC). Both of these populations are small, and have never been reported to contain more than 50 patches.

The USFS erected a formal closure order at one subpopulation (within the larger Roan Mountain population located west of Carvers Gap) in the early 1990s in response to impacts and declines in the rare species found here (including *G. radiatum*). All accounts by those familiar with the site conditions before the closure suggest that it has been largely successful, and that numbers of most rare plant species have rebounded to (or near) historical levels (David Danley, USFS, personal communication, 2004; Donaldson 1999a, 1999b, 2002b).

⁴ These five are Bluff Mountain, Hanging Rock, Mt. Craig, Cliff Top, and Yellow Mountain. The population at Roan Mountain east of Carvers Gap (which consists of two subpopulations) may contain fewer than 50 patches, but additional survey effort is needed.

⁵ Populations monitored (in whole or in part) in conjunction with this effort are: Bluff Mountain (initiated 2008), The Craggies (initiated 2004), Devils Courthouse (initiated 2004), Grandfather Mountain (initiated at two of seven subpopulations in 2008), Mt. Craig (initiated 2008), The Peak (initiated via a sample of the larger population in 2009), Roan Mountain west of Carvers Gap (initiated at six of 16 extant populations since 2005, with annual monitoring expected to continue at four of these six), Roan Mountain east of Carvers Gap (initiated at one of two subpopulations in 2006), Waynesville Watershed (initiated 2005).

⁶ The two populations that appear to have declined from historical levels are Mt. Craig (declines of 58%) and Bluff Mountain (declines of more than 90%), both in North Carolina.

In 2005 and 2006, the USFS erected hidden trail counters at this site, in response to observations that many visitors were violating the closure order by entering closed areas (USFS 2007). The purpose of this investigation was to determine the level of visitation to the observation platform and the percentage of visitors who climbed over established barricades (fences) and entered rare plant habitat. Trail counter data revealed some 2,300 visitors to the platform in 2005 and some 2,000 visitors the following year. In each year, an average of two persons per day violated the closure order. USFS monitoring of *G. radiatum* in 2005 and 2006 (and since) has demonstrated the subpopulation of that species to be stable over this time period. Regardless, the volume of visitation (and violation of the closure order) demonstrated with these hidden trail counters illustrates the potential magnitude of this threat and the need for continued monitoring and management to ensure that it does not reach critical levels of impacts within this or other *G. radiatum* populations.

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

Godt, Johnson and Hamrick examined allozyme diversity in four rare, high-elevation plant species of the southern Appalachians – including *G. radiatum* (Godt et al. 2006). All four species were found to exhibit lower levels of genetic variation (defined as number of alleles per polymorphic locus) relative to the mean for other endemic plants, and three species (including *G. radiatum*) exhibited less genetic diversity at the species level than expected for endemic plants.

Genetic diversity within five *G. radiatum* populations was found to be comparable to the mean of other endemics, and positively associated with population size. The authors characterize the level of population differentiation as “moderate”. These authors did not observe significant correlations between genetic distance and geographic distance.

Recent rates of gene flow were calculated, finding low rates for all species, with the exception of the rate calculated using rare alleles in *G. radiatum*. However, they note that the calculation was based on a single, rare heterozygote and thus is not a robust estimate. They report significant deviations from Hardy-Weinberg expectations, with a general deficit of heterozygotes, and go on to suggest that this (in conjunction with other field observations by Johnson (Johnson 1995)) may be indicative of inbreeding depression in this species.

However, the study by Godt et al. (2006) did not include a robust characterization of fitness in individuals or populations of *G. radiatum*, and the suggestions of inbreeding depression are somewhat speculative. Two of these authors, Johnson and later Hamrick (1994) later advocated for a smaller site to be augmented with material from one of the larger populations, in an effort to boost levels of genetic variation in the smaller population. Their suggestions were debated within the scientific and resource management community (White 1994) and ultimately rejected in favor of augmenting with on-site stock (Johnson 1997).

3.1.4 Taxonomic classification or changes in nomenclature:

The USFWS is not aware of any such changes applicable to this species.

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

The recovery plan described the range of *G. radiatum* to consist of 11 extant populations distributed across Ashe, Avery, Buncombe, Mitchell, Transylvania, Watauga and Yancey counties, North Carolina and Carter and Sever counties, Tennessee. The county-level distribution of *G. radiatum* has not changed since the recovery plan.

The recovery plan alluded to five extirpated populations. Two of these have been rediscovered and confirmed extant (one in Ashe County, North Carolina and another along the Mitchell/Avery county line, also in North Carolina).⁷ Therefore, as of 2009, the number of suspected extirpated populations has been reduced from five to three.

The 11 extant populations known to the USFWS when the recovery plan was written were generally thought to consist of single occurrences (with no subpopulations), with the exception of Grandfather Mountain (two subpopulations) and Roan Mountain (four subpopulations). Thus, when the recovery plan was written, *G. radiatum* was thought to be distributed across 15 spatially discrete locations.

As of 2013, seven of the 15 extant populations consist of more than one subpopulation, with Grandfather Mountain containing seven subpopulations and Roan Mountain containing 18 extant subpopulations and one extirpated subpopulation (NCNHP 2013, TNNHP 2012). Thus the distribution of *G. radiatum* consists of eight populations consisting of a single known location and seven additional populations consisting of a collective total of 36 subpopulations. Because some subpopulations consist of an aggregation of still smaller (and semi-discrete) areas, the number of discretely mapped locations (as represented by Natural Heritage Program element occurrence records, for instance) is still greater (NCNHP 2013, TNNHP 2012).

3.1.6 Habitat

G. radiatum occupies high elevation (4500 to over 6000 ft. above sea level) rocky summits and cliffs in the southern Appalachians of western North Carolina and extreme eastern Tennessee. These rocky summits and cliffs usually appear as smaller-scale, patchy habitats embedded within a larger forested landscape consisting of spruce-fir or northern hardwood forest, or occasionally high elevation red oak forest. However, *G. radiatum* can also occur embedded within a larger matrix of grassy or heath bald habitat. In these conditions, the species is nearly always found over exposed bedrock or other rock outcroppings. However, at some sites (e.g., Phoenix Mountain and some areas at The Peak, as well as at the base of many other cliffs across the species' range) conditions appear to grade toward wet meadows, in which *G. radiatum* occurs over deep and accumulating soils in which competition from other herbaceous species can be particularly intense.

