

Dwarf-flowered heartleaf (*Hexastylis naniflora*)

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



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

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List of Abbreviations

AFO	Asheville Field Office
DPS	Distinct Population Segment
EOR	Element Occurrence (EO) Record
ES	Ecological Services
ESA	Endangered Species Act
ISSRs	Inter Simple Sequence Repeats
NC NHP	North Carolina Natural Heritage Program
NCDOT	North Carolina Department of Transportation
NHP	Natural Heritage Program
NPS	National Parks Service
ROW	Right-of-way
SCDNR	South Carolina Department of Natural Resources
SEM	Scanning Electron Microscopy
SWS	Spartanburg Water System
USFWS	United States Fish and Wildlife Service

5-YEAR REVIEW
Dwarf-flowered heartleaf/*Hexastylis naniflora*

I. GENERAL INFORMATION

A. Methodology used to complete the review

Public notice of the initiation of this 5-year review was given in the *Federal Register* on September 20, 2005 (70 FR 55157) and a 60 day comment period was opened. During the comment period, we did not receive any additional information about dwarf-flowered heartleaf other than responses to specific requests for information from biologists familiar with the species (see Appendix A). Information used in this report was gathered from published and unpublished reports.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.

B. Reviewers

Lead Region – Southeast Region: Kelly Bibb, 404/679-7132

Lead Field Office – Asheville, North Carolina, Ecological Services, Carolyn Wells, 828/258-3939 ext. 231

Cooperating Field Office(s) – Charleston, South Carolina, Ecological Services, Melissa Bimbi, 843/727-4707 ext. 217

C. Background

1. Federal Register Notice citation announcing initiation of this review:
September 20, 2005 (70 FR 55157)

2. Species status: In the 2010 Recovery Data Call, the species status was reported as “uncertain” because monitoring data capable of detecting year-to-year fluctuations in status and trends are largely unavailable. Population trends over the past year were reported as "unknown" and the overall species' status over this time period was reported as "uncertain".

3. Recovery achieved:
(this species does not have defined recovery objectives from a recovery plan)

4. Listing history

Original Listing

FR notice: 54 FR 14964

Date listed: April 14, 1989

Entity listed: Species

Classification: Threatened

5. Review History:

Recovery Data Call – 2010, 2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, 2000, 1999, and 1998

The Service announced the initiation of a multi-species five year review on November 6, 1991 (56 FR 56882). In this review, different species were simultaneously evaluated with no in-depth assessment of the five listing factors as they pertained to each given species' recovery. This review did not propose any changes in federal status for *Hexastylis naniflora*.

6. Species' Recovery Priority Number at start of review (48 FR 43098):

14, corresponding to “low” magnitude of threat, “high” recovery potential, and taxonomic status of “species”

7. Recovery Plan or Outline

A recovery plan has not been completed for this species.

II. REVIEW ANALYSIS

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

Dwarf-flowered heartleaf is a plant and, therefore, not covered by the DPS policy. The other DPS questions will not be addressed further in this review.

B. Recovery Criteria

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

No

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends, demographic features, or demographic trends

Many of those working with *Hexastylis naniflora* have used the terms “sub site”, “site”, “location”, “occurrence” (often, but not always, in reference to Natural Heritage Program Element Occurrence (EO) Records), “subpopulation” and “population” interchangeably. Others have aggregated smaller sites into populations according to subjective criteria which have never been explicitly defined. This generates discrepancies among sources with respect to the abundance and distribution of the species, with the net result being that available data are usually not comparable from one source to the next. Appendix C.1 of this review describes how the numerous small, site-specific locations containing *H.*

naniflora have been aggregated into proxies for 108 biological populations for purposes of this review, using mapping standards devised by NatureServe and its network of Natural Heritage Programs. Throughout this review, the term “population” should be understood to specifically reference the 108 populations (the derivation of which is explained in Appendix C.1) recognized by USFWS for purposes of this review, unless otherwise noted. This review uses the terms “site” or “subpopulation” sparingly, when necessary to convey reference to a portion of one or more of these populations. For further ease of reference, USFWS has assigned a unique numerical identifier to all populations discussed herein. The population numbers assigned by USFWS are provided in the tables of Appendix B.

When *H. naniflora* was federally listed in 1989, the listing rule described 24 extant and one extirpated “populations” (54 FR 14964-14967). Explicit criteria for recognizing these populations were not given in the listing rule, but based upon information in the AFO files it appears that each site-specific location containing the species was counted as a separate population. Across the range of the species, the estimated number of individuals (typically counted as “clumps”, or rosettes) exceeded 5,000 plants, with over 60% of the known individuals found in three large populations each estimated to contain over 1,000 rosettes. In light of the emphasis placed upon populations with more than 1,000 rosettes in the 1989 listing rule, this review uses this threshold to call attention to particularly large populations.

As of 2010, the combined databases of the NC NHP and SCDNR Heritage Trust contain 275 Element Occurrence Records (EORs) for *H. naniflora* (NC NHP, 2010; SCDNR, 2010). These EORs depict roughly 108 locations which are sufficiently geographically distinct to be regarded as proxies for populations of the species (Appendix C.1). Thus, the total number of populations has increased roughly four-fold (from 24 to 108) since the species was listed in 1989.

Few populations have been comprehensively surveyed, and as a result, estimates of abundance are generally not available at the scale of entire populations. Instead, abundance estimates exist for portions of populations (usually corresponding to the 275 EORs mapped by the respective NHPs. These abundance estimates have usually been obtained by different observers employing a variety of means and levels of survey effort. At one extreme, observations may consist of coarse estimates (e.g., 1-50, 50-500, > 1,000 etc.); at the other extreme, they may consist of meticulous counts of every plant present. Still other observers have estimated abundance by extrapolating from counts within smaller areas (delimited with or without the use of plots). Because of the varied methods used in arriving at these estimates, they are not always directly comparable, and must be interpreted with some caution.

The 275 EORs have been reported to contain anywhere from a single rosette to more than 50,000 rosettes. Table B.1 (Appendix B) summarizes existing EORs in

terms of the number of rosettes they were last estimated to contain, and then aggregates this EOR data in terms of the 108 populations recognized here.

Since listing, the number of populations estimated to contain over 1,000 rosettes has increased from three to 27 (Tables B.1 and B.2). This corresponds to 25% of all known populations, and a greater number of populations are now estimated to contain 1,000 rosettes than the total number of populations known when the species was listed. By contrast, 13 populations (12% of all known) are simply known to be extant, with no available estimate of population size (NC NHP, 2010; SCDNR, 2010). If the latest estimates for each EOR are compiled across all observers and years of observation, the 108 populations could conservatively be estimated to contain a collective total of more than 250,000 rosettes (NC NHP, 2010; SCDNR, 2010).

In the majority of cases, trends are not available at the scale of populations or EORs because observations reflect grossly different and incomparable levels of survey effort (e.g., a complete census one year, followed by a coarse estimate the next, or still some other method). In all of these instances, one or more persons familiar with the site have questioned the degree to which the observations accurately reflect actual trends as opposed to incomparable counts/estimates. There are, however, some instances in which meaningful trends can be extracted or inferred from available data.

Only one of the 27 populations estimated to contain over 1,000 rosettes is subject to routine monitoring capable of detecting robust population-level trends. This site is the Foothills Landfill in Caldwell County, NC (USFWS population #3; Tables B.2 and B.3). This population was adversely affected by activities requiring Endangered Species Act Section 7 consultation with the Service (USFWS, 2003). The Section 7 process resulted in minimization of impacts, permanent protection (through a conservation easement on 260 acres) of unaffected portions of the *H. naniflora* population, and long-term monitoring of the species within permanently protected areas for the life of the landfill (30 years). Monitoring is conducted using 0.1 acre sample plots distributed throughout the population, in which all rosettes have been counted during the 2009, 2006, and 2005 field seasons (Golder Associates, 2009; ---, 2006; --- 2005). In 2009, extrapolating the densities within these plots to the larger delineated area of occupied habitat yielded an estimated population of 23,340 rosettes, representing a slight (4%) but presumably biologically insignificant decline from prior years. Thus, preliminary data for this population suggests that it has been relatively stable over this monitoring period.

