

Recovery Plan for

Liatris helleri

Heller's Blazing Star



U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

RECOVERY PLAN

for

Liatris helleri (Heller's Blazing Star)

Original Approved: May 1, 1989

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FIRST REVISION

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Date: _____

1/28/00

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By approving this recovery plan, the Regional Director certifies that the data used in its development represent the best scientific and commercial information available at the time it was written. Copies of all documents reviewed in the development of the plan are available in the administrative record located at the Asheville Field Office in Asheville, North Carolina.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1999. Recovery Plan for *Liatris helleri* Porter (Heller's Blazing Star). First Revision. Atlanta, GA. 25 pp.

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Fish and Wildlife Reference Service
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Phone: 301/492-6403 or
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The illustration on page 3 of this plan was completed by Ms. Susan Sizemore.

EXECUTIVE SUMMARY

Current Status: Heller's blazing star is federally listed as a threatened species. It is currently known from only eight locations, all in North Carolina. Declines have been noted at three of these eight sites within the last 10 years and this plant has not been found at two additional historically occupied sites for over 50 years.

Habitat Requirements and Limiting Factors: This rare perennial (plant with a life span greater than two years) grows on high cliffs, rock outcrops, ledges, and grassy balds (mountain summits with little to no trees) in the Blue Ridge Mountains (a mountain range extending from south Pennsylvania to north Georgia, part of the Appalachians), where it is threatened by recreational and residential development, trampling, collection, and acid precipitation and other forms of atmospheric pollution that have been found to be concentrated at higher elevations in the Southern Appalachians.

Recovery Objective: Delisting.

Recovery Criteria: Heller's blazing star will be considered recovered when there are at least nine self-sustaining populations in existence within the species' historical range that are protected to such a degree that the species no longer meets the definition of a threatened species under the Endangered Species Act of 1973, as amended (Act). (A self-sustaining population is a reproducing population that is large enough to maintain sufficient genetic variation to enable it to survive and respond to natural habitat changes. The number of individuals necessary and the quantity and quality of habitat needed to meet these criteria will be determined as one of the recovery tasks.) Heller's blazing star will be considered for delisting from the Federal List of Endangered and Threatened Wildlife and Plants when the following criteria are met:

1. The eight extant populations are protected.
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.
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).
4. All nine populations and their habitat are protected from present and foreseeable human-related and natural threats that may interfere with their survival.

Actions Needed:

1. Survey suitable habitat for additional populations.
2. Monitor and protect existing populations.
3. Conduct research on the biology of and threats to the species.
4. Establish new populations or rehabilitate marginal populations to the point where they are self-sustaining.
5. Investigate and conduct necessary management activities at all key sites.
6. Obtain public and landowner support through educational outreach.

Cost (\$000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Total
FY 1	4.0	2.5	28.5	5.0	2.0	2.0	44.0
FY 2	---	2.0	25.0	15.0	2.0	1.0	45.0
FY 3	---	1.5	25.0	20.0	10.0	1.0	57.5
TOTAL	4.0	6.0	78.5	40.0	14.0	4.0	146.5

Date of Recovery: The delisting date cannot be estimated at this time.

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PART I

INTRODUCTION

Heller's blazing star (*Liatris helleri*), described by T. C. Porter in 1891 (Porter 1891), is a rare plant endemic (native) to a limited area in the Blue Ridge Mountains of North Carolina. Due to its rarity and vulnerability to threats, the species was federally listed as threatened on November 19, 1987 (U.S. Fish and Wildlife Service 1987). Heller's blazing star is officially listed as threatened by the State of North Carolina under the provisions of its Plant Protection and Conservation Act (General Statute 19b106-202.12-202.19, 1979).

The first recovery plan for Heller's blazing star was completed in May 1989 (U.S. Fish and Wildlife Service 1989). Implementation of the recovery actions specified in that plan generated additional site, life history, and population information. In addition, habitat protection efforts resulted in some level of protection for five of the eight extant populations. This revision reflects these accomplishments and incorporates the latest information in updating recovery objectives and tasks.

Current and Historical Distribution

Only eight populations of Heller's blazing star are now known to exist (all in North Carolina)--three in Avery County, one in Caldwell County, one in Burke County, and three in Ashe County. Although we do not have specific historical data on the number of plants at these locations, declines have been noted at three of the eight extant sites within the last 10 years. Two additional sites were known to have been occupied by the species historically; however, both areas have undergone extensive residential and recreational development since the original collections. Despite numerous searches, no plants have been found at these sites in over 50 years.

