Heller's blazing star
(*Liatris helleri*)

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 review was initiated in the Federal Register (June 20, 2019, 84 FR 28850) and provides the limited new information we have gathered for our second 5-year review for this threatened plant. The addendum shares our analysis to explain the basis for continuing to recommend no change in status for this species.

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LIST OF ABBREVIATIONS

AFO	Asheville Field Office, U.S. Fish and Wildlife Service
ASU	Appalachian State University
BRP	Blue Ridge Parkway
EOR	Element Occurrence Record (a mapping unit commonly used by Natural Heritage Programs)
FR	Federal Register
NCNHP	North Carolina Natural Heritage Program
NPS	National Park Service
NPS-BRP	National Park Service, Blue Ridge Parkway
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service

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I. GENERAL INFORMATION

A. Methodology used to complete the review: We announced initiation of this review and requested information in a published *Federal Register* notice with a 60-day comment period on July 6, 2009 (74 FR 31972). Pertinent data were obtained from the recovery plan, published papers and unpublished reports on this species, and experts familiar with this species. Once all data were gathered for this species, the status information was compiled and the review was completed by the species' recovery lead biologist in the U.S. Fish and Wildlife Service's (USFWS) Asheville Ecological Services Field Office (AFO) in Asheville, North Carolina. In conducting this 5-year review, we relied on the best available information pertaining to historical and current distribution, life history, habitats, and potential threats to this species. During the comment period, we did not receive any additional information about *Liatris helleri* in response to the *Federal Register* notice. However, we did receive additional information about the species in response to requests for specific information that were made (by the USFWS) directly to biologists familiar with the species. A draft of the 5-year review was peer reviewed by three 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.

B. Reviewers.

Lead Region: Southeast Region, Erin Rivenbark (assisting in recovery), 706/613-9493 ext. 234; Kelly Bibb 404/679-7132

Lead Field Office: Asheville ESFO, Asheville, North Carolina – Carolyn Wells (originating author; moved to a new office and position), Mara Alexander (new lead) 828/258-3939, Ext. 238.

C. Background:

1. ***Federal Register* Notice citation announcing initiation of this review:** July 6, 2009 (74 FR 31972)

2. **Species status:**
Declining. The remaining extant populations continue to be threatened by recreational use or poaching.

3. **Recovery achieved:**
1 (1 = 0-25 percent of species' recovery objectives achieved).

4. **Listing history**

   Original Listing
   FR notice: 52 FR 44397
   Date listed: November 19, 1987
   Entity listed: species
   Classification: threatened

5. **Review History:**
   The Service conducted a five-year review for Heller's blazing star 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 the Service 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 propose a rule to modify the species' status. No change in the plant's listing classification was found to be appropriate.
   Recovery Plan: 2000
   Recovery Data Call: 2013 - 1998

6. **Species' Recovery Priority Number at start of 5-year review (48 FR 43098):** 8 (a species with a moderate degree of threat and a high recovery potential)

7. **Recovery Plan:**
   Name of plan: Recovery Plan for *Liatris helleri* T.C. Porter (Heller's blazing star)
   Date issued: January 28, 2000 (1st revision)
   Dates of previous plans, if applicable: May 1, 1989 (Original)

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy: The Endangered Species Act (ESA) defines species as including any subspecies of fish or wildlife or plant, and any distinct population segment (DPS) of any vertebrate fish or wildlife that interbreeds when mature. This definition limits listing a DPS to only vertebrate species of fish and wildlife. Because the species under review is a plant, the DPS policy does not apply.

B. Recovery Criteria

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

2. **Adequacy of recovery criteria.**

   a. **Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?** No. The recovery criteria are based upon a global distribution of eight extant populations; there are now 11 extant populations of the species (Appendix B, Table B.1). More significantly, Nesom (2005) has questioned whether *Liatris helleri* T.C. Porter (1891) and *L. turgida* Gaiser (1946) are valid and distinct species, proposing that these should be treated as a single taxon (*L. helleri*, because this name has nomenclatural seniority). This issue has not been resolved but is discussed in Section II. C. 1. d. (Taxonomic classification or changes in nomenclature).

   b. 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 four listing factors identified as significantly affecting the status of the species in the listing rule (habitat loss, overutilization, the inadequacy of existing regulatory mechanisms, and other natural or manmade factors). There are no new threats affecting the species beyond those mentioned in the listing rule and the recovery plan, although some existing threats to the species are or appear to be increasing in severity and scope (e.g., poaching and drought). Accelerated global climate change is expected to exacerbate those threats already identified. Threats are discussed in Section II. C. 2. (Five-Factor Analysis).

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: The eight extant populations are protected.

   Criterion has been met as currently worded, but should be reevaluated to consider all extant populations (now 11; Appendix B, Table B.1) when appropriate. This increase in the number of known populations is a result of the discovery of two new populations, and a revision to the delineation of three populations counted in the recovery plan. One of the three populations delineated and counted differently than in the recovery plan is here regarded as three separate populations due to the distance among occupied locations (all are within Linville Gorge), and two other populations counted separately in the recovery plan are here treated as a single population due to their proximity (at Grandfather Mountain).

   Eight of the 11 extant populations of *Liatris helleri* are in a form of protective ownership by federal or state agencies, or private conservation partners (Table B.1). The remaining three occur on private lands and are not subject to any form of protection.

Criterion 2: Any necessary management actions have been undertaken for these populations by the landowners or cooperating agencies and it has been documented that this management is successfully ensuring the continued survival of these populations.

Criterion not met. Management is not occurring at any of the three populations in private ownership. At the eight protected populations, management activities primarily consist of attempts to control recreation-related impacts through interpretive materials and/or physical barricades intended to keep the recreating public on established trails or boardwalks. These efforts have been initiated within significant portions of two populations (Linville - Chimneys/Table Rock and Grandfather Mountain). Additional management of encroaching woody vegetation is occurring within NPS-BRP owned portions of the Grandfather Mountain population (Chris Ulrey, NPS, personal communication, 2009). The remaining populations are not subject to active management.

The primary difficulty in satisfying this criterion results from a lack of documentation that existing levels of management (or lack thereof) are successfully maintaining these populations. Most sites for which monitoring data are available appear to have experienced declines in recent years (Table B.2, column "Clump Trends"). However, as discussed in Section II. C. 1. b. (Abundance, population trends, demographic features), available data are generally inadequate to objectively evaluate population trends. One of the more recent and better documented declines occurred in 2009, when two subpopulations were poached with 10-60% of adult plants illegally removed (Ulrey 2009, Kauffman 2009 and 2010). This poaching activity was discovered in conjunction with annual demographic monitoring conducted by NPS-BRP personnel. Without routine site visits, this impact would likely have gone undetected; without the marking of individual plants associated with this demographic data collection, the actual number of plants that were missing could not have been determined. Poaching represents a unique management challenge in that it is difficult or impossible to anticipate. Nonetheless, in 2009, this threat resulted in significant declines (perhaps as great as 40-60%, if all missing plants are assumed to have been poached) well above those attributable to any other recognized threat. Threats are discussed in Section II. C. 2. (Five Factor Analysis).

Criterion 3: Through introduction and/or discovery of new populations, at least one additional self-sustaining population exists within the species' historical range (it is believed that at least nine populations are required to ensure that the species will not become endangered in the foreseeable future).

Criterion not met. Two additional populations have been discovered since the latest revision of the recovery plan (USFWS 1999). However, these

populations are unlikely to be self-sustaining: one (Dun Vegan Mountain) has been estimated to contain only 15-20 clumps, and the other (Lost Cove Cliffs) was poached in 2009, and is currently estimated to contain no more than 55 clumps (Gary Kauffman, USFS, personal communication, 2010).

There have been no attempts to create new populations by introducing the species to new, unoccupied habitats. Portions of two populations have been augmented on one or more occasions: the Linville Gorge-Table Rock subpopulation, and five subpopulations within the larger Grandfather Mountain population (NCNHP 2010). In all instances, plants used for augmentation were grown from seed collected on-site. Augmentation efforts occurred in three episodes: the first in or around 1994, the second (at a single subpopulation) during the years 1999-2006, and the third in 2007.

In the first set of augmentation experiments (conducted in 1994), 999 seedlings were out-planted at Linville Gorge-Table Rock (Burke County) and five subpopulations within the larger Grandfather Mountain population (Avery County). Early observations from these experiments suggested high rates of survivorship among transplants placed at Grandfather Mountain, with NPS personnel reporting 89% survival after six weeks (NCNHP 2010). Unfortunately there appears to have been no attempt to follow up on transplant survivorship after the first field season. In most cases, the number of transplants originally placed into these subpopulations is unknown and augmented plants can no longer be distinguished from the original set of resident, native plants. As a result, the long-term survival of these augmented individuals, and the success of this effort, cannot be determined.

The Hang Glide Cliff subpopulation at Grandfather Mountain was augmented in 1999, with follow-up augmentation trials conducted between 2003 and 2006. Reports from the 1999 attempt are contradictory, with one source reporting either 27 or 38 plants placed out at this subpopulation that year (NCNHP 2010). In either case, 13 transplants were reported alive here in 2001. A second augmentation attempt occurred between 2003 and 2006; however, the number of *L. helleri* individuals planted during this time period is similarly unclear. Based upon information in the AFO files, the total number of transplants is likely to be less than 20 individuals. Additional investigation is needed to evaluate the current status of these prior augmentation efforts, and the number of *L. helleri* individuals remaining at this subpopulation (NCNHP 2010, Donaldson 2002a, Donaldson 2002b).

In 2007, three subpopulations within the Grandfather Mountain population were augmented by NPS-BRP personnel (NCNHP 2010). These subpopulations were among the five subpopulations augmented in the mid 1990s. In 2007, a total of 85 plants were placed out across these three subpopulations; as with the earlier round of augmentation trials, all plants were grown from seed collected from the same subpopulation into which the

greenhouse plants were placed. Transplanting occurred in August amidst dry, hot weather. Transplants did not receive supplemental watering, and transplant locations were recorded with a high accuracy (2-3 cm) rangefinder. All transplants were located within areas previously burned using prescribed fire. As of the 2009 growing season, only 28% of these transplants were still alive (Ulrey 2010a). This high mortality rate may be due to very dry and hot conditions at the time of transplanting.

Criteria for self-sustaining populations have not been developed for *L. helleri*.

Criterion 4: All nine populations and their habitat are protected from present and foreseeable human-related and natural threats that may interfere with their survival.

Criterion not met. All populations and their habitat are not protected from present and foreseeable threats that may interfere with their survival. Unmanaged or inadequately managed recreational use, poaching, feral goats, and vegetation succession remain ongoing threats at most populations (Chris Ulrey, NPS, personal communication, 2010; Gary Kauffman, USFS, personal communication, 2010; NCNHP 2010). Drought has recently been implicated in declines at some sites (Chris Ulrey, NPS, personal communication, 2010), and climate change is expected to exacerbate this and likely many other threats. Narrow-ranging endemics with limited dispersal capabilities (like *L. helleri*) are likely to be disproportionately impacted by these changes. Threats are discussed in Section II.C.2 (Five Factor Analysis).