Wiser et al. (1998) explored the habitat requirements of four southern Appalachian endemic plant species (including *G. radiatum*) by devising predictive models of

⁷ Populations previously thought to be extirpated (and now confirmed extant) are The Peak and Bald Mountain (a.k.a. Yellow Mountain, Raven Cliffs), both in North Carolina. The species continues to be regarded as extirpated at Linville Falls and Green Mountain in North Carolina and Gregory Bald in Tennessee.

occurrence using parametric and nonparametric regression. They constructed models at two scales (100m² and 1m²), noting significant predictors for each species at each scale. They failed to find significant predictors (other than soil iron content) for *G. radiatum* at the 100m² scale, but found soil cations, potential solar radiation, percentage of exposed rock, and vegetation height to be significant predictors of this species' occurrence at the 1m² scale. Interestingly, elevation was not a good predictor for any species, suggesting other factors are more important than elevation *per se*.

Johnson (1995) also characterized the apparent habitat requirements of *G. radiatum* at coarse and fine scales. He notes that the species occurs over a range of rock types including schist, gneiss, and Anakeesta slate, on exposed rock outcrops ranging from 250m² to over 10,000m² (at Phoenix Mountain). Precipitation at these sites can exceed 2000 mm (78 inches) per year (Johnson 1995). Johnson (1995) also examined finer scale microhabitat requirements by analyzing presence/absence and percent cover (patch area) of *G. radiatum* along moisture and light gradients (using logistic regression and least squares multiple regression). He found presence and cover of *G. radiatum* significantly correlated with increasing moisture, with both parameters increasing in consistently wet or saturated soils. Contrary to the findings of Wisser et al. (1998) and his own expectations, Johnson did not find a positive association with increased light levels (Johnson 1995). Johnson explains this finding by noting that under field conditions, high moisture is frequently correlated with low light levels; in his models, when moisture levels were accounted for, light was no longer a significant predictive variable.

3.2 Five-Factor Analysis

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

Of the 15 extant populations of *G. radiatum*, 11 occur on publicly owned lands or lands otherwise managed for conservation. The remaining four grow on private, unconserved land. Although species-specific management agreements do not exist for the majority of these populations, every land owner is cooperative and has expressed willingness to work with the USFWS and its partners toward the management and recovery of this species. However, protection through public ownership can have unintended adverse consequences, in that areas can become subject to increased visitation by the recreating public. Trampling when recreating, rock climbing and rappelling is a significant threat to *G. radiatum*, having resulted or contributed to declines at portions of four populations.⁸ Portions of four populations have been formally closed to the recreating public as a means of last resort.⁹ Two of those four populations show some recovery. Four populations remain unprotected and in private ownership. Although these sites are not protected from development, they do receive comparably lower rates of visitation than sites in protective ownership which are open to the recreating public.

G. radiatum (or its ancestral taxon) presumably migrated southward along the peaks of the Appalachian Mountains during the Pleistocene glaciation (some 10,000 years ago).

⁸ The following four populations have suffered declines at least partially attributable to recreational trampling: Bluff Mountain, The Craggies, Mt. Craig, Roan Mountain west of Carvers Gap (at Roan High Bluff). The Craggies and Roan High Bluff west appear to have recovered, the other populations have not.

⁹ Portions of the following populations are closed to the public: The Craggies, Devil's Courthouse, Grandfather Mountain (at Hang Glide Cliff), and Roan Mountain west of Carvers Gap (Roan High Bluff and Eagle Cliff).

As the glaciers retreated and local temperatures began to warm, it apparently migrated upslope and now resides at the highest peaks in the southern Appalachians – and nowhere else in the world. However, the role of prior glaciation events in influencing the distribution of this taxon cannot be overlooked in considering the effects of accelerated climate change upon this taxon and the availability of its habitat.

The high elevation, exposed habitats occupied by *G. radiatum* are characterized by dense fog, high rainfall and perennial seepage. These sites are also subjected to harsh, extreme winters and high velocity winds – conditions which presumably exceed the tolerances of many species which would attempt to colonize these habitats. These extreme conditions also generate a disturbance pattern in which extensive sheets of ice form and then break free, in the process uprooting and dislodging the established vegetation (including occasional *G. radiatum* plants) upon which the ice has formed. Vegetation succession (primarily by woody species, but also by herbaceous plants) was identified as a threat to the species in the listing rule and recovery plan, and was examined in greater detail by Johnson (1995, Chapters 3 and 4).

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

This threat was mentioned in the listing rule and alluded to in the recovery plan. In 2012, it looked as if someone did dig up a *G. radiatum* plant near the parking area of Roan High Bluff (Mara Alexander, USFWS, personal observation, 2012). Weakley (2012) points to apparent over-collection by scientists, referencing what he regards as an excessive number of herbarium specimens from previously known sites. Thus, this threat remains a potential threat, but not an ongoing, concern.

3.2.3 Disease or predation:

This factor was not regarded as a significant threat to the species in the listing rule or recovery plan, and the USFWS has no additional information to suggest that it now poses a concern for the continued existence of *G. radiatum*.

3.2.4 Inadequacy of existing regulatory mechanisms:

This was acknowledged as a threat in the listing rule and recovery plan, and remains a threat to the species. State laws protecting rare plant species have limited authorities, and neither North Carolina nor Tennessee rare plant statutes protect the species from habitat destruction from recreational use on federal lands (where many populations occur and remain vulnerable to this threat). The North Carolina Plant Conservation and Protection Act (North Carolina Code Article 19B, § 106-202.12) provides limited protection from unauthorized collection and trade of plants listed under that statute. However, the statute does not protect the species or its habitat from destruction in conjunction with development projects or otherwise legal activities. *G. lineare* is protected under the Tennessee Rare Plant Protection Act of 1985 (T.C.A. 51-901), which forbids persons from knowingly uprooting, digging, taking, removing, damaging, destroying, possessing, or otherwise disturbing for any purpose, any endangered species from private or public land without the written permission of the landowner.

