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Chapter 1: INTRODUCTION

The dwarf-flowered heartleaf (*Hexastylis naniflora*) is a species of plant endemic to the upper Piedmont region of western North Carolina and upstate South Carolina. The dwarf-flowered heartleaf has been listed as threatened under the Endangered Species Act of 1973, as amended (Act), since 1989 (FR 54 14964-14967). The Species Status Assessment (SSA) framework (USFWS 2016, entire) summarizes the information compiled and reviewed by the US Fish and Wildlife Service (Service), incorporating the best available scientific and commercial data, to conduct an in-depth review of the species' biology and threats, evaluate its biological status, and assess the resources and conditions needed to maintain long-term viability. The intent is for the SSA to be easily updated as new information becomes available and to support all functions of the Endangered Species Program from listing to consultations to recovery.

A Recovery Plan for the species was never completed. However, over the last 29 years, the Service has worked closely with partners to make significant progress toward recovery of the species. The Service is initiating this SSA to aid in determining the appropriateness of reclassifying the species. In the event that the SSA does not support reclassification, the SSA will be used to inform the development of a Recovery Plan. Importantly, the SSA does not result in a decision by the Service on whether this species should be proposed for reclassification under the Act. Instead, this SSA provides a review of the available information strictly related to the biological status of the dwarf-flowered heartleaf. The reclassification decision will be made by the Service after reviewing this document and all relevant laws, regulations, and policies. The results of a proposed decision will be announced in the *Federal Register*, with appropriate opportunities for public input.

For the purpose of this assessment, we generally define viability as the ability of the species to sustain populations in its natural systems over time. Using the SSA framework (Figure 1.1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation (Wolf *et al.* 2015, entire).

- **Resiliency** describes the ability of populations to withstand stochastic events (arising from random factors). We can measure resiliency based on metrics of population health;

for example, birth versus death rates and population size. Highly resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities.

- **Redundancy** describes the ability of a species to withstand catastrophic events. Measured by the number of populations, their resiliency, and their distribution (and connectivity), redundancy gauges the probability that the species has a margin of safety to withstand or can bounce back from catastrophic events (such as a rare destructive natural event or episode involving many populations).
- **Representation** describes the ability of a species to adapt to changing environmental conditions. Representation can be measured by the breadth of genetic or environmental diversity within and among populations and gauges the probability that a species is capable of adapting to environmental changes. The more representation, or diversity, a species has, the more it is capable of adapting to changes (natural or human caused) in its environment. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics across the geographical range.

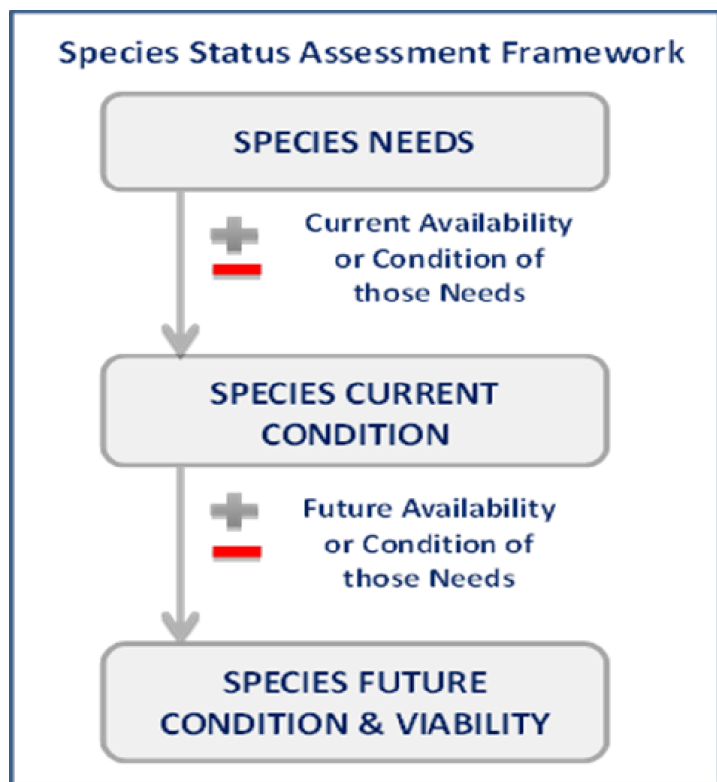


Figure 1.1. Species Status Assessment Framework

To evaluate the biological status of the dwarf-flowered heartleaf, both currently and into the future, we assessed a range of conditions to allow us to consider the species' resiliency, redundancy, and representation (together, the 3Rs). This SSA provides a thorough assessment of biology and natural history, and assesses demographic risks, stressors, and limiting factors in the context of determining the viability and risks of extinction for the species.

The format for this SSA includes: (1) Biology and Species Needs, (2) Current Conditions, (3) Influences on Viability, and (4) Future Conditions. This document is a compilation of the best available scientific and commercial information, and a description of past, present, and likely future risk factors to the dwarf-flowered heartleaf.

Chapter 2: SPECIES BIOLOGY

In this chapter, we provide basic biological information about the dwarf-flowered heartleaf, including its taxonomic history, species description, distribution, life history traits, and habitat characteristics. We then use this information to outline the resource needs within various life stages of dwarf-flowered heartleaf. Here we report those aspects of the life history of the dwarf-flowered heartleaf that are important to our analysis.

Taxonomy and species description

Dwarf-flowered heartleaf is a rare, low growing herbaceous plant in the birthwort family (Aristolochiaceae). The species was described by Blomquist (1957) in his revision of the North American members of the genus *Hexastylis*. The dwarf-flowered heartleaf has been recognized as part of the Virginica Group, and this group was further subdivided into three Subgroups: Virginica, Shuttleworthii, and Heterophylla (Blomquist 1957; Whittemore and Gaddy 1997). Three species have been recognized in the Heterophylla complex, *Hexastylis naniflora*, *H. heterophylla* and *H. minor*, and field biologist have generally recognized that considerable morphological overlap occurs (Murrell et al. 2007). One of the main concerns regarding this complex was the inability to distinguish between species without access to fresh flowers. Even with fresh flowers, Blomquist (1957) and Gaddy (1987) still recognized considerable overlap in flower morphology making species delineation difficult.

Murrell et al. 2007, conducted a comparative genetic analysis using Inter Simple Sequence Repeats, and were unable to find banding patterns that could be used to separate *H. naniflora* from the other members within the complex. However, based on biogeographical, ecological, molecular, morphological, as well as micromorphological work, their results show that *H. naniflora* is a well-defined species.

Although there has been considerable disagreement on the generic distinctiveness of *Hexastylis* and *Asarum* (Barringer 1993 and Kelly 1997, 1998, 2001), a recent phylogeny estimate using chloroplast genes supports that *Hexastylis* is a monophyletic clade and therefore should be

recognized as a genus (Niedenberger 2010). Additionally, most North American publications recognize *Hexastylis* at the generic level (Flora of North America 1997, Weakley 2015).

The Service is not aware of any proposed changes in taxonomy that would affect the continued legal status of *H. naniflora* under the Act. However, 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* (Figure 2.1; Weakley, 2010; Murrell et al. 2007; Gaddy 1987). These geographic areas of overlap in key characters have been the focus of recent genetic analyses (Murrell et al. 2007; Renninger, 2010; Murrell, 2015).

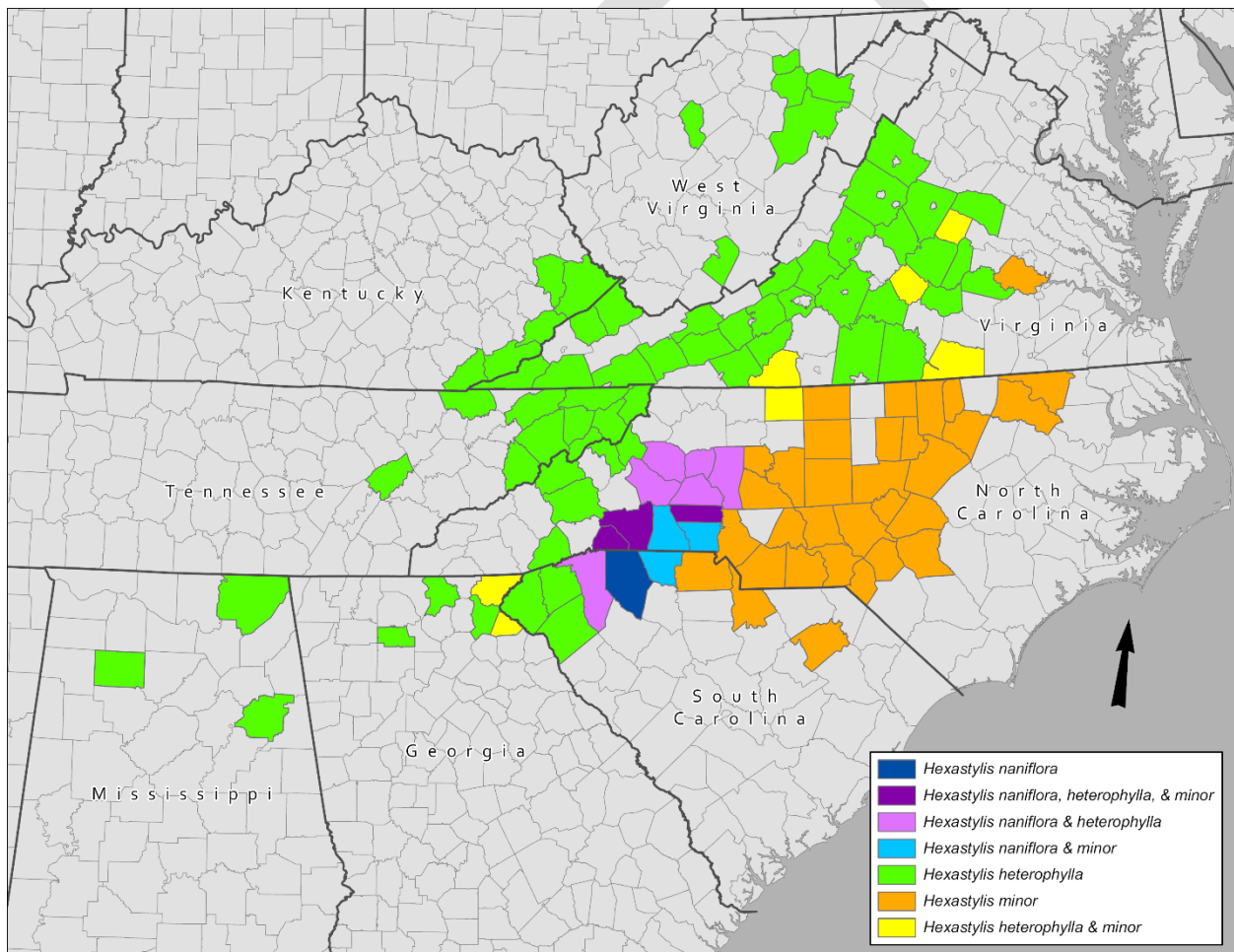


Figure 2.1. Distribution map showing county records for the three species in the *H. heterophylla* complex. Data was gathered from herbarium specimens, Element Occurrence Records (EORs) sheets and field studies. Based on Murrell et al. 2007.

The most outstanding characteristic of this species is the small flowers, which are one of the smallest of any species in North America (Blomquist 1957). The plant's heart shaped leaves are dark green in color, evergreen, and leathery, and are supported by long thin petioles from a subsurface rhizome. The shape of the leaf blades, their pattern of variegation, and the ridged reticulation inside the calyx-tube, place this species inside the Virginica group. It differs from all the other members of this group, aside from the small flowers, in having no flare in the calyx-tube. Maximum height rarely exceeds 15 centimeters (cm). The jug shaped flowers are usually beige to dark brown in color and appear from mid-March to early June. The flowers are small and inconspicuous and are found near the base of the petioles. The fruit matures from mid-May to early July (Blomquist 1957, Gaddy 1980, 1981). Characteristics that distinguish it from other *Hexastylis* species are found in floral structures and pollen characters (Gaddy 1987, Padgett 2004, Niedenberger 2010). *H. naniflora* has a smaller calyx tube orifice, which is typically 5mm or less (sometimes up to 7mm) and the ovary is half-inferior, rather than superior (Blomquist 1957, Gaddy 1987, Padgett 2004, HDR 2005). Pollen surface features have also been shown to be an effective character to identify *H. naniflora*, as it has a microporate surface and, unlike any other *Hexastylis* species, lacks gemmae entirely (Padgett 2004, Niedenberger 2010).

Distribution

Although dwarf-flowered heartleaf is restricted in range, it is not as rare as once thought (USFWS 2010, NCNHP 2016). When dwarf-flowered heartleaf was federally listed in 1989, the listing rule described 24 extant "populations" (and one extirpated population) distributed across eight counties in the upper Piedmont of North and South Carolina. Since 1989, the range has expanded to include four additional counties in North Carolina. In North Carolina, it is found in Alexander, Burke, Caldwell, Catawba, Cleveland, Gaston, Iredell, Lincoln, Polk, and Rutherford Counties. In South Carolina, it is in Cherokee, Greenville, and Spartanburg Counties. As of 2016, the distribution of this species consisted of 113 populations distributed across 13 counties in these two states (Figure 2.2).

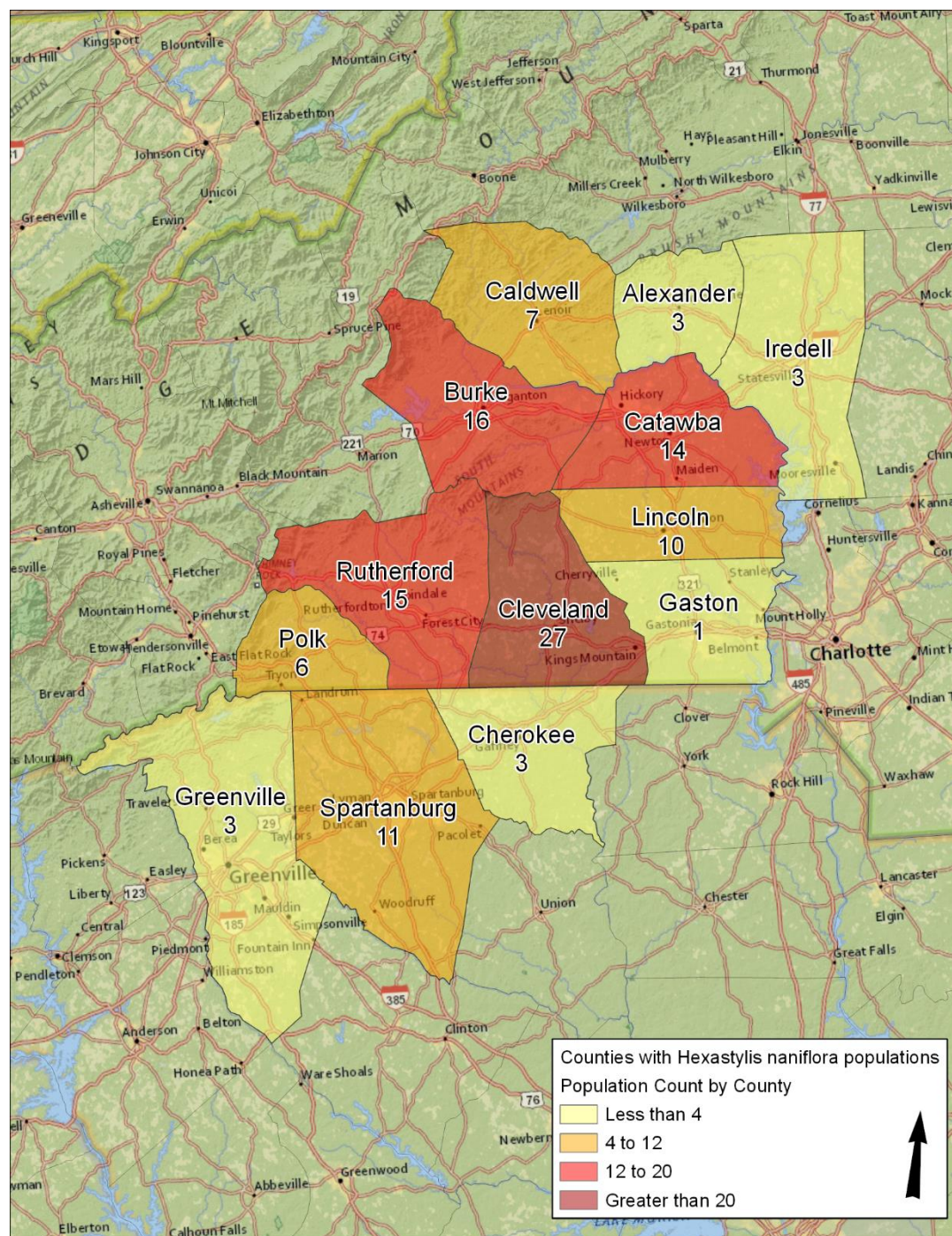


Figure 2.2. Current county distribution for dwarf-flowered heartleaf, with associated number of known populations within each county.

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. We describe how the numerous small, site-specific locations containing *H. naniflora* have been aggregated into proxies for 119 biological populations for purposes of this review, using mapping standards devised by NatureServe and its network of Natural Heritage Programs, in the Species Needs section of this report.

Life History

Demographics

The Service is aware of a single effort to collect demographic-level data (survivorship and recruitment of tagged individuals) for dwarf-flowered heartleaf. 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 (USFWS 2010).

Pollination and Dispersal

The pollination of *Hexastylis* has not been well studied but the genus was thought to be pollinated by insects including flies, wasps, and thrips (Otte 1977). Additionally, Lengyel et al. (2010) described how, within the family Aristolochiaceae, more than 50% of the plant lineage is myrmecochorous (seed dispersal by ants). This supports Gaddy's work (1986), which found

three species within the *Hexastylis heterophylla* subgroup (*H. heterophylla*, *H. naniflora*, and *H. minor*), which employ myrmecochory as a method for seed dispersal.

Ants appear to be a primary dispersal agent for the dwarf-flowered heartleaf (Gaddy 1986; Jones et al. 2014). All diaspores of *Hexastylis naniflora* presented to ants (*Aphaenogaster rudis*) were quickly removed (Gaddy, 1986). This is not to say that they are not occasionally, or even frequently, dispersed and/or pollinated by other means. Jones et al. (2014) suggests that the pollination mechanism is facultative, benefiting from more than one method of pollination/fertilization. Ants were the pollinators in a controlled experiment, and their data supports that when outside molesting forces/pollinators (biotic and abiotic) were limited by their caging procedure, the efficiency of pollination decreased by almost 50%, however, caged flowers did produce seeds, indicating pollination occurred via some alternative method.

Habitat

Dwarf-flowered heartleaf appears to have a restricted range due to its habitat requirements. The habitat where dwarf-flowered heartleaf exists is limited in size and scope due to a multitude of factors including soil type, moisture availability, and slope aspect (Wagner 2013). This unique combination of factors limits not only the range of dwarf-flowered heartleaf, but also the size of a given population. With the limited range and size in populations, questions arise regarding gene flow among populations. How much is occurring and how often does it occur? It is due, in part, to narrow habitat requirements that conservation measures have been implemented for the protection of the species. Any efforts made to protect this species must consider giving protection to the available habitat.

Dwarf-flowered heartleaf occurs on piedmont uplands on acidic sandy-loam soils that are very deep and moderately permeable (Gaddy 1981, 1987). Typical habitats for this species include mesic to dry bluffs, slopes, or ravines in deciduous forests that are frequently associated with *Kalmia latifolia* (Padgett 2004, Weakley 2015, USFWS 2015), or in moist soils adjacent to creeks, streamheads, or along lakes and rivers. Plants have been observed to grow larger and have more frequent flowering in floodplains along rivers, lakes, and streams (Newberry 1993).

Wagner (2013) conducted a habitat suitability study to quantify the habitat requirements for dwarf-flowered heartleaf, which may be used for helping identify the species when not in flower (relative to other *Hexastylis* species habitat preferences), find new populations, or identify suitable sites for transplants.

Soils

The species appears to be restricted to Pacolet sandy loam, Madison gravelly sandy loam, and Musella fine sandy loam soils (Gaddy 1981,1987). The species grows in acidic soils along bluffs and adjacent slopes, in boggy areas next to streams and creekheads, and along the slopes of nearby hillsides and ravines (Gaddy 1980, 1981). The plant is primarily found inhabiting north- to northwest-facing slopes, bluffs, and ravines in close proximity to creeks or streams. Within these areas exists the soil type required for *H. naniflora* to grow. It grows primarily on well-drained, sandy, acidic soils, and will not grow in heavy clay (Gaddy 1981).

The results of soil samples analyzed at the Clemson Soil Lab suggest that major differences in soil chemistry exist between the species in the *H. heterophylla* complex (Murrell et al. 2007). Statistical analysis of the soil samples showed that many of the basic elements were significantly different among the three species. Those significant differences occurred in Phosphorous (P), Potassium (K), Magnesium (Mg), Zinc (Zn), Manganese (Mn), (Na), Sodium, and Cation Exchange Capacity (CEC). Slightly significant differences were seen in Buffer pH (Bu pH), and Acidity.

Soil chemistry showed marked differences between the species in the complex (Murrell et al. 2007). The results indicated that soil chemistry is very different between *H. naniflora* and *H. minor* localities. The results also show that *H. heterophylla* and *H. naniflora* are found in soils where the chemistry is more similar, but still showed significant differences. It would appear that differentiation in soil types could be used as a proxy for species delineation. The soil analysis also indicates that soils must be considered when trying to select sites for relocation of imperiled populations of *H. naniflora*.

Thirteen population sites in North Carolina and South Carolina were examined using the Carolina Vegetation Survey (CVS) method to compare species richness between the three species of the *Hexastylis heterophylla* complex (Murrell et al. 2007). The analysis did not show statistically significant differences among the three species in the *H. heterophylla* complex. However, *H. naniflora* appears to have an association with three oak species that is lacking in the other two species in the complex. There are a number of oak species (*Q. coccinea*, *Q. prinus* (*Q. montana*), and *Q. velutina*), that tend to co-occur with only *H. naniflora*, but are not present with the other two species in the complex. This may be the result of some microbial need or specific soil nutrient required for those species to occur in the same habitat.

Fire

There are little data on the response to fire by *Hexastylis naniflora*, however, prescribed burns have been conducted within the population at Cowpens National Battlefield in Cherokee County, SC. Preliminary data at this site and recent annual monitoring data of this population support the theory that moderate controlled burns do not negatively affect this population (Walker et al. 2009). Additionally, a dormant season wildfire in Caldwell County did not show evidence of negative impacts to a population in Caldwell County (USFWS 2010). Fire suppression could be a hazard to *H. naniflora* by allowing fire intolerant, nonnative and invasive plants to thrive, as well as the accumulation of thick duff or leaf litter that may shade low growing species (Wagner 2013).

Genetics

Analyses on ecology, morphology, soil chemistry, pollen, and molecular genetics have been evaluated for *Hexastylis naniflora* to determine the boundaries within the *Hexastylis heterophylla* complex, which consists of *H. heterophylla*, *H. minor*, and *H. naniflora* (Murrell 2015, Wagner 2013, Niedenburger 2010, USFWS 2010, Murrell et al. 2007, Padgett 2004). These analyses support the continued recognition of these taxa as well-defined, discrete species. 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.

Field observations demonstrate that there are some populations of dwarf-flowered heartleaf with morphological characteristics that do not fit within the range of published values for key traits, overlapping with values for *H. heterophylla* or *H. minor* (Gaddy 1987, Murrell et al. 2007, USFWS 2010, Weakley 2015). These populations with overlap in key characteristics were the focus of a genetic analysis conducted at Appalachian State University (ASU) through funding provided by NCDOT (Murrell 2015). In some populations, floral characteristics are highly variable, which suggests the potential for hybridization or individuals with highly variable flower size and shape (Murrell 2015). Additionally, no vegetative characters were previously known to consistently distinguish *Hexastylis naniflora* from other close relatives. Given the difficulties with field identification of the species, particularly when not in flower, this study sought to develop a microsatellite library of molecular markers to resolve variation in populations of dwarf-flowered heartleaf and apply the markers to populations with highly variable characters, as identified by NCDOT biologists. The morphological and micromorphological information from those variable populations were compared to molecular results with morphological, micromorphological, and distributional data to determine genetic structure, biological boundaries, and placement of putative hybrids or intermediate populations of *H. naniflora* (Murrell 2015).

The preliminary findings of this study suggest that populations in the southern range of dwarf-flowered heartleaf exhibit a more uniform genetic pattern, with some possible hybridization with *H. minor*. Populations in the northern part of the range appear to have hybridized with both *H. heterophylla* and *H. minor*, although there are still individuals with “pure” *H. naniflora* genotypes in the northern range (Murrell 2015). It is critical to note that although these data provide anecdotal evidence of hybridization with the *Hexastylis heterophylla* group, intraspecific variation may be caused by forces other than hybridization, such as convergent morphological

evolution (Dobzhansky 1937), or the species is in the process of speciation and this study shows a case of incomplete speciation (Murrell 2015), and/or other environmental factors are at play (Wagner 2013). On May 11, 2016, a meeting was held with USFWS, NCNHP, NCDOT, and ASU to discuss the status of *H. naniflora* and the current work being conducted among the agencies (Amoroso 2016). Based on discussions during this meeting, the results of this study reported by ASU to NCDOT in 2015 are preliminary. Dr. Matt Estep (ASU) provided additional preliminary results to NCNHP in May 2016, showing which populations were sampled, sample size, and percent of samples that show evidence of hybridization, and hybridizing with which species. ASU continues to work towards a more definitive explanation of the variation in the *H. heterophylla* complex (Murrell 2015, Amoroso 2016).

CHAPTER 3: SPECIES NEEDS

For the purpose of this report, we define viability as the ability of the species to sustain populations in the wild over time. Species with greater numbers (redundancy) of healthy populations (resiliency), encompassing a broad array of ecological and genetic diversity in a spatial arrangement that maintains adequate gene flow (representation), are more likely to be viable. Using the Species Status Assessment framework, we describe the species' viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation.

Delineating Populations

As stated in the USFWS five-year review, many of those working with dwarf-flowered heartleaf 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, in the past, to treat each location as a separate population also artificially inflated the actual number of populations known.

The Natural Heritage Program collects information on occurrences of rare plants, animals, natural communities, and animal assemblages. Collectively, these are referred to as "elements of natural diversity" or simply as "elements." Locations of these elements are referred to as "element occurrences" (EO records). 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 in meaningful units of conservation interest that may approximate biological populations (NatureServe 2002). Since USFWS does not maintain its own database of known locations of *Hexastylis naniflora*, it regards the NHP databases as the best repository for this information (USFWS 2010).

We delineate populations for the purposes of this SSA according to the NatureServe (2002) convention. Separation distances are a key component to delineating populations from EO records. For the dwarf-flowered heartleaf, we used the EO Data Standard which provides a Default Separation Distance of 1 km (~0.62 miles) for plant and animal elements that lack EO specifications, noting that situations involving dispersal barriers could involve even shorter distances. While gene flow declines over distance at different rates for different elements, the minimum default EO separation distance of 1 km has been accepted by the Network as the most suitable round-number metric-system approximation broadly applicable to many (but not all) situations. This results in several dwarf-flowered heartleaf populations being stand-alone EOs, as well as many populations being aggregates of several EOs.

Population Resiliency

For the dwarf-flowered heartleaf to maintain viability, its populations or some portion thereof must be resilient. Stochastic factors that have the potential to affect dwarf-flowered heartleaf include impacts to its habitat, particularly human development pressures, but also climate change and presence of invasive species. Other factors that influence the resiliency of dwarf-flowered heartleaf populations include abundance within populations, and habitat factors such as elevation, slope, aspect, and soil type. Influencing those factors are elements of dwarf-flowered

heartleaf ecology that determine whether populations can grow to maximize habitat occupancy, thereby increasing resiliency of populations. These factors and habitat elements are discussed below (Figure 3.1).

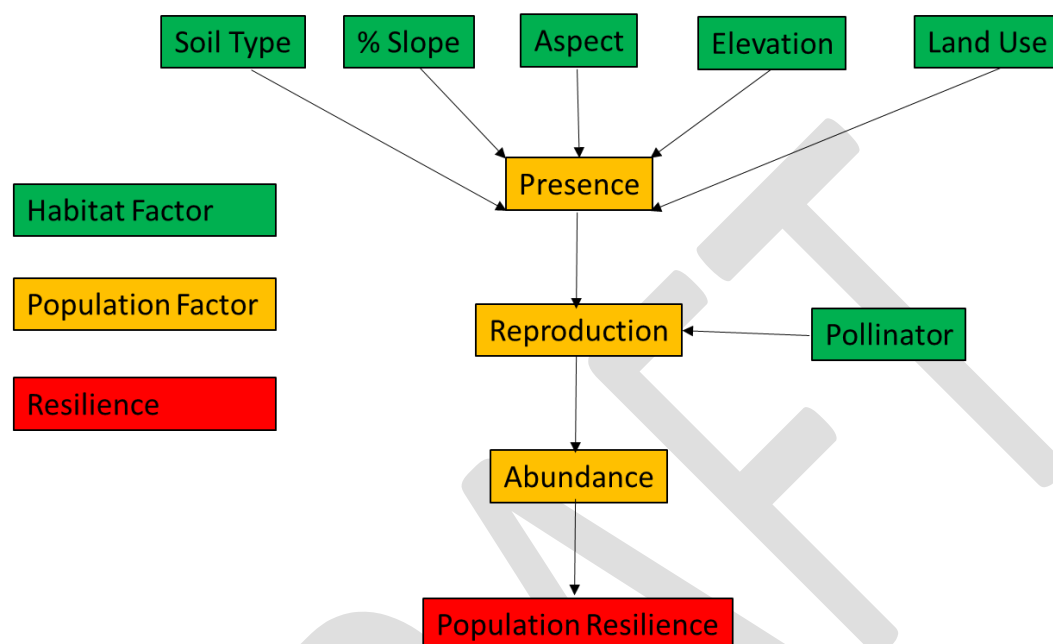


Figure 3.1. Conceptual diagram describing population and habitat factors influencing population resilience for dwarf-flowered heartleaf.

Habitat Factors: Slope, Aspect, Elevation, Soil, and Forest Type

A previous habitat suitability study attempted to quantify the habitat requirements for dwarf-flowered heartleaf (Wagner 2013). With this model in mind, and the input of species experts as to important habitat factors for the species, we used updated habitat data, as well as inclusion of updated EOs, to create a new habitat model to identify potential habitat throughout the species range. All source datasets and variables created are described in Appendix 3.

Source Data and Model Variables

Fifty-three, 10-digit hydrologic units (HUC) comprise the analysis extent (Figure 3.2). In North Carolina, it includes all 10-digit HUC that fall within the boundaries of 8-digit HUC with known occurrence of *Hexastylis naniflora*. In South Carolina, we also included all 10-digit HUC that

fell within the boundaries of 8-digit HUC with known occurrence of *Hexastylis naniflora*, but excluded the southern portions of the HUC-8 areas due to the boundaries being exceedingly large and far away from any known occurrences.

Hexastylis naniflora element occurrence data was obtained from the North Carolina Natural Heritage Program and the South Carolina Heritage Trust Program. Current populations of *Hexastylis naniflora* were identified by reviewing the last observed data in the database and excluding all populations that have not been observed since 2005 to remain consistent in our approach of assessing resiliency described previously. To represent these current population areas in Maxent, a raster cell center was retained for every 30 x 30 meter pixel that was situated within the current element occurrence data polygons.



Figure 3.2. Analysis extent of the habitat model for *Hexastylis naniflora*. Red line indicates Maxent analysis extent, blue lines are 8-digit HUC boundaries, black lines are 10-digit HUC boundaries. The orange line in the inset map indicates where the analysis extent is situated in North and South Carolina

Model Development

We used Maxent software (version 3.4.1) for species habitat modeling (Philips et al., 2018). An initial single model Maxent run was done to determine which variables could be excluded due to limited percent contribution to the model. Any variable that contributed less than 1% to the single model run results was excluded in the final model. The following variables were excluded: landcover diversity, canopy height, SSURGO drainage class, SSURGO hydrologic group, aspect 9-class, aspect 5-class, slope, solar radiation, and maximum annual temperature. It is interesting to note that a previous habitat modelling effort (Wagner 2013) included aspect and slope, whereas the Maxent model excluded these variables. This does not mean these variables are not important components of dwarf-flowered heartleaf habitat, but rather these variables did not significantly improve the model. Also, landform data was included, and perhaps landform, which includes components of aspect and slope combined is a more meaningful variable than aspect or slope independently.

For the final model, a 10-run replicate Maxent model was created using cross-validation. For replicate models, the occurrence data is randomly split into a number of equal-sized groups called “folds”, and separate models are created leaving out each fold in turn. The individual model runs are then averaged together to derive the final model.

Results

Figure 3.3 shows the model output. The minimum cutoff value (to determine if an area is considered potential habitat for a species) of 0.39 was determined by using the average 10th percentile training presence. The 10th percentile training presence uses the suitability threshold associated with the presence record that occurs at the 10th percentile of presence records (Phillips 2018). This value excludes some of the outlier population areas in the Maxent

predictions to focus on the typical habitat conditions for this species. The total area ranked greater than 0.39 in the Maxent model was just 6.00% of the total analysis area (Table 3.1).

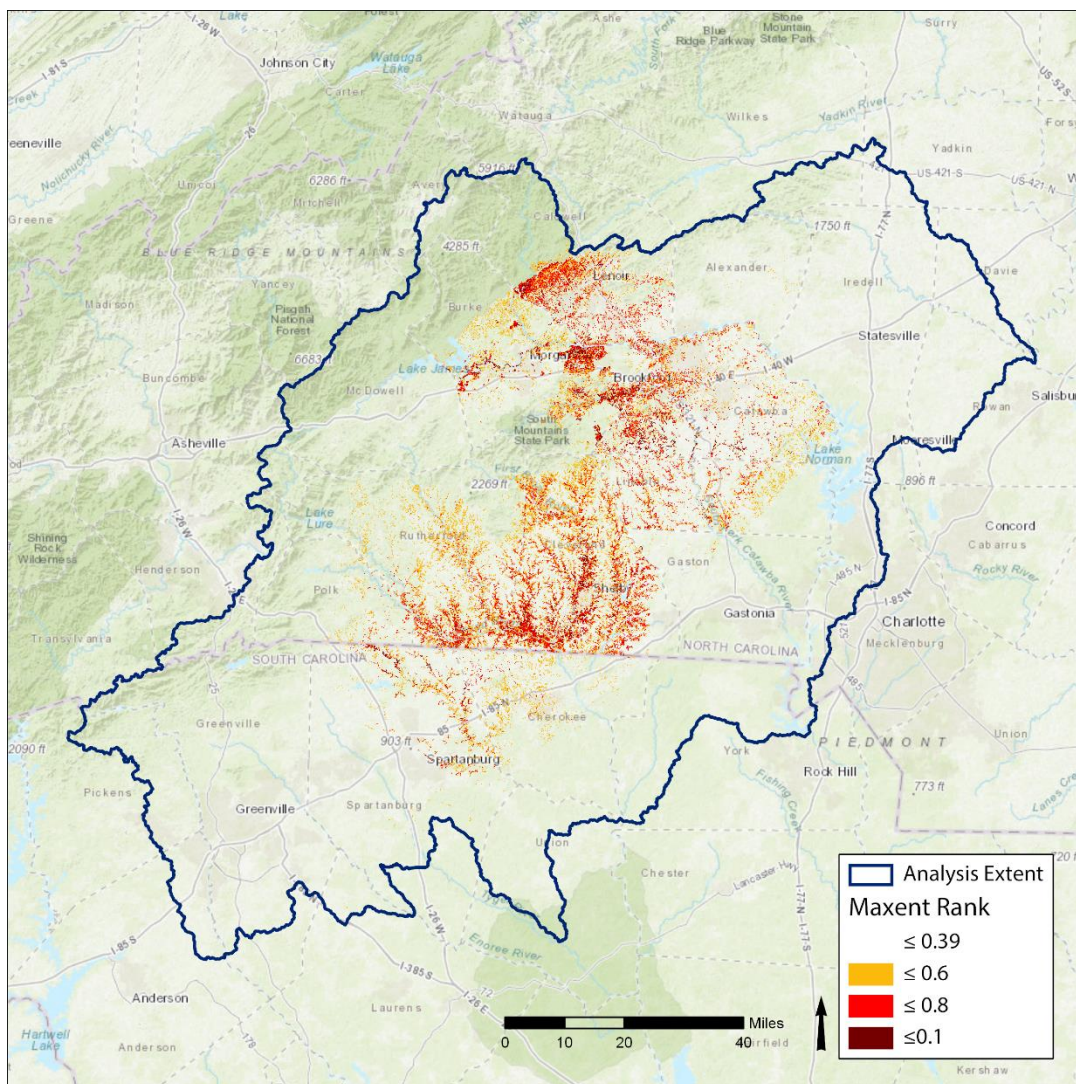


Figure 3.3. Maxent model output map

Table 3.1-Area estimates of the Maxent model

Maxent Score	Acres	Square Miles	Percent of Total
0.39 and greater	302,834.13	473.18	6.02%
0.6 and greater	128,273.52	200.43	2.55%
0.8 and greater	22,115.97	34.56	0.44%

The average area-under-curve (AUC) score for the replicate Maxent model is 0.86. The AUC is calculated from the receiver operating characteristic (ROC) plot. This value has a range of 0 – 1 and may be interpreted as a single test statistic that assesses model performance, indicating the ability of the model to correctly classify the occurrence data used. The model performed well in its predictions, with a mean AUC of 0.86 (AUC value of 0.5 is no better than random; AUC<0.5 is worse than random; AUC>0.5 is greater predictive power than random; Baldwin 2009).

The Maxent output supplies estimates of the relative contributions of the environmental variables to the Maxent model (Table 3.2). SSURGO map unit key) is the top contributing variable. One hundred and thirty-five individual soil types are present within the polygon boundaries of the *Hexastylis naniflora* element occurrences. Many of these individual soil types are part of soil complexes and are separated by things such as percent slope, erosion, how stony/rocky, and amount of clay. The most common individual soil type was Meadowfield-Rhodhiss complex, 25 to 60 percent slopes, very stony (14.1% of total). However, collectively the Meadowfield soils only comprised 14.3% of all soils). The individual Pacolet soil types were very common and collectively comprise 36% of all soil types present. Woolwine, Rion, and Fairview soils were also collectively common, comprising 10.4%, 9.7%, and 8.8% of all soils present respectively.

Table 3.2. Percent contribution of the environmental variables

Environmental Variable	Percent Contribution
SSURGO map unit key	23.5%
Minimum Annual Temperature	17.8%
Average Annual Precipitation	15.7%
Landcover	12.9%
Landcover Majority	12.0%
Landcover Hexastylis Grouping	5.4%
Geomorphons	4.9%
Elevation	4.6%
Canopy Cover	3.2%

The minimum annual average temperature range in the analysis extent is 39 – 51 degrees Fahrenheit. The majority of the *Hexastylis naniflora* element occurrences (89%) are found at the 47 and 48 degrees. The average annual precipitation range in the analysis extent is 42 – 81 inches per year. The majority of the *Hexastylis naniflora* element occurrences (82%) are found in the 47 – 49 inches per year range.

Piedmont forested landcover habitats dominate the land area of the element occurrences. Southern Piedmont Dry Oak-Pine Forest – Hardwood Modifier (53%), Southern Piedmont Mesic Forest (9%), Southern Piedmont Dry Oak-Pine Forest (5.2%), Southern Piedmont Small Floodplain and Riparian Forest (4.4%), and collectively comprise 71% of the element occurrences area. Evergreen Plantation or Managed Pine (9%), Harvested Forest (7.2%), Developed, Open Space (5%), Pasture/Hay (2.1%) collectively comprise 22% of the total element occurrence area. The remaining 6 percent of element occurrence area is comprised of a mix of 14 other natural and disturbed landcover classes, but each at small percentages. The landcover majority classification scheme reduces the total number of landcover classes present in the analysis extent from 23 to 11. Southern Piedmont Dry Oak-Pine Forest – Hardwood Modifier is still the dominant landcover class (58%). However disturbed categories are increased in area (sum total of 35%). Evergreen plantation or managed pine (12%) and Pasture/Hay (12%) are the only other categories that have at least 10% or greater area. The increase in disturbed landcover area representation in the landcover majority layer suggests that many *Hexastylis naniflora* population areas are situated in areas impacted by disturbed landcover. This is likely due to urban encroachment and increasing fragmentation of habitats. The landcover *Hexastylis naniflora* grouping reveals the amount of disturbance present in *Hexastylis naniflora* population areas. Landcover classes grouped as disturbed comprises 27% of the total area. Mixed forest (deciduous and evergreen) comprises 58%, pasture/hay 12%, and hardwood forest 2%. Open water, evergreen and barren landcover groupings are all at less than 1% each.

Geomorphons revealed that the majority of *Hexastylis naniflora* element occurrence areas are situated in concave landforms. Geomorphon categories hollow (13%), valley (46%), and

depression (10%) collectively comprise 69% of all *Hexastylis naniflora* population areas. Flat landforms comprise 15.5% of the area and convex landforms the remaining 15.5%.

Within the analysis extent, the range of elevation present is 335 – 5,265 feet. For *Hexastylis naniflora*, the prime elevation range is from 666 – 908 feet (53% of total element occurrence area). A lesser elevation range is present from 935 – 1,184 (37% of total element occurrence area).

Canopy cover for the *Hexastylis naniflora* populations are dominated by Tree Cover 70-80% (20.2%) and Tree Cover 80-90% (63.9%). The rest of the canopy cover categories are 2% or less.

We performed a Kruskal-Wallis 1-way non-parametric Analysis of Variance (ANOVA) to investigate the relationship between Maxent scores and current resilience of populations (Table 3.3). There are significant differences in the average Maxent scores between the four resilience categories ($p = 0.04$) and the mean Maxent score increases as population resilience increases from low to very high. The model gives us some predictive ability regarding habitat suitability where higher Maxent scores, on average, result in higher population resilience.

Table 3.3 Results of the Kruskal-Wallis 1-way non-parametric ANOVA investigating relationships between Maxent scores and current resilience groups for dwarf-flowered heartleaf.

<i>Groups</i>	<i>Count</i>	<i>Mean Rank</i>
low	13	30.7
moderate	25	30.7
high	5	42.8
very high	28	45.7

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>
Between Groups	4375.7	4	1093.92	2.65	0.0404

Within Groups	28036.3	68	412.30
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Total	32412.0	72	
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Reproduction and Presence of Pollinators

The pollination of *Hexastylis* has not been well studied but the genus is thought to be pollinated by insects including flies, wasps, and thrips (Otte 1977). Additionally, Lengyel et al. (2010) described how, within the family Aristolochiaceae, more than 50% of the plant lineage is myrmecochorous (seed dispersal via ants). This supports Gaddy's work (1986), which found three species within the *Hexastylis* *Heterophylla* subgroup (*H. heterophylla*, *H. naniflora*, and *H. minor*), which employ myrmecochory as a method for seed dispersal.

Because the flower for this species is oftentimes partially or completely covered with soil and leaf litter, possibly inhibiting pollinator activity (Gonzalez 1972), there is still uncertainty in the pollination mechanism for dwarf-flowered heartleaf. Otte (1977) suggests that a variety of possible pollinators reside in this leaf litter, however, the calyx opening is considered to be far too small for efficient pollinating (Gaddy 1981). There are, however, invertebrates within this proposed size limit that could theoretically act as pollinators. It is possible that the species employs self-pollination, with or without a vector, or that cross-pollination occurs by a number of invertebrates. Jones et al. (2014) investigated pollination of dwarf-flowered heartleaf under a manipulative experimental design, and found that while insects may play a significant role in pollination, even without them, flowers managed to produce a partial seed set. However, two points need to be considered here. First, although flowers managed to produce seeds in the absence of insect pollinators, the efficiency of pollination decreased by almost 50%. Also, even if successful pollination occurs in the absence of insect vectors, the dispersal of plants amongst populations would be limited, and could result in decreased resilience due to genetic concerns such as limited gene flow and issues associated with potential inbreeding depression.

Abundance

The influence of stochastic variation in demographic (reproductive and mortality) rates is much higher for small populations than large ones. Stochastic variation in demographic rates causes small populations to fluctuate randomly in size. In general, the smaller the population, the greater the probability that fluctuations will lead to extinction. There are also genetic concerns with small populations, including reduced availability of compatible mates, genetic drift, and inbreeding depression. Small populations of dwarf-flowered heartleaf have low resilience, leaving them particularly vulnerable to stochastic events.

As of 2016, the combined databases of the NCNHP and SCDNR contain 239 Element Occurrence Records (EORs) for *H. naniflora* (NCNHP 2016, SCDNR 2016). These EORs depict roughly 113 locations which are sufficiently geographically distinct to be regarded as proxies for populations of the species (See *Delineating Populations*). Thus, the total number of populations has increased more than four-fold (from 24 to 113) since the species was listed in 1989.

At this time, the largest known populations have been monitored by NCNHP and NCDOT. The estimates for entire populations are based on a consistent monitoring methodology developed by NCDOT, USFWS, and NCNHP with monitoring plots representing roughly 10% of a population. Populations were delineated to get a more accurate boundary and size of the area occupied. All rosettes are counted annually in each monitoring plot to estimate an extrapolated population size, based on the number and density in the plots. As a result of these efforts, better estimates of population sizes for the largest known populations are available, compared to when the last five-year review was completed in 2010 (Robinson and Padgett 2016).

The 113 EORs have been estimated to contain anywhere from a single rosette to over 100,000 rosettes. Appendix 1 was created by NCNHP (2016) to replicate the same format and population data as Table B2 of the most recent USFWS five-year review of *H. naniflora* (USFWS 2010), for comparison of changes since 2010, and summarizes the largest occurrences of *H. naniflora*, with the size of the population based on the number of rosettes it was last estimated to contain. The number of populations estimated to contain over 1,000 rosettes is 26. This is approximately 23%

of the total known populations and many of these populations contain well over 1,000 individuals.

There are, however, 13 populations (12% of all known) that are simply known to be extant, with no available estimate of population size (NCNHP 2016, SCDNR 2016). If the most recent population estimates for each EOR are compiled across years of observation, the 113 populations could conservatively be estimated to contain a collective total of more than 300,000 rosettes (NCNHP 2016, SCDNR 2016).

Population Trends

Although abundance is critical in assessing the resilience of dwarf-flowered heartleaf, trends in population growth can also be informative. Long-term growth trends are typically defined as the degree of change in population size over 200 years, whereas short-term growth is typically measured as that degree of change over a 10 year period. We lack a robust data set to assess trends at either of these time scales. However, from 2012-2016, NCNHP conducted systematic annual surveys of thirteen of the largest populations across the range.

Based on the results of the five-year monitoring efforts completed in 2016, nine out of thirteen populations remain stable during the five years of data collection (Robinson and Padgett 2016). The largest known population, Broad River: Henson's Creek, Brice, & Sandy Mush Outcrop in Rutherford County, NC, is estimated to have over 100,000 rosettes (Robinson and Padgett 2016). This large population consists of many scattered subpopulations on private property; two of the subpopulations are protected as a Registered Heritage Area, although Registry is a non-binding agreement with landowners that can be cancelled at any time (NCNHP 2018).

Two of the thirteen populations increased in numbers from 2012-2016: Cliffside Steam Station and Broad River: Floyds Creek, Long Branch. The Cliffside Steam Station is protected with a voluntary agreement with Duke Energy and was estimated to contain over 39,000 rosettes in 2016. The Broad River: Floyds Creek, Long Branch population is not at all protected, but was last estimated to consist of over 12,000 individuals in 2016 (Robinson and Padgett 2016).

Based on the results of recent surveys and a review of all known populations of *Hexastylis naniflora*, the overall trend over approximately 30 years is estimated to be declining 10-30%. This is estimated by a combination of documented declines of some populations, while many others appear to be remaining relatively stable, and some have increased.

Chapter 4: CURRENT CONDITIONS

Below we assess current resilience, representation, and redundancy as they relate to population and habitat factors known to be important for species viability. Based off of recent reports (Robinson and Padgett 2016; Robinson 2016), the species consists of 119 populations distributed across 12 counties in North Carolina and South Carolina. Populations are composed of both multiple EOs and stand-alone EO records. Recent genetic research discussed in Chapter 2, suggests that dwarf-flowered heartleaf, as originally described, is found in the southern portion of its presumed range based on current EO locations, and the northern portion could be a currently undescribed species (Figure 4.1; Estep pers. Comm. 2018). The genetic analysis to support this is complete, but a review of the morphology is ongoing and a new species has not yet been described (Estep pers. Comm. 2018). For the purpose of this SSA, we assume all EO detections are *H. naniflora*, and represent the best currently available scientific data.

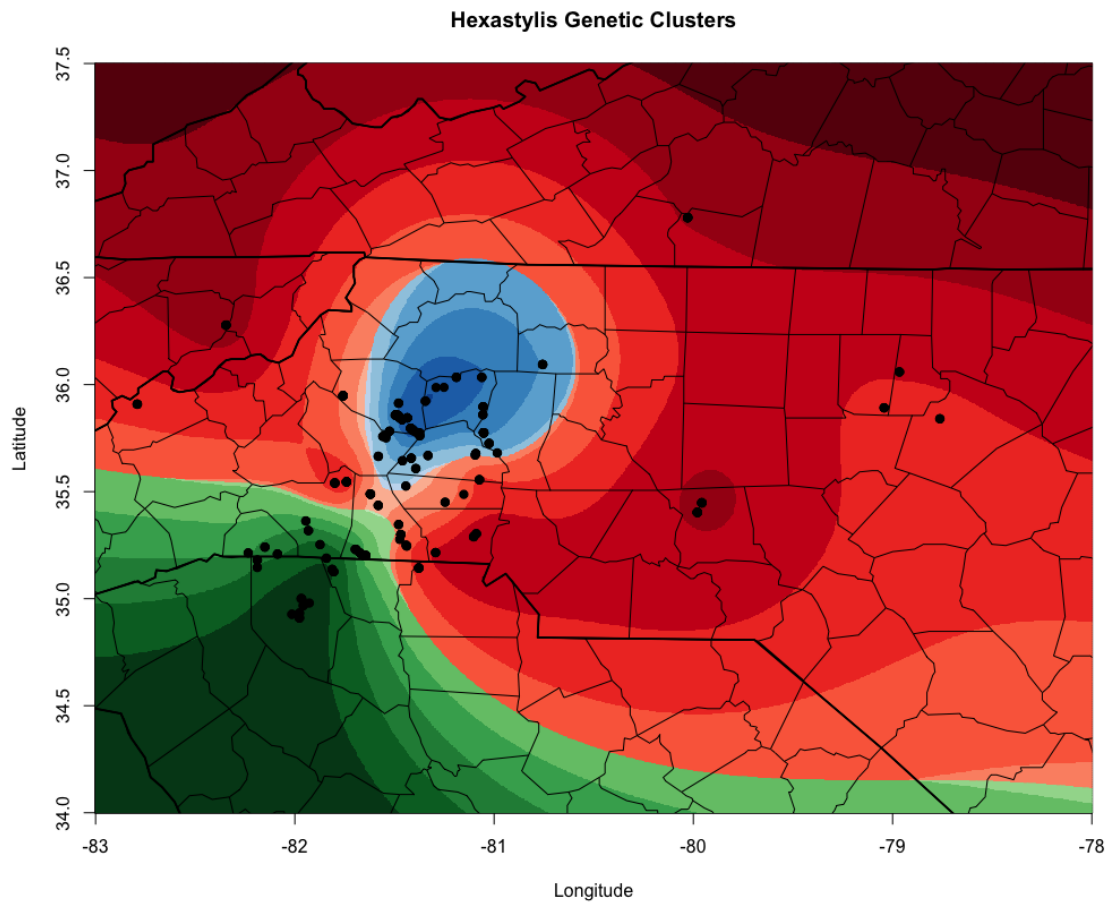


Figure 4.1. Recent genetic analyses detailing clustering of the genus *Hexastylis*. Black dots represent GIS locations of individual plants included in the genetic analysis. Green areas represent “true” *H. naniflora*; Blue represents a possible new species; Red represents other species in the genus (*H. minor*, *H. heterophylla*, etc.).

Current Population Resilience

Categorizing Resilience

For the purposes of this SSA, we use population size as the main driver of population resilience. The unit of measurement for population size in this species is a “clump” (rosette). As discussed previously, populations in North Carolina were delineated by NCNHP, whereas the Service defined populations in South Carolina. These delineations were based off of NatureServe criteria such as EO separation distance and intervening landscape matrix. EO data included a wide range

of years since the species was last observed at a given location (1964-2017), so although recent reports suggest the species consists of 113 populations, some of that data is fairly outdated. For the purposes of this SSA, we only used EOs that were observed since 2005. We did this for several reasons. First, we did not want to go back too far and assume a population was still present. Second, we wanted to be consistent in what we considered “current” for both categorizing resilience and use in the habitat model (discussed later). Also, experts concurred that records as old as 12 years are still likely to persist. Finally, there was a natural break in the data at the year 2005, coinciding with the year the last five-year review was initiated, where the number of EOs dropped off significantly in the years 2004 and earlier. It is important to note that many of the populations that we excluded from our analysis may still persist on the landscape. In fact, many EOs for this species have persisted for decades, despite not having intervening surveys to confirm their persistence.

Based on the criteria (excluding EOs prior to 2005), there are currently 78 populations distributed across the range of dwarf-flowered heartleaf, although this may be an underestimate as discussed above.

To determine overall resilience for populations, we used EO viability ranks and expert opinion to bin population size classes into corresponding resilience categories. EO viability ranks for the species include excellent, good, fair, poor, extant, historical, and failed to find. The primary factor in determining these ranks is EO size (as quantified by number of clumps). Condition of habitat (vegetation community and structure) and landscape context (extent of suitable habitat and physical factors) are also incorporated secondarily. Appendix 2 shows the NCNHP EO rank specifications for dwarf-flowered heartleaf. The EO rank specifications suggest good-excellent viability for populations consisting of at least 500 individuals, given there is sufficient high quality habitat; fair viability for populations consisting of 100-500 individuals, depending on habitat conditions; poor viability for populations consisting of less than 100 individuals. Recent reports (Robinson 2016; Robinson and Padgett 2016) focus monitoring studies on populations with greater than 1,000 individuals, populations that are assumed to be very viable. Because we do not have habitat level information for every population we assessed, we synthesized all of the above population size information and created four resilience categories as follows:

- Very high—populations with >1,000 individuals; very high probability of persistence for 20-30 years at or above the current population size.
- High—populations with 500-1,000 individuals; moderate-high probability of persistence for 20-30 years at or above the current population size.
- Moderate—populations with 100-500 individuals; low probability of persistence for 20-30 years at or above the current population size.
- Low—populations with <100 individuals; low probability of persistence for 20-30 years at or above the current population size, and moderate-high probability of extirpation.

Occupancy and Abundance

There are 78 populations of dwarf-flowered heartleaf that have been observed since 2005 (Table 4.1), and resilience of these populations is as follows: 28 (very high); 5 (high); 26 (moderate); 19 (low). Table 4.2 shows the contribution of each resilience category as follows: 36% (very high); 7% (high); 34% (moderate); 23% (low). When looking at cumulative percentages of resilience, it is interesting to note that 77% of all of the populations are classified as moderate to very high resilience (Table 4.2).

Table 4.1. Current populations of dwarf-flowered heartleaf and associated resilience across the species range. Abundance and last observation date based on Natural Heritage Program data (2018).