C. Updated Information and Current Species Status

1. Biology and Habitat

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

The recovery plan discusses the pioneer habit of *L. helleri*, and calls brief attention to the beneficial role of fire in the maintenance of suitable habitat for other *Liatris* species. There is little empirical data on the specific responses of *L. helleri* to fire, but NPS-BRP is using prescribed burns to selectively control encroaching woody vegetation at occupied sites. Prescribed burns were conducted at three of four subpopulations in 2005 and again in 2007 (the 2005 burns did not carry well and did not achieve the desired intensity). The purpose of these burns was to set-back the succession of associated species that threaten to competitively displace *L. helleri*. NPS personnel reported that this prescribed burning was followed by marked increases (of 60 to 202%) in the number of flowering stems produced by adult *L. helleri* plants (NCNHP 2010).

The Linville Gorge-Shortoff Mountain population (in Burke County) affords another opportunity to learn more about the responses of *L. helleri* to fire. In 2007, a wildfire burned portions of this population; post-fire surveys indicate that fire severity was high enough (in some locations) to consume encroaching vegetation and/or expose mineral soils. These fire effects may be beneficial to *L. helleri*, possibly helping to induce seed germination and/or seedling recruitment in this species. However, baseline (pre-fire) data are lacking for this population; therefore, the capacity to detect changes in the population and attribute them to the 2007 wildfire is rather limited. The USFS initiated an Environmental Assessment (EA) scoping process to help continue prescribed burning in the Wilderness Area of Linville Gorge. The scoping letter was completed in May 2012. The goal is to expand potential habitat via large scale burning and exotic invasive species management. Herbicides are a critically needed component of management here because of the rampant spread of fire-tolerant and/or fire-adapted invasive exotic species like *Paulownia tomentosa* (Princess Tree), whose infestations are expanding in the wake of the 2007 wildfire. These management actions have the potential to significantly benefit *L. helleri* as well as *Hudsonia Montana* (mountain golden heather), a second federally-listed species with which it co-occurs in the Linville Wilderness.

b. **Abundance, population trends (e.g. increasing, decreasing, stable), demographic features, or demographic trends**:

The USFWS reviewed the database of the North Carolina Natural Heritage Program (NCNHP) to determine the best available estimates of population size for extant populations of *Liatris helleri* (NCNHP, 2010). The USFWS does not maintain its own database of known locations of *L. helleri*; instead it regards the NHP databases as the best repository for this information. In recent years, NatureServe and its member Natural Heritage Programs have devised mapping standards to balance the need for fine-scale, highly site-specific element occurrence records (EORs) with the need to aggregate EORs into meaningful units of conservation interest that approximate biological populations (NatureServe, 2004).

The 11 extant populations recognized by USFWS are mapped as nine stand-alone and two parent Element Occurrence Records (EORs) by NCNHP (Appendix B, Tables B.1 and B.2). NCNHP recognizes an additional 17 sub-EORs nested within the two parent records created for the Grandfather Mountain and Linville Gorge Chimneys/Table Rock populations (Table B.1); for discussion purposes, these are best regarded as subpopulations or spatially discrete patches of the species. Therefore, each of the populations recognized by USFWS corresponds to either a parent or stand-alone EOR as mapped by the NCNHP.

Most EORs (whether a parent, stand-alone, or sub-EOR) consist of numerous discretely mapped sites, and it is rare to have estimates of abundance that cover a representative portion of the EOR in any given year (frequently the observations pertain to only a part of the larger mapped area). It is also infrequent for site surveys to be conducted by the same individual from one year to the next, and even less common for observations to apply to the same spatial extent or to represent equivalent levels of survey effort. As a result of these many factors, differences in size estimates within or among EORs must usually be interpreted with considerable caution. Despite these issues, the USFWS regards the NCNHP database as the best available centralized repository for tracking observation data in rare species, and continues to work with partners to get updated observation data into the NCNHP database so that it will inform assessments such as this five year review.

Estimates of abundance vary from partial surveys yielding very coarse estimates of clumps (most locations) to highly precise counts of tagged plants (e.g., the four subpopulations within the Grandfather Mountain population monitored by the NPS-BRP). Individual sites have been estimated to contain anywhere from one to more than 700 clumps over the years; collectively, the 11 extant populations recognized for purposes of this review are unlikely to contain more than a few thousand individuals. It is not possible to arrive at a more precise estimate of the total number of individuals across the range due to the limitations in available data described above.

Population trends in *L. helleri* are generally unknown because monitoring is simply not occurring at a scale that can be reliably extrapolated to entire populations. Most "monitoring" data consist of casual site visits in which the number of *L. helleri* plants has been coarsely estimated within a small portion of the larger population (usually corresponding to a sub-EOR as mapped by the NCNHP). The 11 parent- or stand-alone EORs mapped by NCNHP depict a total of 26 spatially discrete locations where *L. helleri* is known to occur (Table B.2).[1] The last reported observation for 11 of these 26 records occurred before 2000 (NCNHP 2010; Appendix B, Table B.2). Fifteen of the 28 records have three or fewer years of any recorded observations (even presence/absence); only nine have three or more years in which the number of plants (clumps) was estimated. Factoring in these significant caveats, available data suggest that nine locations (meaning sub- or stand-alone EORs) may be declining, four locations may be increasing, and only two locations appear at least somewhat stable (Table B.2). Trends for the remaining 12 records are not possible to infer with any degree of confidence, given the nature of available data.

When NHP EOR data is aggregated by the population boundaries recognized by USFWS (Tables B.1 and B.2), four of the 11 extant populations appear to have declined from historical levels (Linville-Chimneys/Table Rock, Lost

[1] This tally (26) excludes the two parent EORs which serve as a database to aggregate smaller EORs.

Cove Cliffs, Three Top, and Bluff Mountain) and significant portions of a fifth (Grandfather Mountain) also appear to have declined. Only two populations appear relatively stable (Paddy Mountain and Blowing Rock), and one population (Linville-Hawksbill) may have increased. Trends are unknown for the remaining populations.

Demographic data collection is occurring within portions of three populations (Grandfather Mountain, Lost Cove Cliffs, and Paddy Mountain; Appendix B, Table B.1). NPS-BRP initiated demographic data collections at four subpopulations within the larger Grandfather Mountain population in 2004. This effort has progressed to the point that most resident adult plants (clumps) have now been tagged, and their survival and reproduction is monitored annually (Ulrey 2010b). The ultimate objective of this study is to produce a Population Viability Analysis for *L. helleri*; however, this modeling effort will require several more years of data. Only two years of demographic-level data exist for the remaining two populations (Lost Cove Cliffs and Paddy Mountain), from the 2006/2009 and 2009/2010 field seasons, respectively. Because of the preliminary nature of the data for these latter two populations, the remainder of this discussion of demographic trends is drawn almost exclusively from data obtained for NPS-BRP sites.

In 2009, one of the four NPS subpopulations was poached, with 10% (n=12) of adult plants removed illegally (as evidenced by holes left in their place) and another 50% (n=53) possibly poached (Ulrey 2009). The theft of these plants was discovered in conjunction with NPS's annual monitoring efforts. In response to NPS's findings, USFS visited one of their subpopulations and discovered it to have been poached as well, with perhaps as much as 59.5% (n=46) of adult plants illegally removed from that location (Kauffman 2009). It is not known whether or not additional subpopulations across the range of the species were targeted by this illegal activity. For the two subpopulations that were poached, the impacts are quite significant given the exceedingly low rates of seedling recruitment observed in this species. Augmentation (to return the population to pre-poaching levels) remains an option, but has not yet been initiated.

The four NPS subpopulations at Grandfather Mountain collectively contained 361 plants in 2009, down from 400 plants recorded as alive in 2008. This reduction is partially (and perhaps largely) attributable to the poaching that occurred in 2009. Prior to this poaching event, demographic data suggest that *L. helleri* tends to exhibit variable rates of adult mortality accompanied by extremely low rates of seedling recruitment (Ulrey 2010b). When averaged across all years (2004-2009) and all sites (n=4), the average annual rate of adult plant mortality is 22%. This average excludes any plants simply recorded as "lost"– therefore, the mortality rate may be higher still. When examined in greater detail, the percentage of the preceding year's adult plant population recorded as dead the following season has ranged from a low of

5.5% (one subpopulation, in 2006) to a high of 49% (excluding the subpopulation that was poached in 2009, in which adult mortality was 69.9% that year). Since 2004, the maximum number of seedlings observed at any subpopulation is 22. In most years, no seedlings were reported by NPS personnel; however, exhaustive seedling surveys have not been conducted at every monitoring site in every year. When averaged across all years (2004-2009) and all sites (n=4), the average percentage of adult plants (clumps) showing evidence of flowering is 27.2%. In any given year at any given site, the percentage of plants (clumps) flowering has varied from a low of 12% to a high of 53%. The number of flowering stems varies from less than four to more than 200% of the number of adult clumps (NCNHP 2010). As noted previously, flowering appears to be stimulated by burning, with NPS personnel reporting increases in the number of flowering stems anywhere from 60-200% following prescribed burns (NCNHP 2010).

Overall, interim data from the NPS demographic data collection effort indicates that three of the four subpopulations have declined relative to the largest number of clumps recorded at each subpopulation (Ulrey 2010b). This finding particularly stresses the importance of routine monitoring data when attempting to infer trends. There is little reason to assume that the other populations not undergoing regular monitoring are more stable than those being closely followed by NPS.

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

(Although this section summarizes information that was available and referenced in the recovery plan, it is provided here as background information for subsequent sections.)

Godt and Hamrick (1996, 1995) examined genetic variation and outcrossing rates in *Liatris helleri* using allozymes. These authors observed high levels of genetic diversity in this species, with levels averaging three times that typically exhibited by other narrow-ranging endemic plants (Godt and Hamrick 1996). Godt and Hamrick offer three possible explanations for this result: (1) recent derivation from a highly polymorphic species, (2) introgression of genes via hybridization, or (3) a recent range restriction accompanied by drastic reductions in population size. The authors go on to state that their data provide no evidence for hybridization; however, they did not investigate this question directly (no other *Liatris* spp. were evaluated in this study).

Godt and Hamrick (1996) observed patterns of genetic structure that suggested low rates of gene flow between populations, and speculated that the elevation gradients separating sites may serve to limit pollinator movement as well as the dispersal of viable seed. They also noted that viable seed is

increasingly less likely to be dispersed into suitable habitat upon leaving the source population, given that the rock outcrops where *L. helleri* occurs are typically embedded in a forested landscape containing habitat conditions generally unfavorable to this species.

