

**White irisette
(*Sisyrinchium dichotomum*)**

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



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

†Please see Addendum 1 at the end of this, our original 5-year review, document. The Addendum provides the limited new information we have gathered for our second 5-year review for this endangered plant that was initiated in the Federal Register (August 6, 2018, 83 FR 38320) and the analysis we have shared to explain the basis for continuing to recommend no change in status for this species.

5-YEAR REVIEW
White irisette (*Sisyrinchium dichotomum*)

LIST OF ABBREVIATIONS

AFO	Asheville Field Office, U.S. Fish and Wildlife Service
EOR	Element Occurrence Record (a mapping unit commonly used by Natural Heritage Programs)
ES	Ecological Services
ESA	Endangered Species Act
FR	Federal Register
NCDOT	North Carolina Department of Transportation
NCNHP	North Carolina Natural Heritage Program
NCPCP	North Carolina Plant Conservation Program
SCDNR	South Carolina Department of Natural Resources
USFWS	U.S. Fish and Wildlife Service

5-YEAR REVIEW
White irisette/*Sisyrinchium dichotomum*

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Region:

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

Lead Field Office:

Asheville Ecological Services Field Office, Asheville, North Carolina, Carolyn Wells (originating author; moved to a new office and position), Mara Alexander (new lead) 828/258-3939, ext. 238

Cooperating Field Office:

Charleston Ecological Services Field Office, Charleston, South Carolina, Melissa Bimbi, 843/727-4707 ext. 217

1.2 Methodology used to complete the review:

Public notice of the initiation of this 5-year review was given in the *Federal Register* on July 6, 2009 (74 FR 31972) and a 60 day comment period was opened. During the comment period, we did not receive any additional information about *Sisyrinchium dichotomum* other than responses to specific requests for information from biologists familiar with the species (see Appendix A for a summary of peer review of this document). Information used in this report was gathered from published and unpublished reports. Records were provided by North Carolina Natural Heritage Program (NC NHP) and South Carolina Department of Natural Resources (SC DNR) Heritage Trust offices. The review was completed by the lead recovery biologist for the species in Asheville, North Carolina.

1.3 Background:

1.3.1 Federal Register Notice citation announcing initiation of this review:

July 6, 2009 (74 FR 31972)

1.3.2 Species status:

Uncertain. Of the 13 extant populations, several are small. However, quite a few (seven) are in conservation. Substantial work needs to be done to understand how to better monitor this plant to understand its trends.

1.3.3 Recovery achieved:

1 (1 = 0-25 percent of species' recovery objectives achieved).

1.3.4 Listing history

Original Listing

FR notice: 56 FR 48752

Date listed: October 28, 1991

Entity listed: species

Classification: endangered

1.3.5 Associated rulemakings: n/a

1.3.6 Review History:

Recovery Plan: 1995

Recovery Data Call: 2012-1998

1.3.7 Species' Recovery Priority Number at start of 5-year review(48 FR 43098): 5C (reflects a high degree of threat and low recovery potential)

1.3.8 Recovery Plan

Name of plan:

Recovery Plan for white irisette (*Sisyrinchium dichotomum* Bicknell)

Date issued: April 10, 1995

2.0 REVIEW ANALYSIS

2.1 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 plants, and any distinct population segment of any species of 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.

2.2 Recovery Criteria

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

Yes, the species has a final, approved recovery plan. However, the criteria (which were put forth as interim criteria due to a lack of information on the species' life history and the relative importance of identified threats) are subjective and could not be objectively measured.

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

Yes.

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

Yes. The recovery criteria could not be met without adequately addressing the applicable listing factors. There is no new information to consider regarding existing or new threats, although threats such as accelerated climate change are expected to exacerbate previously identified threats (e.g., drought). However, the criteria do not explicitly address the applicable listing factors, but rather rest upon the assumption that protection of a minimum number of self-sustaining populations secured with adequate management could not occur without addressing applicable threats.

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

The recovery plan contains two de-listing criteria, but no criteria for reclassifying the species from endangered to threatened status. The de-listing criteria are as follows:

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

Not met. Criteria for self-sustaining populations have not been developed for *Sisyrinchium dichotomum*, and available data are inadequate for the development of such criteria. Specifically lacking are monitoring data capable of revealing whether populations are currently stable, increasing or decreasing – a fundamental first step toward determining whether or not populations are self-sustaining. Management actions needed to ensure the continued survival of *S. dichotomum* are either poorly understood or have yet to be identified, and are likely to vary by site. There are few observations upon which to base an assessment of the species' response to management activities; existing reports are largely anecdotal and/or do not contain an assessment of baseline (pre-management) conditions (e.g., Franklin *in litt.* 2006).

Drought, invasive exotic plant species, and suppression of natural disturbance regimes (such as grazing/browsing and possibly fire) have been implicated in numerous population declines (Rayner pers. comm. 2010, Anderson pers. comm. 2010, Evans pers. comm. 2010, Padgett pers. comm. 2010, and Pittman pers. comm. 2010). The relative importance of these and other threats needs further investigation so that site-specific management objectives can be established; management actions implemented; and progress toward meeting these objectives evaluated. Some threats (such as drought) are less likely to have straight-forward or practical management solutions, but nonetheless threaten the continued survival of *S. dichotomum*. However, one species expert's observations over many years suggest that *S. dichotomum* exhibits varied levels of susceptibility to drought across its range, with some buffering afforded by deeper soils (Rayner pers. comm. 2010). Observations such as this could prove valuable in the development of land protection strategies geared toward those areas in which *S. dichotomum* is more likely to be resilient to this threat. Given that accelerated climate change is expected to increase the frequency of extreme climatic conditions (e.g., drought and heavy rainfalls) in the Southeast, it would be of value to understand those specific habitat conditions which appear to render *S. dichotomum* most vulnerable to drought, and options for increasing the resiliency of native populations to this threat, both in terms of

being able to withstand drought as it occurs and to re-establish in areas of suitable habitat once drought events subside.

Two other management actions also requiring more investigation are: the use of prescribed fire and the control of invasive exotic plant species.

The fact that *S. dichotomum* is frequently encountered along old road beds and jeep trails suggests the species is associated with disturbance. This is corroborated by available monitoring data which indicates that mortality is higher in deeper soils and accumulated leaf litter, habitats also correlated with smaller plant size (Burroughs *in litt.* 2010a, Rayner pers. comm. 2010). The particular disturbance regimes which tend to favor the persistence and spread of *S. dichotomum* are largely unknown, although fire is increasingly being looked to as either a missing natural disturbance mechanism, or an effective surrogate for such.

Fire scars are periodically observed on older canopy trees within the forests where *S. dichotomum* occurs. In recent years, significant portions of two *S. dichotomum* populations have either been subjected to prescribed burns (the South Mountains (Silver Creek/Little Huckleberry Mountain) population; Table B.1) or wildfire has occurred (the Worlds Edge/Sugarloaf population). Baseline (pre-burn) data are not available for either population, but post-burn observations within portions of the South Mountains (Silver Creek/Little Huckleberry Mountain) population suggest that *S. dichotomum* has responded favorably to these fire events (Franklin *in litt.* 2006). The South Carolina Department of Natural Resources is planning to conduct the first-ever prescribed burn within significant portions of a third population (the Chestnut Ridge portion of the Chestnut/Hooker/Bailey Ridges population) in 2014 (Bunch pers. comm. 2013). This population was monitored five times (using consistent monitoring protocols) during 1998-2007 field seasons, thus providing some pre-burn baseline data against which to evaluate the effects of burning upon *S. dichotomum* (Rayner pers. comm. 2010).

There is also a need to assess the severity and extent of invasive exotic plant infestations across the range of *S. dichotomum* and evaluate the relative effectiveness of management strategies, particularly along road, utility and trail corridors. Invasive exotic plants tend to increase in scope and severity along corridors with higher traffic volumes and/or more frequent disturbance, but these species can also be found (albeit often in lower densities) along narrower corridors subject to less frequent use (e.g., TNC *in litt.* 2010; TNC *in litt.* 2009; TNC *in litt.* 2007). An invasive exotic of particular concern is the herbaceous grass *Microstegium vimineum* (Japanese stiltgrass), which colonizes similar substrates and occupies the same stratum as *S. dichotomum*, thus (presumably) directly competing for the same resources. The dense monocultures typically formed by *M. vimineum* make it unlikely that *S. dichotomum* will continue to persist in areas colonized by this invasive exotic without active management. An objective evaluation of the relative effectiveness and cost of chemical and mechanical control methods is needed. While herbicides are likely to be less labor intensive and thus more cost effective, most of these chemicals have not been evaluated for their effects upon *S. dichotomum*. Hand-removal of *M. vimineum* is labor intensive and thus only practical over small areas, and mowing timed prior to seed set in *M. vimineum* can have the unintended consequence of also preventing seed set in *S. dichotomum* and other desirable vegetation. Mowing along road shoulders can often prove difficult or ineffective when attempted over rocky substrates that require mower blades to be held higher than the seed capsules of *M. vimineum* (Anderson pers. comm. 2010).