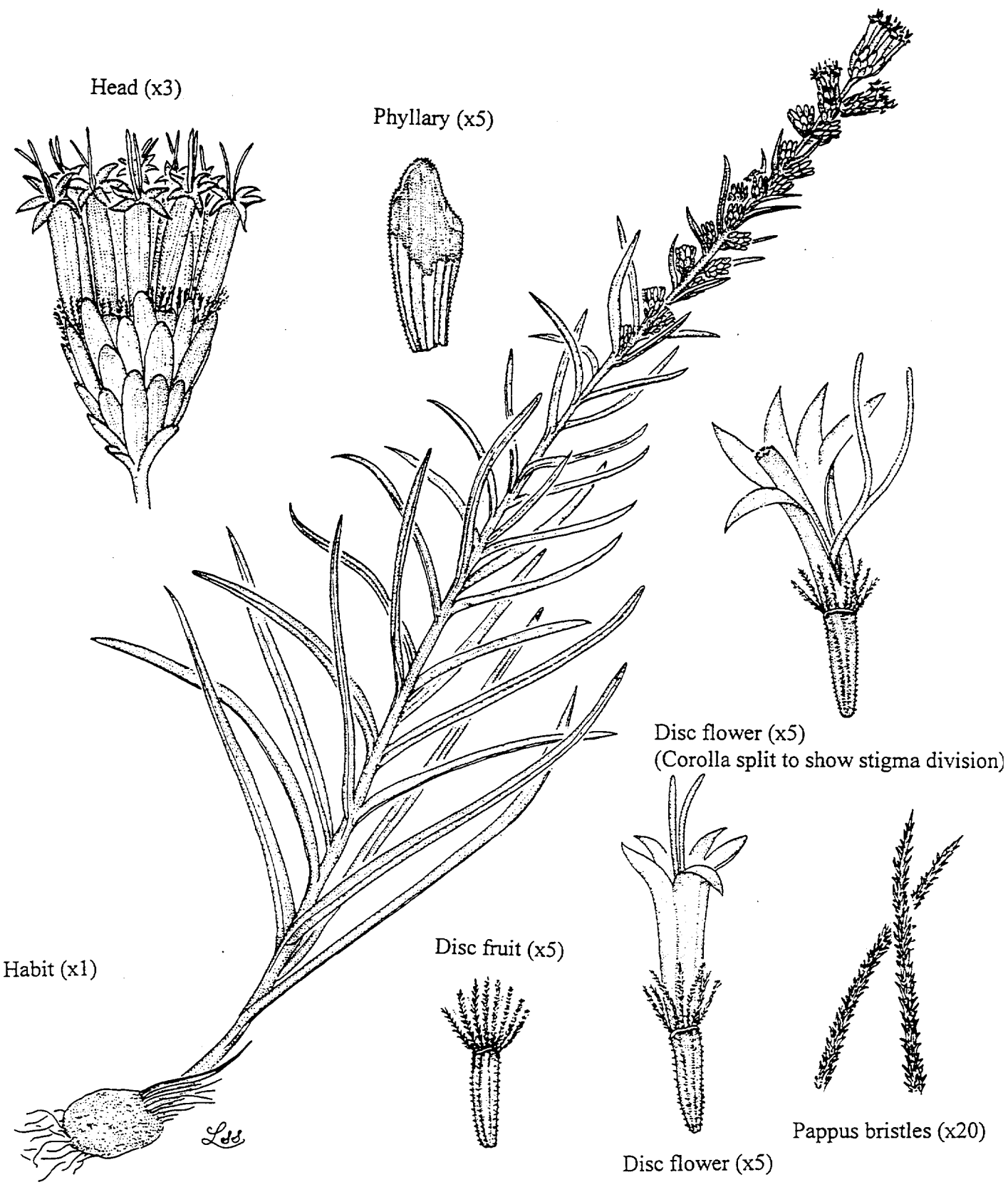
Description

Heller's blazing star is 1 of about 40 species in the native North American genus (a group of closely related species) *Liatris*. The taxonomy (classification of organisms based on genetic similarities) of this group is complex and is sometimes complicated by natural hybridization (creating new plants from genetically dissimilar parent plants), occasionally between species that are not closely related (Cronquist 1980, Small 1933, Gaiser 1946). Other common names applied to the genus include button snakeroot, rattlesnake master, and gay feather. The genus is within the large and equally complex aster family (*Asteraceae*).

Heller's blazing star is a perennial herb that grows from a cormlike rootstock (underground stem) 2.0 to 5.0 centimeters (cm) (0.8 to 2.0 inches (in)) broad. (See illustration on page 3.) One or more erect or arching stems arise from a tuft of narrow

pale green basal (growing from the base of a stem) leaves. The stems reach up to 4.0 decimeters (15.7 in) in height and are topped by a showy spike (the flowering part of a plant with flowers along a long axis, close to the stem) of lavender flowers 7.0 to 20.0 cm (2.8 to 7.9 in) long. The stems, usually stiffly erect, are proximally (towards the base) purplish, distally (towards the top) green, strongly ribbed, and angulate (angled). Both basal and cauline (on the stem) leaves are numerous, with those at the stem base and on short offshoots the longest, often 2.0 to 3.0 decimeters (7.9 to 11.8 in) long. The flat leaf blades are linear-oblongate (tapering towards the base, shaped like a lance), elliptic-linear or linear, acute (having a sharp point), entire, tapering gradually to slender, erect, ribbed petioles (stalk of leaf attaches to the stem). The surfaces are scatteringly punctate (dotted with depressions) and equally pale green, with only the midrib (central rib of a leaf) prominent. The leaves toward the top of the stem become erect and gradually reduced in their length and width, with the petioles becoming shorter and winged; they are often sparsely ciliate (hairy around the margins), gradually grading into the linear bracteal leaves of the inflorescence (showy leaves underneath the flowering cluster part of a plant). The heads of the inflorescence (flower cluster) are sessile (attached to the stem), or nearly so, in an elongate, showy, and narrow determinate spike or spikelike raceme (a plant in which stalked flowers are arranged singly on a stem) 7.0 to 20.0 cm (2.8 to 7.9 in) long. The florets (small flowers in a cluster) measure 1.0 to 1.3 cm (0.4 to 0.5 in) long from base to top.