These authors characterized the amount of genetic variation among *L. helleri* populations (15.9%) as intermediate between the means for outcrossing, animal-pollinated species (19.7%) and wind-pollinated outcrossers (9.9%; Hamrick and Godt 1989). They note that direct estimates of outcrossing rates suggest that *L. helleri* may be self-incompatible (Godt and Hamrick 1995).

d. **Taxonomic classification or changes in nomenclature**:

Nesom (2005) has proposed that *Liatris helleri* T.C. Porter (1891) and *L. turgida* Gaiser (1941) do not represent distinct taxa, and should be combined under the name *Liatris helleri* T.C. Porter (1891) (which has nomenclatural priority). Nesom's analysis was based upon inspection of herbarium specimens, which revealed considerable variation in the primary diagnostic character used to distinguish *L. helleri* from *L. turgida* (pappus length). These observations are consistent with those of numerous field botanists who have long puzzled over the atypically long pappus and subsequent difficulties in assigning identity to some populations of *L. helleri* (e.g., Sutter and Murdock, 1984).

L. turgida is an Appalachian endemic of lower elevation montane habitats (2300-4250 ft. in elevation) in West Virginia and Virginia, with infrequent populations in North Carolina, Alabama and Georgia (Nesom, 2005). In North Carolina, *L. turgida* Gaiser is typically found at lower elevations than *L. helleri* sensu stricto, however the two come in close proximity and may co-occur at Linville Gorge in Burke County. If *L. turgida* were to be subsumed within *L. helleri*, the number of known populations would increase perhaps five-fold or more. Threats to the continued existence of the new taxon (*L. helleri* T.C. Porter (1891) sensu Nesom (2005)) would be significantly lessened when evaluated across that entity's entire range. Thus, if adopted, this nomenclatural change would likely appreciably reduce the justification for retaining *L. helleri* on the federal list of endangered and threatened species.

Nesom's analysis was based on the inspection of herbarium specimens, and was not accompanied by genetic analyses - although he interprets the results from Godt and Hamrick (1996) as providing indirect support for his nomenclatural revision. As previously noted, Godt and Hamrick did find higher than expected levels of allozyme variation within populations of *L. helleri* T.C. Porter (=*L. helleri* sensu stricto), but they did not evaluate the degree of genetic similarity (or dissimilarity) between *L. helleri* and *L. turgida*.

The Service and many of its conservation partners are of the opinion that additional investigation is needed before Nesom's proposed nomenclatural change is fully adopted (Alan Weakley, UNC Herbarium, personal communication, 2010; Gary Kauffman, USFS, personal communication, 2010; Chris Ulrey, NPS, personal communication, 2010).

Researchers at Appalachian State University (ASU) initiated a project in August 2010 to explicitly examine genetic differentiation among *L. helleri* T.C. Porter and *L. turgida* Gaiser, and the potential for hybridization between these two species (Sullins, 2010). By comparing the level of genetic variation between DNA sequences, examining whether or not the species will hybridize, and further comparing the morphology of these species, this study should provide valuable assistance in determining whether or not the two species are in fact more appropriately regarded as a single taxon. The Service is supporting the project by providing technical assistance in the identification of desirable sample sites and the refinement of key questions to be addressed by this project. Sullins sequenced individuals from both *L. helleri* (from nine populations) and *L. turgida* (from six populations). In his research so far, he sees some divergence between the two groups, although the groups also share two haplotypes. Each group has unique chlorotypes which are diagnostic to either species, meaning they are not found in both groups, but there are two chlorotypes that occur in both species. This is typically explained by either hybridization between the two species, or incomplete lineage sorting. Given the geographic distances between the sites that share the haplotypes, hybridization seems like an unlikely explanation. Incomplete lineage sorting seems more plausible and consistent with the fact that the flower morphology is similar as well. Final results are not anticipated for another year; therefore, the Service expects to reach resolution on this issue in the next five year review for this species.

e. **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 recognized eight extant populations of *Liatris helleri* (USFWS 1999). As of 2013, there are 11 extant populations of this species (Appendix B, Table B.1). This increase results from the discovery of two new populations (Dun Vegan Mountain and Lost Cove Cliffs, both in Avery County), and a revision to the delineation of three populations counted in the recovery plan: one of these populations is here regarded as three separate populations due to the distance among occupied locations (all are within Linville Gorge), and two populations counted separately in the recovery plan are here treated as a single population due to their proximity (at Grandfather Mountain).

Therefore, the total distribution of the species consists of 11 extant and two extirpated populations. The extant populations occur in the following North Carolina counties: Ashe (3 populations), Avery (3 populations), Burke (3 populations), Caldwell (1 population), and one population that spans the Avery/Watauga county line. The extirpated populations occur in Avery (Beech Mountain) and Mitchell (Roan Mountain) Counties, North Carolina.

No new counties have been added to the distribution of the species since the listing rule or recovery plan were published. No corrections to the historic range are needed. The level of habitat fragmentation and availability of corridors are not significantly different than when the species was first federally listed.

f. **Habitat or ecosystem conditions**:

Liatris helleri is endemic to the Blue Ridge Mountains of western North Carolina, with populations in Ashe, Avery, Burke, Caldwell, and Watauga Counties. Throughout its limited range, *L. helleri* occurs at mid- to high elevations (3,500 to 6,000 feet), typically associated with sparsely vegetated rock formations located on outcrops, cliffs, or ledges. These rocks are typically igneous (volcanic) and metasedimentary, with shallow, acidic soils (pH 4). Occupied habitats are usually exposed to high winds and abundant sun. *L. helleri* frequently co-occurs with other rare plant species also endemic to the Southern Blue Ridge, many of which are federally listed, including *Geum radiatum* (spreading avens), *Gymnoderma lineare* (rock gnome lichen), *Hedyotis purpurea var. montana* (Roan Mountain bluet), and *Solidago spithamaea* (Blue Ridge goldenrod). In the Linville Gorge, *L. helleri* co-occurs with *Hudsonia montana* (mountain golden heather), another federally listed plant species.

Mid to high elevation rock outcrops are a distinctive feature of the southern Appalachian landscape, but are limited in extent and distribution. They occur, spatially isolated, within a forest matrix of spruce-fir, northern hardwoods, high elevation red oak, or (in the case of Linville Gorge) xeric pine-oak heath. Schafale and Weakley (1990) recognize several types of mid to high elevation rock outcrop communities in North Carolina. Those colonized by *L. helleri* would be typed as High Elevation Rocky Summits, High Elevation Granitic Domes, Montane Acidic Cliffs, or High Elevation Mafic Glade (one example, at Bluff Mountain).

Unfortunately, there is no robust, quantifiable estimate of the amount of mid to high elevation rock outcrop habitat across the southern Appalachians, or North Carolina in particular. Rock outcrops, cliffs and overhangs are a specialized habitat that occupy discrete and usually small patches within an otherwise forested landscape. Because these rock and cliff systems can frequently occur as small, nearly vertical outcroppings of exposed bedrock at

least partially obscured by a forest canopy, they are inherently difficult to detect using remotely sensed imagery.

As previously noted, eight of the 11 extant populations of *L. helleri* are in protective ownership by federal or state agencies, or conservation partners. This land ownership provides protection from habitat conversion (to commercial or residential development), but does not inherently protect *L. helleri* from one of its most significant threats – recreational use, and specifically trampling. The high elevation rock outcrops where this species occurs afford spectacular scenic views, and as such are popular destination points.

While recreation-related threats present challenges in the near term, accelerated climate change presents a substantial threat to the long-term viability of mid- to high-elevation species like *L. helleri*. Although models of future climate scenarios are not yet available at a resolution conducive to site-specific planning, it is reasonable to expect significant shifts in the very temperature and precipitation patterns that define the climatic extremes to which species such as *L. helleri* have become adapted. It remains to be seen whether or not these changes will exceed the adaptive capacity of this species and the numerous others that comprise the signature flora of southern Appalachian rocky summits, cliffs and ledges.

2. Five-Factor Analysis -

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

Liatris helleri was federally listed due to concerns about its limited distribution, small number of known populations, and small population sizes, as well as commercial, residential, and recreational development within areas of occupied habitat (52 FR 44397). The construction of trails, viewing platforms, roads, and buildings was implicated in the decline of some populations, as was trampling by recreational users. The listing rule identified residential development and heavy recreational use as primary factors in the extirpation of two populations.

Eight of the 11 extant populations of *L. helleri* occur on land managed by federal or state natural resource agencies or private-sector conservation partners. The remaining three populations occur on unprotected private land. Two populations are apparently extirpated, with one of these (Roan Mountain) known only from an herbarium specimen dating to 1894.

A principal source of habitat destruction affecting *L. helleri* is the recreating public, who venture out into the species' habitat in search of high elevation views, adventurous rock climbing or boulder-hopping opportunities, or just a

flat and sparsely vegetated picnic spot. Regardless of the reason, trampling compacts the plant's rhizome and can shear plants from the rocks in which they are anchored. In the process, soils that have developed over geologic time frames can also be destroyed, making recolonization of these sites (by this or other species) exceedingly difficult.

Unfortunately, protection of sites through public ownership can (and usually does) lead to increased visitation by the recreating public, thereby increasing the potential for impacts from trampling or construction of recreation-related facilities. Across the range of the species, many subpopulations occur within inches of established paths and popular destination points frequented by visitors who are largely unaware of the destructive potential from a single footstep. Passive interpretation involving the use of signs and physical barricades has proven moderately successful.

NPS-BRP conducted a study in which patterns of visitor use were characterized and quantified using hidden infra-red trail counters stationed near populations of federally listed plant species, including *L. helleri* (Ulrey, 2004). At all of the study sites, visitor use is limited or restricted through barricades, signage, or site closures intended to specifically minimize impacts to rare plant species and sensitive habitat. The combination of measures in place at these *L. helleri* subpopulations is more rigorous than at any other population of this species. Yet despite these measures, this study documented an overall average of 14% of visitors entered closed areas (corresponding to the frequency that a visitor triggered a counter), amounting to an average of 3,000 visitor impacts when projected over the visitor season. Use of digital trail counters (equipped with time stamps) enabled NPS staff to identify peak times of visitor impacts (typically Saturdays); uniformed patrol was effective at reducing visitor impacts by 62%. The study concluded with recommendations for additional measures such as increased/improved signage.

A related concern stems from the construction of facilities intended to control or direct visitor use. These facilities must be sited and constructed appropriately in order to avoid impacts to *L. helleri*. Numerous populations of the species exist in extremely close proximity to boardwalks or roped trails; maintenance of these facilities must be conducted in a manner that does not damage the plants found immediately adjacent to the boardwalk or trail. Landowners should discourage the construction of trails directing visitors to the populations. Periodic monitoring of all sites is needed in order to ensure that visitor access is not posing a problem, and that populations of *L. helleri* are not succumbing to this or other threats. At present, regular monitoring is only occurring within a portion of a single population (NPS-owned portions of Grandfather Mountain), although USFS initiated monitoring at a portion of a second population (Lost Cove Cliffs) in 2005 and the North Carolina Plant Conservation Program initiated monitoring at a third (Paddy Mountain) in

2009. Regardless, available data and ongoing monitoring efforts across the range of the species are largely inadequate for providing an early indication of recreation-related impacts to *L. helleri* (or impacts from any other source). The potential for these impacts is quite significant at some locations: the Grandfather Mountain Biosphere Reserve is estimated to receive some 250,000 visitors a year (Pope 2010).

b. Over utilization for commercial, recreational, scientific, or educational purposes:

This factor was identified as a potential threat to *Liatris helleri* in the listing rule, due to the attractive nature of this plant. Threats due to recreation are discussed above under Factor A.