3.2.5 Other natural or manmade factors affecting its continued existence:

The listing rule identified small population size, limited genetic variation, woody succession, natural rock slides, severe storms or droughts, and the decline of spruce-fir forests as additional threats to the species. In reality, natural rock slides, severe storms or droughts and even limited decline of spruce-fir may also serve to open up additional areas of newly available habitat for an early successional species like *G. radiatum*. Thus, as with many factors the frequency and severity of these disturbance events needs to be better understood for a meaningful evaluation of their effects upon the continued existence of *G. radiatum*.

Accelerated global climate change is likely to disrupt patterns of climate variability to which *G. radiatum* has become adapted, and as such is likely to exacerbate threats already mentioned. However, the current scale of most global models of climate change offers little insight into the changes that will likely occur on southern Appalachian high peaks. While a net warming trend could exceed the tolerances of species adapted to cool, moist conditions, the current range of *G. radiatum* spans a range of conditions which vary widely in their degree of overall sun exposure, humidity, precipitation and soil moisture. The single largest population of the species, at Phoenix Mountain, has been described as notably drier, more exposed and lower in elevation (4430 ft.) than sites elsewhere throughout the species range (Johnson 1995). In reflecting upon this, Johnson theorized that droughts not exceeding the tolerances of *G. radiatum* may actually serve to inhibit the progression of other species advancing into its habitat, thus leaving more habitat open for colonization by this rare species. However, his data suggest that *G. radiatum* is strongly limited by moisture availability and both Johnson and Morgan (1980) noted that *G. radiatum* tends to show reduced vigor and even signs of premature senescence in drier, more exposed conditions (Johnson 1995, Morgan 1980). Thus most available data suggest that climatic disruptions significantly affecting the availability of soil moisture or above-ground seepage are likely to further threaten the long term viability of this high-elevation rock outcrop endemic.

4 Synthesis

Geum radiatum occurs in 15 extant populations distributed across North Carolina and Tennessee. This number (15) is one less than the total number of protected, self-sustaining populations called for in the current recovery criteria (USFWS 1993). Eleven of the 15 extant populations occur on publicly owned lands or lands otherwise managed for conservation. Eight of these 11 occur on lands open to the recreating public, where they remain vulnerable to threats from trampling, rock climbing and rappelling. Portions of four populations have been formally closed to the public as a result of prior or potential recreation-related impacts to this and other rare species. Four populations remain unprotected and in private ownership. Although these sites are not protected from development, they do receive comparably lower rates of visitation than sites in protective ownership which are open to the recreating public.

Across the range of the species, a lack of standardized and sufficiently representative population monitoring precludes straightforward assessment of population status and trends. Monitoring efforts which began in 2003 and since expanded to nine of the 15 known populations show great promise in assessing short term trends, the relative magnitude of site-specific threats, and help us define self-sustaining populations.

Accelerated global climate change threatens to further exacerbate identified threats to the species. However the exact nature of habitat changes likely to result from this threat is largely unknown and only speculative at the present time.

Since the recovery criteria have not been achieved, threats to the species remain (trampling, vegetation succession, poaching/collecting, and possible changes in climate patterns) and population status/trends are uncertain, this species continues to meet the definition of endangered. Therefore, no change in the species' status is recommended.

3.0 RESULTS

Recommended Classification:

 X No change is needed

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

If completed, the existing set of Recovery Tasks identified for this species would ensure the recovery of this species. Rather than drafting additional action items, those Recovery Tasks deemed most urgent and most likely to deliver the greatest end result have been identified and listed in order of relative priority here.

1. Continue annual demographic monitoring at as many sites as possible, including (but not limited to) those nine populations already included in ongoing monitoring efforts (*Recovery Tasks 2.1, 2.3 and 2.5*).
2. Work with NCNHP and TNNHP to satisfactorily incorporate results from prior survey efforts into their respective databases (*Recovery Task 1.2*).
3. Conduct reconnaissance surveys to verify population sizes at exceptionally large sites (e.g., Phoenix Mountain, Three Top, The Peak) and to verify apparent or suspected declines at other sites (e.g., Cliff Top, Potato Hill, Grassy Ridge east of Carvers Gap (Big Roan Ridge subpopulation)).
4. Work with TNC and other appropriate partners to evaluate protection alternatives at remaining unprotected sites (e.g., Hanging Rock, Phoenix Mountain, Potato Hill, Yellow Mountain (Raven Cliffs)), including the use of voluntary landowner agreements (*Recovery Task 1.4*).
5. Compile quantitative data summarizing transplant survivorship across all previously attempted introduction or augmentation efforts involving this species, and evaluate causes for success/failure (*Recovery Task 2.7*).
6. Work with appropriate partners to place representative genetic material in long-term storage, and to evaluate long-term storage requirements for this species (*Recovery Task 3*).
7. Collaborate with appropriate partners to begin stepping down global climate change models to a meaningful scale for purposes of projecting impacts to high elevation southern Appalachian rocky summits and cliffs. Devise and evaluate potential adaptation scenarios for *G. radiatum* (*Recovery Task 1.4*).