In 2009, the North Carolina Department of Transportation (NCDOT) committed to provide the USFWS with updated status information for all or portions of 12 other populations estimated to contain over 1,000 rosettes (Table B.2).¹ This commitment was pledged as a conservation measure associated with a formal

¹ This statement is in reference to USFWS population numbers 2,4,5,7,8,9,10,11,12,13,14, and 23 in Table B.2.

Endangered Species Act Section 7 consultation involving adverse effects to *H. naniflora* (USFWS, 2009). Most of these 12 populations were expected to be adversely affected by road improvement projects previously subject to formal Section 7 consultations with USFWS (Table B.3). These adverse effects were frequently expected to be minimized through relocation of plants and/or commitments to provide on-site protections to plants remaining within NCDOT right-of-way (ROW) following construction. In other instances, populations (or portions of them) were purchased as off-site conservation measures (these are also listed in Table B.3).

As a result of commitments pledged over many years of formal Section 7 consultations with the USFWS, NCDOT now protects more populations (or significant portions of them) than any other conservation partner throughout the range of *H. naniflora*. However, there is a critical need to verify the number of plants remaining post-construction, the survival of transplanted individuals, the number of rosettes protected within ROWs, and/or the number of rosettes protected via off-site land purchases across these numerous sites. This information, anticipated within the next calendar year, will substantially inform future assessments of status and trends in *H. naniflora* populations.

Three South Carolina populations estimated to contain over 1,000 rosettes were addressed by Section 7 consultations with other agencies (Cowpens National Battlefield, Blalock Reservoir, and Peters Creek Heritage Preserve; Tables B.2 and B.3). All or significant portions of these populations are subject to protective ownership, however additional information is needed for estimates of abundance and population trends. At Cowpens National Battlefield (Cherokee County, SC), NPS is conducting prescribed burns within portions of the *H. naniflora* population subject to formal and subsequent informal consultation with the USFWS (Bimbi, 2010; Stone, 2010; Wells, 2009; Walker et al., 2009). This population was last estimated to contain some 10,180 rosettes in 2005 (Rayner, 2006). The scope of NPS's prescribed burning activity is increasing to encompass the majority of this *H. naniflora* population. Preliminary data suggested that burning has had no adverse effects upon growth or flowering (Walker et al., 2009). USFWS has registered concerns over the limited scope of this two-season monitoring effort and has requested a continuation of monitoring to ensure that this large population is not adversely affected by this experimental management approach (Bimbi, 2010; Wells, 2009). There is considerably little information on the response of *H. naniflora* to fire, although anecdotal observation from a second site in Caldwell County, North Carolina suggests that the species was not appreciably harmed by a dormant season wildfire that spread through a portion of that population in the winter of 2009 (Tompkins, 2010).

Blalock Reservoir (Spartanburg County, SC) was once widely regarded as the single largest population of the species, with over 11,000 rosettes estimated in 1997 (JJ&G, 1998).

In 2006, the entire Blalock Reservoir population was reported to consist of a mere 1,400 rosettes (Newberry, 2006). Since that estimate, the SWS conservation area established to protect *H. naniflora* has twice been impacted by illegal encroachments from adjacent landowners (Newberry, 2009; Schneider, 2006; JJ&G, 2006). *H. naniflora* rosettes were impacted or destroyed in both instances: in 2006, 35 rosettes were presumed destroyed (JJ&G, 2006), and in 2009 an estimated 576 plants were presumed lost (Newberry, 2009). Both cases involved adjacent landowners felling trees and/or harvesting timber within areas of occupied habitat. Therefore, the USFWS is concerned that this once significant population may scarcely contain 1,000 rosettes. There have been no reported attempts to estimate the size of the *H. naniflora* population extending off of SWS properties, which were estimated to contain over 5,000 rosettes in 1997 (JJ&G, 1998). However, it would seem unlikely that plants located on privately owned shoreline have fared better than those on properties protected by SWS. Regardless, a comprehensive reassessment of the number of plants remaining in this once sizable, protected population is needed in order to objectively assess its role in the recovery of the species.

The Biological Opinion for the Blalock Reservoir expansion also included an off-site conservation measure for SWS to provide financial assistance to support restoration work within the Peters Creek Heritage Preserve (USFWS, 2001; part of population 26 in Table B.2). As of 2010, USFWS has been unable to confirm that this occurred. The SCNDR Management Plan for Peters Creek briefly alludes to some wetland restoration having been conducted on site (SCDNR, 2006) but it is unclear whether or not this restoration had any appreciable effect upon the status of this *H. naniflora* population. Of even greater concern is the fact that available estimates of population size suggest declines within the larger Peters Creek population (of which Peters Creek Heritage Preserve is a significant part): this population was estimated to contain more than 5,000 rosettes in 1991, but reported to contain fewer than 2,500 when last observed in 2006 (Bunch, 2006). The spatial extent of the 2006 surveys is unclear, and may extend only to portions owned by SCDNR. An updated population estimate (of the larger area once estimated to contain > 5,000 rosettes) is clearly needed to confidently assess status and trends in this population.

The USFWS is aware of a single effort to collect demographic-level data (survivorship and recruitment of tagged individuals) for *H. naniflora*. This effort was conducted during the 1990-1991 field seasons, within a portion of the Peters Creek population in Spartanburg County, SC (Newberry, 1993). This study demonstrated a 96.1% survival rate over these two consecutive seasons, with 50% of the mortality occurring in plants located at the highest position on the forested slope (away from the adjacent floodplain). Mortality was highest in small plants bearing fewer than four leaves. Plant size was variable, with the largest plant bearing 45 leaves and 33 flowers, and situated in the floodplain. In general, plants located in the floodplain were larger than plants located on adjacent slopes. The

percentage of flowering plants averaged 70%, with the highest frequency of flowering occurring among plants situated in the floodplain.

b. Genetics, genetic variation, or trends in genetic variation

Murrell et al. (2007) evaluated species boundaries within the *Hexastylis heterophylla* complex, a group that consists of *H. heterophylla*, *H. minor*, and *H. naniflora* (Murrell et al. 2007; Padgett, 2004). These analyses consisted of ecological, morphological, soil, pollen and molecular genetics techniques. These investigations were interpreted as supporting the continued recognition of these taxa as well-defined, discrete species. However, as frequently noted by field botanists, *H. naniflora* Blomquist was shown to exhibit overlap in key floral characters with both *H. minor* (Ashe) Blomquist and *H. heterophylla* (Ashe) Small, in areas of overlapping distribution among these taxa. Scanning electron microscopy (SEM) consistently distinguished *H. naniflora* from other members of the *H. heterophylla* complex based on pollen microscopy. Principal Components Analysis of floral characters and soil chemistry also consistently distinguished *H. naniflora* from *H. minor* and *H. heterophylla*. However, efforts to obtain consistently distinct banding patterns using Inter Simple Sequence Repeats (ISSRs) were unsuccessful at distinguishing *H. naniflora* from other members of this group (Murrell et al., 2007). These results were based upon an extremely small sample size (n=10 *H. naniflora* individuals), and therefore warrant further investigation.

NCDOT is evaluating a proposal to continue genetic analyses using microsatellites (Renninger, 2010). The primary purpose of this investigation would be to assist in resolving species identification questions at select sites in Caldwell and Catawba Counties, NC. Preliminary discussions among the USFWS, NCDOT and Dr. Murrell (who would be the Principal Investigator on the project) suggest that there is an opportunity to expand the scope of the project to further scrutinize the species boundaries within the *H. heterophylla* complex, thus helping to refine our understanding of the underlying causes of morphological intergradations within these taxa.

The USFWS is not aware of any attempts to characterize patterns or trends of population genetic structure in *H. naniflora*.

c. Taxonomic classification or changes in nomenclature

Although there is considerable disagreement as to the generic distinctiveness of *Hexastylis* from *Asarum* (e.g., Barringer 1993 and Kelly 1997, 1998, 2003), most North American publications (including the most recent treatment in the Flora of North America (Flora of North America, 1997) and Weakley (2010) recognize *Hexastylis* at the generic level.