In 2009, two subpopulations of L. helleri were discovered to have been the target of poaching activity. The first instance was discovered by NPS personnel in conjunction with their annual monitoring activities: at this site, 10% (n=12) of adult plants were confirmed as definitively poached (as evidenced by holes left in their place) and another 50% (n=53) were regarded as having possibly been poached (Chris Ulrey, NPS, personal communication, 2010). In response to NPS's findings, USFS visited one of their subpopulations and discovered it to have been poached as well, with perhaps as much as 59.5% (n=46) of adult plants illegally removed from that location (Gary Kauffman, USFS, personal communication, 2010). It is not known whether or not additional subpopulations across the range of the species were targeted by this illegal activity. For the two subpopulations that were poached, the impacts are quite significant given the exceedingly low rates of seedling recruitment observed in this species.

c. 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 threat to *Liatris helleri*.

d. 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. The North Carolina Plant Conservation and Protection Act (NC State Code Article 19B, § 106-202.12) provides limited protection from unauthorized collection and trade of plants listed under that statute. However, this statute does not protect the species or its habitat from destruction in conjunction with development projects or otherwise legal activities. State laws protecting rare plant species have limited authorities, and North Carolina rare plant statutes do not protect the species from habitat destruction from recreational use on federal lands (where many populations

occur and remain vulnerable to this threat).

e. Other natural or manmade factors affecting its continued existence:

Accelerated global climate change is likely to disrupt patterns of climate variability to which *Liatris helleri* has become adapted, and as such is likely to exacerbate threats already mentioned. In 2010, NPS (Blue Ridge Parkway) personnel reported significant mortality of adult plants, seemingly as a result to prolonged and extreme drought (Chris Ulrey, NPS, personal communication, 2010). The higher temperatures expected under most global climate change models would appear likely to exacerbate this threat. 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.

D. **Synthesis** –

The status of *Liatris helleri* has not appreciably changed since the 2000 recovery plan. The species occurs at eleven extant populations distributed across five western North Carolina counties. All populations are threatened by uncontrolled visitor use (trampling), which has resulted in demonstrable declines to the species and its habitat. Poaching occurred at two subpopulations in 2009; with between 10 to 60% of established adult plants being illegally removed from each site. An associated threat is the construction of recreation-related facilities within the species' habitat. Intended to manage visitor use, if poorly sited, such facilities can be constructed within areas of occupied habitat. Vegetation succession and drought are reported threats at many sites. Accelerated climate change could exacerbate threats already affecting the species. Available genetic data suggests that the species is self-incompatible, and may exhibit low rates of gene flow (Godt and Hamrick 1995a). These life history traits do not suggest this species is likely to colonize new sites rapidly.

A recent proposal (Nesom 2005) to broaden the taxonomic treatment of *Liatris helleri* T.C. Porter needs further investigation. The Service is supporting an ongoing genetic analysis through Appalachian State University (ASU), which is specifically investigating genetic distances between *L. helleri* T.C. Porter and *L. turgida* Gaiser – the taxa which Nesom has suggested should be combined. Collection of genetic samples for the ASU study began in August 2010 and preliminary results show some divergence between the two groups, although the groups also share two haplotypes; the results from this study will be evaluated in conjunction with other data during the next five year review for this species. At the present time, the Service continues to regard the listed taxon as valid. Results from the ongoing genetic analysis are anticipated within the next year; the Service intends to reach resolution on this issue in the next five year review for this species.

The existing recovery criteria are objective and measurable, and generally reflect the best available information on threats to the species and its habitat. No change in the species' status is currently recommended.

III. RESULTS

A. Recommended Classification:

__X__ No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

These actions are listed in order of priority, and cross-walked to tasks identified in the recovery plan, where appropriate.

1. Continue support for the ongoing genetic analysis being conducted by Appalachian State University, assisting with identification of sample sites and refinement of questions to be addressed. Ensure that relevant field observations made during the collection of genetic samples are reported to the NCNHP for incorporation into site records (EORs).
    - (*Recovery Task 5.2)* Prepare articles for popular and scientific publications.
2. Assist landowners or other knowledgeable sources in reporting existing backlogs of relevant observation data to the North Carolina Natural Heritage program, so that this repository of data contains the most accurate, complete and current information.
    - (*Recovery Task 2.1*) Determine population size [and stage class distribution] for all populations.
3. Specifically work with Grandfather Mountain Stewardship Foundation and Atlanta Botanical Garden to determine the number of *L. helleri* plants placed at Hang Glide Cliff subpopulation, and evaluate the success of previous augmentation trials conducted there.
    - (*Recovery Task 2.8*) Develop techniques for re-establishing populations in suitable habitat within the species' historic range.
4. Ensure that monitoring data is sufficient to assist in evaluating the relative stability of populations and the effectiveness of implemented management actions.
    - (*Recovery Task 1.1*) Develop interim research and management plans in conjunction with NPS, USFS, North Carolina state agencies, TNC and Grandfather Mountain Stewardship Foundation
    - (*Recovery Task 2.1*) Determine population size [and stage class distribution] for all populations.
5. Work with USFS and NPS to explore options for augmenting the subpopulations poached in 2009, to minimize the potential for population bottlenecks and long-term genetic implications.
    - (*Recovery Task 2.8*) Develop techniques for re-establishing populations in suitable habitat within the species' historic range.

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of *Liatris helleri* (Heller's blazing star)

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ 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 2/13/13

REGIONAL OFFICE APPROVAL:

for **Lead Regional Director, Fish and Wildlife Service**

Approve _____ Date 8/3/13

Appendix A: Peer Review

Summary of peer review for the five-year review of *Liatris helleri* (Heller's blazing star)

A. **Peer Review Method:** The Service circulated this review to staff of the National Park Service (Blue Ridge Parkway) (NPS-BRP), the U.S. Forest Service (National Forests in North Carolina), Grandfather Mountain Stewardship Foundation, the North Carolina Natural Heritage Program (NC NHP), and University of North Carolina at Chapel Hill. All of these individuals were selected due to their knowledge of the species.

B. **Peer Review Charge:** Peer reviewers were asked to conduct a scientific review of technical information presented. Reviewers were not asked to review the legal status determination.

C. **Summary of Peer Review Comments:** Comments were received from NPS-BRP, Grandfather Mountain Stewardship Foundation, and NC NHP.

NPS-BRP provided updated information on the survival of transplants placed out at three subpopulations in August, 2007 and a correction to the year in which demographic monitoring was initiated at one population (Paddy Mountain).

Grandfather Mountain Stewardship Foundation largely corroborated statements in the draft document. Comments received from this review specifically addressed the issues of trampling and collection (of flowering stems) by the recreating public, and concomitant efforts by the Foundation to address these impacts through signage and uniformed personnel. This reviewer expressed full support for working with the Service to implement or expand formal monitoring of *L. helleri* populations on lands managed by the Foundation.

NCNHP provided comments clarifying the distinction between parent and sub- or stand-alone EORs, and asked for USFWS opinions on aggregating two stand-alone EORs under a common "parent" EOR (at Table Rock). This reviewer also noted additional protection mechanisms in place at some protected populations; and recommended that these be acknowledged in the final version of this document, to fully convey the layers of protection afforded to these sites/populations.

D. Response to Peer Review:

Updated information on NPS-BRP transplant efforts and corrections to monitoring dates were incorporated as appropriate.

Comments from the Grandfather Mountain Stewardship Foundation were used to strengthen the discussion of trampling and other recreation-related impacts, as well as ongoing efforts to control these threats.

The discussion and counting of EORs was revised in response to comments received by NCNHP. NCNHP comments relaying additional protection mechanisms were incorporated into Table B.2 (Appendix B).

Appendix B: Tables

Table B.1. *Liatris helleri* populations as recognized by FWS, cross-walked to Element Occurrence Records mapped by the North Carolina Natural Heritage Program (NHP).

Population	County	Site name	NHP EO number [a]	Subpopulations	Land owner [b]
Extant					
1	Burke	Linville – Shortoff	NCHP*030	5-6	USFS
2	Burke	Linville – Chimneys/ Table Rock	NCHP*031.003-.004	6	USFS
3	Burke	Linville – Hawksbill	NCHP*006	2	USFS
4	Avery	Lost Cove Cliffs	NCHP*025	2	USFS
5	Avery/ Watagua	Grandfather Mtn	NCHP*27.001, 27.002, 27.009, 27.011, 27.012, 27.013, 27.016, 27.017, 27.018, 27.019, 27.021, 27.022[c], 27.023, 27.026, 27.028	20	Grandfather Mountain Stewardship Foundation; NCCWMTF; NCDPR; NPS-BRP; TNC; USFS
6	Ashe	Three Top Mtn	NCHP*015[c]	1	NCWRC
7	Ashe	Bluff Mtn	NCHP*010[c]	3	TNC
8	Ashe	Paddy Mtn	NCHP*020[c]	4	NCPCP
9	Caldwell	Blowing Rock	NCHP*005	1	Private
10	Avery/ Watauga	Hanging Rock	NCHP*008	1	Private
11	Avery	Peak Mtn/Dun Vegan Mtn	NCHP*024	1	Private
Extirpated					
12	Avery	Beech Mountain	NCHP*007	1	Private
13	Mitchell	Roan Mountain	NCHP*014	1	USFS

[a] North Carolina Natural Heritage Program (NHP) Element Occurrence number (NCNHP, 2010).
[b] Land owner abbreviations: NCCWMTF = North Carolina Clean Water Management Trust Fund (protection via easement); NCDPR = North Carolina Division of Parks and Recreation; NCWRC = North Carolina Wildlife Resources Commission; NCPCP = North Carolina Plant Conservation Program; NPS-BRP = National Park Service, Blue Ridge Parkway; TNC = The Nature Conservancy; USFS = U.S. Forest Service.
[c] These sites are afforded additional protection as Dedicated Nature Preserves, a legally binding agreement held with the North Carolina Natural Heritage Program.