Involucral bracts (whorls of showy leaves under each flower) are thinnish, imbricated (overlapping in a regular pattern) in several series, the largest ones inner or medial (middle), approximately 7.0 to 8.0 millimeters (mm) (0.3 to 0.32 in) long, oblong or obovate (egg-shaped), apically (at the tip) rounded, marginally ciliolate (hairy), with the back slightly rounded, longitudinally ribbed, green proximally, maroon distally and with a broad, scarious (thin, membranous, dry), rosy border. All flowers are discoid (shaped like a disc), symmetrical, perfect, 7 to 10 per head; the corolla (the outer petals of a flower) is pale to deep lavender rose, from the tube base to orifice approximately 5.0 mm (0.2 in) long. The tube is scattered-pilose (with fine hairs) within, the lobes narrowly triangular, spreading, 2.0 to 2.5 mm (.08 to 0.1 in) long; the two stigma (the tip of the flower pistil) lobes are long-linear, terete (tapering cylinder shape), well exerted (protruding) and spreading, deep lavender-rose, and papillose (rough, papery). The fruit is a narrowly cuneiform achene (or cypsela) (a small wedge-shaped dry thin walled fruit that does not open when ripe), strongly angled and ribbed, approximately 5.0 mm (0.2 in) long, with the intervals shallowly to deeply concave, the surface nearly black, hispidulous (covered with bristly hairs) along the ribs, with a pappus (tuft) of numerous, rigidly erect, slender, pale purple, antrorsely (pointing upwards) barbed bristles, extending only half to two-thirds of the way to the corolla throat (Kral 1983). Flowering occurs from July through September (Radford *et al.* 1964, Kral 1983), with the apical (top) flower head opening first (Gaiser 1946). Fruits are borne from August to October (Massey *et al.* 1980).



Head (x3)

Phyllary (x5)

Habit (x1)

Disc flower (x5)
(Corolla split to show stigma division)

Disc fruit (x5)

Pappus bristles (x20)

Disc flower (x5)

In general appearance, *L. helleri* closely resembles several other species, particularly high-altitude races of *L. spicata* and *L. graminifolia*. *Liatris helleri* can be distinguished from *L. spicata* primarily by its internally pilose (rather than smooth) corolla tube and its ciliate (versus entire) petioles. It differs from *L. graminifolia*, primarily because of its shorter pappus (which in *L. graminifolia* extends nearly to the disc corolla apex) and its lower, stockier habit (appearance) (Kral 1983). (See illustration on previous page.)

Habitat

Heller's blazing star habitat consists of rock outcrops, ledges, cliffs, and balds at high elevations (1,067 to 1,829 meters or 3,500 to 5,999 feet). The plants grow in humus or clay loams (soils consisting of clay and organic matter) on igneous (volcanic) and metasedimentary rock, including quartz diorite, metagraywacke, metaconglomerates, and metarkoses rich in feldspar and chlorite (Kral 1983, Massey *et al.* 1980). Soils are generally acidic (pH 4) and shallow (ranging from 0 to 40.0 cm (0 to 15.7 in) in depth). Observations of the hydrology (water properties) of occupied sites indicate that most are intermittently (periodically) saturated but excessively drained to moderately poorly drained (Massey *et al.* 1980). Sites occupied by the species are generally exposed to full sun. Common associates include *Deschampsia flexuosa*, *Danthonia compressa*, *Poa* spp., *Carex* spp., *Potentilla tridentata*, *Prenanthes roanensis*, *Arenaria gronlandica*, *Paronychia argyrocoma*, *Picea rubens*, *Leiophyllum buxifolium*, *Sorbus americana*, *Rhododendron catawbiense*, *Aster acuminatus*, *Saxifraga michuxii*, *Heuchera villosa*, and *Solidago* spp. (Massey *et al.* 1980). In addition, *Liatris helleri* often occurs with other rare species, some of which are federally listed or are species of Federal concern, including *Abies fraseri* (Fraser fir) (a species of Federal concern), *Solidago spithamaea* (Blue Ridge goldenrod) (listed as threatened), and *Hedyotis purpurea* var. *montana* and *Geum radiatum* (both listed as endangered).

Ecology and Life History

Very little specific information is available on the life history and population biology of Heller's blazing star. Gaiser (1946) described the growth habits and life history of the genus as follows:

Being perennial plants, all species of *Liatris* have a thickened underground stem from which fibrous roots spread out to anchor the plant. During the first summer of the seedlings' growth they develop a few radical leaves above what appears as a slightly thickened tap root, but at the end of the season an apical bud is developed from a small crown and this, in the second year, produces the first flowering stalk. During successive summers the stem thickens, becoming globular or remaining ovoid (egg-shaped) in most species . . . in some species . . . the corm (underground

stem) while growing slightly deeper, broadens comparatively more during the successive years, sometimes to a width of 10.0 centimeters (3.9 in) or more, thus providing a widened crown from which many flower-stalks arise. Such plants have been found to live for more than 15 years, probably representing the hardiest of the shallow-rooted species, which advantage, along with the provision of numerous flowering spikes, makes them the favored species in [cultivated] perennial flower-borders. Some buds of broad, old stems grow into new corms and upon separation or death of the old become new individuals

Kerster (1968), in studies of the prairie species *Liatris aspera*, suggested that 34 years might be the maximum age of individuals of the species and found that flowering was not common before the ninth year of an individual plant's life.