The USFWS is not aware of any proposed changes in taxonomy that would affect the continued legal status of *H. naniflora* under the Act. However, as noted in the preceding section, within the range of *H. naniflora* there are populations which fall outside of the range of published values for key floral characteristics, overlapping with values described for *H. heterophylla* or *H. minor* (sensu Weakley, 2010; Murrell et al. 2007; Gaddy 1987). These geographic areas of overlap in key characters will be the focus of the proposed genetic analyses described in the preceding section (Renninger, 2010).

d. Spatial distribution, trends in spatial distribution, or historic range

When *H. naniflora* was federally listed in 1989, the listing rule described 24 extant “populations” (and 1 extirpated population) distributed across eight counties in North and South Carolina. As of 2010, the distribution of this species consists of 108 populations (Appendix C.1) distributed across 12 counties in these two states (Appendix B, Figure B.1). Since 1989, the county distribution has expanded to include the following North Carolina counties: Alexander, Caldwell, Iredell, and Polk. The species has not been discovered in any additional counties in South Carolina.

e. Habitat or ecosystem conditions

In preparing this review, the USFWS digitized paper maps depicting the approximate boundaries of the 24 populations of *H. naniflora* referenced in the 1989 listing rule. As mapped as of that time, these sites comprised approximately 254.6 acres. As of 2010, the 90 principal and/or stand-alone EORs mapped by the NC NHP comprise over 2,600 acres (NC NHP, 2010). This is likely an overestimate of occupied habitat, because many EORs are represented by large buffers depicting uncertainty about the precise locations from where plants were known. Precise population boundaries are not currently available for most populations in South Carolina, as most sites have only been mapped as point locations depicting the approximate center of occupied habitat (SCDNR, 2010). Therefore, the actual acreage of occupied habitat cannot be confidently determined with available data.

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

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

A review of existing NHP EOR data reveals that all or portions of 26 populations (24% of the total) have been directly or indirectly impacted through development projects or other causes such as trash disposal, expansion of residential lawns, cattle, or invasive exotics (NC NHP 2010; SCDNR 2010). Another 16 populations have been specifically reported to be threatened by one or more of these same sources. Therefore, threats have either occurred or are reasonably

foreseeable within 42 of the 108 populations (corresponding to 39% of all known populations). Of these 42 populations, all or portions of 22 (50%) have been adversely impacted by activities requiring ESA Section 7 consultation with the USFWS (Table B.3).² The fact that nearly 20% of all known populations have been subject to formal Section 7 consultation illustrates the threats faced by *H. naniflora*.

The most recurrent source of habitat destruction, and certainly the most common trigger for Section 7 consultations involving *H. naniflora* is road and bridge improvement projects. Ten of the 27 largest populations (containing more than 1,000 rosettes) have been the subject of Section 7 consultations between the USFWS and the NCDOT (Tables B.2 and B.3).³ Collectively, these projects have adversely impacted or are currently expected to impact some 22,135 rosettes. In most cases the Section 7 process has resulted in avoidance or minimization of adverse effects through relocation of plants and/or commitments of on-site protection to those plants remaining (post-construction) within NCDOT right-of-way (ROW). Significant portions of other populations (such as Murray's Mill and the Broad River Tract; Table B.2 and B.3) have been purchased by NCDOT as off-site conservation measures in association with these consultations. Over the many years of Section 7 consultations between the USFWS and NCDOT, NCDOT has pledged monitoring and/or management for most of the sites it has acquired, as well as some locations where the species is protected within NCDOT rights-of-way (ROW). In recent years USFWS and NCDOT have recognized a need to follow-up on these commitments by verifying the number of plants remaining post-construction, the number and survival of transplanted individuals, the number of rosettes protected within ROWs, and/or the number of rosettes protected via off-site land purchases. In particular, there remains a need for monitoring data to be collected in a consistent manner from one year to the next for the purposes of meaningfully accounting for trends. In 2009, NCDOT pledged to provide this information to the USFWS as one of many conservation measures associated with another formal consultation involving adverse effects to *H. naniflora* (USFWS, 2009). This information, anticipated within the next calendar year, will substantially inform future assessments of the status, threats, and levels of protection afforded to the species.

Other forms of economic development have also resulted in the destruction or modification of habitats occupied by *H. naniflora*; in many cases, these activities have also required Section 7 consultations with the USFWS (Table B.3). Examples of these activities include the maintenance or expansion of hydroelectric and drinking water reservoirs, construction of an industrial development complex, and maintenance activities (in compliance with Federal Aviation Administration standards) at a regional airport. Collectively, these activities have involved the loss or relocation of several thousand rosettes (Table

² This statement is in reference to all sites in Table B.3, with the exception of those listed as being associated with off-site conservation measures.

³ This statement is in reference to USFWS population numbers 2,4,7,8,9,10,11,12,13,and 23 in Table B.2.

B.3).

Blalock Reservoir in Spartanburg County, South Carolina was once estimated to contain the largest population of *H. naniflora*, with over 11,000 rosettes reported here in 1997 (JJ&G, 1998). This population was the subject of a section 7 consultation as a result of a proposal to raise the elevation of Blalock Reservoir, which provides water supply storage to Spartanburg County and the City of Spartanburg (USFWS, 2001). Approximately one-third of this population was directly threatened by inundation, and the Federal agency committed to the relocation of some 3,054 rosettes to remaining areas of occupied habitat around the reservoir. At the conclusion of formal section 7 consultation, the USFWS anticipated that as many as 6,619 rosettes (assuming that all transplants survived) would be afforded protection through restrictive covenants placed on properties owned by the Spartanburg Water System (SWS) surrounding Blalock Reservoir. However, this population was last reported to contain a mere 1,400 rosettes (Newberry, 2006), and has twice since been impacted by encroachments from adjacent landowners (Newberry, 2009; Schneider, 2006, and JJ&G, 2006). The SWS has pursued each encroachment and settled for damages out of court (Jon Morgan, Blalock Reservoir Lake Warden, pers. comm.; Schneider, 2006). As of this review, this population may have declined by more than 88% since 1997 (from 11,000 rosettes to fewer than 1,400). Some of these apparent declines could be partially an artifact of incomplete survey effort, in that the exhaustive surveys which led to the 1997 estimate (of 11,000 rosettes) have never been repeated. However, it seems unlikely that plants occurring on privately owned shoreline not subject to restrictive covenants would be any more stable than those occurring on properties specifically protected and managed for the species (by SWS). Regardless, the total size of this once significant population needs verification and the strength of existing protection mechanisms requires further investigation.

A final example of habitat modification bears mentioning here, although it is presently unknown whether the long-term effects to *H. naniflora* will be adverse or beneficial. One of the largest remaining populations of the species occurs at Cowpens National Battlefield in Cherokee County, South Carolina (Tables B.2 and B.3). This population has been estimated to contain over 10,000 rosettes (Rayner, 2006). NPS has begun using prescribed fire as a vegetation management tool at this site, pursuant to consultations with USFWS due to the presence of *H. naniflora* within their prescribed burn units (Bimbi, 2010; Stone, 2010; Wells, 2009; Walker et al., 2009). The scope of NPS's prescribed burning activity is increasing to encompass the majority of this *H. naniflora* population. Preliminary data suggested that burning has had no adverse effects upon growth or flowering (Walker et al., 2009). USFWS has registered concerns over the limited scope of this two-season monitoring effort and has requested a continuation of monitoring to ensure that this large population is not adversely affected by this experimental management approach (Bimbi, 2010; Wells, 2009). There is little information on the response of *H. naniflora* to fire, although anecdotal observation from a second

site in Caldwell County, North Carolina suggests that the species was not appreciably harmed by a dormant season wildfire that spread through a portion of that population in the winter of 2009 (Tompkins, 2010). The continued use of prescribed burning at Cowpens National Battlefield, if accompanied by continued monitoring of the *H. naniflora* population, has the potential to significantly inform management strategies for this species.

b. Overutilization for commercial, recreational, scientific, or educational purposes

Overutilization is not known to be a threat at this time.

c. Disease or predation

When the species was federally listed in 1989, this was not known to be a significant factor affecting the status of the species. We have no new information to suggest that this has changed.

d. 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 *H. naniflora*.