Table B.2. Summary of observation and trend data for extant Natural Heritage Program Element Occurrence Records (EORs) of *Liatris helleri* [a]

FWS POPULATION NUMBER [b]	EOR NUMBER	YEAR LAST OBSERVED	TOTAL YEARS OF REPORTED OBSERVATIONS	TOTAL YEARS OF CLUMP COUNTS	CLUMPS (MAXIMUM)[c]	CLUMPS (MINIMUM)[d]	CLUMPS TREND [e]	EO RANK [g]	COUNTY
1	030	2001	1	1	434	434	not available	A	Burke
2	31.003	2005	4	2	430	50	D?	B	Burke
2	31.004	2005	3	3	185	6	D?	B	Burke
3	006	2001	3	2	293	50	I?	B	Burke
4	025	2009	3	3	99	53	D	E	Avery
5	27.001	2006	7	4	> 700	133	I?	A	Avery
5	27.002	2009	7	6	69	40	D	AB	Avery
5	27.009	2009	8	7	58	24	D	C	Avery
5	27.011	1990	4	2 [f]			not available	D?	Avery
5	27.012	1994	2	2	22	a few	I?	D	Avery
5	27.013	1991	1	1			not available	A	Avery
5	27.016	1991	1	1			not available	D	Avery
5	27.017	2001	3	2	400	48	D	C	Avery
5	27.018	1991	2	1	128	128	not available	AB	Avery
5	27.019	2009	9	6	154	58	D	C	Avery
5	27.021	1995	2	1	> 500	> 500	not available	A	Watauga
5	27.022	1994	1	0			not available	A	Watauga
5	27.023	1994	1	0			not available	BC	Watauga
5	27.026	2009	11	6	213	138	I	AB	Avery
5	27.028	1998	1	1	27 (38?)	27 (38?)	not available	E	Avery

[a] Primary source: NCNHP, 2010. Secondary sources: Kauffman, 2010; Ulrey, 2010b.
[b] This number corresponds to the FWS population number used in Appendix B, Table B.1.
[c] The *maximum* number of clumps reported for this site (EOR), regardless of year. Provided to give a coarse indication of relative size of the population (or subpopulation) at this location.
[d] The *minimum* number of clumps reported for this site (EOR), regardless of year. Provided to give a coarse indication of the relative size of the population (or subpopulation) at this location.

[e] The apparent trend in number of clumps, taking into account the chronology of observations reported to NCNHP. "Not available" = trends not available from current data; "D" = decreasing"; "I" = Increasing. Question marks indicate significant uncertainty as to whether available data should be taken at face value.
[f] Although counts of clumps are available for two years, they apply to different portions of the site and therefore cannot be used to infer trends.
[g] A = Excellent estimated viability/ecological integrity; B = Good estimated viability/ecological integrity; C = Fair estimated viability/ecological integrity; D = Poor estimated viability/ ecological integrity; E = Verified extant (viability/ecological integrity not assessed)

Table B.2. Continued. [a]

FWS POPULATION NUMBER [b]	EOR NUMBER	YEAR LAST OBSERVED	TOTAL YEARS OF REPORTED OBSERVATIONS	TOTAL YEARS OF CLUMP COUNTS	CLUMPS (MAXIMUM) [c]	CLUMPS (MINIMUM) [d]	CLUMPS TREND [e]	EO RANK	COUNTY
6	015	2001	6	2	1000	11	D	BC	Ashe
7	010	2009	5	5	235	36	D	B	Ashe
8	020	2009	6	2	500	200	S?	A?	Ashe
9	005	2007	6	3	100	100	S?	B	Caldwell
10	008	1989	2	1	22	22	not available	C	Avery, Watauga
11	024	1998	1	1	15-20	15-20	not available	E	Avery

[a] Primary source: NCNHP, 2010. Secondary sources: Kauffman, 2010; Ulrey, 2010b.
[b] This number corresponds to the FWS population number used in Appendix B, Table B.1.
[c] The *maximum* number of clumps reported for this site (EOR), regardless of year. Provided to give a coarse indication of relative size of the population (or subpopulation) at this location.
[d] The *minimum* number of clumps reported for this site (EOR), regardless of year. Provided to give a coarse indication of the relative size of the population (or subpopulation) at this location.
[e] The apparent trend in number of clumps, taking into account the chronology of observations reported to NCNHP. "Not available" = trends not available from current data; "D" = decreasing"; "I" = Increasing. Question marks indicate significant uncertainty as to whether available data should be taken at face value.

5-YEAR REVIEW OF HELLER'S BLAZING STAR (*Liatris helleri*)

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 June 20, 2019 (84 FR 28850). No comments were received during the 60-day public comment period following this notice. However, the U.S. Fish and Wildlife Service (Service) received 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 South Atlantic-Gulf Region. Additionally, the Service conducted independent peer review on new information (see Appendix A of this addendum). The Service sought review from four knowledgeable experts on this species and its habitats. Comments have been addressed and incorporated into this addendum as appropriate and necessary.

I. GENERAL INFORMATION

B. Reviewers

Lead Region: Atlanta Regional Office, Carrie Straight, (404) 679-7226.

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

C. Background

1. **Federal Register Notice citation announcing initiation of this review:** 84 FR 28850; June 20, 2019.

2. **Species Status:** Decreasing. The number of documented Heller's blazing star (*Liatris helleri*) populations (11) has remained the same since the 2013 5-year review; however, because of inconsistent and infrequent monitoring, the status and trend of most populations cannot be adequately assessed at this time. Populations and subpopulations that are consistently monitored show a decreasing trend at three of five sites in two populations. 0See Section II.C.1b for additional information.

5. **Review History:** The Service finalized a 5-year review for Heller's blazing star in 2013. The review recommended the species remain classified as threatened due to known threats, such as recreational user impacts, construction of recreation-related facilities, poaching, succession, and drought (Service 2013).

II. REVIEW ANALYSIS

B. Recovery Criteria

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. The eight extant populations are protected.

The recovery plan indicates eight populations were extant in four counties in North Carolina at the time of plan development; however, populations are not referenced by name and it is unclear which plant sites were included within a population (Service 2000). Additionally, the 2013 5-year review suggests the intent of this criterion was that all extant populations be protected (Service 2013). For purposes of this review, we will assume this criterion has been met when all known, extant populations are protected.

Of the 11 extant populations of Heller's blazing star, nine occur on publicly or privately owned lands that are managed for conservation (NC Natural Heritage Program (NCNHP) 2020). One Avery County population, identified in the 2013 5-year review as having private ownership, now has permanent protection after fee simple purchase by the Blue Ridge Conservancy (BRC) in 2020 (BRC 2020). Six populations have public access and landowners include Grandfather Mountain Stewardship Foundation (GMSF), North Carolina State Parks (Grandfather Mountain), USFS (Pisgah National Forests), North Carolina Wildlife Resources Commission (Three Top Mountain Game Lands), and the National Park Service, Blue Ridge Parkway (NPS, BLRI). Five populations are not accessible to the public and landowners include private landowners, the NC Plant Conservation Program (NCPCP), and land trusts (The Nature Conservancy and the BRC). Although nine populations are on protected land, the threats referenced in this document are still present and affecting populations.

Table 1. Summary of protection status and access.

Site Name	Public or Private Managed for Conservation	Public Access	Owner
Linville Gorge (EO30)	Y	Y	USFS
Linville Gorge (EO31)	Y	Y	USFS
Linville Gorge (EO6)	Y	Y	USFS
Little Lost Cove	Y	Y	USFS
Grandfather Mtn	Y	Y	GMSF, Grandfather Mtn State Park, BLRI, The Nature Conservancy
Three Top Mtn	Y	Y	WRC
Bluff Mtn	Y	N	TNC
Paddy Mtn	Y	N	NCPCP
Blowing Rock	N	N	Private
Hanging Rock	N	N	Private

Dun Vegan Mtn	Y	N	BRC
Total	*11 populations*	*6 populations*	

Criterion 2. Any necessary management actions have been undertaken for these populations by the landowners or cooperating agencies and it has been documented that this management is successfully ensuring the continued survival of these populations.

Management is occurring in varying capacity at nine of 11 populations. Within the Grandfather Mountain population, some subpopulations owned and managed by the GMSF are subject to management activities primarily consisting of attempts to control recreation-related impacts. The GMSF monitors and manages visitor use at their "attraction" location at the top of Grandfather Mountain and is successful at reducing impacts to plants. Also within the Grandfather Mountain population, subpopulations owned and managed by the BLRI are subject to prescribed fire to manage encroaching woody vegetation. The NCPCP evaluates their preserve, which contains the Paddy Mountain population, annually and manually removes encroaching vegetation, as needed. See Section II.C.2a for additional information.

Remaining populations in protective ownership are occasionally managed; however, they are not subject to routine monitoring at an interval or intensity necessary to determine the success of management. Management is not occurring at two populations in private ownership.

Criterion 3. Through introduction and/or discovery of new populations, at least one additional self-sustaining population exist within the species' historical range (it is believed that at least nine populations are required to ensure that the species will not become endangered in the foreseeable future).

Two additional populations have been discovered since the latest revision of the recovery plan (Service 2000). However, these populations are unlikely to be self-sustaining due to population size (Service 2013): one (Dun Vegan Mountain) contained eight plants in 2018 and the other (Little Lost Cove Cliffs) contained 22 plants in 2018 (NCNHP 2020).

There have been no attempts to create new populations by introducing the species to new, unoccupied habitats. As mentioned in the 2013 5-year review, portions of two populations have been augmented on one or more occasions: the Linville Gorge-Table Rock subpopulation, and five subpopulations within the larger Grandfather Mountain population (Service 2013). In all instances, plants used for augmentation were grown from seed collected on site. Augmentation occurred in three efforts: the first in or around 1994, the second during the years 1999-2006, and the third in 2007. A fourth augmentation effort, with the goal of outplanting approximately 500 plants, is planned within the Grandfather Mountain population at subpopulations owned and managed by the BLRI. Seeds for this effort were collected in 2019 and plants are growing at the BLRI plant nursery for 2-3 years prior to outplanting (NPS 2020).

Although criteria for self-sustaining populations have not been developed for Heller's blazing star, a Population Viability Analysis (PVA) will be conducted using demographic data collected by BLRI (Grandfather Mountain population) since 2003 (Ulrey 2018). The BLRI will collaborate with Archbold Biological Station and the University of Central Florida to complete the analysis. The analysis will be the first such analysis for Heller's blazing star and only the second of its kind in the region (spreading avens [*Geum radiatum*], completed by the same team, was the first). At conclusion of the PVA, BLRI staff will learn if populations of Heller's blazing star at BLRI are viable and the current risk of extinction. Results of this work will play a leading role in conservation of the species by guiding actions of the BLRI and other conservation partners in the region tasked with managing Heller's blazing star.

Criterion 4. All nine populations and their habitat are protected from present and foreseeable human-related and natural threats that may interfere with their survival.

The destruction of habitat and trampling of plants due to recreational use has not been eliminated. In addition to trampling, fire suppression and invasive species have also been a suspected cause of Heller's blazing star decline. At this time, it is likely that each population continues to be threatened by at least one human-related threat. See Sections II.C.2a and II.C.2e for additional information.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. New information on the species' biology and life history: The Service is not aware of any new information regarding species' biology and life history since the 2013 5-year review.

b. Abundance, population trends (e.g., increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends: The listing rule recognized seven extant populations of Heller's blazing star and the recovery plan recognized eight extant populations; however, there is no estimation of total abundance in these documents (Service 1987, Service 2000).