Various hymenopterans (order of species which includes bees, wasps, and ants) have been observed visiting the flowers, but the pollinators have not been identified for *L. helleri*. The seeds are transported primarily by the wind, germinating (sprouting) and growing only when they land in locations with suitable habitat. As stated by Gaiser (1946), new rootstocks form on the periphery of old ones and subsequently separate or form new plants when the old rootstocks die. The relative importance to the species of each mode of reproduction (sexual versus vegetative) is unknown. Godt and Hamrick (1995) found strong evidence that the species is self-incompatible, and because of this, they suggested that individuals isolated from the main body of a population might be pollen-limited. In extreme cases where the genetic diversity is severely reduced due to population reductions ("bottlenecks") or other stochastic events, all the surviving plants could have the same mating type, in which case the population would be effectively sterile.

Although other species of *Liatris* are known to hybridize in nature, producing plants with intermediate characteristics and making identification even more difficult, hybridization of *L. helleri* with other species has not been documented (Gaiser 1946). Information on seed set, germination, survival of seedlings, flowering frequency, and response of populations to climatic extremes and various forms of disturbance is not available for this species. However, in studies of other species in this genus, it has been shown that some type of disturbance is often necessary to maintain the plants at a particular site since they are early successional species (Kerster 1968). Kerster stated:

It is possible that *L. aspera* becomes established on a site only through the intervention of fire and other disturbance, experiences progressively poorer recruitment as the effects of disturbance fade, and, in the absence of new disturbance, is slowly eliminated from the site by adult mortality. If the species is fortunate, the light, pappus-equipped seed (with a tuft of bristles, like a dandelion) will settle in an area of fresh disturbance before the parent colony is extinct. The colony history postulated above pictures

L. aspera as a colonizer in the loosely steady-state prairie and accounts for the combination of parachute-equipped seed with long vegetative life To survive as individuals for periods of many years, plants must be equipped to withstand a variety of yearly environments, under conditions which preclude the establishment of a genotype (genetic makeup of a species) suited to the new conditions. The necessary consequence is a species composed of broadly homeostatic (internally stable or balanced) individuals, as opposed to a species dependent upon population level plasticity.

Tilman (1986), also working with *Liatris aspera*, found that this and associated pioneer species dominated their competitors in early successional situations by means of an enhanced ability to compete for soil nitrogen. Roberts *et al.* (1977), working with *Liatris spicata* in Canada, also found that some form of periodic disturbance was necessary for the perpetuation (continuance) of the species. Another interesting study by Schaal (1978a) that could have important consequences for *L. helleri* showed that the foraging pattern of certain pollinators is dependent on the density and size of plant populations. Schaal states, "at very low densities the experimental population attracted few bees and only few plants were visited, while at high densities many bees were attracted and each plant was repeatedly visited." Several of the remaining populations of *L. helleri* are extremely small, with one having less than a dozen plants. The implications from Schaal's study are that pollinators might entirely miss such tiny isolated populations, with consequent detrimental effects on seed set, viability (ability to germinate and grow each year), and recruitment (to add new plants). Also potentially important to the conservation of *L. helleri* is the work of Bowles and Maun (1982), who found that *Liatris cylindracea* was relatively intolerant of human trampling. (This form of disturbance is apparently detrimental, whereas natural types of disturbance, such as fire, seem to be beneficial, and in some cases essential, to the survival of other members of the genus.) Schaal (1978b) also postulated that an unstable age structure found in populations of *Liatris acidota* on the Texas Gulf Coast was due to similar forms of environmental perturbation (disturbance).

Although *Liatris helleri* has not yet been studied for potentially valuable medicinal or industrial chemicals, other species of the genus are widely reported in the literature to yield such compounds. Particularly notable are an antileukemic drug derived from *Liatris chapmanii* and antitumor constituents of *Liatris pycnostachya* and other species (Herz and Sharma 1976, Herz and Sharma 1975, Carr *et al.* 1986, Wagner *et al.* 1973, Herz and Wahlberg 1973a, Herz and Wahlberg 1973b, Kupchan *et al.* 1971, Herz *et al.* 1975).

Threats and Population Limiting Factors

Confined to small areas on a few rocky summits in the Blue Ridge Mountains, this species and many of its rare associates are extremely vulnerable to seemingly minor

threats, such as trampling by hikers, climbers, and sightseers (Gaddy 1983). More pervasive potential threats to the species include acid precipitation and other forms of atmospheric pollution that have been found to be concentrated at higher elevations in the Southern Appalachians.

Residential development is underway at one of the privately owned sites. Only a few plants have been found at this site, all on a single rock face, where they are inherently vulnerable to any form of disturbance. Three of the other sites, also privately owned, have already been developed as commercial recreational facilities. The blazing stars have disappeared from one of these sites since the original recovery plan was completed in 1989. Three of the eight remaining populations are within a few hundred feet of heavily traveled paved roads. An additional threat to this species, although not an imminent one, is that of natural succession (the gradual development of a biological community, like a forest, to a mature or older, climax state).