Significant portions of seven populations are owned and managed by natural resource agencies and/or conservation organizations (Table B.2). Key landowners/managers include the South Carolina Department of Natural Resources (SCDNR), the North Carolina Plant Conservation Program (NCPCP), the North Carolina Wildlife Resources Commission (NCWRC), the North Carolina Division of Parks and Recreation (NC State Parks; NCDPR), The Nature Conservancy (TNC), and Pacolet Area Conservancy (PAC). Although the missions and objectives of these respective organizations frequently differ, most are at least somewhat receptive to the use of prescribed fire as a management tool, and have expressed willingness to discuss opportunities to apply this tool toward the enhancement of *S. dichotomum* populations. Less certain are the resources available to each agency or organization for controlling invasive exotic plant species – some of which may be exacerbated, at least over the short term, with increased fire use.

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

Not met. However, inasmuch as protecting populations from threats (present and foreseeable) involves some form of a management response this criterion is not substantively different from the first and will not be discussed further here.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 Abundance, population trends

Abundance

The recovery plan references a total of seven populations of *S. dichotomum*. In *S. dichotomum*, as with most plant species, the term “population” can reference an area containing more than one spatially discrete area of occupied habitat (a.k.a. a colony, or subpopulation). The recovery plan does not provide explicit criteria for aggregating smaller, site-specific locations into populations. Pollinators, pollen and seed dispersal distances, and/or population genetic structure are fundamental considerations when delineating population boundaries in plant species. Such knowledge is lacking for *S. dichotomum*, and therefore any attempt to delineate population boundaries must rely instead upon the use of somewhat arbitrary geographic separation distances. In this review, “populations” have been defined loosely in accordance with NatureServe’s Element Occurrence mapping standards for plant species (NatureServe 2004). This approach uses a default separation distance of 2km, with deviations as needed to account for dispersal barriers such as interstates, large rivers or streams, or other intervening stretches of unsuitable habitat. In North Carolina, the populations recognized for purposes of this review largely correspond with the parent or principal Element Occurrence Records (EORs) mapped by the North Carolina Natural Heritage Program (NCNHP *in litt.* 2010). The SCDNR Heritage Trust Program does not aggregate records using principal or parent EORs (SCDNR *in litt.* 2010); the USFWS has aggregated many of the EORs mapped by the SCDNR into “populations” for purposes of this review. Using this approach, there are now a total of 13 extant populations of the species (Reference USFWS’s Figure B.1, Table B.1).

At present, precise estimates of the number of spatially discrete locations from which *S. dichotomum* is known are hindered by a tendency for observers to use terms such as “population”, “subpopulation”, and “colony” interchangeably and according to different criteria. Thus, an area described as containing multiple “subpopulations” by one source may be described and/or mapped as consisting of a single “subpopulation” by another. In many cases, the term “subpopulation” has been applied to areas sufficiently close together as to be better regarded as discrete monitoring locations (e.g., plots). This lack of consistent terminology makes it virtually impossible to reconcile different sources, especially without maps showing how “colonies”, “subpopulations”, or other areas have been delineated by a given source. Because it implies meta-population structure and knowledge of population genetic structure that does not yet exist for *S. dichotomum*, the term “subpopulation” is avoided here. Instead, the many smaller, spatially discrete locations from which the species is known are preferentially termed “colonies”, or simply “spatially discrete locations.”

The corresponding state Natural Heritage databases depict 177-196 spatially discrete locations (166-185 in NC; 11 in SC) containing *S. dichotomum* across the species’ range (NCNHP *in litt.* 2010; SCDNR *in litt.* 2010). These numbers do not represent one-to-one correspondence with the number of EORs mapped by these state agencies, primarily because many individual EORs represent multiple spatially discrete locations. In either case, the number of spatially discrete locations should be regarded as an extremely coarse and somewhat subjective estimate, and is presented here simply as another metric of overall abundance.

The recovery plan does not provide an estimate of the number of individuals known across the range of *S. dichotomum*, and this estimate remains difficult to obtain from available information. SCDNR database records generally do not contain estimates of the number of individuals present (SCDNR *in litt.* 2010). NCNHP database records typically contain at least one estimate of the number of individuals (typically reported as “clumps” of plants) at each mapped location, although these estimates have been compiled using widely varied levels of survey effort, over numerous years and different observers (NCNHP *in litt.* 2010). Regardless, taking the NCNHP estimates in aggregate (and using the most recent estimate where more than one exists), this portion of the range may contain between 5,000 and 10,000 clumps. North Carolina populations range in size from a mere 3-5 clumps (Hall Knob in Burke County) to perhaps 1,000 to 5,000 clumps (Whiteoak / Chestnut / Miller Mountains in Polk County).

Population trends

The USFWS is aware of two sustained monitoring efforts capable of revealing population trends. The first consisted of five monitoring episodes spanning from 1998-2007, and occurred within the Chestnut/Hooker/Bailey Ridges population in South Carolina and the Melrose Mountain population spanning the North Carolina –South Carolina state line (Figure B.1 and Table B.1; Rayner pers. comm. 2010 and Rayner, et al. *in litt.* 2008). The second has occurred nearly every year from 2002-2009 within the Rumbling Bald / Cedar Knob / Round Top Mountain population in North Carolina (TNC *in litt.* 2010).

Rayner et al. monitored *S. dichotomum* by flagging all plants in the Chestnut / Hooker / Bailey Ridges population and the nearby Melrose Mountain population (Rayner pers. comm. 2010; also Rayner, et. al. *in litt.* 2008). During the 1998, 2001, 2002, 2005 and 2007 field seasons, flagged plants were categorized by size class and assessed for fruit production. Soil and leaf litter depth were also measured at each plant, although it is

presently unclear how frequently these site parameters were assessed. Aspect and slope were also assessed for each colony. In the first two monitoring events (1998 and 2001), Rayner et al. observed mortality rates of 60% and 65.2% in the Chestnut Ridge and Melrose Mountain populations, respectively. Over the ten year monitoring interval, the Chestnut Ridge population fluctuated widely (n=337 in 1998; n=92 in 2001; n=191 in 2002; n=299 in 2005; n=179 in 2007). Year-to-year trends in the Melrose Mountain population were not readily available at the time of this review. Correlations with soil and leaf litter depth, when statistically significant, applied to one population but never both. Of note, however, was the finding that leaf litter and soil depth were each negatively correlated with size class at the Melrose Mountain population. This finding substantiates concerns that deeper soils and/or accumulated leaf litter may hinder growth and/or recruitment in *S. dichotomum*, and suggests that this species may in fact be disturbance-dependant (Rayner pers. comm. 2010, also Burroughs pers. comm. 2010).

The second monitoring effort targeting *S. dichotomum* has been conducted within the Rumbling Bald/Cedar Knob/Round Top Mountain population, and has been primarily led by The Nature Conservancy (TNC *in litt.* 2010; TNC *in litt.* 2009; TNC *in litt.* 2007). Monitoring is conducted in three spatially discrete locations last found to contain six, 24 and 476 plants (respectively) when counted in June, 2010. The two smaller monitoring locations have been monitored more or less consistently (using consistent counting protocols) in years 2007, 2009, and 2010 – with new plants discovered each year. In one case (Rainbow Falls), newly discovered plants were found within areas previously searched, and may represent legitimate population increases. In the other case (Cedar Knob) newly discovered plants were found outside of previously searched areas, and may represent broader/greater survey effort rather than actual population expansion. The largest monitoring location (Rumbling Bald, with n=476 plants in 2010) consists of seven fixed monitoring points that have been monitored yearly since 2005 (with the exception of 2008) with a subset of these also counted in preceding years. Consistent with the observations of Rayner et al. (2008), the total number of plants at the Rumbling Bald monitoring site has fluctuated considerably over time (n=297 in 2005; n=693 in 2006; n=523 in 2007; n=478 in 2009; n=476 in 2010).

A number of recent events have significant implications for current and future trends within the population spanning Whiteoak/Chestnut/Miller Mountains in Polk County, North Carolina, although objective monitoring data are limited. The Whiteoak Mountain portion of this population was described in the 1991 listing rule as the largest across the species' range, with over 1,000 plants (56 FR 48752). The North Carolina Department of Transportation (NCDOT) widened and paved Skyuka Mountain Road, which traverses Whiteoak Mountain, during the years 2006-2008. This road project was subject to formal ESA Section 7 consultation with the USFWS (USFWS *in litt.* 2006), and is discussed in greater detail in Section 2.3.2 (Five Factor Analysis).