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Spreading avens (*Geum radiatum*)

Current Classification: Endangered

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: Carolyn Wells (originally) and Mara Alexander (completed final document), Asheville Ecological Services Field Office, Asheville, NC.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve  Date 2/15/13

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve  Date 3/8/13

Appendices

Appendix A
Summary of peer review for the 5-year review of the
spreading avens (*Geum radiatum*)

- A. Peer Review Method:** A draft 5-year review was sent to 13 biologists who have extensive knowledge of this and similar species, as an attachment to an email, requesting their review and any other changes or additions that should be included in the document. These reviewers were from the U.S. Forest Service, National Park Service, North Carolina Department of Natural Resources, The Nature Conservancy, Tennessee Department of Environment and Conservation, and the North Carolina Department of Agriculture.
- B. Peer Review Charge:** Reviewers were charged with providing a review of the document, including any other appropriate comments and/or additions. Reviewers were not asked to comment on the legal status of the species.
- C. Summary of Peer Review Comments/Report:** Reviewers responded by email. All reviewers thought the information in the document provided to them was accurate.
- D. Response to Peer Review:** Recommendations from the reviewers were incorporated into the document as appropriate. These consisted primarily of additional information concerning the status of certain populations, threats to the species, and recommendations for future actions.

Appendix B

Table B.1. Population summary and cross-walk between populations as recognized by USFWS and NHP Element Occurrence records.

USFWS population number	State	County	FWS population (site)	NHP EO number	Ownership
1	NC	Avery	Grandfather Mountain (near Calloway Peak)	NCHP*44.014	NC State Parks
1	NC		Grandfather Mountain (near Raven Rocks)	NCHP*44.018	NC State Parks
1	NC		Grandfather Mountain (Hang Glide Cliff)	NCHP*44.003	Grandfather Mountain Foundation
1	NC		Grandfather Mountain (Swinging Bridge)	NCHP*44.002	Grandfather Mountain Foundation
2	NC	Avery, Watauga	Hanging Rock	NCHP*016	Private (unconserved)
3	NC	Avery	Roan Mountain (east of Carvers Gap)	NCHP*004	USFS
4	NC, TN	Mitchell, Carter	Roan Mountain (west of Carvers Gap)	NCNP EORS: 36.008-.011, 36.020-36.022, 36.024, 36.027-.039, 36.046-.048	US Forest Service
				TNHP EORS: 004, 005, 007	
5	NC	Avery, Mitchell	Raven Cliffs	NCHP*023	Private (unconserved)
6	NC	Watauga	Potato Hill	NCHP*017	Private (unconserved)
7	NC	Ashe	The Peak	NCHP*015	NC State Parks
8	NC	Ashe	Three Top	NCHP*006	NC Wildlife Resources Commission
9	NC	Ashe	Bluff Mountain (Perkins Rock)	NCHP*001	TNC
9	NC		Bluff Mountain (Saddle Pile Rock)		
10	NC	Ashe	Phoenix Mountain	NCHP*012	Private (unconserved)
11	NC	Yancey	Mt. Mitchell (Mt. Craig)	NCHP*005	NC State Parks
12	NC	Buncombe	The Craggies (Pinnacle)	NCHP*26.041	National Park Service, Blue Ridge Parkway
12	NC		The Craggies (East Cliff)	NCHP*26.043	
12	NC		The Craggies (West Cliff)	NCHP*26.042	
13	NC	Transylvania	Devils Courthouse	NCHP*013	
14	NC	Haywood	Waynesville Watershed (Lickstone Ridge)	NCHP*040	Town of Waynesville
15	TN	Sevier	Mt. LeConte (Cliff Top)	TNHP*002	National Park Service, Great Smoky Mountains National Park

**5-YEAR REVIEW OF SPREADING AVENS
(*Geum radiatum*)**

Addendum 1. Summary of new information obtained since the 2013 5-year review.

The *Federal Register* notice announcing the initiation of this 5-year review was published on April 11, 2019 (84 FR 14669). No comments were received during the 60-day public comment period following this notice. However, the US Fish and Wildlife Service (Service) received additional information about the species, from biologists familiar with the species, in response to requests for specific information.

Updated information is presented below. Internal review was conducted by four members of the Service's Southeast Region. Additionally, the Service conducted independent peer review of new information (see Appendix A of this addendum). The Service sought review from eight knowledgeable experts on this species and its habitats. Comments have been addressed and incorporated into this addendum as appropriate and necessary.

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Region: Southeast Region, Kelly Bibb, (404) 679-7132.

Lead Field Office: Asheville Ecological Services, Rebekah Reid, (828) 258-3939.

Cooperating Field Office: Tennessee Ecological Services, Geoff Call, (931) 525-6481.

1.3 Background

- 1. Federal Register Notice citation announcing initiation of this review:** 84 FR 14669; April 11, 2019.
- 2. Species Status:** Declining. Currently, survey sites support spreading avens (*Geum radiatum*) at slightly less than replacement level (death rate is slightly higher than recruitment rate) indicating nearly stable demography under current conditions, but with a slow decline (Ulrey *et al.* 2016). The total number of populations has remained the same since the 2013 5-year review (NCNHP 2019a, TNHP 2019). Reference Section 3.1.2 for additional information regarding species status and trends.
- 6. Review History:** The Service finalized a 5-year review for spreading avens in 2013. The review recommended the species remain classified as endangered due to trampling, vegetation succession, poaching/collecting, possible changes in climate patterns, and uncertain status and trends (Service 2013). Each year, the Service reviews and updates listed species information for inclusion in the required Recovery Report to Congress. Through 2013, the Service conducted a recovery data call that included status recommendations for this species. We continue to show this species' status

recommendation as part of our 5-year reviews. The last review for this species to inform the Recovery Report to Congress was conducted in 2019.

2.0 REVIEW ANALYSIS

2. Recovery Criteria

2.3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met:

Criterion 1. It has been documented that at least 16 self-sustaining populations exist and that necessary management actions have been undertaken by the landowners or cooperating agencies to ensure their continued survival (Service 1993).

Criterion 2. All of the above populations and their habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations (Service 1993).