Liatris helleri, like most other members of the genus, is a pioneer species that is not capable of surviving underneath the spruce-fir forest, which is the climax vegetation of the high mountains within its range. Because of its very limited distribution and the small number of plants remaining at most of the sites where it occurs, certain populations of this species are potentially vulnerable to natural climatic extremes, such as severe drought, ice and wind damage, and the accompanying erosion of the steep slopes where it occurs. Thus far, collecting has not been observed to be a serious problem; however, the rarity of this beautiful species and the publicity accompanying its addition to the endangered species list may make it more desirable to collectors. The availability of suitable habitat adjacent to seed sources appears to be the major limiting factor for *Liatris helleri*; however, much remains unknown about its specific biology and habitat requirements. Reductions in genetic diversity could also threaten small populations (see the "Ecology and Life History" section).

Conservation Efforts

In 1983, we signed a conservation agreement with the North Carolina Department of Agriculture and Grandfather Mountain, Inc., for the purpose of providing for the conservation of Heller's blazing star, as well as the threatened Blue Ridge goldenrod (*Solidago spithamea*), on the Grandfather Mountain site in Avery County, North Carolina. Mr. Hugh Morton, owner of Grandfather Mountain, has been exceptionally cooperative in conservation efforts for rare species on his property, and the populations of Heller's blazing star there are the largest and most vigorous known, despite heavy recreational use of the general area. Also, Mr. Morton has recently donated a permanent conservation easement to The Nature Conservancy for a substantial portion of his property, which will protect part of the blazing star population. The owner of Blowing Rock Park in North Carolina also promised assistance in protecting the species there. Bluff Mountain, in Ashe County, is owned by The Nature Conservancy, which protects

the area by strictly limiting access and providing a full-time on-site caretaker. The names of the other privately owned sites are intentionally not specified in this plan in order to protect the privacy of those landowners whose land is not open to public visitation. One of these sites has been partially acquired by the North Carolina Wildlife Resources Commission and is being managed as part of that agency's gamelands system. Negotiations for protection are underway with the owners of the other sites, including the site of a newly discovered population.

Linville Gorge in Burke County, North Carolina, is administered by the U.S. Forest Service (Pisgah National Forest) and is managed primarily for public recreation, as is the Rough Ridge area in Avery County (National Park Service, Blue Ridge Parkway). These areas are exceptionally scenic and well known and attract thousands of visitors each year. Heavy trampling in recent years at parts of these sites has resulted in degradation of the fragile cliff-edge habitat required by Heller's blazing star. The U. S. Forest Service has cooperated with us to reroute trails, erect educational signs, burn portions of the habitat, and augment declining populations with transplanted seedlings. The National Park Service has worked with us in the Rough Ridge area to divert trails away from areas occupied by this species and, where trails could not be diverted, has erected boardwalks and warning signs in an attempt to minimize damage to the plants. In cooperation with the North Carolina Plant Conservation Program, we established permanent plots to monitor the results of these efforts by measuring changes in the status and health of the population. The National Park Service also solicited the cooperation of local rock-climbing groups in avoiding those areas most important to *L. helleri*.

In 1995, with the help of staff from the U.S. Forest Service; National Park Service; Grandfather Mountain, Inc.; interns from The Nature Conservancy; and dozens of volunteers, we transplanted nearly 3,000 seedlings back into the wild populations from which the seeds had come. The seedlings were grown by the University of Georgia at Athens to provide material for genetic research. After the research was completed, the surplus plants were transferred to the North Carolina Arboretum for holding and acclimatization in a "coolhouse" that we helped fund. They were then transplanted back into the wild at three sites. Transplants were done at Linville Gorge in the Pisgah National Forest, at a cliff site on Blue Ridge Parkway land, and on Grandfather Mountain. Survival of transplanted seedlings after 1 year was excellent, especially at Linville Gorge, where the site had been burned earlier that year. Godt and Hamrick's genetic analyses (1996) found that populations were partially isolated by distance in spite of the species' limited range. These authors recommended that population distinctiveness be maintained in restoration efforts. Transplants were carried out so that seedlings were returned only to the parent populations.

We have developed an illustrated fact sheet on this species to be used in public education. Our office and the Raleigh, North Carolina, Field Office are working to make species information, range maps, and color illustrations available on the Internet. Also, our office

and Jackson, Mississippi, Field Office, in cooperation with the U.S. Forest Service, has completed a set of field identification cards for over 50 listed plants in the Southeastern United States. These pocket-sized cards have color photos of the species, range maps, and species management information and are being distributed to State, Federal, and private managers throughout the Southeast.

In order to accomplish the goal of removing *L. helleri* from the list of endangered and threatened species, it is necessary to protect existing populations and manage the habitat to ensure their continued survival. Because so little is known about this species, it is also necessary, for the full protection of the plant, to conduct population studies and ecological research for the purpose of developing a management strategy. The ultimate effects of various kinds of disturbance on *L. helleri* populations must be investigated and means of alleviating adverse effects must be explored.

PART II
RECOVERY

A. Recovery Objective and Criteria

The ultimate objective of this recovery plan is to remove Heller's blazing star from the Federal List of Endangered and Threatened Wildlife and Plants.