The overwhelming majority of *H. naniflora* populations have been discovered as a direct result of surveys conducted to ensure compliance with the Endangered Species Act. Even more significantly, the majority of sites that have the potential to afford long-term protection to the species have been protected as a direct result of the provisions of Section 7 of the ESA, which directs consulting agencies to minimize adverse effects to federally listed species through conservation measures pledged as a part of the project description.

The section 7 consultation process has resulted in avoidance or minimization of adverse impacts, the protection of unaffected portions of *H. naniflora* populations, and/or monitoring of the species within protected areas. However, while conducting this review the USFWS discovered numerous examples in which conservation measures pledged during prior section 7 consultations had yet to be satisfactorily completed, or for which satisfactory evidence of completion was lacking. The USFWS is actively working to follow-up on commitments previously pledged on behalf of *H. naniflora*. It is unlikely that any of these sites would have been afforded protection without this statutory protection.

e. Other natural or manmade factors affecting its continued existence

Invasive exotic plant species are rampantly spreading throughout riparian corridors and ravines across the range of this species. Invasive exotics such as English Ivy (*Hedera helix*), Chinese privet (*Ligustrum* spp.), Japanese honeysuckle (*Lonicera japonica*) and Japanese Nepal grass (*Microstegium vimineum*) are known to threaten several populations; however, the scope and magnitude of this threat has not been comprehensively assessed. This threat requires active management in order to be successfully abated. At present, the majority of protected populations are secured against habitat conversion, but lack designated managers with the technical expertise and available resources (funding and personnel) to address this threat.

In recent years, the southeast has experienced moderate to severe droughts that many observers have implicated in population declines and poor transplant survivorship (NC NHP, 2010; and references throughout this review). A wildfire, presumably brought on or at least exacerbated by drought conditions, burned portions of one of the largest known populations in 2009 (Foothills Landfill in Caldwell County; Golder and Associates, 2009). Accelerated climate change is expected to increase the frequency and extent of drought conditions across the southeast (Karl, et al. 2009). The extent to which these climate changes will significantly affect populations of *H. naniflora* is currently unknown.

D. Synthesis

The number of populations of *Hexastylis naniflora* has increased from 24 to 108, and the total number of populations last estimated to exceed 1,000 rosettes (27 populations, or 24% of all known) is now greater than the total number of populations known when the species was listed in 1989 (Table B.2). Portions of 30 populations are at least partially protected by fee title ownership by a conservation partner, conservation easements, deed restrictions, voluntary landowner agreements, or occurrence in NCDOT ROW where NCDOT has pledged permanent protection (Tables B.2, B.4, and B.5).⁴ Protected sites are reasonably well distributed across the species' range, with at least one in each of nine counties across the 12-county distribution of the species (Figure B.1). Eighteen of the 27 largest populations of *H. naniflora* (last estimated to contain over 1,000 rosettes) are at least partially protected (Table B.2). In the case of all but six of these 18 populations, the protected portion of these larger populations is also likely to exceed 1,000 rosettes.⁵

However, the USFWS does not have strong confidence in many of the last available population estimates, and the best available information suggests significant declines at several populations once expected to factor heavily in the

⁴ This statement refers to USFWS population numbers 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 19, 23, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38 and 39 in Tables B.2-B.5.

⁵ Protected populations in which at least 1,000 rosettes occur on properties subject to protective ownership are: USFWS population numbers 3, 4, 8, 9, 10, 12, 15, 19, 23, 24, 26, and 27 in Table B.2.

recovery of *H. naniflora* (particularly Blalock Reservoir and Peters Creek, both in South Carolina). Three of the six protected populations in South Carolina are currently suspected to contain fewer than 50 rosettes, introducing significant concerns over the long-term viability of these populations (Table B.4). The majority of protected populations are currently protected from development, but lack managers with sufficient resources to monitor the species or provide management of threats (such as from invasive exotics, sedimentation or erosion, or encroachments from adjacent landowners).

Most available estimates of population size have been assembled from partial population surveys conducted by different observers in different years, usually using widely different protocols and levels of survey effort (NC NHP, 2010; SCDNR, 2010). Monitoring data are generally lacking, making it difficult to assess whether existing populations are stable and providing no baseline against which to judge the effectiveness of protection mechanisms and management actions.

In 2009, NCDOT made a commitment to address these and other information needs within 12 of the 27 largest populations of *H. naniflora* (USFWS, 2009). These 12 populations for which NCDOT has pledged additional information have been affected by one or more NCDOT road projects and/or were intended to provide off-site conservation to *H. naniflora* in association with projects adversely affecting the species. These updates were unavailable as this review was being finalized, but are expected during the 2011 calendar year.

As noted above, the best available information suggests significant declines at Blalock Reservoir in Spartanburg County, South Carolina (Table B.2). This site was once estimated to contain over 11,000 rosettes and as such was once regarded as the largest population of the species (JJ&G, 1998). In 2006 the population was reported to contain a mere 1,400 rosettes (Newberry, 2006). These declines have occurred despite restrictive covenants which have been placed over significant portions of the population, and active efforts to enforce these covenants by Spartanburg Water System (SWS). The historically large population size, existence of protective mechanisms and a strong landowner (SWS) commitment provide a strong potential role for this population in the recovery of this species. As such, the USFWS places a particularly high priority on working with SWS and other partners to address critical information needs and strengthening existing protections within this population.

A review of existing NHP EOR data reveals that threats have either occurred or are anticipated to occur within 42 of the 108 populations known (corresponding to 39% of all known populations; NC NHP, 2010 and SCDNR, 2010). Twenty-two of these 42 populations (50%) have been threatened with activities subject to ESA section 7 consultations (Table B.3). These consultations have resulted in avoidance or minimization of impacts, on- and off-site protections from development or other sources of habitat loss/alteration, and commitments to

monitor the status of numerous populations.

The increase in the number of known populations, supplemented by the protections now afforded to all or significant portions of 30 populations, has considerably lessened the threat of extinction for *H. naniflora*. With the acquisition of up-to-date population size estimates and landowner commitments for those populations currently in protective ownership, along with an objective demonstration that these populations are reasonably likely to remain viable over the long-term, the USFWS expects that this species would no longer be threatened with extinction in the foreseeable future, and as such should be proposed for removal from the federal list of endangered and threatened species. However, in recognition of the need to confirm the size, trends, and levels of protection at several focal populations that are expected to significantly contribute to this species' recovery, the USFWS is not recommending removal from the federal list at this time. The USFWS is committed to work toward this goal by pursuing the recommended future actions provided in the following section. The USFWS regards these actions as achievable within the next 5 years, at which time a recommendation to remove the species from the federal list may be appropriate.

III. RESULTS

A. Recommended Classification:

 x No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

The following actions would be expected to satisfactorily support a decision to remove *H. naniflora* from the federal list of endangered and threatened species. A decision to remove the species would be premature and unsubstantiated without accomplishment of these tasks, which is why the recommendation of this five year review is to retain the species as threatened.

1. Prepare a recovery outline for the species.
2. Convene a meeting of partners with significant knowledge and/or involvement (through ownership, monitoring, or management) with populations expected to play a key role in the recovery of the species. At this meeting:
 - a. Seek confirmation of the current size and spatial extent of all populations estimated to contain more than 1,000 rosettes (e.g., all populations listed in Table B.2). If such information is lacking, prioritize and seek partner assistance for the 2011 field season, to obtain a robust estimate of current population size.
 - b. Seek cooperation from partners for the collection of 2-3 years of baseline monitoring data capable of depicting status and trends in *H. naniflora* at each focal recovery site. These data would also establish a baseline against which post-delisting monitoring data would be compared.
3. Obtain written confirmation of the type of protection afforded to all potentially protected populations, with an emphasis upon the larger populations most likely to represent self-sustaining populations of the species (e.g., Table B.2). This documentation should include:
 - i. the full spatial extent of the known *H. naniflora* population (either fully or partially in protective ownership),
 - ii. the boundaries of the area subject to protective ownership,
 - iii. a description of the nature of protection afforded to the property (e.g., fee title, conservation easement, deed restriction, NCDOT owned right-of-way, or some other registry or agreement), and
 - iv. provisions for management (including identification of responsible parties)
 - v. landowner agreement to continue to uphold existing levels of protection and management even after the species is removed from the federal list of endangered and threatened species.