Site Name	State	County	Last Observed	Total plants	Resilience
Glade Creek, Alex County	NC	Alexander	2017	>1000	very high
Catawba River: Hoyle Crk-Micol Crk	NC	Burke	2013	>1000	very high
Island Creek Heath Bluff	NC	Burke	2016	>1000	very high
Gunpowder Creek: South of Hudson	NC	Caldwell	2012	>1000	very high
Peaked Top Rare Plant Site/Foothills Landfill	NC	Caldwell	2014	>1000	very high
Jacob Fork West Corridor	NC	Catawba	2012	>1000	very high
Murrays Mill/Upper Balls Creek NA	NC	Catawba	2013	>1000	very high
NCDOT TIP: R-2824	NC	Catawba	2015	>1000	very high
South Fork Catawba R: Clark Crk, Miller Br, Cata Mem Hos	NC	Catawba	2013	>1000	very high
Cowpens NBF - Site 1	SC	Cherokee	2016	>1000	very high

Site Name	State	County	Last Observed	Total plants	Resilience
Cliffside Steam Station	NC	Cleveland/Rutherford	2016	>1000	very high
Broad River/Sandy Run NA	NC	Cleveland	2012	>1000	very high
Broad River: Brushy Creek	NC	Cleveland	2016	>1000	very high
Buffalo Creek: Kings Mountain Res	NC	Cleveland	2016	>1000	very high
Buffalo Creek: Tributaries N and S of SR 2047	NC	Cleveland	2012	>1000	very high
Rhyne Conservation Preserve	NC	Lincoln	2016	>1000	very high
Mill Creek Forest and Seep	NC	Polk	2016	>1000	very high
New Hope Springhead Swamp	NC	Polk	2016	>1000	very high
Big Horse Creek Rare Plant Site	NC	Rutherford	2015	>1000	very high
Broad River: Floyds Creek	NC	Rutherford	2016	>1000	very high
Davenport Road/Mountain View Rare Plant Site	NC	Rutherford	2016	>1000	very high
Facebook Site	NC	Rutherford	2016	>1000	very high
Floyds Creek Tributary Rare Plant Site	NC	Rutherford	2012	>1000	very high
New Bethel Rare Plant Site	NC	Rutherford	2015	>1000	very high
Richardson Creek trib above Toms Lake	NC	Rutherford	2016	>1000	very high
DNR Peters Creek Heritage Preserve	SC	Spartanburg	2016	>1000	very high
Taylor Blalock Res	SC	Spartanburg	2016	>1000	very high
Leepers Creek Heartleaf Site	NC	Lincoln	2006	>1000	very high
Little Gunpowder Creek Rare Plant Site 1	NC	Caldwell	2015	500-1000	high
Little Gunpowder Creek Rare Plant Site 2	NC	Caldwell	2015	500-1000	high
Northern Catawba County	NC	Catawba	2017	500-1000	high
Rock Barn Solar Farm	NC	Catawba	2010-2011	500-1000	high
Buffalo Creek Rare Plant Site	NC	Cleveland	2012	500-1000	high
Third Creek Rare Plant Site	NC	Alexander	2010	100-500	moderate
Hickory Area	NC	Burke/Catawba/Caldwell	2016	100-500	moderate
Burke County - Drowning Creek UT	NC	Burke	2017	100-500	moderate
Simms Hill/Little River Uplands	NC	Burke	2015	100-500	moderate
Smith Cliff/Henry Fork River	NC	Burke	2015	100-500	moderate
NCDOT non-TIP Div 12 road const at SR 1115 South Fork Catawba River Jacobs Fork and Camp Creek	NC	Catawba	2016	100-500	moderate
NCDOT TIP R-2824	NC	Catawba	2015	100-500	moderate
South Fork Catawba River, Henry Fork	NC	Catawba	2007	100-500	moderate
Broad River/Sandy Run NA	NC	Cleveland	2012	100-500	moderate
Brushy Creek Headwaters	NC	Cleveland	2014	100-500	moderate
First Broad River: Crooked Run Creek	NC	Cleveland	2010	100-500	moderate
No Business Creek, Boyd Tract	NC	Cleveland	2007	100-500	moderate

Site Name	State	County	Last Observed	Total plants	Resilience
West Shelby Mesic Slope	NC	Cleveland	2016	100-500	moderate
UT of Kings Mountain Res	NC	Gaston	2012	100-500	moderate
Buffalo Shoals Creek	NC	Iredell	2014	100-500	moderate
Cat Square Heartleaf Forest	NC	Lincoln	2012	100-500	moderate
Collinsville (Hughes) Creek Slopes	NC	Polk	2016	100-500	moderate
Fox Knoll Farm	NC	Polk	2016	100-500	moderate
Forest City: Adj to Isothermal CC	NC	Rutherford	2010	100-500	moderate
Jonas Road Rare Plant Site	NC	Rutherford	2014	100-500	moderate
Knob Creek NA	NC	Cleveland	2005	100-500	moderate
Buffalo Creek	NC	Cleveland	2005	100-500	moderate
Kross Keys NA	NC	Polk	2005	100-500	moderate
Catawba River: North Fork Mountain Creek	NC	Catawba	2005	100-500	moderate
Catawba River: Lake James	NC	Burke	2006	100-500	moderate
Hogpen Branch Transplant Site	NC	Rutherford	2005	100-500	moderate
NCDOT TIP R-3603A	NC	Alexander	2017	<100	low
South Mountains Pleasant Grove Uplands	NC	Burke	2016	<100	low
Gunpowder Creek	NC	Caldwell	2012	<100	low
Killian Crossroads	NC	Catawba	2010	<100	low
Pott Creek	NC	Catawba	2012	<100	low
Beaverdam Crk at First Broad River	NC	Cleveland	2011	<100	low
Buffalo Creek: Potts Creek	NC	Cleveland	2012	<100	low
Buffalo Creek: Ravine	NC	Cleveland	2007	<100	low
Hickory Creek - UT (Shelby High School)	NC	Cleveland	2016	<100	low
Boulder Creek Subdivision - Jordan Road	SC	Greenville	2016	<100	low
Gateway Elementary School	SC	Greenville	2017	<100	low
Fanjoy Road Site	NC	Iredell	2015	<100	low
Levan Family Farm	NC	Iredell	2013	<100	low
Lincoln County, SR-1314	NC	Lincoln	2014	<100	low
Northeast Lincolnton: UT Walker Branch	NC	Lincoln	2009	<100	low
Sandy Spring Church Springhead Swamp	NC	Polk	2005	<100	low
First Broad River: Hickory Creek	NC	Cleveland	2006	<100	low
Smith Cliff/Henry Fork River	NC	Burke	2005	<100	low
First Broad River: Beaverdam Creek Tribs	NC	Cleveland	2006	<100	low

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682 **Table 4.2.** Population resilience categories by county for dwarf-flowered heartleaf.

County	Very High	High	Moderate	Low	Totals
Alexander	1		1	1	3
Burke/Catawba/Caldwell			1		1
Burke	2		4	2	8
Caldwell	2	2		1	5
Catawba	4	2	4	2	12

Cherokee	1				1
Cleveland/Rutherford	1				1
Cleveland	4	1	7	6	18
Gaston			1		1
Greenville				2	2
Iredell			1	2	3
Lincoln	2		1	2	5
Polk	2		3	1	6
Rutherford	7		3		10
Spartanburg	2				2
Totals	28	5	26	19	78
<i>% of total</i>	<i>36</i>	<i>7</i>	<i>34</i>	<i>23</i>	<i>100</i>
<i>Cumulative %</i>	<i>40</i>	<i>43</i>	<i>77</i>	<i>100</i>	<i>--</i>

Population Trends

Although we lack an adequate past time series of abundance data for all populations to estimate growth rates or population trends, NCNHP conducted surveys of thirteen of the largest populations across the range of the species from 2012-2016. Table 4.3 shows the results of all of these surveys. Two populations show an increasing trend, nine show a stable trend, and two show a decreasing trend.

Table 4.3. Summary of population trends over 5 years of monitoring data for 13 of the largest populations of dwarf-flowered heartleaf across its range (from: Robinson and Padgett 2016).

Trend	Survey	Site	2016 estimated number of plants (Rosettes)	2016 area occupied (Acres)
Increasing	NCNHP	Cliffside Steam Station (EO 276)	39,535	52
	NCNHP	Broad River: Floyds Creek, Long Branch (EO 177)	12,687	5.67
Stable	NCNHP	Island Creek Bluff/Love Lady Site (EO 029)	50,481	61.76
	NCNHP	Rhyne Preserve (EO 302)	19,873	22.43
	NCNHP	Mills Creek Forest and Seep (EO 023)	1,733	1.39
	NCNHP	New Hope Springhead Swamp (EO 125)	12,235	5.03

	NCNHP	Broad River: Henson's Creek, Brice, & Sandy Mush Outcrop (EO099)	106,940	83.39
	NCNHP	Broad River: Cleghorn Creek, US 221 (EO 176)	6,750	7.24
	NCNHP	Cowpens National Battlefield (SC EO 016, 017, 018)	2,823	6.05
	NCNHP	Peters Creek Preserve (SC EO 011)	3,306	8.98
	NCNHP	Blalock Reservoir (SC EO 007, 031)	3,505	7.59
Decreasing	NCNHP	Second Broad River (Forest City Industrial Complex) (EO 154)	2,576	4.74
	NCNHP	South Fork Catawba River: Jacob Fork, Camp Creek (EO 158)	123	0.09

Current Species Representation

Representation describes the ability of a species to adapt to changing environmental conditions. We lack genetic and ecological diversity data to characterize representation for dwarf-flowered heartleaf. In the absence of species-specific genetic and ecological diversity information, we typically evaluate representation based on the extent and variability of habitat characteristics across the geographical range. However, the dwarf-flowered heartleaf has a very limited range, and after consulting with experts, we decided delineating representative units was not appropriate for this species.

Current Species Redundancy

For the dwarf-flowered heartleaf to maintain viability, the species also needs to exhibit some degree of redundancy. Species-level redundancy reflects the ability of a species to withstand catastrophic events, and is best achieved by having multiple, widely distributed populations relative to the spatial occurrence of catastrophic events. Redundancy for dwarf-flowered heartleaf is the total number and resilience of population segments and their distribution across the species range.

An important question when investigating redundancy for dwarf-flowered heartleaf is, “what exactly is a catastrophe?” We consider a catastrophe to be any population level disturbance that

has the potential to negatively influence population resiliency outside of normal environmental and demographic stochasticity. Disturbances often act quickly, like hurricanes, and often with devastating effects, however they can also occur over long periods of time. A disturbance that occurs as a relatively discrete event in time is referred to as a “pulse” disturbance, while more gradual or cumulative pressures on a system are referred to as “press” disturbance. Both types of disturbances are part of the natural variability of dwarf-flowered heartleaf ecological systems, and must be considered when assessing redundancy. While there is certainly a variety of potential pulse disturbances for the species (timber harvest, hydrological alterations, road and right-of-way construction), the primary potential catastrophic disturbances are press disturbances from long term climate change, which have great potential to affect ecosystem processes and communities by altering the underlying abiotic conditions (DeWan et al. 2010).

As stated previously, there are 78 populations of dwarf-flowered heartleaf that have been observed since 2005 (Table 4.1), and resilience of these populations is as follows: 28 (very high); 5 (high); 26 (moderate); 19 (low). The populations are spread across the range, although a majority occur in North Carolina. Although, there appears to be adequate redundancy within the range of dwarf-flowered heartleaf to withstand the impacts of localized press catastrophic disturbances, the species range is very small, making it potentially vulnerable to long-term catastrophic events, such as climate change.

CHAPTER 5: INFLUENCES ON VIABILITY

Hexastylis naniflora populations occur in rapidly growing urban areas with expanding suburbs of Charlotte, NC, to the east; Hickory, NC, to the north; and Greenville and Spartanburg, SC, to the south. At the time of listing, it was determined that the species was most threatened by habitat loss due to the conversion of land to residential, commercial, and industrial use in these areas. In addition to threats associated with residential, commercial, and industrial development, other documented threats include habitat loss from land conversion to agricultural use, timber harvest, hydrological alterations from the damming of ponds, impacts from grazing cattle, ORV damage, trampling from foot traffic, invasive species, highway or road improvements, and erosion or

siltation (NCNHP 2016, Robinson and Padgett 2016). Climate change may exacerbate these risk factors through changes in temperature and precipitation.

Threats were assessed for populations monitored by NCNHP during 2012-2016 (Robinson and Padgett 2016), and EOs were reviewed for other documented threats to populations. Indirect or direct threats that were observed, inferred, or suspected to have an impact on populations were recorded and assigned a ranking based on their severity, scope, and immediacy from field observations. The rank for each threat factor determines the overall value for each threat observed at each population. No significant changes in threats within populations were noted from 2012-2016. Threats observed during these years included development, incompatible forestry practices, agriculture, trampling, invasive exotic species, sedimentation, erosion, and road construction.

Below, we summarize primary threats to the viability of dwarf-flowered heartleaf. Primary influences will be carried forward in our future projections in the next section.

Human Population Change

Increasing human populations drive development. With increases in population, there will be increasing conversion of open space to more impervious cover, with a subsequent increase in roads and other associated infrastructure. Increases in roads and impervious cover have the potential to lead to habitat loss and/or fragmentation, a primary risk factor for dwarf-flowered heartleaf. Tables 5.1-5.2 and Figures 5.1-5.2 show the estimated human population increases for North Carolina and South Carolina counties within the range of the species. The most populous counties include Greenville and Spartanburg in South Carolina, and Catawba, Gaston and Iredell counties in North Carolina.

Table 5.1-Human population projections for North Carolina counties within the range of dwarf-flowered heartleaf. *Source: North Carolina OSBM, Standard Population Estimates.*

County	2018	2023	2028	2033	2037
Alexander	38,609	39,244	39,686	39,992	40,169
Burke	90,865	93,124	95,382	97,644	99,452

Caldwell	83,919	86,723	88,689	91,126	92,870
Catawba	157,424	159,799	162,175	164,549	166,447
Cleveland	98,862	99,685	100,004	100,128	100,170
Gaston	221,112	227,667	237,344	245,276	252,388
Iredell	179,740	195,623	211,501	227,383	240,088
Lincoln	84,494	91,034	96,865	103,069	107,858
Polk	21,273	21,823	22,288	22,681	22,955
Rutherford	67,880	68,154	68,283	68,341	68,368

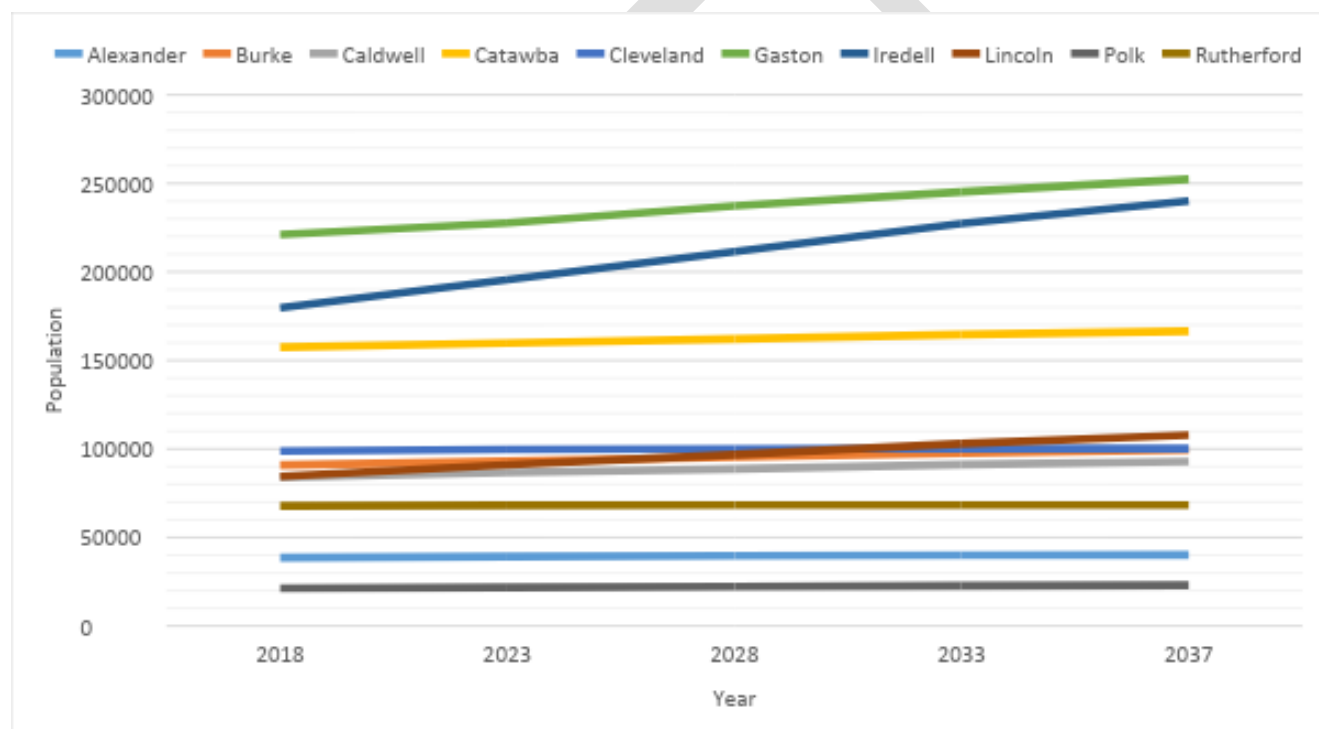


Figure 5.1- Human population projections for North Carolina counties within the range of dwarf-flowered heartleaf. *Source: North Carolina OSBM, Standard Population Estimates.*

Table 5.2- Human population projections for South Carolina counties within the range of dwarf-flowered heartleaf. *Source: U.S. Census Bureau, 2000 Census and 2007 Population Estimates. Population projections calculated by South Carolina Budget and Control Board, Office of Research and Statistics.*

County	2020	2025	2030	2035
Cherokee	61,760	64,760	67,350	70,170

Greenville	492,890	517,740	542,290	567,010
Spartanburg	310,220	323,550	336,810	350,110

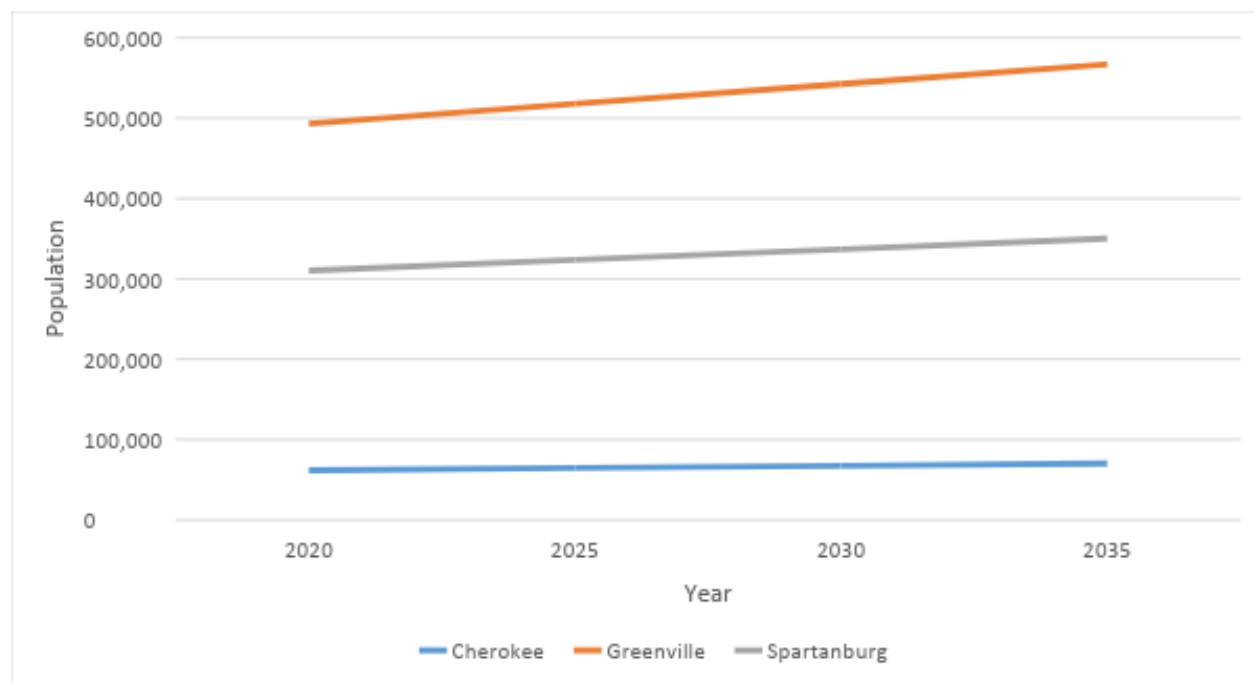


Figure 5.2. Human population projections for South Carolina counties within the range of dwarf-flowered heartleaf. Source: U.S. Census Bureau, 2000 Census and 2007 Population Estimates. Population projections calculated by South Carolina Budget and Control Board, Office of Research and Statistics.

Development

A large number of the known populations occur near expanding urban areas and are threatened by the residential, commercial, and industrial development associated with this growth. Populations occurring in more rural areas are threatened by habitat alteration or loss from land conversion to pasture or other agricultural uses, cattle grazing, intensive timber harvesting, residential construction, and construction of small ponds.

A 2010 review of existing NHP EOR data revealed that all or portions of 26 populations (24% of the total) had been directly or indirectly impacted through development projects or other causes such as trash disposal, expansion of residential lawns, cattle, or invasive exotics (NCNHP 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 113 populations (corresponding to 37% of all known populations). Of these 42 populations, all or portions of 22 (50%) had been adversely impacted by activities requiring ESA Section 7 consultation with the USFWS. The fact that nearly 20% of all known populations had been subject to formal Section 7 consultation illustrates the threats faced by the species.

In the same 2010 review, 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. 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).

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. 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.

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). 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).

Invasive Species and Woody Encroachment

Several of the known populations of dwarf-flowered heartleaf occur on steep ravine slopes which also support stands of mixed hardwoods with an understory of mountain laurel (*Kalmia latifolia*) or *Rhododendron spp.* These stands are often very dense and reduce the amount of light reaching the dwarf-flowered heartleaf plants growing below. Under these conditions the plants often show reduced vigor and reduced flower and fruit production. Careful, selective logging or natural tree fall and limited understory removal would open up these populations to more light. Additional light, if not accompanied by increased siltation from the intensive soil disturbances associated with forest clear-cutting, probably would benefit these populations (Gaddy 1981).

Invasive exotic plant species are rampantly spreading throughout riparian corridors and ravines across the range of this species (USFWS 2011). 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.

Climate Change

There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (McLaughlin *et al.* 2002, p. 6074; Golladay *et al.* 2004, p. 504; Cook *et al.* 2004, p. 1015). Because typical habitats for this species include moist soils adjacent to creeks, streamheads, or along lakes and rivers, and plants have been observed to grow larger and have more frequent flowering in floodplains along rivers, lakes, and streams (Newberry 1993), specific effects of climate change to the dwarf-flowered heartleaf are likely related to changes in soil moisture associated with potential increases in drought.

Warming in the Southeast is expected to be greatest in the summer (NCCV 2016) which is predicted to increase drought frequency, while annual mean precipitation is expected to increase slightly, leading to increased flooding events (IPCC 2013, p.7; NCCV 2016). Changes in climate may affect ecosystem processes and communities by altering the abiotic conditions experienced by biotic assemblages resulting in potential effects on community composition and individual species interactions (DeWan *et al.* 2010, p.7).

Despite the recognition of potential climate effects on ecosystem processes, there is uncertainty about what the exact climate future for the Southeastern US will be and how the ecosystems and species in this region will respond. Although climate change was not a factor leading to the original listing of the species, it should be recognized that the greatest threat from climate change may come from synergistic effects. That is, factors associated with a changing climate may act as risk multipliers by increasing the risk and severity of more imminent threats. As a result, impacts from rapid urbanization in the region might be exacerbated under even a mild to moderate climate future.

Regardless of a pessimistic, optimistic, or status quo climate future, the following systematic changes are expected to be realized to varying degrees in the Southeastern US (IPCC 2013):

- More frequent drought
- More extreme heat (resulting in increases in air and water temperatures, Figure 5-3)
- Increased heavy precipitation events (e.g., flooding)
- More intense storms (e.g., frequency of major hurricanes increases)
- Rising sea level and accompanying storm surge

In recent years, the Southeast has experienced moderate to severe droughts that many observers have implicated in population declines and poor transplant survivorship (NCNHP, 2010). 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 dwarf-flowered heartleaf is currently unknown.

Appendices 4a and 4b gives summary reports on historical and future predicted climate parameters from the USGS National Climate Change Viewer for both North Carolina and South Carolina. As discussed above, the trend for these States is consistent with the general trend in the Southeast: more frequent drought, more extreme heat, and increased precipitation events. If these predictions hold true, dwarf-flowered heartleaf habitat would likely be impacted through increased evaporative rates and decreased soil moisture (Appendices 4a and 4b), increased potential for catastrophic wildfire events, as well as potential disruption of stream bank morphology through increased flooding events. Our habitat model indicates a preferred temperature and precipitation range, indicating that the species would be sensitive to a changing climate.

Chapter 6: FUTURE CONDITION

Future Considerations

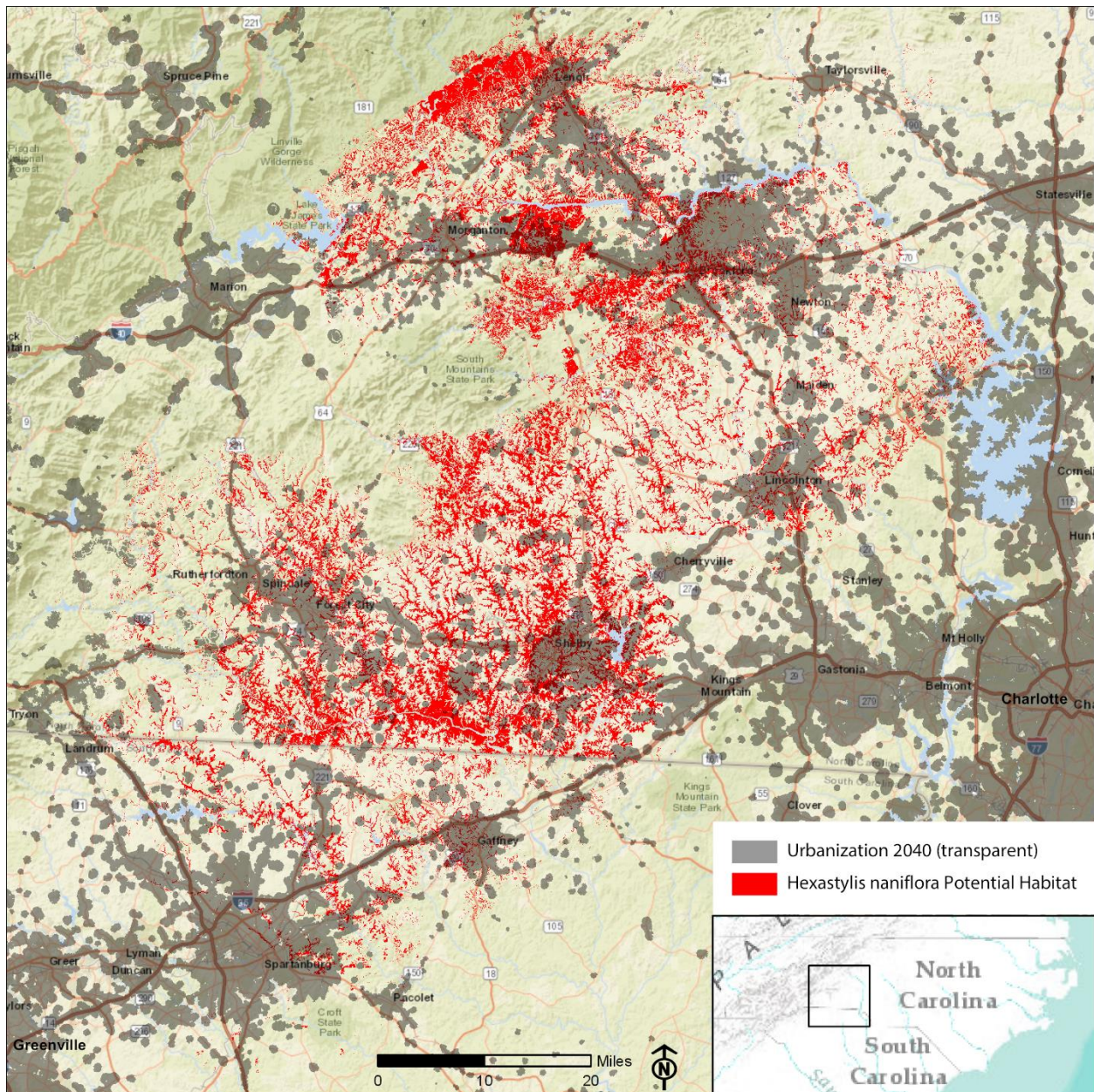
Our analysis of the past, current, and future influences on what the dwarf-flowered heartleaf needs for long term viability revealed that there are several influences that pose risks to future viability of the species. These risks are primarily related to habitat changes from development and long term climate change. We use projections of urban development to assess potential habitat loss and fragmentation. We also considered how climate change may exacerbate the impacts of development in a qualitative fashion using a narrative approach.

Because the actual impacts of urbanization are unknown, we use three scenarios, projected out to the year 2040, to capture the uncertainty related to the potential impacts to each population's resiliency: Status Quo, Targeted Conservation, and High Development. Results of future projections within each scenario are focused on current populations and potential habitat identified by the Maxent model as described below. Based on the life span of the species, expert input, development as the key risk factor brought forward, uncertainty about future conditions, and lack of knowledge about where additional populations may persist on the landscape, we chose to project populations out to the year 2040 under each scenario, but no further.

In constructing our scenarios, we considered two main influences by which species viability projections could be affected: location of additional populations (positive influence) and habitat loss and fragmentation due to urban development (negative influence). Habitat quantity can be negatively impacted by development or land use change (particularly on private lands) or positively impacted by land acquisition, restoration, and/or introductions into unoccupied sites that already have suitable habitat.

We use the Slope, Land cover, Exclusion, Urbanization, Transportation, and Hillshade (SLEUTH) models to determine areas predicted to be urbanized by 2040 (Figure 6.1). SLEUTH is a cellular automata model that applies transition rules to the states of a gridded series of cells, and in this case the transition is that from undeveloped to developed land cover, otherwise known as urbanization, and has been successfully applied worldwide over the last 15 years to simulate land use change (Clarke 1995).

Figure 6.1. Results of the SLEUTH model with *Hexastylis naniflora* potential habitat predicted by the MAXENT model overlaid.



The SLEUTH model predictions are broken down by probabilities of urbanization, ranging from 0-100%. We chose 80% probability as our cutoff, as this cutoff has been used by USGS and other SSAs, and this threshold represents a highly likely outlook for urbanization of the landscape. To forecast viability using urban development projections, we assessed the following:

- % increase in projected development (SLEUTH probability of urbanization >80%) within current populations (from Current Conditions—68 populations)

- % increase in projected development (SLEUTH probability of urbanization >80%) within areas delineated as potential habitat by the Maxent habitat model

There is no data available on the exact relationships between urbanization and the impacts to dwarf-flowered heartleaf. We do know that several current populations are located in areas with surrounding urban landscapes. We also know that urban development has led to extirpation of populations in the past through loss of habitat. Because of this uncertainty, we attempted to capture unknowns in two ways. First, our scenarios reflect a range of potential impacts from urban development. Also, we used two thresholds for % increase in urban development to capture potential deleterious effects: 25% and 50%. Our assumptions were that very small increases in development are unlikely to negatively impact populations; development increase of at least 25% of the area of current populations was likely to have some negative impacts; development increase of at least 50% was likely to have significant impacts to populations. We also assume that populations currently on protected lands are likely to see smaller impacts from urbanization compared to those that are not protected, but protection status (perpetuity vs non-perpetuity) matters. For example, Registered Heritage Areas are non-binding agreements with a land owner, and if the land changes ownership, or the owner decides not to continue with the agreement, then the Registry is no longer valid. Appendix 4 shows the protection status of each delineated population which helped to inform our assessment of resilience under each scenario.

We also assessed potential positive effects by integrating the potential location or rediscovery of additional populations throughout the range into two of our scenarios: Targeted Conservation and Status Quo. We believe this is appropriate for several reasons. First, location of new EOs is common; many of the populations we consider for Current Conditions include detections that have occurred within the last few years. Second, we did not include many older detections (i.e. only included detections since 2005), although many of those detections are likely to persist. Dwarf-flowered heartleaf is a long-lived perennial, and several EOs have been revisited after more than 10 years and the species was present. For example, one such EO was first observed in 1957 and next observed in 2001. It seems as long as suitable habitat is still present it is reasonable to assume that the species is still there. Finally, there is plenty of predicted suitable

habitat present within older EOs based on the Maxent model predictions that were not included as current populations.

The first step in identifying additional areas where dwarf-flowered heartleaf is likely to be found in the future, was to identify EOs from populations that were last observed prior to 2005 (i.e. our cut-off for current populations). Although our focus is on older EOs, where dwarf-flowered heartleaf is likely to persist into the future, we also included current EOs (2005-current) in our analysis because we were interested in how the older EOs compared to those known to be persisting on the landscape since 2005. Also, by including older EOs that are within current delineated populations, we can investigate whether current populations might be predicted to contain more plants than the most recent abundance estimate. For example, many of our current populations consist of multiple EOs, and we only considered EOs that were detected from 2005-current. If these older EOs within current populations that were not included in our Current Condition assessment are found to be likely to persist, then it is possible we underestimated the resilience of that population.

Once these older EOs were identified, we created a 1,000 meter buffer around the population and calculated a number of useful metrics including resilience category based on the last known abundance estimate, Maxent habitat model metrics, and the results of the SLEUTH model to further refine a list of potential sites where the species would likely be found to persist within our 20-25 year projection window. Resilience categories were assessed using last known abundance in the same way as populations assessed in the Current Conditions section (i.e. low = less than 100 individuals; moderate = 100-500 individuals; high = 500-1000 individuals; very high = greater than 1,000 individuals). We assessed two habitat metrics for these older EOs: average Maxent score and % Maxent classified as 0.8-1.0 score. Average Maxent score was calculated by taking the mean Maxent score of all potential habitat within the 1,000 foot buffer. The % Maxent classified as 0.8-1.0 represents the percentage of all potential habitat within the 1,000 foot buffer that falls within the highest habitat class. Together, these two habitat metrics give general estimates of habitat quantity and quality. Finally, we calculated the total percentage of the 1,000 foot buffer around each EO that is projected to be urbanized in the year 2040, which helps capture the primary risk factor of development when assessing the areas where dwarf-

flowered heartleaf is likely to persist. Table 6.1 (North Carolina) and 6.2 (South Carolina) show all of the EOs we considered and the corresponding metrics associated with resilience categories, urban development, and habitat scores.

Table 6.1. North Carolina raw data for metrics assessed to investigate potential sites where dwarf-flowered heartleaf was historically found and is likely to persist. Resilience categories are based on last known abundance estimates as follows: 1 = low; 2 = moderate; 3 = high; 4 = very high. MAXENT Average Mean refers to the mean Maxent score of all potential habitat. % Maxent classified as 0.8-1.0 represents the percentage of all potential habitat that falls within the highest habitat class. % Urban Development refers to the percentage of the 1,000 foot buffer around the EO that is projected to be urbanized in the year 2040.

EO not part of a current population
EO included as part of a current population
EO is a part of a current population but last detection was prior to 2005
Eliminated/not scored

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	2	34	1	3
2				
3	2	22	0	10
4	2	22	0	7
5	2	21	0	0
6				
8	1	27	0	6
9	3	44	4	0
10	4	33	2	0
11				
12	4	54	10	0
13	1	31	1	30
14	2	61	16	7
15				
16	4	18	0	47
17	1	50	13	0
18	1	36	8	2
19				
20	2	22	1	88
21	2	34	4	54
23	4	15	0	8
25	1	47	15	30
27				

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
28	2	43	12	29
29	4	43	8	30
30	4	27	2	74
31	4	30	3	86
32	2	34	2	47
33	2	33	3	0
34	1	49	13	63
35	1	42	10	23
36	1	19	0	12
37	4	41	6	17
38	2	14	0	46
39	1	19	0	11
40	2	37	2	32
44	4	20	0	59
45	1	27	5	13
46	3	42	6	6
47	1	28	1	96
48	1	14	0	12
49	4	61	14	5
50				
51	4	52	11	18
52	2	46	4	0
53	1	35	4	24
54	1	35	1	10
55	4	30	0	0
56	2	40	2	6
57	2	21	0	80
58	1	42	5	0
59	2	11	0	49
60	1	25	0	2
61	3	41	0	0
62	2	34	0	0
63	1	27	0	6
64	2	39	9	11
69	2	46	11	19
70	2	38	1	0
71	2	30	2	0
72	2	52	14	0
73	4	60	17	1

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
74	3	65	14	4
75	4	47	6	9
76	4	42	4	10
77	3	31	1	27
79	2	39	1	0
80	1	43	4	15
83	2	17	0	11
84	2	13	0	1
85	2	42	4	5
87				
89	2	13	2	0
90	2	28	2	0
91	1	49	5	0
92	2	15	0	30
106	4	39	4	38
107	1	14	0	40
113	4	46	4	7
114				
115	2	37	3	26
118	3	42	0	9
121	2	41	5	0
122	1	12	0	39
124	1	12	0	9
125	4	15	0	41
130	2	17	0	24
149	4	64	17	3
151	2	16	0	27
154	4	30	1	22
157	2	20	0	0
158	3	36	7	5
159	4	62	24	60
160	3	62	24	32
161	4	64	28	30
162	1	32	2	58
163	2	15	0	56
164	3	18	0	52
165	1	13	0	56
166	1	14	0	40
167	4	30	0	20

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
168	4	19	0	34
169	1	30	0	12
170	2	17	0	40
172	1	39	3	7
173	2	30	1	48
174	1	42	4	16
175				
180	2	21	1	0
181	4	29	2	0
182	4	45	4	0
183	2	15	0	5
184	4	19	0	19
187	2	20	1	35
188	2	24	0	53
189	1	25	0	14
190				
191	2	34	2	0
192	2	35	3	0
193	2	36	7	6
194	4	51	14	18
195	1	21	0	96
196	1	23	4	67
197	4	35	8	38
198	2	32	6	25
199	2	29	5	43
200	1	26	2	87
201	1	39	4	63
202	4	35	4	85
203	1	43	4	49
204				
205	2	43	1	49
206	1	37	3	66
207	2	33	2	85
208	1	32	1	67
209	2	33	2	94
210				
212	1	37	3	85
213	1	36	4	72
219	1	32	1	4

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
222	2	23	3	7
223				
224	1	22	3	17
225	2	24	2	12
227	4	55	2	5
229	2	28	0	21
230	1	54	15	13
231	1	41	7	0
233	4	53	12	14
235	2	50	8	6
236	2	62	14	5
237	2	67	16	5
238	4	51	15	0
239	2	63	14	5
240	1	57	18	0
241	2	62	16	3
242	1	53	9	0
246	1	62	13	4
249	4	47	5	0
250	4	45	4	0
251	4	43	4	0
254	2	54	18	6
255				
256	2	54	15	13
258	3	19	0	51
259	4	25	0	0
262	4	29	2	50
263				
264				
265				
266				
267	2	29	1	0
268	1	33	2	0
269	2	49	17	0
270	1	46	18	1
271	1	26	7	0
272	1	33	0	71
273	2	28	2	0
274	2	50	8	0

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
275	2	12	0	0
276	4	42	5	21
277				
278				
279	1	32	4	89
280	2	64	30	30
281	1	64	31	36
282	1	64	31	51
283	1	65	34	59
284	1	64	35	45
286				
287	2	15	0	35
291	2	21	1	84
292	2	14	0	83
293	1	8	0	16
294	2	36	4	61
296	2	3	0	5
297				
298	2	16	0	1
299	1	12	0	0
300	1	9	0	18
303	2	31	0	0
304	2	31	0	0
305	1	30	2	0
306	1	4	0	53
308	2	15	0	3
309	1	5	0	0
310	4	58	26	35
311	2	15	0	0
312	4	17	0	57
313				
314				
315	1	36	4	61
317	1	15	0	53
318	2	34	4	52
319	4	43	4	10
320	4	41	6	98
321				

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
Min	1	3	0	0
Max	4	67	35	98

Table 6.2. South Carolina raw data for metrics assessed to investigate potential sites where dwarf-flowered heartleaf was historically found and is likely to persist. Resilience categories are based on last known abundance estimates as follows: 1 = low; 2 = moderate; 3 = high; 4 = very high. MAXENT Average Mean refers to the mean Maxent score of all potential habitat. % Maxent classified as 0.8-1.0 represents the percentage of all potential habitat that falls within the highest habitat class. % Urban Development refers to the percentage of the 1,000 foot buffer around the EO that is projected to be urbanized in the year 2040.

EO not part of a current population

EO included as part of a current population

EO is a part of a current population but last detection was prior to 2005

Eliminated/not scored

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	2	21	0	0
2	2	1	0	4
3				
4	1	13	0	10
5	2	0	0	64
6	1	0	0	36
7	4	27	0	35
8	2	0	0	14
9				
10				
11	4	14	0	52
12				
13	1	7	0	100
14	4	14	0	43
15	1	0	0	4
16	4	22	0	38
17	4	22	0	33
18	3	19	0	52
19	1	12	0	65
20	2	5	0	100
21	3	5	0	90
22	1	0	0	0
23				

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
24	1	4	0	3
25	1	14	0	48
26	4	12	0	65
27	4	18	1	40
28	4	19	1	49
29				
30	2	7	0	88
31	4	0	0	0
32	2	7	0	93
33	2	2	0	20
34	1	31	3	1
35	1	23	1	53
36	2	6	0	0
37	1	24	2	0
38	4	5	0	37
39	1	6	0	1
40	2	6	0	20
41	1	11	0	87
42	2	3	0	6
43	1	23	0	43
44				
45				
46	1	10	0	96
47				
48				
49	3	8	0	70
50	2	5	0	54
51	1	0	0	35
52	3	0	0	0
53	2	10	0	66
54	2	9	0	91
55	1	4	0	99
56	2	14	0	96
57	3	15	0	38
59	2	4	0	17
60	4	17	1	12

Min	1	0	0	0
Max	4	31	3	100

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
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Next, we implemented a set of ranking rules using the data from Tables 6.1 and 6.2 to further assess which EOs had a higher likelihood of persistence on the landscape. We used SMART methodology to quantify and implement our ranking rules. Because the metrics of interest vary in data type (i.e. categorical vs continuous) and range of values (i.e. not all continuous variables have the same maximum and minimum), our first step was to normalize all of the data on a scale of 0-100. Normalization techniques allow for aggregation of criteria with numerical and comparable data. We decided to analyze North and South Carolina data separately because the Maxent model predicts habitat differently across state lines due to differences in soil classification. We weighted each variable according to our opinion of the level of contribution each variable had to the probability of persistence of that particular EO. This resulted in abundance having the highest weight (100%), with habitat (as calculated by average Maxent score) and urbanization given relatively similar weighting (80%). The results of the normalization procedure and weighting can be found in Tables 6.3 and 6.4.

Table 6.3. Normalized scores for SMART analysis of North Carolina EOs and weighting scores. Resilience category represents the normalized scoring based on the last known abundance (0=low; 33=moderate; 67=high; 100=very high); MAXENT Mean is the normalized score of the average Maxent rank of all potential habitat; MAXENT percent 0.8-1 represents the normalized score of the percentage of potential habitat that falls within the highest rank category; 80% or greater SLEUTH Percent of Total is the total amount of current urbanization plus predicted urbanization at year 2040 (>80% probability) from the SLEUTH model.

EO not part of a current population

EO included as part of a current population

EO is a part of a current population but last detection was prior to 2005

Eliminated/not scored

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	33	49	3	97
2				
3	33	30	0	90
4	33	29	0	93
5	33	28	1	100
6				

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
8	0	37	0	94
9	67	65	11	100
10	100	46	6	100
11				
12	100	80	28	100
13	0	43	2	69
14	33	90	44	93
15				
16	100	23	0	52
17	0	73	37	100
18	0	52	22	98
19				
20	33	30	3	11
21	33	48	12	45
23	100	19	0	92
25	0	68	42	69
27				
28	33	62	33	71
29	100	63	22	69
30	100	38	5	24
31	100	43	8	12
32	33	48	5	52
33	33	47	8	100
34	0	73	37	35
35	0	60	29	77
36	0	25	0	88
37	100	60	17	82
38	33	17	0	53
39	0	24	0	89
40	33	54	7	67
44	100	26	1	40
45	0	37	14	86
46	67	60	18	94
47	0	39	2	2
48	0	17	0	88
49	100	91	39	95
50				
51	100	77	31	82
52	33	68	11	100

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
53	0	50	11	76
54	0	49	1	90
55	100	43	0	100
56	33	58	7	94
57	33	28	0	19
58	0	60	15	100
59	33	12	0	50
60	0	34	1	98
61	67	59	1	100
62	33	49	0	100
63	0	38	0	94
64	33	56	24	88
69	33	67	31	80
70	33	55	3	100
71	33	42	5	100
72	33	77	41	100
73	100	89	48	99
74	67	97	41	95
75	100	69	16	91
76	100	61	11	89
77	67	43	2	72
79	33	56	4	100
80	0	62	11	85
83	33	22	0	89
84	33	15	0	99
85	33	61	10	95
87				
89	33	15	5	100
90	33	38	5	100
91	0	71	13	100
92	33	18	0	70
106	100	56	10	61
107	0	16	0	59
113	100	68	11	93
114				
115	33	53	8	74
118	67	61	1	91
121	33	59	13	100
122	0	14	0	60

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
124	0	13	0	91
125	100	19	0	58
130	33	22	0	76
149	100	95	49	97
151	33	20	0	72
154	100	41	2	78
157	33	26	0	100
158	67	51	20	95
159	100	92	69	39
160	67	92	69	68
161	100	95	79	69
162	0	45	7	41
163	33	18	0	43
164	67	24	0	47
165	0	16	0	43
166	0	16	0	59
167	100	41	0	79
168	100	25	0	65
169	0	42	0	88
170	33	22	0	60
172	0	56	8	93
173	33	42	3	52
174	0	62	12	84
175				
180	33	28	2	100
181	100	41	6	100
182	100	66	12	100
183	33	18	1	95
184	100	24	0	81
187	33	27	2	64
188	33	33	0	46
189	0	33	1	86
190				
191	33	48	7	100
192	33	49	10	100
193	33	51	19	94
194	100	75	40	81
195	0	28	0	3
196	0	30	10	32

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
197	100	50	24	61
198	33	45	18	74
199	33	41	14	56
200	0	35	6	11
201	0	56	11	36
202	100	49	11	13
203	0	62	11	50
204				
205	33	62	4	50
206	0	52	8	33
207	33	47	4	14
208	0	45	4	32
209	33	46	5	4
210				
212	0	53	9	14
213	0	52	11	27
219	0	45	2	96
222	33	31	9	92
223				
224	0	29	8	83
225	33	32	6	88
227	100	81	7	95
229	33	39	0	79
230	0	80	44	87
231	0	59	20	100
233	100	79	34	86
235	33	74	22	94
236	33	93	41	95
237	33	100	46	95
238	100	74	41	100
239	33	94	40	94
240	0	85	51	100
241	33	93	47	97
242	0	78	27	100
246	0	93	38	95
249	100	68	13	100
250	100	65	12	100
251	100	62	11	100
254	33	80	51	93

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
255				
256	33	80	44	87
258	67	25	0	48
259	100	34	0	100
262	100	41	6	49
263				
264				
265				
266				
267	33	41	3	100
268	0	46	7	100
269	33	72	49	100
270	0	67	52	99
271	0	35	19	100
272	0	47	0	28
273	33	39	7	100
274	33	73	23	100
275	33	14	0	100
276	100	61	14	79
277				
278				
279	0	46	11	9
280	33	95	85	70
281	0	95	88	64
282	0	96	88	48
283	0	97	95	40
284	0	95	100	54
286				
287	33	18	0	64
291	33	28	4	14
292	33	16	0	16
293	0	7	0	84
294	33	52	11	38
296	33	0	0	95
297				
298	33	20	0	99
299	0	13	0	100
300	0	9	0	82
303	33	44	1	100

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
304	33	43	0	100
305	0	42	5	100
306	0	1	0	46
308	33	18	0	97
309	0	3	0	100
310	100	86	75	64
311	33	19	0	100
312	100	22	0	42
313				
314				
315	0	51	10	38
317	0	19	0	46
318	33	48	12	47
319	100	63	12	89
320	100	60	17	0
321				

Weights			
100	60	20	80

Table 6.4. Normalized scores for SMART analysis of South Carolina EOs and weighting scores. Resilience category represents the normalized scoring based on the last known abundance (0=low; 33=moderate; 67=high; 100=very high); MAXENT Mean is the normalized score of the average Maxent rank of all potential habitat; MAXENT percent 0.8-1 represents the normalized score of the percentage of potential habitat that falls within the highest rank category; 80% or greater SLEUTH Percent of Total is the total amount of current urbanization plus predicted urbanization at year 2040 (>80% probability) from the SLEUTH model.

EO not part of a current population

EO included as part of a current population

EO is a part of a current population but last detection was prior to 2005

Eliminated/not scored

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	33	67	14	100
2	33	2	0	96
3				
4	0	42	3	90
5	33	0	0	36

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
6	0	0	0	64
7	100	87	2	65
8	33	0	0	86
9				
10				
11	100	43	0	48
12				
13	0	23	0	0
14	100	43	0	57
15	0	0	0	96
16	100	72	1	62
17	100	70	1	67
18	67	62	0	48
19	0	37	0	35
20	33	16	0	0
21	67	15	0	10
22	0	1	0	100
23				
24	0	13	0	97
25	0	44	0	52
26	100	40	0	35
27	100	56	18	60
28	100	60	28	51
29				
30	33	22	0	12
31	100	0	0	100
32	33	23	0	7
33	33	5	0	80
34	0	100	100	99
35	0	75	34	47
36	33	18	0	100
37	0	78	66	100
38	100	16	0	63
39	0	19	0	99
40	33	18	0	80
41	0	36	0	13
42	33	10	0	94
43	0	72	0	57
44				

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
45				
46	0	32	0	4
47				
48				
49	67	27	0	30
50	33	16	0	46
51	0	1	0	65
52	67	0	0	100
53	33	33	0	34
54	33	29	0	9
55	0	13	0	1
56	33	43	0	4
57	67	47	8	62
59	33	13	0	83
60	100	53	21	88

Weights			
100	60	20	80

To determine a final rank for likelihood of persistence, we calculated a weighted sum for each EO. We then converted the weighted sum to a final rank value that ranged from 0-100. Finally, we determined the top 10% or 90th percentile, and top 25% or 75th percentile ranking for EOs in each state. Table 6.5 summarizes the final ranks and top 10% and 25% percentile ranks for North and South Carolina. We will include the top 10% in the status quo scenario, and the top 25% in the conservation scenario.

Table 6.5. Final Rank Scores for EOs in North and South Carolina. Dark green represents the top 10% of scores, and light green includes the top 25% of scores.

EO not part of a current population
EO included as part of a current population
EO is a part of a current population but last detection was prior to 2005
Eliminated/not scored

South Carolina		North Carolina	
EO_Code	Final Score	EO_Code	Final Score
60	79	149	94
7	79	73	93
17	75	49	92

16	74
27	71
28	70
31	69
14	66
11	63
38	62
34	61
1	60
26	59
52	56
57	56
18	55
37	54
36	48
42	44
2	43
40	42
59	41
49	41
8	39
33	39
4	37
39	35
35	34
43	34
24	33
21	32
22	31
53	31
50	31
15	30
25	26
56	24
5	24
54	22
30	22
32	20
51	20
6	20
19	19

12	90
238	90
161	88
227	87
249	86
233	86
182	85
250	85
251	84
194	84
51	84
310	84
75	84
113	84
319	81
76	81
74	81
10	80
181	79
55	79
37	79
276	78
259	77
159	77
29	76
160	73
167	72
9	72
154	72
23	71
106	71
197	71
61	70
46	70
184	69
237	69
158	68
118	68
241	68
239	67
236	66

20	17
41	12
46	8
13	5
55	3
3	0
9	0
10	0
12	0
23	0
29	0
44	0
45	0
47	0
48	0

14	66
72	64
168	64
254	64
269	64
262	64
280	63
274	62
256	62
125	61
235	60
52	60
16	60
121	58
77	58
85	57
79	57
44	57
70	57
312	56
192	56
56	56
69	55
33	55
30	55
191	55
193	55
64	55
62	55
202	55
240	54
1	54
303	54
246	54
71	54
320	54
304	54
267	53
273	53
90	53
31	53

28	51
242	51
17	51
5	50
180	50
270	50
157	50
222	49
230	49
115	48
281	48
91	48
4	48
298	48
311	48
225	48
198	47
89	47
3	47
84	47
308	47
275	47
183	46
40	46
284	46
258	46
231	46
229	46
58	46
164	46
83	45
282	44
18	44
205	43
172	42
296	42
283	42
268	42
80	41
130	41
174	41

305	41
199	41
271	40
25	40
32	40
219	40
35	40
151	40
54	39
318	39
187	39
173	39
92	39
21	39
60	38
63	38
8	38
294	37
169	37
287	37
170	36
45	36
53	36
188	34
189	34
299	34
38	33
224	33
39	33
36	33
13	32
309	31
124	31
59	31
48	31
34	30
203	30
163	30
207	28
293	27
300	27

57	25
209	25
201	25
315	24
291	24
162	23
20	23
206	23
107	22
166	22
122	22
292	21
213	21
208	20
272	20
317	19
196	18
212	17
165	17
306	14
279	14
200	12
47	10
195	7
2	0
6	0
11	0
15	0
19	0
27	0
50	0
87	0
114	0
175	0
190	0
204	0
210	0
223	0
255	0
263	0
264	0

265	0
266	0
277	0
278	0
286	0
297	0
313	0
314	0
321	0

1113
1114
1115 Below we describe how we integrated potential positive and negative influences across the
1116 scenarios. We can assume there is some tipping point at which an area becomes so urbanized it
1117 is unsuitable for dwarf-flowered heartleaf, but we don't know exactly what that tipping point is.
1118 Similarly, we can assume additional populations are likely to be found or rediscovered across the
1119 range, but there is no clear way to predict the exact number or location of these populations.
1120 Although there is great uncertainty associated with how the species will be influenced by these
1121 factors, the three scenarios are intended to capture the range of this uncertainty. Note, changes in
1122 climate have potential to exacerbate the effects of urbanization, but these effects are not likely to
1123 occur within our projection window (e.g. 2040).

1124 1125 *Status Quo Scenario*

1126 Under the status quo scenario, we assume a few populations will be identified as persisting
1127 throughout the range, and that there will be a range of impacts from urbanization that are related
1128 to the % increase in urban development and whether a population is protected or not. We
1129 assessed population resilience under the following assumptions:

- 1130 ● Two additional populations are identified as persisting based on Maxent model metrics,
1131 last known abundance category, and total predicted urbanization from SLEUTH
1132 modelling. Six additional EOs within currently delineated populations not included in
1133 our Current Conditions analysis are predicted to persist based on the same metrics.
- 1134 ● Potential impacts of urban development based on SLEUTH Model projections focused on
1135 current delineated populations:
 - 1136 ○ Protected areas

- Protected in perpetuity—no negative impacts from urbanization
- Voluntary protection/non-perpetuity—population drops 1 resilience rank if % increase in urbanization exceeds >50% threshold
- Non-protected—population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold

High Development Scenario

Under the high development scenario, we assume no additional populations will be identified as persisting throughout the range, and that impacts from urbanization that are relatively high, and are also affected by whether a population is protected or not. We assessed population resilience under the following assumptions:

- No additional populations are identified as persisting
- Potential impacts of urban development based on SLEUTH Model projections focused on current delineated populations:
 - Protected areas
 - Protected in perpetuity— population drops 1 resilience rank if % increase in urbanization exceeds >50% threshold
 - Voluntary protection/non-perpetuity— population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold
 - Non-protected—population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold; extirpation of populations if % increase in urbanization exceeds >90% threshold.

Targeted Conservation Scenario

Under the targeted conservation scenario, we assume it is likely several additional populations (i.e. more than status quo scenario) will be identified as persisting throughout the range. The

range of impacts from urbanization are the same as the Status Quo scenario. We assessed population resilience under the following assumptions:

- Six populations are identified as persisting based on Maxent model metrics, last known abundance category, and total predicted urbanization from SLEUTH modelling. Six additional EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist based on the same metrics.
- Potential impacts of urban development based on SLEUTH Model projections focused on current delineated populations:
 - Protected areas
 - Protected in perpetuity—no impacts from urbanization
 - Voluntary protection/non-perpetuity—population drops 1 resilience rank if % increase in urbanization exceeds >50% threshold
 - Non-protected—population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold

Future Resilience

Our focus on future resilience of dwarf-flowered heartleaf is on the potential impacts from urbanization. Table 6.6 shows a summary of currently delineated populations and the predicted urban development to occur within each of the populations. The table only includes those populations that already have some current amount of urban development, or are predicted to have some amount of development occur by the year 2040. Populations not included in this table are not predicted to be urbanized at all, so for the purposes of future analysis, will be assumed to retain the same resilience category as current. For those populations included in the table, we focus on those populations that are anticipated to increase in urbanization beyond a threshold value, depending on the scenario, but thresholds include >25% and >50% increases. Also taken into account is whether or not a population is on protected lands, and if so, whether the population is protected in perpetuity or not. Below is a summary of projected future resilience under each of the three scenarios.

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Table 6.6. Results of the SLEUTH model. Populations consist of both stand-alone EOs and aggregates of multiple EOs following the definition of delineating demographic populations from Chapter 4. Included are only those populations that already have some current amount of urban development, or are predicted to have some amount of development occur by the year 2040. Red cells indicate populations that are predicted to increase >50% in urbanization. Orange cells indicate populations that are predicted to increase >25% in urbanization.