Before it was widened and paved, Skyuka Mountain Road consisted of a narrow, secondary gravel road lined with mild to moderate levels of invasive exotic plants (esp. *Microstegium vimineum*) and an array of residential developments. In many respects, these baseline conditions are representative of most roadside occurrences of *S. dichotomum* throughout the species' range. The widening and paving of Skyuka Mountain Road resulted in direct impacts to approximately 25% (943 out of an estimated 3,989) of the plants located within 10 feet of the road margin (Burroughs *in litt.* 2010a, Burroughs *in litt.* 2010b, USFWS *in litt.* 2006). During 2006 and 2007, these plants (941 of the 943 removed) were relocated to suitable habitats within the greater Whiteoak

Mountain area. However, in 2010 NCDOT was reporting over 55% mortality in permanent plots established to monitor the survival of plants relocated from the construction footprint (Burroughs *in litt.* 2010a).

It remains to be seen whether (or to what extent) the widening and paving of Skyuka Mountain Road will exacerbate pre-existing threats from invasive exotic species, residential development, and the various forms of infrastructure required to support such development. During Section 7 consultation, NCDOT pledged a number of conservation measures intended to further minimize some of these anticipated indirect effects (see also Section 2.3.2, Five Factor Analysis). Perhaps most notable among these were measures intended to contain and control existing infestations of invasive exotic plant species along Skyuka Mountain Road. NCDOT has been moderately successful in containing and controlling infestations of woody invasive exotics along the road corridor (Anderson pers. comm. 2010). However, NCDOT has also encountered difficulty in its efforts to preclude seed set in *Microstegium vimineum* through modified mowing practices, due in large part to the rocky substrate which requires mower blades to be held higher than the flowers borne by *M. vimineum* plants (Anderson *in litt.* 2010). Like many invasive exotics, *M. vimineum* tends to spread along corridors in response to soil or canopy disturbance. Without an effective means of controlling the spread of this species, it is likely to competitively displace *S. dichotomum* from many areas where it presently occurs.

Demography

Rayner et al. flagged plants within the Chestnut Ridge and Melrose Mountain populations, and monitored them in five monitoring events between the 1998 and 2007 field seasons. Detailed demographic data are currently unavailable, and this monitoring effort has not yet been summarized in any form other than an abstract for a professional meeting (Rayner et. al. *in litt.* 2008). During the preparation of this review, the USFWS contacted Rayner for additional observations (Rayner pers. comm. 2010). He recalled observing significant turnover in adult plants, seemingly in response to drought, followed by high rates of seedling recruitment (which he interprets as indicative of a strong and persistent seed bank). Rayner never observed cotyledons (seed leaves) in the field, but defined seedlings as short-statured plants (1-2 cm tall). Rates of adult plant mortality were so high that he remains uncertain of the requisite number of years until a plant reaches flowering, and is reluctant to speculate on longevity.

2.3.1.2 Genetics, genetic variation, or trends in genetic variation

During the preparation of this review, the USFWS learned that Dr. Doug Rayner collected genetic tissue samples from across the range of *Sisyrinchium dichotomum* in 2001 (Rayner pers. comm. 2010). These samples were provided to a collaborator with the intention of future analysis which has yet to be performed. Dr. Rayner has agreed to locate and provide us with current contact information for the person holding the tissue samples, so we may inquire about the feasibility of using them for genetic analyses. Dr. Rayner was unable to provide this contact information as this review was being finalized, but follow-up actions relating to these samples are recommended in Section 4.0 (Recommended Future Actions).

2.3.1.3 Taxonomic classification or changes in nomenclature

The USFWS is not aware of any changes to the classification or nomenclature of *Sisyrinchium dichotomum*.

2.3.1.4 Spatial distribution, trends in spatial distribution

The recovery plan references a total of seven populations, distributed across Polk and Rutherford Counties in North Carolina and adjacent Greenville County, South Carolina. As of this review, there are a total of 13 extant populations distributed across four North Carolina counties (Burke, Henderson, Polk, and Rutherford) and Greenville County, South Carolina. Thus, two North Carolina counties (Burke and Henderson) have been added to the known range of *S. dichotomum* since the recovery plan was finalized. The county-level distribution of *S. dichotomum* in South Carolina has not changed.

Four of the 13 extant populations consist of a single discrete location (Figure B.1; Table B.1). Of the remaining nine populations, the Worlds Edge/Sugarloaf Mountain population is the most extensive, consisting of some 55-58 spatially discrete locations and straddling the boundary where three North Carolina counties meet (Henderson, Polk and Rutherford). Fortunately, the majority of this population is now protected as one of the more recently acquired North Carolina State Parks (Chimney Rock State Park). In terms of overall spatial extent, the next largest populations are the Whiteoak/Chestnut/Miller Mountains population in Polk County, NC; the Melrose Mountain population, straddling the boundaries of Polk County, NC and Greenville County, SC; and the South Mountains (Yellowtop/Biggerstack/Middle Mountains) population in Rutherford County, NC (Figure B.1).

Residential development on the scenic, mountainous slopes that support *S. dichotomum* typically has the effect of fragmenting existing habitat, both through the construction of homes, lawns, driveways, and new or improved roads to support increased traffic. These land use changes also threaten nearby natural areas managed for conservation by creating vectors for invasive exotic plant species while also reducing the potential to experiment and/or manage with prescribed fire. Road improvements intended to accommodate increased traffic specifically alter habitat through removal of additional forest canopy, straightening of curves, and construction of new cut- and fill- slopes which must be stabilized with aggressive seed mixtures to prevent erosion. Even if areas containing *S. dichotomum* are avoided during these road improvement activities, altered (increased) light levels, soil disturbance, and use of aggressive seed mixes are likely to increase the potential for the introduction and spread of invasive exotic plant species throughout the road corridor. Although densities of *S. dichotomum* may initially be higher along these corridors than in adjacent forests, the direct, indirect and cumulative effects of residential development, road upgrades and utility construction renders suitable habitat for *S. dichotomum* increasingly fragmented, less abundant, and less suitable over time.

2.3.1.6 Habitat or ecosystem conditions

The population boundaries depicted in Figure B.1 do not represent ecological boundaries, but rather coarsely delineated boundaries intended only to encompass the colonies aggregated for purposes of defining populations. As such, these boundaries contain large expanses of unoccupied or unsurveyed habitat and therefore are inappropriate for purposes of quantifying occupied or suitable habitat for *S. dichotomum*. There are no robust estimates of the amount of habitat occupied by *Sisyrinchium dichotomum*, as most

locations have been mapped as a single centroid rather than polygons depicting the full extent of the colony(-ies).

As noted elsewhere throughout this review, *S. dichotomum* appears to require at least moderate levels of disturbance, as evidenced by its frequent occurrence over thin and/or slightly eroding soils adjacent to old road beds and jeep trails that meander through second-growth dry-mesic oak hickory forests. *S. dichotomum* tends to occur at higher densities along the road/trail corridor than further back within the forest interior, perhaps because soils are more recently and/or frequently subject to patterns of disturbance long since missing or suppressed within the forest interior. In the forest, *S. dichotomum* can often be found in micro-sites characterized by thinner soils and less accumulated leaf litter, such as immediately downslope of larger canopy trees (sometimes bearing fire scars). It is also worth noting that most surveys for *S. dichotomum* have tended to be biased toward road/trail corridors, thus its actual abundance within adjacent forests may be greater than perceived, albeit at lower densities than observed along roads and trails.

S. dichotomum persists alongside wider gravel roads subject to heavier use, which presumably represent upgrades to pre-existing roadbeds and jeep trails. Little to nothing is known about survival and recruitment rates in *S. dichotomum* as road conditions change: at least initially, modest road improvements may benefit the species by mimicking canopy gaps and exposing mineral soils. However, in as much as road improvements facilitate more residential development and/or the introduction or spread of invasive exotic plant species, these short-term benefits are likely to be negated.

With respect to invasive exotic plant species, of particular concern is the herbaceous exotic *Microstegium vimenium* (Japanese stiltgrass), which colonizes similar substrates and occupies the same stratum as *S. dichotomum*, thus (presumably) directly competing for the same resources. If *S. dichotomum* is to persist within these areas, the spread of this and other invasive exotic species must be controlled; however cost-effective strategies frequently rely upon the use of herbicides that have not been evaluated for their effects upon *S. dichotomum*.

2.3.2 Five-Factor Analysis

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

Sisyrinchium dichotomum faces an array of threats to its habitat, namely drought, invasive exotic plant species, residential development, road widening and paving projects, utility corridor construction, and a lack of natural disturbance regimes such as grazing, browsing, and possibly fire. Many of these factors (such as residential development, road or utility construction, and invasive exotic plant species) are interrelated, with one factor tending to exacerbate the other. Accelerated climate change is likely to further exacerbate certain threats, such as drought or the establishment and spread of invasive exotic plant species.

S. dichotomum occurs on forested, steep mountain slopes and often in greater densities along the old earthen roadbeds; jeep, logging and hiking trails; and even some gravel road corridors that meander through these habitats. As these forested slopes are targeted for residential development, these winding roads and trails are often upgraded (widened, straightened and/or paved) to accommodate increased traffic volumes. An example of this

threat occurred in 2006-2008, when the NCDOT widened and paved Skyuka Mountain Road in Polk County, North Carolina. Skyuka Mountain Road bisects a significant portion of the Whiteoak / Chestnut / Miller Mountain population of *S. dichotomum*, described as the largest population of the species (at over 1,000 plants) in the listing rule (56 FR 48752).