4. In association with the above efforts, specifically work to address lingering uncertainties and/or increased protections at the following *H. naniflora* populations, expected to play a key role in the recovery of the species and any associated decisions to remove the species from the federal list:
 - a. Cleveland County Landfill, Cleveland County, NC
 - b. Cliffside Stream Station, Cleveland County and Rutherford Counties, NC
 - c. Forest City Industrial Complex, Rutherford County, NC
 - d. Cowpens National Battlefield, Cherokee County, SC
 - e. Blalock Reservoir, Spartanburg County, SC
 - f. Peters Creek, Spartanburg County, SC

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**U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Hexastylis naniflora***

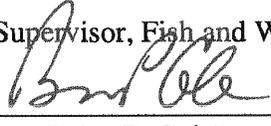
Current Classification: Threatened
Recommendation resulting from the 5-Year Review

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

Review Conducted By: Carolyn Wells

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve  Date 9/22/10
(Brian P. Cole)

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

Lead Regional Director, Fish and Wildlife Service

 Approve  Date 5/2/11

The Lead Region must ensure that other regions within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. If a change in classification is recommended, written concurrence from other regions is required.

APPENDICES

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APPENDIX A: Peer Review

Summary of peer review for the 5-year review of dwarf-flowered heartleaf (*Hexastylis naniflora*)

A. Peer Review Method:

During the preparation of the review, the species recovery lead circulated various components of the review (especially summary tables containing site-specific information, presented in the Appendices of this document) to species experts and relevant natural resource agencies with specific requests for verification of the information presented. This process was repeated until outstanding issues or questions could be resolved, or else identified as needing further investigation (these unresolved issues are identified throughout the review and noted in Section IV, “Recommendations for Future Actions”).

A draft version of the complete review was then circulated to those who provided information during its preparation. Review was specifically sought from the personnel representing the North Carolina Department of Transportation, South Carolina Department of Natural Resources (SC DNR), North Carolina Natural Heritage Program, and the USFWS Asheville and Raleigh Field Offices.

B. Peer Review Charge:

The draft review was circulated with the request that those reviewing the document verify that personal communications attributed to them were accurate, and that the information presented herein was accurate and up-to-date. Specific requests were made to assist in verification of population/site size estimates, impacts, and levels of protection. USFWS and NCDOT staff included in the request to review the document were specifically asked to verify information pertaining to project areas (and resultant or anticipated impacts or species protections) associated with projects with which they were familiar or had been directly involved. Reviewers were not asked to comment on the status of the listed species.

C. Summary of Peer Review Comments/Report –

Five reviewers returned comments.

Three USFWS reviewers provided comments; most of these were primarily grammatical and editorial, with corrections to numbers derived from summaries of information presented in tables. In addition to these, one USFWS reviewer suggested that Section IV (“Recommended Future Actions”) include the specific recommendation to prepare a recovery outline for the species, and to incorporate recommendations of previous coordination meetings and other relevant documents containing potential recovery criteria.

A reviewer from SCNDNR provided clarification regarding legal protections for the species in South Carolina, and clarification that the Peters Creek Heritage Preserve was not purchased with funds associated with an ESA Section 7 consultation (contrary to information in the USFWS Asheville Field Office Files).

A reviewer from NCDOT provided numerous substantive comments. These comments ranged from requests for clarification on the necessary steps to proceed with de-listing the species to clarifications on the level of impacts as well as on- and off-site protections to *H. naniflora* associated with various NCDOT projects.

D. Response to Peer Review –

Editorial and grammatical corrections from all reviewers were reviewed and incorporated as appropriate.

In response to the specific comment from one USFWS reviewer, we included a recommendation to produce a recovery outline for the species, into Section IV (“Recommended Future Actions”).

In response to the comments provided by the reviewer from SCDNR, we clarified statements regarding the legal protection afforded to the species in the state of South Carolina, and inserted a recommended future action (Section IV; Action 4) to follow-up with SCDNR, the Charleston FWS ES Office (which authored the associated Opinion), and the U.S. Army Corps of Engineers to determine if the terms and conditions of the Opinion have been met for the raising of lake levels at Lake Blalock (USFWS, 2001).

In response to comments provided by NCDOT, we updated population size estimates as well as estimates of anticipated impacts throughout the document. We continue to work with NCDOT and NC NHP personnel to ensure that this information is accurately captured in the NC NHP database records for this species. As of 2010, all of the population updates provided by this reviewer had been incorporated into the corresponding NHP database records. Updated NHP records (from April, 2010) were used for the latest version of this review.

APPENDIX B: Tables and Figures.

Table B.1. Summary of estimated population sizes for all known extant populations of *Hexastylis naniflora*, based upon Natural Heritage Program data and supplemented by information on file with the Asheville Field Office.

Minimum number of rosettes	Number of EORs: North Carolina ^a	Number of populations: North Carolina	Number of EORs: South Carolina ^a	Number of populations: South Carolina
< 50	27	12	5	4
50-99	20	7	10	3
100-249	43	12	8	3
250-499	34	19	3	1
500-999	17	7	2	0
1,000-4,999	20	13	9	2
> 5,000	8	10	3	2
extant, but size not known (no estimate available)	20	10	17	3
extirpated	1	1	0	0
TOTAL	191^b	90	57	18

^a EOR = Element Occurrence Record, a mapping/database unit used by Natural Heritage Programs.

^b NC NHP has mapped a total of 275 Element Occurrence Records (EORs) for *H. naniflora*, however 27 of these EORs are parent/principal EORs that serve to aggregate smaller, more spatially defined sub-EORs. Therefore, these 27 EORs should not be regarded as additional locations, but rather a data management tool intended to aggregate sub-EORs into biologically meaningful units. Size estimates are typically not available for these parent/principal EORs, therefore these parent EORs are not included in this tally.

Table B.2. Populations estimated to contain over 1,000 *Hexastylis naniflora* rosettes at the time of this review. Populations known or reasonably expected to be afforded some protection (in whole or in part) are indicated in **bold**.[†]

USFWS population number	State	County	NHP EO numbers (2010) ^a	NHP EO rank (2010) ^b	Site	Latest estimate of population size (year)	Estimate of plants protected on-site (year)	Protection comments
1	NC	Burke	029	A	Island Creek Heath Bluff (Lovelady Sites 3-8)	98,789 (2004)		
2	NC	Burke	178.159-.161, 178.254-.256, 178.280-282 (protected site has no EO number as of yet)	A?	Catawba River: Lovelady (Hoyle and Micol Creeks) (includes NCDOT site 9)	10,050 (2005-2009)	< 200? (awaiting updates from NCDOT)	<u>Anticipated</u> future protection in NCDOT ROW
3	NC	Caldwell	227	A	Foothills Landfill	23,340 (2009)	23,340 (2009)	Conservation easement (260 acres); population stable
4	NC	Caldwell	044	AB	Little Gunpowder Creek Site 1	4,262 (2005)	> 1,000? (awaiting updates from NCDOT)	Awaiting verification of plants protected in NCDOT ROW
5	NC	Catawba	158	C	South Fork Catawba River: Jacob Fork, Camp Creek	1,392 (2005)	Unknown (awaiting updates from NCDOT)	Awaiting verification of plants protected in NCDOT ROW
6	NC	Catawba	243.012, 243.242, 243.269-.270	A	Catawba Wildlife Club	1,279 (1995-2007)		
7	NC	Catawba	031	C?	US 321, southeast Hickory	10,700 (2001)	Unknown (awaiting updates from NCDOT)	Awaiting verification of plants protected in NCDOT ROW
8	NC	Catawba	96.038, 96.039, * 96.184*	AB	Murrays Mill/ Upper Balls Creek	~ 9,150 (2005)	~ 9,000? (awaiting updates from NCDOT)	Fee title by NCDOT (~ 34 acres)
9	NC	Cleveland	100.014, * 100.049-.051* , * 100.073-.074* , * 100.149* , * 101.233* , 100.236-.237, * 100.238-.241* , 100.246	A	Broad River/Sandy Run Natural Areas (a.k.a. "Broad River Tract")	~ 10,726 (2001-2009)	> 5,000? (awaiting updates from NCDOT)	Fee title by Broad River Greenway (1,000 acres)
10	NC	Cleveland	208	A	Buffalo Creek: Potts Creek	3,572 (2007)	> 1,000? (awaiting updates from NCDOT)	Awaiting verification of plants protected in NCDOT ROW
11	NC	Cleveland	211.072, * 211.194*	A?	First Broad River: Hop-Hornbeam Natural Area	> 1,965 (2000)	~ 400? (awaiting updates)	<u>Anticipated</u> future protection in NCDOT ROW