Heller's blazing star (*Liatris helleri*) will be considered recovered when there are at least nine self-sustaining populations in existence within the species' historical range that are protected to such a degree that the species no longer meets the definition of a threatened species under the Endangered Species Act of 1973, as amended (Act). (A self-sustaining population is a reproducing population that is large enough to maintain sufficient genetic variation to enable it to survive and respond to natural habitat changes. The number of individuals necessary and the quantity and quality of habitat needed to meet these criteria will be determined as one of the recovery tasks.) Heller's blazing star will be considered for delisting when the following criteria are met:

1. The eight extant populations are protected.
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.
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).
4. All nine populations and their habitat are protected from present and foreseeable human-related and natural threats that may interfere with their survival.

B. Narrative Outline

1. Protect existing populations and essential habitat. There are now only eight known populations of Heller's blazing star, all within North Carolina. Because of the small number of populations and individuals within populations, it is critical to the continued survival of the species that these populations be protected and their survival is ensured.

1.1 Develop interim research and management plans in conjunction with the National Park Service, U.S. Forest Service, and private landowners. Very little is known about specific management practices necessary to ensure the long-term survival of this species. Therefore, immediate emphasis will be on protection (e.g., prevention of site alteration), in cooperation with the landowners, until appropriate management procedures have been developed through research. Where trampling or other forms of habitat degradation pose an immediate threat to the species, immediate protection measures (e.g., redesigning or rerouting of trails, etc.) should be initiated.

1.2 Search for additional populations. Although several intensive searches for the species have been conducted within historical habitat, a thorough and systematic effort to locate additional populations is still needed. (Very small populations, consisting of only a few plants, are easily missed in less intensive efforts.) Searches should be preceded by an examination of soil and topographic maps and aerial photographs to determine potential habitat and to develop a priority list of sites to search. Many of the areas that may support additional colonies or populations of the species consist of vertical cliff faces which will require the expertise of experienced rock climbers. Two additional populations were discovered after completion of the original recovery plan, which offset the loss of one of the originally identified populations.

1.3 Determine habitat protection priorities. Because of the small number of existing populations, it is essential to protect all eight of them. However, efforts should probably be concentrated first on the most threatened sites. Recovery efforts have a greater potential for success on land owned by the National Park Service and U.S. Forest Service, where protection is mandated by Federal law and where cooperation has already been established. The Grandfather Mountain population probably should be next in priority, because it supports the largest and most vigorous known population. Part of this population is now protected by a conservation easement donated to The Nature Conservancy. Next should be the two newly discovered populations. The Beech Mountain population, which was extremely small, surviving in only one small crevice, has been extirpated. The newly discovered populations and the one at Blowing Rock (which occur in the middle of

recreational development) should precede Bluff Mountain in priority, because ownership by The Nature Conservancy ensures the protection of the Bluff Mountain population.

- 1.4 Evaluate habitat protection alternatives.** The greatest possible protection should be obtained for the eight existing populations. Fee simple acquisition or a conservation easement provides habitat preservation in perpetuity and, therefore, offers the greatest degree of protection. Protection through management agreements or short-term leases may provide adequate short-term protection but should only be considered as intermediate steps in the process of ultimately providing for permanent protection. Shorter-term protection strategies may be necessary if private landowners are not amenable to, or monies are not available for, acquisition of conservation easements or fee simple title. The U.S. Forest Service (which administers the Linville Gorge site) and the National Park Service (which administers Rough Ridge and adjacent sites) have indicated their willingness to take the measures necessary for the protection and conservation of this species on national forest and park land.
- 2. Determine and implement the management necessary for long-term reproduction, establishment, maintenance, and vigor.** Although protection of the species' habitat is the obvious first step in ensuring its long-term survival, this alone may not be sufficient. Habitat management may be necessary to allow the species to successfully perpetuate its life cycle over the long term. However, since very little is known about this species, information on its population biology and ecology is necessary before management guidelines can be formulated and implemented.

 - 2.1 Determine population size and stage class distribution for all populations.** Population size and stage class distribution data are needed for the eight existing populations and for any new populations discovered in the course of additional surveys.
 - 2.2 Study abiotic and biotic features of the species' habitat.** Recommended sites for these studies are Grandfather and Bluff Mountains, Linville Gorge, and Rough Ridge. Grandfather Mountain, having one of the largest and most vigorous populations of the species, is an obvious choice for study. Rough Ridge colonies, on the other hand, are relatively small and vulnerable and have been exposed to considerable foot traffic since the opening of the National Park Service's new Tanawah Trail. The National Park Service has already established permanent plots here, with assistance from the North Carolina Plant Conservation Program and the Service. Continued monitoring of these plots could yield the information needed to determine why heavy

trampling appears to have been detrimental at some sites and not at others, such as Grandfather Mountain (where the number of people passing through areas of similar size is probably greater). If possible, the study should include impacted and unimpacted colonies at these and/or other sites. The Linville Gorge colonies have sustained considerable impact from hiking traffic and other recreational activities. Bluff Mountain could provide a good contrasting situation, where human impact is strictly limited by The Nature Conservancy. Some baseline data are available for all of the above sites. Permanent plots should be selected and established to determine the relationship between abiotic factors (such as soil depth and type, moisture, light intensity and aspect) and biotic factors (such as reproduction, germination, and degree of competition and predation). This information is necessary to determine if active management is needed to ensure the continued vigor of existing populations and to select good sites for potential reintroduction.