The Skyuka Mountain Road construction project was subject to ESA Section 7 consultation (USFWS *in litt.* 2006). At the conclusion of formal consultation (in 2006), NCDOT estimated that 25% of all plants located within 10 feet of the road edge, were expected to incur direct impacts from the road improvement project (Burroughs pers. comm. 2010). The NCDOT removed 943 plants from the construction footprint due to anticipated direct and adverse impacts (Burroughs *in litt.* 2010b). As of 2010, NCDOT was reporting more than 55% mortality within permanent plots established to monitor the survival of plants relocated out of the construction footprint. Although NCDOT's formal monitoring does not allow for a robust comparison of survivorship among relocated and non-relocated plants, NCDOT personnel are of the opinion that transplants exhibited considerably higher mortality than resident (non-relocated) plants during this time period (Burroughs pers. comm. 2010). Further illustrating the limitations of transplanting as a minimization strategy, NCDOT personnel have expressed concerns that seeds from the invasive exotic *Microstegium vimenium* may have been moved along with some of the *S. dichotomum* plants transplanted out of the road corridor (Burroughs pers. comm. 2010; Anderson, pers. comm. 2010). The preliminary findings illustrate that transplanting may not be an effective means of off-setting adverse effects from development or other infrastructure projects. Pursuant to the conservation measures pledged by NCDOT for the Skyuka Road project, plants located within the 138 permanent monitoring plots were monitored again in 2012. In these plots, there was a decrease in the overall number of plants (Herman pers. comm. 2013). The NCDOT also monitored portions of the roadside population not expected to be directly impacted from construction activities, in the same set of plots used to provide a baseline estimate in 2008. The number of plants in these plots remained stable between 2008 and 2012 (Herman pers. comm. 2013).

As noted above, prior to road improvements, Skyuka Mountain Road contained mild to moderate infestations from invasive exotic plant species and ongoing residential development. These threats present additional concerns beyond the direct impacts from road construction (including the poor survivorship of transplants relocated out of the construction footprint). The USFWS remains concerned that these pre-existing threats to *S. dichotomum* will be exacerbated by the widening and paving of Skyuka Mountain Road. At least one NCDOT biologist has noted anecdotal increases in traffic volumes and residential development since the road project was completed (Burroughs *in litt.* 2010a). Another NCDOT biologist has noted difficulties in NCDOT's efforts to manage invasive exotic vegetation along the road corridor through modified mowing regimes (Anderson *in litt.* 2010). It is currently unknown whether, and to what extent, these threats are also influencing population trends along Skyuka Mountain Road.

NCDOT pledged numerous other conservation measures intended to minimize indirect effects upon invasive species populations resulting from the Skyuka Mountain Road improvement project. These conservation measures included for example conducting construction in a downhill direction to help reduce the potential to distribute invasive exotic plant seeds.

Within another population of the species (Worlds Edge / Sugarloaf), the densest infestations of invasive exotics (esp. *M. vimenium* but also *Pueria lobata* (kudzu)) occur along the main roads leading into and out of Chimney Rock State Park.

The residential development which accompanies these road construction projects reduces the availability and cohesiveness of suitable habitat as the forested slopes upon which *S. dichotomum* occurs are subdivided into homes, lawns, driveways, and utility corridors. These actions further increase the potential for invasive exotic species to establish and spread, and can also reduce the feasibility of managing nearby natural areas with prescribed fire (a management tool with considerable potential to provide the forms of disturbance that *S. dichotomum* may periodically require for seedling recruitment).

Two other instances of adverse impact to roadside colonies of *S. dichotomum* further illustrate this species' inherent vulnerability where it occurs in these locations. In 2004, a portion of the Worlds Edge / Sugarloaf population along Sugarloaf Mountain Road was impacted by grading and seeding activities along the road corridor (NCNHP *in litt.* 2010). Although NCDOT maintains a program to sign roadside rare plant locations (for federally listed plant species) to avoid such impacts, a lapse in signage and/or miscommunications led to portions of the *S. dichotomum* population being heavily graded and seeded with fescue, an invasive that may have permanently displaced a significant percentage of this roadside colony. Upon learning of this incident, NCDOT biologists promptly notified local NCDOT district personnel of the species' presence along the road corridor, and re-installed signs bracketing the extent of the roadside occurrence. No additional impacts are known to have occurred at this location.

The second instance occurred in 2005, when TNC notified the USFWS that an adjacent landowner had either knowingly or accidentally cut a roadbed on portions of TNC property suspected as formerly containing *S. dichotomum* (Stifel pers. comm. 2005). The USFWS accompanied TNC on site visits and confirmed that the newly cut road did traverse seemingly suitable habitat, and *S. dichotomum* plants were located immediately beyond the footprint of the new roadbed. To USFWS's knowledge, trespass charges were never filed. It remains unknown how many *S. dichotomum* may have been lost as a result of this activity.

2.3.2.2 Over utilization for commercial, recreational, scientific, or educational purposes:

This was not known to be a significant threat to *S. dichotomum* at the time of listing, and we have no new information to suggest that this now represents a significant threat to the species.

2.3.2.3 Disease or predation:

This was not known to be a significant threat to *S. dichotomum* at the time of listing, and we have no new information to suggest that this now represents a significant threat to the species.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

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. Plant species are afforded even less protection in South Carolina, where they are protected only from disturbance where they occur on those properties owned by the state and specifically managed as South Carolina Heritage Preserves (SC State Code of Regulations Part 123 § 200-204). There are no other federal or state statutes that afford significant protections to *S. dichotomum*.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

None beyond those already addressed.

2.4 Synthesis –

The status of *Sisyrinchium dichotomum* has not appreciably changed since listing, and the current federal status of endangered remains appropriate. The global distribution of this narrow-ranging endemic of the Carolinas is confined to four North Carolina counties (Burke, Henderson, Polk, Rutherford) and Greenville County, South Carolina. There are a total of 13 extant populations of the species. The recovery criteria for *S. dichotomum* have not been met, although significant portions of seven populations are subject to conservation ownership. Those management actions necessary to ensure the continued survival of the species are inadequately understood; this lack of knowledge hinders progress toward stabilizing populations in the face of known and suspected threats, and evaluating the relative importance of these threats. More information is specifically needed on the responses of *S. dichotomum* to fire (both natural and prescribed), specifically whether (as is strongly suspected) fire may enhance survival and even stimulate recruitment through reduction in leaf litter and woody debris, exposure of mineral soils, and thinning of the sub-canopy and canopy strata. Invasive exotic plant species threaten significant portions of most populations, but the severity and scope of this threat varies considerably among sites (with severity, immediacy and scope tending to be greatest along the widest road corridors with the heaviest traffic volume). This plant species remains threatened by residential development and associated road improvements. Those most familiar with the species in the field repeatedly observe widespread mortality during drought years; accelerated climate change is likely to exacerbate these threats.

3.0 RESULTS

3.1 Recommended Classification:

 X **No change is needed**

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

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

Recovery Task 1.3: Determine habitat protection priorities

- Assess the current condition and extent of known populations; work with partners to standardize the mapping and assessment of populations (and subpopulations); and iteratively assess protection priorities in light of the relative importance of known populations. In particular:
 - Devise standard separation distances and mapping criteria for recognizing subpopulations. Work with partners to encourage consistent use of terminology in monitoring reports, and in observations reported to the respective state NHPs.
 - Devise interim criteria for self-sustaining populations, using Rayner’s monitoring data as a baseline and supplemented by other monitoring data as available/appropriate. Seek to devise objective and quantitative criteria that apply across populations, supplemented by population-specific criteria where necessary.
 - Conduct surveys to determine the number of plants found within, and the approximate spatial extent of, protected portions of known populations.
 - Determine number of colonies and corresponding SCHAT EORs protected within TNC’s Greenville Watershed conservation easement.
- Conduct surveys beyond the extent of known populations, to determine the true extent of the known range of the species.

Recovery Task 1.1: Develop interim research and management plans in conjunction with landowners (and)

Recovery Task 2.5: Define criteria for self-sustaining populations

- Work with landowners to develop standardized methods of counting and mapping their populations (using Rayner’s protocols where feasible), so that a baseline can be established for evaluating trends, vulnerability to threats (such as invasive exotic plant species), and responses to management (such as prescribed fire and/or efforts to control invasive exotic plant species).
- Work with landowners, managers and others to expand the scope of monitoring (using Rayner’s protocol, where feasible) to additional populations in North Carolina.
- Locate and pursue analysis of genetic tissue samples collected by Rayner in 2001.

Recovery Task 6: Annually assess success of recovery efforts

- The two existing recovery criteria (for de-listing) are largely redundant; establish criteria that are more specific, objective, and measurable.
- Establish down-listing criteria (for reclassification from endangered to threatened).