							from NCDOT)	
12	NC	Cleveland	214.201, *214.202-.203*, 214.204, *214.205*, *214.209*, 214.212, *214.213*	A	Buffalo Creek: tributaries north and south of SR 2047	6,447 (2000-2007)	> 1,000? (awaiting updates from NCDOT)	Anticipated future protection in NCDOT ROW
13	NC	Cleveland	216.197-.198, *216.199- .200*	A	Buffalo Creek: Kings Mountain Reservoir	3,004 (2000 in pt., 2007 in pt.)	~ 300? (awaiting updates from NCDOT)	Anticipated future protection in NCDOT ROW
14	NC	Cleveland	157	AB	First Broad River: Crooked Run Creek	1,394 (2005)	Unknown (awaiting updates from NCDOT)	Awaiting verification of plants protected in NCDOT ROW
15	NC	Cleveland/ Rutherford	276	B	Cliffside Stream Station	5,550 (2005-2008)	5,500 (2009)	Voluntary agreement with Duke Energy (protected acreage unknown)
16	NC	Lincoln	261.258-.259, 261.263	B	Lincoln County Airport and Leepers Creek	7,032 (2005-2006)		
17	NC	Polk	023	A	Mills Creek Forest and Seep	≥ 1,000 (2005)		
18	NC	Polk	125	A	Broad River: New Hope Springhead Swamp	1,500 (2005)		
19	NC	Rutherford	154	E	Second Broad River (a.k.a. "Forest City Industrial Complex")	~ 2,478 (2008)	2,478 (2008)	Deed restrictions (12 acres); significant threats from sedimentation/erosion, invasive exotics
20	NC	Rutherford	99.009-010, 99.037, 99.052, 99.053, 99.055, 99.061-063, 99.075-.076, 99.079, 99.090, 99.121, 99.172, 99.181, 99.182	A	Broad River: Hensons Creek Ravine, Brice Rare Plant Site, and Sandy Mush Outcrop	~ 7,765 (2001-2010)		
21	NC	Rutherford	176.167-.170	A	Broad River: Cleghorn Creek tributary/US 221	4,964 (2005)		
22	NC	Rutherford	177.016, 177.107, 177.122, 177.163-.166	B	Broad River: Floyds Creek, Long Branch	2,156 (2005-2008)		
23	NC	Rutherford	247.080, 247.106, 247.114-.115, 247.173- .174, *247.286*	A	Broad River: Floyds Creek near Harris	3,081 (2003-2010)	> 1,000? (awaiting updates from NCDOT)	Conservation easement (8 acres)
24	SC	Cherokee	016-018	BC	Cowpens Battlefield	10,180 (2005)	~10,000? (needs verification)	National Park Service, National Battlefield (protected acreage unknown)
25	SC	Greenville/ Spartanburg	002, 004, 024, 032, 033, 036, 038, 039, 040, 041,	(various, AB-BD)	South Pacolet River and tributaries	5,205 (1991-1998)		

			042, 049, 050, 054					
26	SC	Spartanburg	011, 014, 026-028, 047, 048, 057	(various, AB-BD)	Peters Creek Heritage Preserve/Mineral Springs Creek	2,481 (2006)	> 1,000? (needs verification)	State Heritage Preserve (194 acres)
27	SC	Spartanburg	007, 029	BD, H?	Blalock Reservoir	1,400 (2006)	> 1,000? (needs verification)	Restrictive covenants (protected acreage unknown); significant threats to remaining population

[†] In the case of partially protected populations, the column “NHP EO numbers” indicates the specific portions of the population afforded protection in bold font, bracketed by asterisks.

^a NHP EO Numbers use the following format: PrincipalEO.SubEO.

^b Refer to Appendix C.2 for NHP EO rank criteria for this species. In cases involving parent/principal EOs, only the rank for the parent/principal EO is given.

Table B.3. Populations (or portions thereof) of *Hexastylis naniflora* evaluated in conjunction with USFWS Section 7 consultations.

USFWS population number	State	County	NHP EO ^a	Project name &/or site description	USFWS log number	Other identifiers	# plants in project area (year) ^b	Impacts estimate (year)	Plants protected on-site (year)
Adversely affected; no on-site protections									
16 (in pt.)	NC	Lincoln	None	Lincolnton-Lincoln County Regional Airport	ASNC 4-2-06-99		1,246 (2006)	675 (2006)	0
Adversely affected; on-site protections									
2 (in pt.)	NC	Burke	178.160-.161	Lovelady Road (including new NCDOT Site #9)	ASNC 4-2-09-367	NCDOT R-2824	3,731 (2009)	366 (2009)	Awaiting verification from NCDOT
2 (in pt.)	NC	Burke	178.254-255	Burke County School Site	ASNC 4-2-06-020		515 (2006)	286 (2006)	173 (2009)
3	NC	Caldwell	227	Foothills Landfill	ASNC 4-2-02-454		30,780 (2006)	6,150 (2003)	23,340 (2009)
4	NC	Caldwell	44	Bridge 84, Little Gunpowder Creek	ASNC 4-2-98-147 & 4-2-09-367	NCDOT B-2923	4,262 (2005)	324 (1995)	Awaiting verification from NCDOT
15	NC	Cleveland /Rutherford	276	Cliffside Stream Station	ASNC 4-2-07-155 & 4-2-08-290		5,500 (2009)	< 1,051 (2009)	< 5,500 (2009)
19	NC	Rutherford	154	Forest City Industrial Complex	ASNC 4-2-04-247		2,500 (2006)	160 (2006)	>2,340 (2008)
23 (in pt.)	NC	Rutherford	247.106	US 221 Rutherfordton Bypass	ASNC 4-2-09-100. & 4-2-09-367	NCDOT R-2233	4,478 (2009)	1,070 (2009)	Awaiting verification from NCDOT
27	SC	Spartanburg	007, 029	Blalock Reservoir	CHSC 4-6-01-115		11,285 (2001)	3,054 (2001)	< 1,500 (2006); Verification needed
28 (in pt.)	NC	Burke	226.222-226.224	Paddy Creek sites (Duke sites # 1-3)	ASNC 4-2-0234	FERC # 2232	1,400 (2004)	>200 (2005)	< 500 (2006)
29 (in pt.)	NC	Caldwell	77	Bridge 90, Gunpowder Creek	ASNC 4-2-03-415 & 4-2-09-367	NCDOT B-3126	344 (2006)	184 (2006)	Awaiting verification from NCDOT
30	NC	Catawba	32	I-40 interchange; Trib. to Henry Fork	ASNC 4-2-95-102 & 4-2-09-367	NCDOT U-2528AA	> 1,000 (1996)	619 (2005)	Awaiting verification from NCDOT
31	NC	Catawba	252.019, 252.020	US 321 Bypass	ASNC 4-2-92-051 &	NCDOT R-0085	14,433 (1995)	≥ 3,235 (1995)	Awaiting verification