The NCNHP maps and maintains species occurrence data as Element Occurrences (EOs). For this species, principle EOs represent an entire population and can contain multiple sub-EOs (a smaller geographically distinct area contained within a principle EO). A stand-alone EO contains one occurrence, representing a population, with no sub-EOs. Principle and stand-alone EOs can be thought of as proxies for populations and sub-EOs as proxies for subpopulations in the absence of species-specific information on pollination and dispersal distances.

The 2013 5-year review recognizes 11 extant populations mapped as nine stand-alone and two principle EOs with 17 sub-EOs. Total abundance was estimated at "a few thousand individuals" (Service 2013). Based on the most recent data present in the NCNHP

database, the species range still includes 11 extant populations mapped as nine stand-alone and two principle EOs but with 16 sub-EOs. This change is because plants were not relocated at two Grandfather Mountain sub-EOs; however, one additional location was discovered (representing a new Grandfather Mountain sub-EO). Additionally, the NCNHP includes Dun Vegan Mountain as a sub-EO of the Grandfather Mountain population. To remain consistent with the 2013 5-year review, we have left it as a separate population.

Current population size estimates are difficult to determine because of inconsistency in monitoring methods and counting units among observers, along with partial counts that do 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. As a result, ambiguous reporting such as "present" or "numerous" also make abundance estimates difficult. However, based on the NCNHP data available, we estimate approximately 5,000 plants throughout the species range (NCNHP 2020). In the 2013 5-year review, total plant abundance was reported as a general estimate and cannot be compared to current abundance at this time.

Data are insufficient to adequately assess status and trends at most populations; however, consistent monitoring is occurring at several populations and subpopulations.

The BLRI has been consistently monitoring four subpopulations within the Grandfather Mountain population since 2003 (Ulrey 2020a). All plants are tagged at each site and demographic characteristics of plants such as height of plants, leaf width, number of rosettes, and number of flowering stems are tracked annually. In 2019, 437 live plants were monitored at the four subpopulations.

Monitoring has shown that sites contain more plants with single rosettes than any other size class and smaller plants have lower survival rates than larger plants (Ulrey 2020a). A percentage of plants flower each year (3-75% depending on site conditions and weather) and there can be an increase in flowering in the years following a prescribed burn. Seed germination rates are low but can be increased after prescribed fire when mineral soil is exposed; however, rates of seedling survival are low. Seedlings survival was tracked early in the demographic study and 21% of seedlings found in 2005 were still alive in 2006 (Ulrey 2006). Overall, the long-term monitoring data (2003-present) indicates slightly decreasing trends in three of the four subpopulations monitored by the BLRI. A PVA will be conducted using demographic data collected from this study. At conclusion of the PVA, BLRI staff will learn if subpopulations of Heller's blazing star at BLRI are viable and the current risk of extinction. This information will be available for and incorporated into the next 5-year review.

The Paddy Mountain population, owned and managed by the NCPCP, has been monitored using the same protocol as BLRI sites. Monitoring occurred from 2009-2010 and again from 2017-2019 (Ulrey 2020a). In 2019, 135 live plants were monitored at the population. Paddy Mountain is an example of an undisturbed, mature population and has a more even distribution of size classes when compared to the BLRI sites. This site also

has the highest flowering percentage of the sites monitored with approximately 73% of plants flowering in 2019. Overall, the long-term monitoring data (2009-present) indicates an increasing trend at this population.

c. Genetics, genetic variation, or trends in genetic variation (e.g. loss of genetic variation, genetic drift, inbreeding, etc.): The degree of relation between Heller's blazing star and a closely related species, turgid blazing star (*Liatris turgida*) has become a point of taxonomic contention. Previous morphological and genetic studies have suggested the possibility that these species do not fall discretely into separate taxonomic treatments, which has led to unclear species boundaries. Previous genetic studies employed lower resolution markers such as allozymes and cpDNA markers (Godt and Hamrick 1996; Sullins 2013). Allozyme studies found highly structured populations, with high genetic diversity. The approach used by Sullins (2013) employed cpDNA markers, which provided no clear separation of the species, resulting in incomplete lineage sorting. The only findings from these studies that could contribute as evidence toward speciation in these taxa was the low level of gene flow observed in Heller's blazing star (Godt and Hamrick 1996), but the authors did not look at Heller's blazing star in relation to turgid blazing star. The lack of morphological differentiation and incomplete lineage sorting with cpDNA found in these studies offer evidence against separate lineages in these taxa.

In his 2019 thesis, Clarke investigated species boundaries between Heller's blazing star and turgid blazing star using 17 high-resolution genetic markers (microsatellites) developed during the project. The goal of the microsatellite analysis was to identify possible hybrid zones along with genetically distinct populations of both species. Genetic clustering was evaluated using two scenarios, dividing the data into two genetic clusters or four. These clusters were chosen as the most informative due to the high statistical support (two clusters) and biological relevance for management implications (four clusters). The analysis of two genetic clusters were interpreted to represent Heller's blazing star and turgid blazing star. In this scenario, the Little Lost Cove Cliffs population and several (but not all) subpopulations in the Grandfather Mountain population seem to represent the purest populations for Heller's blazing star; however, they are not without some introgression of turgid blazing star. The remaining populations show a moderate to strong affinity toward turgid blazing star or display evidence of admixture between species. The analysis of four genetic clusters were interpreted to represent Heller's blazing star, turgid blazing star, and two additional, yet to be described, taxa. In this scenario, populations in the amphibolite mountains and Linville Gorge are two distinct genetic clusters, the Little Lost Cove Cliffs population and Grandfather Mountain subpopulations owned and managed by BLRI are a distinct genetic cluster representing the purest populations of Heller's blazing star, and remaining populations show a moderate to strong affinity to turgid blazing star (a genetic cluster).

Genetic work on this species is still under review and researchers will continue to assess data relative to the understanding of the species, populations, and genetic exchange with turgid blazing star. Should these findings be accepted, they suggest a further reduction in the number of populations/subpopulations considered to be Heller's blazing star than

previously suggested and the species may be more critically imperiled than previously thought. Although this study does not fully resolve the taxonomy of these taxa, it does offer genetic data useful for management and conservation of the species. We hope to include additional information in the next status review for the species.

Field determination of the clusters, using morphology, is not currently possible with available taxonomic keys. For the purposes of this review, and until findings are further defined and accepted, current delineations of known occurrences as identified in NCNHP database are maintained.

d. 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 (ITIS 2020). Clarke's (2019) research identified genetically distinct populations of Heller's blazing star, genetically distinct populations of turgid blazing star, and two additional, yet to be described taxa. Although taxonomy of these four taxa have not been fully resolved, based on the findings generated in Clarke's thesis (2019), Heller's blazing star should retain its species distinction separable from turgid blazing star.

e. Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors, etc.), or historical range (e.g., corrections to the historical range, change in distribution of the species within its historical range, etc.): When the species was federally listed in 1987, the listing rule recognized extant populations in four counties in North Carolina (Ashe, Avery, Burke, and Caldwell) (Service 1997). The 2013 5-year review recognizes extant populations in Ashe, Avery, Burke, Caldwell, and one population that spans the Avery/Watuaga county line (Service 2013). Although a new sub-population was found, no new counties have been added to the distribution of the species.

f. Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem): The Service is not aware of any new information regarding the amount or distribution of habitat since the 2013 5-year review. See Sections II.C.2a and II.C.2e for updated information regarding threats to habitat.

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

a. Present or threatened destruction, modification or curtailment of its habitat or range: The listing rule cites habitat disturbance and trampling due to heavy recreational use of habitat, and development for commercial recreational facilities and residential purposes as primary threats to the species (Service 1987). These threats are still present.

Recreation

Although many populations are on protected land, threats related to recreation are still present and affecting populations. The destruction of habitat and trampling of plants due to recreational use has not been eliminated even when trails and camping sites are closed to the public. Land protection alone does not abate these threats and often, recreational

use of lands is encouraged. Several examples of impacts due to recreational use are discussed below.

The Linville Gorge Wilderness (LGW) is a popular recreational destination and the USFS defines usage as "heavy" (USFS 2019). The Service georeferenced a popular trail map (LGMaps 2018) and overlaid known, extant Heller's blazing star locations (NCNHP 2020). All populations in the LGW (three) and their associated subpopulations contain plants that are adjacent to a mapped trail. The listing rule and 2013 5-year review identified recreational user impacts, primarily hiking, as a threat to the species (Service 1987, Service 2013). However, recreational activities of other kinds – rock climbing, slacklining, etc. – can also contribute to destruction of habitat and trampling, and should be included when discussing recreational user impact. Social trails are also abundant in these areas. These unofficial and unmapped trails lead to views, camping sites, climbing routes, and/or slacklining locations. The unintended consequence of social trails is impact to these areas. In many locations where recreation and suitable habitat overlap, Heller's blazing star was previously or is currently present. Although not specifically tracked, trampling is often observed during monitoring and identified as, at least, a contributing factor in declining populations. NCNHP data contains general notes such as "recreation is the main concern for this population", "need to prevent hikers/climbers from trampling", "plants seemed healthiest along less accessed areas of the summit", etc (NCNHP 2020).

Although difficult to quantify, anecdotal evidence indicates an increase in visitor use in recent years and all LGW populations (three) have the potential to be impacted by increased use. Table Rock, the Chimneys, Hawk's Bill, and Shortoff Mountain are popular destinations on the east side of the LGW; however, exact visitation numbers are not known (Wood 2017). Wild South, a CFLRP partner, is exploring how to use crowd-sourced "activity" data from a popular social media-fitness mobile application to help quantify visitor use and identify usage patterns in the LGW (Massey 2019, Wild South, pers. comm.). If successful, use and pattern data could be compared with known locations of rare species. This information could be used to help prioritize sites for additional conservation or management, identify locations where use pattern could be changed, etc.

Visitors to the LGW often travel off-trail and Wild South has observed increased trampling of rare species and habitat, especially in trailside populations. Initially focusing on a mountain golden heather (*Hudsonia montana*) population, they will experiment with the placement of large, immovable boulders along the trail in an attempt to passively change the use pattern. Ideally, these boulders will direct visitors away from mountain golden heather by making certain areas more difficult to traverse (Massey 2019, Wild South, pers. comm.). Additionally, they are exploring the feasibility of relocating common, native shrub species into specific areas to break the line-of-sight from the trail to the enticing off-trail location (often an unofficial overlook or rock feature). If successful, this method could be employed in other locations for the benefit of other rare species, such as Heller's blazing star.