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5-YEAR REVIEW of *Sisyrinchium dichotomum* (white irisette)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

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

Appropriate Listing/Reclassification Priority Number, if applicable:

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

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve  Date 2/15/13

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve  Date 5/3/13

Appendix A: Peer Review

Summary of peer review for the five-year review of *Sisyrinchium dichotomum* (white irisette)

A. Peer Review Method:

A draft of this document was circulated to those with direct and substantive knowledge of *Sisyrinchium dichotomum*, including personnel from the North Carolina Natural Heritage Program (NCNHP), the North Carolina Department of Agriculture Plant Conservation Program (NCPCP), the North Carolina Department of Transportation (NCDOT), the South Carolina Department of Natural Resources (SCDNR), and Dr. Douglas Rayner from Wofford College.

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 NCNHP (one reviewer) and NCDOT (two reviewers). Editorial comments provided by reviewers were incorporated as appropriate. A brief summary of substantive comments follows.

The first NCDOT reviewer expressed doubt that the widening and paving of Skyuka Mountain Road would have “significant implications” for the population of *S. dichotomum* located along that road, a concern expressed by USFWS in the initial draft of this document. This reviewer noted that this population of *S. dichotomum* was threatened by invasive exotics and residential development prior to the widening and paving of Skyuka Mountain Road, and questioned whether the road improvements would significantly accelerate these threats.

This reviewer also noted difficulties encountered by NCDOT during its efforts to modify roadside mowing regimes to prevent seed set in *Microstegium vimineum* (Japanese stilt grass, an invasive exotic) along Skyuka Mountain Road had proved ineffective. Modification of roadside mowing was pledged as a conservation measure during the Section 7 consultation addressing impacts from the Skyuka Mountain Road widening and paving project. This reviewer noted two primary difficulties with the implementation of this measure, namely that (1) early mowing timed to preclude seed set in *M. vimineum* appears to have the unintended effect of precluding seed set in desirable native species, and (2) *M. vimineum* occurs most densely in rocky ditch lines which cannot be effectively reached by mowers.

The second NCDOT reviewer provided additional information and preliminary results from NCDOT’s monitoring of transplants relocated out of the footprint of the Skyuka Mountain Road project. This reviewer also noted an additional conservation measure pledged by NCDOT not identified in the initial draft of this review (to schedule and conduct construction in two phases in order to minimize spread of invasive exotic plant species already located along the road corridor). This reviewer also commented that residential development and traffic volumes along Skyuka Mountain Road have increased since the completion of the road project, but did not provide any specifics or quantitative measure of these changes.

D. Response to Peer Review:

All substantive comments received from reviewers were reviewed by USFWS and incorporated into a revised version of this document, where appropriate. However, USFWS remains concerned

that road improvement projects (such as, but not limited to, the widening and paving of Skyuka Mountain Road) are likely to facilitate residential development and the spread of invasive exotic plant species, thus leading to greater degradation and eventual loss of habitat suitable for *S. dichotomum*. Therefore, the comment from the first NCDOT reviewer expressing doubt that these factors are interdependent is acknowledged, but the USFWS did not find it appropriate to modify the section which prompted this comment (Section 2.3.1.1, Abundance, population trends).

Appendix B: Tables and Figures

Figure B.1. The global distribution of *Sisyrrinchium dichotomum* (white irisette).

Table B.1. *Sisyrrinchium dichotomum* populations and the number of colonies they are estimated to contain.

Table B.2. Protected colonies of *Sisyrrinchium dichotomum*.

Figure B.1. The global distribution of *Sisyrinchium dichotomum* (white irisette).

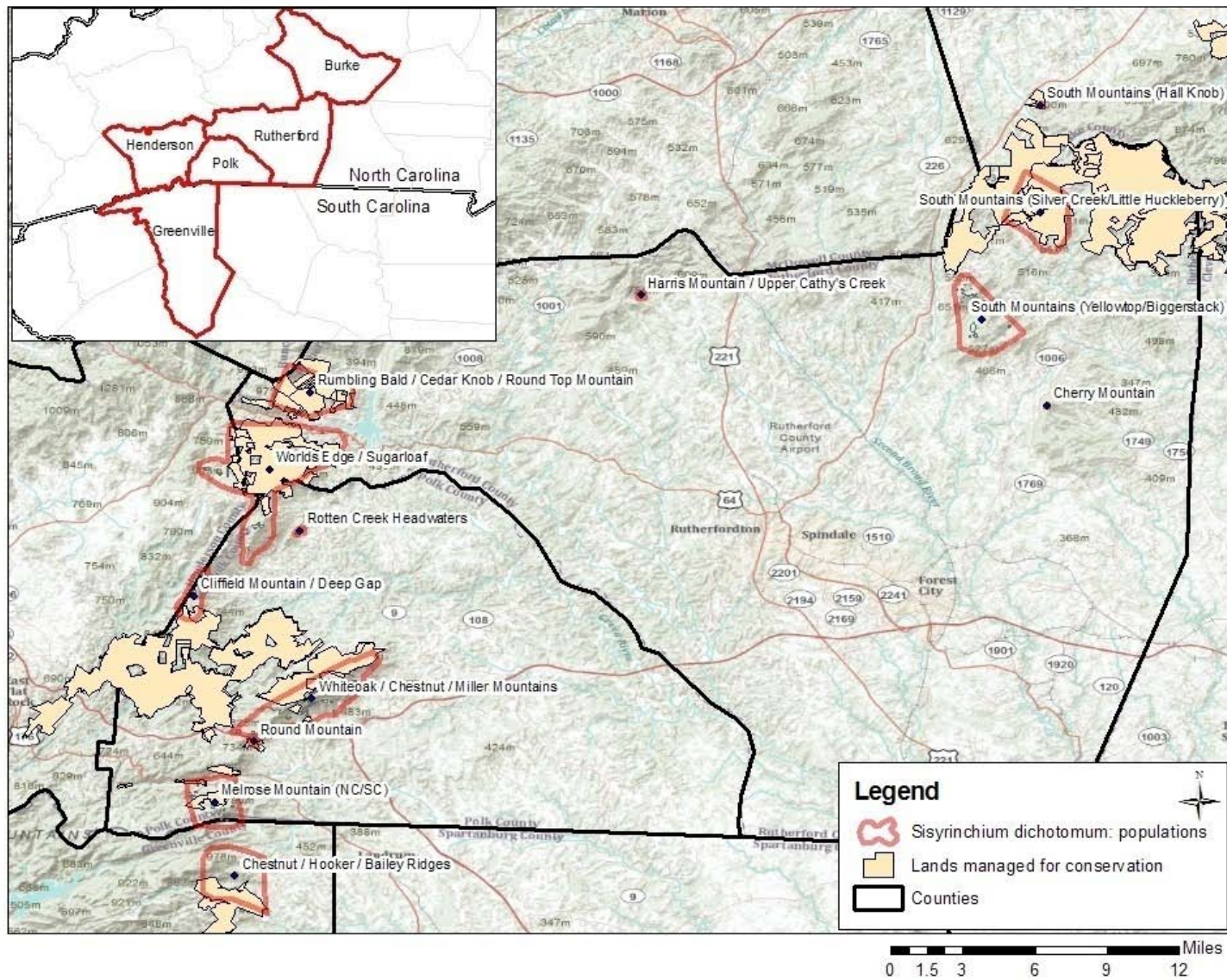


Table B.1. *Sisyrinchium dichotomum* populations and the number of colonies they are estimated to contain. Also noted are the corresponding Natural Heritage Program (NHP) element occurrence records (EORs) located within the boundary of each population recognized by USFWS.

Population number	State	County	Population name	Colonies (total)	Protected colonies	NHP EORs
1	SC	Greenville	Chestnut / Hooker / Bailey Ridges	10?	6?	SC*003-006, 008-011, 013, 015
2	SC / NC	Greenville (SC) / Polk (NC)	Melrose Mountain	32-39	12	SC*002, 007; NC*32.002, .015-.018
3	NC	Polk	Round Mountain	1-5	0	NC*019
4	NC	Polk	Whiteoak / Chestnut / Miller Mountains	36-40	8?	NC*29.001, .004, .006, .009, .010, .012, .013, .040, .065
5	NC	Henderson / Polk	Clifffield Mountain / Deep Gap	6	0	NC*008
6	NC	Henderson / Polk / Rutherford	Worlds Edge / Sugarloaf	55-58	46-47	NC*38.003,.005,.011, .020-.022, .027, .035-.037, .046-.049, .052-.055, .057-.058, .064, .066-.067, .069
7	NC	Polk	Rotten Creek Headwaters	1	0	NC*014
8	NC	Rutherford	Rumbling Bald / Cedar Knob / Round Top Mountain	8	8	NC*45.024,.031
9	NC	Rutherford	Harris Mountain / Upper Cathy's Creek	1	0	NC*030
10	NC	Rutherford	South Mountains (Yellowtop / Biggerstack / Middle Mountains)	15-16	0	NC*42.034,.039,.041
11	NC	Rutherford	Cherry Mountain	1	0	NC*033
12	NC	Burke / Rutherford	South Mountains (Silver Creek / Little Huckleberry Mountain)	11	11	NC*70.028,.050
13	NC	Burke	South Mountains (Hall Knob)	1	0	NC*056

Table B.2. Protected colonies of *Sisyrinchium dichotomum*.