					4-2-09-367				from NCDOT
10, 11, 12, 13, 32, 33 (all in pt.)	NC	Cleveland	multiple; Table B.4	US 74 (Shelby) Bypass; see also Table B.4	ASNC 4-2-95-031 & 4-2-09-367	NCDOT R-2707	16,405 (anticipated)	10,321 (anticipated)	Awaiting verification from NCDOT
Adversely affected; on-site protections uncertain									
5	NC	Catawba	158	SR 1115	ASNC 4-2-09-367	(NCDOT Division 12 project)	Unknown	Unknown	Awaiting verification from NCDOT
7	NC	Catawba	31	US 321, southeast Hickory	ASNC 4-2-95-102 & 4-2-09-367	NCDOT U-2307C	10,700 (2001)	5,400 (2001)	Awaiting verification from NCDOT
14	NC	Cleveland	157	SR 1519	ASNC 4-2-09-367	(NCDOT Division 12 project)	Unknown	Unknown	Awaiting verification from NCDOT
24	SC	Cherokee	016-018	Cowpens Battlefield	CHSC 2007-F-0387		10,180 (2005)	TBD	Verification needed
34 (in pt.)	NC	Catawba	179.030	Tate Boulevard Extension	ASNC 4-2-09-367	NCDOT U-2414A	TBD	TBD	Awaiting verification from NCDOT
34 (in pt.)	NC	Cleveland	179.162	SR 1473	ASNC 4-2-09-367	(NCDOT Division 12 project)	Unknown	Unknown	Awaiting verification from NCDOT
Associated with off-site conservation measures									
8 (in pt.)	NC	Catawba	96.184	Murray's Mill	ASNC 4-2-95-102 & 4-2-09-367	NCDOT B-2119	> 9,000 (2004)	616 (2001)	Awaiting verification from NCDOT ^c
9 (in pt.)	NC	Cleveland	100.049- .051, 100.073- .074, 100.149. 101.233, 100.238- .241	Broad River Tract	ASNC 4-2-95-031 & 4-2-09-367	NCDOT R-2707	n/a	n/a	Awaiting verification from NCDOT
26	SC	Spartanburg	011, 014, 026-028, 047, 048, 057	Peters Creek Heritage Preserve	CHSC 4-6-01-115		n/a	n/a	2,481 (2006); Verification needed
35	NC	Lincoln	262.131,	Rhyne Preserve	ASNC		n/a	n/a	745

			262.260		4-2-06-99				(2005-2006)
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^a NHP Element Occurrence Numbers use the following format: PrincipalEO.Sub(or stand-alone) EO.

^b This is an estimate of plants within area surveyed for project review purposes, and may not encompass all of area delineated for the corresponding NHP EO.

Table B.4. Reasonably foreseeable impacts to *Hexastylis naniflora* identified by NCDOT in conjunction with the proposed US 74 (Shelby) Bypass (ASNC log no. 4-2-95-031), including anticipated levels of on-site protection pledged by NCDOT in conjunction with this project. Populations (or portions thereof) expected to receive on-site protection are indicated in **bold**.

USFWS population number	NHP EO number ^a	NHP EO rank ^b	NCDOT Site Number	Total size (rosettes)	Potentially impacted (rosettes)	Anticipated Protected (rosettes)
EORs expected to be extirpated						
12 (in pt.)	214.201	D	NCDOT site 26-27	78	78	
12 (in pt.)	214.204	A?	NCDOT site 31, 43	3,094	3,094	
12 (in pt.)	214.212	D	NCDOT site 23	97	97	
13 (in pt.)	216.197	A	NCDOT site 13	2,067	2067	
13 (in pt.)	216.198	D	NCDOT site 14	87	87	
32 (in pt.)	217.190	D	NCDOT site 4	3	3	
32 (in pt.)	217.192	C	NCDOT site 8	311	311	
32 (in pt.)	217.193	C	NCDOT site 9	271	271	
33	189	D	NCDOT site 39	3	3	
Subtotal				6,011	6,011	
EORs expected to be partially impacted, but also expected to receive on-site protection ^c						
10	208	A	NCDOT site 32-36	3,592	2,069	1,523
11 (in pt.)	211.194	A?	NCDOT sites 10-12	1,965	1,559	406
12 (in pt.)	214.202	A	NCDOT site 24	1,641	14	1,559
12 (in pt.)	214.203	B	NCDOT site 28-29	247	151	96
12 (in pt.)	214.205	D	NCDOT site 30	184	50	134
12 (in pt.)	214.209	BC	NCDOT site 22	332	137	195
12 (in pt.)	214.213	BC	NCDOT site 25	743	158	457
13 (in pt.)	216.199	B	NCDOT site 15-19	408	132	276
13 (in pt.)	216.200	D	NCDOT site 20-21	35	20	15
32 (in pt.)	217.191	D	NCDOT site 5-7	157	20	137
Subtotal				9,304	4,301	4,798
TOTAL				15,315	10,321	4,798

^a NHP Element Occurrence Numbers use the following format: PrincipalEO.Sub(or stand-alone)EO.

^b Refer to Appendix C.2 for NHP EO rank criteria for this species.

^c These sites are assured to fall within the proposed limits of NCDOT's right-of-way upon completion of this road project. NCDOT has pledged to protect (monitor and manage) *H. naniflora* at these locations in perpetuity (ASNC log. No. 4-2-95-031).

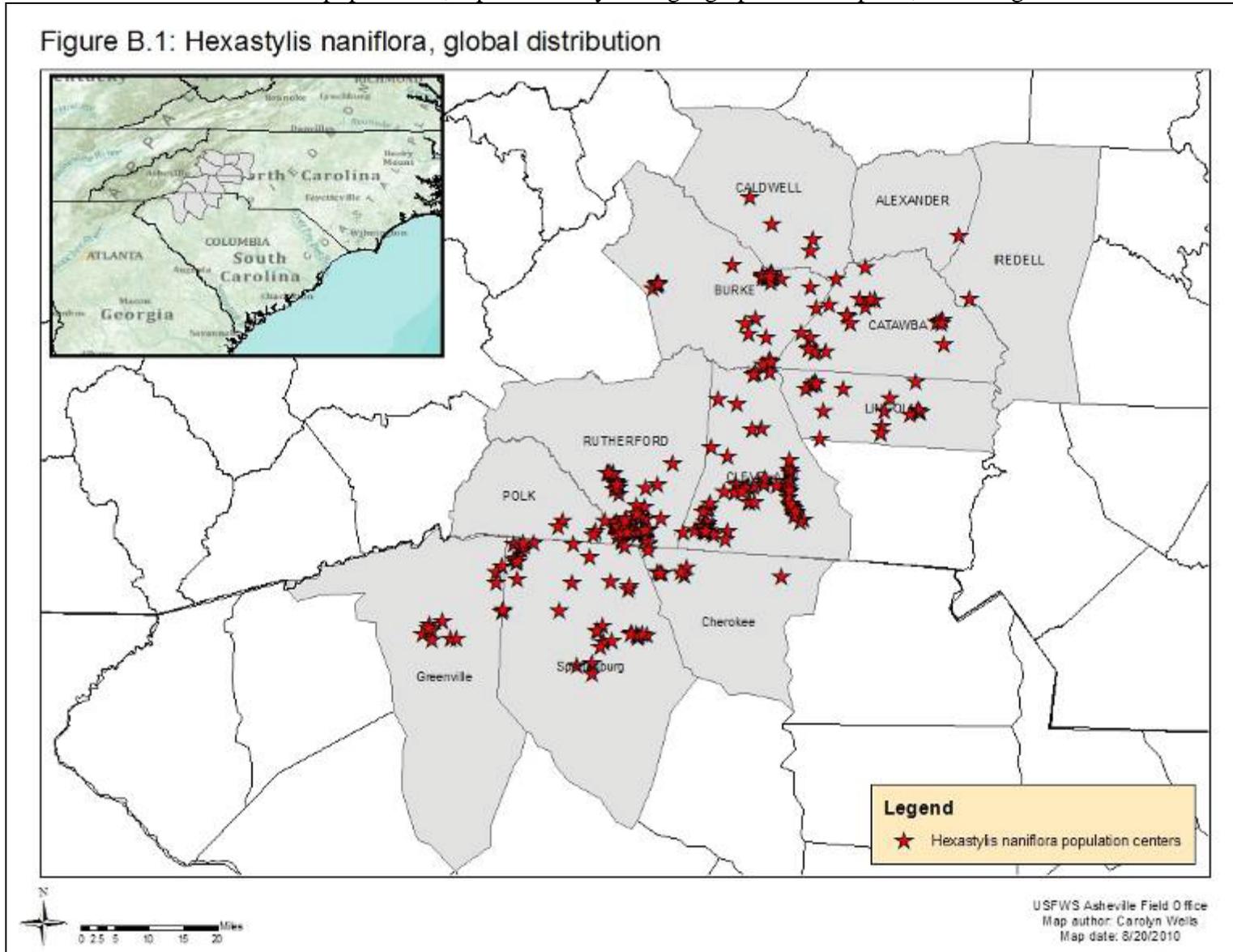
Table B.5. Remaining sites (not listed in preceding tables) with some potential to afford long-term protection to *Hexastylis naniflora*.