Criterion 1 and 2 are interrelated and are discussed together. As of 2019, there are 15 extant populations of spreading avens in North Carolina and Tennessee (NCNHP 2019a, TNHP 2019). An ongoing demographic study initiated from 2003-2009, which includes nine populations of spreading avens (whole or in part) and subsequent demographic modeling show that survey sites support spreading avens at slightly less than replacement level. This indicates nearly stable demography under current conditions, but with a slow decline (Ulrey *et al.* 2016). Niche (species distribution) modeling, using different climate change scenarios and timeframes, shows favorable climatic conditions are expected to drop below current minimum suitability criteria in 58%-83% of survey sites by 2050 or 2080 (Ulrey *et al.* 2016). Sustainability of populations in the future, given predicated climate change, is uncertain. Reference Section 3.2.5 for additional information.

At the time of the 2013 5-year review, 11 of 15 spreading avens populations were owned and managed by natural resource agencies and/or conservation organizations (Service 2013). Currently, 13 of the 15 extant spreading avens populations are in conservation ownership (NCNHP 2019a, TNHP 2019). Preservation of the two additional populations includes registration of a private property as a Registered Heritage Area and purchase of property by the State of North Carolina and The Nature Conservancy (TNC). A Registered Heritage Area is a voluntary agreement protecting outstanding examples of natural diversity and preserves populations of endangered, threatened, rare, or important plant and animal species (NCNHP 2019b). Although progress has been made protecting populations, previously identified threats still affect spreading avens. Recreational impacts to areas where spreading avens grows is still occurring and expected to increase, and predicted climate change may render current habitat less suitable for the species in the future. Land protection alone does not abate these threats. Reference Sections 3.2.1 and 3.2.5 for additional information.

3. Updated Information and Current Species Status

3.1 Biology and Habitat

3.1.2 Abundance, population trends, demographic features, or demographic trends: The listing rule and recovery plan recognized 11 extant populations of spreading avens and the 2013 5-year review recognized 15 extant populations; however, there is no estimation of total abundance in these documents (Service 1990, Service 1993, Service 2013). Population size estimates were difficult to determine because of inconsistency in monitoring methods and counting units among observers, along with partial counts that did not include all occupied or suitable habitat. Habitat preference, including rugged, high elevation rock outcrops and vertical to near-vertical cliffs, make surveys difficult and many plants are inaccessible.

The National Park Service, Blue Ridge Parkway (BLRI), US Forest Service (USFS), North Carolina State Parks (Mt. Mitchell, Grandfather Mountain, and Elk Knob), and the Service have been working together to consistently monitor nine populations (whole or in part), including 20 survey sites (Ulrey *et al.* 2016). Monitoring efforts were initiated from 2003-2009, with survey sites having 10-16 years of annual monitoring data to date (from initiation through 2019). Demographic characteristics of plants such as length and width of canopy, number of rosettes, and number of flowering stems are tracked annually within survey sites. A complete annual census occurs at 17 survey sites while three sites are sampled due to inaccessibility or safety concerns. At sample sites, all safely accessible plants are monitored each year. Eight hundred and sixty-two plants are included in the demographic study and Ulrey estimates that approximately 98% of known plants at survey sites are monitored each year (Ulrey 2019, BLRI, pers. comm.). Monitoring has shown that smaller plants have lower survival rates than larger plants, and larger plants rarely died, with an average year-to-year adult survival rate of over 90% (Ulrey *et al.* 2016). Individual plants could grow or shrink in canopy area or number of rosettes, and when all plants were considered, there was not a consistent increase in size from year to year. However, smaller plants did show consistent growth over time, with single rosette plants doubling in size approximately every four years (Ulrey *et al.* 2016). Among survey sites, 21-85% of plants flowered. Probability of flowering was dependent on plant canopy area, with larger plants blooming more frequently. Flowering status in successive years was inconsistent for small and medium plants but consistent for larger plants (Ulrey *et al.* 2016). Seedling recruitment was rarely observed, with fewer than five seedlings observed annually across all survey sites. Seedling survival was moderate, averaging 25% over the first three years (Ulrey *et al.* 2016). Monitoring at survey sites is expected to continue into the future.

Currently, survey sites support spreading avens at slightly less than replacement level indicating nearly stable demography under current conditions, but with a slow decline (Ulrey *et al.* 2016). Ulrey *et al.* (2016) modeled effects of different levels of seedling recruitment on current population growth rate. Depending on habitat, 20-70 seedlings would need to be added across the range each year to bring population growth rates to replacement level.

In 2018, a Ph.D. graduate student at North Carolina State University began working on unmanned aerial system (UAS), also known as drone, identification of rare plant species. This project is currently focusing on spreading avens at Roan Mountain, with the intention of expanding the process to identify other federally listed species. The project utilizes machine learning, UAS, and computer vision to find the locations of plants in previously inaccessible areas. Machine learning and species distribution modeling identify probable plant locations based on environmental characteristics and an automated program plans optimal UAS flight patterns from the modeling results. Data collected from UAS flights is subsequently used to perform computer vision analysis, which can identify plant locations (Reckling 2019). This project is ongoing.

3.1.3 Genetics, genetic variation, or trends in genetic variation: A recent genetic study sampled 310 individuals in 14 of the known spreading avens populations and used microsatellite markers to measure genetic diversity and population structure (Hay *et al.* 2019). The analysis demonstrates there is diversity within and among populations, and spreading avens has more genetic diversity and population structure than previously reported. Analysis strongly suggests four genetic clusters across three geographical areas. Populations in the northern portion of the range, known as the Amphibolite Mountains Macrosite (AMM), contains one genetic cluster with little differentiation, even over multiple mountaintops. The central and southern portions of the range contain three genetic clusters and have greater differentiation between populations when compared to the northern AMM populations. Due to past augmentations, the Roan Mountain population, in the center of the species range, contains all genetic clusters identified in the analysis, with the highest amount of diversity and the least differentiation from other populations. Additionally, the analysis was able to differentiate transplanted individuals and admixed individuals within the population.

Hay *et al.* (2019) highlight the risk of augmenting populations with unknown genotypes, which can result in outbreeding depression (reduction of fitness because of crossing genetically distant populations). Although augmentations at Roan Mountain in the 1990s increased diversity, it is unknown if augmentations increase the species' chances of long-term survival. Additional analysis is needed to determine if outbreeding depression is occurring at the Roan Mountain population.