Population name	Colony name	Conservation Landowner ^a	Protection type	NHP EORs	Subpopulations protected ^b
Chestnut / Hooker / Bailey Ridge (SC)					
	Chestnut Ridge Heritage Preserve	SCDNR	State Heritage Preserve	SC*005, 006, 009, 010, 011, 015	6?
	Greenville Watershed	TNC	Conservation easement	TBD (needs verification)	TBD (needs verification)
Melrose Mountain (NC/SC)					
	Melrose Mountain Plant Conservation Preserve	NCDACS	State Plant Conservation Preserve & Dedicated Nature Preserve	NC*032.002 (in pt.), 032.016 (in pt.)	12?
Round Mountain (NC)					
	Round Mountain	Pacolet Area Conservancy	Conservation easement	NC*019	1?
Chestnut / Miller / Whiteoak Mountains (NC)					
	Green River Game lands: Whiteoak Mountain (Southwest)	NCWRC	State Game Lands & Dedicated Nature Preserve	NC*029.001 (in pt.)	1
	Whiteoak Mountain Plant Conservation Preserve	NCDACS	State Plant Conservation Preserve	NC*029.001 (in pt.), 029.012 (in pt.)	3?
	Jenkins Tract	Pacolet Area Conservancy	Conservation easement	NC*029.004 (in pt.)	1
	Green River Game Lands: Whiteoak Mountain (Northeast)	NCWRC	State Game Lands & Dedicated Natural Heritage Preserve	NC*029.065 (in pt.)	3
Worlds Edge / Sugarloaf (NC)					
	Chimney Rock State Park	NCDPR	State Park	NC*038.003,.005,.021,.022,.027,.035-.037,.046-.049,.052-.055,.057,.058,.066,.067	46-47

Table B.2, continued.

Rumbling Bald / Cedar Knob / Round Top Mountain (NC)					
	Rumbling Bald / Cedar Knob / Round Top Mountain	TNC, NCDPR	State Park (in pt.), TNC Preserve (in pt.)	NC*045.024,.031	8
Rollins / South Mountains (NC)					
	South Mountains Game lands: Devils Fork Mountain / Oakey Knob / Shoal Mountain Little Huckleberry Mountain/Silver Creek Knob	NCWRC	State Game Lands & Dedicated Nature Preserve	NC*70.028, .050	11

^aLandowner abbreviations: NCDACS = North Carolina Department of Agriculture and Consumer Services; NCDPR = North Carolina Division of Parks and Recreation; NCWRC = North Carolina Wildlife Resources Commission; SCDNR = South Carolina Department of Natural Resources; TNC = The Nature Conservancy

^bThe *estimated* number of subpopulations, or spatially discrete locations, mapped by the NC NHP that fall within protected land holdings as mapped by the NC NHP Managed Areas layer or the NC One Map Division of Parks and Recreation ownership layer. Instances in which available information is contradictory, or protection is for some other reason in doubt, are indicated by a question mark (?).

5-YEAR REVIEW OF WHITE IRISSETTE
(*Sisyrinchium dichotomum*)

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 August 6, 2018 (83 FR 38320). No comments were received during the 60-day public comment period following this notice. However, the US Fish and Wildlife Service (Service) did receive additional information about the species, from biologists familiar with the species, in response to requests for specific information.

Updated information is presented below. Internal review was conducted by four members of the Service's Southeast Region. Additionally, the Service conducted independent peer review on new information (Appendix A). 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.

1.0 GENERAL INFORMATION

1.1 Reviewers

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

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

Cooperating Field Office: Charleston Ecological Services, April Punsalan, (843) 727-4707.

1.3 Background

1.3.1 Federal Register Notice citation announcing initiation of this review: 83 FR 38320; August 6, 2018.

1.3.2 Species Status: Declining. In the 2013 5-year review, it was estimated that 5,000-10,000 clumps of plants were present in the North Carolina portion of the range (Service 2013). Current estimates include approximately 4,500-5,000 clumps throughout the entire range of North Carolina and South Carolina (NCNHP 2018; SCHTP 2018; Rayner 2019a, Wofford College, personal communication). The known range of *Sisyrinchium dichotomum* has expanded to include a population that is partially in McDowell County, North Carolina; however, this population contains only 21 clumps of plants (NCNHP 2018). Population 1 in the 2013 5-year review, the Chestnut/Hooker/Bailey Ridges population, has been divided into two populations at the recommendation of a biologist familiar with the sites (Rayner 2019b, Wofford College, personal communication). This division does not represent the discovery of a new population, only the revision of population boundaries. Rough estimates from 2013 and 2018 indicate an apparent decrease in overall abundance; however, inconsistent and

infrequent monitoring increases uncertainties associated with the species' status and trends.

1.3.6 Review History: The Service finalized a 5-year review for *Sisyrinchium dichotomum* in 2013. The review recommended the species remain classified as endangered due to narrow range, known threats, and inadequate understanding of needed management (Service 2013). Each year, the Service reviews and updates listed species information for inclusion in the required Recovery Report to Congress. Through 2013, the Service did a recovery data call that included status recommendations such as “declining” for this plant. We continue to show this species' status recommendation as part of our 5-year reviews. The last review for this species to inform the Recovery Report to Congress was conducted in 2018.

2.0 REVIEW ANALYSIS

2.2 Recovery Criteria

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

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

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

Criterion 1 and 2 are interrelated and will be discussed together. Completion of Recovery Task 2 (determine and implement the management necessary for long-term reproduction, establishment, maintenance, and vigor) and its associated subtasks would provide for the development of objective criteria for self-sustaining populations (Service 1995); however, these tasks have only partially begun on a limited number of populations. As a result, criteria for self-sustaining populations have not been developed for *Sisyrinchium dichotomum*.

Completion of Recovery Task 2 and its associated subtasks would also provide for an improved understanding of necessary management actions needed to ensure the species' continued survival. Management actions needing more investigation include use of prescribed fire and control of invasive, exotic species. The South Carolina Department of Natural Resources (SCDNR) planned to conduct a prescribed burn within a significant portion of the Chestnut Ridge population (Greenville County) in 2014; however, the burn was postponed in part due to concerns that fire would promote the spread of tree-of-heaven (*Ailanthus altissima*) (Pickhardt 2019, SCDNR, personal communication). At the South Mountains Game Lands, a portion of the Silver Creek/Little Huckleberry Mountain population has been burned by prescribed fire four times (2005, 2008, 2011, and 2017) (Simon 2019, retired WRC, personal communication), and monitoring indicated an increase

in population size between 2005 and 2008 (NCNHP 2018). Visual observations by those familiar with the site indicate population increases after each burn; however, additional monitoring has not occurred at the site. At a portion of the White Oak/Chestnut/Miller Mountains (Polk County) population, the North Carolina Plant Conservation Program (NCPCP) used a leaf blower to remove leaf litter in occupied and surrounding suitable habitat (NCPCP 2017). Response to this management activity remains unknown until further monitoring can be conducted at the site. The NCPCP is pursuing prescribed burning at the White Oak Mountain and Melrose Mountain plant preserves; however, no burning has taken place to date (Starke 2019, NCPCP, personal communication).

Invasive, epigeic (non-burrowing) earthworms (discussed in Section 2.3.2.3), which negatively affect seed germination and overall plant condition, have also been identified as a potential threat to the species (Rayner and Gwinn 2014). In a generalized study investigating control of invasive earthworms using fire, Blackmon (2009) introduced earthworms to soil cores collected post-fire, and assessed survival and earthworm biomass over eight weeks. To determine if direct mortality of earthworms occurs during fire, a prescribed fire was simulated. Although mortality of earthworms was not directly caused by fire during the simulated burn, earthworms in soil that experienced wildfire continuously lost biomass until death (Blackmon 2009). The suggested cause of mortality is starvation and/or habitat alteration caused by fire (Blackmon 2009). Results of additional experiments conducted by Hiroshi et al. (2014) concluded that if earthworms can temporarily escape heat by burrowing, they can survive the direct impacts of the fire. While fire may not decrease the number of earthworms directly, it can decrease viability of cocoons, which would contribute to decline in the next generation (Hiroshi et al. 2014). Hiroshi et al. suggest that prescribed fire could be a viable tool for control of invasive earthworms without negatively impacting native earthworms. Prescribed fire as a management tool used to control invasive, epigeic earthworms present in suitable habitat for *Sisyrinchium dichotomum* warrants further investigation.