Population Number	Total Area (sq m)	Already classed Urban	80% chance	90% chance	95% chance	97.5% chance	100% chance	>80%
206	17346.37096	0.40%	0.00%	0.00%	0.00%	6.24%	93.41%	99.65%
306	7804.656249	0.00%	15.11%	49.91%	7.83%	0.00%	22.40%	95.24%
208	55360.86786	17.31%	0.00%	0.00%	0.00%	0.00%	82.69%	82.69%
279	1951.661571	0.00%	0.00%	0.00%	0.00%	0.00%	80.85%	80.85%
214	15043.2984	0.00%	0.00%	1.44%	10.97%	0.00%	55.72%	68.13%
248	25486.15611	28.80%	0.00%	3.22%	0.02%	0.02%	53.03%	56.30%
316	43177.79587	20.06%	0.00%	16.68%	7.08%	0.00%	20.67%	44.43%
247	49898.17159	5.87%	0.00%	6.37%	0.00%	0.00%	23.35%	29.73%
291	11666.76374	35.39%	12.28%	13.53%	2.43%	0.00%	0.23%	28.47%
287	7901.775408	0.00%	0.00%	11.50%	0.00%	0.00%	14.25%	25.75%
312	6535.273235	0.00%	25.28%	0.00%	0.00%	0.00%	0.00%	25.28%
32	31220.60253	60.74%	0.00%	20.39%	0.00%	0.00%	0.00%	20.39%
177	26954.54153	25.34%	12.19%	0.92%	0.10%	5.31%	0.13%	18.66%
292	15611.18205	0.00%	0.00%	0.00%	0.00%	0.00%	18.40%	18.40%
261	21644.22924	0.00%	0.00%	13.21%	3.35%	0.00%	0.00%	16.56%
295	23486.00987	18.20%	0.00%	3.41%	11.99%	0.25%	0.00%	15.65%
125	20742.3249	0.00%	1.02%	5.65%	0.00%	6.67%	0.00%	13.34%
59	8172.007769	0.00%	13.09%	0.00%	0.00%	0.00%	0.00%	13.09%
302	120342.0641	1.46%	2.55%	2.55%	0.77%	2.33%	3.98%	12.19%
178	376781.2214	28.59%	2.79%	2.40%	0.68%	0.59%	2.64%	9.11%
93	43754.11642	0.19%	0.00%	0.00%	0.00%	0.00%	7.82%	7.82%
77	6044.427562	0.00%	1.51%	6.14%	0.00%	0.00%	0.00%	7.64%
179	15145.19453	85.06%	1.14%	0.00%	5.12%	0.00%	0.49%	6.75%
44	15081.76951	61.17%	0.27%	0.00%	0.00%	0.00%	4.68%	4.95%
252	39595.93143	63.47%	0.00%	3.80%	0.00%	0.00%	0.00%	3.80%
100	423621.7376	9.01%	1.32%	1.10%	0.72%	0.14%	0.00%	3.27%
276	123688.7819	0.61%	0.36%	1.87%	0.01%	0.00%	0.00%	2.24%
216	66424.06073	0.00%	0.91%	0.00%	0.00%	0.00%	0.00%	0.91%
154	33924.92259	0.00%	0.00%	0.37%	0.00%	0.00%	0.00%	0.37%
29	249998.8742	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%	0.05%
1	30711.68144	0.41%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2	36339.91976	11.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3	24498.03483	24.77%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
31	42929.76479	100.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
96	95947.32128	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
130	1168.240433	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
176	39787.48373	0.89%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
195	7805.599588	99.94%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
317	584.7346337	99.70%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
318	5396.859208	99.74%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
320	125.5182447	98.79%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Status Quo Scenario

In the Status Quo scenario, there are predicted to be 75 populations of dwarf-flowered heartleaf on the landscape (Table 6.7). The predicted resilience of the extant populations are as follows:

very high (27); high (6); moderate (23); low (17); and 2 additional populations identified as persisting, with an unknown resilience. Six EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist, but resilience is unchanged because each of the populations are already predicted to be of very high resilience. When comparing future population resilience to current condition a few populations drop in their resilience category. One current population of very high resilience is predicted to drop to high resilience; two moderate populations are predicted to drop to low resilience; and five populations (one currently moderate and four currently low) are predicted to be extirpated due to urban development. Of the seven additional populations predicted to persist under this scenario, four are in South Carolina, and three in North Carolina. We did not assess resilience for these additional populations, but it is worth mentioning that the last time these populations were detected, resilience was very high (2), high (1), and moderate (4).

Table 6.7. Predicted resilience categories for *Hexastylis naniflora* populations under the Status Quo scenario, and comparison to current condition.

Site Name	Current Resilience	Status Quo
DNR Peters Creek Heritage Preserve	very high	very high
Cowpens NBF	very high	very high
Mill Creek Forest and Seep	very high	very high
Island Creek Heath Bluff	very high	very high
NCDOT TIP: R-2824	very high	very high
Murrays Mill/Upper Balls Creek NA	very high	very high
Big Horse Creek Rare Plant Site	very high	very high
Broad River/Sandy Run NA	very high	very high
New Hope Springhead Swamp	very high	very high
Facebook Site	very high	very high
Davenport Road/Mountain View Rare Plant Site	very high	very high
Broad River: Floyds Creek	very high	very high
Catawba River: Hoyle Crk-Micol Crk	very high	very high
South Fork Catawba R: Clark Crk, Miller Br, Cata Mem Hos	very high	very high
Buffalo Creek: Tributaries N and S of SR 2047	very high	high
Buffalo Creek: Kings Mountain Res	very high	very high
Broad River: Brushy Creek	very high	very high
Peaked Top Rare Plant Site/Foothills Landfill	very high	very high
Jacob Fork West Corridor	very high	very high
Floyds Creek Tributary Rare Plant Site	very high	very high

Site Name	Current Resilience	Status Quo
New Bethel Rare Plant Site	very high	very high
Leepers Creek Heartleaf Site	very high	very high
Cliffside Steam Station	very high	very high
Rhyne Conservation Preserve	very high	very high
Glade Creek, Alex County	very high	very high
Richardson Creek trib above Toms Lake	very high	very high
Gunpowder Creek: South of Hudson	very high	very high
Taylor Blaylock Res	very high	very high
Little Gunpowder Creek Rare Plant Site 1	high	high
Little Gunpowder Creek Rare Plant Site 2	high	high
Buffalo Creek Rare Plant Site	high	high
Northern Catawba County	high	high
Rock Barn Solar Farm	high	high
NCDOT TIP R-2824	moderate	moderate
Third Creek Rare Plant Site	moderate	moderate
Knob Creek NA	moderate	moderate
Buffalo Creek: Northeast of SR 1903	moderate	moderate
West Shelby Mesic Slope	moderate	low
Cat Square Heartleaf Forest	moderate	low
Kross Keys NA	moderate	moderate
First Broad River: Crooked Run Creek	moderate	moderate
NCDOT non-TIP Div 12 road const at SR 1115 South Fork Catawba River Jacobs Fork and Camp Creek	moderate	moderate
Catawba River: North Fork Mountain Creek	moderate	moderate
Catawba River: Lake James	moderate	moderate
Hogpen Branch Transplant Site	moderate	moderate
Jonas Road Rare Plant Site	moderate	extirpated
South Fork Catawba River, Henry Fork	moderate	moderate
No Business Creek, Boyd Tract	moderate	moderate
Broad River/Sandy Run NA	moderate	moderate
Buffalo Shoals Creek	moderate	moderate
Fox Knoll Farm	moderate	moderate
Forest City: Adj to Isothermal CC	moderate	moderate
Hickory Area	moderate	moderate
UT of Kings Mountain Res	moderate	moderate
Brushy Creek Headwaters	moderate	moderate
Smith Cliff/Henry Fork River	moderate	moderate
Simms Hill/Little River Uplands	moderate	moderate
Collinsville (Hughes) Creek Slopes	moderate	moderate

Site Name	Current Resilience	Status Quo
Burke County - Drowning Creek UT	moderate	moderate
Sandy Spring Church Springhead Swamp	low	low
First Broad River: Hickory Creek	low	low
Buffalo Creek: Ravine	low	extirpated
Buffalo Creek: Potts Creek	low	extirpated
Smith Cliff/Henry Fork River	low	low
Pott Creek	low	low
Northeast Lincolnton: UT Walker Branch	low	extirpated
Gunpowder Creek	low	low
Killian Crossroads	low	low
Beaverdam Crk at First Broad River	low	low
Lincoln County, SR-1314	low	low
Levan Family Farm	low	low
Fanjoy Road Site	low	extirpated
First Broad River: Beaverdam Creek Tribs	low	low
South Mountains Pleasant Grove Uplands	low	low
NCDOT TIP R-3603A	low	low
Hickory Creek - UT (Shelby High School)	low	low
Boulder Creek Subdivision	low	low
Gateway Elementary School	low	low
First Broad River (North Carolina)	n/a	present
Cherokee Creek/Bonner and Robin School Roads	n/a	present

High Development Scenario

In the High Development scenario, there are predicted to be 72 populations of dwarf-flowered heartleaf on the landscape (Table 6.8). The predicted resilience of the extant populations are as follows: very high (27); high (4); moderate (25); and low (16). No new future populations are predicted to be discovered. When comparing future population resilience to current condition a few populations drop in their resilience category. One current population of very high resilience is predicted to drop to moderate resilience; one high resilience population is predicted to drop to moderate; two moderate populations are predicted to drop to low resilience; and six populations (one currently moderate and five currently low) are predicted to be extirpated due to urban development.

Table 6.8. Predicted resilience categories for *Hexastylis naniflora* populations under the High Development scenario, and comparison to current condition.

Site Name	Current Resilience	High Development
DNR Peters Creek Heritage Preserve	very high	very high
Cowpens NBF	very high	very high
Mill Creek Forest and Seep	very high	very high
Island Creek Heath Bluff	very high	very high
NCDOT TIP: R-2824	very high	very high
Murrays Mill/Upper Balls Creek NA	very high	very high
Big Horse Creek Rare Plant Site	very high	very high
Broad River/Sandy Run NA	very high	very high
New Hope Springhead Swamp	very high	very high
Facebook Site	very high	very high
Davenport Road/Mountain View Rare Plant Site	very high	very high
Broad River: Floyds Creek	very high	very high
Catawba River: Hoyle Crk-Micol Crk	very high	very high
South Fork Catawba R: Clark Crk, Miller Br, Cata Mem Hos	very high	very high
Buffalo Creek: Tributaries N and S of SR 2047	very high	moderate
Buffalo Creek: Kings Mountain Res	very high	very high
Broad River: Brushy Creek	very high	very high
Peaked Top Rare Plant Site/Foothills Landfill	very high	very high
Jacob Fork West Corridor	very high	very high
Floyds Creek Tributary Rare Plant Site	very high	very high
New Bethel Rare Plant Site	very high	very high
Leepers Creek Heartleaf Site	very high	very high
Cliffside Steam Station	very high	very high
Rhyne Conservation Preserve	very high	very high
Glade Creek, Alex County	very high	very high
Richardson Creek trib above Toms Lake	very high	very high
Gunpowder Creek: South of Hudson	very high	very high
Taylor Blaylock Res	very high	very high
Little Gunpowder Creek Rare Plant Site 1	high	high
Little Gunpowder Creek Rare Plant Site 2	high	high
Buffalo Creek Rare Plant Site	high	high
Northern Catawba County	high	moderate
Rock Barn Solar Farm	high	high
NCDOT TIP R-2824	moderate	moderate
Third Creek Rare Plant Site	moderate	moderate
Knob Creek NA	moderate	moderate
Buffalo Creek: Northeast of SR 1903	moderate	moderate
West Shelby Mesic Slope	moderate	low
Cat Square Heartleaf Forest	moderate	low

Site Name	Current Resilience	High Development
Kross Keys NA	moderate	moderate
First Broad River: Crooked Run Creek	moderate	moderate
NCDOT non-TIP Div 12 road const at SR 1115 South Fork Catawba River Jacobs Fork and Camp Creek	moderate	moderate
Catawba River: North Fork Mountain Creek	moderate	moderate
Catawba River: Lake James	moderate	moderate
Hogpen Branch Transplant Site	moderate	moderate
Jonas Road Rare Plant Site	moderate	extirpated
South Fork Catawba River, Henry Fork	moderate	moderate
No Business Creek, Boyd Tract	moderate	moderate
Broad River/Sandy Run NA	moderate	moderate
Buffalo Shoals Creek	moderate	moderate
Fox Knoll Farm	moderate	moderate
Forest City: Adj to Isothermal CC	moderate	moderate
Hickory Area	moderate	moderate
UT of Kings Mountain Res	moderate	moderate
Brushy Creek Headwaters	moderate	moderate
Smith Cliff/Henry Fork River	moderate	moderate
Simms Hill/Little River Uplands	moderate	moderate
Collinsville (Hughes) Creek Slopes	moderate	moderate
Burke County - Drowning Creek UT	moderate	moderate
Sandy Spring Church Springhead Swamp	low	low
First Broad River: Hickory Creek	low	low
Buffalo Creek: Ravine	low	extirpated
Buffalo Creek: Potts Creek	low	extirpated
Smith Cliff/Henry Fork River	low	low
Pott Creek	low	low
Northeast Lincolnton: UT Walker Branch	low	extirpated
Gunpowder Creek	low	extirpated
Killian Crossroads	low	low
Beaverdam Crk at First Broad River	low	low
Lincoln County, SR-1314	low	low
Levan Family Farm	low	low
Fanjoy Road Site	low	extirpated
First Broad River: Beaverdam Creek Tribs	low	low
South Mountains Pleasant Grove Uplands	low	low
NCDOT TIP R-3603A	low	low
Hickory Creek - UT (Shelby High School)	low	low
Boulder Creek Subdivision	low	low

Site Name	Current Resilience	High Development
Gateway Elementary School	low	low

Targeted Conservation Scenario

In the Targeted Conservation scenario, there are predicted to be 79 populations of dwarf-flowered heartleaf on the landscape (Table 6.9). The predicted resilience of the extant populations are as follows: very high (27); high (6); moderate (23); low (17); and 6 additional populations discovered to persist, with an unknown resilience. Six EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist, but resilience is unchanged because each of the populations are already predicted to be of very high resilience. When comparing future population resilience to current condition a few populations drop in their resilience category. One current population of very high resilience is predicted to drop to high resilience; two moderate populations are predicted to drop to low resilience; and five populations (one currently moderate and four currently low) are predicted to be extirpated due to urban development. Of the sixteen additional populations predicted to persist under this scenario, ten are in South Carolina, and six in North Carolina. We did not assess resilience for these additional populations, but it is worth mentioning that the last time these populations were detected, resilience was very high (2), high (1), moderate (11), and low (2).

Table 6.9. Predicted resilience categories for *Hexastylis naniflora* populations under the Targeted Conservation scenario, and comparison to current condition.

Site Name	Current Resilience	Targeted Conservation
DNR Peters Creek Heritage Preserve	very high	very high
Cowpens NBF	very high	very high
Mill Creek Forest and Seep	very high	very high
Island Creek Heath Bluff	very high	very high
NCDOT TIP: R-2824	very high	very high
Murrays Mill/Upper Balls Creek NA	very high	very high
Big Horse Creek Rare Plant Site	very high	very high
Broad River/Sandy Run NA	very high	very high
New Hope Springhead Swamp	very high	very high
Facebook Site	very high	very high
Davenport Road/Mountain View Rare Plant Site	very high	very high

Site Name	Current Resilience	Targeted Conservation
Broad River: Floyds Creek	very high	very high
Catawba River: Hoyle Crk-Micol Crk	very high	very high
South Fork Catawba R: Clark Crk, Miller Br, Cata Mem Hos	very high	very high
Buffalo Creek: Tributaries N and S of SR 2047	very high	high
Buffalo Creek: Kings Mountain Res	very high	very high
Broad River: Brushy Creek	very high	very high
Peaked Top Rare Plant Site/Foothills Landfill	very high	very high
Jacob Fork West Corridor	very high	very high
Floyds Creek Tributary Rare Plant Site	very high	very high
New Bethel Rare Plant Site	very high	very high
Leepers Creek Heartleaf Site	very high	very high
Cliffside Steam Station	very high	very high
Rhyne Conservation Preserve	very high	very high
Glade Creek, Alex County	very high	very high
Richardson Creek trib above Toms Lake	very high	very high
Gunpowder Creek: South of Hudson	very high	very high
Taylor Blaylock Res	very high	very high
Little Gunpowder Creek Rare Plant Site 1	high	high
Little Gunpowder Creek Rare Plant Site 2	high	high
Buffalo Creek Rare Plant Site	high	high
Northern Catawba County	high	high
Rock Barn Solar Farm	high	high
NCDOT TIP R-2824	moderate	moderate
Third Creek Rare Plant Site	moderate	moderate
Knob Creek NA	moderate	moderate
Buffalo Creek: Northeast of SR 1903	moderate	moderate
West Shelby Mesic Slope	moderate	low
Cat Square Heartleaf Forest	moderate	low
Kross Keys NA	moderate	moderate
First Broad River: Crooked Run Creek	moderate	moderate
NCDOT non-TIP Div 12 road const at SR 1115 South Fork Catawba River Jacobs Fork and Camp Creek	moderate	moderate
Catawba River: North Fork Mountain Creek	moderate	moderate
Catawba River: Lake James	moderate	moderate
Hogpen Branch Transplant Site	moderate	moderate
Jonas Road Rare Plant Site	moderate	extirpated
South Fork Catawba River, Henry Fork	moderate	moderate
No Business Creek, Boyd Tract	moderate	moderate
Broad River/Sandy Run NA	moderate	moderate

Site Name	Current Resilience	Targeted Conservation
Buffalo Shoals Creek	moderate	moderate
Fox Knoll Farm	moderate	moderate
Forest City: Adj to Isothermal CC	moderate	moderate
Hickory Area	moderate	moderate
UT of Kings Mountain Res	moderate	moderate
Brushy Creek Headwaters	moderate	moderate
Smith Cliff/Henry Fork River	moderate	moderate
Simms Hill/Little River Uplands	moderate	moderate
Collinsville (Hughes) Creek Slopes	moderate	moderate
Burke County - Drowning Creek UT	moderate	moderate
Sandy Spring Church Springhead Swamp	low	low
First Broad River: Hickory Creek	low	low
Buffalo Creek: Ravine	low	extirpated
Buffalo Creek: Potts Creek	low	extirpated
Smith Cliff/Henry Fork River	low	low
Pott Creek	low	low
Northeast Lincolnton: UT Walker Branch	low	extirpated
Gunpowder Creek	low	low
Killian Crossroads	low	low
Beaverdam Crk at First Broad River	low	low
Lincoln County, SR-1314	low	low
Levan Family Farm	low	low
Fanjoy Road Site	low	extirpated
First Broad River: Beaverdam Creek Tribs	low	low
South Mountains Pleasant Grove Uplands	low	low
NCDOT TIP R-3603A	low	low
Hickory Creek - UT (Shelby High School)	low	low
Boulder Creek Subdivision	low	low
Gateway Elementary School	low	low
First Broad River (North Carolina)	n/a	present
First Broad Hop-Hornbeam NA	n/a	present
Big Island Carolina Hemlock Bluff	n/a	present
Cherokee Creek/Bonner and Robin School Roads	n/a	present
Arrowood Branch	n/a	present
Cherokee Creek/SC 11	n/a	present

1281

1282 *Viability Summary*

Urban development is predicted to have negative impacts on several of the current populations under all of our scenarios. However, this loss of resilience and extirpation of a few populations is offset by the fact that several additional populations were found to persist in the Status Quo and Targeted Conservation scenarios. In the High Development Scenario, there is a predicted loss of 6 populations, with loss of resilience in several additional populations. Regardless of the scenario, the majority of the populations expected to persist on the landscape in 2040 are of at least moderate resilience.

Given the relatively high number of populations across each scenario, redundancy remains similar to current conditions. That is to say, there appears to be adequate redundancy within the range of dwarf-flowered heartleaf to withstand the impacts of localized press catastrophic disturbances, however the species range is relatively small, making it potentially vulnerable to long-term catastrophic events, such as climate change.

Given that dwarf-flowered heartleaf has a very limited range, and after consulting with experts, we decided delineating representative units was not appropriate for this species. It is worth noting that in two of our scenarios (Status Quo and Targeted Conservation), additional populations are found to persist in South Carolina, an area where we have relatively few current populations. As discussed below, we believe there are opportunities to find additional populations based on the amount of predicted unoccupied potential habitat. Although we did not delineate representative units, we believe our scenarios do not predict declines in species representation.

Table 6.10. Viability summary for *Hexastylis naniflora* under 3 future scenarios (projected to year 2040) and compared to Current Condition.

	CURRENT	STATUS QUO	HIGH DEVELOPMENT	TARGETED CONSERVATION
VERY HIGH	28	27	27	27
HIGH	5	6	4	6
MODERATE	26	23	25	23
LOW	19	17	16	17

EXTIRPATED	n/a	5	6	5
PERSISTING	n/a	2	0	6
TOTAL	78	75	72	79

Opportunities for Additional Conservation

Although our scenarios focus on areas where dwarf-flowered heartleaf have been found in the past, the Maxent model identifies a number of areas as high quality potential habitat for the species that falls outside the immediately known occurrence areas. A few of these areas are detailed below (Figure 6.2).

1. West of the city of Lenoir, south of Highway 90/Adako Rd., north of Highway 64 within Caldwell County. This area identifies a large block of potential habitat. This area falls just outside the administrative boundary of the Pisgah National Forest. The bluffs and tributaries along the Johns River are identified as the best habitat, but there is also ample habitat identified along the forested areas of Celia, Husband, Abingdon and Greasy Creeks. The only known occurrence within this area is associated with Abingdon Creek and is under a conservation easement.
2. Henry Fork River bluffs and tributaries east of Highway 18 within Burke County. A historic element occurrence is present by the Burke County line, but the entire area is identified as good quality potential habitat for the species where forested habitats remain.
3. South West corner of Catawba County west of Highway 321. Several disjointed patches of high quality potential habitat are identified in this region associated with the river and creek slopes. Rock Creek, Jacob Fork River, Pott Creek, and their associated tributaries all contain blocks of potential habitat. A number of element occurrences are identified within this area, but additional habitat is identified both upstream and downstream of the known occurrences.
4. Clark, Pinch Gut, Maiden, and Allen Creeks, north of the town of Maiden. The slopes along these creeks all contain quality potential habitat. Known element occurrences are in the general area, but none are situated within the creeks listed.

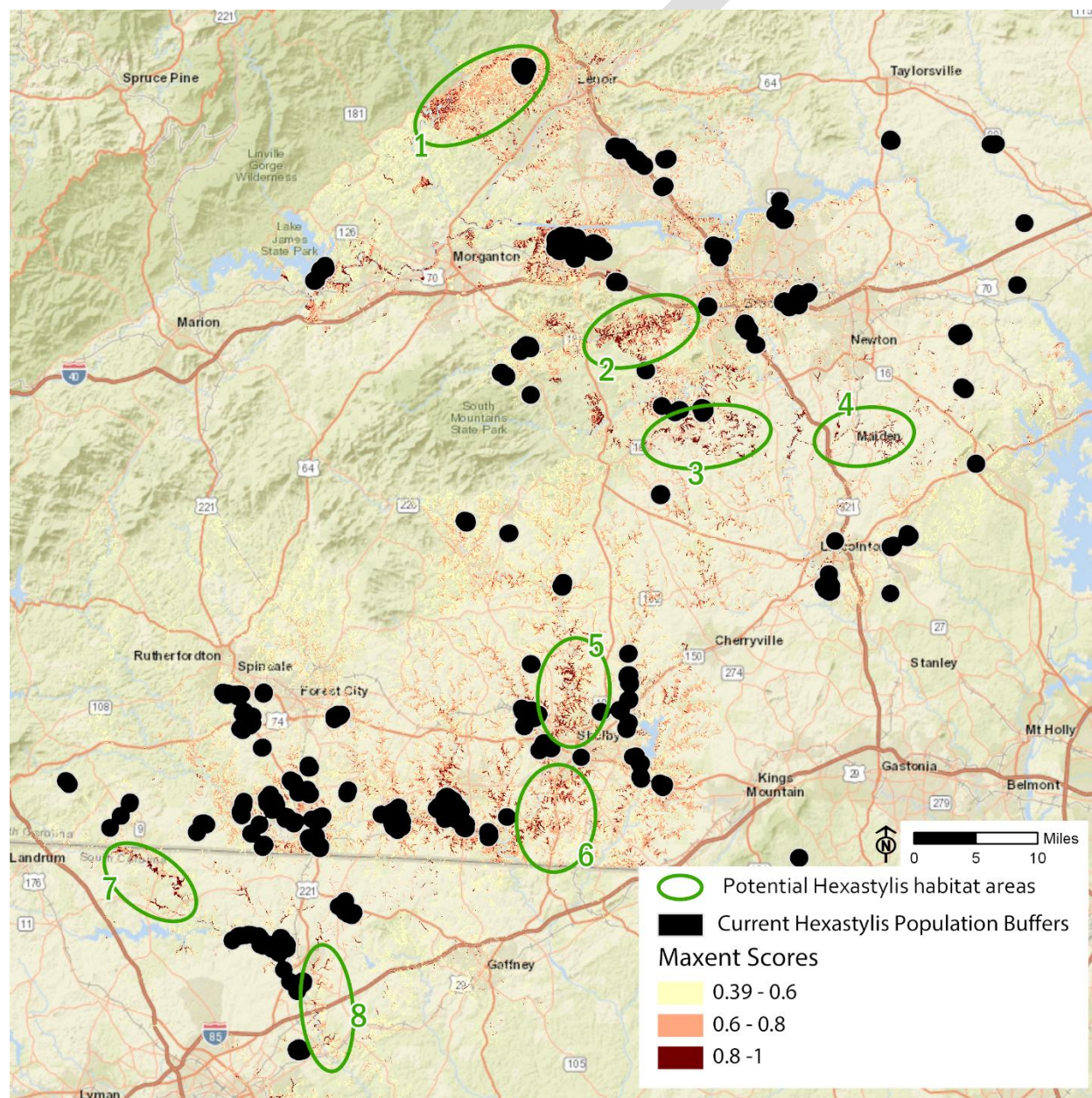
5. First Broad River North of Highway 74, Rutherford County. Two older element occurrences are located within this area, however, the forested bluffs along the First Broad River and associated tributaries are identified as good quality potential habitat in many additional upstream and downstream areas in this system.

6. Hickory Creek, Sulphur Springs Branch (Little Hickory), Shoal Creek, and tributaries draining into First Broad River South of the Town of Shelby, north of the South Carolina border. The town of Shelby has likely disconnected this site from area 5 listed above. Here, slopes along the creeks and tributaries draining into the First Broad River are identified as potential habitat more so than the slopes along the First Broad River themselves. There is only a single element occurrence known upstream along Hickory Creek.

7. North Pacolet River and Obed Creek, north of where they join. The majority of potential habitat falls along the slopes of the North Pacolet River. Two older element occurrences (1991 last observation) are found in the tributaries draining into the North Pacolet River, and many occurrences are found further upstream. The habitat model suggests that additional undiscovered habitat areas are present.

8. Pacolet River and Island Creek, north of Peters Creek, downstream of the Pacolet River dam. This area displays limited amounts of good quality potential habitat. Recent element occurrences are present in the upper headwaters of Peters and Zekial Creeks (Zekial Creek drains into Peters Creek) and in areas north of the Pacolet River dam, but none are known along the areas identified in this immediate area.

Figure 6.2. Areas identified as high quality potential habitat by Maxent model for *Hexastylis naniflora* that fall outside the immediately known occurrence areas.



Literature Cited

- Amoroso, J.L. 2016. *Hexastylis naniflora* status meeting with USFWS, NCNHP, ASU, and NCDOT [meeting minutes]. North Carolina Department of Natural and Cultural Resources office, Asheville, NC, 11 May 2016.
- Baldwin, R.A. 2009. Use of maximum entropy modeling in wildlife research. *Entropy*. 11:854-866.
- Barringer, K. 1993. New combinations in North American *Asarum* (Aristolochiaceae). *Novon* 3:225-227.
- Blomquist, H.L. 1957. A Revision of *Hexastylis* in North America. *Brittonia* 8:255-281.
- Clarke, K.C., Riggan, P., and Brass, J.A., 1995. A cellular automaton model of wildfire propagation and extinction, *Photogram. Eng. Rem S.* 60, 1355-1367.
- Dobzhansky, T. 1937. *Genetics and the origin of species*. Columbia University Press, New York, NY.
- DeWan, A., N. Dubois, K. Theoharides, and J. Boshoven. 2010. Understanding the impacts of climate change on fish and wildlife in North Carolina.
- Flora of North America 1997. *Flora of North America north of Mexico*. Volume 3, Magnoliophyta: Magnoliidae and Hamamelidae. Oxford University Press, New York, NY. 590 pp. Contains Whittmore and Gaddy's treatment of *Asarum* and *Hexastylis*.
- Gaddy, L.L. 1980. Status Report on *Hexastylis naniflora* Blomquist. Prepared for and submitted to USFWS, Endangered Species Office, Region 4, Atlanta, Georgia. July 1980.
- Gaddy, L.L. 1981. The status of *Hexastylis naniflora* Blomquist in North Carolina. Unpublished report prepared under contract to the Plant Conservation Program, North Carolina Department of Agriculture, Raleigh.
- Gaddy, L. 1986. Twelve new ant-dispersed species from the southern Appalachians. *Bulletin of the Torrey Botanical Club* 113: 247-251.
- Gaddy, L.L. 1987. A review of the taxonomy and biogeography of *Hexastylis* (Aristolochiaceae). *Castanea* 52(3):186-196.
- Golder Associates, Inc. 2009. Year 5 Monitoring Report, *Hexastylis naniflora*, Foothills Conservation Area, Caldwell County, North Carolina. Submitted to: Republic Services of North Carolina, LLC; copies (per cover letter) distributed to US Army Corps of Engineers, Asheville Regulatory Office and USFWS Asheville ES Office. June 26, 2009.

- Golladay SW, Gagnon P, Kearns M, Battle JM. Hicks DW. Response of freshwater mussel assemblages (Bivalvia: Unionidae) to a record drought in the Gulf Coastal Plain of southwest Georgia. *J. N. Am. Benthol. Soc.* 2004;23:494–506.
- Gonzalez, V. C. 1972. The ecology of *Hexastylis arifolia*, an evergreen herb in the North Carolina deciduous forest. Ph.D. dissertation, Duke University. Durham, North Carolina, USA. HDR. 2005. Identification of *Hexastylis naniflora*. Notes on characteristics and field observations provided to the North Carolina Natural Heritage Program, Raleigh.
- IPCC, 2013: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
- Jones M.S., T. H. Jones, and J. J. English. 2014. The Pollination of *Hexastylis naniflora* in Cleveland County, North Carolina. *Castanea*: June 2014, Vol. 79, No. 2, pp. 74-77.
- Jordan, Jones and Goulding (JJ&G), Inc. 1998. Section 404 Application and Conceptual Mitigation Plan, Lake Blalock Expansion Project. USFWS Log number 4-6-97-358. ACOE Project # 80-97-1732 (S). Section 9: *Hexastylis naniflora* Biological Assessment. Received by the Asheville Field Office July 16, 1998.
- Jordan, Jones and Goulding (JJ&G), Inc. 2006. Lake Blalock Buffer Disturbance – Vicinity of Casey Creek Road. Memorandum to: Eddie Dearbury, Spartanburg Water Systems. Date: October 25, 2006.
- Karl, T. R., Melillo, J. M., & Peterson, T. C. (Eds.). (2009). *Global Climate Change Impacts in the United States*. Washington, DC: U.S. Global Change Research Program.
- Kelly, L. M. 1997. A Cladistic Analysis of *Asarum* (Aristolochiaceae) and Implications for the Evolution of Herkogamy. *American Journal of Botany* 84:1752-1765.
- Kelly, L. M. 1998. Phylogenetic Relationships in *Asarum* (Aristolochiaceae) Based on Morphology and ITS Sequences. *American Journal of Botany* 85:1454-1467.
- Kelly, L. M. 2001. Taxonomy of *Asarum* Section *Asarum* (Aristolochiaceae). *Systematic Botany* 26:17-53.
- Lengyel, S., A. D. Gove, A. M. Latimer, J. D. Majer, and R. R. Dunn. 2010. Convergent evolution of seed dispersal by ants, and phylogeny and biogeography in flowering plants: A global survey. *Perspectives in Plant Ecology, Evolution and Systematics* 12: 43-55.
- McLaughlin, J.F. et al. (2002). Climate change hastens population extinctions. *Proceedings of the National Academy of Sciences* 99(9): 6070–6074.
- Murrell, Z. et al. 2007. Ecological, Morphological, Micromorphological and Molecular Analyses of the Species in the *Hexastylis heterophylla* Complex. A report to the North Carolina

- Department of Transportation. NCDOT and CTE Joint Project 2002-2004, FHWA/NC/2004-01. May 2007.
- Murrell, Z. 2015. Development of molecular and morphological tools to circumscribe and identify the Dwarf Flowered Heartleaf (*Hexastylis naniflora*). Report to the North Carolina Department of Transportation, NCDOT Project 2012-2111, July 2015.
- National Climate Change Viewer. 2016. USGS. Accessed at https://www2.usgs.gov/climate_landuse/clu_rd/nccv.asp, January 2018.
- NatureServe. 2002. Element Occurrence Data Standard, 6 February 2002. NatureServe, Arlington, Virginia. Accessed at http://www.natureserve.org/library/deliminting_plant_eos_Oct_2004.pdf, August 2016.
- NCOSBM. North Carolina Budget and Management County and State Population Projections. Accessed at <https://www.osbm.nc.gov/demog/county-projections>, March 2018.
- Newberry, G. 2006. South Carolina Populations of *Hexastylis naniflora*: 2006 updates. Received by the USFWS Asheville Field Office, September 7, 2006.
- Newberry, G. 2009. University of South Carolina at Spartanburg. Evaluation of damage to *Hexastylis naniflora* plants on acreage bordering the hunt club. Letter to Jon Morgan, Lake Warden, Spartanburg Water Systems. Dated February 24, 2009.
- North Carolina Natural Heritage Program (NCNHP). 2016. Element Occurrence Records for *Hexastylis naniflora* (dwarf-flowered heartleaf). As of: August 5, 2016.
- North Carolina Natural Heritage Program (NCNHP). 2018. Natural Heritage Element Occurrences. Accessed at <https://www.ncnhp.org/activities/conservation/natural-heritage-element-occurrences>, January 2018.
- Newberry, G. 1993. Progress Report on Monitoring Studies of *Hexastylis naniflora*. Unpublished report. Copy submitted to the USFWS Asheville Field Office, on September 7, 2006.
- Niedenberger, B.A. 2010. Molecular phylogeny and comparative pollen morphology of the genus *Hexastylis* (Aristolochiaceae). M.S. thesis. Appalachian State University, Boone, NC.
- Otte, D. 1977. The pollination biology of *Hexastylis arifolia* (Michx.) Small var. *arifolia* and *H. minor* (Ashe) Blomquist (Aristolochiaceae) in the area of Chapel Hill, North Carolina. M.S. Thesis, University of North Carolina Chapel Hill, Chapel Hill, North Carolina, USA.
- Padgett, J. E. 2004. Biogeographical, ecological, morphological, and micromorphological analyses of the species in the *Hexastylis heterophylla* complex. M.S. thesis. Appalachian State University, Boone, NC.

- Phillips, S. J. 2018. A Brief Tutorial on Maxent. Available from url:
http://biodiversityinformatics.amnh.org/open_source/maxent/. Accessed on 2018-02/21.
- Renninger, H. 2010. North Carolina Department of Transportation (NCDOT). E-mail communication to Carolyn Wells, USFWS Asheville Field Office. Date: May 28, 2010. Subject: Dwarf-flowered heartleaf research proposal.
- Robinson L.G. 2016. Dwarf-flowered Heartleaf range-wide status report. Final report to U.S. Department of Interior—U.S. Fish and Wildlife Service by North Carolina Natural Heritage Program. August 2016.
- Robinson, L.G. and J.E. Padgett. 2016. Dwarf-flowered Heartleaf (*Hexastylis naniflora*) comprehensive review and monitoring report. Final report to the U.S. Department of Interior—U.S. Fish and Wildlife Service by the North Carolina Natural Heritage Program. August 2016.
- Schneider, S. 2006. Spartanburg Water System (SWS) & Sanitary Sewer District, Assistant General Manager. E-mail communication to Lora Zimmerman, USFWS (formerly with the Charleston Field Office), dated December 18, 2006. Subject: Meeting at SWS on December 21, 2006 [to discuss Lake Blalock Buffer Disturbance].
- South Carolina Department of Natural Resources (SCDNR) Heritage Trust. 2016. Element Occurrence Records for *Hexastylis naniflora* (dwarf-flowered heartleaf). As of: February 4, 2016.
- USFWS. 2001. Biological Opinion for Spartanburg Water System, Lake Blalock, P/N 2000-IP-194-W, USFWS log number 4-6-01-F-115. May 10, 2001.
- USFWS. 2010. Draft Five Year Review for *Hexastylis naniflora* (dwarf flowered heartleaf). September 30, 2010. Submitted to the USFWS Southeast Regional Office September 30, 2010.
- USFWS. 2015, August. Fact sheet for *Hexastylis naniflora*. Retrieved from https://www.fws.gov/raleigh/species/es_dwarf-flowered_heartleaf.html.
- USFWS. 2016. USFWS species status assessment framework: an integrated analytical framework for conservation. Version 3.4.8, August 2016.
- Wagner, J. 2013. Developing new morphological, geographic, and molecular tools to circumscribe *Hexastylis naniflora*. M.S. thesis. Appalachian State University, Boone, NC.
- Walker, J. et al. 2009. What are the effects of prescribed fire on *Hexastylis naniflora*, a federally protected plant species? Unpublished final report prepared by U.S. Forest Service, Southern Research Station, Clemson University, Clemson, SC. Submitted to Timothy Stone, Superintendent, Cowpens National Battlefield. In partial fulfillment for Agreement

- 04-IA-11330138-234, between the NPS and USFS Southern Research Station. Revised March 19, 2009.
- Warren II, R. J., 2008. Mechanisms driving understory evergreen herb distributions across slope aspects: as derived from landscape position. *Plant Ecology* 198: 297-308.
- Weakley, A. 2010. Flora of the Southern and Mid-Atlantic States. University of North Carolina Herbarium (NCU), North Carolina Botanical Garden, University of North Carolina at Chapel Hill. Working Draft as of March 8, 2010.
- Weakley, A. 2015. Flora of the Southern and Mid-Atlantic States. University of North Carolina Herbarium (NCU), North Carolina Botanical Garden, University of North Carolina at Chapel Hill. Working Draft as of 21 May 2015.
- Whittemore, A. T., and L. L. Gaddy. 1997. Hexastylis. In Flora of North America Editorial Committee [Eds.], Flora of North America north of Mexico, vol. 3, 54–58. Oxford University Press, New York, New York, USA.
- Wolf, S., B. Hartl, C. Carroll, M.C. Neel, and D.N. Greenwald. 2015. Beyond PVA: why recovery under the Endangered Species Act is more than population viability. *BioScience* 65:200-207.

Name	Chapter	Page	Line #	Comment
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Briefing Paper for Departmental Clearance of *Federal Register* Documents

I. Subject: Proposed Delisting Rule for Dwarf-flowered heartleaf

II. RIN (for rulemaking documents): 1018-BD95

III. Docket or tracking number: FWS-R4-ES-2019-0081

IV. DCN (from DTS):

V. Summary: We are proposing to delist the dwarf-flowered heartleaf (*Hexastylis naniflora*). This recommendation is based on a thorough review of the best available scientific and commercial information, which indicates that this species does not meet the definition on an endangered species or threatened species.

VI. Is the action controversial? ☐ Yes. ☒ No.

Commented [KNN1]: Since we answer no to this question, we don't need to answer VIa - VIc

If yes, please answer the following:

a. ~~What are the controversial issues? We are not aware of any controversy regarding this proposed reclassification.~~

a.

b. Who will care about these issues? ~~Interested parties includes state agencies in North Carolina and South Carolina and conservation groups.~~

c. How strongly will they care? ~~We do not anticipate interested parties to speak out strongly regarding this proposed determination. Interested parties will have ample time to provide comments during the 60-day comment period following the publication of this proposed rule in the Federal Register.~~

VII. Communications:

a. Has the bureau communications office coordinated with DOI communications staff?

☒ Yes. ☐ No.

If yes, please note whom you contacted and how (e.g., email, voicemail):

Brian Hires via email.

b. Does this document require a press release?

☒ Yes. ☐ No.

Press release title: Conservation Success Story: Threatened Plant Proposed for Removal from Endangered species List

Press release first paragraph: Tens of thousands of threatened dwarf-flowered heartleaf plants are conserved by Duke Energy along the Broad River. Another population is conserved at Cowpens National Battlefield, in upstate South Carolina. A third is part of the Broad River Greenway, a local park in North Carolina's Cleveland County. These are three of many conservation efforts for the heartleaf, leading the U.S. Fish and Wildlife Service (Service) to propose removing it from the federal threatened and endangered species list.

VIII. Is timing critical? ☒ Yes. ☐ No.

Target date to clear DOI: 9/30/2019, or as priorities allow.

No-later-than date to clear DOI (if applicable): 9/30/2019.

If you provided an NLT date, please answer the following:

a. What is the main driver of the timing? ~~This is on the DOI priority worksheet. This action is on our National Delisting/ Downlisting Workplan for FY19~~

b. What happens if the deadline is missed? ~~Our commitment to our conservation partners to follow through with our recommendations in a timely manner will not be met.~~

Commented [FB2]: These are not realistic dates. Please remove and do not include a date.

IX. Background ~~(use this space to provide additional helpful information):~~ ~~The dwarf-flowered heartleaf is a low growing herbaceous plant in the birthwort family.~~ On April 14, 1989, we published a final rule in the Federal Register (FR 54 14964) listing the dwarf-flowered heartleaf as threatened due to residential and industrial development, conversion of habitat to pasture or small ponds, timber harvesting and cattle grazing (FR 54 14964). ~~A recovery plan for the species was never completed. Over the last 29 years, the Service has worked closely with partners to recover this species. A recovery plan for the species was never completed. However, over the last 29 years, the Service has worked closely with partners to recover this species. The Service initiated a Species Status Assessment (SSA) to aid in determining the appropriateness of reclassifying the species in 2018. The dwarf-flowered heartleaf is a low growing herbaceous plant in the birthwort family.~~ When dwarf-flowered heartleaf was federally listed in 1989, the listing rule described 24 extant "populations" (and one extirpated population) distributed across eight counties in the upper Piedmont of North and South Carolina. ~~Since 1989, the range has expanded to include five additional counties in North Carolina. In North Carolina, it is found in Alexander, Burke, Caldwell, Catawba, Cleveland, Gaston, Iredell, Lincoln, Polk, and Rutherford Counties. In South Carolina, it is in Cherokee, Greenville, and Spartanburg Counties.~~ As of 2018, the distribution of this species consisted of 119 populations distributed across 13 counties in these two states. ~~We Therefore, we~~ propose to ~~remove-delist~~ the dwarf-flowered heartleaf (*Hexastylis naniflora*), from the Federal List of Endangered and Threatened Wildlife (List), due

Commented [KNN3]: Which of these are the original 8 counties and which of them are the 5 new counties the species has expanded into?

to recovery. ~~This determination is based on the best available scientific and commercial data, which indicate that the threats to the species have been eliminated or reduced to the point that the species has recovered and no longer meets the definition of an endangered or a threatened species under the Endangered Species Act of 1973, as amended (Act).~~

X. Is there an information collection associated with this document?

☐ Yes. ☒ No.

If yes, please answer the following:

a. Does the document have any approved OMB control number(s)? ☐ Yes. ☐ No.

If yes, provide the OMB control number(s) and expiration date(s):

b. Does the document require ☐ a new OMB control number or ☐ a renewal of an existing approval?

If a new number or a renewal is required, what is the current status?

XI. Approval is requested to send the document to:

☒ The Office of the Federal Register for publication, or

☐ OIRA for review.

XII. Primary contact:

Name: Gary Frazier, Assistant Director, ~~Ecological Services~~

Phone: 202-208-4646

Email: gary_frazier@fws.gov

Scenarios	Urbanization			Non-Current Populations Predicted to Persist
	Protected Areas		Non-Protected Areas	
	Perpetuity	Voluntary/Non-Perpetuity		
Status Quo	No change.	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	EOs prior to 2005 in the top 10% based on weighted ranking.
High Development	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2 If increase in urbanization is >90% THEN extirpation	None
Conservation	No change.	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	EOs prior to 2005 in the top 25% based on weighted ranking.

Chapter 1: INTRODUCTION

The dwarf-flowered heartleaf (*Hexastylis naniflora*) is a ~~species of~~ plant endemic to the upper Piedmont region of western North Carolina and upstate South Carolina. ~~The dwarf-flowered heartleaf~~ has been listed as threatened under the Endangered Species Act of 1973, as amended (Act), since 1989 (FR 54 14964-14967). The Species Status Assessment (SSA) framework (USFWS 2016, entire) summarizes the information compiled and reviewed by the US Fish and Wildlife Service (Service), incorporating the best available scientific and commercial data, to conduct an in-depth review of the species' biology and threats, evaluate its biological status, and assess the resources and conditions needed to maintain long-term viability. Importantly, the SSA does not result in a decision by the Service on whether this species should be proposed for reclassification under the Act. The intent is for the SSA to be easily updated as new information becomes available and to support all functions of the Endangered Species Program from listing to consultations to recovery.

A ~~Recovery recovery Plan plan~~ for the species was never completed, ~~h~~. However, over the last 29 years, the Service has worked closely with partners to make significant progress toward recovery of the species. The Service ~~is initiating~~ initiated this SSA to aid in determining the appropriateness of reclassifying the species. ~~In the event that the SSA does not support reclassification~~ Should the species not be reclassified, the SSA will ~~be used to inform the recovery plan development~~ development of a Recovery Plan. ~~Importantly, the SSA does not result in a decision by the Service on whether this species should be proposed for reclassification under the Act. Instead, this SSA provides a review of the available information strictly related to the biological status of the dwarf-flowered heartleaf. The reclassification decision will be made by the Service after reviewing this document and all relevant laws, regulations, and policies. The results of a proposed decision will be announced in the *Federal Register*, with appropriate opportunities for public input.~~

For the purpose of this assessment, we generally define viability as the ability of the species to sustain populations in its natural ~~systems~~ habitat over time. Using the SSA framework (Figure

1.1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation (Wolf *et al.* 2015, entire).

- **Resiliency** describes the ability of populations to withstand stochastic events (arising from random factors). We can measure resiliency based on metrics of population health; for example, birth versus death rates and population size. Highly-resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities.
- **Redundancy** describes the ability of a species to withstand catastrophic events. Measured by the number of populations, their resiliency, and their distribution (and connectivity), redundancy gauges the probability that the species has a margin of safety to withstand or can bounce back from catastrophic events (such as a rare destructive natural event or episode involving many populations).
- **Representation** describes the ability of a species to adapt to changing environmental conditions. Representation can be measured by the breadth of genetic or environmental diversity within and among populations and gauges the probability that a species is capable of adapting to environmental changes. The more representation, or diversity, a species has, the more it is capable of adapting to changes (natural or human caused) in its environment. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics across the geographical range.

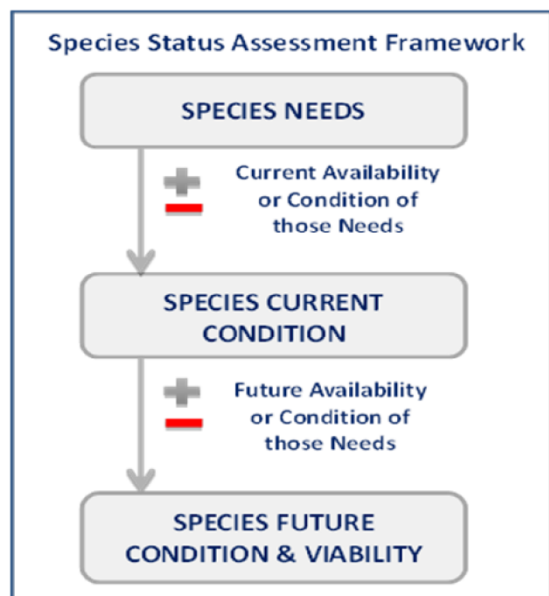


Figure 1.1. Species Status Assessment Framework

To evaluate the biological status of the dwarf-flowered heartleaf, both currently and into the future, we assessed a range of conditions to allow us to consider the species' resiliency, redundancy, and representation (together, the 3Rs). This SSA provides a thorough assessment of biology and natural history, and assesses demographic risks, stressors, and limiting factors in the context of determining the viability and risks of extinction for the species.

~~The format for this SSA includes: (1) Biology and Species Needs, (2) Current Conditions, (3) Influences on Viability, and (4) Future Conditions.~~ This document is a compilation of the best available scientific and commercial information, and includes: (1) biology and species needs, (2) current conditions, (3) influences on viability, and (4) future conditions. ~~a description of past, present, and likely future risk factors to the dwarf-flowered heartleaf.~~

Chapter 2: SPECIES BIOLOGY

In this chapter, we provide basic biological information about the dwarf-flowered heartleaf, including its taxonomic history, species description, distribution, life history traits, and habitat characteristics. We then use this information to outline the resource needs within various life stages of dwarf-flowered heartleaf. ~~Here we report those aspects of the life history of the dwarf-flowered heartleaf that are important to our analysis.~~

Taxonomy and species description

Dwarf-flowered heartleaf is a rare, low growing herbaceous plant in the birthwort family (Aristolochiaceae). The species was described by Blomquist (1957) in his revision of the North American members of the genus *Hexastylis*. The dwarf-flowered heartleaf has been recognized as part of the Virginica Group, and this group was further subdivided into three Subgroups: Virginica, Shuttleworthii, and Heterophylla (Blomquist 1957; Whittemore and Gaddy 1997). Three species have been recognized in the Heterophylla complex, *Hexastylis naniflora*, *H. heterophylla* and *H. minor*, and field biologists have generally recognized that considerable morphological overlap occurs (Murrell et al. 2007). One ~~of the main~~ concerns regarding this complex ~~was-is~~ the inability to distinguish between species without access to fresh flowers. Even with fresh flowers, Blomquist (1957) and Gaddy (1987) still recognized considerable overlap in flower morphology making species delineation difficult.

Murrell et al. 2007, conducted a comparative genetic analysis using Inter Simple Sequence Repeats, and were unable to ~~find banding patterns that could be used to~~ separate *H. naniflora* from the other members within the complex. However, based on biogeographical, ecological, molecular, morphological, as well as micromorphological work, their results show that *H. naniflora* is a well-defined species.

Although there has been considerable disagreement on the generic distinctiveness of *Hexastylis* and *Asarum* (Barringer 1993 and Kelly 1997, 1998, 2001), a recent phylogeny estimate using chloroplast genes supports that *Hexastylis* is a monophyletic clade and ~~therefore~~ should be

recognized as a genus (Niedenberger 2010). Additionally, most North American publications recognize *Hexastylis* at the generic level (Flora of North America 1997, Weakley 2015).

The Service is not aware of any proposed changes in taxonomy that would affect the continued legal status of *H. naniflora* under the Act. However, 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* (Figure 2.1; Weakley, 2010; Murrell et al. 2007; Gaddy 1987). These geographic areas of overlap in key characters have been the focus of recent genetic analyses (Murrell et al. 2007; Renninger, 2010; Murrell, 2015).

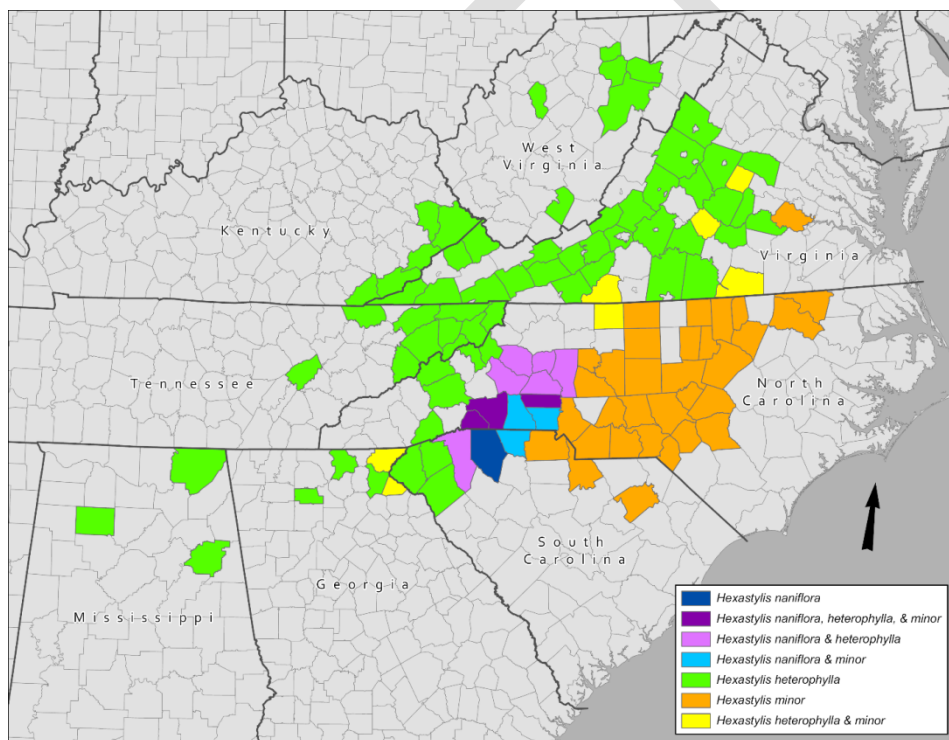


Figure 2.1. Distribution map showing county records for the three species in the *H. heterophylla* complex. Data was gathered from herbarium specimens, Element Occurrence Records (EORs) sheets and field studies. Based on Murrell et al. 2007.

The most outstanding characteristic of this species is the small flowers, which are one of the smallest of any *Hexastylis* species in North America (Blomquist 1957). The plant's heart-shaped leaves are dark green in color, evergreen, and leathery, and are supported by long thin petioles from a subsurface rhizome. The shape of the leaf blades, their pattern of variegation, and the ridged reticulation inside the calyx-tube, place this species inside the Virginica group. It differs from all the other members of this group, aside from the small flowers, in having no flare in the calyx-tube. Maximum height rarely exceeds 15 centimeters (cm). The jug-shaped flowers are usually beige to dark brown in color and appear from mid-March to early June. The flowers are small and inconspicuous and are found near the base of the petioles. The fruit matures from mid-May to early July (Blomquist 1957, Gaddy 1980, 1981). Characteristics that distinguish it from other *Hexastylis* species are found in floral structures and pollen characters (Gaddy 1987, Padgett 2004, Niedenberger 2010). *H. naniflora* has a smaller calyx tube orifice, which is typically 5mm or less (sometimes up to 7mm) and the ovary is half-inferior, rather than superior (Blomquist 1957, Gaddy 1987, Padgett 2004, HDR 2005). Pollen surface features have also been shown to be an effective character to identify *H. naniflora*, as it has a microporate surface and, unlike any other *Hexastylis* species, lacks gemmae entirely (Padgett 2004, Niedenberger 2010).

Distribution

Although dwarf-flowered heartleaf is restricted in range, it is not as rare as once thought (USFWS 2010, NCNHP 2016). When dwarf-flowered heartleaf was federally listed in 1989, the listing rule described 24 extant "populations" (and one extirpated population) distributed across eight counties in the upper Piedmont of North and South Carolina. Since 1989, the range has expanded to include four additional counties in North Carolina. In North Carolina, it is found in Alexander, Burke, Caldwell, Catawba, Cleveland, Gaston, Iredell, Lincoln, Polk, and Rutherford Counties. In South Carolina, it is in Cherokee, Greenville, and Spartanburg Counties. As of 2016, the distribution of this species consisted of 113 populations distributed across 13 counties in these two states (Figure 2.2).

Commented [PG1]: And one more in South Carolina?

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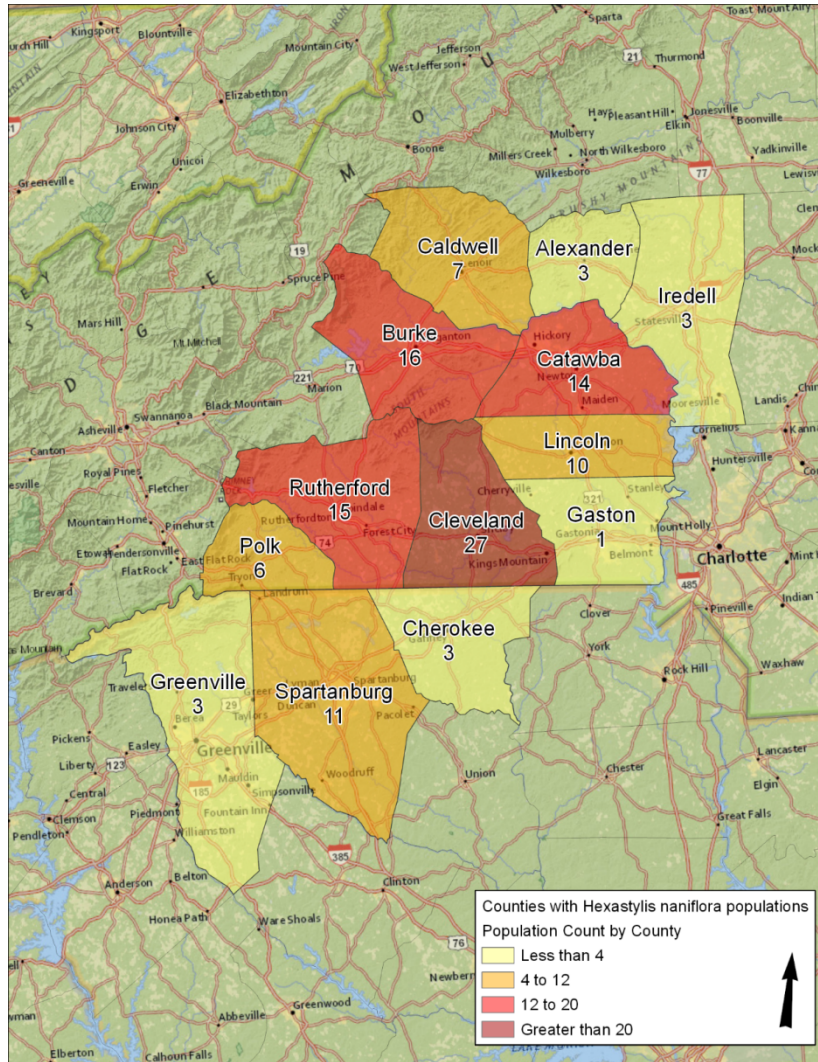


Figure 2.2. Current county distribution for dwarf-flowered heartleaf, with associated number of known populations within each county.

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~~ resulting in data ~~are~~ usually not comparable from one source to the next. We describe how the numerous small, site-specific locations containing *H. naniflora* have been aggregated into proxies for biological populations for purposes of this review, using mapping standards devised by NatureServe and its network of Natural Heritage Programs, in the “Species-species Needs-needs” section of this report.

Life History

Demographics

The Service is aware of a single effort to collect demographic-level data (survivorship and recruitment of tagged individuals) for dwarf-flowered heartleaf. ~~It 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-growing~~ 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-i~~ situated in the floodplain (USFWS 2010).

Pollination and Dispersal

The pollination of *Hexastylis* has not been well studied but the genus was thought to be pollinated by insects including flies, wasps, and thrips (Otte 1977). Additionally, Lengyel et al. (2010) described how, within the family Aristolochiaceae, more than 50% of the plant lineage is myrmecochorous (seed dispersal by ants). This supports Gaddy’s work (1986), which found

three species within the *Hexastylis heterophylla* subgroup (*H. heterophylla*, *H. naniflora*, and *H. minor*), which employ myrmecochory as a method for seed dispersal.