Because seedling recruitment is exceptionally low (Ulrey *et al.* 2016), loss of a single plant could mean loss of unique genetic make-up for populations as a whole. Hay *et al.* (2019) suggests ensuring long-term species survival and genetic diversity by continuing current protections and limiting recreational development and use around populations. Hay *et al.* (2019) identifies the most important targets for conservation as the AMM populations, which are genetically unique and interbreeding between mountaintops and the Roan Mountain population, which contains the best overall representation of the genetic diversity, containing all four genetic clusters identified in the species.

3.1.4 Taxonomic classification or changes in nomenclature: The Service is not aware of any changes in taxonomic classification or nomenclature since the 2013 5-year review.

3.1.5 Spatial distribution, trends in spatial distribution, or historic range: The 1990 listing rule and 1993 recovery plan identified the species range as including seven North Carolina counties (Ashe, Avery, Buncombe, Mitchell, Transylvania, Watauga, and Yancey) and two Tennessee counties (Carter and Sevier). The 2013 5-year review noted that county-level distribution had not changed; however, a population in Haywood County, North Carolina was first observed in 2006 (NCNHP 2019a); therefore, the current species range includes eight North Carolina counties and two Tennessee counties.

3.1.6 Habitat or ecosystem condition: Ulrey *et al.* (2016) placed portable weather stations at five survey sites from 2010-2014 as part of their demographic and climate study. The stations collected temperature and relative humidity data every 20 minutes. Data were then scaled up to monthly, seasonal, and annual averages. The local weather at study sites during the observation period was cool and humid. Temperatures averaged 42–48 °F (6–9 °C) among sites for the entire year and were very seldom above 75 °F (24 °C). Relative humidities averaged 78–90% among sites for the entire year, but were generally above 90% at most sites during the growing season. High relative humidities were likely due to a combination of frequent fog, ground water seepage, and limited direct sunlight on north facing cliffs. Sites varied in local weather, which reflected the elevation, aspect, and relative shelter at each site. The overall local weather reflects high elevation, northerly aspect, and generally steep slopes.

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

3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range: The listing rule cites succession; trampling, soil erosion, compaction, and other forms of habitat disturbance due to heavy recreational use of habitat; and development for commercial recreational facilities and residential purposes as primary threats to the species (Service 1990). These threats are still present.

Of the 15 extant populations of spreading avens, 13 occur on publicly or privately owned lands that are managed for conservation (NCNHP 2019a, TNHP 2019). Eight populations have public access and landowners include Grandfather Mountain Stewardship Foundation, North Carolina State Parks (Grandfather Mountain and Mt. Mitchell), USFS (Pisgah and Cherokee National Forests), North Carolina Wildlife Resources Commission (Three Top Mountain Game Lands), and National Park Service (BLRI and Great Smoky Mountains). Five populations are not accessible to the public and landowners include a private landowner (property is a Registered Heritage Area with the NCNHP), Elk Knob State Park (area with spreading avens has no public access at this time), and land trusts (TNC and Southern Appalachian Highlands Conservancy (SAHC)). Although these 13 populations are on protected land and managed for conservation, the threats referenced above are still present and affecting populations.

The Watagua County Tourism Development Authority commissioned a multi-use trail master plan, finalized in 2017, to link Howard Knob and Elk Knob in Watauga County to Three Top Mountain and Mount Jefferson in Ashe County (Sherrill 2019). The proposed trail, roughly 40 miles long and known as the Northern Peaks State Trail, includes proposed routing through Three Top Mountain Game Lands and Elk Knob State Park, sites containing spreading avens (Destination by Design (DBD) 2017). Additionally, the trail includes proposed routing through the Tater Hill Plant Conservation Preserve (DBD 2017), which has spreading avens immediately adjacent to the preserve (on private property) (NCNHP 2019a). The portion of Elk Knob State Park containing spreading avens is inaccessible to the public and the Tater Hill Plant Conservation Preserve is accessible only by permit. In 2019, the North Carolina General Assembly authorized the North Carolina Department of Natural and Cultural Resources to add the Northern Peaks State Trail to the North Carolina State Parks system as a State Trail. This allows the State to receive donations of land and purchase needed tracts with existing State, Federal, and other funds (Sherrill 2019). While the exact route has not been finalized and access may not be granted to all desired locations, the proposed trail still poses a significant threat to spreading avens, and other rare species and habitats previously inaccessible to the public. The trail master plan (DBD 2017) estimates between 146,060-219,090 unique visitors will use the trail each year. These figures assume that a visitor only visits once per year. According to the 2015 North Carolina State Parks System-wide Plan, the majority (64%) of park users visit a North Carolina State Park at least three time per year. If this holds true, the number of visitors to the Northern Peaks State Trail could be significantly higher than estimated (DBD 2017). Currently, the minimal impacts to plants at Elk Knob State Park and the Tater Hill Plant Conservation Preserve from recreational use is a by-product of the remote and inaccessible character of these areas. This character should be maintained to ensure continued existence of the species.

In 2019, a trail counter was installed along a popular trail leading to an overlook along the BLRI. There is a population of spreading avens adjacent to the overlook and it is common for visitors to trample plants and habitat by jumping over stone barriers (low walls) delineating the viewing area. In 2019, the trail and overlook received 47,388 visitors between May 23 and August 20 (Ulrey 2019a, BLRI, pers. comm.). The fall season generally has the most visitors to the trail and overlook, and BLRI personnel estimate an additional 20,000 visitors to the area from August 21 to the end of October (Ulrey 2019b, BLRI, pers. comm.). To manage and monitor visitor use of the area, the BLRI tested a volunteer program during fall of 2018 and after a successful season, expanded the program to include dates from Memorial Day to the end of October in 2019. Uniformed volunteers staff the overlook in two, four-hour shifts. Duties include education and outreach, and ensuring compliance with signage and barriers. In 2019, the volunteers served over 1,200 hours and had contact with 12,166 visitors from Memorial Day to the end of October, approximately 18% of the total estimated number of visitors (Ulrey 2019b, BLRI, pers. comm.). In June of 2019, BLRI staff installed three indicator plots with coir matting and common plants to observe the level of trampling adjacent to the overlook (Ulrey 2019a, BLRI, pers. comm.). Observations were used to determine appropriateness of potential spreading avens augmentation efforts in the future. Two plots were installed on the main rock adjacent to the designated overlook and one plot