The USFS has proposed the Linville Gorge South End Trails Project (USFS 2017). This is a community and partner-driven project with the goal of providing access to rock climbing areas and overlooks while mitigating impacts to threatened and endangered plant species. The project includes relocating trails, away from rare plants, where feasible and providing official access to desirable locations while eliminating social trails that are unsustainable and difficult to maintain. This project will begin after review and approval by the USFS, with a projected start date in 2020.

The Service georeferenced a popular Grandfather Mountain trail map (Polaris 2018) and overlaid known, extant Heller's blazing star locations (NCNHP 2020). Of the 14 extant populations within the Grandfather Mountain population, eight subpopulations are adjacent to a mapped trail and three others are within 500 feet. As with the LGW, social trails are abundant and harbor the same threats.

Grandfather Mountain is the largest population of Heller's blazing star, containing the majority (>75%) of all known plants throughout the range (NCNHP 2020). While we do not have studies specific to Heller's blazing star and trampling, there are studies researching co-occurring species with applicable results. Thompson (2017), with North Carolina State University, conducted range-wide monitoring of Blue Ridge goldenrod, a species that co-occurs with Heller's blazing star on property owned and managed by the GMSF, in 2016 and 2017. Thompson divided Linville Peak, the largest of all subpopulations for Blue Ridge goldenrod and Heller's blazing star, into two locations: the trailhead and the swinging bridge. She noted 72% of Blue Ridge goldenrod clumps at the trailhead and 38% at the swinging bridge had signs of trampling (Thompson 2018a). While we do not have exact counts of trampling for Heller's blazing star, we can assume trampling impacts for Heller's blazing star at similar rates. The trailhead is in an area easily accessible to visitors and adjacent to a parking lot. Although the swinging bridge is also easily accessible to the public, there are railings and seasonal natural resources staff to encourage visitors to stay on designated pathways and overlooks. Thompson consulted with the GMSF regarding language to use on signs that would deter visitors from unknowingly impacting rare plants. Signs ask visitors to avoid rare plants by only stepping on bare rock. While data has not been collected to quantify effects the signs may be having on rare plants, observations suggest that the response may be positive (Thompson 2018b, NCSU, personal communication). Additionally, the GMSF is developing a Land Resource Management Plan that will guide resource management practices and levels of resource protections while providing a recreational experience to visitors (Cavney 2018).

In 2004, a visitor use study was initiated at two Heller's blazing star subpopulations owned and managed by the BLRI (Grandfather Mountain population). The goals of the study were to quantify the volume of visitor impacts in and around sensitive habitats, identify when visitor impacts occur, and evaluate the effectiveness of ranger patrols on reducing visitor impacts to sensitive areas (Ulrey 2004). Visitor usage in these areas is limited or restricted through site closures, trail barricades, and signage. Trail counters were deployed in on-trail (foot travel is permitted) and off-trail (foot travel is not permitted) locations from April 15 to November 15. The busiest day of the week was

Saturday and the busiest times of day occurred in the afternoon hours (Ulrey 2004). Throughout the study period, uniformed biological technicians (trail rovers) patrolled the area, primarily weekends and holidays, in an attempt to reduce off trail impacts. Trail rovers spent 36 days (288 person hours) patrolling Grandfather Mountain sites included in the study. Despite patrolling, 14.9% of visitor impacts were in closed areas, corresponding to 3,354 visitor impacts during the study period; however, these impacts did not occur while trail rovers were present. Trail rovers reported that while they were present at the site (11AM – 5PM on weekends and holidays) no visitors entered closed, off-trail areas. A 62% reduction in visitor impacts occurred when comparing patrol days versus non-patrol days (Ulrey 2004). While patrolling the area did reduce visitor impacts and trampling in sensitive habitats, it did not eliminate the threat. Increasing patrols, both in number of days and duration would have further decreased impacts to Heller's blazing star subpopulations at BLRI. Although this study is from 2004, the trend of visitor impacts are still applicable, but magnified due to the overall increase of visitors using the BLRI and increase in popularity of the Grandfather Mountain area (Ulrey 2020, BLRI, pers. comm.). Trail rovers are not currently patrolling the sites; however, BLRI would like to recreate this study in the future to update their findings (Ulrey 2020a).

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 the Paddy Mountain Plant Conservation Preserve, sites containing Heller's blazing star (Destination by Design (DBD) 2017). The portion of Three Top Mountain Game Lands containing Heller's blazing star is currently accessible to the public but the new trail would make accessibility easier and invite additional visitors. The Paddy Mountain 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 Heller's blazing star (two populations), 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 Three Top Game Lands and the Paddy Mountain 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.

Fire

In addition to recreation, fire suppression, which facilitates threats from competing vegetation and suppresses seedling recruitment, has been a suspected cause of Heller's blazing star decline. Heller's blazing star is thought to be fire-adapted and BLRI has conducted experiments using fire as a management tool. It is known that fire influences vegetation distributions, and that distributions have been altered by fire suppression (Frost 1998). While most fires are anthropogenic in origin, understanding the natural fire regime can provide forest managers with information needed for conservation of fire-adapted species affected by fire suppression. We have limited studies specific to Heller's blazing star and fire; however, there are studies researching co-occurring species with applicable results and the BLRI has conducted prescribed fire in their subpopulations.

Frantz and Sutter (1987) estimated that lightning-ignited fires once occurred in the LGW every five to 10 years. Lightning-ignition records from 1955-1971 and 1974-1985 indicate 17 lightning-ignited fires within the LGW or within proximities, which would enable possible spreading into the LGW. In an analysis of fire effects on mountain golden heather, a co-occurring species with Heller's blazing star in the LGW, ten of the 17 fires were on ledges burning near occupied mountain golden heather habitat, the years in which these fires occurred suggest a much shorter lightning-ignited fire return interval of 2.9 years (Kauffman 2019a, USFS, pers. comm.). Since the 1950s, fire prevention has successfully minimized and reduced forest fires (Frost 1990) and within the last 20 years, there have been four lightning-ignited fires in the LGW (Kauffman 2019a, USFS, pers. comm.).

In his 2016 thesis, Denman sought to understand lightning-ignited fires in the Grandfather Ranger District of the Pisgah National Forest (including the LGW), in part, by investigating the climatic conditions that are optimal for lightning-ignited fires. Additional analysis was used to determine if spatial distribution of mountain golden heather is associated with spatial distribution of lightning-ignitions.

Using a 20-year dataset of lightning-ignitions, Denman (2016) found lightning-ignition locations and mountain golden heather populations to be random at small scales and aggregated at large scales. This suggests lightning-ignitions and mountain golden heather populations are not spatially associated, and lightning-ignited fires would need to burn large areas to affect the plant species. Denman (2016) also found not all mountain golden heather locations were burned during the 20-year timeframe, indicating that lightning-ignited fires are not burning mountain golden heather locations at intervals needed to maintain viable populations. Despite the presence of lightning-ignited fires almost yearly, most fires burned relatively small areas due to changes in historic fuel loads, landscape fragmentation, and fire suppression. Denman (2016) suggests small fire size may be the main reason why lightning-ignitions are infrequently associated with known plant locations. Although lightning-ignition did not burn many mountain golden heather locations during the timeframe, the importance of lightning-ignitions in the LGW should not be undervalued. Denman (2016) concluded that managers will have to utilize prescribed burning to supplement lightning-ignited fires. This conclusion is also applicable to Heller's blazing star in the LGW.

Congress established the Collaborative Forest Landscape Restoration Program (CFLRP) to encourage the collaborative, science-based ecosystem restoration of priority forest landscapes and in 2012 and the Grandfather Restoration Project was funded. The project is a 10-year effort with the goal of increasing prescribed burning and other management practices to more than 40,000 acres of the Grandfather Ranger District in Pisgah National Forest. The project aims to restore fire-adapted forest ecosystems and benefit a variety of native plants and wildlife; and control exotic, invasive species. A wide variety of partners are collaborating with the USFS on the project and the LGW, including populations of Heller's blazing star, has benefited as a result of the program and partnerships.

Although prescribed burning in the LGW remains difficult to achieve and burning relies heavily on wildfires, which by nature are unpredictable with regards to timing, location, and intensity, the USFS's Fire Use Policy includes allowing wildfires to burn when beneficial to listed species and not a threat to other natural resources or public safety (Service 2013). In 2013, the Table Rock Fire, a wildfire suspected to be cause by a rekindled campfire, burned approximately 2,400 acres (Morrison 2014) including one population (Linville Gorge-East Rim population containing two subpopulations) of Heller's blazing star and surrounding habitat (Kauffman 2018a, USFS, pers. comm.). In 2007, the Shortoff Fire, a wildfire suspected to be caused by lightning strike, burned approximately 4,500 acres including portions of the Shortoff population. In 2017, the White Creek Fire, another lightning-ignited fire in the vicinity of the Shortoff population, burned 5,500 acres (Kauffman 2018a, USFS, pers. comm.; CFLRP 2017). Fire intensity during the White Creek Fire was more subdued overall when compared to the 2007 Shortoff Fire (Kauffman 2019a, USFS, pers. comm.).

The USFS developed a fire priority model to prioritize burning for fire-adapted plant communities, including rare plants and animals (Kauffman 2019a, USFS, pers. comm.). Federally-listed species, as well as endemic species, received the highest weight for rare species. In an effort to use prescribed fire in the LGW, the USFS will complete an environmental assessment (EA) for burning specific rare plant habitat or expand the document to include all fire-adapted communities in the LGW (Kauffman 2019a, USFS, pers. comm.). Strong public opposition to burning in the LGW has been difficult to overcome in the past and significant outreach will be needed to gain support from the surrounding community.

The BLRI manages Heller's blazing star subpopulations with the goal of increasing recruitment by improving habitat conditions and improving health of adult plants by reducing competition (Ulrey 2017). In 2007, prescribed burns of no more than 40 square-meters in multiple "spots" were conducted in areas near to but not containing Heller's blazing star at BLRI sites (Ulrey 2017). This was a trial treatment and the intent was to push back the encroaching vegetation. In addition, approximately 85, 3-year old plants, grown from seed at the park headquarters, were transplanted into the burned spots (local population genetic integrity was preserved). Only 28% of plants remained in 2009; however, seed germination was observed in the old burned spots in 2013. Overall, the

burning technique was successful at removing encroaching vegetation and the litter layer, which allowed for seedling recruitment (Ulrey 2017). Prescribed fire, using the same methods, was utilized again in 2019 at all four known BLRI subpopulations of Heller's blazing star. The low intensity burn was conducted in March of 2019 while the species was dormant. The objective was to remove competing vegetation and expose mineral soil by consuming the litter and duff layers. While the prescribed burn was successful at decreasing the shrub cover in areas where Heller's blazing star occur, objectives could have been further met had fuels been drier and more receptive to fire. Igniters were unable to remove the litter and duff layer down to mineral soil (important for Heller's blazing star seed germination). In addition, weather conditions prevented igniters from reducing shrub cover over a larger area in the allotted amount of time. BLRI staff expressed a need to potentially burn again. Despite difficulties with the 2019 burn, demography data show that prescribed burning can benefit this species. Two subpopulations have had an increase in the number of plants in all size classes since burning began in 2005 or 2007 (Ulrey 2020a).

b. Overutilization for commercial, recreational, scientific, or educational purposes: Currently, Heller's blazing star is not known to be threatened by overutilization; however, poaching still remains a threat.