Ants appear to be a primary dispersal agent for the dwarf-flowered heartleaf (Gaddy 1986; Jones et al. 2014). All diaspores of *Hexastylis naniflora* presented to ants (*Aphaenogaster rudis*) were quickly removed (Gaddy, 1986). This is not to say that they are not occasionally, or even frequently, dispersed and/or pollinated by other means. Jones et al. (2014) suggests that the pollination mechanism is facultative, benefiting from more than one method of pollination/fertilization. Ants were the pollinators in a controlled experiment, and their data supports that when outside molesting forces/pollinators (biotic and abiotic) were limited by their caging procedure, the efficiency of pollination decreased by almost 50%, however, caged flowers did produce seeds, indicating pollination occurred via some alternative method.

Habitat

Dwarf-flowered heartleaf appears to have a restricted range due to its habitat requirements. The ~~Its habitat where dwarf-flowered heartleaf exists~~ is limited in size and scope due to a multitude of factors including soil type, moisture availability, and slope aspect (Wagner 2013). This unique combination of factors limits not only the range of dwarf-flowered heartleaf, but also the size of a given population. With the limited range and size in populations, questions arise regarding gene flow among populations. How much is occurring and how often does it occur? It is due, in part, to narrow habitat requirements that conservation measures have been implemented for the protection of the species. ~~Any efforts made to protect this species must consider giving protection to the available habitat.~~

Dwarf-flowered heartleaf occurs on piedmont uplands on acidic sandy-loam soils that are very deep and moderately permeable (Gaddy 1981, 1987). Typical habitats for this species include mesic to dry bluffs, slopes, or ravines in deciduous forests that are frequently associated with *Kalmia latifolia* (Padgett 2004, Weakley 2015, USFWS 2015), or in moist soils adjacent to creeks, streamheads, or along lakes and rivers. Plants have been observed to grow larger and have more frequent flowering in floodplains ~~along rivers, lakes, and streams~~ (Newberry 1993).

Wagner (2013) conducted a habitat suitability study to quantify the habitat requirements for dwarf-flowered heartleaf, which may be used for helping identify the species when not in flower (relative to other *Hexastylis* species habitat preferences), find new populations, or identify suitable sites for transplants.

Soils

The species appears to be restricted to Pacolet sandy loam, Madison gravelly sandy loam, and Musella fine sandy loam soils (Gaddy 1981, 1987). The species grows in acidic soils along bluffs and adjacent slopes, in boggy areas next to streams and creekheads, and along the slopes of nearby hillsides and ravines (Gaddy 1980, 1981). ~~The plant~~It is primarily found inhabiting north- to northwest-facing slopes, bluffs, and ravines in close proximity to creeks or streams. Within these areas exists the soil type required for *H. naniflora* to grow. It grows primarily on well-drained, sandy, acidic soils, and will not grow in heavy clay (Gaddy 1981).

The results of soil samples analyzed at the Clemson Soil Lab suggest that major differences in soil chemistry requirements exist between the species in the *H. heterophylla* complex (Murrell et al. 2007). Statistical analysis of the soil samples showed that many of the basic elements were significantly different among the three species. Those significant differences occurred in Phosphorous (P), Potassium (K), Magnesium (Mg), Zinc (Zn), Manganese (Mn), (Na), Sodium, and Cation Exchange Capacity (CEC). Slightly significant differences were seen in Buffer pH (Bu pH), and Acidity.

Soil chemistry showed marked differences between the species in the complex (Murrell et al. 2007). The results indicated that soil chemistry is very different between *H. naniflora* and *H. minor* localities. The results also show that *H. heterophylla* and *H. naniflora* are found in soils where the chemistry is more similar, but still showed significant differences. It would appear that differentiation in soil types could be used as a proxy for species delineation. The soil analysis also indicates that soils must be considered when trying to select sites for relocation of imperiled populations of *H. naniflora*.

Thirteen population sites in North Carolina and South Carolina were examined using the Carolina Vegetation Survey (CVS) method to compare species richness between the three species of the *Hexastylis heterophylla* complex (Murrell et al. 2007). The analysis did not show statistically significant differences among the three species in the *H. heterophylla* complex. However, *H. naniflora* appears to have an association with three oak species that is lacking in the other two species in the complex. There are a number of oak species (*Q. coccinea*, *Q. prinus* (*Q. montana*), and *Q. velutina*), that tend to co-occur with only *H. naniflora*, but are not present with the other two species in the complex. This may be the result of some microbial need or specific soil nutrient required for those species to occur in the same habitat.

Fire

There are little data on the response to fire by *Hexastylis naniflora*, however, prescribed burns have been conducted within the population at Cowpens National Battlefield in Cherokee County, SC. Preliminary data at this site and recent annual monitoring data of this population support the theory that moderate controlled burns do not negatively affect this population (Walker et al. 2009). Additionally, a dormant season wildfire in Caldwell County did not show evidence of negative impacts to a population in Caldwell County (USFWS 2010). Fire suppression could be a hazard to *H. naniflora* by allowing fire intolerant, nonnative and invasive plants to thrive, as well as the accumulation of thick duff or leaf litter that may shade low-growing species (Wagner 2013).

Genetics

Analyses on ecology, morphology, soil chemistry, pollen, and molecular genetics have been evaluated for *Hexastylis naniflora* to determine the boundaries within the *Hexastylis heterophylla* complex, which consists of *H. heterophylla*, *H. minor*, and *H. naniflora* (Murrell 2015, Wagner 2013, Niedenburger 2010, USFWS 2010, Murrell et al. 2007, Padgett 2004). These analyses support the continued recognition of these taxa as well-defined, discrete species. 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.

Field observations demonstrate that there are some populations of dwarf-flowered heartleaf with morphological characteristics that do not fit within the range of published values for key traits, overlapping with values for *H. heterophylla* or *H. minor* (Gaddy 1987, Murrell et al. 2007, USFWS 2010, Weakley 2015). These populations ~~with overlap in key characteristics~~ were the focus of a genetic analysis conducted at Appalachian State University (ASU) through funding provided by NCDOT (Murrell 2015). In some populations, floral characteristics are highly variable, ~~which suggests~~suggesting the potential for hybridization or individuals with highly variable flower size and shape (Murrell 2015). Additionally, no vegetative characters were previously known to consistently distinguish *Hexastylis naniflora* from other close relatives. Given the difficulties with field identification of the species, particularly when not in flower, this study sought to develop a microsatellite library of molecular markers to resolve variation in populations of dwarf-flowered heartleaf and apply the markers to populations with highly variable characters, as identified by NCDOT biologists. The morphological and micromorphological information from those variable populations were compared to molecular results with morphological, micromorphological, and distributional data to determine genetic structure, biological boundaries, and placement of putative hybrids or intermediate populations of *H. naniflora* (Murrell 2015).

The preliminary findings of this study suggest ~~that~~ populations in the southern range of dwarf-flowered heartleaf exhibit a more uniform genetic pattern, with some possible hybridization with *H. minor*. Populations in the northern part of the range appear to have hybridized with both *H. heterophylla* and *H. minor*, although there are still individuals with “pure” *H. naniflora* genotypes in the northern range (Murrell 2015). It is critical to note that although these data provide anecdotal evidence of hybridization with the *Hexastylis heterophylla* group, intraspecific

variation may be caused by forces other than hybridization, such as convergent morphological evolution (Dobzhansky 1937), or the species is in the process of speciation and this study shows a case of incomplete speciation (Murrell 2015), and/or other environmental factors are at play (Wagner 2013). On May 11, 2016, a meeting was held with USFWS, NCNHP, NCDOT, and ASU to discuss the status of *H. naniflora* and the current work being conducted among the agencies (Amoroso 2016). Based on discussions during this meeting, the results of this study reported by ASU to NCDOT in 2015 are preliminary. Dr. Matt Estep (ASU) provided additional preliminary results to NCNHP in May 2016, showing which populations were sampled, sample size, and percent of samples that show evidence of hybridization, and hybridizing with which species. ASU continues to work towards a more definitive explanation of the variation in the *H. heterophylla* complex (Murrell 2015, Amoroso 2016).

CHAPTER 3: SPECIES NEEDS

For the purpose of this report, we define viability as the ability of the species to sustain wild populations ~~in the wild~~ over time. Species with greater numbers (redundancy) of healthy populations (resiliency), encompassing a broad array of ecological and genetic diversity in a spatial arrangement that maintains adequate gene flow (representation), are more likely to be viable. Using the Species Status Assessment framework, we describe the species' viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation.

Delineating Populations

As stated in the USFWS five-year review, many of those working with dwarf-flowered heartleaf 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, ~~in the past~~, to treat each location as a separate population also artificially inflated the actual number of populations known.

The Natural Heritage Program collects information on occurrences of rare plants, animals, natural communities, and animal assemblages. Collectively, these are referred to as "elements of natural diversity" or simply as "elements." Locations of these elements are referred to as "element occurrences" (EO records). 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 in meaningful units of conservation interest that may approximate biological populations (NatureServe 2002). Since the USFWS does not maintain its own database of known locations of *Hexastylis naniflora*, it regards the NHP databases as the best repository for this information (USFWS 2010).

We delineate populations for the purposes of this SSA according to the NatureServe (2002) convention. Separation distances are a key component to delineating populations from EO records. For the dwarf-flowered heartleaf, we used the EO Data Standard which provides a Default Separation Distance of 1 km (~0.62 miles) for plant and animal elements that lack EO specifications, noting that situations involving dispersal barriers could involve even shorter distances. While gene flow declines over distance at different rates for different elements, the minimum default EO separation distance of 1 km has been accepted by the Network as the most suitable round-number metric-system approximation broadly applicable to many (but not all) situations. This results in several dwarf-flowered heartleaf populations being stand-alone EOs, as well as many populations being aggregates of several EOs.

Population Resiliency

For the dwarf-flowered heartleaf to maintain viability, its populations or some portion thereof must be resilient. Stochastic factors that have the potential to affect dwarf-flowered heartleaf include impacts to its habitat, particularly human development pressures, but also climate change and presence of invasive species. Other factors that influence the resiliency of dwarf-flowered

heartleaf populations include abundance within populations, and habitat factors such as elevation, slope, aspect, and soil type. Influencing those factors are elements of dwarf-flowered heartleaf ecology that determine whether populations can grow to maximize habitat occupancy, thereby increasing resiliency of populations. These factors and habitat elements are discussed below (Figure 3.1).

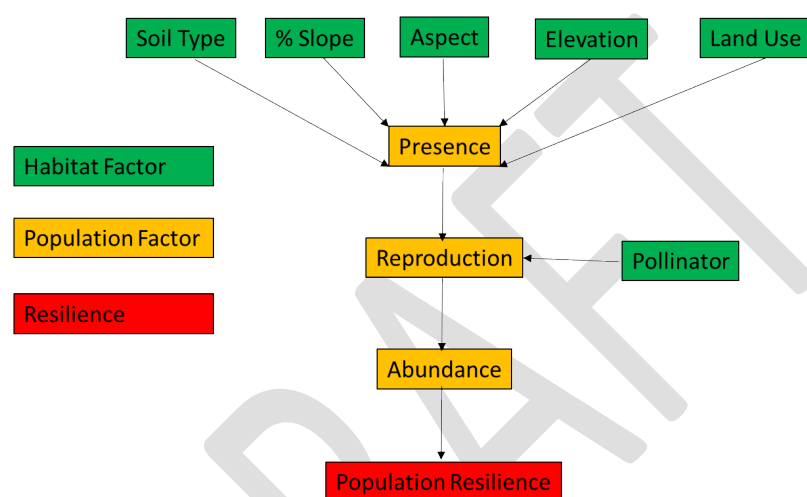


Figure 3.1. Conceptual diagram describing population and habitat factors influencing population resilience for dwarf-flowered heartleaf.

Habitat Factors: Slope, Aspect, Elevation, Soil, and Forest Type

A previous habitat suitability study attempted to quantify the habitat requirements for dwarf-flowered heartleaf (Wagner 2013). With this model in mind, and the input of species experts as to important habitat factors for the species, we used updated habitat data, as well as inclusion of updated EOs, to create a new habitat model to identify potential habitat throughout the species range. All source datasets and variables created are described in Appendix 3.

Source Data and Model Variables

Fifty-three, 10-digit hydrologic units (HUC) comprise the analysis extent (Figure 3.2). In North Carolina, it includes all 10-digit HUC that fall within the boundaries of 8-digit HUC with known occurrence of *Hexastylis naniflora*. In South Carolina, we also included all 10-digit HUC that fell within the boundaries of 8-digit HUC with known occurrence of *Hexastylis naniflora*, but excluded the southern portions of the HUC-8 areas due to the boundaries being exceedingly large and far away from any known occurrences.

Hexastylis naniflora element occurrence data was obtained from the North Carolina Natural Heritage Program and the South Carolina Heritage Trust Program. Current populations of *Hexastylis naniflora* were identified by reviewing the last observed data in the database and excluding all populations that have not been observed since 2005 to remain consistent in our approach of assessing resiliency described previously. To represent these current population areas in Maxent, a raster cell center was retained for every 30 x 30 meter pixel that was situated within the current element occurrence data polygons.



Figure 3.2. Analysis extent of the habitat model for *Hexastylis naniflora*. Red line indicates Maxent analysis extent, blue lines are 8-digit HUC boundaries, black lines are 10-digit HUC boundaries. The orange line in the inset map indicates where the analysis extent is situated in North and South Carolina

Model Development

We used Maxent software (version 3.4.1) for species habitat modeling (Philips et al., 2018). An initial single model Maxent run was done to determine which variables could be excluded due to limited percent contribution to the model. Any variable that contributed less than 1% to the single model run results was excluded in the final model. The following variables were excluded: landcover diversity, canopy height, Soil Survey Geographic Database (SSURGO) drainage class, SSURGO hydrologic group, aspect 9-class, aspect 5-class, slope, solar radiation, and maximum annual temperature. It is interesting to note that a previous habitat modelling

effort (Wagner 2013) included aspect and slope, whereas the Maxent model excluded these variables. This does not mean these variables are not important components of dwarf-flowered heartleaf habitat, but rather these variables did not significantly improve the model. Also, landform data was included, and perhaps landform, which includes components of aspect and slope combined is a more meaningful variable than aspect or slope independently.

For the final model, a 10-run replicate Maxent model was created using cross-validation. For replicate models, the occurrence data is randomly split into a number of equal-sized groups called “folds”, and separate models are created leaving out each fold in turn. The individual model runs are then averaged together to derive the final model.

Results

Figure 3.3 shows the model output. The minimum cutoff value (to determine if an area is considered potential habitat for a species) of 0.39 was determined by using the average 10th percentile training presence. The 10th percentile training presence uses the suitability threshold associated with the presence record that occurs at the 10th percentile of presence records (Phillips 2018). This value excludes some of the outlier population areas in the Maxent predictions to focus on the typical habitat conditions for this species. The total area ranked greater than 0.39 in the Maxent model was just 6.00% of the total analysis area (Table 3.1).

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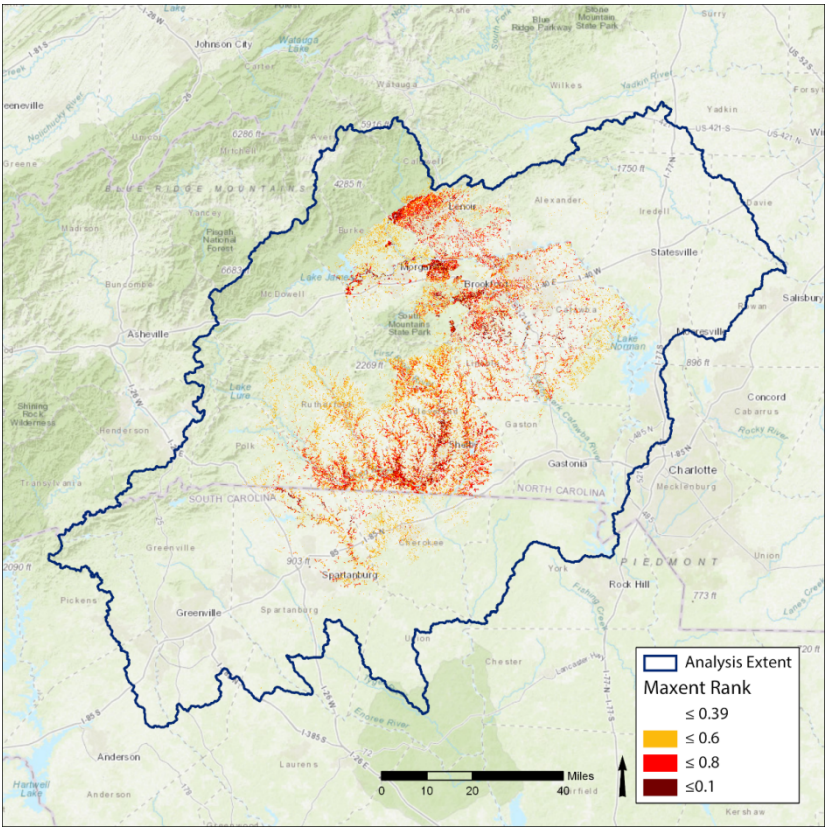


Figure 3.3. Maxent model output map

Table 3.1-Area estimates of the Maxent model

Maxent Score	Acres	Square Miles	Percent of Total
0.39 and greater	302,834.13	473.18	6.02%
0.6 and greater	128,273.52	200.43	2.55%
0.8 and greater	22,115.97	34.56	0.44%

The average area-under-curve (AUC) score for the replicate Maxent model is 0.86. The AUC is calculated from the receiver operating characteristic (ROC) plot. This value has a range of 0 – 1 and may be interpreted as a single test statistic that assesses model performance, indicating the

ability of the model to correctly classify the occurrence data used. The model performed well in its predictions, with a mean AUC of 0.86 (AUC value of 0.5 is no better than random; AUC<0.5 is worse than random; AUC>0.5 is greater predictive power than random; Baldwin 2009).

The Maxent output supplies estimates of the relative contributions of the environmental variables to the Maxent model (Table 3.2). SSURGO map unit key (i.e. soil class) is the top contributing variable. One hundred and thirty-five individual soil types are present within the polygon boundaries of the *Hexastylis naniflora* element occurrences. Many of these individual soil types are part of soil complexes and are separated by things such as percent slope, erosion, how stony/rocky, and amount of clay. The most common individual soil type was Meadowfield-Rhodhiss complex, 25 to 60 percent slopes, very stony (14.1% of total). However, collectively the Meadowfield soils only comprised 14.3% of all soils). The individual Pacolet soil types were very common and collectively comprise 36% of all soil types present. Woolwine, Rion, and Fairview soils were also collectively common, comprising 10.4%, 9.7%, and 8.8% of all soils present respectively.

Table 3.2. Percent contribution of the environmental variables

Environmental Variable	Percent Contribution
SSURGO map unit key	23.5%
Minimum Annual Temperature	17.8%
Average Annual Precipitation	15.7%
Landcover	12.9%
Landcover Majority	12.0%
Landcover Hexastylis Grouping	5.4%
Geomorphons	4.9%
Elevation	4.6%
Canopy Cover	3.2%

The minimum annual average temperature range in the analysis extent is 39 – 51 degrees Fahrenheit. The majority of the *Hexastylis naniflora* element occurrences (89%) are found at the 47 and 48 degrees. The average annual precipitation range in the analysis extent is 42 – 81

inches per year. The majority of the *Hexastylis naniflora* element occurrences (82%) are found in the 47 – 49 inches per year range.

Piedmont forested landcover habitats dominate the land area of the element occurrences. Southern Piedmont Dry Oak-Pine Forest – Hardwood Modifier (53%), Southern Piedmont Mesic Forest (9%), Southern Piedmont Dry Oak-Pine Forest (5.2%), Southern Piedmont Small Floodplain and Riparian Forest (4.4%), and collectively comprise 71% of the element occurrences area. Evergreen Plantation or Managed Pine (9%), Harvested Forest (7.2%), Developed, Open Space (5%), Pasture/Hay (2.1%) collectively comprise 22% of the total element occurrence area. The remaining 6 percent of element occurrence area is comprised of a mix of 14 other natural and disturbed landcover classes, but each at small percentages. The landcover majority classification scheme reduces the total number of landcover classes present in the analysis extent from 23 to 11. Southern Piedmont Dry Oak-Pine Forest – Hardwood Modifier is still the dominant landcover class (58%). However disturbed categories are increased in area (sum total of 35%). Evergreen plantation or managed pine (12%) and Pasture/Hay (12%) are the only other categories that have at least 10% or greater area. The increase in disturbed landcover area representation in the landcover majority layer suggests that either many *Hexastylis naniflora* population areas are situated in areas impacted by disturbed landcover, or that the majority of surveys have taken place in disturbed areas because of required surveys due to development.

The landcover *Hexastylis naniflora* grouping reveals the amount of disturbance present in *Hexastylis naniflora* population areas. Landcover classes grouped as disturbed comprises 27% of the total area. Mixed forest (deciduous and evergreen) comprises 58%, pasture/hay 12%, and hardwood forest 2%. Open water, evergreen and barren landcover groupings are all at less than 1% each.

Geomorphons revealed that the majority of *Hexastylis naniflora* element occurrence areas are situated in concave landforms. Geomorphon categories hollow (13%), valley (46%), and depression (10%) collectively comprise 69% of all *Hexastylis naniflora* population areas. Flat landforms comprise 15.5% of the area and convex landforms the remaining 15.5%.

Within the analysis extent, the range of elevation present is 335 – 5,265 feet. For *Hexastylis naniflora*, the prime elevation range is from 666 – 908 feet (53% of total element occurrence area). A lesser elevation range is present from 935 – 1,184 (37% of total element occurrence area).

Canopy cover for the *Hexastylis naniflora* populations are dominated by Tree Cover 70-80% (20.2%) and Tree Cover 80-90% (63.9%). The rest of the canopy cover categories are 2% or less.

We performed a Kruskal-Wallis 1-way non-parametric Analysis of Variance (ANOVA) to investigate the relationship between Maxent scores and current resilience of populations (Table 3.3). There are significant differences in the average Maxent scores between the four resilience categories ($p = 0.04$) and the mean Maxent score increases as population resilience increases from low to very high. The model gives us some predictive ability regarding habitat suitability where higher Maxent scores, on average, result in higher population resilience. In a nutshell, the model indicates that larger, more resilient populations occur in habitat that scored higher.

Table 3.3 Results of the Kruskal-Wallis 1-way non-parametric ANOVA investigating relationships between Maxent scores and current resilience groups for dwarf-flowered heartleaf.

Groups	Count	Mean Rank
low	13	30.7
moderate	25	30.7
high	5	42.8
very high	28	45.7

Source of Variation	SS	df	MS	F	P-value
Between Groups	4375.7	4	1093.92	2.65	0.0404
Within Groups	28036.3	68	412.30		

Total	32412.0	72
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Reproduction and Presence of Pollinators

The pollination of *Hexastylis* has not been well studied but the genus is thought to be pollinated by insects including flies, wasps, and thrips (Otte 1977). Additionally, Lengyel et al. (2010) described how, within the family Aristolochiaceae, more than 50% of the plant lineage is myrmecochorous (seed dispersal via ants). This supports Gaddy's work (1986), which found three species within the Hexastylis Heterophylla subgroup (*H. heterophylla*, *H. naniflora*, and *H. minor*), which employ myrmecochory as a method for seed dispersal.

Because the flower for this species is oftentimes partially or completely covered with soil and leaf litter, possibly inhibiting pollinator activity (Gonzalez 1972), there is still uncertainty of the pollination mechanism for dwarf-flowered heartleaf. Otte (1977) suggests that a variety of possible pollinators reside in this leaf litter, however, the calyx opening is considered to be far too small for efficient pollinating (Gaddy 1981). There are, however, invertebrates within this proposed size limit that could theoretically act as pollinators. It is possible that the species employs self-pollination, with or without a vector, or that cross-pollination occurs by a number of invertebrates. Jones et al. (2014) investigated pollination of dwarf-flowered heartleaf under a manipulative experimental design, and found that while insects may play a significant role in pollination, even without them, flowers managed to produce a partial seed set. However, two points need to be considered here. First, although flowers managed to produce seeds in the absence of insect pollinators, the efficiency of pollination decreased by almost 50%. Also, even if successful pollination occurs in the absence of insect vectors, the dispersal of plants amongst populations would be limited, and could result in decreased resilience due to genetic concerns such as limited gene flow and issues associated with potential inbreeding depression.

Abundance

The influence of stochastic variation in demographic (reproductive and mortality) rates is much higher for small populations than large ones. Stochastic variation in demographic rates causes small populations to fluctuate randomly in size. In general, the smaller the population, the greater the probability that fluctuations will lead to extinction. There are also genetic concerns with small populations, including reduced availability of compatible mates, genetic drift, and inbreeding depression. Small populations of dwarf-flowered heartleaf have low resilience, leaving them particularly vulnerable to stochastic events.

As of 2016, the combined databases of the NCNHP and SCDNR contain 239 Element Occurrence Records (EORs) for *H. naniflora* (NCNHP 2016, SCDNR 2016). These EORs depict roughly 113 locations which are sufficiently geographically distinct to be regarded as proxies for populations of the species (See *Delineating Populations*). Thus, the total number of populations has increased more than four-fold (from 24 to 113) since the species was listed in 1989.

At this time, the largest known populations have been monitored by NCNHP and NCDOT. The estimates for entire populations are based on a consistent monitoring methodology developed by NCDOT, USFWS, and NCNHP with monitoring plots representing roughly 10% of a population. Populations were delineated to get a more accurate boundary and size of the area occupied. All rosettes are counted annually in each monitoring plot to estimate an extrapolated population size, based on the number and density in the plots. As a result of these efforts, better estimates of population sizes for the largest known populations are available, compared to when the last five-year review was completed in 2010 (Robinson and Padgett 2016).

The 113 EORs have been estimated to contain anywhere from a single rosette to over 100,000 rosettes. Appendix 1 was created by NCNHP (2016) to replicate the same format and population data as Table B2 of the most recent USFWS five-year review of *H. naniflora* (USFWS 2010), for comparison of changes since 2010, and summarizes the largest occurrences of *H. naniflora*, with the size of the population based on the number of rosettes it was last estimated to contain. The number of populations estimated to contain over 1,000 rosettes is 26. This is approximately 23% of the total known populations and many of these populations contain well over 1,000 individuals.

There are, however, 13 populations (12% of all known) that are simply known to be extant, with no available estimate of population size (NCNHP 2016, SCDNR 2016). If the most recent population estimates for each EOR are compiled across years of observation, the 113 populations could conservatively be estimated to contain a collective total of more than 300,000 rosettes (NCNHP 2016, SCDNR 2016).

Population Trends

Although abundance is critical in assessing the resilience of dwarf-flowered heartleaf, trends in population growth can also be informative. Long-term growth trends are typically defined as the degree of change in population size over 200 years, whereas short-term growth is typically measured as that degree of change over a 10 year period. We lack a robust data set to assess trends at either of these time scales. However, from 2012-2016, NCNHP conducted systematic annual surveys of thirteen of the largest populations across the range.

Based on the results of the five-year monitoring efforts completed in 2016, nine out of thirteen populations remain stable during the five years of data collection (Robinson and Padgett 2016). The largest known population, Broad River: Henson's Creek, Brice, & Sandy Mush Outcrop in Rutherford County, NC, is estimated to have over 100,000 rosettes (Robinson and Padgett 2016). This large population consists of many scattered subpopulations on private property; two of the subpopulations are protected as a Registered Heritage Area, although Registry is a non-binding agreement with landowners that can be cancelled at any time (NCNHP 2018).

Two of the thirteen populations increased in numbers from 2012-2016: Cliffside Steam Station and Broad River: Floyds Creek, Long Branch. The Cliffside Steam Station is protected with a voluntary agreement with Duke Energy and was estimated to contain over 39,000 rosettes in 2016. The Broad River: Floyds Creek, Long Branch population is not at all protected, but was last estimated to consist of over 12,000 individuals in 2016 (Robinson and Padgett 2016).

Based on the results of recent surveys and a review of all known populations of *Hexastylis naniflora*, the overall trend over approximately 30 years is estimated to be declining 10-30%. This is estimated by a combination of documented declines of some populations, while many others appear to be remaining relatively stable, and some have increased.

Chapter 4: CURRENT CONDITIONS

Below we assess current resilience, representation, and redundancy as they relate to population and habitat factors known to be important for species viability. Based off of recent data and reports (Robinson and Padgett 2016; Robinson 2016), the species consists of 119 populations distributed across 12 counties in North Carolina and South Carolina. Populations are composed of both multiple EOs and stand-alone EO records. Recent genetic research discussed in Chapter 2, suggests that dwarf-flowered heartleaf, as originally described, is found in the southern portion of its presumed range based on current EO locations, and the northern portion could be a currently undescribed species (Figure 4.1; Estep pers. Comm. 2018). The genetic analysis to support this is complete, but a review of the morphology is ongoing and a new species has not yet been described (Estep pers. Comm. 2018). For the purpose of this SSA, we assume all EO detections are *H. naniflora*, and represent the best currently available scientific data.

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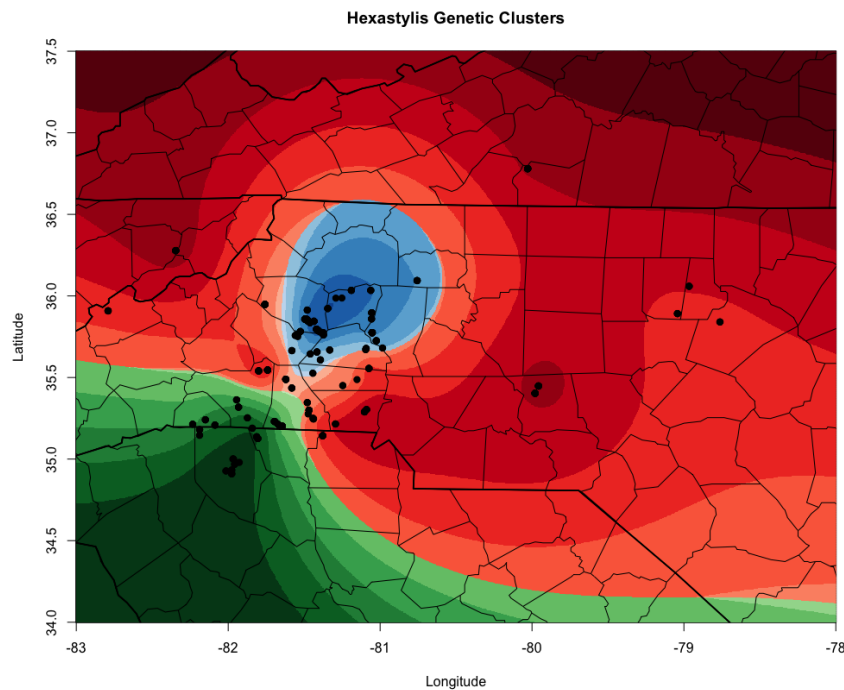


Figure 4.1. Recent genetic analyses detailing clustering of the genus *Hexastylis*. Black dots represent GIS locations of individual plants included in the genetic analysis. Green areas represent “true” *H. naniflora*; Blue represents a possible new species; Red represents other species in the genus (*H. minor*, *H. heterophylla*, etc.).

Current Population Resilience

Categorizing Resilience

For the purposes of this SSA, we use population size as the main driver of population resilience. The unit of measurement for population size in this species is a “clump” (rosette). As discussed previously, populations in North Carolina were delineated by NCNHP, whereas the Service defined populations in South Carolina. These delineations were based off of NatureServe criteria such as EO separation distance and intervening landscape matrix. EO data included a wide range

of years since the species was last observed at a given location (1964-2017), so although recent data and reports suggest the species consists of 119 populations, some of that data is fairly outdated. For the purposes of this SSA, we only used EOs that were observed since 2005. We did this for several reasons. First, we did not want to go back too far and assume a population was still present. Second, we wanted to be consistent in what we considered “current” for both categorizing resilience and use in the habitat model (discussed later). Also, experts concurred that records as old as 12 years are still likely to persist. Finally, there was a natural break in the data at the year 2005, coinciding with the year the last five-year review was initiated, where the number of EOs dropped off significantly in the years 2004 and earlier. It is important to note that many of the populations that we excluded from our analysis may still persist on the landscape. In fact, many EOs for this species have persisted for decades, despite not having intervening surveys to confirm their persistence.

Based on the criteria (excluding EOs prior to 2005), there are currently 78 populations distributed across the range of dwarf-flowered heartleaf, although this may be an underestimate as discussed above.

To determine overall resilience for populations, we used EO viability ranks and expert opinion to bin population size classes into corresponding resilience categories. EO viability ranks for the species include excellent, good, fair, poor, extant, historical, and failed to find. The primary factor in determining these ranks is EO size (as quantified by number of clumps). Condition of habitat (vegetation community and structure) and landscape context (extent of suitable habitat and physical factors) are also incorporated secondarily. Appendix 2 shows the NCNHP EO rank specifications for dwarf-flowered heartleaf. The EO rank specifications suggest good-excellent viability for populations consisting of at least 500 individuals, given there is sufficient high quality habitat; fair viability for populations consisting of 100-500 individuals, depending on habitat conditions; poor viability for populations consisting of less than 100 individuals. Recent reports (Robinson 2016; Robinson and Padgett 2016) focus monitoring studies on populations with greater than 1,000 individuals, ~~populations that are (-assumed to be very viable).~~ Because we do not have habitat-level information for every population we assessed, we synthesized all of the above population size information and created four resilience categories as follows:

- Very high—populations with >1,000 individuals; very high probability of persistence for 20-30 years at or above the current population size.
- High—populations with 500-1,000 individuals; moderate-high probability of persistence for 20-30 years at or above the current population size.
- Moderate—populations with 100-500 individuals; low probability of persistence for 20-30 years at or above the current population size.
- Low—populations with <100 individuals; low probability of persistence for 20-30 years at or above the current population size, and moderate-high probability of extirpation.

Occupancy and Abundance

There are 78 populations of dwarf-flowered heartleaf that have been observed since 2005 (Table 4.1), and resilience of these populations is as follows: 28 (very high); 5 (high); 26 (moderate); 19 (low). Table 4.2 shows the contribution of each resilience category as follows: 36% (very high); 7% (high); 34% (moderate); 23% (low). When looking at cumulative percentages of resilience, it is interesting to note that 77% of all of the populations are classified as moderate to very high resilience (Table 4.2).

Table 4.1. Current populations of dwarf-flowered heartleaf and associated resilience across the species range. Abundance and last observation date based on Natural Heritage Program data (2018).

Site Name	State	County	Last Observed	Total plants	Resilience
Glade Creek, Alex County	NC	Alexander	2017	>1000	very high
Catawba River: Hoyle Crk-Micol Crk	NC	Burke	2013	>1000	very high
Island Creek Heath Bluff	NC	Burke	2016	>1000	very high
Gunpowder Creek: South of Hudson	NC	Caldwell	2012	>1000	very high
Peaked Top Rare Plant Site/Foothills Landfill	NC	Caldwell	2014	>1000	very high
Jacob Fork West Corridor	NC	Catawba	2012	>1000	very high
Murrays Mill/Upper Balls Creek NA	NC	Catawba	2013	>1000	very high
NCDOT TIP: R-2824	NC	Catawba	2015	>1000	very high
South Fork Catawba R: Clark Crk, Miller Br, Cata Mem Hos	NC	Catawba	2013	>1000	very high
Cowpens NBF - Site 1	SC	Cherokee	2016	>1000	very high

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Site Name	State	County	Last Observed	Total plants	Resilience
Cliffside Steam Station	NC	Cleveland/Rutherford	2016	>1000	very high
Broad River/Sandy Run NA	NC	Cleveland	2012	>1000	very high
Broad River: Brushy Creek	NC	Cleveland	2016	>1000	very high
Buffalo Creek: Kings Mountain Res	NC	Cleveland	2016	>1000	very high
Buffalo Creek: Tributaries N and S of SR 2047	NC	Cleveland	2012	>1000	very high
Rhyne Conservation Preserve	NC	Lincoln	2016	>1000	very high
Mill Creek Forest and Seep	NC	Polk	2016	>1000	very high
New Hope Springhead Swamp	NC	Polk	2016	>1000	very high
Big Horse Creek Rare Plant Site	NC	Rutherford	2015	>1000	very high
Broad River: Floyds Creek	NC	Rutherford	2016	>1000	very high
Davenport Road/Mountain View Rare Plant Site	NC	Rutherford	2016	>1000	very high
Facebook Site	NC	Rutherford	2016	>1000	very high
Floyds Creek Tributary Rare Plant Site	NC	Rutherford	2012	>1000	very high
New Bethel Rare Plant Site	NC	Rutherford	2015	>1000	very high
Richardson Creek trib above Toms Lake	NC	Rutherford	2016	>1000	very high
DNR Peters Creek Heritage Preserve	SC	Spartanburg	2016	>1000	very high
Taylor Blalock Res	SC	Spartanburg	2016	>1000	very high
Leepers Creek Heartleaf Site	NC	Lincoln	2006	>1000	very high
Little Gunpowder Creek Rare Plant Site 1	NC	Caldwell	2015	500-1000	high
Little Gunpowder Creek Rare Plant Site 2	NC	Caldwell	2015	500-1000	high
Northern Catawba County	NC	Catawba	2017	500-1000	high
Rock Barn Solar Farm	NC	Catawba	2010-2011	500-1000	high
Buffalo Creek Rare Plant Site	NC	Cleveland	2012	500-1000	high
Third Creek Rare Plant Site	NC	Alexander	2010	100-500	moderate
Hickory Area	NC	Burke/Catawba/Caldwell	2016	100-500	moderate
Burke County - Drowning Creek UT	NC	Burke	2017	100-500	moderate
Simms Hill/Little River Uplands	NC	Burke	2015	100-500	moderate
Smith Cliff/Henry Fork River	NC	Burke	2015	100-500	moderate
NCDOT non-TIP Div 12 road const at SR 1115 South Fork Catawba River Jacobs Fork and Camp Creek	NC	Catawba	2016	100-500	moderate
NCDOT TIP R-2824	NC	Catawba	2015	100-500	moderate
South Fork Catawba River, Henry Fork	NC	Catawba	2007	100-500	moderate
Broad River/Sandy Run NA	NC	Cleveland	2012	100-500	moderate
Brushy Creek Headwaters	NC	Cleveland	2014	100-500	moderate
First Broad River: Crooked Run Creek	NC	Cleveland	2010	100-500	moderate
No Business Creek, Boyd Tract	NC	Cleveland	2007	100-500	moderate

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Site Name	State	County	Last Observed	Total plants	Resilience
West Shelby Mesic Slope	NC	Cleveland	2016	100-500	moderate
UT of Kings Mountain Res	NC	Gaston	2012	100-500	moderate
Buffalo Shoals Creek	NC	Iredell	2014	100-500	moderate
Cat Square Heartleaf Forest	NC	Lincoln	2012	100-500	moderate
Collinsville (Hughes) Creek Slopes	NC	Polk	2016	100-500	moderate
Fox Knoll Farm	NC	Polk	2016	100-500	moderate
Forest City: Adj to Isothermal CC	NC	Rutherford	2010	100-500	moderate
Jonas Road Rare Plant Site	NC	Rutherford	2014	100-500	moderate
Knob Creek NA	NC	Cleveland	2005	100-500	moderate
Buffalo Creek	NC	Cleveland	2005	100-500	moderate
Kross Keys NA	NC	Polk	2005	100-500	moderate
Catawba River: North Fork Mountain Creek	NC	Catawba	2005	100-500	moderate
Catawba River: Lake James	NC	Burke	2006	100-500	moderate
Hogpen Branch Transplant Site	NC	Rutherford	2005	100-500	moderate
NC DOT TIP R-3603A	NC	Alexander	2017	<100	low
South Mountains Pleasant Grove Uplands	NC	Burke	2016	<100	low
Gunpowder Creek	NC	Caldwell	2012	<100	low
Killian Crossroads	NC	Catawba	2010	<100	low
Pott Creek	NC	Catawba	2012	<100	low
Beaverdam Crk at First Broad River	NC	Cleveland	2011	<100	low
Buffalo Creek: Potts Creek	NC	Cleveland	2012	<100	low
Buffalo Creek: Ravine	NC	Cleveland	2007	<100	low
Hickory Creek - UT (Shelby High School)	NC	Cleveland	2016	<100	low
Boulder Creek Subdivision - Jordan Road	SC	Greenville	2016	<100	low
Gateway Elementary School	SC	Greenville	2017	<100	low
Fanjoy Road Site	NC	Iredell	2015	<100	low
Levan Family Farm	NC	Iredell	2013	<100	low
Lincoln County, SR-1314	NC	Lincoln	2014	<100	low
Northeast Lincolnton: UT Walker Branch	NC	Lincoln	2009	<100	low
Sandy Spring Church Springhead Swamp	NC	Polk	2005	<100	low
First Broad River: Hickory Creek	NC	Cleveland	2006	<100	low
Smith Cliff/Henry Fork River	NC	Burke	2005	<100	low
First Broad River: Beaverdam Creek Tribs	NC	Cleveland	2006	<100	low

Table 4.2. Population resilience categories by county for dwarf-flowered heartleaf.

County	Very High	High	Moderate	Low	Totals
Alexander	1		1	1	3
Burke/Catawba/Caldwell			1		1
Burke	2		4	2	8
Caldwell	2	2		1	5
Catawba	4	2	4	2	12

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Cherokee	1				1
Cleveland/Rutherford	1				1
Cleveland	4	1	7	6	18
Gaston			1		1
Greenville				2	2
Iredell			1	2	3
Lincoln	2		1	2	5
Polk	2		3	1	6
Rutherford	7		3		10
Spartanburg	2				2
Totals	28	5	26	19	78
% of total	36	7	34	23	100
Cumulative %	40	43	77	100	--

Population Trends

Although we lack an adequate past time series of abundance data for all populations to estimate growth rates or population trends, NCNHP conducted surveys of thirteen of the largest populations across the range of the species from 2012-2016. Table 4.3 shows the results of all of these surveys. Two populations show an increasing trend, nine show a stable trend, and two show a decreasing trend.

Table 4.3. Summary of population trends over 5 years of monitoring data for 13 of the largest populations of dwarf-flowered heartleaf across its range (from: Robinson and Padgett 2016).

Trend	Survey	Site	2016 estimated number of plants (Rosettes)	2016 area occupied (Acres)
Increasing	NCNHP	Cliffside Steam Station (EO 276)	39,535	52
	NCNHP	Broad River: Floyds Creek, Long Branch (EO 177)	12,687	5.67
Stable	NCNHP	Island Creek Bluff/Love Lady Site (EO 029)	50,481	61.76
	NCNHP	Rhyne Preserve (EO 302)	19,873	22.43
	NCNHP	Mills Creek Forest and Seep (EO 023)	1,733	1.39
	NCNHP	New Hope Springhead Swamp (EO 125)	12,235	5.03

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	NCNHP	Broad River: Henson's Creek, Brice, & Sandy Mush Outcrop (EO099)	106,940	83.39
	NCNHP	Broad River: Cleghorn Creek, US 221 (EO 176)	6,750	7.24
	NCNHP	Cowpens National Battlefield (SC EO 016, 017, 018)	2,823	6.05
	NCNHP	Peters Creek Preserve (SC EO 011)	3,306	8.98
	NCNHP	Blalock Reservoir (SC EO 007, 031)	3,505	7.59
Decreasing	NCNHP	Second Broad River (Forest City Industrial Complex) (EO 154)	2,576	4.74
	NCNHP	South Fork Catawba River: Jacob Fork, Camp Creek (EO 158)	123	0.09

Current Species Representation

Representation describes the ability of a species to adapt to changing environmental conditions. We lack genetic and ecological diversity data to characterize representation for dwarf-flowered heartleaf. In the absence of species-specific genetic and ecological diversity information, we typically evaluate representation based on the extent and variability of habitat characteristics across the geographical range. However, the dwarf-flowered heartleaf has a very limited range, and after consulting with experts, we decided delineating representative units was not appropriate for this species.

Current Species Redundancy

For the dwarf-flowered heartleaf to maintain viability, the species also needs to exhibit some degree of redundancy. Species-level redundancy reflects the ability of a species to withstand catastrophic events, and is best achieved by having multiple, widely distributed populations relative to the spatial occurrence of catastrophic events. Redundancy for dwarf-flowered heartleaf is the total number and resilience of population segments and their distribution across the species range.

An important question when investigating redundancy for dwarf-flowered heartleaf is, “what exactly is a catastrophe?” We consider a catastrophe to be any population-level disturbance

~~that has with~~ the potential to negatively influence population resiliency outside of normal environmental and demographic stochasticity. Disturbances often act quickly, like hurricanes, and often with devastating effects, however they can also occur over long periods of time. A disturbance that occurs as a relatively discrete event in time is referred to as a “pulse” disturbance, while more gradual or cumulative pressures on a system are referred to as “press” disturbance. Both types of disturbances are part of the natural variability of dwarf-flowered heartleaf ecological systems, and must be considered when assessing redundancy. While there is certainly a variety of potential pulse disturbances for the species (timber harvest, hydrological alterations, road and right-of-way construction), the primary potential catastrophic disturbances are press disturbances from long term climate change, which have great potential to affect ecosystem processes and communities by altering the underlying abiotic conditions (DeWan et al. 2010).

As stated previously, there are 78 populations of dwarf-flowered heartleaf that have been observed since 2005 (Table 4.1), and resilience of these populations is as follows: 28 (very high); 5 (high); 26 (moderate); 19 (low). The populations are spread across the range, although a majority occur in North Carolina. Although, there appears to be adequate redundancy within the range of dwarf-flowered heartleaf to withstand the impacts of localized press catastrophic disturbances, the species range is very small, making it potentially vulnerable to long-term catastrophic events, such as climate change.

CHAPTER 5: INFLUENCES ON VIABILITY

Hexastylis naniflora populations occur in rapidly growing urban areas with expanding suburbs of Charlotte, NC, to the east; Hickory, NC, to the north; and Greenville and Spartanburg, SC, to the south. At the time of listing, ~~it was determined that~~ the species was most threatened by habitat loss due to the conversion of land to residential, commercial, and industrial use in these areas. In addition to threats associated with residential, commercial, and industrial development, other documented threats include habitat loss from land conversion to agricultural use, timber harvest, hydrological alterations from the damming of ponds, impacts from grazing cattle, ORV damage, trampling from foot traffic, invasive species, highway or road improvements, and erosion or

siltation (NCNHP 2016, Robinson and Padgett 2016). Climate change may exacerbate these risk factors through changes in temperature and precipitation.

Threats were assessed for populations monitored by NCNHP during 2012-2016 (Robinson and Padgett 2016), and EOs were reviewed for other documented threats to populations. Indirect or direct threats that were observed, inferred, or suspected to have an impact on populations were recorded and assigned a ranking based on their severity, scope, and immediacy from field observations. The rank for each threat factor determines the overall value for each threat observed at each population. No significant changes in threats within populations were noted from 2012-2016. Threats observed during these years included development, incompatible forestry practices, agriculture, trampling, invasive exotic species, sedimentation, erosion, and road construction.

Below, we summarize primary threats to the viability of dwarf-flowered heartleaf. Primary influences will be carried forward in our future projections in the next section.

Human Population Change

Increasing human populations drive development. With increases in population, there will be increasing conversion of open space to more impervious cover, with a subsequent increase in roads and other associated infrastructure. Increases in roads and impervious cover have the potential to lead to habitat loss and/or fragmentation, a primary risk factor for dwarf-flowered heartleaf. Tables 5.1-5.2 and Figures 5.1-5.2 show the estimated human population increases for North Carolina and South Carolina counties within the range of the species. The most populous counties include Greenville and Spartanburg in South Carolina, and Catawba, Gaston and Iredell counties in North Carolina.

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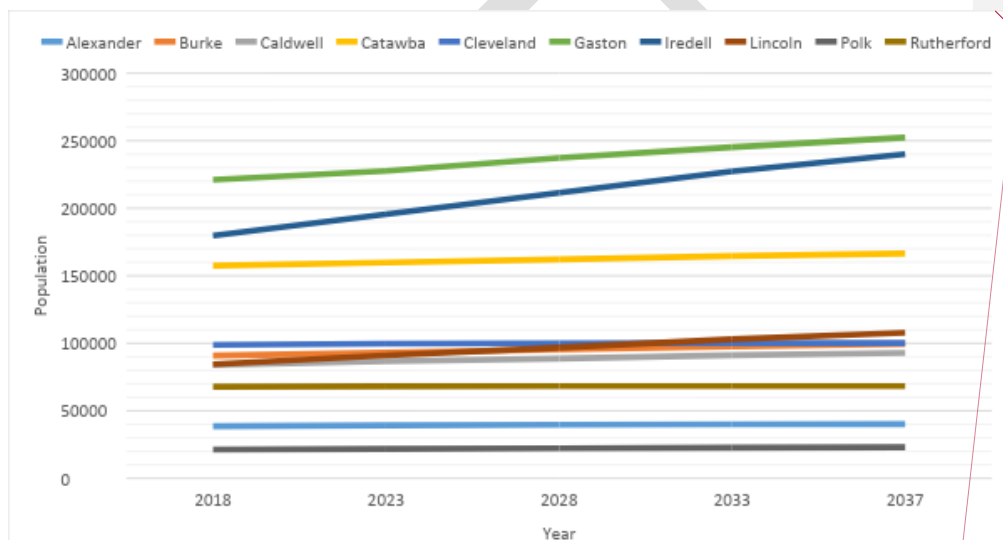
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Table 5.1-Human population projections for North Carolina counties within the range of dwarf-flowered heartleaf. *Source: North Carolina OSBM, Standard Population Estimates.*

County	2018	2023	2028	2033	2037
Alexander	38,609	39,244	39,686	39,992	40,169
Burke	90,865	93,124	95,382	97,644	99,452

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Caldwell	83,919	86,723	88,689	91,126	92,870
Catawba	157,424	159,799	162,175	164,549	166,447
Cleveland	98,862	99,685	100,004	100,128	100,170
Gaston	221,112	227,667	237,344	245,276	252,388
Iredell	179,740	195,623	211,501	227,383	240,088
Lincoln	84,494	91,034	96,865	103,069	107,858
Polk	21,273	21,823	22,288	22,681	22,955
Rutherford	67,880	68,154	68,283	68,341	68,368



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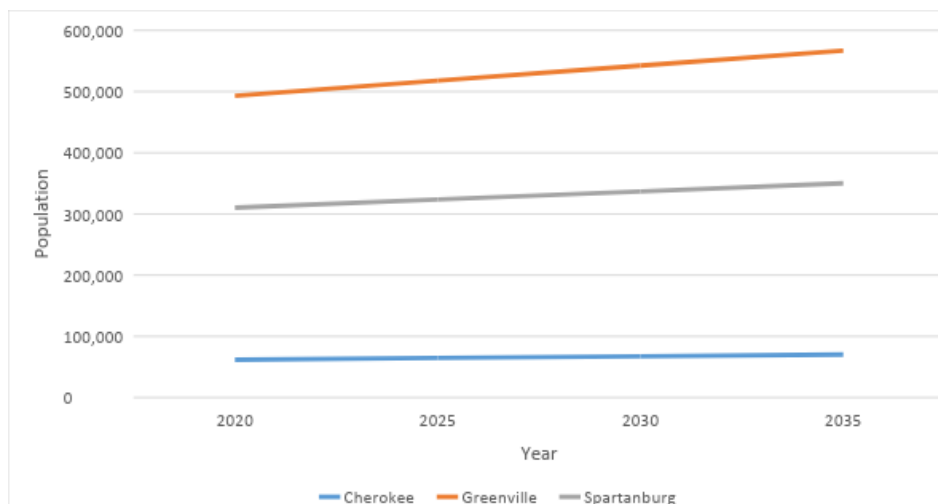
Figure 5.1- Human population projections for North Carolina counties within the range of dwarf-flowered heartleaf. *Source: North Carolina OSBM, Standard Population Estimates.*

Table 5.2- Human population projections for South Carolina counties within the range of dwarf-flowered heartleaf. *Source: U.S. Census Bureau, 2000 Census and 2007 Population Estimates. Population projections calculated by South Carolina Budget and Control Board, Office of Research and Statistics.*

County	2020	2025	2030	2035
Cherokee	61,760	64,760	67,350	70,170

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Greenville	492,890	517,740	542,290	567,010
Spartanburg	310,220	323,550	336,810	350,110



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Figure 5.2. Human population projections for South Carolina counties within the range of dwarf-flowered heartleaf. *Source: U.S. Census Bureau, 2000 Census and 2007 Population Estimates. Population projections calculated by South Carolina Budget and Control Board, Office of Research and Statistics.*

Development

A large number of the known populations occur near expanding urban areas and are threatened by the residential, commercial, and industrial development associated with this growth. Populations occurring in more rural areas are threatened by habitat alteration or loss from land conversion to pasture or other agricultural uses, cattle grazing, intensive timber harvesting, residential construction, and construction of small ponds.

A 2010 review of existing NHP EOR data revealed that all or portions of 26 populations (24% of the total) had been directly or indirectly impacted through development projects or other causes such as trash disposal, expansion of residential lawns, cattle, or invasive exotics (NCNHP 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 populations (corresponding to 37% of all known populations). Of these 42 populations, all or portions of 22 (50%) had been adversely impacted by activities requiring ESA Section 7 consultation with the USFWS. The fact that nearly 20% of all known populations had been subject to formal Section 7 consultation illustrates the threats faced by the species.

In the same 2010 review, 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. 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).

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. 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.

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). 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).

Invasive Species and Woody Encroachment

Several ~~of the known~~ populations of dwarf-flowered heartleaf occur on steep ravine slopes ~~which also support with~~ stands of mixed hardwoods with an understory of mountain laurel (*Kalmia latifolia*) or *Rhododendron spp.* These stands are often very dense and reduce the amount of light reaching the dwarf-flowered heartleaf plants growing below. Under these conditions, the plants often show reduced vigor and reduced flower and fruit production. Careful, selective logging or natural tree fall and limited understory removal would open up these populations to more light. Additional light, if not accompanied by increased siltation from the intensive soil disturbances associated with forest clear-cutting, probably would benefit these populations (Gaddy 1981).

Invasive exotic plant species are rampantly spreading throughout riparian corridors and ravines across the range of this species (USFWS 2011). 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.

Commented [PG7]: Never heard this before. I've heard Japanese stiltgrass and Nepalese browntop, but not this. Seems odd to have a common name that references two distinct locations.

Climate Change

There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (McLaughlin *et al.* 2002, p. 6074; Golladay *et al.* 2004, p. 504; Cook *et al.* 2004, p. 1015). Because typical habitats for this species include moist soils adjacent to creeks, streamheads, or along lakes and rivers, and plants have been observed to grow larger and have more frequent flowering in floodplains along rivers, lakes, and streams (Newberry 1993), specific effects of climate change to the dwarf-flowered heartleaf are likely related to changes in soil moisture associated with potential increases in drought.

Warming in the Southeast is expected to be greatest in the summer (NCCV 2016) which is predicted to increase drought frequency, while annual mean precipitation is expected to increase slightly, leading to increased flooding events (IPCC 2013, p.7; NCCV 2016). Changes in climate may affect ecosystem processes and communities by altering the abiotic conditions experienced by biotic assemblages resulting in potential effects on community composition and individual species interactions (DeWan *et al.* 2010, p.7).

Despite the recognition of potential climate effects on ecosystem processes, there is uncertainty about what the exact climate future for the Southeastern US will be and how the ecosystems and species in this region will respond. Although climate change was not a factor leading to the original listing of the species, it should be recognized that the greatest threat from climate change may come from synergistic effects. That is, factors associated with a changing climate may act as risk multipliers by increasing the risk and severity of more imminent threats. As a result, impacts from rapid urbanization in the region might be exacerbated under even a mild to moderate climate future.

Regardless of a pessimistic, optimistic, or status quo climate future, the following systematic changes are expected to be realized to varying degrees in the Southeastern US (IPCC 2013):

- More frequent drought
- More extreme heat (resulting in increases in air and water temperatures, Figure 5-3)
- Increased heavy precipitation events (e.g., flooding)
- More intense storms (e.g., frequency of major hurricanes increases)
- Rising sea level and accompanying storm surge

In recent years, the Southeast has experienced moderate to severe droughts that many observers have implicated in population declines and poor transplant survivorship (NCNHP, 2010). 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), and although moderate controlled burns do not negatively affect this population (Walker et al. 2009), severe wildfires could have negative effects. 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 dwarf-flowered heartleaf is currently unknown.

Appendices 4a and 4b gives summary reports on historical and future predicted climate parameters from the USGS National Climate Change Viewer for both North Carolina and South Carolina. As discussed above, the trend for these States is consistent with the general trend in the Southeast: more frequent drought, more extreme heat, and increased precipitation events. If these predictions hold true, dwarf-flowered heartleaf habitat would likely be impacted through increased evaporative rates and decreased soil moisture (Appendices 4a and 4b), increased potential for catastrophic wildfire events, as well as potential disruption of stream bank morphology through increased flooding events. Our habitat model indicates a preferred temperature and precipitation range, indicating that the species would be sensitive to a changing climate.

Chapter 6: FUTURE CONDITION

Future Considerations

Our analysis of the past, current, and future influences on what the dwarf-flowered heartleaf needs for long term viability revealed that there are several influences that pose risks to future viability of the species. These risks are primarily related to habitat changes from development and long term climate change. We use projections of urban development to assess potential habitat loss and fragmentation. We also considered how climate change may exacerbate the impacts of development in a qualitative fashion using a narrative approach.

Because the actual impacts of urbanization are unknown, we use three scenarios, projected out to the year 2040, to capture the uncertainty related to the potential impacts to each population's resiliency: Status Quo, Targeted Conservation, and High Development. Results of future projections within each scenario are focused on current populations and potential habitat identified by the Maxent model as described below. Based on the life span of the species, expert input, development as the key risk factor brought forward, uncertainty about future conditions, and lack of knowledge about where additional populations may persist on the landscape, we chose to project populations out to the year 2040 under each scenario, but no further.