was installed in a “safe zone” where trampling was not expected. By the end of summer, all plots had been trampled (Ulrey 2019a, BLRI, pers. comm.). Augmentation of the existing spreading avens population is not prudent in this location until visitor use can be better controlled at and adjacent to the overlook. BLRI staff have discussed strategies to reduce the number of visitors to the area (reduction in parking, trail closures, etc.); however, these actions are not currently under consideration (Ulrey 2019a, BLRI, pers. comm.).

Roan Mountain, a feature of the Pisgah and Cherokee National Forests, is a popular recreational destination. Roan Mountain is home to two populations of spreading avens (NCNHP 2019a, TNHP 2019). A Roan Stewardship Committee was established to foster partnerships and share knowledge and resources to benefit the Roan Highlands (including Roan Mountain). Member organizations, including agencies, work on many projects throughout the year. Examples of projects benefiting spreading avens include camping closures and campfire bans, outreach, and trail work. The SAHC has been collaborating with the USFS, Appalachian Trail Conservancy (ATC), Service, and a local hiking club to establish a camping closure and campfire ban in sensitive habitats at Roan Mountain (Crockett 2019a and 2019b, SAHC, pers. comm.). These actions will benefit spreading avens, and other rare species and habitats east of Carver’s Gap. The camping closure should be in place by spring of 2020 and the campfire ban to follow in spring of 2021. SAHC and ATC employ a Roan Naturalist each year during the peak summer season. The primary responsibilities of the naturalist are to educate hikers about the sensitive ecology in the Roan Highlands, teach Leave No Trace outdoor ethics to minimize recreational impacts, and perform basic ecology and stewardship functions to support management programs for grassy balds and open areas. The Roan Naturalist engages 7,500-10,000 trail users each season (Crockett 2019c, SAHC, pers. comm.). The ATC, USFS, and Service are working together to steward a population of spreading avens along the Appalachian Trail at Roan Mountain. It was brought to the group’s attention that spreading avens was being trampled as hikers stepped into the vegetated area upslope of the trail to avoid a wet spot in the trail (Donaldson 2017, Eastern Tennessee State University, pers. comm.). Additionally, encroaching vegetation was shading plants in that location. The ATC coordinated the placement of large boulders to divert hikers away from plants and habitat upslope of the trail (Drury 2017, ATC, pers. comm.), and the USFS removed encroaching vegetation and placed a rope barrier with signage indicating the area upslope of the trail was closed (Stoehrel 2018, USFS, pers. comm.).

Visitation at Roan Mountain is high, although difficult to quantify. Limited data (number of visitors) is collected when visitors enter the USFS fee area (accessed from Forest Service Road 130) and pay for day use of the area; however, because the pay station is usually unstaffed, the compliance rate is generally 60-70% (Fruchey 2019, USFS, pers. comm.). With available data, an estimated 36,000 visitors use the fee area each year from May 1 to October 31 (McFee 2019, USFS, pers. comm.). In addition to not capturing all visitors using the fee area, there is no official tracking of visitors using Carver’s Gap (outside of the fee area) to access the area; however, it is estimated that Carver’s Gap averages 40-50 cars per day (Fruchey 2019, USFS, pers. comm.). Usage peaks around the annual Rhododendron Festivals (one in North Carolina and one in

Tennessee) in June when thousands of visitors flock to Roan Mountain to see blooming rhododendrons and azaleas (Crockett 2019c, SAHC, pers. comm.). Visitation to the area is expected to increase due to promotion of the area as a tourist destination by local municipalities and social media exposure (Crockett 2019c, SAHC, pers. comm.). Visitors to Roan Mountain often create social trails or disregard closure orders and designated viewing areas (Service 2013). Social trails are unofficial trails leading to views, camping sites, or other destinations. Many of these areas include rare species and sensitive habitats. The unintended consequence of high visitation, social trails, and disregard for closure orders is negative impact to these areas.

The listing rule cited natural rockslides as another potential threat to spreading avens (Service 1990). In 2018, a rockslide occurred at one Roan Mountain survey site and four plants were lost (Ulrey 2019b, BLRI, pers. comm.). Considering low seedling recruitment (Ulrey *et al.* 2016), lost plants may not be naturally replaced.

3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes: In 2018, the Service and USFS were made aware of unauthorized seed collection from spreading avens at Roan Mountain (Reid 2018). Although the individual's initial intent is unclear, plants were offered to, but declined by, a private entity for use at their site. Status of the plants is unknown. Because seedling recruitment is low (Ulrey *et al.* 2016), unauthorized collection of seed could be detrimental to the species.

3.2.3 Disease or predation: Currently, spreading avens is not known to be threatened by disease or predation.

3.2.4 Inadequacy of existing regulatory mechanisms: In addition to the regulations referenced in the 2013 5-year review, there are other regulations and policies that protect plants on USFS property. USFS regulation 36 CFR 261.9 prohibits removing or damaging any plant species that is classified as threatened, endangered, sensitive, rare, or unique (USFS 2003). Additionally, Forest Service Manual 2673 establishes policy that prohibits the removal and collection of any threatened or endangered plants on USFS lands under Federal jurisdiction, except when authorized by permits (USFS 2009). Although these regulations and policies should protect spreading avens on USFS property, lack of resources prevents adequate compliance monitoring and enforcement.