In the 2013 5-year review, portions of seven populations were identified as owned and managed by natural resource agencies and/or conservation organizations. Currently, portions of 11 populations, including 61% of colonies (spatially discrete locations), are owned by natural resource agencies, conservation organizations, and/or municipalities (Table B1). Three of the 11 populations include colonies that are in protective ownership by municipalities or conservation easements (not identified in the previous review). Two additional populations now have at least partial protection as a part of the Green River Game Lands or South Mountains State Park, and one new population is protected under a Registered Heritage Area. Although land and habitat is protected, objectives of each entity differ and management specifically targeted at *Sisyrinchium dichotomum* is limited and poorly understood.

2.3. Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 Abundance, population trends: The listing rule recognized four extant populations of *Sisyrinchium dichotomum* and the recovery plan recognized seven extant populations; however, there is no estimation of population sizes in these documents (Service 1991; Service 1995). The 2013 5-year review estimated 13 populations containing 178-197 colonies across the range, with 5,000 -10,000 clumps of plants in North Carolina populations (Service 2013). The current estimate, based on available data, is 15 populations, containing 189 colonies with 4,500-5,000 clumps of plants, across the range (NCNHP 2018; SCHTP 2018; Rayner 2019a, Wofford College, personal communication; Table B1). Population size estimates are difficult to determine because of the inconsistency in monitoring methods and counting units among observers, along with partial counts that do not include all occupied or suitable habitat.

In April of 2007, 84 plants were relocated from construction limits of the Skyuka Mountain Road widening project to the NCPCP's White Oak Mountain Preserve in Polk County. Fourteen plots with six transplants and one native plant each were placed at the site (98 plants in plots). From 2007 to 2012, the plots experienced severe decline with only ten of 98 plants remaining in eight plots. During monitoring in 2017, only one plant remained. In April of 2017, the NCPCP used a leaf blower to remove leaf litter from the plots and surrounding areas. Response to this management activity remains unknown until further monitoring can be conducted at the site. *Sisyrinchium dichotomum* is located on other portions of the site and, in 2012, 50 naturally occurring plants were observed. In 2017, 54 naturally occurring plants were observed throughout the site. This total may be an under estimation since not all suitable habitat was surveyed (NCPCP 2017).

Plants were also relocated to the nearby Jenkins tract and to unimpacted areas of the Skyuka Mountain Road right-of-way (ROW). Monitoring of naturally occurring plants and transplants in the ROW concluded in 2012. As stated in the 2013 5-year review, there was a decrease in the overall number of plants at these sites (Service 2013). Mortality was over 70% for all relocation plots in the ROW (Wells n.d.) The Jenkins tract experienced an 80% decline in its population size. Possible factors contributing to these declines include severe drought in the years after relocation, erosion, trampling, leaf litter accumulation, new residential construction and associated land clearing, and road maintenance (Wells n.d.). Mortality rates, at these sites, suggest that direct relocation may not be an appropriate strategy for minimizing impacts to the species from development projects.

The Chestnut Ridge population (Greenville County) in South Carolina has been monitored since 1998 (Rayner 2019a, Wofford College, personal communication; SCHTP 2018). In 1998, there were 337 clumps of plants in eight colonies (Rayner et al. 2008). As of 2019, there are 81 clumps of plants (a 76% decline) in six of the locations (Rayner 2019a, Wofford College, personal communication). The majority of plants were located in areas without leaf litter accumulation. The number of plants at each of the six

locations ranges from three to 40 clumps. It is Rayner's (2019a, Wofford College, personal communication) opinion that only one colony, containing 40 clumps of plants, is sustainable. The cause of decline in this population is unknown; however, Rayner observed deep leaf litter, herbivory, and earthworm castings.

The South Carolina portion of the Melrose Mountain population (Greenville County) has also been monitored since 1998 (Rayner 2019a, Wofford College, personal communication; SCHTP 2018; NCNHP 2018). In 1998, there were 602 clumps of plants in 17 colonies (Rayner et al. 2008). Of the 602 clumps, 217 clumps of plants were found in five colonies. These five locations were revisited in 2019 and contained only 13 clumps (a 94% decline) in two of the locations (Rayner 2019a, Wofford College, personal communication). As with Chestnut Ridge, the cause of decline in this population is unknown; however, Rayner observed similar conditions at both sites.

In 2011, a small seed bank study was conducted by Rayner (2019a, Wofford College, personal communication). Soil samples were taken downslope from vigorous *Sisyrinchium dichotomum* plants and analyzed for the presence of seeds. Few seeds were found and none germinated. Negative impacts to the seed bank and challenges to germination warrant further investigation.

2.3.1.2 Genetics, genetic variation, or trends in genetic variation: The 2013 5-year review mentions that Rayner collected genetic tissue samples from across the species range in 2001. The samples were provided to a collaborator with the intention of future analysis. Genetic analysis has yet to be performed and contact information for the collaborator has not been provided.

2.3.1.4 Spatial distribution, trends in spatial distribution: The listing rule identified the range of *Sisyrinchium dichotomum* as including three counties in North Carolina: Polk, Henderson, and Rutherford (Service 1991). Since that time, the range has expanded to include Burke and McDowell Counties in North Carolina and Greenville County, South Carolina (Service 1995; Service 2013; NCNHP 2018; Table B1).

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

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range: The listing rule cites residential development, roadway improvements and maintenance, erosion, natural succession due to suppression of disturbance, land clearing, trampling, and encroachment by invasive, exotic species as primary threats to the species (Service 1991). These threats are still present.

The North Carolina Department of Transportation widened Skyuka Mountain Road from 2006-2008; the project was subject to ESA Section 7 consultation (Service 2013). Although management and monitoring obligations outlined in the Biological Opinion were concluded in 2012, the NCDOT has continued to manage habitat along Skyuka Mountain Road with periodic long-arm mowing and herbicide application to eradicate kudzu (McHenry 2019, NCDOT, personal communication). Management of the Skyuka

Mountain Road ROW remains a challenge for NCDOT due to rocky substrate that hampers mowing and presence of invasive species adjacent to the road corridor. Recent monitoring has not occurred at the site; however, the number of plants within monitoring plots in the ROW declined by 73% from 2006 to 2012 (Wells n.d.).

As noted in the 2013 5-year review, there is still a need to assess the severity and extent of invasive, exotic plant species in *Sisyrinchium dichotomum* populations throughout the range and determine the effectiveness of management strategies (Service 2013). The NCPCP has experimented with the use of a leaf blower to remove leaf litter in occupied and surrounding suitable habitat (NCPCP 2017). Response to this management activity remains unknown until further monitoring can be conducted at the site. The NCPCP is also pursuing prescribed burning at the White Oak Mountain and Melrose Mountain plant preserves; however, no burning has taken place to date (Starke 2019, NCPCP, personal communication). At the South Mountains Game Lands, a portion of the Silver Creek/Little Huckleberry Mountain population has been burned by prescribed fire four times (2005, 2008, 2011, and 2017) (Simon 2019, retired WRC, personal communication). Monitoring indicated an increase in population size between 2005 and 2008 (NCNGP 2018); however, additional monitoring has not occurred at the site. Findings of follow-up monitoring at the South Mountains Game Lands and the plant preserves will inform future management strategies at sites containing *Sisyrinchium dichotomum* and suitable habitat.

2.3.2.3 Disease or predation: Rayner and Gwinn (2014) investigated invasive, epigeic (non-burrowing) earthworms as a possible cause of *Sisyrinchium dichotomum* decline within the Chestnut Ridge population in Greenville County. They conducted a pilot study of the ingestion/digestion of seeds by the earthworms found on site. Epigeic earthworms ingested and digested significantly more seeds than anecic (burrowing) earthworms; however, epigeic earthworms liquefied within two days of ingestion, indicating seed toxicity.

Rayner and Gwinn (2014) also found a significant correlation between plant condition and soil depth with deeper soils supporting plants in better condition. The humus layer around all plants was lacking and worm castings were present. Additional studies are planned to further investigate the relationship between *Sisyrinchium dichotomum* decline and invasive epigeic earthworms. Rayner and Gwinn (2014) have hypothesized that epigeic earthworms negatively affect seed germination and establishment, along with overall plant condition, by rapidly consuming the humus layer in soil and selectively removing seeds from the seed bank.

2.4 Synthesis

The distribution of this narrow-ranging endemic has not appreciably changed and only one additional population has been identified since the last 5-year review. Although monitoring is mostly infrequent and inconsistent, available data suggests a decrease in overall abundance of the species. The four sites that have been consistently monitored (White Oak Mountain and Skyuka Mountain Road in North Carolina and Chestnut Ridge and Melrose Mountain in South Carolina)

have declined steeply and clear reasons for the declines are unknown. What constitutes a “self-sustaining” population has not been defined and successful management strategies that reduce or eliminate threats have yet to be determined. The known threats to the species remain unchanged and one potential new threat (invasive, epigeic earthworms) has been identified. Data and information outlined in this review highlight the need for management research and consistent monitoring of abundance and threats throughout the range. *Sisyrinchium dichotomum* should remain classified as endangered.