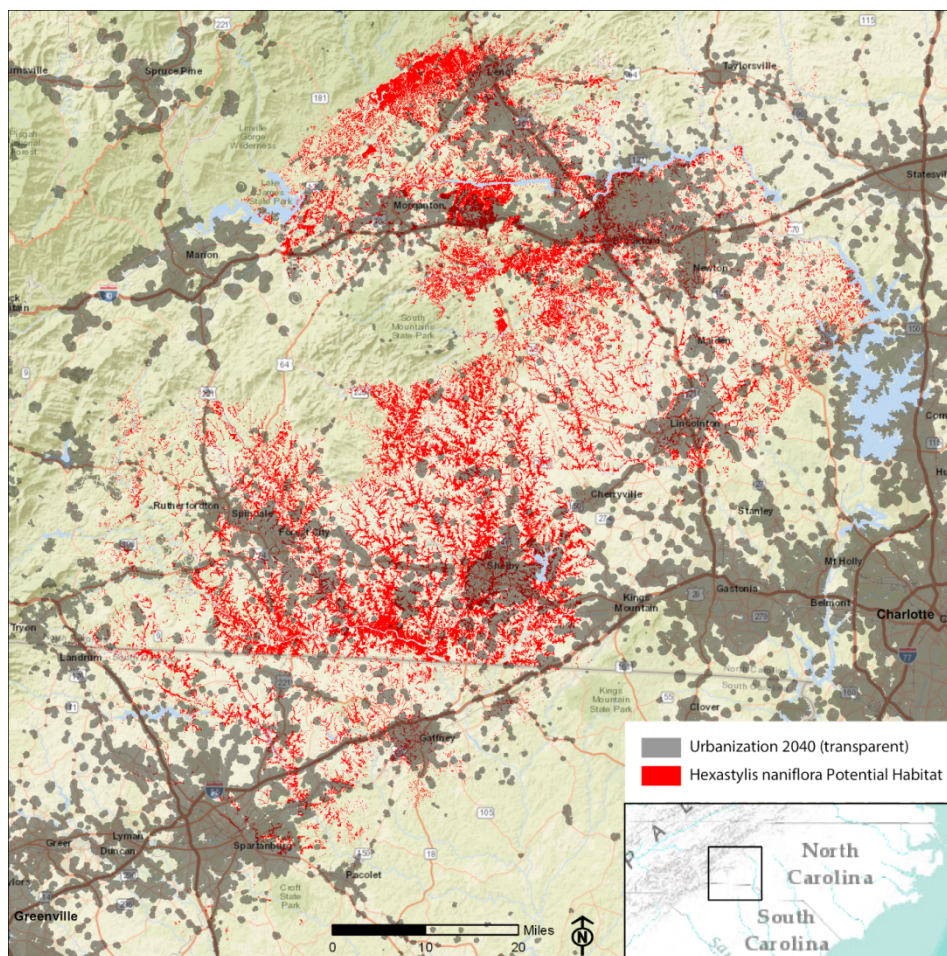
In constructing our scenarios, we considered two main influences by which species viability projections could be affected: location of additional populations (positive influence) and habitat loss and fragmentation due to urban development (negative influence). Habitat quantity can be negatively impacted by development or land use change (particularly on private lands) or positively impacted by land acquisition, restoration, and/or introductions into unoccupied sites that already have suitable habitat.

We use the Slope, Land cover, Exclusion, Urbanization, Transportation, and Hillshade (SLEUTH) models to determine areas predicted to be urbanized by 2040 (Figure 6.1). SLEUTH is a cellular automata model that applies transition rules to the states of a gridded series of cells, and in this case the transition is that from undeveloped to developed land cover, otherwise

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known as urbanization, and has been successfully applied worldwide over the last 15 years to simulate land use change (Clarke 1995).

Figure 6.1. Results of the SLEUTH model with *Hexastylis naniflora* potential habitat predicted by the MAXENT model overlaid.



The SLEUTH model predictions are broken down by probabilities of urbanization, ranging from 0-100%. We chose 80% probability as our cutoff, as this cutoff has been used by USGS and

other SSAs, and this threshold represents a highly likely outlook for urbanization of the landscape. To forecast viability using urban development projections, we assessed the following:

- % increase in projected development (SLEUTH probability of urbanization >80%) within current populations
- % increase in projected development (SLEUTH probability of urbanization >80%) within areas delineated as potential habitat by the Maxent habitat model

There is no data available on the exact relationships between urbanization and the impacts to dwarf-flowered heartleaf. We do know that several current populations are located in areas with surrounding urban landscapes. We also know that urban development has led to extirpation of populations in the past through loss of habitat. Because of this uncertainty, we attempted to capture unknowns in two ways. First, our scenarios reflect a range of potential impacts from urban development. Also, we used two thresholds for % increase in urban development to capture potential deleterious effects: 25% and 50%. Our assumptions were that very small increases in development are unlikely to negatively impact populations; development increase of at least 25% of the area of current populations was likely to have some negative impacts; development increase of at least 50% was likely to have significant impacts to populations. We also assume that populations currently on protected lands are likely to see smaller impacts from urbanization compared to those that are not protected, but protection status (perpetuity vs non-perpetuity) matters. For example, Registered Heritage Areas are non-binding agreements with a land owner, and if the land changes ownership, or the owner decides not to continue with the agreement, then the Registry is no longer valid. Appendix 4 shows the protection status of each delineated population which helped to inform our assessment of resilience under each scenario.

We also assessed potential positive effects by integrating the potential location or rediscovery of additional populations throughout the range into two of our scenarios: Targeted Conservation and Status Quo. We believe this is appropriate for several reasons. First, location of new EOs is common; many of the populations we consider for Current Conditions include detections that have occurred within the last few years. Second, we did not include many older detections (i.e. only included detections since 2005), although many of those detections are likely to

persist. Dwarf-flowered heartleaf is a long-lived perennial, and several EOs have been revisited after more than 10 years and the species was present. For example, one such EO was first observed in 1957 and next observed in 2001. It seems as long as suitable habitat is still present it is reasonable to assume that the species is still there. Finally, there is plenty of predicted suitable habitat present within older EOs based on the Maxent model predictions that were not included as current populations due to the relatively long time since last observation.

The first step in identifying additional areas where dwarf-flowered heartleaf is likely to be found in the future, was to identify EOs from populations that were last observed prior to 2005 (i.e. our cut-off for current populations). Although our focus is on older EOs, where dwarf-flowered heartleaf is likely to persist into the future, we also included current EOs (2005-current) in our analysis because we were interested in how the older EOs compared to those known to be persisting on the landscape since 2005. Also, by including older EOs that are within current delineated populations, we can investigate whether current populations might be predicted to contain more plants than the most recent abundance estimate. For example, many of our current populations consist of multiple EOs, and we only considered EOs that were detected from 2005-current. If these older EOs within current populations that were not included in our Current Condition assessment are found to be likely to persist, then it is possible we underestimated the resilience of that population.

Once these older EOs were identified, we created a 1,000 meter buffer around the population and calculated a number of useful metrics including resilience category based on the last known abundance estimate, Maxent habitat model metrics, and the results of the SLEUTH model to further refine a list of potential sites where the species would likely be found to persist within our 20-25 year projection window. Resilience categories were assessed using last known abundance in the same way as populations assessed in the Current Conditions section (i.e. low = less than 100 individuals; moderate = 100-500 individuals; high = 500-1000 individuals; very high = greater than 1,000 individuals). We assessed two habitat metrics for these older EOs: average Maxent score and % Maxent classified as 0.8-1.0 score. Average Maxent score indicates habitat suitability, where in general, the higher the score, the better the habitat, and was calculated by taking the mean Maxent score of all potential habitat within the 1,000 foot buffer. The %

Maxent classified as 0.8-1.0 represents the percentage of all potential habitat within the 1,000 foot buffer that falls within the highest suitability habitat class. Together, these two habitat metrics give general estimates of habitat quantity and quality. Finally, we calculated the total percentage of the 1,000 foot buffer around each EO that is projected to be urbanized in the year 2040, which helps capture the primary risk factor of development when assessing the areas where dwarf-flowered heartleaf is likely to persist. Table 6.1 (North Carolina) and 6.2 (South Carolina) show all of the EOs we considered and the corresponding metrics associated with resilience categories, urban development, and habitat scores.

Table 6.1. North Carolina raw data for metrics assessed to investigate potential sites where dwarf-flowered heartleaf was historically found and is likely to persist. Resilience categories are based on last known abundance estimates as follows: 1 = low; 2 = moderate; 3 = high; 4 = very high. MAXENT Average Mean refers to the mean Maxent score of all potential habitat. % Maxent classified as 0.8-1.0 represents the percentage of all potential habitat that falls within the highest habitat class. % Urban Development refers to the percentage of the 1,000 foot buffer around the EO that is projected to be urbanized in the year 2040.

EO not part of a current population

EO included as part of a current population

EO is a part of a current population but last detection was prior to 2005

Eliminated/not scored

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	2	34	1	3
2				
3	2	22	0	10
4	2	22	0	7
5	2	21	0	0
6				
8	1	27	0	6
9	3	44	4	0
10	4	33	2	0
11				
12	4	54	10	0
13	1	31	1	30
14	2	61	16	7
15				
16	4	18	0	47
17	1	50	13	0
18	1	36	8	2

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
19				
20	2	22	1	88
21	2	34	4	54
23	4	15	0	8
25	1	47	15	30
27				
28	2	43	12	29
29	4	43	8	30
30	4	27	2	74
31	4	30	3	86
32	2	34	2	47
33	2	33	3	0
34	1	49	13	63
35	1	42	10	23
36	1	19	0	12
37	4	41	6	17
38	2	14	0	46
39	1	19	0	11
40	2	37	2	32
44	4	20	0	59
45	1	27	5	13
46	3	42	6	6
47	1	28	1	96
48	1	14	0	12
49	4	61	14	5
50				
51	4	52	11	18
52	2	46	4	0
53	1	35	4	24
54	1	35	1	10
55	4	30	0	0
56	2	40	2	6
57	2	21	0	80
58	1	42	5	0
59	2	11	0	49
60	1	25	0	2
61	3	41	0	0
62	2	34	0	0
63	1	27	0	6

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
64	2	39	9	11
69	2	46	11	19
70	2	38	1	0
71	2	30	2	0
72	2	52	14	0
73	4	60	17	1
74	3	65	14	4
75	4	47	6	9
76	4	42	4	10
77	3	31	1	27
79	2	39	1	0
80	1	43	4	15
83	2	17	0	11
84	2	13	0	1
85	2	42	4	5
87				
89	2	13	2	0
90	2	28	2	0
91	1	49	5	0
92	2	15	0	30
106	4	39	4	38
107	1	14	0	40
113	4	46	4	7
114				
115	2	37	3	26
118	3	42	0	9
121	2	41	5	0
122	1	12	0	39
124	1	12	0	9
125	4	15	0	41
130	2	17	0	24
149	4	64	17	3
151	2	16	0	27
154	4	30	1	22
157	2	20	0	0
158	3	36	7	5
159	4	62	24	60
160	3	62	24	32
161	4	64	28	30

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
162	1	32	2	58
163	2	15	0	56
164	3	18	0	52
165	1	13	0	56
166	1	14	0	40
167	4	30	0	20
168	4	19	0	34
169	1	30	0	12
170	2	17	0	40
172	1	39	3	7
173	2	30	1	48
174	1	42	4	16
175				
180	2	21	1	0
181	4	29	2	0
182	4	45	4	0
183	2	15	0	5
184	4	19	0	19
187	2	20	1	35
188	2	24	0	53
189	1	25	0	14
190				
191	2	34	2	0
192	2	35	3	0
193	2	36	7	6
194	4	51	14	18
195	1	21	0	96
196	1	23	4	67
197	4	35	8	38
198	2	32	6	25
199	2	29	5	43
200	1	26	2	87
201	1	39	4	63
202	4	35	4	85
203	1	43	4	49
204				
205	2	43	1	49
206	1	37	3	66
207	2	33	2	85

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
208	1	32	1	67
209	2	33	2	94
210				
212	1	37	3	85
213	1	36	4	72
219	1	32	1	4
222	2	23	3	7
223				
224	1	22	3	17
225	2	24	2	12
227	4	55	2	5
229	2	28	0	21
230	1	54	15	13
231	1	41	7	0
233	4	53	12	14
235	2	50	8	6
236	2	62	14	5
237	2	67	16	5
238	4	51	15	0
239	2	63	14	5
240	1	57	18	0
241	2	62	16	3
242	1	53	9	0
246	1	62	13	4
249	4	47	5	0
250	4	45	4	0
251	4	43	4	0
254	2	54	18	6
255				
256	2	54	15	13
258	3	19	0	51
259	4	25	0	0
262	4	29	2	50
263				
264				
265				
266				
267	2	29	1	0
268	1	33	2	0

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
269	2	49	17	0
270	1	46	18	1
271	1	26	7	0
272	1	33	0	71
273	2	28	2	0
274	2	50	8	0
275	2	12	0	0
276	4	42	5	21
277				
278				
279	1	32	4	89
280	2	64	30	30
281	1	64	31	36
282	1	64	31	51
283	1	65	34	59
284	1	64	35	45
286				
287	2	15	0	35
291	2	21	1	84
292	2	14	0	83
293	1	8	0	16
294	2	36	4	61
296	2	3	0	5
297				
298	2	16	0	1
299	1	12	0	0
300	1	9	0	18
303	2	31	0	0
304	2	31	0	0
305	1	30	2	0
306	1	4	0	53
308	2	15	0	3
309	1	5	0	0
310	4	58	26	35
311	2	15	0	0
312	4	17	0	57
313				
314				
315	1	36	4	61

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
317	1	15	0	53
318	2	34	4	52
319	4	43	4	10
320	4	41	6	98
321				

Min	1	3	0	0
Max	4	67	35	98

Table 6.2. South Carolina raw data for metrics assessed to investigate potential sites where dwarf-flowered heartleaf was historically found and is likely to persist. Resilience categories are based on last known abundance estimates as follows: 1 = low; 2 = moderate; 3 = high; 4 = very high. MAXENT Average Mean refers to the mean Maxent score of all potential habitat. % Maxent classified as 0.8-1.0 represents the percentage of all potential habitat that falls within the highest habitat class. % Urban Development refers to the percentage of the 1,000 foot buffer around the EO that is projected to be urbanized in the year 2040.

EO not part of a current population
EO included as part of a current population
EO is a part of a current population but last detection was prior to 2005
Eliminated/not scored

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	2	21	0	0
2	2	1	0	4
3				
4	1	13	0	10
5	2	0	0	64
6	1	0	0	36
7	4	27	0	35
8	2	0	0	14
9				
10				
11	4	14	0	52
12				
13	1	7	0	100
14	4	14	0	43
15	1	0	0	4
16	4	22	0	38
17	4	22	0	33

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
18	3	19	0	52
19	1	12	0	65
20	2	5	0	100
21	3	5	0	90
22	1	0	0	0
23				
24	1	4	0	3
25	1	14	0	48
26	4	12	0	65
27	4	18	1	40
28	4	19	1	49
29				
30	2	7	0	88
31	4	0	0	0
32	2	7	0	93
33	2	2	0	20
34	1	31	3	1
35	1	23	1	53
36	2	6	0	0
37	1	24	2	0
38	4	5	0	37
39	1	6	0	1
40	2	6	0	20
41	1	11	0	87
42	2	3	0	6
43	1	23	0	43
44				
45				
46	1	10	0	96
47				
48				
49	3	8	0	70
50	2	5	0	54
51	1	0	0	35
52	3	0	0	0
53	2	10	0	66
54	2	9	0	91
55	1	4	0	99
56	2	14	0	96

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
57	3	15	0	38
59	2	4	0	17
60	4	17	1	12

Min	1	0	0	0
Max	4	31	3	100

Next, we implemented a set of ranking rules using the data from Tables 6.1 and 6.2 to further assess which EOs had a higher likelihood of persistence on the landscape. We used Simple Multi Attribute Rating Technique (SMART) methodology to quantify and implement our ranking rules. Because the metrics of interest vary in data type (i.e. categorical vs continuous) and range of values (i.e. not all continuous variables have the same maximum and minimum), our first step was to normalize all of the data on a scale of 0-100. Normalization techniques allow for aggregation of criteria with numerical and comparable data. We decided to analyze North and South Carolina data separately because the Maxent model predicts habitat differently across state lines due to differences in soil classification. We weighted each variable according to our opinion of the level of contribution each variable had to the probability of persistence of that particular EO. This resulted in abundance having the highest weight (100%), with habitat (as calculated by average Maxent score) and urbanization given relatively similar weighting (80%). The results of the normalization procedure and weighting can be found in Tables 6.3 and 6.4.

Table 6.3. Normalized scores for SMART analysis of North Carolina EOs and weighting scores. Resilience category represents the normalized scoring based on the last known abundance (0=low; 33=moderate; 67=high; 100=very high); MAXENT Mean is the normalized score of the average Maxent rank of all potential habitat; MAXENT percent 0.8-1 represents the normalized score of the percentage of potential habitat that falls within the highest rank category; 80% or greater SLEUTH Percent of Total is the total amount of current urbanization plus predicted urbanization at year 2040 (>80% probability) from the SLEUTH model.

EO not part of a current population
EO included as part of a current population
EO is a part of a current population but last detection was prior to 2005
Eliminated/not scored

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	33	49	3	97
2				
3	33	30	0	90
4	33	29	0	93
5	33	28	1	100
6				
8	0	37	0	94
9	67	65	11	100
10	100	46	6	100
11				
12	100	80	28	100
13	0	43	2	69
14	33	90	44	93
15				
16	100	23	0	52
17	0	73	37	100
18	0	52	22	98
19				
20	33	30	3	11
21	33	48	12	45
23	100	19	0	92
25	0	68	42	69
27				
28	33	62	33	71
29	100	63	22	69
30	100	38	5	24
31	100	43	8	12
32	33	48	5	52
33	33	47	8	100
34	0	73	37	35
35	0	60	29	77
36	0	25	0	88
37	100	60	17	82
38	33	17	0	53
39	0	24	0	89
40	33	54	7	67
44	100	26	1	40
45	0	37	14	86
46	67	60	18	94

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
47	0	39	2	2
48	0	17	0	88
49	100	91	39	95
50				
51	100	77	31	82
52	33	68	11	100
53	0	50	11	76
54	0	49	1	90
55	100	43	0	100
56	33	58	7	94
57	33	28	0	19
58	0	60	15	100
59	33	12	0	50
60	0	34	1	98
61	67	59	1	100
62	33	49	0	100
63	0	38	0	94
64	33	56	24	88
69	33	67	31	80
70	33	55	3	100
71	33	42	5	100
72	33	77	41	100
73	100	89	48	99
74	67	97	41	95
75	100	69	16	91
76	100	61	11	89
77	67	43	2	72
79	33	56	4	100
80	0	62	11	85
83	33	22	0	89
84	33	15	0	99
85	33	61	10	95
87				
89	33	15	5	100
90	33	38	5	100
91	0	71	13	100
92	33	18	0	70
106	100	56	10	61
107	0	16	0	59

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
113	100	68	11	93
114				
115	33	53	8	74
118	67	61	1	91
121	33	59	13	100
122	0	14	0	60
124	0	13	0	91
125	100	19	0	58
130	33	22	0	76
149	100	95	49	97
151	33	20	0	72
154	100	41	2	78
157	33	26	0	100
158	67	51	20	95
159	100	92	69	39
160	67	92	69	68
161	100	95	79	69
162	0	45	7	41
163	33	18	0	43
164	67	24	0	47
165	0	16	0	43
166	0	16	0	59
167	100	41	0	79
168	100	25	0	65
169	0	42	0	88
170	33	22	0	60
172	0	56	8	93
173	33	42	3	52
174	0	62	12	84
175				
180	33	28	2	100
181	100	41	6	100
182	100	66	12	100
183	33	18	1	95
184	100	24	0	81
187	33	27	2	64
188	33	33	0	46
189	0	33	1	86
190				

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
191	33	48	7	100
192	33	49	10	100
193	33	51	19	94
194	100	75	40	81
195	0	28	0	3
196	0	30	10	32
197	100	50	24	61
198	33	45	18	74
199	33	41	14	56
200	0	35	6	11
201	0	56	11	36
202	100	49	11	13
203	0	62	11	50
204				
205	33	62	4	50
206	0	52	8	33
207	33	47	4	14
208	0	45	4	32
209	33	46	5	4
210				
212	0	53	9	14
213	0	52	11	27
219	0	45	2	96
222	33	31	9	92
223				
224	0	29	8	83
225	33	32	6	88
227	100	81	7	95
229	33	39	0	79
230	0	80	44	87
231	0	59	20	100
233	100	79	34	86
235	33	74	22	94
236	33	93	41	95
237	33	100	46	95
238	100	74	41	100
239	33	94	40	94
240	0	85	51	100
241	33	93	47	97

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
242	0	78	27	100
246	0	93	38	95
249	100	68	13	100
250	100	65	12	100
251	100	62	11	100
254	33	80	51	93
255				
256	33	80	44	87
258	67	25	0	48
259	100	34	0	100
262	100	41	6	49
263				
264				
265				
266				
267	33	41	3	100
268	0	46	7	100
269	33	72	49	100
270	0	67	52	99
271	0	35	19	100
272	0	47	0	28
273	33	39	7	100
274	33	73	23	100
275	33	14	0	100
276	100	61	14	79
277				
278				
279	0	46	11	9
280	33	95	85	70
281	0	95	88	64
282	0	96	88	48
283	0	97	95	40
284	0	95	100	54
286				
287	33	18	0	64
291	33	28	4	14
292	33	16	0	16
293	0	7	0	84
294	33	52	11	38

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
296	33	0	0	95
297				
298	33	20	0	99
299	0	13	0	100
300	0	9	0	82
303	33	44	1	100
304	33	43	0	100
305	0	42	5	100
306	0	1	0	46
308	33	18	0	97
309	0	3	0	100
310	100	86	75	64
311	33	19	0	100
312	100	22	0	42
313				
314				
315	0	51	10	38
317	0	19	0	46
318	33	48	12	47
319	100	63	12	89
320	100	60	17	0
321				

Weights			
100	60	20	80

Table 6.4. Normalized scores for SMART analysis of South Carolina EOs and weighting scores. Resilience category represents the normalized scoring based on the last known abundance (0=low; 33=moderate; 67=high; 100=very high); MAXENT Mean is the normalized score of the average Maxent rank of all potential habitat; MAXENT percent 0.8-1 represents the normalized score of the percentage of potential habitat that falls within the highest rank category; 80% or greater SLEUTH Percent of Total is the total amount of current urbanization plus predicted urbanization at year 2040 (>80% probability) from the SLEUTH model.

EO not part of a current population
EO included as part of a current population
EO is a part of a current population but last detection was prior to 2005
Eliminated/not scored

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	33	67	14	100
2	33	2	0	96
3				
4	0	42	3	90
5	33	0	0	36
6	0	0	0	64
7	100	87	2	65
8	33	0	0	86
9				
10				
11	100	43	0	48
12				
13	0	23	0	0
14	100	43	0	57
15	0	0	0	96
16	100	72	1	62
17	100	70	1	67
18	67	62	0	48
19	0	37	0	35
20	33	16	0	0
21	67	15	0	10
22	0	1	0	100
23				
24	0	13	0	97
25	0	44	0	52
26	100	40	0	35
27	100	56	18	60
28	100	60	28	51
29				
30	33	22	0	12
31	100	0	0	100
32	33	23	0	7
33	33	5	0	80
34	0	100	100	99
35	0	75	34	47
36	33	18	0	100
37	0	78	66	100
38	100	16	0	63
39	0	19	0	99

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
40	33	18	0	80
41	0	36	0	13
42	33	10	0	94
43	0	72	0	57
44				
45				
46	0	32	0	4
47				
48				
49	67	27	0	30
50	33	16	0	46
51	0	1	0	65
52	67	0	0	100
53	33	33	0	34
54	33	29	0	9
55	0	13	0	1
56	33	43	0	4
57	67	47	8	62
59	33	13	0	83
60	100	53	21	88

Weights				
100	60	20	80	

1109
 1110 To determine a final rank for likelihood of persistence, we calculated a weighted sum for each
 1111 EO. We then converted the weighted sum to a final rank value that ranged from 0-100. Finally,
 1112 we determined the top 10% or 90th percentile, and top 25% or 75th percentile ranking for EOs in
 1113 each state. Table 6.5 summarizes the final ranks and top 10% and 25% percentile ranks for
 1114 North and South Carolina. We will include the top 10% in the status quo scenario, and the top
 1115 25% in the conservation scenario.

1116
 1117
 1118
 1119
 1120
 1121
 1122

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Table 6.5. Final Rank Scores for EOs in North and South Carolina. Dark green represents the top 10% of scores, and light green includes the top 25% of scores.

EO not part of a current population
EO included as part of a current population
EO is a part of a current population but last detection was prior to 2005
Eliminated/not scored

South Carolina		North Carolina	
EO_Code	Final Score	EO_Code	Final Score
60	79	149	94
7	79	73	93
17	75	49	92
16	74	12	90
27	71	238	90
28	70	161	88
31	69	227	87
14	66	249	86
11	63	233	86
38	62	182	85
34	61	250	85
1	60	251	84
26	59	194	84
52	56	51	84
57	56	310	84
18	55	75	84
37	54	113	84
36	48	319	81
42	44	76	81
2	43	74	81
40	42	10	80
59	41	181	79
49	41	55	79
8	39	37	79
33	39	276	78
4	37	259	77
39	35	159	77
35	34	29	76

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43	34	160	73
24	33	167	72
21	32	9	72
22	31	154	72
53	31	23	71
50	31	106	71
15	30	197	71
25	26	61	70
56	24	46	70
5	24	184	69
54	22	237	69
30	22	158	68
32	20	118	68
51	20	241	68
6	20	239	67
19	19	236	66
20	17	14	66
41	12	72	64
46	8	168	64
13	5	254	64
55	3	269	64
3	0	262	64
9	0	280	63
10	0	274	62
12	0	256	62
23	0	125	61
29	0	235	60
44	0	52	60
45	0	16	60
47	0	121	58
48	0	77	58
		85	57
		79	57
		44	57
		70	57
		312	56
		192	56
		56	56
		69	55
		33	55
		30	55

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191	55
193	55
64	55
62	55
202	55
240	54
1	54
303	54
246	54
71	54
320	54
304	54
267	53
273	53
90	53
31	53
28	51
242	51
17	51
5	50
180	50
270	50
157	50
222	49
230	49
115	48
281	48
91	48
4	48
298	48
311	48
225	48
198	47
89	47
3	47
84	47
308	47
275	47
183	46
40	46
284	46

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258	46
231	46
229	46
58	46
164	46
83	45
282	44
18	44
205	43
172	42
296	42
283	42
268	42
80	41
130	41
174	41
305	41
199	41
271	40
25	40
32	40
219	40
35	40
151	40
54	39
318	39
187	39
173	39
92	39
21	39
60	38
63	38
8	38
294	37
169	37
287	37
170	36
45	36
53	36
188	34
189	34

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299	34
38	33
224	33
39	33
36	33
13	32
309	31
124	31
59	31
48	31
34	30
203	30
163	30
207	28
293	27
300	27
57	25
209	25
201	25
315	24
291	24
162	23
20	23
206	23
107	22
166	22
122	22
292	21
213	21
208	20
272	20
317	19
196	18
212	17
165	17
306	14
279	14
200	12
47	10
195	7
2	0

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6	0
11	0
15	0
19	0
27	0
50	0
87	0
114	0
175	0
190	0
204	0
210	0
223	0
255	0
263	0
264	0
265	0
266	0
277	0
278	0
286	0
297	0
313	0
314	0
321	0

1131
1132
1133 Below we describe how we integrated potential positive and negative influences across the
1134 scenarios. We can assume there is some tipping point at which an area becomes so urbanized it
1135 is unsuitable for dwarf-flowered heartleaf, but we don't know exactly what that tipping point is.
1136 Similarly, we can assume additional populations are likely to be found or rediscovered across the
1137 range, but there is no clear way to predict the exact number or location of these populations.
1138 Although there is great uncertainty associated with how the species will be influenced by these
1139 factors, the three scenarios are intended to capture the range of this uncertainty. Note, changes in
1140 climate have potential to exacerbate the effects of urbanization, but these effects are not likely to
1141 occur within our projection window (e.g. 2040).

1142
1143 *Status Quo Scenario*

Under the status quo scenario, we assume a few populations will be identified as persisting throughout the range, and that there will be a range of impacts from urbanization that are related to the % increase in urban development and whether a population is protected or not. We assessed population resilience under the following assumptions:

- Two additional populations are identified as persisting based on Maxent model metrics, last known abundance category, and total predicted urbanization from SLEUTH modelling. Six additional EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist based on the same metrics.
- Potential impacts of urban development based on SLEUTH Model projections focused on current delineated populations:
 - Protected areas
 - Protected in perpetuity—no negative impacts from urbanization
 - Voluntary protection/non-perpetuity—population drops 1 resilience rank if % increase in urbanization exceeds >50% threshold
 - Non-protected—population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold

High Development Scenario

Under the high development scenario, we assume no additional populations will be identified as persisting throughout the range, and that impacts from urbanization are relatively high, and are also affected by whether a population is protected or not. We assessed population resilience under the following assumptions:

- No additional populations are identified as persisting
- Potential impacts of urban development based on SLEUTH Model projections focused on current delineated populations:
 - Protected areas
 - Protected in perpetuity—population drops 1 resilience rank if % increase in urbanization exceeds >50% threshold

- Voluntary protection/non-perpetuity— population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold
- Non-protected—population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold; extirpation of populations if % increase in urbanization exceeds >90% threshold.

Targeted Conservation Scenario

Under the targeted conservation scenario, we assume it is likely several additional populations (i.e. more than status quo scenario) will be identified as persisting throughout the range. The range of impacts from urbanization are the same as the Status Quo scenario. We assessed population resilience under the following assumptions:

- Six populations are identified as persisting based on Maxent model metrics, last known abundance category, and total predicted urbanization from SLEUTH modelling. Six additional EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist based on the same metrics.
- Potential impacts of urban development based on SLEUTH Model projections focused on current delineated populations:
 - Protected areas
 - Protected in perpetuity—no impacts from urbanization
 - Voluntary protection/non-perpetuity—population drops 1 resilience rank if % increase in urbanization exceeds >50% threshold
 - Non-protected—population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold

Future Resilience

Our focus on future resilience of dwarf-flowered heartleaf is on the potential impacts from urbanization. Table 6.6 shows a summary of currently delineated populations and the predicted urban development to occur within each of the populations. The table only includes those populations that already have some current amount of urban development, or are predicted to have some amount of development occur by the year 2040. Populations not included in this table are not predicted to be urbanized at all, so for the purposes of future analysis, will be assumed to retain the same resilience category as current. For those populations included in the table, we focus on those populations that are anticipated to increase in urbanization beyond a threshold value, depending on the scenario, but thresholds include >25% >50%, and >90% increases. Also taken into account is whether or not a population is on protected lands, and if so, whether the population is protected in perpetuity or not. Below is a summary of projected future resilience under each of the three scenarios.

Table 6.6. Results of the SLEUTH model. Populations consist of both stand-alone EOs and aggregates of multiple EOs following the definition of delineating demographic populations from Chapter 4. Included are only those populations that already have some current amount of urban development, or are predicted to have some amount of development occur by the year 2040. Red cells indicate populations that are predicted to increase >50% in urbanization. Orange cells indicate populations that are predicted to increase >25% in urbanization.

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Population Number	Total Area (sq m)	Already classed Urban	80% chance	90% chance	95% chance	97.5% chance	100% chance	>80%
206	17346.37096	0.40%	0.00%	0.00%	0.00%	6.24%	93.41%	99.65%
306	7804.656249	0.00%	15.11%	49.91%	7.83%	0.00%	22.40%	95.24%
208	55360.86786	17.31%	0.00%	0.00%	0.00%	0.00%	82.69%	82.69%
279	1951.661571	0.00%	0.00%	0.00%	0.00%	0.00%	80.85%	80.85%
214	15043.2984	0.00%	0.00%	1.44%	10.97%	0.00%	55.72%	68.13%
248	25486.15611	28.80%	0.00%	3.22%	0.02%	0.02%	53.03%	56.30%
316	43177.79587	20.06%	0.00%	16.68%	7.08%	0.00%	20.67%	44.43%
247	48898.17159	5.87%	0.00%	6.37%	0.00%	0.00%	23.35%	29.73%
291	11666.76374	35.39%	12.28%	13.53%	2.43%	0.00%	0.23%	28.47%
287	7901.775408	0.00%	0.00%	11.50%	0.00%	0.00%	14.25%	25.75%
312	6535.273235	0.00%	25.28%	0.00%	0.00%	0.00%	0.00%	25.28%
32	31220.60253	60.74%	0.00%	20.39%	0.00%	0.00%	0.00%	20.39%
177	26954.54153	25.34%	12.19%	0.92%	0.10%	5.31%	0.13%	18.66%
292	15611.18205	0.00%	0.00%	0.00%	0.00%	0.00%	18.40%	18.40%
261	21644.22924	0.00%	0.00%	13.21%	3.35%	0.00%	0.00%	16.56%
295	23486.00987	18.20%	0.00%	3.41%	11.99%	0.25%	0.00%	15.65%
125	20742.3249	0.00%	1.02%	5.65%	0.00%	6.67%	0.00%	13.34%
59	8172.007769	0.00%	13.09%	0.00%	0.00%	0.00%	0.00%	13.09%
302	120342.0641	1.46%	2.55%	2.55%	0.77%	2.33%	3.98%	12.19%
178	376781.2214	28.59%	2.79%	2.40%	0.68%	0.59%	2.64%	9.11%
93	43754.11642	0.19%	0.00%	0.00%	0.00%	0.00%	7.82%	7.82%
77	6044.427562	0.00%	1.51%	6.14%	0.00%	0.00%	0.00%	7.64%
179	15145.19453	85.06%	1.14%	0.00%	5.12%	0.00%	0.49%	6.75%
44	15081.76951	61.17%	0.27%	0.00%	0.00%	0.00%	4.68%	4.95%
252	39595.93143	63.47%	0.00%	3.80%	0.00%	0.00%	0.00%	3.80%
100	423621.7376	9.01%	1.32%	1.10%	0.72%	0.14%	0.00%	3.27%
276	123688.7819	0.61%	0.36%	1.87%	0.01%	0.00%	0.00%	2.24%
216	66424.06073	0.00%	0.91%	0.00%	0.00%	0.00%	0.00%	0.91%
154	33924.92259	0.00%	0.00%	0.37%	0.00%	0.00%	0.00%	0.37%
29	249998.8742	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%	0.05%
1	30711.68144	0.41%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2	36339.91976	11.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3	24498.03483	24.77%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
31	42929.76479	100.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
96	95947.32128	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
130	1168.240433	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
176	39787.48373	0.89%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
195	7805.599588	99.94%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
317	584.7346337	99.70%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
318	5396.859208	99.74%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
320	125.5182447	98.79%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Status Quo Scenario

In the Status Quo scenario, there are predicted to be 75 populations of dwarf-flowered heartleaf on the landscape in 2040 (Table 6.7). The predicted resilience of the extant populations are as

follows: very high (27); high (6); moderate (23); low (17); and 2 additional populations identified as persisting, with an unknown resilience. Six EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist, but resilience is unchanged because each of the populations are already predicted to be of very high resilience. When comparing future population resilience to current condition a few populations drop in their resilience category. One current population of very high resilience is predicted to drop to high resilience; two moderate populations are predicted to drop to low resilience; and five populations (one currently moderate and four currently low) are predicted to be extirpated due to urban development. Of the seven additional populations predicted to persist under this scenario, four are in South Carolina, and three in North Carolina. We did not assess resilience for these additional populations, but it is worth mentioning that the last time these populations were detected, resilience was very high (2), high (1), and moderate (4).

Table 6.7. Predicted resilience categories for *Hexastylis naniflora* populations under the Status Quo scenario, and comparison to current condition.

Site Name	Current Resilience	Status Quo
DNR Peters Creek Heritage Preserve	very high	very high
Cowpens NBF	very high	very high
Mill Creek Forest and Seep	very high	very high
Island Creek Heath Bluff	very high	very high
NCDOT TIP: R-2824	very high	very high
Murrays Mill/Upper Balls Creek NA	very high	very high
Big Horse Creek Rare Plant Site	very high	very high
Broad River/Sandy Run NA	very high	very high
New Hope Springhead Swamp	very high	very high
Facebook Site	very high	very high
Davenport Road/Mountain View Rare Plant Site	very high	very high
Broad River: Floyds Creek	very high	very high
Catawba River: Hoyle Crk-Micol Crk	very high	very high
South Fork Catawba R: Clark Crk, Miller Br, Cata Mem Hos	very high	very high
Buffalo Creek: Tributaries N and S of SR 2047	very high	high
Buffalo Creek: Kings Mountain Res	very high	very high
Broad River: Brushy Creek	very high	very high
Peaked Top Rare Plant Site/Foothills Landfill	very high	very high
Jacob Fork West Corridor	very high	very high
Floyds Creek Tributary Rare Plant Site	very high	very high

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Site Name	Current Resilience	Status Quo
New Bethel Rare Plant Site	very high	very high
Leepers Creek Heartleaf Site	very high	very high
Cliffside Steam Station	very high	very high
Rhyne Conservation Preserve	very high	very high
Glade Creek, Alex County	very high	very high
Richardson Creek trib above Toms Lake	very high	very high
Gunpowder Creek: South of Hudson	very high	very high
Taylor Blaylock Res	very high	very high
Little Gunpowder Creek Rare Plant Site 1	high	high
Little Gunpowder Creek Rare Plant Site 2	high	high
Buffalo Creek Rare Plant Site	high	high
Northern Catawba County	high	high
Rock Barn Solar Farm	high	high
NCDOT TIP R-2824	moderate	moderate
Third Creek Rare Plant Site	moderate	moderate
Knob Creek NA	moderate	moderate
Buffalo Creek: Northeast of SR 1903	moderate	moderate
West Shelby Mesic Slope	moderate	low
Cat Square Heartleaf Forest	moderate	low
Kross Keys NA	moderate	moderate
First Broad River: Crooked Run Creek	moderate	moderate
NCDOT non-TIP Div 12 road const at SR 1115 South Fork Catawba River Jacobs Fork and Camp Creek	moderate	moderate
Catawba River: North Fork Mountain Creek	moderate	moderate
Catawba River: Lake James	moderate	moderate
Hogpen Branch Transplant Site	moderate	moderate
Jonas Road Rare Plant Site	moderate	extirpated
South Fork Catawba River, Henry Fork	moderate	moderate
No Business Creek, Boyd Tract	moderate	moderate
Broad River/Sandy Run NA	moderate	moderate
Buffalo Shoals Creek	moderate	moderate
Fox Knoll Farm	moderate	moderate
Forest City: Adj to Isothermal CC	moderate	moderate
Hickory Area	moderate	moderate
UT of Kings Mountain Res	moderate	moderate
Brushy Creek Headwaters	moderate	moderate
Smith Cliff/Henry Fork River	moderate	moderate
Simms Hill/Little River Uplands	moderate	moderate
Collinsville (Hughes) Creek Slopes	moderate	moderate

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Site Name	Current Resilience	Status Quo
Burke County - Drowning Creek UT	moderate	moderate
Sandy Spring Church Springhead Swamp	low	low
First Broad River: Hickory Creek	low	low
Buffalo Creek: Ravine	low	extirpated
Buffalo Creek: Potts Creek	low	extirpated
Smith Cliff/Henry Fork River	low	low
Pott Creek	low	low
Northeast Lincolnton: UT Walker Branch	low	extirpated
Gunpowder Creek	low	low
Killian Crossroads	low	low
Beaverdam Crk at First Broad River	low	low
Lincoln County, SR-1314	low	low
Levan Family Farm	low	low
Fanjoy Road Site	low	extirpated
First Broad River: Beaverdam Creek Tribs	low	low
South Mountains Pleasant Grove Uplands	low	low
NCDOT TIP R-3603A	low	low
Hickory Creek - UT (Shelby High School)	low	low
Boulder Creek Subdivision	low	low
Gateway Elementary School	low	low
First Broad River (North Carolina)	n/a	present
Cherokee Creek/Bonner and Robin School Roads	n/a	present

High Development Scenario

In the High Development scenario, there are predicted to be 72 populations of dwarf-flowered heartleaf on the landscape in 2040 (Table 6.8). The predicted resilience of the extant populations are as follows: very high (27); high (4); moderate (25); and low (16). No new future populations are predicted to be discovered. When comparing future population resilience to current condition a few populations drop in their resilience category. One current population of very high resilience is predicted to drop to moderate resilience; one high resilience population is predicted to drop to moderate; two moderate populations are predicted to drop to low resilience; and six populations (one currently moderate and five currently low) are predicted to be extirpated due to urban development.

Table 6.8. Predicted resilience categories for *Hexastylis naniflora* populations under the High Development scenario, and comparison to current condition.

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Site Name	Current Resilience	High Development
DNR Peters Creek Heritage Preserve	very high	very high
Cowpens NBF	very high	very high
Mill Creek Forest and Seep	very high	very high
Island Creek Heath Bluff	very high	very high
NCDOT TIP: R-2824	very high	very high
Murrays Mill/Upper Balls Creek NA	very high	very high
Big Horse Creek Rare Plant Site	very high	very high
Broad River/Sandy Run NA	very high	very high
New Hope Springhead Swamp	very high	very high
Facebook Site	very high	very high
Davenport Road/Mountain View Rare Plant Site	very high	very high
Broad River: Floyds Creek	very high	very high
Catawba River: Hoyle Crk-Micol Crk	very high	very high
South Fork Catawba R: Clark Crk, Miller Br, Cata Mem Hos	very high	very high
Buffalo Creek: Tributaries N and S of SR 2047	very high	moderate
Buffalo Creek: Kings Mountain Res	very high	very high
Broad River: Brushy Creek	very high	very high
Peaked Top Rare Plant Site/Foothills Landfill	very high	very high
Jacob Fork West Corridor	very high	very high
Floyds Creek Tributary Rare Plant Site	very high	very high
New Bethel Rare Plant Site	very high	very high
Leepers Creek Heartleaf Site	very high	very high
Cliffside Steam Station	very high	very high
Rhyne Conservation Preserve	very high	very high
Glade Creek, Alex County	very high	very high
Richardson Creek trib above Toms Lake	very high	very high
Gunpowder Creek: South of Hudson	very high	very high
Taylor Blaylock Res	very high	very high
Little Gunpowder Creek Rare Plant Site 1	high	high
Little Gunpowder Creek Rare Plant Site 2	high	high
Buffalo Creek Rare Plant Site	high	high
Northern Catawba County	high	moderate
Rock Barn Solar Farm	high	high
NCDOT TIP R-2824	moderate	moderate
Third Creek Rare Plant Site	moderate	moderate
Knob Creek NA	moderate	moderate
Buffalo Creek: Northeast of SR 1903	moderate	moderate
West Shelby Mesic Slope	moderate	low
Cat Square Heartleaf Forest	moderate	low

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Site Name	Current Resilience	High Development
Kross Keys NA	moderate	moderate
First Broad River: Crooked Run Creek	moderate	moderate
NCDOT non-TIP Div 12 road const at SR 1115 South Fork Catawba River Jacobs Fork and Camp Creek	moderate	moderate
Catawba River: North Fork Mountain Creek	moderate	moderate
Catawba River: Lake James	moderate	moderate
Hogpen Branch Transplant Site	moderate	moderate
Jonas Road Rare Plant Site	moderate	extirpated
South Fork Catawba River, Henry Fork	moderate	moderate
No Business Creek, Boyd Tract	moderate	moderate
Broad River/Sandy Run NA	moderate	moderate
Buffalo Shoals Creek	moderate	moderate
Fox Knoll Farm	moderate	moderate
Forest City: Adj to Isothermal CC	moderate	moderate
Hickory Area	moderate	moderate
UT of Kings Mountain Res	moderate	moderate
Brushy Creek Headwaters	moderate	moderate
Smith Cliff/Henry Fork River	moderate	moderate
Simms Hill/Little River Uplands	moderate	moderate
Collinsville (Hughes) Creek Slopes	moderate	moderate
Burke County - Drowning Creek UT	moderate	moderate
Sandy Spring Church Springhead Swamp	low	low
First Broad River: Hickory Creek	low	low
Buffalo Creek: Ravine	low	extirpated
Buffalo Creek: Potts Creek	low	extirpated
Smith Cliff/Henry Fork River	low	low
Pott Creek	low	low
Northeast Lincolnton: UT Walker Branch	low	extirpated
Gunpowder Creek	low	extirpated
Killian Crossroads	low	low
Beaverdam Crk at First Broad River	low	low
Lincoln County, SR-1314	low	low
Levan Family Farm	low	low
Fanjoy Road Site	low	extirpated
First Broad River: Beaverdam Creek Tribs	low	low
South Mountains Pleasant Grove Uplands	low	low
NCDOT TIP R-3603A	low	low
Hickory Creek - UT (Shelby High School)	low	low
Boulder Creek Subdivision	low	low

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Site Name	Current Resilience	High Development
Gateway Elementary School	low	low

Targeted Conservation Scenario

In the Targeted Conservation scenario, there are predicted to be 79 populations of dwarf-flowered heartleaf on the landscape in 2040 (Table 6.9). The predicted resilience of the extant populations are as follows: very high (27); high (6); moderate (23); low (17); and 6 additional populations discovered to persist, with an unknown resilience. Six EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist, but resilience is unchanged because each of the populations are already predicted to be of very high resilience. When comparing future population resilience to current condition a few populations drop in their resilience category. One current population of very high resilience is predicted to drop to high resilience; two moderate populations are predicted to drop to low resilience; and five populations (one currently moderate and four currently low) are predicted to be extirpated due to urban development. Of the sixteen additional populations predicted to persist under this scenario, ten are in South Carolina, and six in North Carolina. We did not assess resilience for these additional populations, but it is worth mentioning that the last time these populations were detected, resilience was very high (2), high (1), moderate (11), and low (2).

Table 6.9. Predicted resilience categories for *Hexastylis naniflora* populations under the Targeted Conservation scenario, and comparison to current condition.

Site Name	Current Resilience	Targeted Conservation
DNR Peters Creek Heritage Preserve	very high	very high
Cowpens NBF	very high	very high
Mill Creek Forest and Seep	very high	very high
Island Creek Heath Bluff	very high	very high
NCDOT TIP: R-2824	very high	very high
Murrays Mill/Upper Balls Creek NA	very high	very high
Big Horse Creek Rare Plant Site	very high	very high
Broad River/Sandy Run NA	very high	very high
New Hope Springhead Swamp	very high	very high
Facebook Site	very high	very high
Davenport Road/Mountain View Rare Plant Site	very high	very high

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Site Name	Current Resilience	Targeted Conservation
Broad River: Floyds Creek	very high	very high
Catawba River: Hoyle Crk-Micol Crk	very high	very high
South Fork Catawba R: Clark Crk, Miller Br, Cata Mem Hos	very high	very high
Buffalo Creek: Tributaries N and S of SR 2047	very high	high
Buffalo Creek: Kings Mountain Res	very high	very high
Broad River: Brushy Creek	very high	very high
Peaked Top Rare Plant Site/Foothills Landfill	very high	very high
Jacob Fork West Corridor	very high	very high
Floyds Creek Tributary Rare Plant Site	very high	very high
New Bethel Rare Plant Site	very high	very high
Leepers Creek Heartleaf Site	very high	very high
Cliffside Steam Station	very high	very high
Rhyne Conservation Preserve	very high	very high
Glade Creek, Alex County	very high	very high
Richardson Creek trib above Toms Lake	very high	very high
Gunpowder Creek: South of Hudson	very high	very high
Taylor Blaylock Res	very high	very high
Little Gunpowder Creek Rare Plant Site 1	high	high
Little Gunpowder Creek Rare Plant Site 2	high	high
Buffalo Creek Rare Plant Site	high	high
Northern Catawba County	high	high
Rock Barn Solar Farm	high	high
NCDOT TIP R-2824	moderate	moderate
Third Creek Rare Plant Site	moderate	moderate
Knob Creek NA	moderate	moderate
Buffalo Creek: Northeast of SR 1903	moderate	moderate
West Shelby Mesic Slope	moderate	low
Cat Square Heartleaf Forest	moderate	low
Kross Keys NA	moderate	moderate
First Broad River: Crooked Run Creek	moderate	moderate
NCDOT non-TIP Div 12 road const at SR 1115 South Fork Catawba River Jacobs Fork and Camp Creek	moderate	moderate
Catawba River: North Fork Mountain Creek	moderate	moderate
Catawba River: Lake James	moderate	moderate
Hogpen Branch Transplant Site	moderate	moderate
Jonas Road Rare Plant Site	moderate	extirpated
South Fork Catawba River, Henry Fork	moderate	moderate
No Business Creek, Boyd Tract	moderate	moderate
Broad River/Sandy Run NA	moderate	moderate

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Site Name	Current Resilience	Targeted Conservation
Buffalo Shoals Creek	moderate	moderate
Fox Knoll Farm	moderate	moderate
Forest City: Adj to Isothermal CC	moderate	moderate
Hickory Area	moderate	moderate
UT of Kings Mountain Res	moderate	moderate
Brushy Creek Headwaters	moderate	moderate
Smith Cliff/Henry Fork River	moderate	moderate
Simms Hill/Little River Uplands	moderate	moderate
Collinsville (Hughes) Creek Slopes	moderate	moderate
Burke County - Drowning Creek UT	moderate	moderate
Sandy Spring Church Springhead Swamp	low	low
First Broad River: Hickory Creek	low	low
Buffalo Creek: Ravine	low	extirpated
Buffalo Creek: Potts Creek	low	extirpated
Smith Cliff/Henry Fork River	low	low
Pott Creek	low	low
Northeast Lincolnton: UT Walker Branch	low	extirpated
Gunpowder Creek	low	low
Killian Crossroads	low	low
Beaverdam Crk at First Broad River	low	low
Lincoln County, SR-1314	low	low
Levan Family Farm	low	low
Fanjoy Road Site	low	extirpated
First Broad River: Beaverdam Creek Tribs	low	low
South Mountains Pleasant Grove Uplands	low	low
NCDOT TIP R-3603A	low	low
Hickory Creek - UT (Shelby High School)	low	low
Boulder Creek Subdivision	low	low
Gateway Elementary School	low	low
First Broad River (North Carolina)	n/a	present
First Broad Hop-Hornbeam NA	n/a	present
Big Island Carolina Hemlock Bluff	n/a	present
Cherokee Creek/Bonner and Robin School Roads	n/a	present
Arrowood Branch	n/a	present
Cherokee Creek/SC 11	n/a	present

1299

1300 *Viability Summary*

Urban development is predicted to have negative impacts on several of the current populations under all of our scenarios. However, this loss of resilience and extirpation of a few populations is offset by the fact that several additional populations were found to persist in the Status Quo and Targeted Conservation scenarios. In the High Development Scenario, there is a predicted loss of 6 populations, with loss of resilience in several additional populations. Regardless of the scenario, the majority of the populations expected to persist on the landscape in 2040 are of at least moderate resilience.

Given the relatively high number of populations across each scenario, redundancy remains similar to current conditions. That is to say, there appears to be adequate redundancy within the range of dwarf-flowered heartleaf to withstand the impacts of localized press catastrophic disturbances, however the species range is relatively small, making it potentially vulnerable to long-term catastrophic events, such as climate change.

Given that dwarf-flowered heartleaf has a very limited range, and after consulting with experts, we decided delineating representative units was not appropriate for this species. It is worth noting that in two of our scenarios (Status Quo and Targeted Conservation), additional populations are found to persist in South Carolina, an area where we have relatively few current populations. As discussed below, we believe there are opportunities to find additional populations based on the amount of predicted unoccupied potential habitat. Although we did not delineate representative units, we believe our scenarios do not predict declines in species representation.

Table 6.10. Viability summary for *Hexastylis naniflora* under 3 future scenarios (projected to year 2040) and compared to Current Condition.

	CURRENT	STATUS QUO	HIGH DEVELOPMENT	TARGETED CONSERVATION
VERY HIGH	28	27	27	27
HIGH	5	6	4	6
MODERATE	26	23	25	23
LOW	19	17	16	17

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EXTIRPATED	n/a	5	6	5
PERSISTING	n/a	2	0	6
TOTAL	78	75	72	79

Opportunities for Additional Conservation

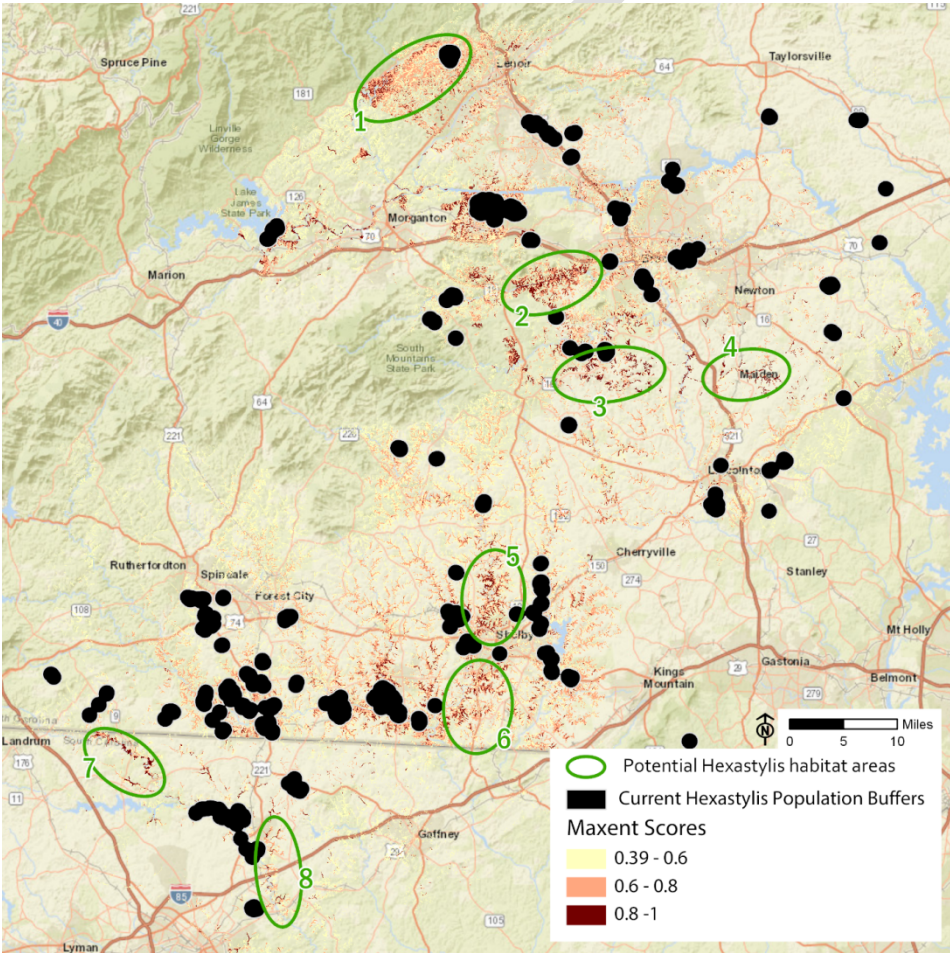
Although our scenarios focus on areas where dwarf-flowered heartleaf have been found in the past, the Maxent model identifies a number of areas as high quality potential habitat for the species that falls outside the immediately known occurrence areas. A few of these areas are detailed below (Figure 6.2).

1. West of the city of Lenoir, south of Highway 90/Adako Rd., north of Highway 64 within Caldwell County. This area identifies a large block of potential habitat. This area falls just outside the administrative boundary of the Pisgah National Forest. The bluffs and tributaries along the Johns River are identified as the best habitat, but there is also ample habitat identified along the forested areas of Celia, Husband, Abingdon and Greasy Creeks. The only known occurrence within this area is associated with Abingdon Creek and is under a conservation easement.
2. Henry Fork River bluffs and tributaries east of Highway 18 within Burke County. A historic element occurrence is present by the Burke County line, but the entire area is identified as good quality potential habitat for the species where forested habitats remain.
3. South West corner of Catawba County west of Highway 321. Several disjointed patches of high quality potential habitat are identified in this region associated with the river and creek slopes. Rock Creek, Jacob Fork River, Pott Creek, and their associated tributaries all contain blocks of potential habitat. A number of element occurrences are identified within this area, but additional habitat is identified both upstream and downstream of the known occurrences.
4. Clark, Pinch Gut, Maiden, and Allen Creeks, north of the town of Maiden. The slopes along these creeks all contain quality potential habitat. Known element occurrences are in the general area, but none are situated within the creeks listed.

5. First Broad River North of Highway 74, Rutherford County. Two older element occurrences are located within this area, however, the forested bluffs along the First Broad River and associated tributaries are identified as good quality potential habitat in many additional upstream and downstream areas in this system.
6. Hickory Creek, Sulphur Springs Branch (Little Hickory), Shoal Creek, and tributaries draining into First Broad River South of the Town of Shelby, north of the South Carolina border. The town of Shelby has likely disconnected this site from area 5 listed above. Here, slopes along the creeks and tributaries draining into the First Broad River are identified as potential habitat more so than the slopes along the First Broad River themselves. There is only a single element occurrence known upstream along Hickory Creek.
7. North Pacolet River and Obed Creek, north of where they join. The majority of potential habitat falls along the slopes of the North Pacolet River. Two older element occurrences (1991 last observation) are found in the tributaries draining into the North Pacolet River, and many occurrences are found further upstream. The habitat model suggests that additional undiscovered habitat areas are present.
8. Pacolet River and Island Creek, north of Peters Creek, downstream of the Pacolet River dam. This area displays limited amounts of good quality potential habitat. Recent element occurrences are present in the upper headwaters of Peters and Zekial Creeks (Zekial Creek drains into Peters Creek) and in areas north of the Pacolet River dam, but none are known along the areas identified in this immediate area.