The Service is aware of one minor poaching event in 2018. A hiker in the LGW, not knowing the plant was federally protected, dug one plant including five flowering stalks. Although the hiker did not appear to have ill-intent, the person was fined by the USFS and the plant was confiscated (Kaufmann 2018b, USFS, pers. comm.).

During a site visit in 2018, associated with genetics research discussed above, Clarke and Grandfather Mountain State Park (GMSP) ranger, Luke Appling, visited a known population and found no plants remaining at the site (Appling 2020, GMSP, pers.comm). As many as 500 plants had been seen at the site in the past (NCNHP 2020). While some plants may remain in inaccessible areas, none were observed from accessible areas of the site after an extensive search. With no other cause for such population decline observed, Appling suspects the site may have been poached. Clarke and Appling also discovered construction of illegal social trails through sensitive rare plant habitat. Those working with the species should be mindful of the potential for collection and report any observations to the Service. Threats due to recreation are discussed above with Factor A.

c. Disease or predation: Herbivory was not identified in the 2013 5-year review as a primary threat to Heller's blazing star; however, it should be considered and investigated as a threat to the species. Herbivory was tracked in 2018 during demographic monitoring. At seven sites, including one stand-alone population (Paddy Mountain) and four subpopulations of the Grandfather Mountain population, herbivory ranged from 5.6% to 53.3% (Ulrey 2020b). The specific herbivore predating Heller's blazing star is unknown, but is likely a small mammal. The three declining populations mentioned in Section II.C.1b. also have the highest rates of herbivory (Ulrey 2020b).

d. Inadequacy of existing regulatory mechanism: 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 that is classified as a threatened, endangered, sensitive, rare, or unique species (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). Gathering and removing plants or plant parts is currently prohibited in National Park System areas unless specifically authorized by federal statute, treaty rights, or conducted under the limited circumstances authorized by existing codified regulations (NPS 2019). Although these regulations and policies should protect Heller's blazing star on USFS and National Park Service property, lack of resources prevents monitoring of compliance and enforcement.

e. Other natural or manmade factors affecting its continued existence:

Invasive Species

The listing rule and 2013 5-year review do not identify exotic, invasive species as a threat to Heller's blazing star (Service 1987, Service 2013); however, more than ten different species have been documented throughout the LGW (Wild South 2012). The three species that pose the most serious threat are: princess tree (*Paulownia tomentosa*), Chinese silver grass (*Miscanthus sinensis*), and mullein (*Verbascum thapsus*). These species are prolific colonizers of disturbed land, and the area's high propensity for wildfire has made it especially susceptible to invasion. If left unchecked, these species can crowd and reduce sunlight to Heller's blazing star. Kuppinger et al. (2010) studied the invasion of princess tree, a disturbance-dependent invasive plant, across three burns in the southern Appalachian Mountains, including a burn at the LGW. Following initial widespread establishment after fire, princess tree only persisted on more exposed and xeric sites (Kuppinger et al. 2010). The lack of competition within this habitat suggests that princess tree may be able to further reproduce and increase in dominance. Although fire is beneficial to Heller's blazing star and habitat conditions, additional burning could also increase the abundance and extent of princess tree (Kuppinger et al. 2010). The control of princess tree in rare species habitat may require special attention from land managers.

A comprehensive exotic, invasive species survey was conducted in the LGW in 2010, after the Shortoff Fire in 2007 (Kauffman 2019a, USFS pers. comm.). This survey provided data to support the completion of an EA to manage exotic, invasive species across all Wilderness areas in their jurisdiction, including the LGW. It is anticipated that development of the EA will begin in 2020. Wild South, with guidance from the USFS, led multiple efforts to manage exotic, invasive species and three of the most recent and largest efforts were in 2012, 2014, and 2017.

In 2012, Wild South received a TogetherGreen grant for "an innovative conservation project". They focused their efforts on removing exotic, invasive plants from the LGW

by engaging community volunteers, veterans, wilderness therapy programs, and other conservation organizations (Wild South 2012).

After the Table Rock Fire in 2013, the USFS conducted a Burn Area Emergency Response (BAER) assessment indicating the need for exotic, invasive management and availability of funding for removal of exotic, invasive species seedlings, primarily princess tree. In 2014, the USFS Grandfather Ranger District entered into an agreement with Wild South to organize interns and volunteers to pull exotic, invasive species seedlings (Kauffman 2019a, USFS, pers.comm.). The effort was largely successful with 92 volunteers contributing 633 hours to exotic, invasive plant removal during one year of the effort (Massey 2019, Wild South, pers. comm.).

In 2017, after the White Creek Fire, a BAER assessment also documented the need for exotic, invasive species management within the fire boundary, primarily princess tree and Chinese silver grass. CFLRP partners, using three separate participatory agreements, developed a strategy to survey and treat invasive species within the fire boundary. An extensive survey and treatment effort took place during the summer and fall of 2017, with partner organizations working together, under the guidance of the USFS, to survey and treat exotic, invasive species. Work focused on detection and removal or treatment of princess tree, Chinese silver grass, mullein, tree-of-heaven (*Ailanthus altissima*), and Japanese spiraea (*Spiraea japonica*). Tens-of-thousands of princess tree seedlings were pulled from fall of 2017 to early 2018. Over 2,500 acres have been inventoried, mapped, and treated within the fire boundary (Massey 2019, Wild South, pers. comm.; Kauffman. 2019a, pers. Comm.). Also in 2017, chemical treatment of scattered exotic, invasive species was completed on approximately 1,000 acres in the area adjacent and east of the LGW; the area was retreated in 2019 (Kauffman 2019a, USFS pers. comm.).

The work described above is critical not only to controlling existing populations of exotic, invasive species, but informing the USFS on how exotic, invasive species interact with wildfire and prescribed fire on a large scale. This type of exotic, invasive species management will likely be required to help meet Criterion 2 of the Heller's blazing star recovery plan.

Climate Change

Plants existing in small and isolated populations 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. While we do not have studies specific to Heller's blazing star and climate change, there are applicable studies researching other high-elevation Southern Blue Ridge endemics. 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. Although Heller's blazing star was not the target species of this study, the results are applicable and demonstrate climate refugia that currently buffer rare species from macroclimatic extremes may not be able to do so under anticipated climate change.

D. Synthesis

Heller's blazing star should remain classified as threatened. The distribution of the narrow-ranging endemic has not appreciably changed and threats identified in the 1987 listing rule, the 2000 Recovery Plan, and the 2013 5-year review – recreation and fire suppression - are still current threats and conservation ownership alone does not completely abate these threats. Additional threats, such as herbivory, invasive species, and climate change, have also been identified as threats to the species. Status and trends at most populations cannot be adequately assessed at this time; however, three of five populations or subpopulations that are consistently monitored show a decreasing trend. Data and information outlined in this review highlight the need for continued management and monitoring throughout the range and shows Heller's blazing star continues to meet the definition of a threatened species under the Endangered Species Act.

III. RESULTS

A. Recommended Classification: No change is needed.

IV. RECOMMENDATIONS FOR FUTURE ACTION

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

- Continue support for the ongoing genetic analysis being conducted by Appalachian State University (ASU), assisting with identification of sample sites and refinement of questions to be addressed. Ensure that relevant field observations made during the collection of genetic samples are reported to the NCNHP for incorporation into site records.
- Assist landowners or other knowledgeable sources in reporting existing backlogs of relevant observation data to the NCNHP, so that this repository of data contains the most accurate, complete and current information.
- Specifically work with GMSF and Atlanta Botanical Garden to determine the number of Heller's blazing star plants placed at Hang Glide Cliff subpopulation, and evaluate the success of previous augmentation trials conducted there.
- Ensure that monitoring data is sufficient to assist in evaluating the relative stability of populations and the effectiveness of implemented management actions.

- Work with USFS and BLRI to explore options for augmenting the subpopulations poached in 2009, to minimize the potential for population bottlenecks and long-term genetic implications.

The following future actions are recommended to improve recovery of the species.

- Continue support for the most recent genetic analysis conducted by ASU. Work with ASU and species experts to determine implications of the study on recovery.
- Work with and support partners to quantify visitor use and identify visitor use patterns to prioritize management that would minimize recreational impacts to the species.
- Work with and support partners to monitor or census populations every five years using a standardized protocol, prioritizing sites that have not been monitored or censused in at least five years. Explore a partnership with the recreational climbing community to inventory sites with difficult access.
- Coordinate with partners and an appropriate botanical garden to collect and bank seeds. Highest priority sites should be those with purest genetics and no prior seed collection.
- Work with the USFS and support efforts to complete an EA for prescribed burning in fire-adapted habitats across all Wilderness areas, including the LGW.
- Work with the USFS and support efforts to complete an EA for control of exotic, invasive species across all Wilderness areas, including the LGW.
- Work with and support the USFS, Wild South, and other CFLRP partners, to continue exotic, invasive species inventory and management projects at the LGW.
- As staff time and office resources allow, consider the need to reevaluate the recovery criteria and amend the recovery plan. If deemed necessary, work with the Regional Office to include recovery plan updates and/or amendments into the regional workplan.
- Heller's blazing star 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. Pre-monitoring, 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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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW OF HELLER'S BLAZING STAR

Current Classification: Threatened.

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ 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: 2020.08.26 15:05:04 -04'00' Date _____

APPENDIX A
Peer Review

Summary of peer review for the 5-year review of Heller's blazing star (*Liatris helleri*).

A. Peer Review Method: Peer review was coordinated by the U.S. Fish and Wildlife Service's (Service) Raleigh Ecological Services Field Office in North Carolina. Four peer reviewers were selected by the Service for their knowledge of and expertise with Heller's blazing star. Individual responses were received from two reviewers. Additionally, internal review was conducted by four members of the Service's South Atlantic-Gulf Region.

B. Peer Reviewers: The peer review request included personnel from:
Appalachian State University
National Park Service, Blue Ridge Parkway
North Carolina Natural Heritage Program (NCNHP)
U.S. Forest Service

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 and Responses: No comments were received during the 60-day public comment period.

The representative from the U.S. Forest Service did not respond to the request for review. Two representatives from NCNHP reviewed the document but had no comments. Representatives from Appalachian State University and this National Park Service did provide comments. All substantive comments received were reviewed by the Service and incorporated into a revised version of this document, where appropriate. A brief summary of substantive comments is below.

The reviewer from the Appalachian State University provided additional information about probable poaching at Grandfather Mountain State Park and recommended following up with park staff for details. Additional information was incorporated in Section II.C.2b.

The reviewer from the National Park Service suggested population monitoring using a standard protocol since censusing populations may be difficult due to terrain. This suggestion was incorporated in the future actions.