The vectors of seed dispersal must be determined, and their effectiveness under different ecological and spatial conditions should be assessed. At least some seed dispersal is by wind; however, little else is known, including how far seeds can be dispersed by this method and others and what conditions are optimal for dispersal. Major pollinators need to be determined. Although various hymenopterans have been observed visiting the flowers, the species' pollinators remain unidentified. The relative importance of sexual and vegetative reproduction to the long-term survival of the species is unknown and must be determined for effective management to take place.

Relationships with competing species must be investigated. *Liatris helleri* is apparently a successional pioneer, like other species in the genus. It cannot survive under the climax forest adjacent to the open areas it occupies. The effects and exact interactions between this species and potential competitors, including *Rhododendron* spp. and *Leiophyllum buxifolium*, are unknown.

2.3 Conduct long-term demographic studies. Long-term demographic studies should be conducted in permanent subplots located within each study plot established for habitat analysis. Plots should be visited in late summer at the peak of flowering (early to mid-August) and once after seed set has occurred (October to November). These observations should be repeated annually for at least 4 consecutive years. The location of individual plants of all stage classes should be mapped; data should be collected for each mapped plant as applicable on height, leaf length, inflorescence size, fruit size and number, and seed set. Measurement of these characters should provide a reasonable indication of plant stage and vigor. The plots established in Task 2.2 should be monitored for seed germination and seedling establishment. Seedlings should be mapped and measured. Any changes in the habitat within each plot

(soil disturbance, tree fall, increases or decreases in shade, etc.) should be noted at each visit. (See Task 2.2 on study/site selection.)

- 2.4 Determine the effects of past and ongoing disturbances.** The establishment and long-term monitoring of permanent plots may be the most effective means of assessing the effects of disturbance. The Grandfather Mountain, Rough Ridge, and Linville Gorge populations are probably the most likely candidates for this type of study.
- 2.5 Investigate the potential effects of acid precipitation or other atmospheric pollution.** Abnormally high levels of heavy metals and other atmospheric pollutants and unusually low pH readings have been found at higher elevations in the Southern Appalachians. Heller's blazing star receives much, if not most, of its moisture from mist or fog, which is believed to play a primary role in the deposition of atmospheric pollution at the high elevations where the species occurs. It is unknown whether, or how, this affects the species.
- 2.6 Define the prerequisites for self-sustaining populations and develop appropriate habitat management guidelines based on the data obtained from Tasks 2.2 through 2.5.** More information is needed on what biological and physical parameters are necessary to maintain populations and what constitutes a self-sustaining population (numbers of individuals, stage class distribution, area occupied, etc.).
- 2.7 Implement appropriate management techniques as they are developed from previous tasks.**
- 2.8 Develop techniques for reestablishing populations in suitable habitat within the species' historical range.** Techniques for seed collection, germination, propagation, and transplantation have been developed by the University of Georgia at Athens and the North Carolina Arboretum. In 1995, nearly 3,000 seedlings were successfully transplanted back into three wild populations. Seedlings were first acclimated in a "coolhouse" at the North Carolina Arboretum, which was designed to mimic the cooler temperatures of the high-elevation cliffs of the Southern Appalachian Mountains. The 1-year survival rate of transplanted seedlings on previously burned habitat in Linville Gorge exceeded 90 percent. Survival rates on the Blue Ridge Parkway and Grandfather Mountain were somewhat less but still exceeded 50 percent after 1 year. The difference in survival may be a reflection of the higher elevation and resultant severity of winter weather at Grandfather Mountain, coupled with browsing damage by an unknown animal. The fire at Linville Gorge may have provided a superior substrate for seedling survival. Additional work of this type is needed, particularly with prescribed burning.

2.9 Evaluate potential reintroduction sites, develop a list of suitable areas, and implement reintroduction. Following reintroduction attempts, transplant sites in native habitat must be closely monitored to determine success and to adjust methods of reestablishment.

3. Develop a cultivated source of plants and provide for long-term seed storage.

The North Carolina Arboretum at Asheville, North Carolina, is currently maintaining this species in cultivation and has developed techniques for seed storage and germination. However, facilities and manpower are limited there, and additional appropriate facilities are needed. A ready source of cultivated material should ease the threat of taking from wild populations.

4. Enforce laws protecting the species and/or its habitat. The Act prohibits the taking of *L. helleri* from Federal land without a permit and regulates trade. Section 7 of the Act provides additional habitat protection from impacts related to federally funded or authorized projects. In addition, for listed plants the 1988 amendments to the Act prohibit (1) their malicious damage or destruction on Federal land and (2) their removal, cutting, digging, damaging, or destroying in knowing violation of any State law or regulation, including State criminal trespass law. The State of North Carolina prohibits the taking of this species without a permit and the landowner's written permission and regulates trade in the species. Federal and State enforcement agents whose jurisdiction includes the known range of *L. helleri* should be made aware of the threats to the species and be able to identify specimens. Signs should be posted wherever collecting is a potential problem, explaining the prohibitions on the taking of these plants (without specifically identifying the species so as not to draw undesirable attention; this has already been done by the landowner at Grandfather Mountain). Taking could become a significant threat for this showy-flowered species, because there is already a demand for cultivated blazing stars of other species.