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Figure 6.2. Areas identified as high quality potential habitat by Maxent model for *Hexastylis naniflora* that fall outside the immediately known occurrence areas.



Literature Cited

- Amoroso, J.L. 2016. *Hexastylis naniflora* status meeting with USFWS, NCNHP, ASU, and NCDOT [meeting minutes]. North Carolina Department of Natural and Cultural Resources office, Asheville, NC, 11 May 2016.
- Baldwin, R.A. 2009. Use of maximum entropy modeling in wildlife research. *Entropy*. 11:854-866.
- Barringer, K. 1993. New combinations in North American *Asarum* (Aristolochiaceae). *Novon* 3:225-227.
- Blomquist, H.L. 1957. A Revision of *Hexastylis* in North America. *Brittonia* 8:255-281.
- Clarke, K.C., Riggan, P., and Brass, J.A., 1995. A cellular automaton model of wildfire propagation and extinction, *Photogram. Eng. Rem S.* 60, 1355-1367.
- Dobzhansky, T. 1937. *Genetics and the origin of species*. Columbia University Press, New York, NY.
- DeWan, A., N. Dubois, K. Theoharides, and J. Boshoven. 2010. Understanding the impacts of climate change on fish and wildlife in North Carolina.
- Flora of North America 1997. *Flora of North America north of Mexico*. Volume 3, Magnoliophyta: Magnoliidae and Hamamelidae. Oxford University Press, New York, NY. 590 pp. Contains Whittemore and Gaddy's treatment of *Asarum* and *Hexastylis*.
- Gaddy, L.L. 1980. Status Report on *Hexastylis naniflora* Blomquist. Prepared for and submitted to USFWS, Endangered Species Office, Region 4, Atlanta, Georgia. July 1980.
- Gaddy, L.L. 1981. The status of *Hexastylis naniflora* Blomquist in North Carolina. Unpublished report prepared under contract to the Plant Conservation Program, North Carolina Department of Agriculture, Raleigh.
- Gaddy, L. 1986. Twelve new ant-dispersed species from the southern Appalachians. *Bulletin of the Torrey Botanical Club* 113: 247-251.
- Gaddy, L.L. 1987. A review of the taxonomy and biogeography of *Hexastylis* (Aristolochiaceae). *Castanea* 52(3):186-196.
- Golder Associates, Inc. 2009. Year 5 Monitoring Report, *Hexastylis naniflora*, Foothills Conservation Area, Caldwell County, North Carolina. Submitted to: Republic Services of North Carolina, LLC; copies (per cover letter) distributed to US Army Corps of Engineers, Asheville Regulatory Office and USFWS Asheville ES Office. June 26, 2009.

- Golladay SW, Gagnon P, Kearns M, Battle JM, Hicks DW. Response of freshwater mussel assemblages (Bivalvia: Unionidae) to a record drought in the Gulf Coastal Plain of southwest Georgia. *J. N. Am. Benthol. Soc.* 2004;23:494–506.
- Gonzalez, V. C. 1972. The ecology of *Hexastylis arifolia*, an evergreen herb in the North Carolina deciduous forest. Ph.D. dissertation, Duke University. Durham, North Carolina, USA. HDR. 2005. Identification of *Hexastylis naniflora*. Notes on characteristics and field observations provided to the North Carolina Natural Heritage Program, Raleigh.
- IPCC, 2013: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
- Jones M.S., T. H. Jones, and J. J. English. 2014. The Pollination of *Hexastylis naniflora* in Cleveland County, North Carolina. *Castanea*: June 2014, Vol. 79, No. 2, pp. 74-77.
- Jordan, Jones and Goulding (JJ&G), Inc. 1998. Section 404 Application and Conceptual Mitigation Plan, Lake Blalock Expansion Project. USFWS Log number 4-6-97-358. ACOE Project # 80-97-1732 (S). Section 9: *Hexastylis naniflora* Biological Assessment. Received by the Asheville Field Office July 16, 1998.
- Jordan, Jones and Goulding (JJ&G), Inc. 2006. Lake Blalock Buffer Disturbance – Vicinity of Casey Creek Road. Memorandum to: Eddie Dearbury, Spartanburg Water Systems. Date: October 25, 2006.
- Karl, T. R., Melillo, J. M., & Peterson, T. C. (Eds.). (2009). *Global Climate Change Impacts in the United States*. Washington, DC: U.S. Global Change Research Program.
- Kelly, L. M. 1997. A Cladistic Analysis of *Asarum* (Aristolochiaceae) and Implications for the Evolution of Herkogamy. *American Journal of Botany* 84:1752-1765.
- Kelly, L. M. 1998. Phylogenetic Relationships in *Asarum* (Aristolochiaceae) Based on Morphology and ITS Sequences. *American Journal of Botany* 85:1454-1467.
- Kelly, L. M. 2001. Taxonomy of *Asarum* Section *Asarum* (Aristolochiaceae). *Systematic Botany* 26:17-53.
- Lengyel, S., A. D. Gove, A. M. Latimer, J. D. Majer, and R. R. Dunn. 2010. Convergent evolution of seed dispersal by ants, and phylogeny and biogeography in flowering plants: A global survey. *Perspectives in Plant Ecology, Evolution and Systematics* 12: 43-55.
- McLaughlin, J.F. et al. (2002). Climate change hastens population extinctions. *Proceedings of the National Academy of Sciences* 99(9): 6070–6074.
- Murrell, Z. et al. 2007. Ecological, Morphological, Micromorphological and Molecular Analyses of the Species in the *Hexastylis heterophylla* Complex. A report to the North Carolina

- 1492 Department of Transportation. NCDOT and CTE Joint Project 2002-2004,
1493 FHWA/NC/2004-01. May 2007.
1494
- 1495 Murrell, Z. 2015. Development of molecular and morphological tools to circumscribe and
1496 identify the Dwarf Flowered Heartleaf (*Hexastylis naniflora*). Report to the North
1497 Carolina Department of Transportation, NCDOT Project 2012-2111, July 2015.
1498
- 1499 National Climate Change Viewer. 2016. USGS. Accessed at
1500 https://www2.usgs.gov/climate_landuse/clu_rd/nccv.asp, January 2018.
1501
- 1502 NatureServe. 2002. Element Occurrence Data Standard, 6 February 2002. NatureServe,
1503 Arlington, Virginia. Accessed at
1504 http://www.natureserve.org/library/deliminting_plant_eos_Oct_2004.pdf, August 2016.
1505
- 1506 NCOSBM. North Carolina Budget and Management County and State Population Projections.
1507 Accessed at <https://www.osbm.nc.gov/demog/county-projections>, March 2018.
1508
- 1509 Newberry, G. 2006. South Carolina Populations of *Hexastylis naniflora*: 2006 updates. Received
1510 by the USFWS Asheville Field Office, September 7, 2006.
1511
- 1512 Newberry, G. 2009. University of South Carolina at Spartanburg. Evaluation of damage to
1513 *Hexastylis naniflora* plants on acreage bordering the hunt club. Letter to Jon Morgan,
1514 Lake Warden, Spartanburg Water Systems. Dated February 24, 2009.
1515
- 1516 North Carolina Natural Heritage Program (NCNHP). 2016. Element Occurrence Records for
1517 *Hexastylis naniflora* (dwarf-flowered heartleaf). As of: August 5, 2016.
1518
- 1519 North Carolina Natural Heritage Program (NCNHP). 2018. Natural Heritage Element
1520 Occurrences. Accessed at [https://www.ncnhp.org/activities/conservation/natural-heritage-](https://www.ncnhp.org/activities/conservation/natural-heritage-element-occurrences)
1521 [element-occurrences](https://www.ncnhp.org/activities/conservation/natural-heritage-element-occurrences), January 2018.
1522
- 1522 Newberry, G. 1993. Progress Report on Monitoring Studies of *Hexastylis naniflora*. Unpublished
1523 report. Copy submitted to the USFWS Asheville Field Office, on September 7, 2006.
1524
- 1525 Niedenberger, B.A. 2010. Molecular phylogeny and comparative pollen morphology of the
1526 genus *Hexastylis* (Aristolochiaceae). M.S. thesis. Appalachian State University, Boone,
1527 NC.
1528
- 1529 Otte, D. 1977. The pollination biology of *Hexastylis arifolia* (Michx.) Small var. *arifolia* and *H.*
1530 *minor* (Ashe) Blomquist (Aristolochiaceae) in the area of Chapel Hill, North Carolina.
1531 M.S. Thesis, University of North Carolina Chapel Hill, Chapel Hill, North Carolina,
1532 USA.
1533
- 1534 Padgett, J. E. 2004. Biogeographical, ecological, morphological, and micromorphological
1535 analyses of the species in the *Hexastylis heterophylla* complex. M.S. thesis. Appalachian
1536 State University, Boone, NC.
1537

- 1538 Phillips, S. J. 2018. A Brief Tutorial on Maxent. Available from url:
1539 http://biodiversityinformatics.amnh.org/open_source/maxent/. Accessed on 2018-02/21.
1540
- 1541 Renninger, H. 2010. North Carolina Department of Transportation (NCDOT). E-mail
1542 communication to Carolyn Wells, USFWS Asheville Field Office. Date: May 28, 2010.
1543 Subject: Dwarf-flowered heartleaf research proposal.
1544
- 1545 Robinson L.G. 2016. Dwarf-flowered Heartleaf range-wide status report. Final report to U.S.
1546 Department of Interior—U.S. Fish and Wildlife Service by North Carolina Natural
1547 Heritage Program. August 2016.
1548
- 1549 Robinson, L.G. and J.E. Padgett. 2016. Dwarf-flowered Heartleaf (*Hexastylis naniflora*)
1550 comprehensive review and monitoring report. Final report to the U.S. Department of
1551 Interior—U.S. Fish and Wildlife Service by the North Carolina Natural Heritage
1552 Program. August 2016.
1553
- 1554 Schneider, S. 2006. Spartanburg Water System (SWS) & Sanitary Sewer District, Assistant
1555 General Manager. E-mail communication to Lora Zimmerman, USFWS (formerly with
1556 the Charleston Field Office), dated December 18, 2006. Subject: Meeting at SWS on
1557 December 21, 2006 [to discuss Lake Blalock Buffer Disturbance].
1558
- 1559 South Carolina Department of Natural Resources (SCDNR) Heritage Trust. 2016. Element
1560 Occurrence Records for *Hexastylis naniflora* (dwarf-flowered heartleaf). As of: February
1561 4, 2016.
1562
- 1563 USFWS. 2001. Biological Opinion for Spartanburg Water System, Lake Blalock, P/N 2000-IP-
1564 194-W, USFWS log number 4-6-01-F-115. May 10, 2001.
1565
- 1566 USFWS. 2010. Draft Five Year Review for *Hexastylis naniflora* (dwarf flowered heartleaf).
1567 September 30, 2010. Submitted to the USFWS Southeast Regional Office September 30,
1568 2010.
1569
- 1570 USFWS. 2015, August. Fact sheet for *Hexastylis naniflora*. Retrieved from
1571 https://www.fws.gov/raleigh/species/es_dwarf-flowered_heartleaf.html.
1572
- 1573 USFWS. 2016. USFWS species status assessment framework: an integrated analytical
1574 framework for conservation. Version 3.4.8, August 2016.
1575
- 1576 Wagner, J. 2013. Developing new morphological, geographic, and molecular tools to
1577 circumscribe *Hexastylis naniflora*. M.S. thesis. Appalachian State University, Boone,
1578 NC.
1579
- 1580 Walker, J. et al. 2009. What are the effects of prescribed fire on *Hexastylis naniflora*, a federally
1581 protected plant species? Unpublished final report prepared by U.S. Forest Service,
1582 Southern Research Station, Clemson University, Clemson, SC. Submitted to Timothy
1583 Stone, Superintendent, Cowpens National Battlefield. In partial fulfillment for Agreement

- 1584 04-IA-11330138-234, between the NPS and USFS Southern Research Station. Revised
1585 March 19, 2009.
- 1586
- 1587 Warren II, R. J., 2008. Mechanisms driving understory evergreen herb distributions across slope
1588 aspects: as derived from landscape position. *Plant Ecology* 198: 297-308.
- 1589
- 1590 Weakley, A. 2010. Flora of the Southern and Mid-Atlantic States. University of North Carolina
1591 Herbarium (NCU), North Carolina Botanical Garden, University of North Carolina at
1592 Chapel Hill. Working Draft as of March 8, 2010.
- 1593 Weakley, A. 2015. Flora of the Southern and Mid-Atlantic States. University of North Carolina
1594 Herbarium (NCU), North Carolina Botanical Garden, University of North Carolina at
1595 Chapel Hill. Working Draft as of 21 May 2015.
- 1596
- 1597 Whittemore, A. T., and L. L. Gaddy. 1997. Hexastylis. In Flora of North America Editorial
1598 Committee [Eds.], Flora of North America north of Mexico, vol. 3, 54–58. Oxford
1599 University Press, New York, New York, USA.
- 1600 Wolf, S., B. Hartl, C. Carroll, M.C. Neel, and D.N. Greenwald. 2015. Beyond PVA: why
1601 recovery under the Endangered Species Act is more than population viability. *BioScience*
1602 65:200-207.
- 1603

Appendix 1

Populations of *Hexastylis naniflora* estimated to contain over 1,000 rosettes in 2010, with updated information in 2016¹, and protection measures for these populations.

Populations known to be afforded some protection are indicated in **bold**.²

USFWS population number	State	County	NHP EO numbers (2016) ³	NHP EO rank (2016) ^{4,5}	Site	Latest estimate of population size (year)	Estimate of plants on-site protection (year)	Protection comments
1	NC	Burke	029	A	Island Creek Heath Bluff (Lovelady Sites)	50,000+ (2016)	0	Not protected.
2	NC	Burke	178.159-178.161 178.254-178.256 178.280-178.282	A	Catawba River: Love Lady (Hoyle and Micol Creek)	~6,738 (2008-2011)	Awaiting data from NCDOT.	Possible NCDOT protected R-O-W, protection unconfirmed. In early 2016, the Town of Valdese applied to CWMTF to acquire part of this population.
3	NC	Caldwell	227	A	Peaked Top Rare Plant Site (Foothills Landfill)	16,463 (2014)	16,463 (2014)	Conservation Easement (Foothills Conservancy of NC).
4	NC	Caldwell	044	AB	Little Gunpowder Creek Rare Plant Site 1	2,707 (2015)	2,424 (2015)	DOT mitigation site.
5	NC	Catawba	158	D	South Fork Catawba River: Jacob Fork, Camp Creek	123 (2016)	27 (2015)	Some plants occur within an undetermined acreage within NCDOT R-O-W (Bassette 2016). Protection unconfirmed.
6	NC	Catawba	243.012, 243.242 243.269, 243.270	A	Catawba Wildlife Club	1,000-1300 (1995-2007)	>1,000 (1995-2007)	Catawba County Wildlife Club Registered Heritage Area (EO 12) The Nature Conservancy Conservation Easement (EO 270).
7	NC	Catawba	031	C?	US 321, southeast Hickory	1,202 (2010)	161 (2010)	161 plants within NCDOT R-O-W (Bassette 2016).
8	NC	Catawba	96.184, 96.038 96.039	A	Murrays Mill/Upper Balls Creek	~9,150 (2005)	11,860 (2013)	Fee title by NCDOT (~34 acres).
9	NC	Cleveland	100.014, 100.049, 100.050, 100.051, 100.073, 100.074 100.149, 100.233	A	Broad River/Sandy Run Natural Areas (aka "Broad River Tract")	~33,500 (2001-2015)	32,702 (2015)	Fee title by Broad River Greenway (1,000 acres).

USFWS population number	State	County	NHP EO numbers (2016) ³	NHP EO rank (2016) ^{4,5}	Site	Latest estimate of population size (year)	Estimate of plants on-site protection (year)	Protection comments
			100.236, 100.237 100.238, 100.239 100.240, 100.241, 100.246					
10	NC	Cleveland	208	A?	Buffalo Creek: Potts Creek	3,572 (2007)		Awaiting verification that plants are protected in NCDOT R-O-W. Protection unconfirmed.
11	NC	Cleveland	211.072, 211.194		First Broad River: Hop-Hornbeam Natural Area	1,965 (2000)		Awaiting verification that plants are protected in NCDOT R-O-W. Protection unconfirmed.
12	NC	Cleveland	214.201, 214.202, 214.203, 214.204, 214.205, 214.209, 214.212, 214.213,	A	Buffalo Creek: tributaries north and south of SR2047	6,447 (200-2007)		Awaiting verification that plants are protected in NCDOT in R-O-W, bold in EO column. Protection unconfirmed (EO 202, 203, 205, 209, 213).
13	NC	Cleveland	216.028, 216.196, 216.197, 216.198, 216.199, 216.200	A	Buffalo Creek: Kings Mountain Reservoir	3,310 (200-2016)	~500? (2000-2007) (awaiting updates)	Awaiting verification that plants are protected in NCDOT in R-O-W, bold in EO column. Protection unconfirmed (EO 199, 200).
14	NC	Cleveland	157	AB	First Broad River: Crooked Run Creek	330 (2010)		None of the population is protected within NCDOT R-O-W, determined too far away from roadside, DOT stopped monitoring in 2010 (Bassette 2016).
15	NC	Cleveland/ Rutherford	276	A	Cliffside Steam Station	39,545 (2016)	~39,545 (2016)	Voluntary agreement with Duke Energy; protected acreage unknown.
16	NC	Lincoln	261.252, 261.259, 261.263	B	Lincoln County Airport and Leepers Creek	7,032 (2005-2006)		Not protected.
17	NC	Polk	023	A	Mills Creek Forest and Seep	1,459 (2016)		Not protected.

USFWS population number	State	County	NHP EO numbers (2016) ³	NHP EO rank (2016) ^{4,5}	Site	Latest estimate of population size (year)	Estimate of plants on-site protection (year)	Protection comments
18	NC	Polk	125	A	Broad River: New Hope Springhead Swamp	12,235 (2016)	1,000-3,000 estimated (2016)	New Hope Springhead Swamp Registered Heritage Area (voluntary conservation agreement).
19	NC	Rutherford	154	C	Second Broad River (Forest City Industrial Complex)	2,576 (2016)	2478 (2008)	Deed restrictions (12 acres). Significant threats from industrial development, invasive exotics, erosion, sedimentation in a fragmented landscape.
20	NC	Rutherford	99.009, 99.010, 99.037, 99.052, 99.053, 99.055, 99.061, 99.063, 99.075, 99.076 , 99.079, 99.090, 99.121, 99.172 , 99.181, 99.182, 99.249-.251, 99.267, 99.268	A	Broad River: Hensons Creek Ravine, Brice Rare Plant Site, Sandy Mush Outcrop	106,940 (2016)	~200-250 (2007-2012)	Parris Heartleaf Registered Heritage Area (voluntary conservation agreement on subEO 076 and 172).
21	NC	Rutherford	176.167-176.170	A	Broad River: Cleghorn Creek Tributary/US221	6,750 (2016)		Not protected.
22	NC	Rutherford	177.016, 177.107, 177.122, 177.063, 177.164, 177.165, 177.166	A	Broad River: Floyds Creek, Long Branch	12,687 (2008-2016)		Not protected.
23	NC	Rutherford	247.013, 247.056, 247.080, 247.106 , 247.114, 247.115, 247.173, 247.174, 247.286	A	Broad River: Floyds Creek (aka New Bethel Rare Plant Site)	~5,480 (2003-2015)	4,873 (2015)	Tate Conservation Easement (8 acres) (SubEOs 106 and 286).
24	SC	Cherokee	016, 017, 018	BC	Cowpens Battlefield	2,823 (2016)	2,823? (2016)	National Park Service, National Battlefield.

USFWS population number	State	County	NHP EO numbers (2016) ³	NHP EO rank (2016) ^{4,5}	Site	Latest estimate of population size (year)	Estimate of plants on-site protection (year)	Protection comments
25	SC	Greenville /Spartanburg	002, 004, 024, 032, 033, 036, 038, 039, 040, 041, 042, 049, 050, 054	Various AB-BD	South Pacolet River and tributaries	5,205 (1991-1998)		Not protected.
26	SC	Spartanburg	011, 014, 026--028, 047, 048, 057	Various AB-BD	Peters Creek Heritage Preserve	3,306 (2016)	3,306 (2016)	State Heritage Preserve (194 acres).
27	SC	Spartanburg	007, 029	BD, H?	Blalock Reservoir	3,505 (2016)	3,505? (2016)	Restrictive covenants (protected acreage unknown); significant threats to remaining population.
28 ⁶	NC	Lincoln	302.046, 302.262	A	Rhyne Preserve	19,880 (2016)	19,873 (2016)	Rhyne Preserve (fee title by Catawba Lands Conservancy).

¹This table was replicated in the same format and populations as Table B.2 from the most recent USFWS five-year Review of *Hexastylis naniflora* (USFWS 2010) for comparison of changes since the time of the five-year review. Populations that are not believed to contain over 1,000 rosettes but were included in the original Table B.2 are included here, but the “NHP EO rank” and in the “Latest estimate of population size” reflects the smaller size.

²In the case of partially protected populations, the column “NHP EO numbers” indicates the specific portions of the population afforded protection in bold font.

³NHP EO numbers use the following format: Principal EO.SubEO. Only one number is listed if it is a stand-alone principal EO.

⁴NHP EO rank specifications are defined in Appendix B2. In cases involving principal/sub EOs, only the rank for the principal EO is given.

⁵EO ranks with two letters indicate a degree of uncertainty within the range provided (e.g. a rank of “AB” indicates possibly excellent to good viability).

⁶Population that is currently estimated to have over 1,000 rosettes that was not known to be large populations in 2010 have been added to this table.

Appendix 2

NC Natural Heritage Program (NCNHP) Element Occurrence Rank Specifications for *Hexastylis naniflora*

"A" Rank Specifications (excellent viability)

An A-ranked population of *Hexastylis naniflora* should have 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" Rank Specifications (good viability)

A B-ranked population of *Hexastylis naniflora* should have 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 occurring in less than one acre of high quality forest or on land impacted by human disturbance such as logging, grazing, mowing, etc.

"C" Rank Specifications (fair viability)

A C-ranked population of *Hexastylis naniflora* should have 100-200 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 - 200- 500 clumps occurring in less than one acre of high quality forest or on land impacted by human disturbance such as logging, grazing, mowing, etc.

"D" Rank Specifications (poor viability)

A D-ranked population of *Hexastylis naniflora* should have fewer 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 occurring in less than one acre of high quality forest or on land impacted by human disturbance such as logging, grazing, mowing, etc.

"E" Rank Specifications (extant)

An E-ranked population of *Hexastylis naniflora* is an occurrence that has recently been verified as still existing, but sufficient information for the factors used to estimate viability has not yet been obtained.

"H" Rank Specification (historical)

An H-ranked population of *Hexastylis naniflora* lacks recent field information verifying the continued existence of the occurrence. In the absence of known disturbance and with the habitat still extant, H is generally recommended for occurrences that have not been reconfirmed for approximately 30 or more years.

"F" Rank Specification (failed to find)

An F-ranked population of *Hexastylis naniflora* has not been found despite a search by an experienced observer at a time and under conditions appropriate for the Element at a location where it was previously reported, but the occurrence still might be confirmed to exist at that location with additional field survey efforts. For occurrences with vague locational information, the search must include areas of appropriate habitat within the range of locational uncertainty.

"X" Rank Specification (failed to find)

An X-ranked population of *Hexastylis naniflora* is considered destroyed based on adequate surveys by one or more experienced observers at times and under conditions appropriate for the species at the occurrence location, or other persuasive evidence indicates that the species no longer exists there or that the habitat has been destroyed to such an extent that it can no longer support the species.

"U" Rank Specification (failed to find)

A U-ranked population of *Hexastylis naniflora* cannot be assigned a rank due to lack of sufficient information on the occurrence or the species identification has not been confirmed.

Rank Specifications Justification

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

Appendix 3

Maxent Model Methodology

Study Extent, Coordinate System, and Cell Size

Fifty three 10-digit hydrologic units (HUC) comprise the analysis extent (Figure 1). In North Carolina it includes all 10-digit HUC that fall within the boundaries of 8-digit HUC with known occurrence of *Hexastylis*. In South Carolina we also included all 10-digit HUC that fell within the boundaries of 8-digit HUC with known occurrence of *Hexastylis*, but excluded the southern portions of the HUC-8 areas due to the boundaries being exceedingly large and far away from any known occurrences.

Figure 1. Analysis extent. Red line indicates Maxent analysis extent, blue lines are 8-digit HUC boundaries, black lines are 10-digit HUC boundaries. The orange line in the inset map indicates where the analysis extent is situated in North and South Carolina



Coordinate System: USA Contiguous Albers Equal Area Conic USGS version

Cell Size: 30 x 30 meters derived from the USGS National GAP Landcover

Source Element Occurrence Data

Hexastylis naniflora element occurrence data was obtained from the North and South Carolina Natural Heritage Programs. These data were in polygon format and digitized at scale that accurately identified the boundaries of the individual population areas. Current populations of Hexastylis naniflora were identified by reviewing the last observed data in the database and excluding all populations that have not been observed in the last 10 years (2007). To represent these current population areas in Maxent, a raster cell center was retained for every 30 x 30 meter pixel that was situated within the current element occurrence data polygons.

Source Datasets Used:

USGS National GAP Landcover - The GAP National Terrestrial Ecosystems – Ver 3.0 is a 2011 update of the National Gap Analysis Program Land Cover Data – Version 2.2 for the conterminous U.S. The GAP National Terrestrial Ecosystems – Version 3.0 represents a highly thematically detailed land cover map of the U.S at a 30 x 30 meter pixel resolution. The map legend includes types described by NatureServe's Ecological Systems Classification (Comer et al. 2002) as well as land use classes described in the National Land Cover Dataset 2011 (Homer et al. 2015). These data cover the entire continental U.S. and are a continuous data layer. The land cover map identifies 49 different land cover types within the range of Hexastylis Naniflora.

LandFire - Landscape Fire and Resource Management Planning Tools, is a shared program between the wildland fire management programs of the U.S. Department of Agriculture Forest Service and U.S. Department of the Interior, providing landscape scale geo-spatial products to support cross-boundary planning, management, and operations.

SSURGO Soils - The SSURGO database contains information about soil as collected by the National Cooperative Soil Survey over the course of a century. The information was gathered by walking over the land and observing the soil. Many soil samples were analyzed in laboratories. The maps outline areas called map units. The map units describe soils and other components that have unique properties, interpretations, and productivity. The information was collected at scales ranging from 1:12,000 to 1:63,360.

National Elevation Dataset - The NED is a seamless dataset with the best available raster elevation data of the conterminous United States, Alaska, Hawaii, and territorial islands. The NED is derived from diverse source data that are processed to a common coordinate system and unit of vertical measure. NED data are available nationally (except for Alaska) at resolutions of 1 arc-second (about 30 meters) and 1/3 arc-second (about 10 meters), and in limited areas at 1/9 arc-second (about 3 meters). The 1/3 arc-second database was used for HENA modelling purposes.

PRISM Climate Data - The PRISM Climate Group gathers climate observations from a wide range of monitoring networks, applies sophisticated quality control measures, and develops spatial climate datasets to reveal short- and long-term climate patterns. The resulting datasets incorporate a variety of modeling techniques and are available at multiple spatial/temporal resolutions, covering the period from 1895 to the present.

Model Variables Created:

Landcover – Landcover represented by the default landcover classification (Table 1).

Landcover Hexastylis Grouping – Landcover represented by a grouping of landcover types. For the purposes of discussing Hexastylis naniflora habitat, many of the default landcover classifications are similar and could be grouped together. The definition of each landcover classification was reviewed and categorized using a much broader habitat definition (Table 1).

Table 1. Landcover classification

Default Landcover Classification	Hexastylis Grouping
Southern Piedmont Glade and Barrens	Barren
Southern Ridge and Valley / Cumberland Dry Calcareous Forest	Barren
Undifferentiated Barren Land	Barren
Cultivated Cropland	Disturbed
Deciduous Plantations	Disturbed
Developed, High Intensity	Disturbed
Developed, Low Intensity	Disturbed
Developed, Medium Intensity	Disturbed
Developed, Open Space	Disturbed
Disturbed/Successional - Grass/Forb Regeneration	Disturbed
Disturbed/Successional - Shrub Regeneration	Disturbed
Evergreen Plantation or Managed Pine	Disturbed
Harvested Forest - Grass/Forb Regeneration	Disturbed
Harvested Forest-Shrub Regeneration	Disturbed
Introduced Upland Vegetation - Annual Grassland	Disturbed
Introduced Upland Vegetation - Shrub	Disturbed
Introduced Upland Vegetation - Treed	Disturbed
Pasture/Hay	Disturbed
Quarries, Mines, Gravel Pits and Oil Wells	Disturbed
Ruderal forest	Disturbed
Southern Appalachian Low Mountain Pine Forest	Evergreen
Southern Appalachian Montane Pine Forest and Woodland	Evergreen
Southern and Central Appalachian Cove Forest	Hardwood
Southern and Central Appalachian Oak Forest	Hardwood
Southern and Central Appalachian Oak Forest - Xeric	Hardwood
Southern Piedmont Mesic Forest	Hardwood

Central and Southern Appalachian Montane Oak Forest	High Elevation
Central and Southern Appalachian Northern Hardwood Forest	High Elevation
Central and Southern Appalachian Spruce-Fir Forest	High Elevation
Southern Appalachian Grass and Shrub Bald	High Elevation
Southern Appalachian Grass and Shrub Bald - Shrub Modifier	High Elevation
Appalachian Hemlock-Hardwood Forest	Mixed
Southern Piedmont Dry Oak-(Pine) Forest - Hardwood Modifier	Mixed
Southern Piedmont Dry Oak-(Pine) Forest - Loblolly Pine Modifier	Mixed
Southern Piedmont Dry Oak-(Pine) Forest - Mixed Modifier	Mixed
Southern Ridge and Valley Dry Calcareous Forest	Mixed
Southern Ridge and Valley Dry Calcareous Forest - Pine modifier	Mixed
Open Water (Fresh)	Open Water/Wetland
Southern and Central Appalachian Bog and Fen	Open Water/Wetland
Southern Piedmont/Ridge and Valley Upland Depression Swamp	Open Water/Wetland
Southern Appalachian Granitic Dome	Outcrop
Southern Appalachian Montane Cliff	Outcrop
Southern Appalachian Rocky Summit	Outcrop
Southern Piedmont Cliff	Outcrop
Southern Piedmont Granite Flatrock	Outcrop
South-Central Interior Large Floodplain - Forest Modifier	Riparian
South-Central Interior Small Stream and Riparian	Riparian
Southern Piedmont Large Floodplain Forest - Forest Modifier	Riparian
Southern Piedmont Small Floodplain and Riparian Forest	Riparian

Landcover Diversity – Identifies the number of landcover classes (default classification) within a 10-cell radius (300 meters) of an individual pixel.

Landcover Majority – Identifies the dominant landcover class (default classification) within a 10-cell radius (300 meters) of an individual pixel.

Landfire Canopy Height – Represents the vertically projected percent cover of the live vegetation canopy.

Landfire Canopy Cover – Represents the average height of the dominant vegetation across the landscape.

SSURGO mukey – SSURGO soils dataset represented by the Map Unit Key (mukey)

SSURGO Drainage Class – SSURGO soils dataset represented by wettest drainage class. Drainage class refers to the frequency and duration of wet periods in conditions similar to those under which the soil formed.

SSURGO Hydrologic Group – SSURGO soils dataset represented by hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

Elevation – National elevation dataset elevation values. This 10-meter dataset was reclassified to 30-meters.

Aspect 9-class – Using the national elevation dataset, the aspect was derived and categorized into the following classes: Flat, North, Northeast, East, Southeast, South, Southwest, West, and Northwest.

Aspect 5-class – Using the national elevation dataset, the aspect was derived and categorized into the following classes: Flat, North, East, South, and West.

Slope – The national elevation dataset represented by degree of slope.

Geomorphons – A pattern recognition analysis that converts a digital elevation dataset into 10 common landform elements: flat, peak, ridge, shoulder, spur, slope, pit, valley, footslope, and hollow. The national elevation dataset was used as the source elevation for the analysis.

Solar Radiation – An analysis of the amount of solar radiation (radiant energy) reaching the earth's surface using the national elevation dataset as the elevation model. The output solar model is reported in watt hours per square meter (WH/m²)

Average Annual Precipitation – Climate dataset of average annual precipitation according to a model using point precipitation and elevation data for the 30-year period of 1971-2000.

Maximum Average Annual Temperature – Climate dataset of average annual maximum temperature according to a model using point temperature data for the 30-year period of 1981-2010.

Minimum Average Annual Temperature – Climate dataset of average annual minimum temperature according to a model using point temperature data for the 30-year period of 1981-2010.

Maxent Model Development

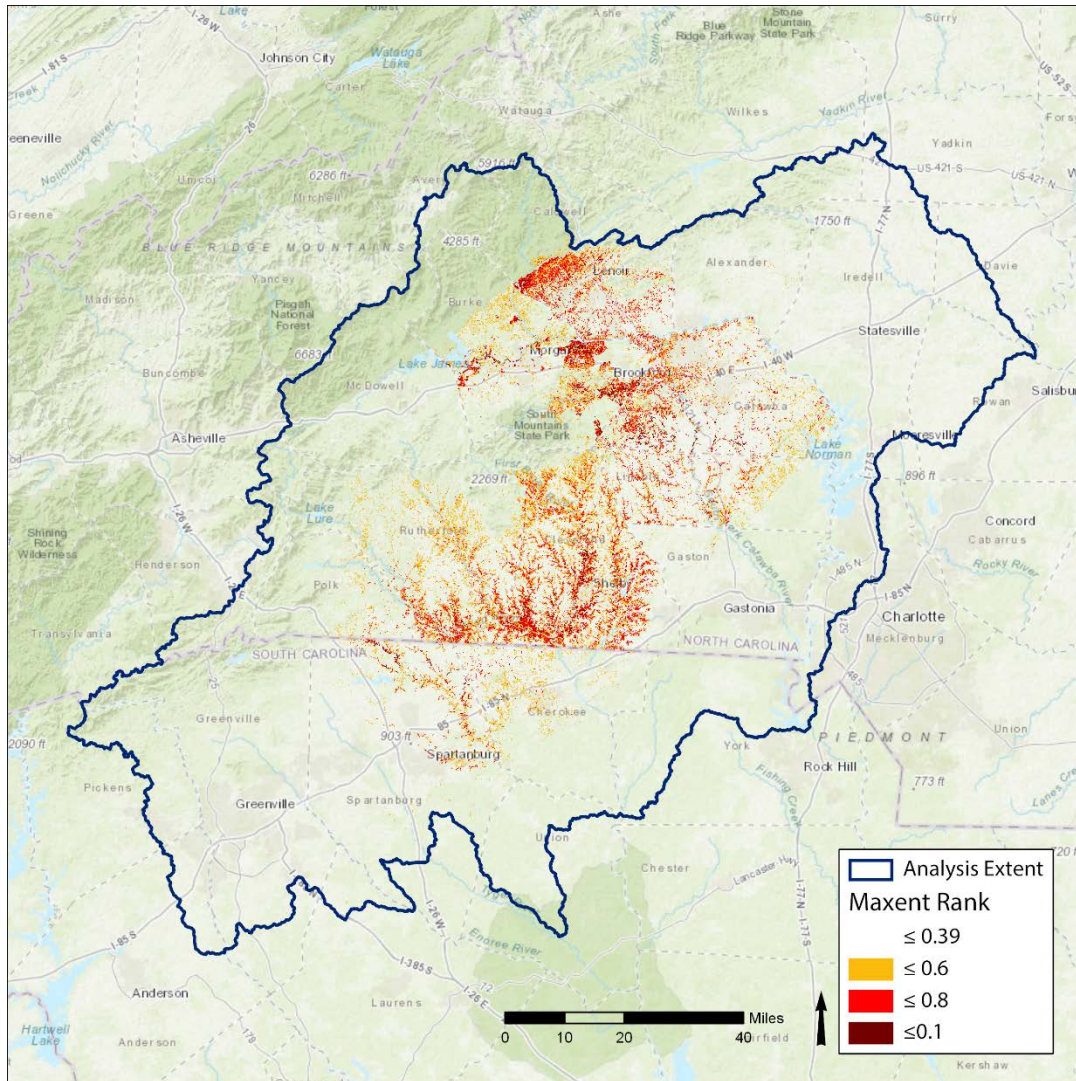
Maxent software for species habitat modeling (version 3.4.1) was used (Philips et al., 2018).

An initial single model Maxent run was done to determine which variables could be excluded due to limited percent contribution to the model. Any variable that contributed less than 1% to the single model run results was excluded in the final model. The following variables were excluded:

landcover diversity, canopy height, SSURGO drainage class, SSURGO hydrologic group, aspect 9-class, aspect 5-class, slope, solar radiation, and maximum annual temperature.

For the final model a 10-run replicate Maxent model was created using crossvalidation. For replicate models, the occurrence data is randomly split into a number of equal-sized groups called "folds", and separate models are created leaving out each fold in turn. The individual model runs are then averaged together to derive the final model. Cloglog output format was used. Cloglog output gives an estimate between 0 and 1 of probability of presence assuming an appropriate sampling design.

Figure 2. Maxent model output map.



Results

Figure 2 shows the model output. The minimum cutoff value (to determine if an area is considered potential habitat for a species) of 0.39 was determined by using the average 10th percentile training presence. The 10th percentile training presence uses the suitability threshold associated with the presence record that occurs at the 10th percentile of presence records (Phillips 2018). This value excludes some of the outlier population areas in the Maxent predictions to focus on the typical habitat conditions for this species. The total area ranked greater than 0.39 in the Maxent model was just 6.0% of the total analysis area (Table 1).

Table 1. Area estimates of the Maxent model

Maxent Score	Acres	Square Miles	Percent of Total
0.406 and greater	302,834.13	473.18	6.02%
0.6 and greater	128,273.52	200.43	2.55%
0.8 and greater	22,115.97	34.56	0.44%

The average area-under-curve (AUC) score for the replicate Maxent model is 0.86. The AUC is calculated from the receiver operating characteristic (ROC) plot. This value has a range of 0 – 1 and may be interpreted as a single test statistic that assesses model performance, indicating the ability of the model to correctly classify the occurrence data used. AUC values close to 0.50 indicate a model fit no better than random, values less than 0.5 indicate a model fit worse than random, a value of 1.0 indicate a perfect fit (Baldwin 2009). A value of 0.86 is a good fitting model.

The Maxent output supplies estimates of the relative contributions of the environmental variables to the Maxent model (Table 2.)

Table 2. Percent contribution of the environmental variables

Environmental Variable	Percent Contribution
SSURGO mukey	23.5%
Minimum Annual Temperature	17.8%
Average Annual Precipitation	15.7%
Landcover	12.9%
Landcover Majority	12.0%
Landcover Hexastylis Grouping	5.4%
Geomorphons	4.9%
Elevation	4.6%
Canopy Cover	3.2%

SSURGO mukey is the top contributing variable. 135 different individual soil types are present within the polygon boundaries of the Hexastylis element occurrences. Many of these individual soil types are part of soil complexes and are separated by things such as percent slope, erosion, how stony/rocky, and amount of clay. The most common individual soil type was Meadowfield-Rhodhiss complex, 25 to 60 percent slopes, very stony (14.1% of total). However, collectively the Meadowfield soils only comprised 14.3% of all soils). The individual Pacolet soil types were very common and collectively comprise 32.2% of all soil types present. Woolwine, Rion, and Fairview

soils were also collectively common, comprising 10.4%, 9.7%, and 8.8% of all soils present respectively.

The minimum annual average temperature range in the analysis extent is 39 – 51 degrees Fahrenheit. The majority of the *Hexastylis* element occurrences (89%) are found at the 47 and 48 degrees. The Average annual precipitation range in the analysis extent is 42 – 81 inches per year. The majority of the *Hexastylis* element occurrences (82%) are found in the 47 – 49 inches per year range.

Piedmont forested landcover habitats dominate the land area of the element occurrences. Southern Piedmont Dry Oak-Pine Forest – Hardwood Modifier (53%), Southern Piedmont Mesic Forest (9%), Southern Piedmont Dry Oak-Pine Forest (5.2%), Southern Piedmont Small Floodplain and Riparian Forest (4.4%), and collectively comprise 71% of the element occurrences area. Unfortunately, non-native habitats are also present. Evergreen Plantation or Managed Pine (9%), Harvested Forest (7.2%), Developed, Open Space (5%), Pasture/Hay (2.1%) collectively comprise 22% of the total element occurrence area. The Remaining 6 percent of element occurrence area is comprised of a mix of 14 other natural and disturbed landcover classes, but each at small percentages.

The landcover majority classification scheme reduces the total number of landcover classes present in the analysis extent from 23 to 11. Southern Piedmont Dry Oak-Pine Forest – Hardwood Modifier is still the dominant landcover class (58%). However disturbed categories are increased in area (sum total of 35%). Evergreen plantation or managed pine (12%) and Pasture/Hay (12%) are the only other categories that have at least 10% or greater area. The increase in disturbed landcover area representation in the landcover majority layer suggests that many *Hexastylis* population areas are situated in areas impacted by disturbed landcover. This is likely due to urban encroachment and increasing fragmentation of habitats.

The landcover *Hexastylis* grouping reveals the amount of disturbance present in *Hexastylis* population areas. Landcover classes grouped as disturbed comprises 27% of the total area. Mixed forest (deciduous and evergreen) comprises 58%, pasture/hay 12%, and hardwood forest 2%,

Geomorphons revealed that the majority of *Hexastylis* element occurrence areas are situated in concave landforms. Geomorphon categories hollow (13%), valley (46%), and depression (10%) collectively comprise 69% of all *Hexastylis* population areas. Flat landforms comprise 15.5% of the area and convex landforms the remaining 15.5%.

Within the analysis extent, the range of elevation present is 335 – 5,265 feet. For *Hexastylis*, the prime elevation range is from 666 – 908 feet (53% of total element occurrence area). A lesser elevation range is present from 935 – 1,184 (37% of total element occurrence area).

Canopy cover for the *Hexastylis* populations are dominated by Tree Cover 70-80% (20.2%) and Tree Cover 80-90% (63.9%). The rest of the canopy cover categories are 2% or less.

Citations

Baldwin, R.A. 2009. Use of maximum entropy modeling in wildlife research. *Entropy*. 11:854-866.

Phillips, S. J. 2018. A Brief Tutorial on Maxent. Available from url:

http://biodiversityinformatics.amnh.org/open_source/maxent/. Accessed on 2018-02/21.

Steven J. Phillips, Miroslav Dudík, Robert E. Schapire. [Internet] Maxent software for modeling species niches and distributions (Version 3.4.1). Available from url:

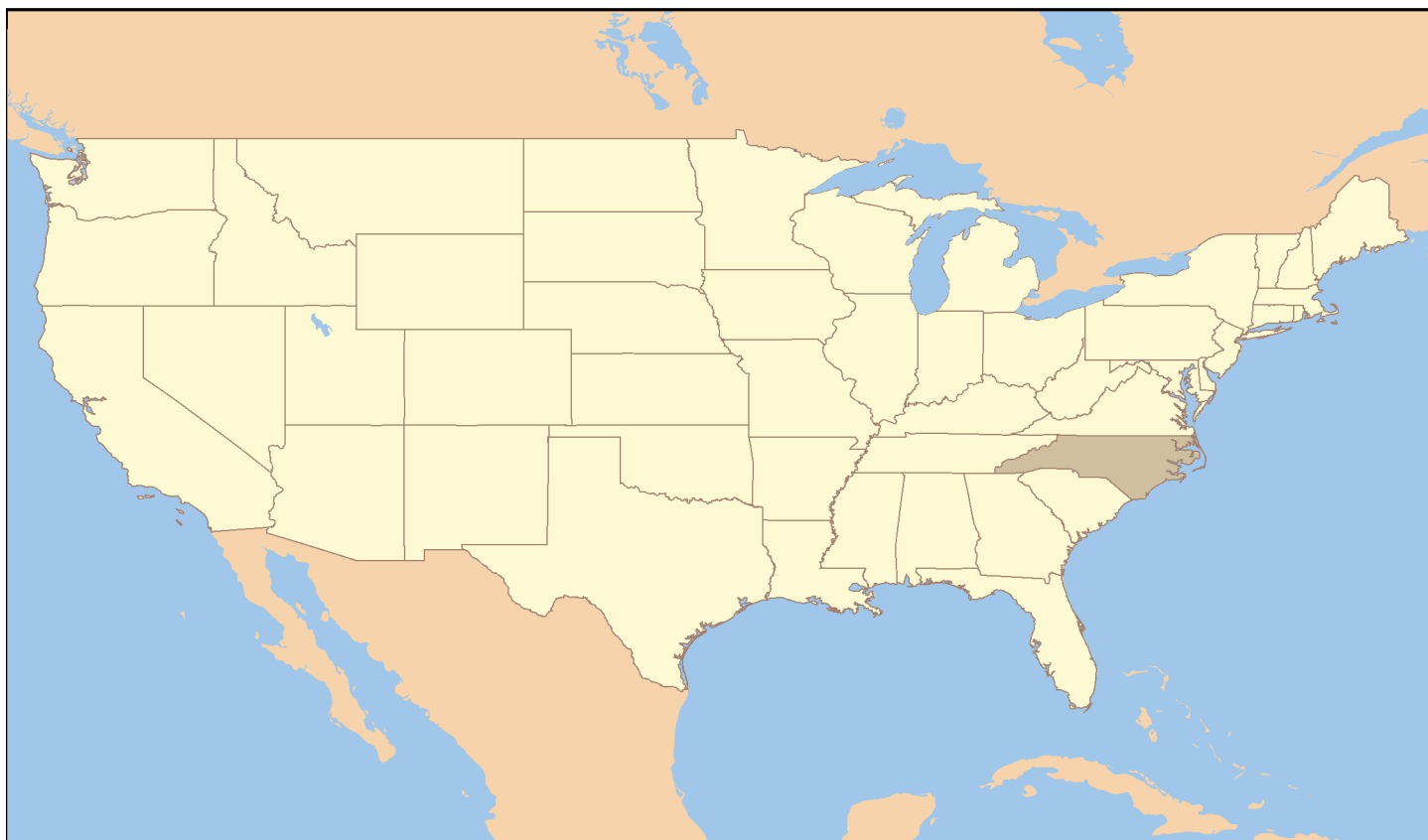
http://biodiversityinformatics.amnh.org/open_source/maxent/. Accessed on 2018-2-20.

Appendix 4a



U.S. Geological Survey - National Climate Change Viewer

Summary of North Carolina



December 1, 2016

1 Maximum 2-m Air Temperature

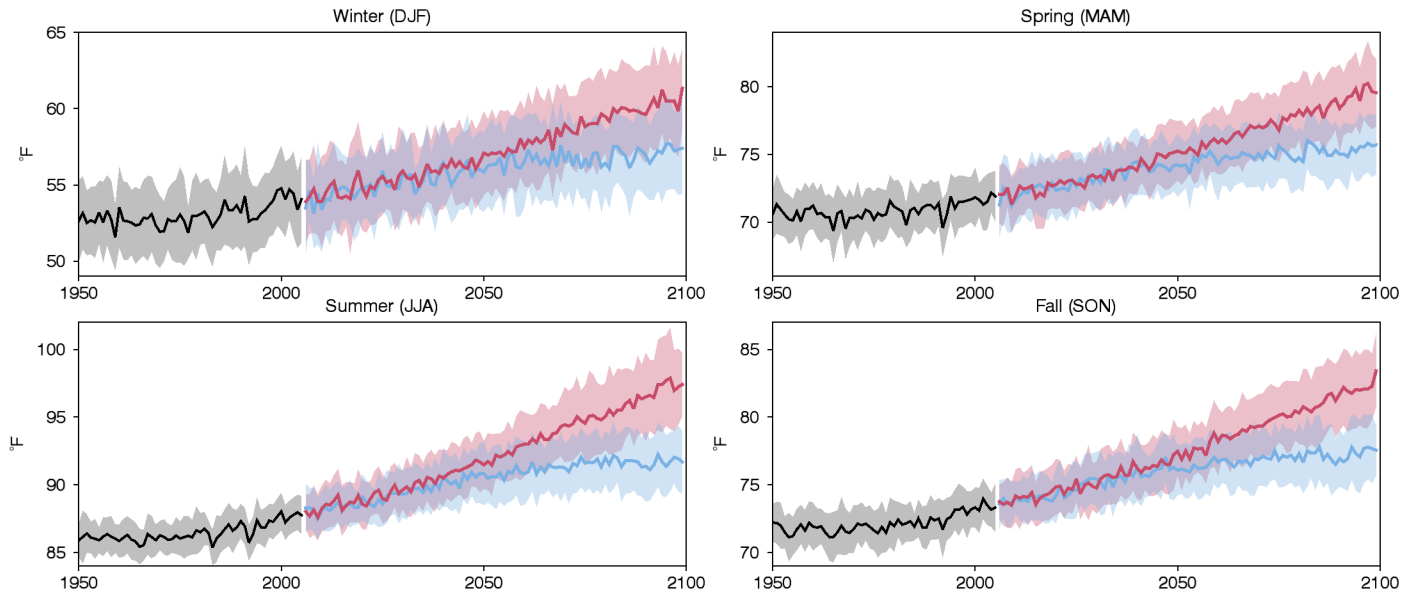


Figure 1: Seasonal average time series of maximum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

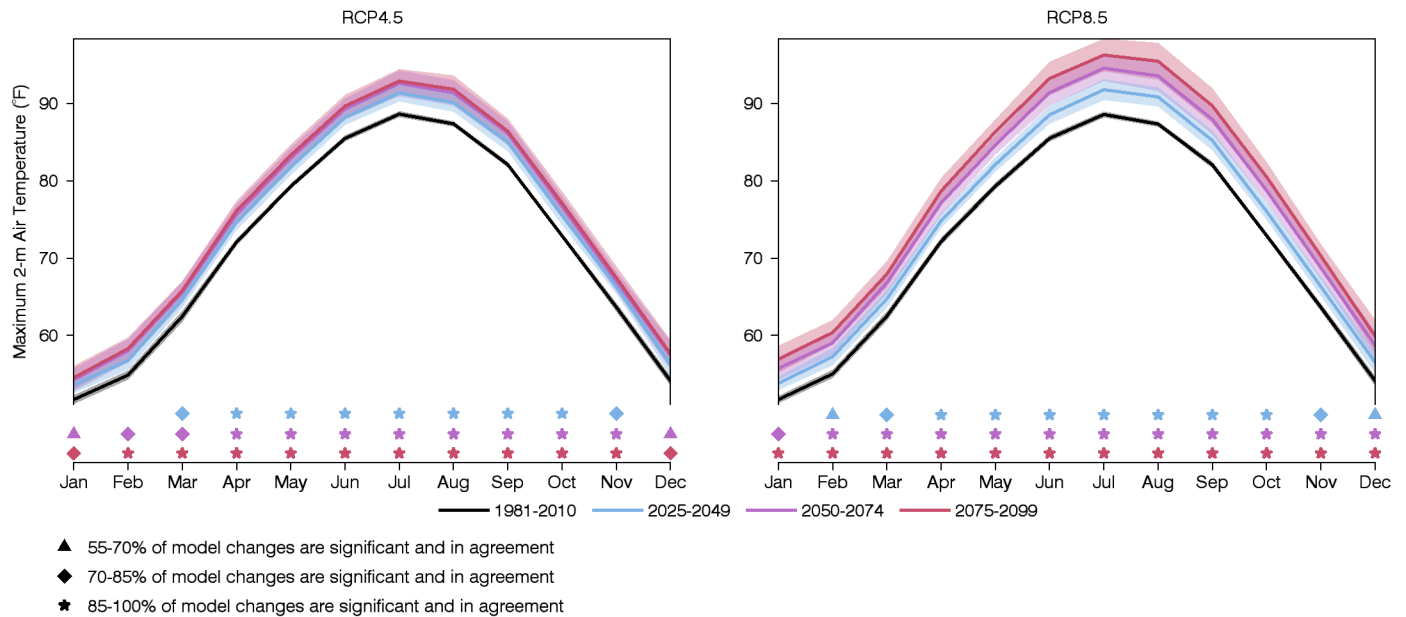


Figure 2: Monthly averages of maximum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

2 Minimum 2-m Air Temperature

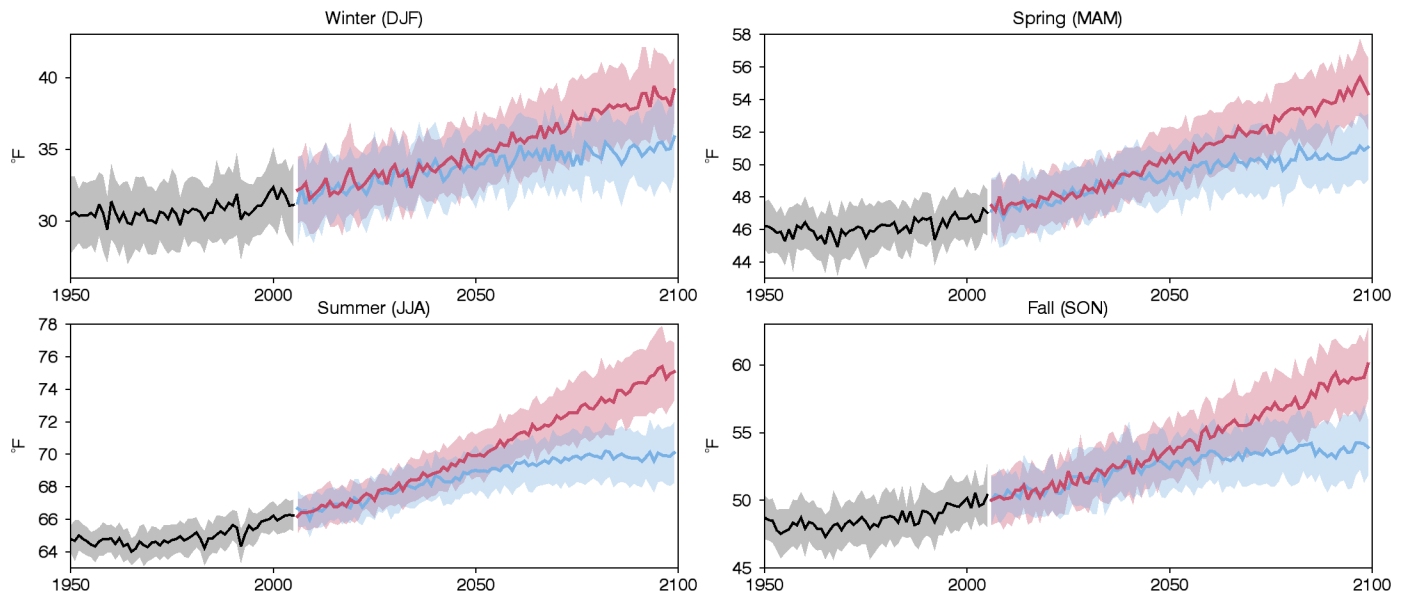


Figure 3: Seasonal average time series of minimum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

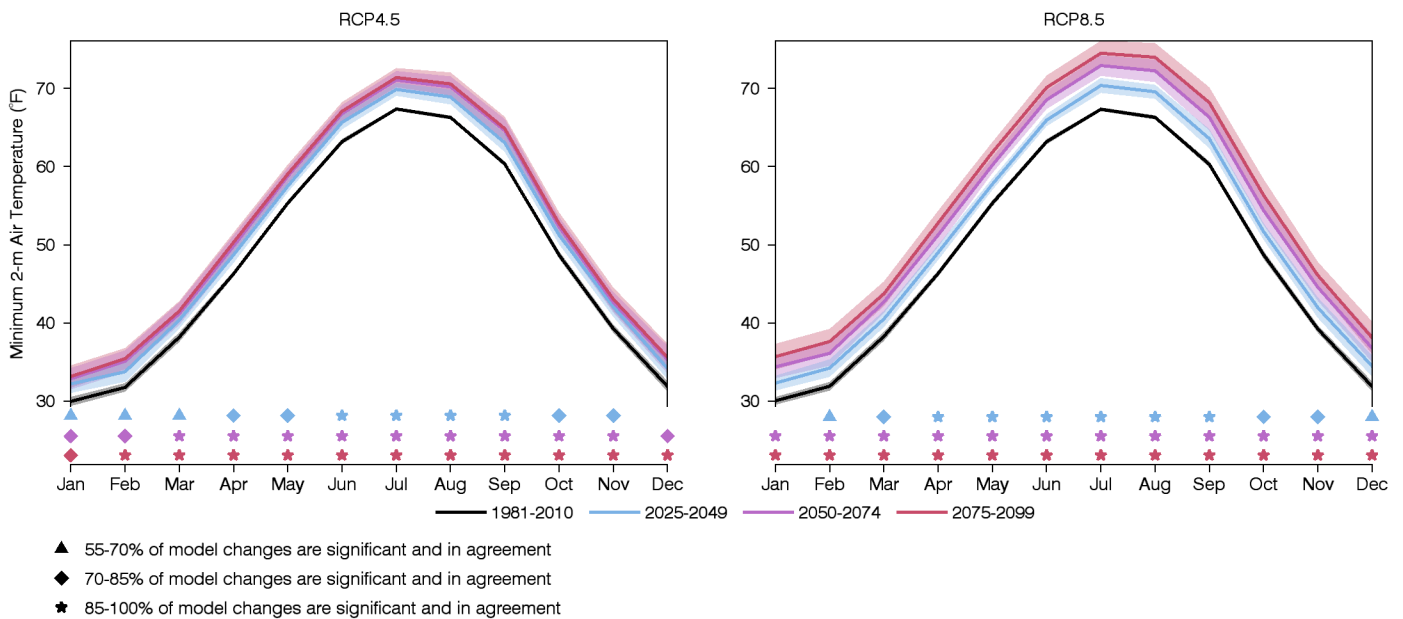


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3 Precipitation

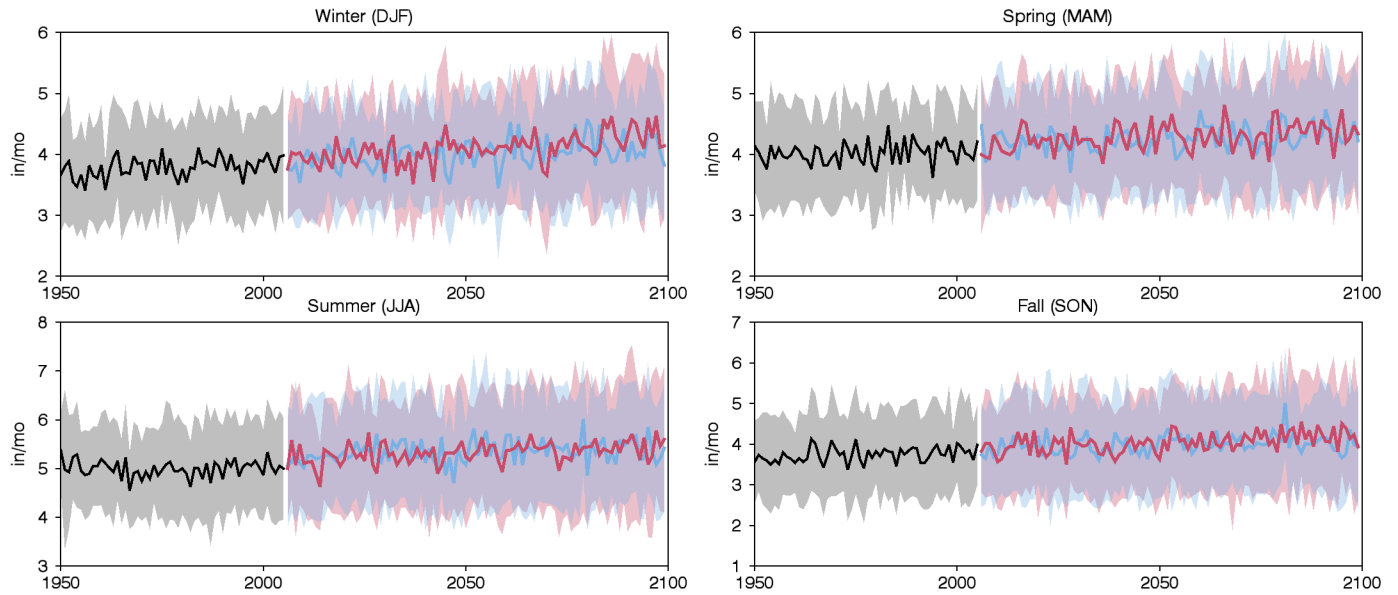


Figure 5: Seasonal average time series of precipitation for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