3.2.5 Other natural or manmade factors affecting its continued existence: Plants existing in small and isolated populations, such as spreading avens, often depend on microclimatic refugia buffered from macroclimatic conditions (Ulrey *et al.* 2016). Because high elevation species already occur at their environmental limit, the ability of refugia to protect these species from climate change is under question. Ulrey *et al.* (2016) evaluated the ability of current refugial habitats of spreading avens to continue to serve as refugia under present and future climatic conditions. They combined two approaches to measure the biological effectiveness of presumed refugia for spreading avens. First, they used demographic models to estimate population growth and relate the growth to relative humidity (a key climatic parameter). Second, they developed

macroclimatic niche models that are sensitive to microtopographic features associated with the locally buffered climates favored by spreading avens. By comparing model predictions, they evaluated the current ability of climate refugia to support viable populations of spreading avens and determine whether these refugia are likely to buffer the species from altered conditions given anticipated climate change. Niche models predicted that all survey sites would have reduced climatic suitability by 2050 or 2080, with 58–83% of sites falling below minimum suitability levels, depending on the climate scenario. Spreading avens' has nearly stable demography under current conditions; however, it is extremely vulnerable to projected climate change even within its current refugial habitats (Ulrey *et al.* 2016). This study demonstrates climate refugia that currently buffer rare species from macroclimatic extremes may not be able to do so under anticipated climate change.

4. Synthesis

Spreading avens should remain classified as endangered. The distribution of this narrow-ranging endemic has not changed since the last 5-year review. Eight of the 15 populations have readily accessible public access, impacts from recreational use remain a threat, and a newly proposed trail may provide access to previously inaccessible sites. Despite nearly stable demography, spreading avens' persistence into the future is uncertain if predicted changes in climate occur. Successful management strategies that significantly reduce or eliminate these threats have yet to be determined. Data and information outlined in this review highlight the need for continued management and monitoring throughout the range and show spreading avens continues to meet the definition of an endangered species under the Endangered Species Act.

3.0 RESULTS

Recommended Classification: No change is needed.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

The 2013 5-year review included a list of recommendations to improve recovery of the species. These actions (7), listed below, remain applicable to species recovery.

- Continue annual demographic monitoring at as many sites as possible, including (but not limited to) those nine populations already included in ongoing monitoring.
- Work with NCNHP and TNHP to satisfactorily incorporate results from prior survey efforts into their respective databases.
- Conduct reconnaissance surveys to verify population sizes at exceptionally large sites and to verify apparent or suspected declines at other sites.
- Work with TNC and other appropriate partners to evaluate protection alternatives at remaining unprotected sites including the use of voluntary landowner agreements.
- Compile quantitative data summarizing transplant survivorship across all previously attempted introduction or augmentation efforts involving this species, and evaluate causes for success/failure.

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- Work with appropriate partners to place representative genetic material in long-term storage, and to evaluate long-term storage requirements for this species.
- Collaborate with appropriate partners to begin stepping down global climate change models to a meaningful scale for purposes of projecting impacts to high elevation southern Appalachian rocky summits and cliffs. Devise and evaluate potential adaptation scenarios for spreading avens.

Additional future actions, in light of new information, are recommended below.

- Work with partners to investigate/research potential outbreeding depression at Roan Mountain populations.
- Continue working with and supporting partners to quantify visitor use and identify visitor use patterns to prioritize management that would minimize recreational impacts to the species.
- Continue working with and supporting North Carolina State University to identify rare species using UAS (drone).
- Formalize an agreement (Memorandum of Understanding or other appropriate agreement) to continue demographic monitoring at spreading avens survey sites.
- Develop a plan for conserving the species in ex-situ collections – either through conservation gardens or seed banking.
- Spreading avens co-occurs with other federally listed species. Impacts from monitoring could inadvertently occur if field staff conducting monitoring are unaware of other species present or how to identify them. Tailgate meetings should occur prior to each monitoring event when species co-occur. Field staff should be briefed on species present, how to identify them, and strategies for avoidance.

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US FISH AND WILDLIFE SERVICE

5-YEAR REVIEW OF SPREADING AVENS

Current Classification: Endangered.

Recommendation resulting from the 5-Year Review:

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

Review Conducted By: Rebekah Reid, Asheville Ecological Services Field Office.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve JANET MIZZI Digitally signed by JANET MIZZI
Date: 2020.03.17 12:23:00 -04'00'

Date _____

APPENDIX A

Summary of peer review for the 5-year review of spreading avens (*Geum radiatum*).

- A. **Peer Review Method:** Peer review was coordinated by the Service's Raleigh Ecological Services Field Office in North Carolina. Eight peer reviewers were selected by the Service for their knowledge of and expertise with spreading avens. Individual responses were received from four of the eight reviewers. Additionally, internal review was conducted by four members of the Service's Southeast Region.
- B. **Peer Reviewers:** The peer review request included personnel from:
Appalachian State University (ASU)
National Parks Service-Blue Ridge Parkway (BLRI)
NC Natural Heritage Program (NCNHP)
NC Plant Conservation Program (NCPCP)
Southern Appalachian Highlands Conservancy (SAHC)
US Forest Service (USFS, Pisgah and Cherokee National Forests) – three reviewers
- C. **Peer Review Charge:** Reviewers were asked to conduct a scientific review of technical information presented. Reviewers were not asked to review the legal status determination.
- D. **Summary of Peer Review Comments:** Peer reviewers from SAHC and USFS did not respond to the request for review. The peer reviewer from NCNHP had no comments. Peer reviewers from ASU, BLRI, and NCPCP provided comments. A brief summary of substantive comments is below:
- The reviewer from ASU provided information about the proposed Northern Peaks State Trail. Comments support conclusions in the review and changes to the review are not necessary.
- The reviewer from BLRI recommended future actions related to ongoing demographic monitoring and ex-situ conservation. We support these actions and they are now included in Section 4.0.
- The reviewer from NCPCP asked many clarification questions which when addressed improve the document. The NCPCP reviewer also provided information regarding access to plant conservation preserves. Additional information was added throughout the document where appropriate.
- E. **Response to Peer Review:** All substantive comments received were reviewed by the Service and incorporated into a revised version of this document, where appropriate.