5. Develop materials to inform the public about the status of the species and the recovery plan objectives. Public support for the conservation of *L. helleri* could play an important part in encouraging landowner assistance and conservation efforts. Informational materials should be nonspecific in terms of the plant's locations so as not to increase the threat of taking.

5.1 Prepare and distribute news releases and informational brochures. News releases concerning the status and significance of the species should be prepared and distributed to major newspapers throughout western North Carolina, to smaller newspapers in the vicinity of the species' habitat, and to larger newspapers in more distant areas, as appropriate. Detailed information should be posted on the Internet.

- 5.2 Prepare articles for popular and scientific publications.** The need to protect the species in its native habitat and cooperation among local, State, and Federal organizations and individuals should be stressed. Scientific publications should emphasize the additional research that is needed and solicit research assistance from colleges and universities that may have conducted studies on closely related species.
- 6. Annually evaluate the success of recovery efforts for the species.** A review of new information and an evaluation (and redirection, if necessary) of ongoing actions are essential for ensuring that full recovery is achieved as quickly and efficiently as possible.

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PART III

IMPLEMENTATION SCHEDULE

Priorities in column 1 of the following Implementation Schedule are assigned as follows:

1. Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
2. Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.
3. Priority 3 - All other actions necessary to meet the recovery objective.

Key to Acronyms Used in This Implementation Schedule

- ES - Ecological Services Division, U.S. Fish and Wildlife Service.
FS - U.S. Forest Service.
FWS - U.S. Fish and Wildlife Service.
NPS - National Park Service
R4 - Region 4 (Southeast Region), U.S. Fish and Wildlife Service.
SCA - State Conservation Agencies - Includes the North Carolina Department of Environment and Natural Resources (Natural Heritage Program), the North Carolina Department of Agriculture and Consumer Services (Plant Conservation Program), and the North Carolina Wildlife Resources Commission.

HELLER'S BLAZING STAR IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates (\$000s)			Comments
				FWS	Other	FY1	FY2	FY3	
1	1.1	Develop interim research and management plans in conjunction with NPS, FS, and private landowners.	2 years	R4/ES	NPS, FS, SCA	2.0	2.0	---	
1	1.3	Determine habitat protection priorities.	1 year	R4/ES	NPS, FS, SCA	0.5	---	---	
1	1.4	Evaluate habitat protection alternatives.	2 years	R4/ES	NPS, FS, SCA	0.5	0.5	---	
1	4.0	Enforce laws protecting the species and/or its habitat.	Ongoing	R4/ES	NPS, FS, SCA	1.0	1.0	1.0	
2	2.1	Determine population size and stage class distribution for all populations.	1 year	R4/ES	NPS, FS, SCA	5.0	5.0	5.0	
2	2.2	Study abiotic and biotic features of the species' habitat.	4 years	R4/ES	NPS, FS, SCA	3.5	2.0	2.0	
2	2.3	Conduct long-term demographic studies.	4 years	R4/ES	NPS, FS, SCA	5.0	5.0	5.0	
2	2.4	Determine the effects of past and ongoing disturbances.	3 years	R4/ES	NPS, FS, SCA	5.0	3.0	3.0	
2	2.6	Define the prerequisites for self-sustaining populations and develop appropriate habitat management guidelines based on the data obtained from Tasks 2.2 through 2.5.	1 year	R4/ES	NPS, FS, SCA	---	---	10.0	

HELLER'S BLAZING STAR IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates (\$000s)			Comments
				FWS	Other	FY1	FY2	FY3	
2	2.7	Implement appropriate management techniques as they are developed from previous tasks.	Unknown	R4/ES	NPS, FS, SCA	?	?	?	Costs unknown.
3	1.2	Search for additional populations.	1 year	R4/ES	NPS, FS, SCA	4.0	---	---	May involve hiring rock climbers to search vertical cliffs.
3	2.5	Investigate the potential effects of acid precipitation or other atmospheric pollution.	Ongoing	R4/ES	NPS, FS, SCA	10.0	10.0	10.0	
3	2.8	Develop techniques for reestablishing populations in suitable habitat within the species' historic range.	5 years	R4/ES	NPS, FS, SCA	---	---	5.0	
3	2.9	Evaluate potential reintroduction sites, develop a list of suitable areas, and implement reintroduction.	5 years	R4/ES	NPS, FS, SCA	---	10.0	10.0	
3	3.0	Develop a cultivated source of plants and provide for long-term seed storage.	3 to 5 years	R4/ES	NPS, FS, SCA	5.0	5.0	5.0	
3	5.1	Prepare and distribute news releases and informational brochures and post information on the Internet.	Ongoing	R4/ES	NPS, FS, SCA	1.0	0.5	0.5	
3	5.2	Prepare articles for popular and scientific publications.	Ongoing	R4/ES	NPS, FS, SCA	1.0	0.5	0.5	

HELLER'S BLAZING STAR IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates (\$000s)			Comments
				FWS	Other	FY1	FY2	FY3	
3	6.0	Annually assess the success of recovery efforts for the species.	Ongoing	R4/ES	NPS, FS, SCA	0.5	0.5	0.5	

PART IV

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