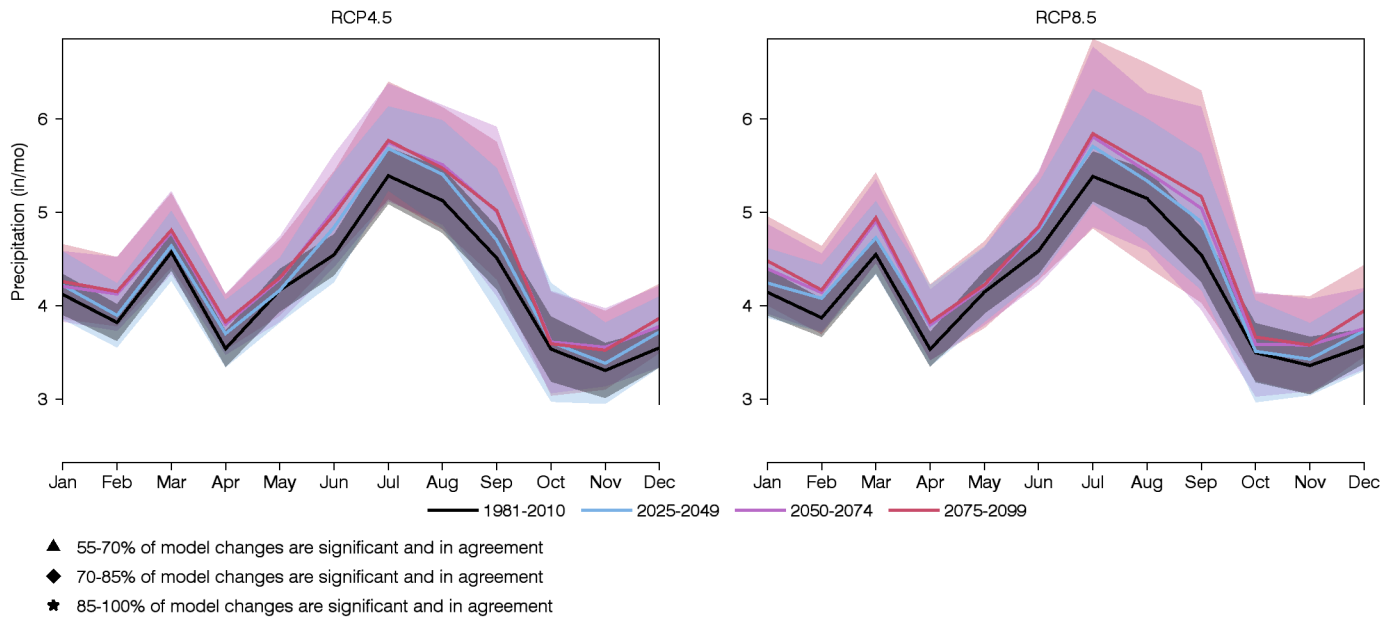


Figure 6: Monthly averages of precipitation for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

4 Snow Water Equivalent

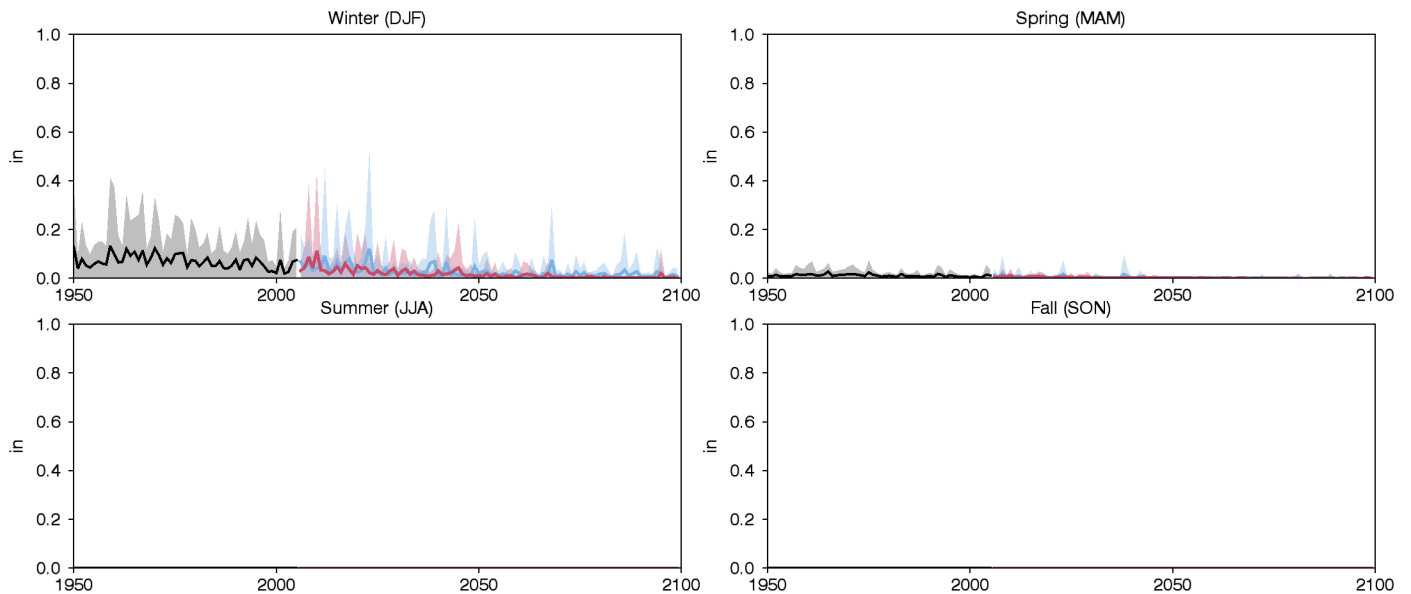


Figure 7: Seasonal average time series of snow water equivalent for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

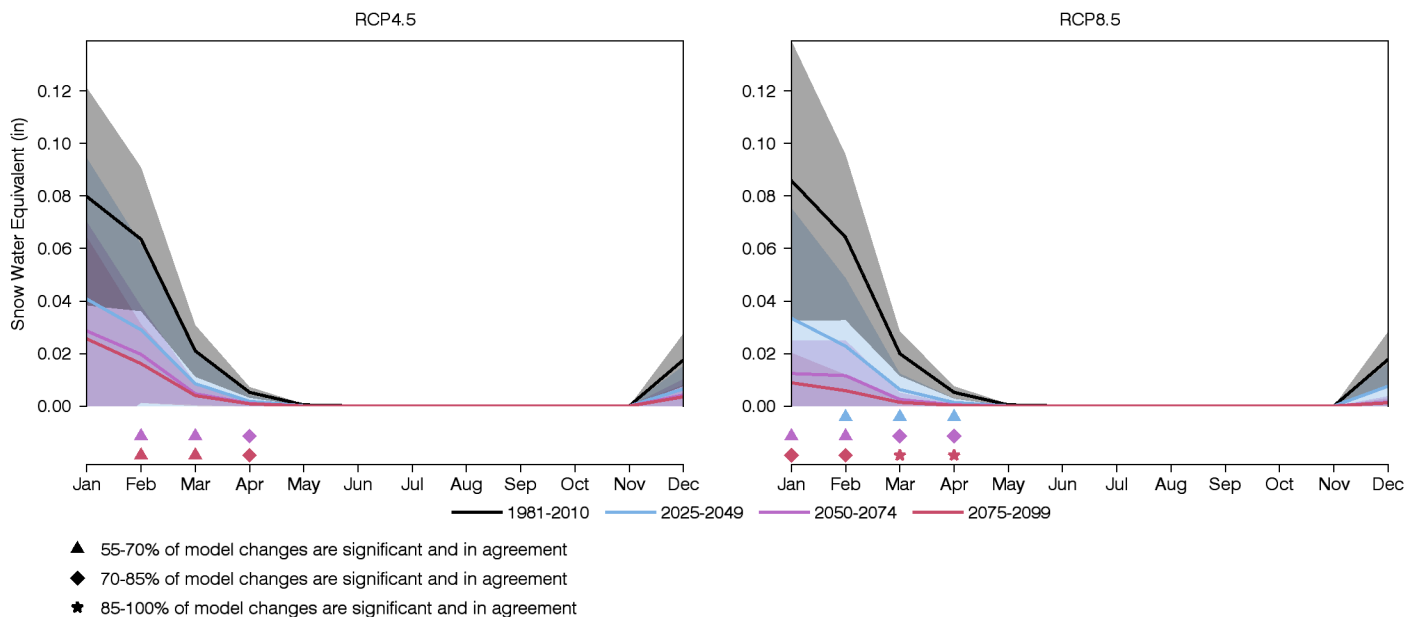


Figure 8: Monthly averages of snow water equivalent for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Student's t-test is used to establish significance ($\rho \leq 0.05$).

5 Runoff

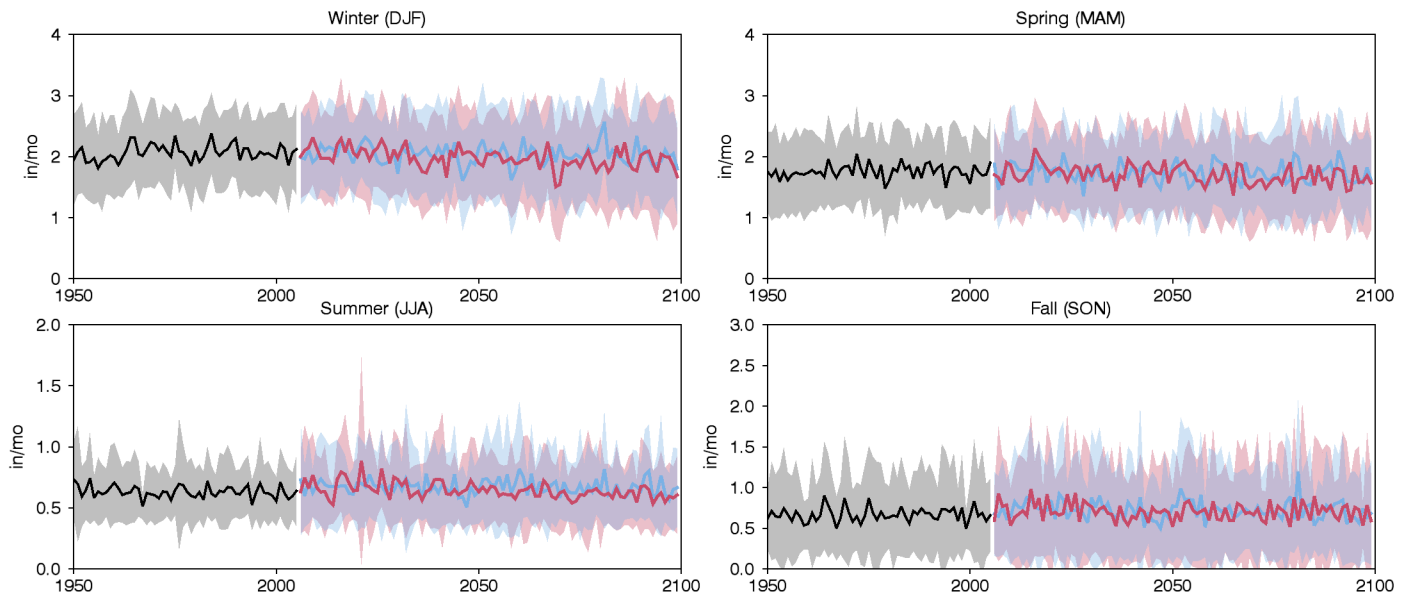


Figure 9: Seasonal average time series of runoff for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

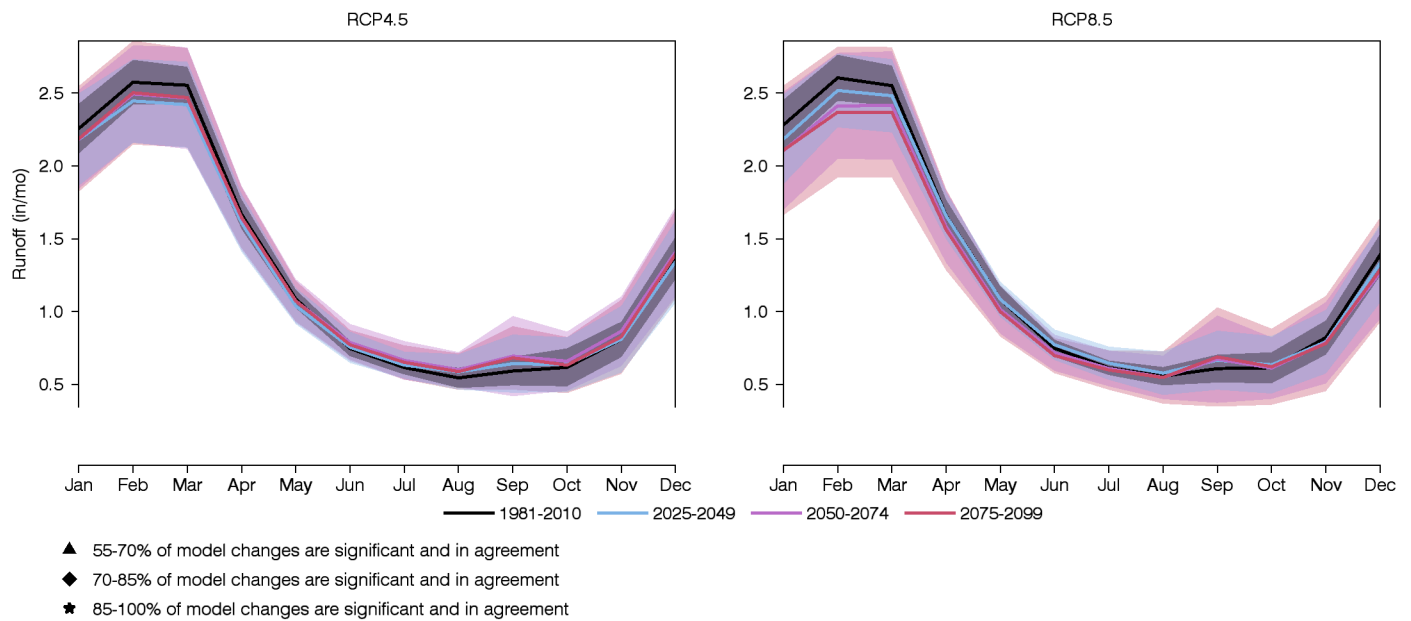


Figure 10: Monthly averages of runoff for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

6 Soil Water Storage

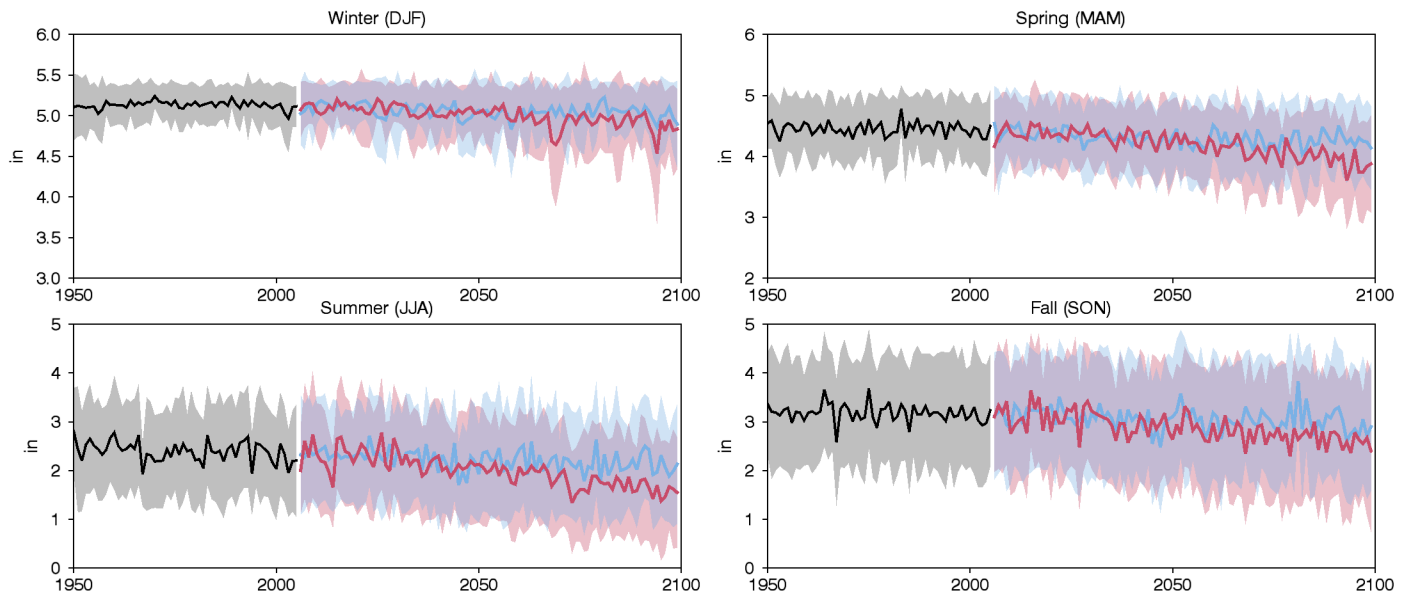


Figure 11: Seasonal average time series of soil water storage for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

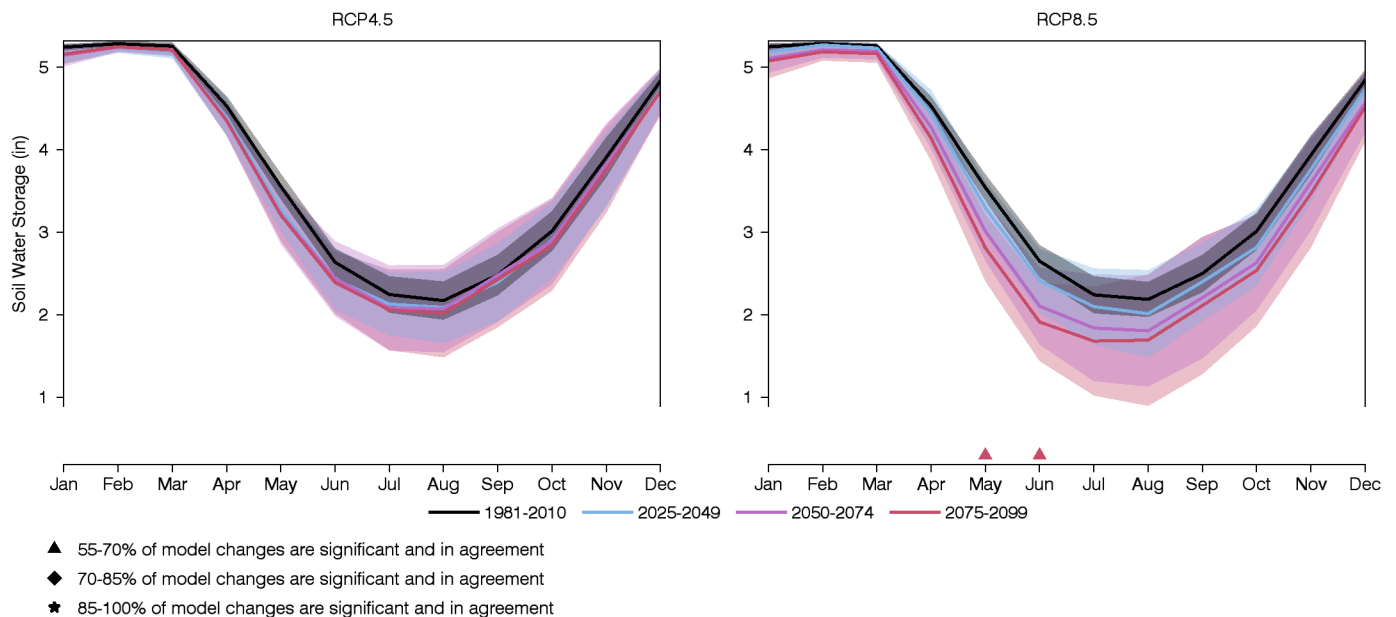


Figure 12: Monthly averages of soil water storage for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

7 Evaporative Deficit

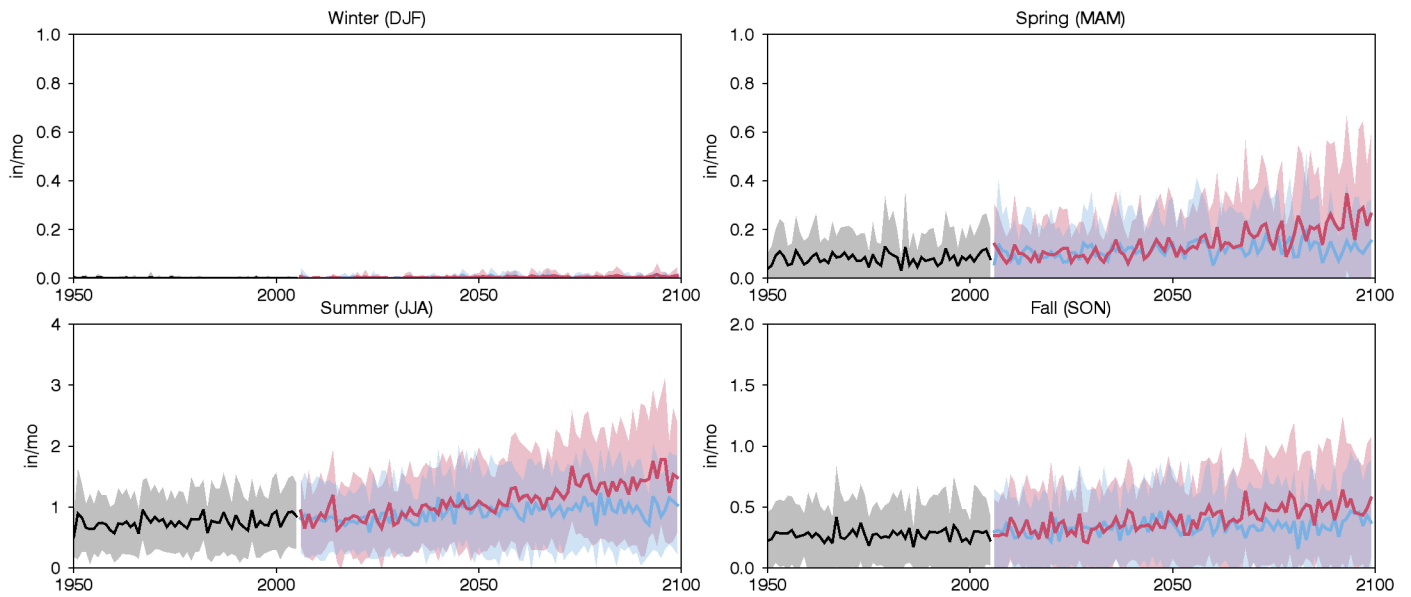


Figure 13: Seasonal average time series of evaporative deficit for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

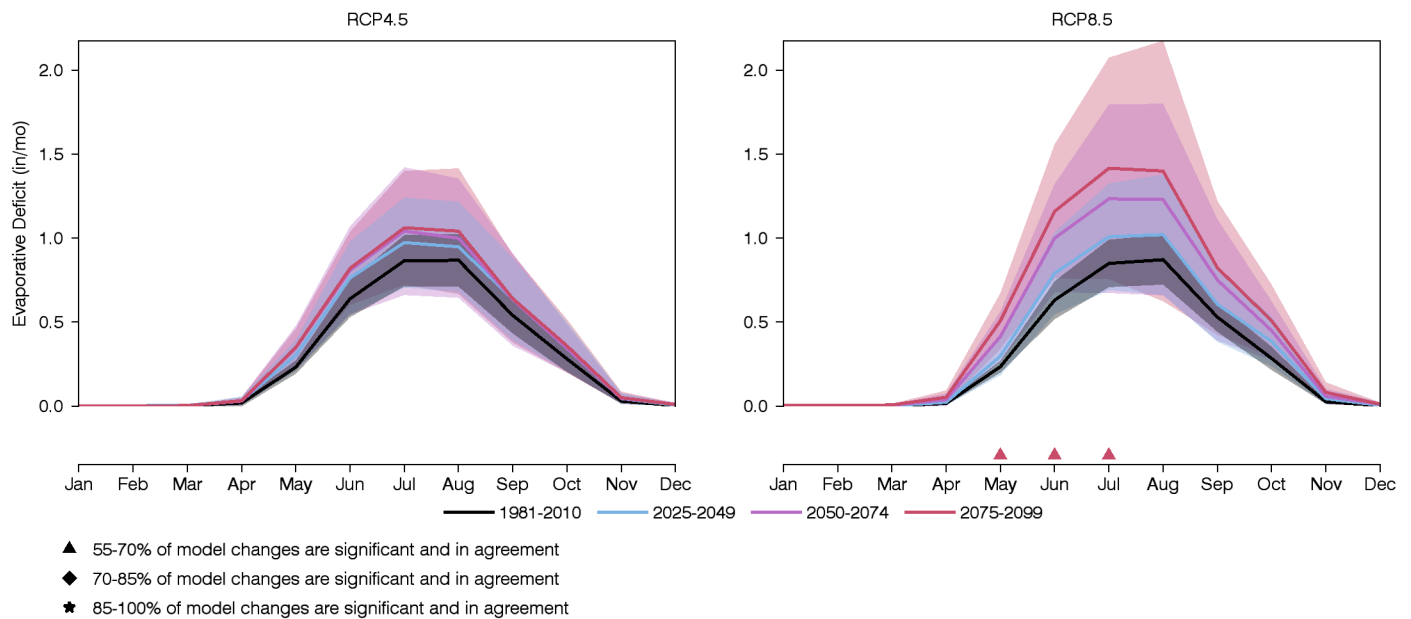


Figure 14: Monthly averages of evaporative deficit for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

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9 Models

ACCESS1-0	bcc-csm1-1	bcc-csm1-1-m	BNU-ESM	CanESM2	CCSM4
CESM1-BGC	CMCC-CM	CNRM-CM5	CSIRO-Mk3-6-0	FGOALS-g2	FIO-ESM
GFDL-CM3	GFDL-ESM2G	GFDL-ESM2M	GISS-E2-R	HadGEM2-AO	HadGEM2-CC
HadGEM2-ES	inmcm4	IPSL-CM5A-LR	IPSL-CM5A-MR	IPSL-CM5B-LR	MIROC5
MIROC-ESM	MIROC-ESM-CHEM	MPI-ESM-LR	MPI-ESM-MR	MRI-CGCM3	NorESM1-M

10 Citation Information

Alder, J. R. and S. W. Hostetler, 2013. USGS National Climate Change Viewer. US Geological Survey http://www.usgs.gov/climate_landuse/clu_rd/nccv.asp doi:10.5066/F7W9575T.

Hostetler, S.W. and Alder, J.R., 2016. Implementation and evaluation of a monthly water balance model over the U.S. on an 800 m grid. *Water Resources Research*, 52, doi:10.1002/2016WR018665.

Thrasher, B., J. Xiong, W. Wang, F. Melton, A. Michaelis, and R. Nemani, 2013. New downscaled climate projections suitable for resource management in the U.S. *Eos, Transactions American Geophysical Union* 94, 321-323, doi:10.1002/2013EO370002.

11 Disclaimer

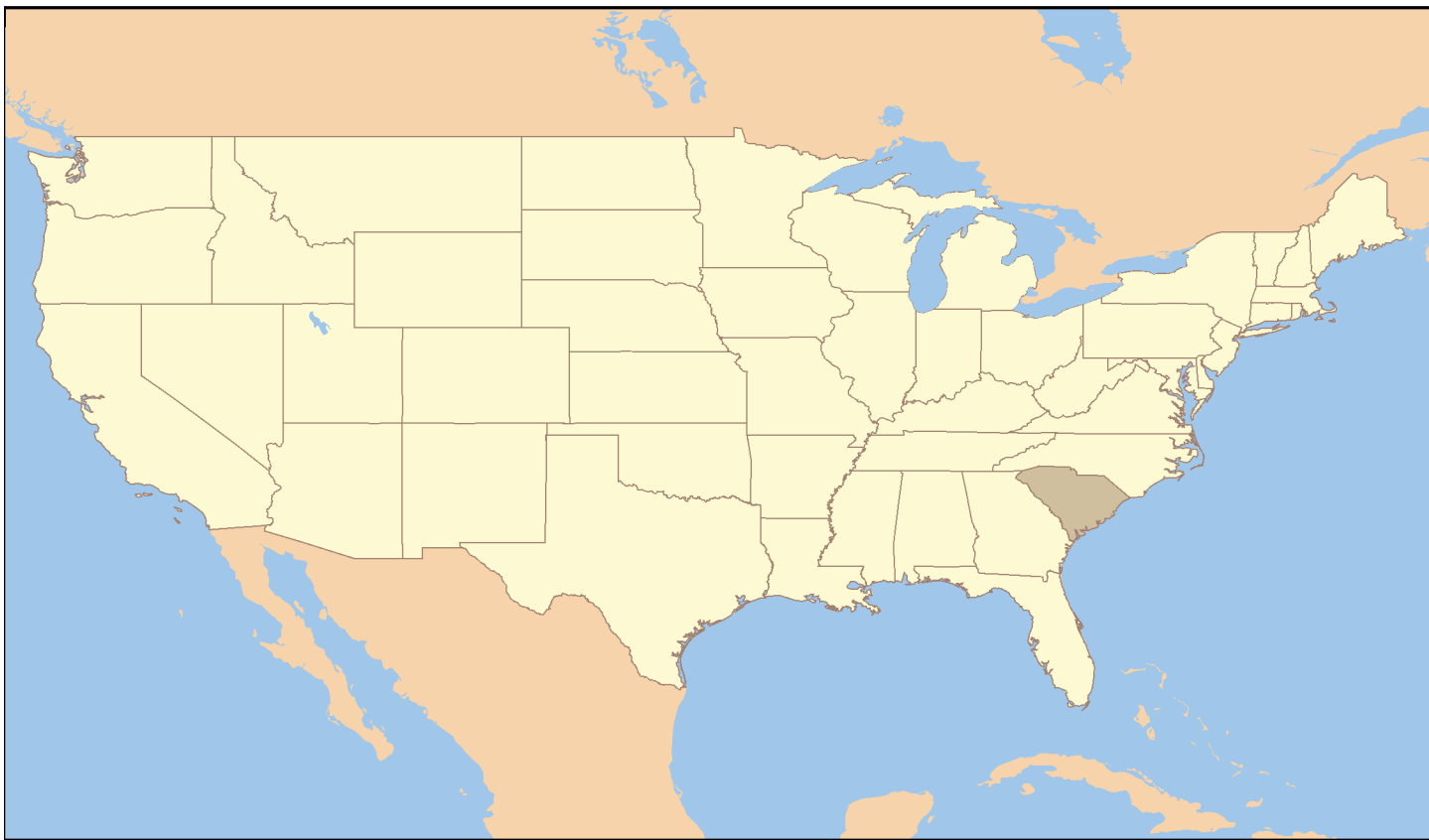
These freely available, derived data sets were produced by J. Alder and S. Hostetler, US Geological Survey (USGS). The original climate data are from the NEX-DCP30 dataset, which was prepared by the Climate Analytics Group and NASA Ames Research Center using the NASA Earth Exchange, and is distributed by the NASA Center for Climate Simulation. No warranty expressed or implied is made by the USGS regarding the display or utility of the derived data on any other system, or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. The USGS shall not be held liable for improper or incorrect use of the data described and/or contained herein.

Appendix 4b



U.S. Geological Survey - National Climate Change Viewer

Summary of South Carolina



December 1, 2016

1 Maximum 2-m Air Temperature

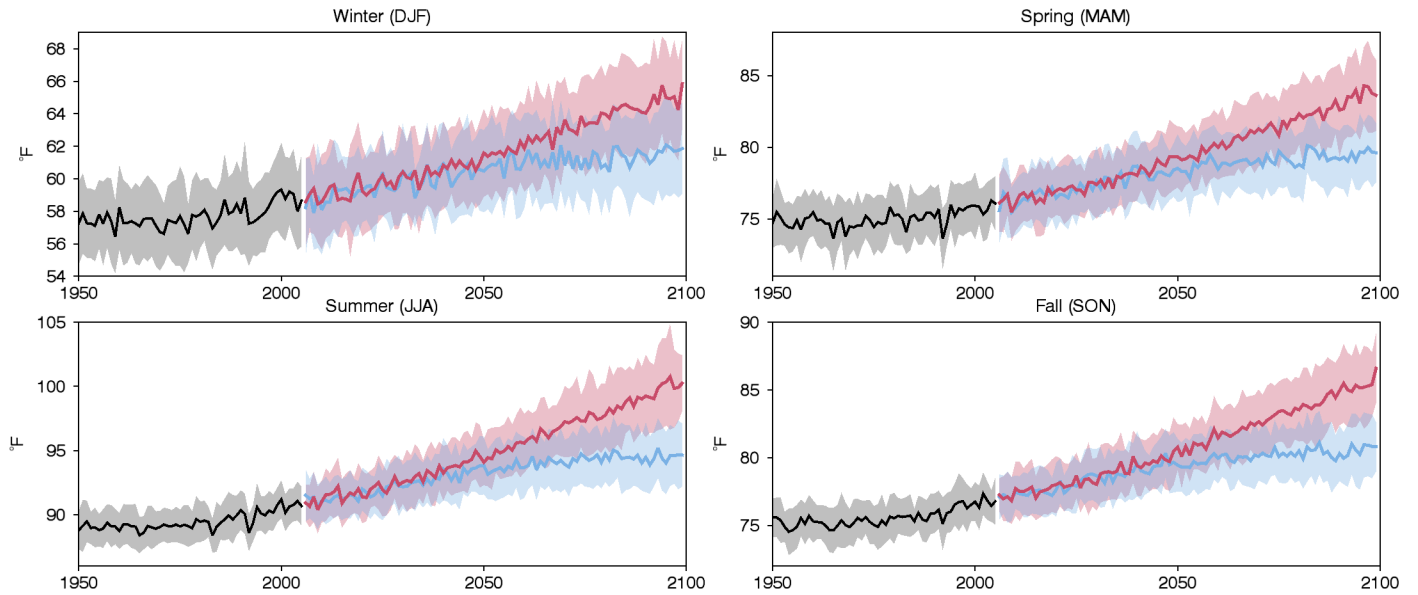


Figure 1: Seasonal average time series of maximum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

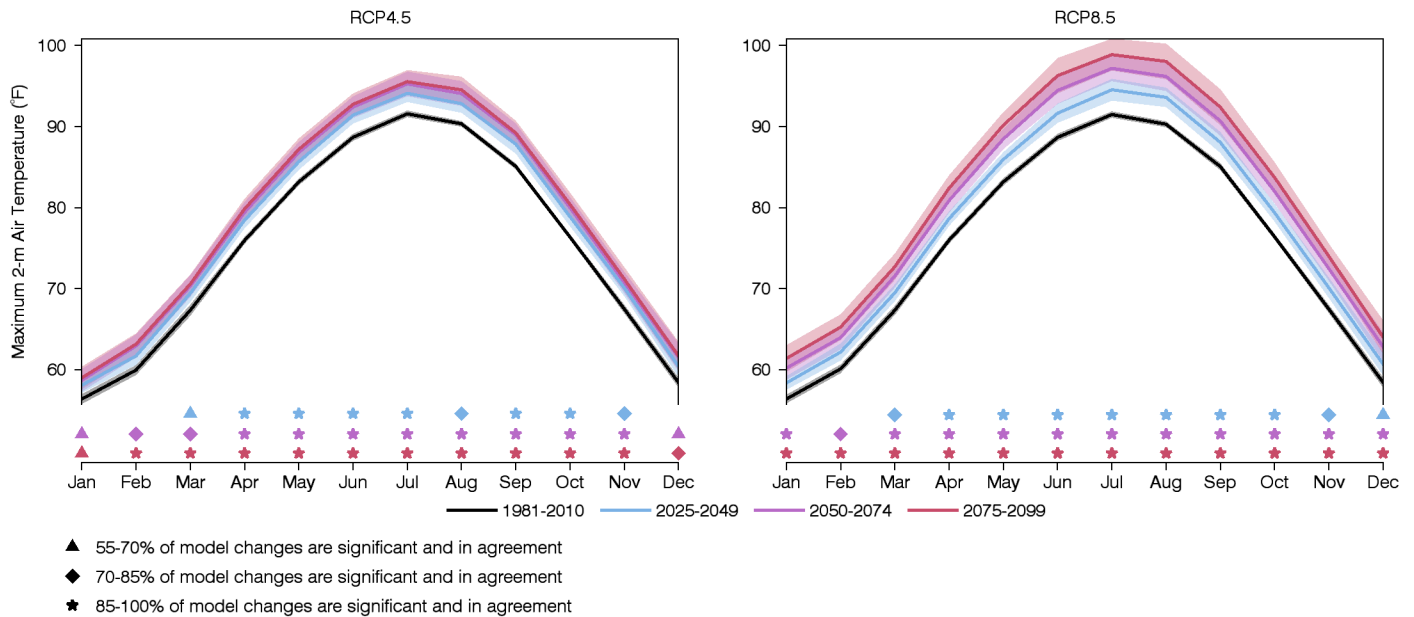


Figure 2: Monthly averages of maximum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

2 Minimum 2-m Air Temperature

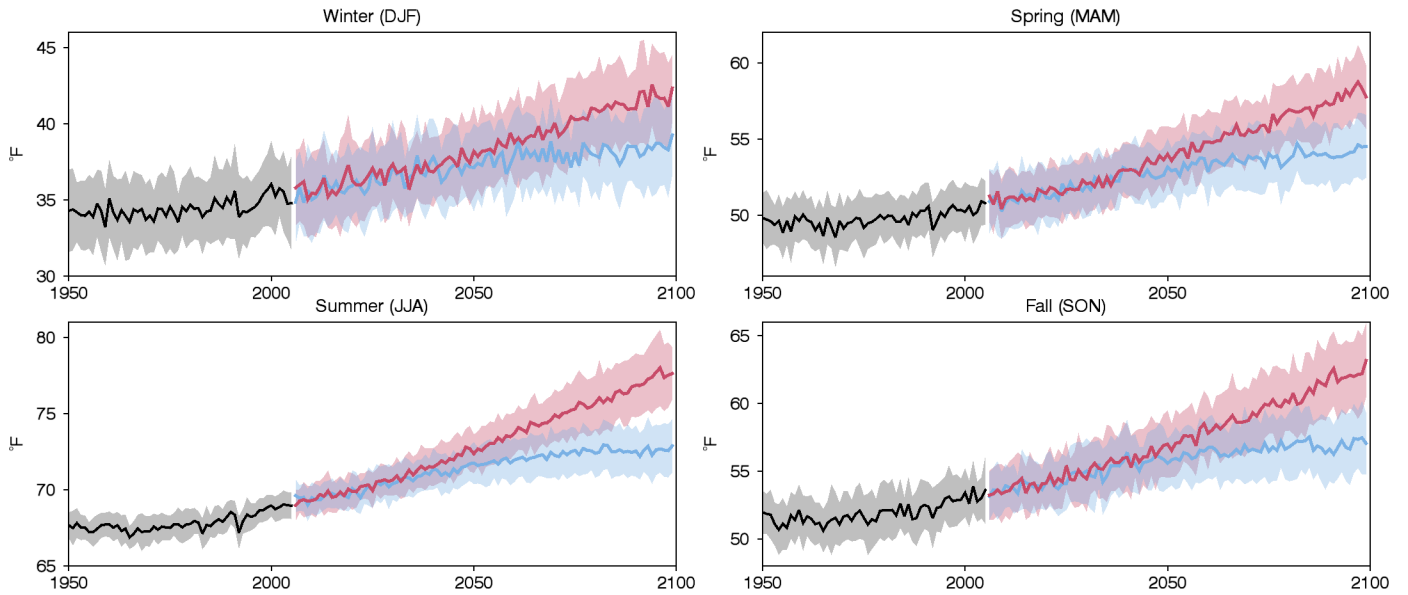


Figure 3: Seasonal average time series of minimum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

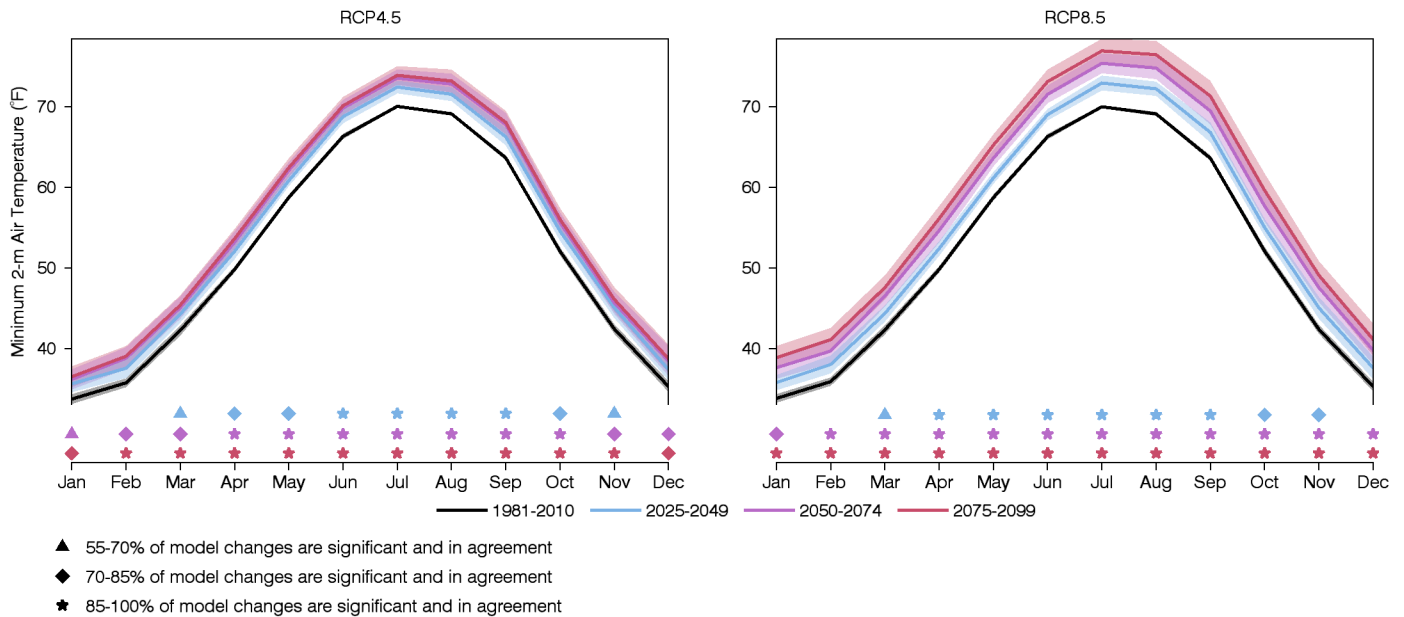


Figure 4: Monthly averages of minimum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

3 Precipitation

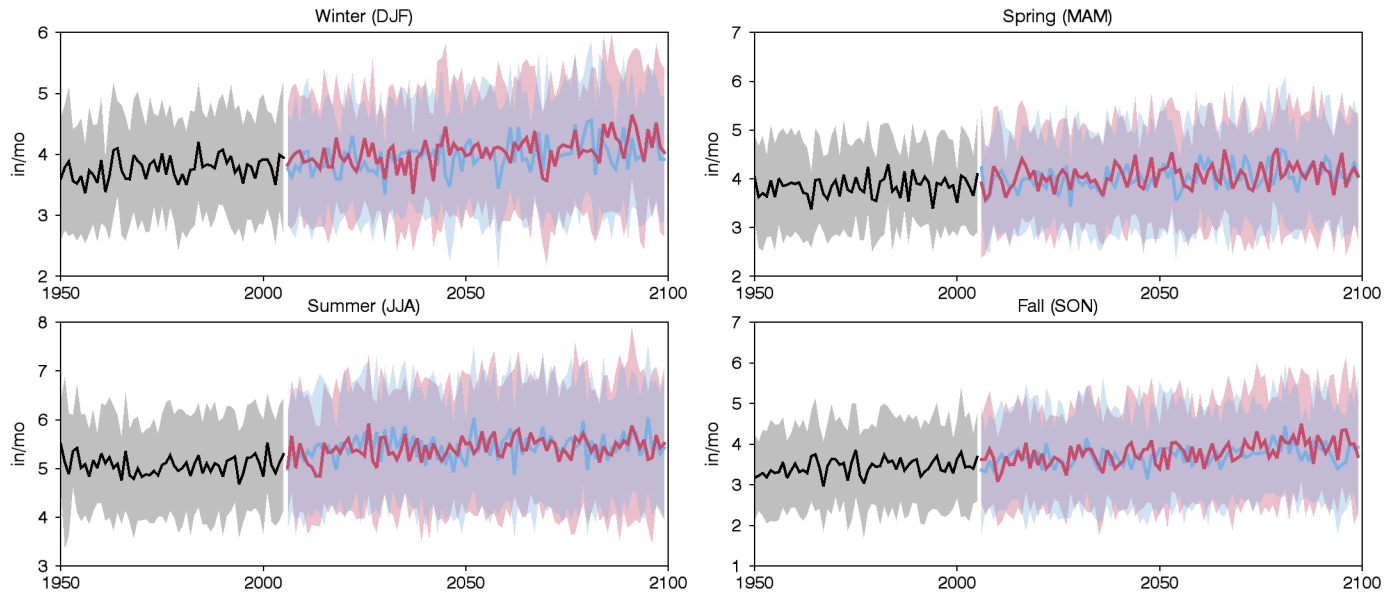


Figure 5: Seasonal average time series of precipitation for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

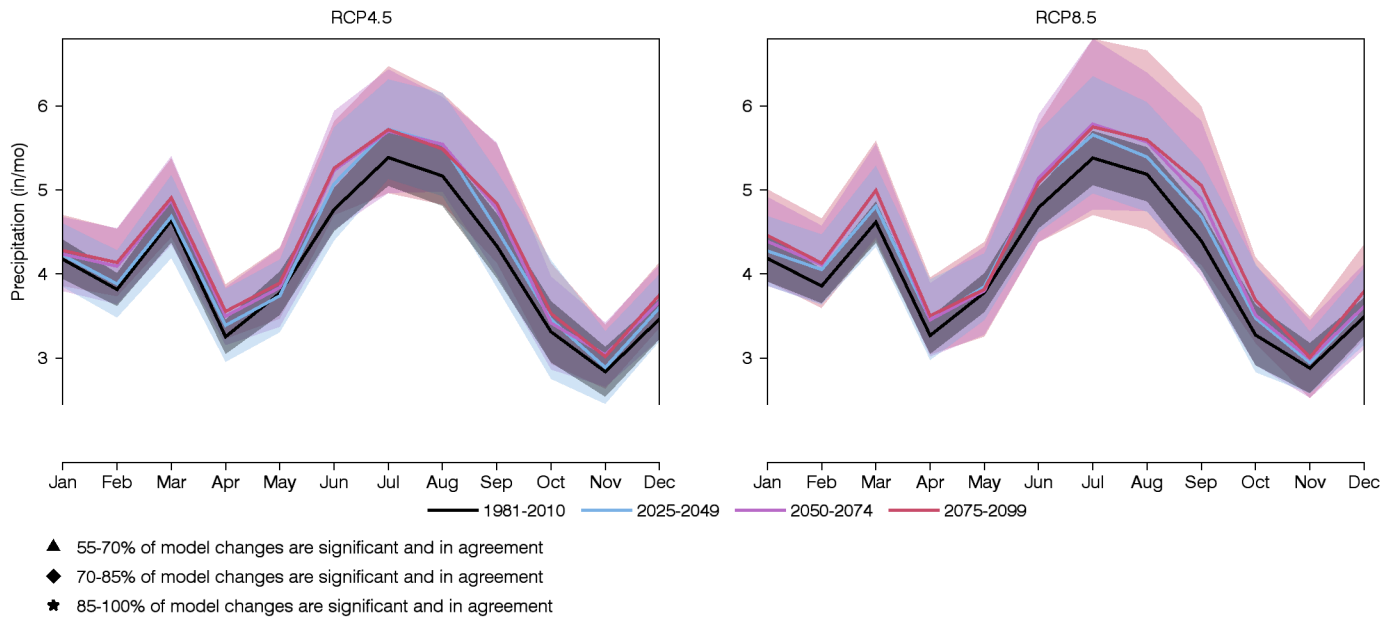


Figure 6: Monthly averages of precipitation for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

4 Snow Water Equivalent

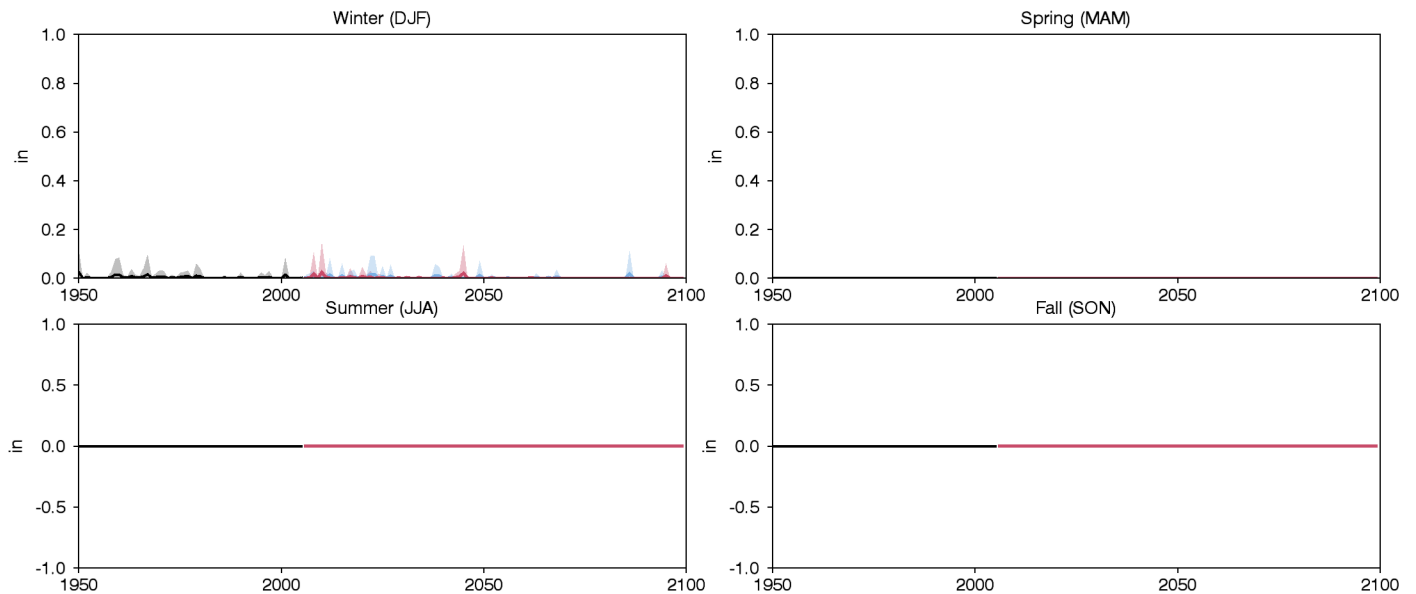


Figure 7: Seasonal average time series of snow water equivalent for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

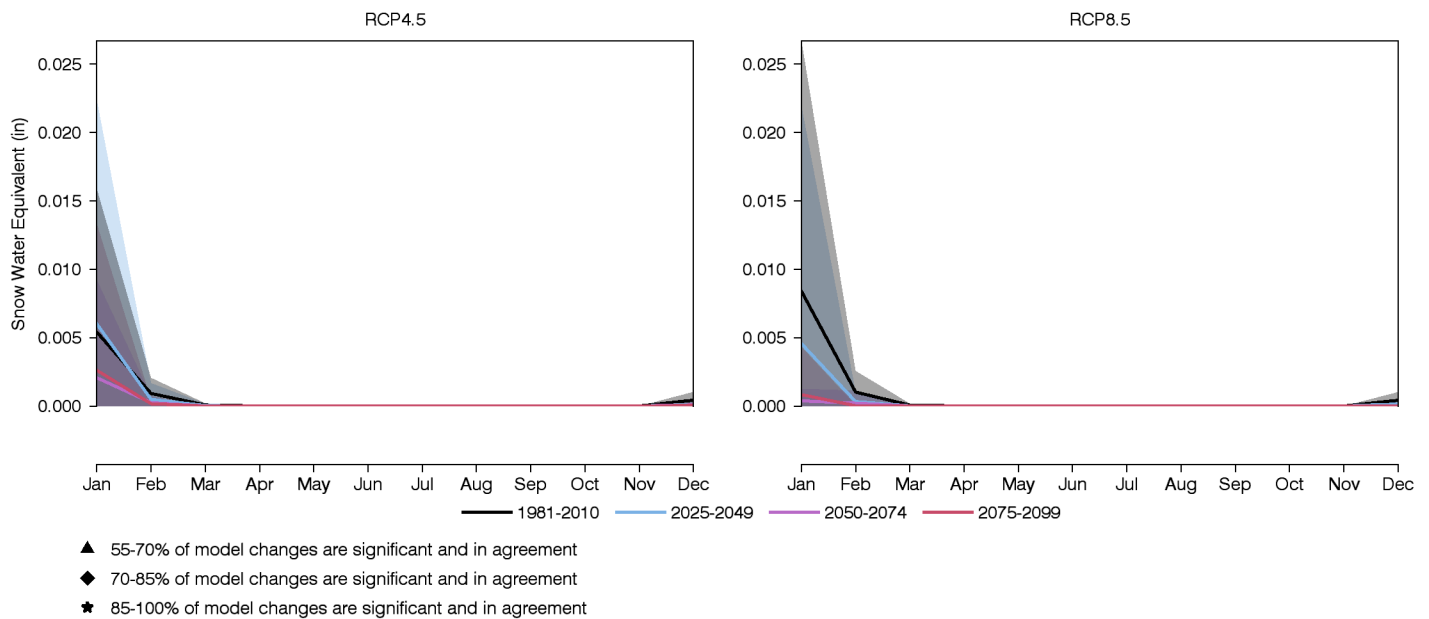


Figure 8: Monthly averages of snow water equivalent for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