3.0 RESULTS

A. **Recommended Classification:** No change is needed.

4.0 RECOMMENDATIONS FOR FUTURE ACTION

The 2013 5-year review included a list of recommendations to improve recovery of the species. These actions remain applicable to species recovery. Accomplishments toward recommended actions are summarized below.

Determine number of colonies and corresponding SCHAT EORs protected within TNC’s Greenville Watershed conservation easement.

Greenville Watersheds is the collective name for two properties (watersheds) managed by Greenville Water – Table Rock Watershed and North Saluda Watershed (TNC 2014). The Nature Conservancy (TNC) has a conservation easement on a large portion of the North Saluda Watershed (TNC 2014) and the North Saluda Watershed has known occurrences of *Sisyrinchium dichotomum*. Using GIS, South Carolina tax parcel data, and South Carolina Heritage Trust Program data, it was determined that South Carolina Element Occurrence Records 003, 004, and 008 are located on the TNC conservation easement. Other plants in the population are protected by the SCDNR as a State Heritage Preserve and the City of Landrum as a water supply watershed.

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

- A. Work with partners to investigate/research management strategies that will minimize or eliminate threats to the species with regards to invasive, exotic plant management and leaf litter accumulation.
- B. Work with partners to investigate/research the impact invasive, epigeic earthworms may be having on *Sisyrinchium dichotomum* and suitable habitat.
- C. Discontinue the use of direct plant relocations as a method of minimizing impacts to the species from development projects until more information is known about what makes a relocation successful. Work with partners to conduct research into transplant methods and post-transplant management.

D. Work with partners and/or botanical gardens to determine seed germination requirements and rate of seed viability. Develop a plan for conserving the species in ex situ collections – either through conservation gardens or seed banking.

E. Work with partners to conduct a range-wide census of all populations.

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US FISH AND WILDLIFE SERVICE

5-YEAR REVIEW OF WHITE IRISETTE

Current Classification: Endangered.

Recommendation resulting from the 5-Year Review:

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

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

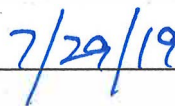
FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve

 _____

Date

 _____

APPENDIX A

Summary of peer review for the 5-year review of white irisette (*Sisyrinchium dichotomum*).

- A. **Peer Review Method:** Peer review was coordinated by the Service's Jackson Ecological Services Field Office in Mississippi. Four peer reviewers were selected by the Service for their knowledge of and expertise with white irisette. Individual responses were received from three of the four reviewers. Additionally, internal review was conducted by four members of the Service's Southeast Region.
- B. **Peer Reviewers:** The peer review request included personnel from the NC Plant Conservation Program (NCPCP), Wofford College, the NC Natural Heritage Program (NCNHP), and the SC Heritage Trust Program (SCHTP).
- 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:** The peer reviewer from SCHTP did not respond to the request for review. Peer reviewers from NCPCP, Wofford College, and NCNHP provided comments. A brief summary of substantive comments is below:
- The reviewer from NCPCP provided additional comments regarding proposed future management actions on NCPCP plant preserves.
- The reviewer from Wofford College recommended dividing the Chestnut/Hooker/Bailey Ridges population in SC into two separate populations due to separation distance and likely lack of genetic exchange.
- The reviewer from NCNHP suggested additional recommended actions.
- E. **Response to Peer Review:** All substantive comments received were reviewed by the Service and incorporated into a revised version of this document, where appropriate.

APPENDIX B
Tables

Table B1. Protected colonies of *Sisyrinchium dichotomum*.

Table B2. *Sisyrinchium dichotomum* populations and the number of colonies they are estimated to contain.

Table B1. Protected colonies of *Sisyrinchium dichotomum*.

Population Name	Site Name	Landowner or Conservation Partner ^a	Protection Type	Protected NHP EORs	Protected Colonies (estimated total) ^b
Chestnut Ridge (SC) ^c					
	Chestnut Ridge Heritage Preserve	SCDNR	State Heritage Preserve	SC*005-006, 010-011, 015	5
Hooker/Bailey Ridges (SC) ^c					
	North Saluda Watershed	TNC	Conservation Easement	SC*003-004, 008	3
	Landrum Watershed	City	Water Supply	SC*013	1
Melrose Mountain (NC/SC)					
	Melrose Mountain Plant Conservation Preserve	NCDACS-PCP	State Plant Conservation Preserve	NC*32.002, .016	18
	Big Falls Creek Watershed	Town	Water Supply	NC*32.002	5
	North Saluda Watershed	Town	Water Supply	NC*32.018; SC*002, 007	6
Round Mountain (NC)					
	Round Mountain	CC	Conservation Easement	NC*019	1
White Oak/Chestnut/Miller Mountains (NC)					
	White Oak Mountain (Southwest)	NCWRC	Green River Game Lands	NC*29.001	1
	White Oak Mountain Plant Conservation Preserve	NCDACS - PCP	State Plant Conservation Preserve	NC*29.001, .012	4
	Jenkins Tract	CC	Conservation Easement	NC*29.004, .072	2
	White Oak Mountain (Northeast)	NCWRC	Green River Game Lands	NC*29.065	6
Clifffield Mountain/Deep Gap (NC)					
	Clifffield Mountain/Deep Gap	NCWRC	Green River Game Lands	NC*008	1

World's Edge/Sugarloaf (NC)					
	World's Edge/Sugarloaf	NCDPR	Chimney Rock State Park	NC*38.001, .005, .021-.022, .027, .035-.037, .046-.049, .052-.055, .057-.058, .066-.067	37
	Lake Lure/Harris	CC	Conservation Easement	NC*38.064	2
	Pryor Tract	CC	Conservation Easement	NC*38.069	2
Rumbling Bald/Cedar Knob/Round Top Mountain (NC)					
	Rumbling Bald/Cedar Knob/Round Top Mountain	NCDPR	Chimney Rock State Park	NC*45.024, .031, .071	9
South Mountains: Silver Creek/Little Hucklebery Mountain (NC)					
	Silver Creek/Little Hucklebery Mountain	NCWRC	South Mountains Game Lands	NC*70.028, .050	8
South Mountains: Hall Knob (NC)					
	Hall Knob	NCDPR	South Mountains State Park	NC*056	1
South Mountains: Mike Mountain/Windy Gap (NC)					
	Mike Mountain/Windy Gap	Private	Registered Heritage Area	NC*074	3

^a Landowner or Conservation Partner:

CC = Conserving Carolina, NCDACS-PCP = NC Department of Agriculture and Consumer Services, Plant Conservation Program, NCDPR = NC Department of Parks and Recreation, NCWRC = NC Wildlife Resources Commission, SCDNR = SC Department of Natural Resources, NC = The Nature Conservancy.

^b Protected whole or in part.

^c Chestnut/Hooker/Bailey Ridges population has been divided into two populations at the recommendation of a biologist familiar with the sites. This division does not represent the discovery of a new population, only the revision of population boundaries.

Table B2. *Sisyrinchium dichotomum* populations and the number of colonies they are estimated to contain.

Population Number	State	County	Population Name	Colonies (estimated total)	Protected Colonies (estimated total) ^a	NHP EORs
1	SC	Greenville	Chestnut Ridge	5	5	SC*005-006, 010-011, 015
2	SC	Greenville	Hooker/Bailey Ridges	4	4	SC*003-004, 008, 013
3	SC/NC	Greenville (SC) Polk (NC)	Melrose Mountain	37	29	SC*002, 007; NC*32.002, .015-.018
4	NC	Polk	Round Mountain	1	1	NC*019
5	NC	Polk	White Oak/Chestnut/Miller Mountains	39	13	NC*29.001, .004, .006, .009-.010, .012-.013, .040, .065, .072
6	NC	Henderson Polk	Clifffield Mountain/Deep Gap	6	1	NC*008
7	NC	Henderson Polk Rutherford	World's Edge/Sugarloaf	56	41	NC*38.003, .005, .011, .020-.022, .027, .035-.037, .046-.049, .052-.055, .057-.058, .064, .066-.067, .069
8	NC	Polk	Rotten Creek Headwaters	1	0	NC*014
9	NC	Rutherford	Rumbling Bald/Cedar Knob/Round Top Mountain	9	9	NC*45.024, .031, .071
10	NC	Rutherford	Harris Mountain/Upper Cathy's Creek	1	0	NC*030
11	NC	Rutherford	South Mountains: Yellowtop/ Biggerstack/Middle Mountains	16	0	NC*42.034, .039, .041
12	NC	Rutherford	Cherry Mountain	1	0	NC*033
13	NC	Burke Rutherford	South Mountains: Silver Creek/Little Huckleberry Mountain	8	8	NC*70.028, .050
14	NC	Burke	South Mountains: Hall Knob	1	1	NC*056
15	NC	Rutherford McDowell	South Mountains: Mike Mountain/Windy Gap	4	3	NC*074

^a Protected whole or in part.

^b Chestnut/Hooker/Bailey Ridges population, has been divided into two populations at the recommendation of a biologist familiar with the sites. This division does not represent the discovery of a new population, only the revision of population boundaries.