USFWS population number	State	County	NHP EO numbers (2010) ^a	NHP EO rank (2010) ^b	Site	Protection type (2010)	Plants protected (year of estimate)	Comments
36 (in pt.)	NC	Cleveland	228.028	B	Cleveland (Shelby) County Landfill	Protected Natural Area (County)	300-400 (2005)	Protection and population size/trends needs verification
37	SC	Greenville	52	AC	Bunched Arrowhead SCNDR Preserve (formerly Mark Hall Farms Preserve)	State Heritage Preserve (SCDNR)	25-30 (1996)	Small population, questionable viability
38	SC	Spartanburg	037	CD	Harris (Bear Creek)	Easement (Pacolet Area Conservancy) -- Needs verification	56 (1996)	Protection and population size needs verification
39	SC	Spartanburg	021	BD	Raintree Creek	Conservation easement	Needs verification	Population size and viability needs verification; invasive exotics are encroaching upon the population

^a NHP Element Occurrence Numbers use the following format: PrincipalEO.Sub(or stand-alone)EO.

^b Refer to Appendix C.2 for NHP EO rank criteria for this species. In cases involving parent/principal EOs, only the rank for the parent/principal EO is given. SCDNR Heritage Trust does not assign EO ranks to their database records.

Figure B.1. Distribution of all known populations, represented by their geographic center point, as of August 2010.



APPENDIX C: Natural Heritage Methods applicable to this review

Appendix C.1.

Principal- and Sub-Element Occurrence Records, and “populations” as defined for the purposes of this review.

Many of those working with *Hexastylis naniflora* have used the terms “sub site”, “site”, “location”, “occurrence” (often, but not always, in reference to Natural Heritage Program Element Occurrence Records), and “population” interchangeably, while others have aggregated sites into populations according to subjective criteria which have never been explicitly defined. This has generated considerable discrepancies among sources with respect to the number of known populations within a given area (or across the species’ range), to the extent that numbers are not comparable from one source to the next. The tendency to treat each location as a separate population also artificially inflates the actual number of populations known. This review attempts to avoid this problem by refraining from use of the term “population” unless accompanied by clearly defined criteria for aggregating smaller areas (“sites”, “locations”, or “occurrences”) into “populations”.

When the species was federally listed in 1989, there were a total of 22 NHP element occurrence (EO) records in the combined databases of the NC and SC Heritage Programs (NC NHP and SCNDR, respectively). Four of the populations known and addressed in the 1989 federal register listing notice had not yet been assigned Natural Heritage Program (NHP) Element Occurrence (EO) numbers in 1989.

As of 2010, there are a total of 275 NHP EO records for *Hexastylis naniflora* in the databases managed by NC NHP and SCDNR. However, it is critical to note that this number in no way indicates the number of populations of the species, because in some instances discrete EOs have been mapped in extremely close proximity to one another, whereas in other cases a single EO may consist of more than one spatially discrete aggregation of plants. In recent years, NatureServe and its member Natural Heritage Programs have devised mapping standards to balance the need for fine-scale, highly site-specific EO records (required for monitoring and management) with the need to aggregate these records meaningful units of conservation interest that may approximate biological populations (NatureServe, 2004).⁶ The USFWS does not maintain its own database of known locations of *Hexastylis naniflora*; instead it regards the NHP databases as the best repository for this information.

NC NHP has mapped its EO records in accordance with NatureServe mapping protocols. As of April, 2010 NC NHP had mapped 27 parent/principal EOs and another 63 stand-alone EOs of *Hexastylis naniflora*. As previously stated, principal or stand-alone EOs can be thought of as proxies for populations in the absence of species-specific information on pollination and

⁶ NatureServe has developed a habitat-based strategy for mapping element occurrences of plant species, available at http://www.natureserve.org/library/delimiting_plant_eos_Oct_2004.pdf. NC NHP has applied this mapping protocol to its records for *Hexastylis naniflora*. SCDNR Heritage Trust has not yet revised its records in accordance with these standards, but intends to do so in coming years (Julie Holling, SCDNR Heritage Trust, Data manager, personal communication, August, 2006.) In that this protocol uses a default separation distance of 1km (=0.62 mile), it is roughly equivalent to the aforementioned agreements among those working with this species to treat sites within 0.5 mile of each other as members of the same population. Additional information on NatureServe and Natural Heritage methods is available at <http://www.natureserve.org/prodServices/heritagemethodology.jsp>.

dispersal distances. As such, for purposes of this review, USFWS regards these 27 parent and 63 stand-alone EO records as 90 populations of the species.

SCDNR has not yet aggregated its records for the species into principal and stand-alone EOs. As a result, the 57 EO records currently mapped for the species in this state often include several records in sufficiently close proximity to one another as to be better regarded as a single population. Applying a buffer of 2km (the default and minimum separation distance according to NatureServes' data standard) to these records reveals a maximum of 18 spatially discrete aggregations of sites in the state of South Carolina. These aggregations separated by 2km are regarded as 18 populations for purposes of this review.

Therefore, for purposes of this review, the current range of *Hexastylis naniflora* has been defined as consisting of (90+18=) 108 spatially discrete populations of the species.

Appendix C.2.

Natural Heritage Program (NHP) Element Occurrence (EO) Rank Specifications for *Hexastylis naniflora*

The following species-specific criteria are used by the North Carolina Natural Heritage Program (NC NHP) for ranking Element Occurrences of *Hexastylis naniflora*. These ranks are given in Appendix B, Tables B.2 and B.4 of this review.

EO Rank	Specifications
A	More than 500 clumps (rosettes) occurring in greater than one acre of high quality forest such as Dry-Mesic Oak Hickory Forest or Mesic Mixed Hardwood Forest.
B	200-500 clumps (rosettes) occurring in greater than one acre of high quality forest such as Dry-Mesic Oak Hickory Forest or Mesic Mixed Hardwood Forest -OR- More than 500 clumps (rosettes) occurring in less than one acre of high quality forest or on land impacted by human disturbance such as logging, grazing, mowing, etc.
C	100-200 clumps (rosettes) occurring in greater than one acre of high quality forest such as Dry-Mesic Oak Hickory Forest or Mixed Mesic Hardwood Forest -OR- 200-500 clumps (rosettes) occurring in less than one acre of high quality forest or on land impacted by human disturbance such as logging, grazing, mowing, etc.
D	Less than 100 clumps (rosettes) occurring in greater than one acre of high quality forest such as Dry-Mesic Oak Hickory Forest or Mesic Mixed Hardwood Forest -OR- Less than 200 clumps (rosettes) occurring in less than one acre of high quality forest or on land impacted by human disturbance such as logging, grazing, mowing, etc.

Rank Specs Justification (also from NC NHP):

The unit of measurement for population size in this species is “clump” (rosette). EO size (as quantified by number of clumps or rosettes) is the primary rank factor. Condition of habitat (vegetation community and structure) and landscape context (extent of suitable habitat and physical factors) are also incorporated secondarily.

The species thrives most in undisturbed habitat. However, disturbed lands, that have been logged, grazed, mown, or converted to pasture, orchards, or tree plantations have been found to support remnant patches of *Hexastylis naniflora*. The extent to which this species can withstand

disturbance is unknown. Populations in disturbed habitat are considered at risk, with relatively poor viability (C or D).

Care should be taken when estimating population size, as population estimates have been found to vary widely from the number counted in population censuses.

Specifications are based on the largest known populations and expert opinion (including James Padgett, Carolyn Wells, Misty Buchanan (formerly Franklin), and Brenda Wichmann).