5 Runoff

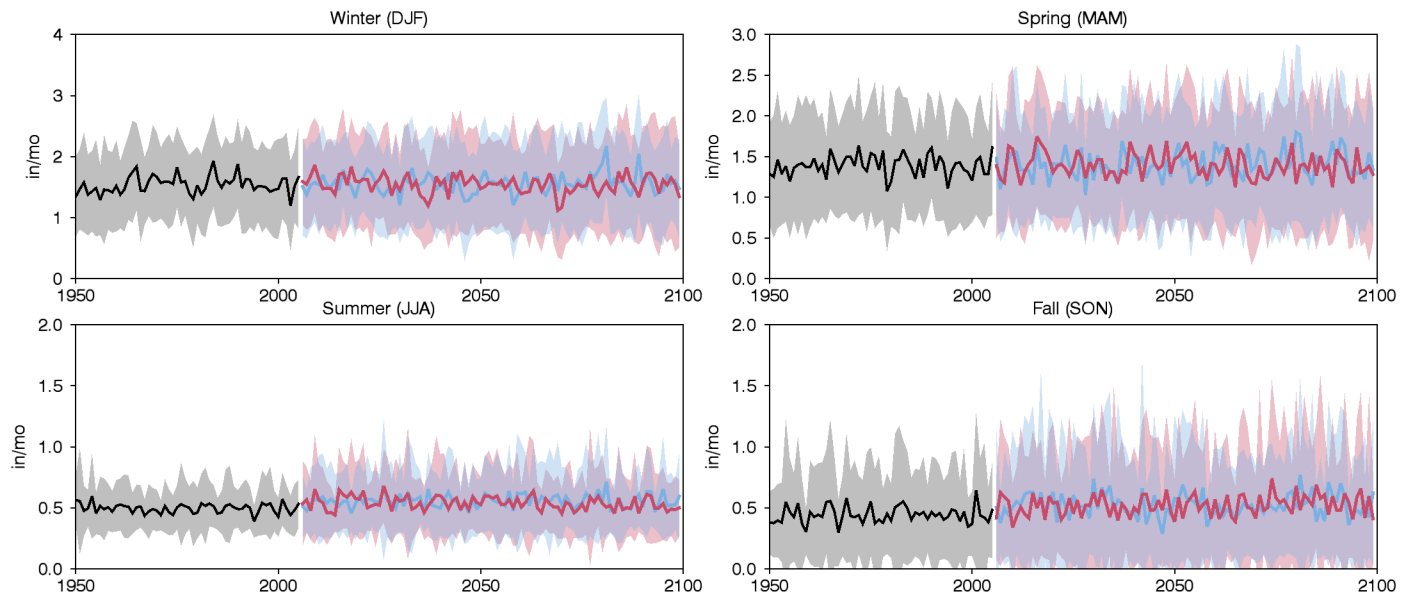


Figure 9: Seasonal average time series of runoff for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

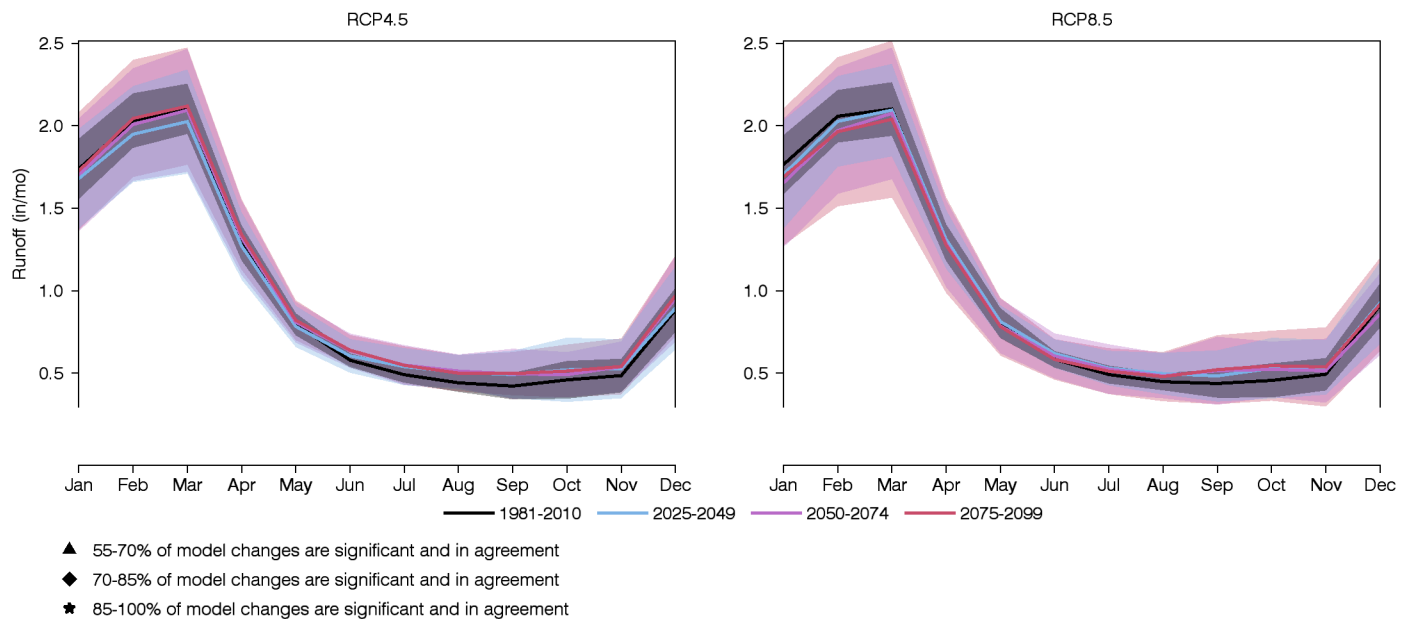


Figure 10: Monthly averages of runoff for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

6 Soil Water Storage

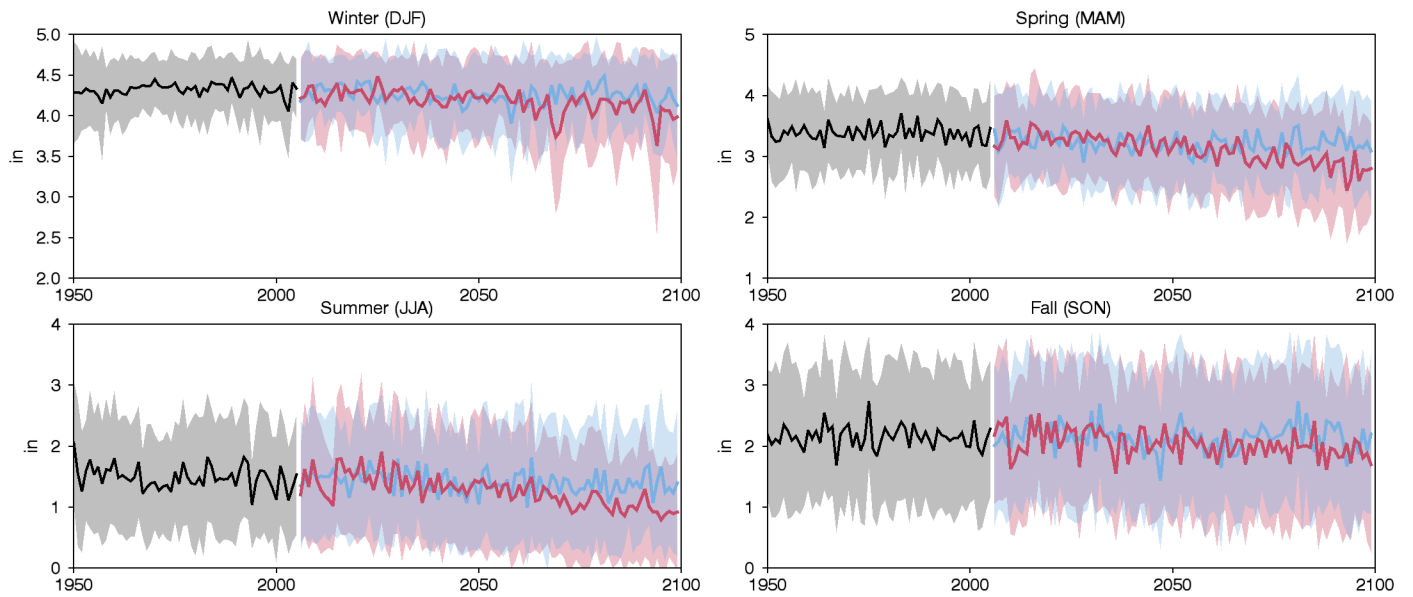


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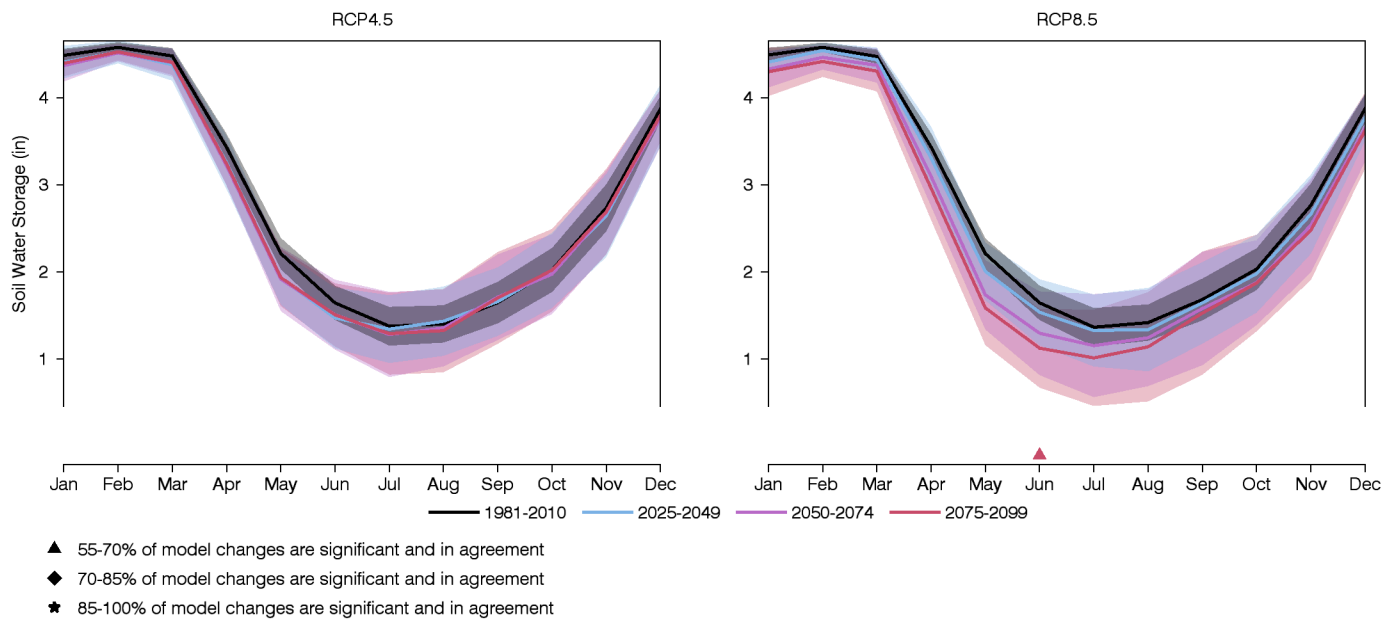


Figure 12: Monthly averages of soil water storage for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

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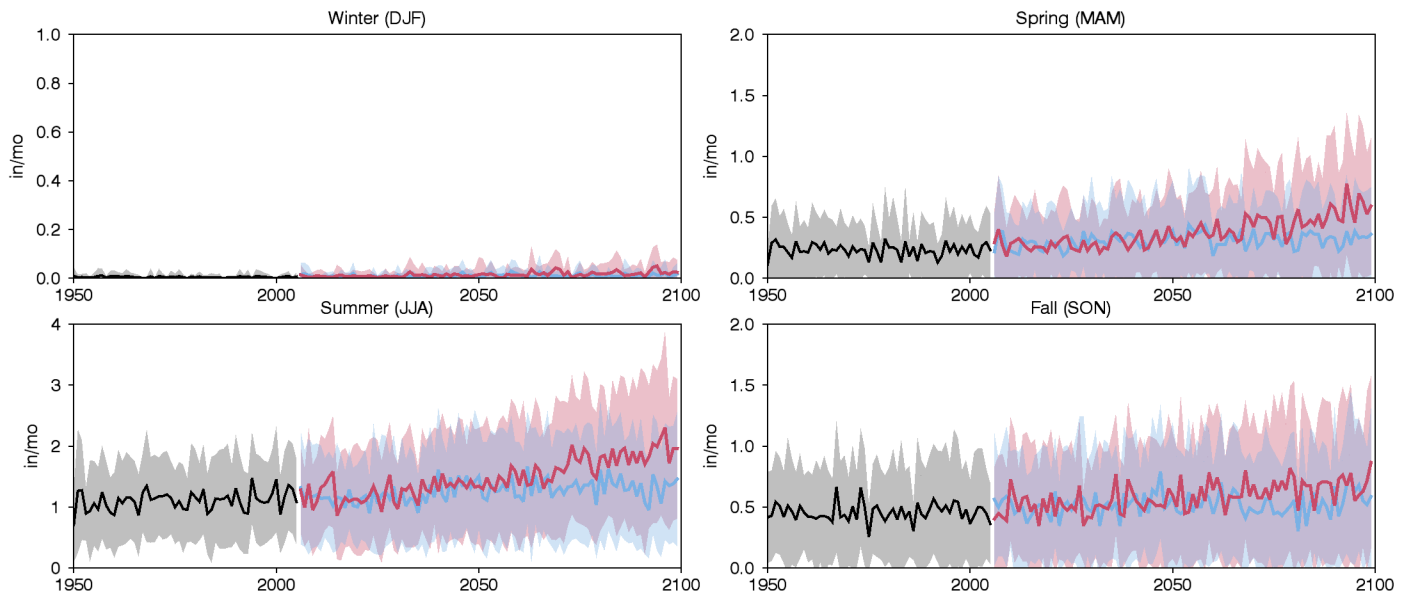


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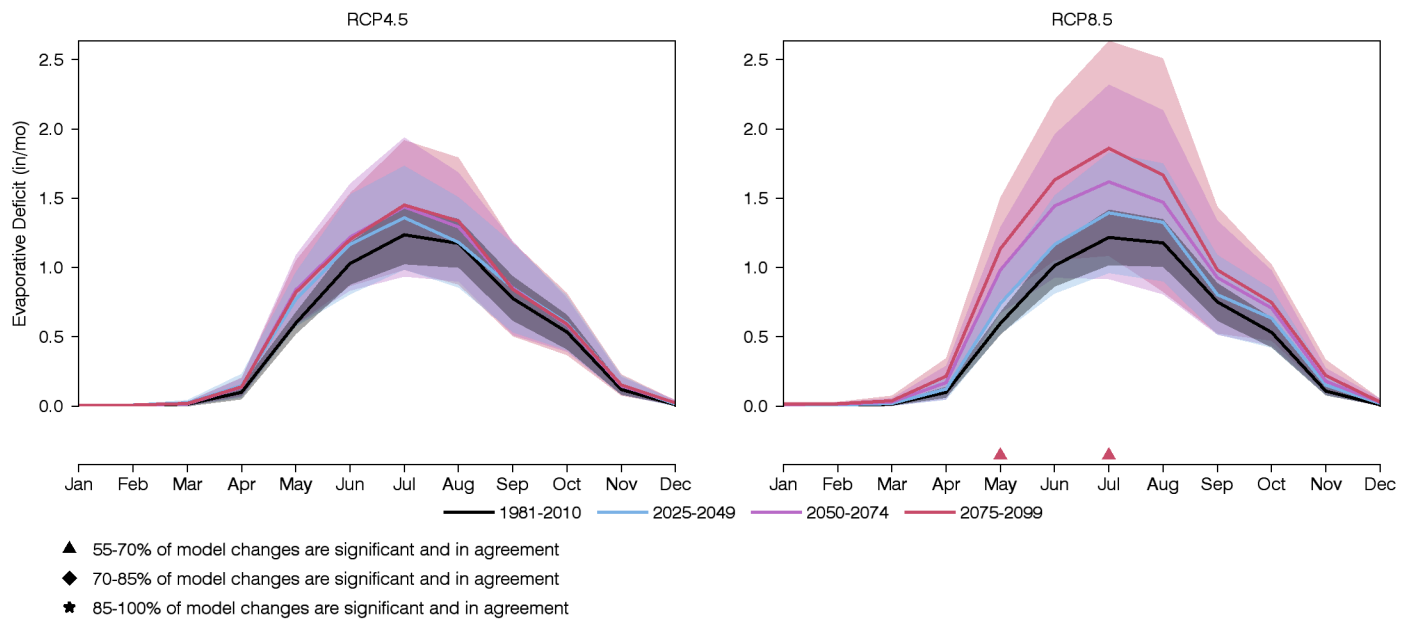


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ACCESS1-0	bcc-csm1-1	bcc-csm1-1-m	BNU-ESM	CanESM2	CCSM4
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GFDL-CM3	GFDL-ESM2G	GFDL-ESM2M	GISS-E2-R	HadGEM2-AO	HadGEM2-CC
HadGEM2-ES	inmcm4	IPSL-CM5A-LR	IPSL-CM5A-MR	IPSL-CM5B-LR	MIROC5
MIROC-ESM	MIROC-ESM-CHEM	MPI-ESM-LR	MPI-ESM-MR	MRI-CGCM3	NorESM1-M

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Appendix 5

Protected status of current populations throughout the range of the dwarf-flowered heartleaf.
Protected status is as follows: 1-protected in perpetuity; 2-protected, but not in perpetuity; 3-not protected.

Population Number	Protection Status
1	1
2	1
3	1
4	1
5	3
2	2 (part)
23	3
29	3
31	2 (part)
44	1
59	2(part)
71	3
77	1
85	3
93	3
96	1 (part)
98	3
99	2 (part)
100	1 (part)
124	3
125	2
130	3
154	1
157	3
158	2/3
176	3
177	3
178	2
179	2(part)
183	1
195	3
206	3
208	2
214	2 (part)
216	2 (part)
217	1
219	3
226	1 (part)
227	1
229	1
232	3
243	1/2 (part)
245	2/3
247	1 (part)

248	3
252	?
261	3
271	1
272	3
274	3
275	3
276	2
279	3
287	1
291	2(part)
292	3
293	3
295	2 (part)
296	3
297	3
298	3
299	3
300	3
302	1 (part)
303	1/2
304	1
306	3
307	2(part)
308	2 (part)
309	3
311	1
312	1
316	?
317	3
318	2 (part)
320	3
321	3
Rock Barn Solar Farm	1

Emailed to
Mike 5-16-18

FOR INFORMATION QUALITY
STRUED TO REPRESENT ANY AGENCY

John Comments
5-16

Chapter 1: INTRODUCTION

The dwarf-flowered heartleaf (*Hexastylis naniflora*) is a species of plant endemic to the upper Piedmont region of western North Carolina and upstate South Carolina. The dwarf-flowered heartleaf has been listed as threatened under the Endangered Species Act of 1973, as amended (Act), since 1989 (FR 54 14964-14967). The Species Status Assessment (SSA) framework (USFWS 2016, entire) summarizes the information compiled and reviewed by the US Fish and Wildlife Service (Service), incorporating the best available scientific and commercial data, to conduct an in-depth review of the species' biology and threats, evaluate its biological status, and assess the resources and conditions needed to maintain long-term viability. The intent is for the SSA to be easily updated as new information becomes available and to support all functions of the Endangered Species Program from listing to consultations to recovery.

A Recovery Plan for the species was never completed. However, over the last 29 years, the Service has worked closely with partners to make significant progress toward recovery of the species. The Service is initiating this SSA to aid in determining the appropriateness of reclassifying the species. In the event that the SSA does not support reclassification, the SSA will be used to inform the development of a Recovery Plan. Importantly, the SSA does not result in a decision by the Service on whether this species should be proposed for reclassification under the Act. Instead, this SSA provides a review of the available information strictly related to the biological status of the dwarf-flowered heartleaf. The reclassification decision will be made by the Service after reviewing this document and all relevant laws, regulations, and policies. The results of a proposed decision will be announced in the *Federal Register*, with appropriate opportunities for public input.

For the purpose of this assessment, we generally define viability as the ability of the species to sustain populations in its natural systems over time. Using the SSA framework (Figure 1.1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation (Wolf *et al.* 2015, entire).

- **Resiliency** describes the ability of populations to withstand stochastic events (arising from random factors). We can measure resiliency based on metrics of population health;

for example, birth versus death rates and population size. Highly resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities.

- **Redundancy** describes the ability of a species to withstand catastrophic events. Measured by the number of populations, their resiliency, and their distribution (and connectivity), redundancy gauges the probability that the species has a margin of safety to withstand or can bounce back from catastrophic events (such as a rare destructive natural event or episode involving many populations).
- **Representation** describes the ability of a species to adapt to changing environmental conditions. Representation can be measured by the breadth of genetic or environmental diversity within and among populations and gauges the probability that a species is capable of adapting to environmental changes. The more representation, or diversity, a species has, the more it is capable of adapting to changes (natural or human caused) in its environment. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics across the geographical range.

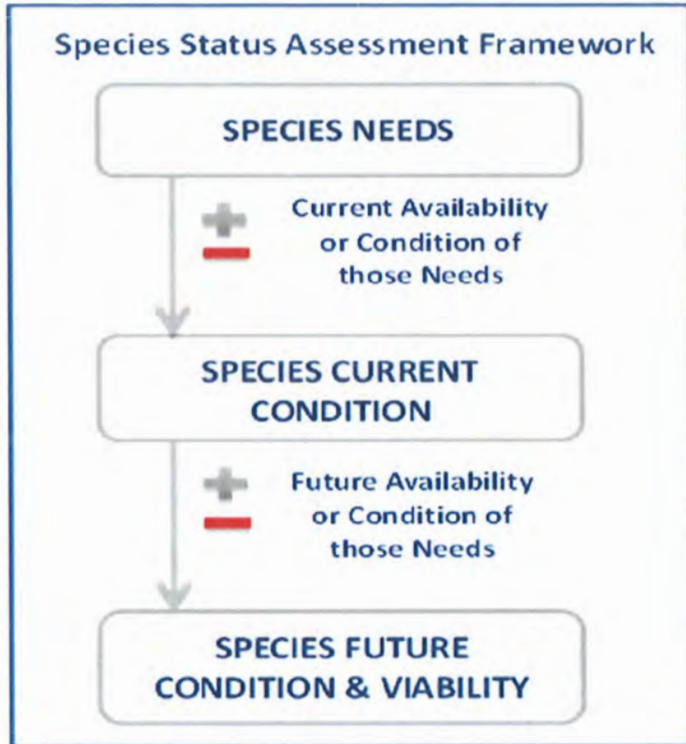


Figure 1.1. Species Status Assessment Framework

To evaluate the biological status of the dwarf-flowered heartleaf, both currently and into the future, we assessed a range of conditions to allow us to consider the species' resiliency, redundancy, and representation (together, the 3Rs). This SSA provides a thorough assessment of biology and natural history, and assesses demographic risks, stressors, and limiting factors in the context of determining the viability and risks of extinction for the species.

The format for this SSA includes: (1) Biology and Species Needs, (2) Current Conditions, (3) Influences on Viability, and (4) Future Conditions. This document is a compilation of the best available scientific and commercial information, and a description of past, present, and likely future risk factors to the dwarf-flowered heartleaf.

Chapter 2: SPECIES BIOLOGY

In this chapter, we provide basic biological information about the dwarf-flowered heartleaf, including its taxonomic history, species description, distribution, life history traits, and habitat characteristics. We then use this information to outline the resource needs within various life stages of dwarf-flowered heartleaf. Here we report those aspects of the life history of the dwarf-flowered heartleaf that are important to our analysis.

Taxonomy and species description

Dwarf-flowered heartleaf is a rare, low growing herbaceous plant in the birthwort family (Aristolochiaceae). The species was described by Blomquist (1957) in his revision of the North American members of the genus *Hexastylis*. The dwarf-flowered heartleaf has been recognized as part of the Virginica Group, and this group was further subdivided into three Subgroups: Virginica, Shuttleworthii, and Heterophylla (Blomquist 1957; Whittemore and Gaddy 1997). Three species have been recognized in the Heterophylla complex, *Hexastylis naniflora*, *H. heterophylla* and *H. minor*, and field biologist have generally recognized that considerable morphological overlap occurs (Murrell et al. 2007). One of the main concerns regarding this complex was the inability to distinguish between species without access to fresh flowers. Even with fresh flowers, Blomquist (1957) and Gaddy (1987) still recognized considerable overlap in flower morphology making species delineation difficult.

Murrell et al. 2007, conducted a comparative genetic analysis using Inter Simple Sequence Repeats, and were unable to find banding patterns that could be used to separate *H. naniflora* from the other members within the complex. However, based on biogeographical, ecological, molecular, morphological, as well as micromorphological work, their results show that *H. naniflora* is a well-defined species.

Although there has been considerable disagreement on the generic distinctiveness of *Hexastylis* and *Asarum* (Barringer 1993 and Kelly 1997, 1998, 2001), a recent phylogeny estimate using chloroplast genes supports that *Hexastylis* is a monophyletic clade and therefore should be

recognized as a genus (Niedenberger 2010). Additionally, most North American publications recognize *Hexastylis* at the generic level (Flora of North America 1997, Weakley 2015).

The Service is not aware of any proposed changes in taxonomy that would affect the continued legal status of *H. naniflora* under the Act. However, 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* (Figure 2.1; Weakley, 2010; Murrell et al. 2007; Gaddy 1987). These geographic areas of overlap in key characters have been the focus of recent genetic analyses (Murrell et al. 2007; Renninger, 2010; Murrell, 2015).

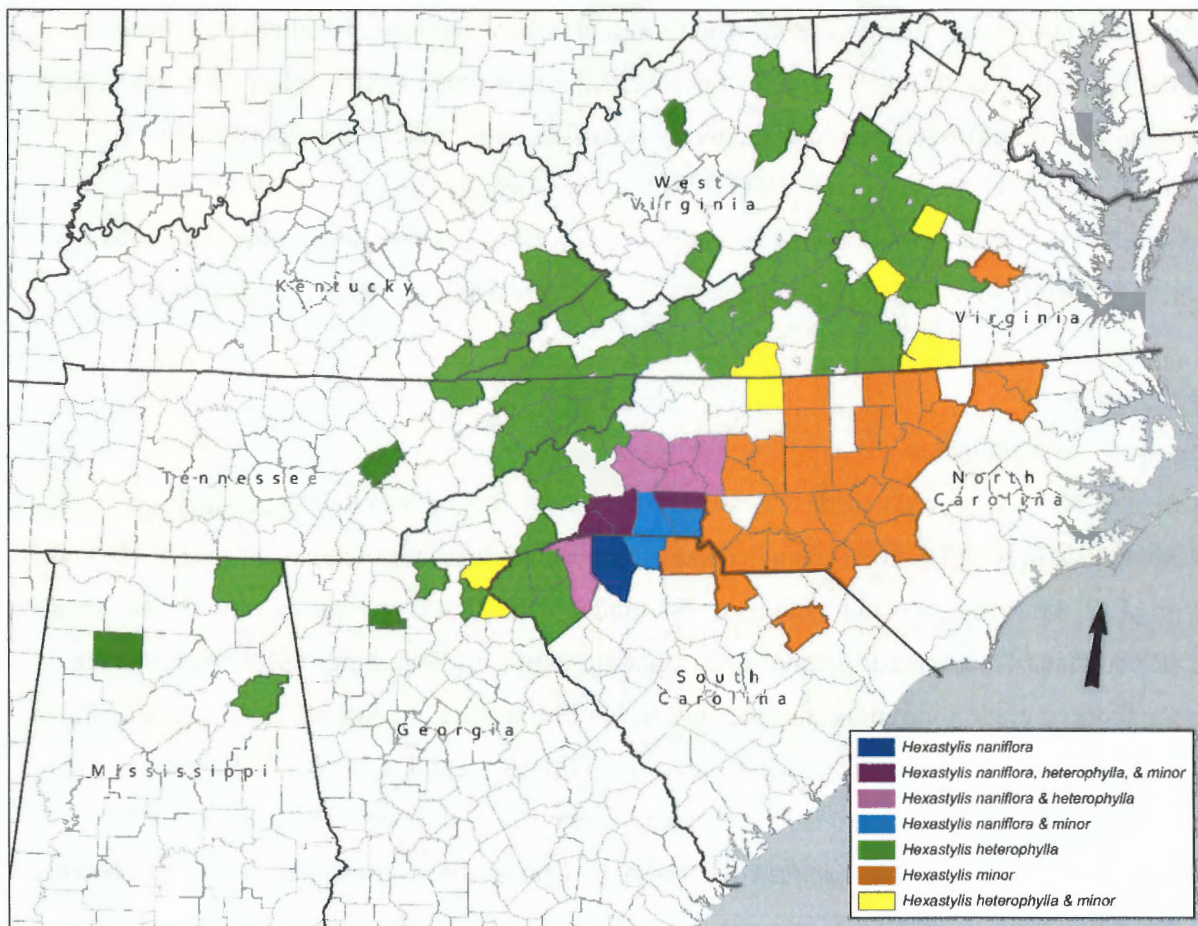


Figure 2.1. Distribution map showing county records for the three species in the *H. heterophylla* complex. Data was gathered from herbarium specimens, Element Occurrence Records (EORs) sheets and field studies. Based on Murrell et al. 2007.

The most outstanding characteristic of this species is the small flowers, which are one of the smallest of any species in North America (Blomquist 1957). The plant's heart shaped leaves are dark green in color, evergreen, and leathery, and are supported by long thin petioles from a subsurface rhizome. The shape of the leaf blades, their pattern of variegation, and the ridged reticulation inside the calyx-tube, place this species inside the *Virginica* group. It differs from all the other members of this group, aside from the small flowers, in having no flare in the calyx-tube. Maximum height rarely exceeds 15 centimeters (cm). The jug shaped flowers are usually beige to dark brown in color and appear from mid-March to early June. The flowers are small and inconspicuous and are found near the base of the petioles. The fruit matures from mid-May to early July (Blomquist 1957, Gaddy 1980, 1981). Characteristics that distinguish it from other *Hexastylis* species are found in floral structures and pollen characters (Gaddy 1987, Padgett 2004, Niedenberger 2010). *H. naniflora* has a smaller calyx tube orifice, which is typically 5mm or less (sometimes up to 7mm) and the ovary is half-inferior, rather than superior (Blomquist 1957, Gaddy 1987, Padgett 2004, HDR 2005). Pollen surface features have also been shown to be an effective character to identify *H. naniflora*, as it has a microporate surface and, unlike any other *Hexastylis* species, lacks gemmae entirely (Padgett 2004, Niedenberger 2010).

Distribution

Although dwarf-flowered heartleaf is restricted in range, it is not as rare as once thought (USFWS 2010, NCNHP 2016). When dwarf-flowered heartleaf was federally listed in 1989, the listing rule described 24 extant "populations" (and one extirpated population) distributed across eight counties in the upper Piedmont of North and South Carolina. Since 1989, the range has expanded to include four additional counties in North Carolina. In North Carolina, it is found in Alexander, Burke, Caldwell, Catawba, Cleveland, Gaston, Iredell, Lincoln, Polk, and Rutherford Counties. In South Carolina, it is in Cherokee, Greenville, and Spartanburg Counties. As of 2016, the distribution of this species consisted of 113 populations distributed across 13 counties in these two states (Figure 2.2).

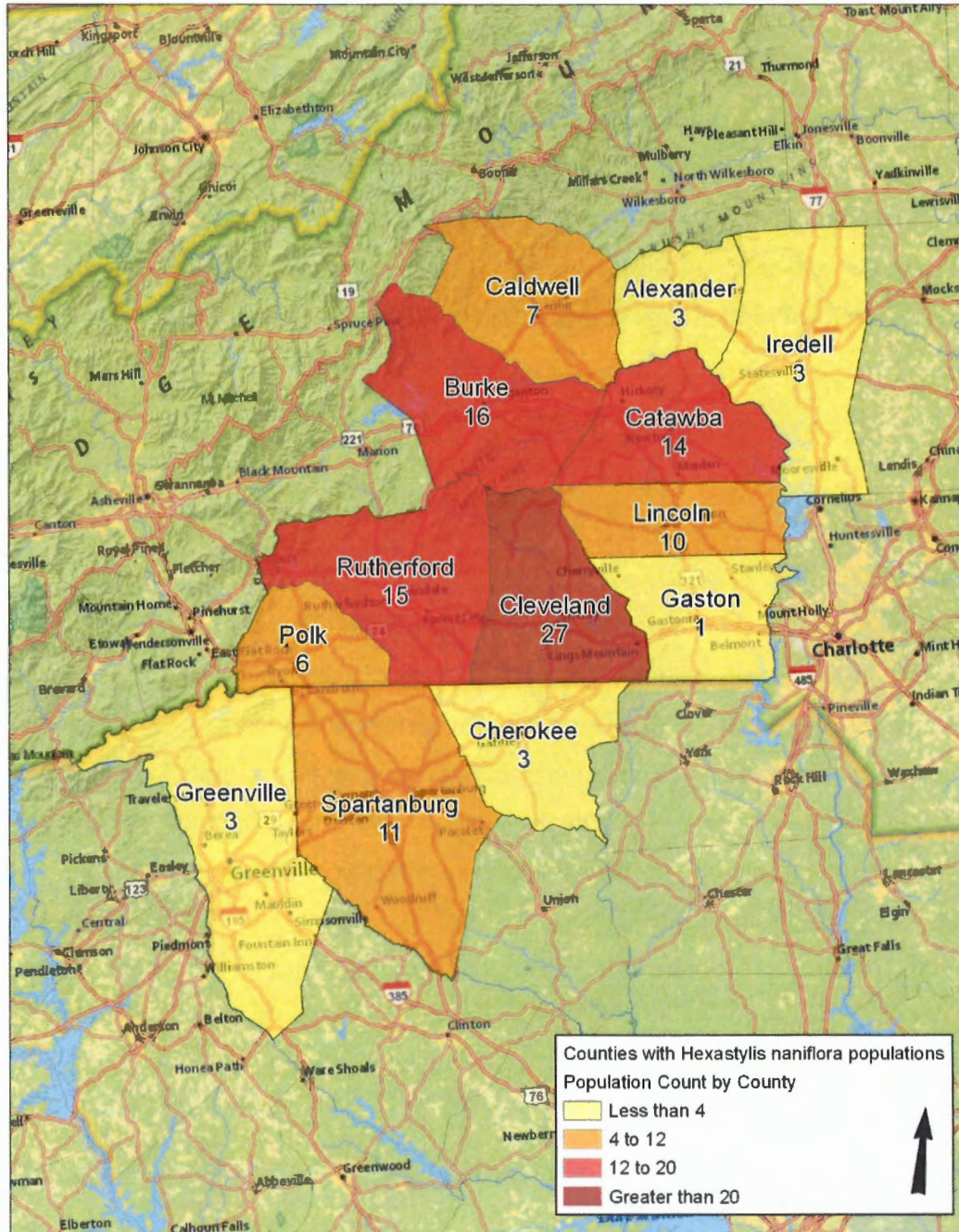


Figure 2.2. Current county distribution for dwarf-flowered heartleaf, with associated number of known populations within each county.

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. We describe how the numerous small, site-specific locations containing *H. naniflora* have been aggregated into proxies for 119 biological populations for purposes of this review, using mapping standards devised by NatureServe and its network of Natural Heritage Programs, in the Species Needs section of this report.

Life History

Demographics

The Service is aware of a single effort to collect demographic-level data (survivorship and recruitment of tagged individuals) for dwarf-flowered heartleaf. 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 (USFWS 2010).

Pollination and Dispersal

The pollination of *Hexastylis* has not been well studied but the genus was thought to be pollinated by insects including flies, wasps, and thrips (Otte 1977). Additionally, Lengyel et al. (2010) described how, within the family Aristolochiaceae, more than 50% of the plant lineage is myrmecochorous (seed dispersal by ants). This supports Gaddy's work (1986), which found

three species within the *Hexastylis heterophylla* subgroup (*H. heterophylla*, *H. naniflora*, and *H. minor*), which employ myrmecochory as a method for seed dispersal.

Ants appear to be a primary dispersal agent for the dwarf-flowered heartleaf (Gaddy 1986; Jones et al. 2014). All diaspores of *Hexastylis naniflora* presented to ants (*Aphaenogaster rudis*) were quickly removed (Gaddy, 1986). This is not to say that they are not occasionally, or even frequently, dispersed and/or pollinated by other means. Jones et al. (2014) suggests that the pollination mechanism is facultative, benefiting from more than one method of pollination/fertilization. Ants were the pollinators in a controlled experiment, and their data supports that when outside molesting forces/pollinators (biotic and abiotic) were limited by their caging procedure, the efficiency of pollination decreased by almost 50%, however, caged flowers did produce seeds, indicating pollination occurred via some alternative method.

Habitat

Dwarf-flowered heartleaf appears to have a restricted range due to its habitat requirements. The habitat where dwarf-flowered heartleaf exists is limited in size and scope due to a multitude of factors including soil type, moisture availability, and slope aspect (Wagner 2013). This unique combination of factors limits not only the range of dwarf-flowered heartleaf, but also the size of a given population. With the limited range and size in populations, questions arise regarding gene flow among populations. How much is occurring and how often does it occur? It is due, in part, to narrow habitat requirements that conservation measures have been implemented for the protection of the species. Any efforts made to protect this species must consider giving protection to the available habitat.

Dwarf-flowered heartleaf occurs on piedmont uplands on acidic sandy-loam soils that are very deep and moderately permeable (Gaddy 1981, 1987). Typical habitats for this species include mesic to dry bluffs, slopes, or ravines in deciduous forests that are frequently associated with *Kalmia latifolia* (Padgett 2004, Weakley 2015, USFWS 2015), or in moist soils adjacent to creeks, streamheads, or along lakes and rivers. Plants have been observed to grow larger and have more frequent flowering in floodplains along rivers, lakes, and streams (Newberry 1993).

Wagner (2013) conducted a habitat suitability study to quantify the habitat requirements for dwarf-flowered heartleaf, which may be used for helping identify the species when not in flower (relative to other *Hexastylis* species habitat preferences), find new populations, or identify suitable sites for transplants.

Soils

The species appears to be restricted to Pacolet sandy loam, Madison gravelly sandy loam, and Musella fine sandy loam soils (Gaddy 1981,1987). The species grows in acidic soils along bluffs and adjacent slopes, in boggy areas next to streams and creekheads, and along the slopes of nearby hillsides and ravines (Gaddy 1980, 1981). The plant is primarily found inhabiting north- to northwest-facing slopes, bluffs, and ravines in close proximity to creeks or streams. Within these areas exists the soil type required for *H. naniflora* to grow. It grows primarily on well-drained, sandy, acidic soils, and will not grow in heavy clay (Gaddy 1981).

The results of soil samples analyzed at the Clemson Soil Lab suggest that major differences in soil chemistry exist between the species in the *H. heterophylla* complex (Murrell et al. 2007). Statistical analysis of the soil samples showed that many of the basic elements were significantly different among the three species. Those significant differences occurred in Phosphorous (P), Potassium (K), Magnesium (Mg), Zinc (Zn), Manganese (Mn), (Na), Sodium, and Cation Exchange Capacity (CEC). Slightly significant differences were seen in Buffer pH (Bu pH), and Acidity.

Soil chemistry showed marked differences between the species in the complex (Murrell et al. 2007). The results indicated that soil chemistry is very different between *H. naniflora* and *H. minor* localities. The results also show that *H. heterophylla* and *H. naniflora* are found in soils where the chemistry is more similar, but still showed significant differences. It would appear that differentiation in soil types could be used as a proxy for species delineation. The soil analysis also indicates that soils must be considered when trying to select sites for relocation of imperiled populations of *H. naniflora*.

Thirteen population sites in North Carolina and South Carolina were examined using the Carolina Vegetation Survey (CVS) method to compare species richness between the three species of the *Hexastylis heterophylla* complex (Murrell et al. 2007). The analysis did not show statistically significant differences among the three species in the *H. heterophylla* complex. However, *H. naniflora* appears to have an association with three oak species that is lacking in the other two species in the complex. There are a number of oak species (*Q. coccinea*, *Q. prinus* (*Q. montana*), and *Q. velutina*), that tend to co-occur with only *H. naniflora*, but are not present with the other two species in the complex. This may be the result of some microbial need or specific soil nutrient required for those species to occur in the same habitat.

Fire

There are little data on the response to fire by *Hexastylis naniflora*, however, prescribed burns have been conducted within the population at Cowpens National Battlefield in Cherokee County, SC. Preliminary data at this site and recent annual monitoring data of this population support the theory that moderate controlled burns do not negatively affect this population (Walker et al. 2009). Additionally, a dormant season wildfire in Caldwell County did not show evidence of negative impacts to a population in Caldwell County (USFWS 2010). Fire suppression could be a hazard to *H. naniflora* by allowing fire intolerant, nonnative and invasive plants to thrive, as well as the accumulation of thick duff or leaf litter that may shade low growing species (Wagner 2013).

Genetics

Analyses on ecology, morphology, soil chemistry, pollen, and molecular genetics have been evaluated for *Hexastylis naniflora* to determine the boundaries within the *Hexastylis heterophylla* complex, which consists of *H. heterophylla*, *H. minor*, and *H. naniflora* (Murrell 2015, Wagner 2013, Niedenburger 2010, USFWS 2010, Murrell et al. 2007, Padgett 2004). These analyses support the continued recognition of these taxa as well-defined, discrete species. 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.

Field observations demonstrate that there are some populations of dwarf-flowered heartleaf with morphological characteristics that do not fit within the range of published values for key traits, overlapping with values for *H. heterophylla* or *H. minor* (Gaddy 1987, Murrell et al. 2007, USFWS 2010, Weakley 2015). These populations with overlap in key characteristics were the focus of a genetic analysis conducted at Appalachian State University (ASU) through funding provided by NCDOT (Murrell 2015). In some populations, floral characteristics are highly variable, which suggests the potential for hybridization or individuals with highly variable flower size and shape (Murrell 2015). Additionally, no vegetative characters were previously known to consistently distinguish *Hexastylis naniflora* from other close relatives. Given the difficulties with field identification of the species, particularly when not in flower, this study sought to develop a microsatellite library of molecular markers to resolve variation in populations of dwarf-flowered heartleaf and apply the markers to populations with highly variable characters, as identified by NCDOT biologists. The morphological and micromorphological information from those variable populations were compared to molecular results with morphological, micromorphological, and distributional data to determine genetic structure, biological boundaries, and placement of putative hybrids or intermediate populations of *H. naniflora* (Murrell 2015).

The preliminary findings of this study suggest that populations in the southern range of dwarf-flowered heartleaf exhibit a more uniform genetic pattern, with some possible hybridization with *H. minor*. Populations in the northern part of the range appear to have hybridized with both *H. heterophylla* and *H. minor*, although there are still individuals with “pure” *H. naniflora* genotypes in the northern range (Murrell 2015). It is critical to note that although these data provide anecdotal evidence of hybridization with the *Hexastylis heterophylla* group, intraspecific variation may be caused by forces other than hybridization, such as convergent morphological

evolution (Dobzhansky 1937), or the species is in the process of speciation and this study shows a case of incomplete speciation (Murrell 2015), and/or other environmental factors are at play (Wagner 2013). On May 11, 2016, a meeting was held with USFWS, NCNHP, NCDOT, and ASU to discuss the status of *H. naniflora* and the current work being conducted among the agencies (Amoroso 2016). Based on discussions during this meeting, the results of this study reported by ASU to NCDOT in 2015 are preliminary. Dr. Matt Estep (ASU) provided additional preliminary results to NCNHP in May 2016, showing which populations were sampled, sample size, and percent of samples that show evidence of hybridization, and hybridizing with which species. ASU continues to work towards a more definitive explanation of the variation in the *H. heterophylla* complex (Murrell 2015, Amoroso 2016).

CHAPTER 3: SPECIES NEEDS

For the purpose of this report, we define viability as the ability of the species to sustain populations in the wild over time. Species with greater numbers (redundancy) of healthy populations (resiliency), encompassing a broad array of ecological and genetic diversity in a spatial arrangement that maintains adequate gene flow (representation), are more likely to be viable. Using the Species Status Assessment framework, we describe the species' viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation.

Delineating Populations

As stated in the USFWS five-year review, many of those working with dwarf-flowered heartleaf 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, in the past, to treat each location as a separate population also artificially inflated the actual number of populations known.

The Natural Heritage Program collects information on occurrences of rare plants, animals, natural communities, and animal assemblages. Collectively, these are referred to as "elements of natural diversity" or simply as "elements." Locations of these elements are referred to as "element occurrences" (EO records). 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 in meaningful units of conservation interest that may approximate biological populations (NatureServe 2002). Since USFWS does not maintain its own database of known locations of *Hexastylis naniflora*, it regards the NHP databases as the best repository for this information (USFWS 2010).

We delineate populations for the purposes of this SSA according to the NatureServe (2002) convention. Separation distances are a key component to delineating populations from EO records. For the dwarf-flowered heartleaf, we used the EO Data Standard which provides a Default Separation Distance of 1 km (~0.62 miles) for plant and animal elements that lack EO specifications, noting that situations involving dispersal barriers could involve even shorter distances. While gene flow declines over distance at different rates for different elements, the minimum default EO separation distance of 1 km has been accepted by the Network as the most suitable round-number metric-system approximation broadly applicable to many (but not all) situations. This results in several dwarf-flowered heartleaf populations being stand-alone EOs, as well as many populations being aggregates of several EOs.

Population Resiliency

For the dwarf-flowered heartleaf to maintain viability, its populations or some portion thereof must be resilient. Stochastic factors that have the potential to affect dwarf-flowered heartleaf include impacts to its habitat, particularly human development pressures, but also climate change and presence of invasive species. Other factors that influence the resiliency of dwarf-flowered heartleaf populations include abundance within populations, and habitat factors such as elevation, slope, aspect, and soil type. Influencing those factors are elements of dwarf-flowered

heartleaf ecology that determine whether populations can grow to maximize habitat occupancy, thereby increasing resiliency of populations. These factors and habitat elements are discussed below (Figure 3.1).

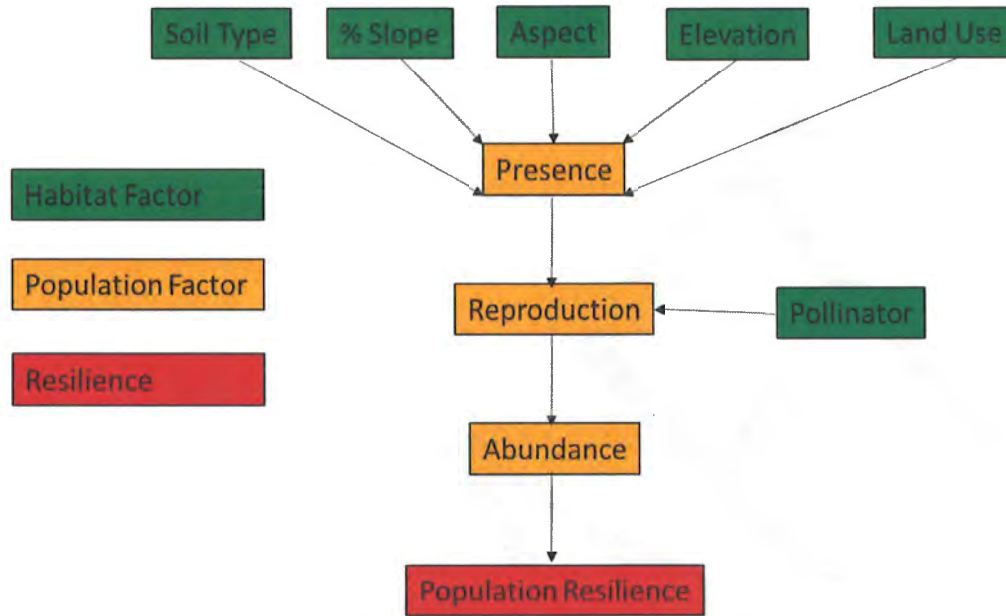


Figure 3.1. Conceptual diagram describing population and habitat factors influencing population resilience for dwarf-flowered heartleaf.

Habitat Factors: Slope, Aspect, Elevation, Soil, and Forest Type

A previous habitat suitability study attempted to quantify the habitat requirements for dwarf-flowered heartleaf (Wagner 2013). With this model in mind, and the input of species experts as to important habitat factors for the species, we used updated habitat data, as well as inclusion of updated EOs, to create a new habitat model to identify potential habitat throughout the species range. All source datasets and variables created are described in Appendix 3.

Source Data and Model Variables

Fifty-three, 10-digit hydrologic units (HUC) comprise the analysis extent (Figure 3.2). In North Carolina, it includes all 10-digit HUC that fall within the boundaries of 8-digit HUC with known occurrence of *Hexastylis naniflora*. In South Carolina, we also included all 10-digit HUC that

fell within the boundaries of 8-digit HUC with known occurrence of *Hexastylis naniflora*, but excluded the southern portions of the HUC-8 areas due to the boundaries being exceedingly large and far away from any known occurrences.

Hexastylis naniflora element occurrence data was obtained from the North Carolina Natural Heritage Program and the South Carolina Heritage Trust Program. Current populations of *Hexastylis naniflora* were identified by reviewing the last observed data in the database and excluding all populations that have not been observed since 2005 to remain consistent in our approach of assessing resiliency described previously. To represent these current population areas in Maxent, a raster cell center was retained for every 30 x 30 meter pixel that was situated within the current element occurrence data polygons.

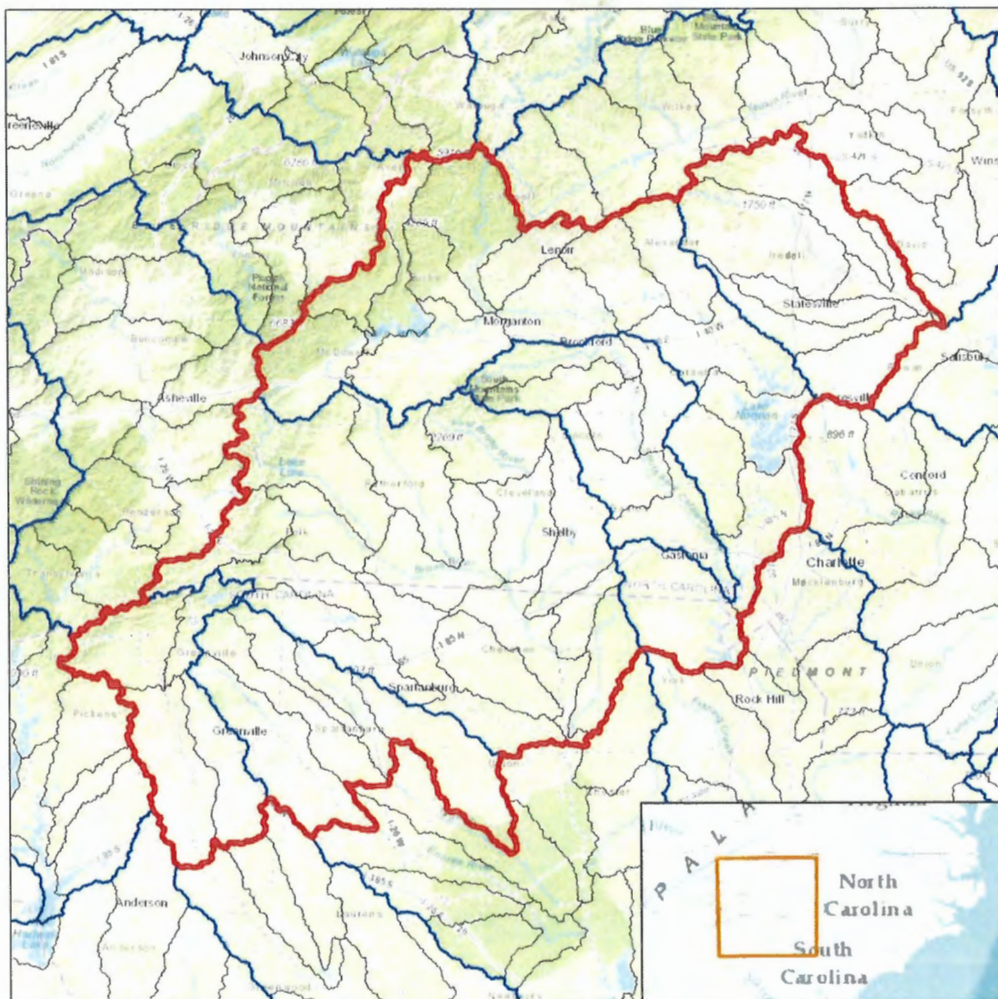


Figure 3.2. Analysis extent of the habitat model for *Hexastylis naniflora*. Red line indicates Maxent analysis extent, blue lines are 8-digit HUC boundaries, black lines are 10-digit HUC boundaries. The orange line in the inset map indicates where the analysis extent is situated in North and South Carolina

Model Development

We used Maxent software (version 3.4.1) for species habitat modeling (Philips et al., 2018). An initial single model Maxent run was done to determine which variables could be excluded due to limited percent contribution to the model. Any variable that contributed less than 1% to the single model run results was excluded in the final model. The following variables were excluded: landcover diversity, canopy height, SSURGO drainage class, SSURGO hydrologic group, aspect 9-class, aspect 5-class, slope, solar radiation, and maximum annual temperature. It is interesting to note that a previous habitat modelling effort (Wagner 2013) included aspect and slope, whereas the Maxent model excluded these variables. This does not mean these variables are not important components of dwarf-flowered heartleaf habitat, but rather these variables did not significantly improve the model. Also, landform data was included, and perhaps landform, which includes components of aspect and slope combined is a more meaningful variable than aspect or slope independently.

For the final model, a 10-run replicate Maxent model was created using cross-validation. For replicate models, the occurrence data is randomly split into a number of equal-sized groups called “folds”, and separate models are created leaving out each fold in turn. The individual model runs are then averaged together to derive the final model.

Results

Figure 3.3 shows the model output. The minimum cutoff value (to determine if an area is considered potential habitat for a species) of 0.39 was determined by using the average 10th percentile training presence. The 10th percentile training presence uses the suitability threshold associated with the presence record that occurs at the 10th percentile of presence records (Phillips 2018). This value excludes some of the outlier population areas in the Maxent

predictions to focus on the typical habitat conditions for this species. The total area ranked greater than 0.39 in the Maxent model was just 6.00% of the total analysis area (Table 3.1).

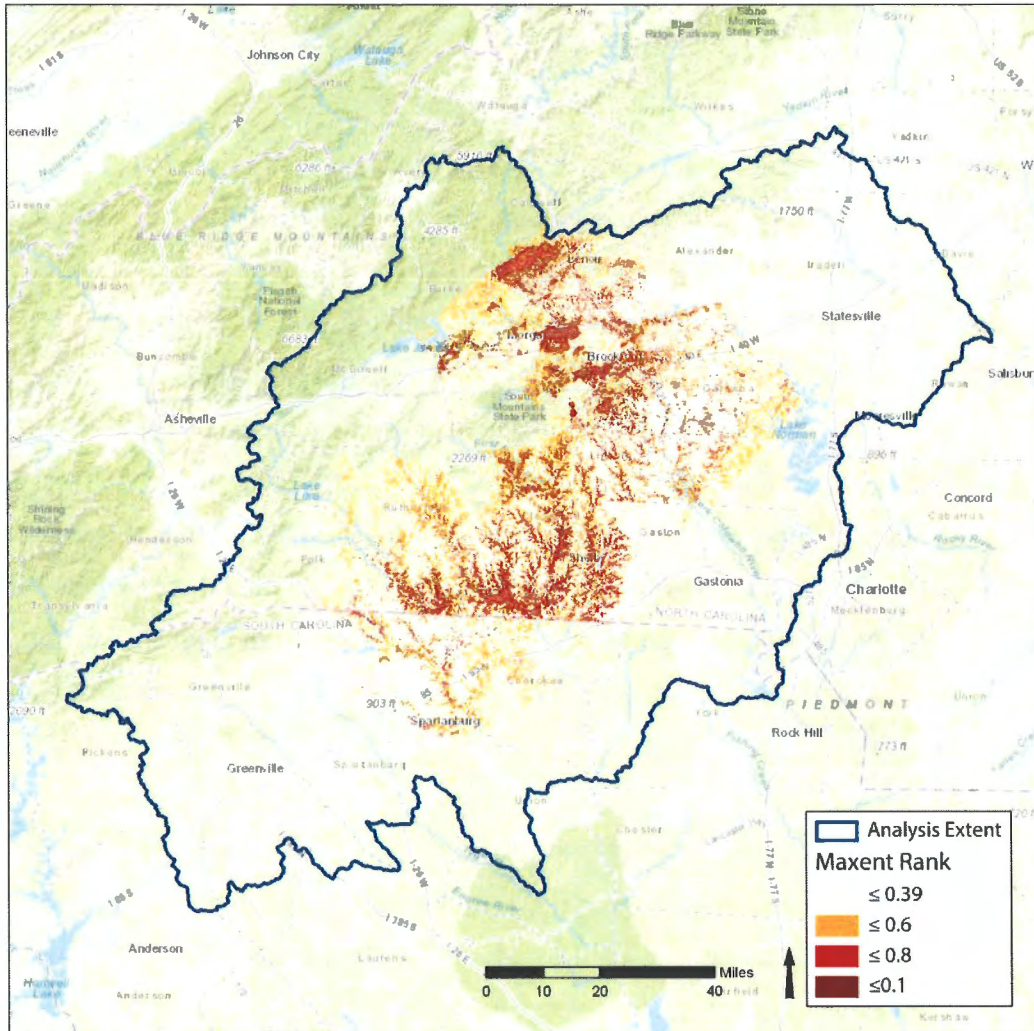


Figure 3.3. Maxent model output map

Table 3.1-Area estimates of the Maxent model

Maxent Score	Acres	Square Miles	Percent of Total
0.39 and greater	302,834.13	473.18	6.02%
0.6 and greater	128,273.52	200.43	2.55%
0.8 and greater	22,115.97	34.56	0.44%

The average area-under-curve (AUC) score for the replicate Maxent model is 0.86. The AUC is calculated from the receiver operating characteristic (ROC) plot. This value has a range of 0 – 1 and may be interpreted as a single test statistic that assesses model performance, indicating the ability of the model to correctly classify the occurrence data used. The model performed well in its predictions, with a mean AUC of 0.86 (AUC value of 0.5 is no better than random; AUC<0.5 is worse than random; AUC>0.5 is greater predictive power than random; Baldwin 2009).

The Maxent output supplies estimates of the relative contributions of the environmental variables to the Maxent model (Table 3.2). SSURGO map unit key is the top contributing variable. One hundred and thirty-five individual soil types are present within the polygon boundaries of the *Hexastylis naniflora* element occurrences. Many of these individual soil types are part of soil complexes and are separated by things such as percent slope, erosion, how stony/rocky, and amount of clay. The most common individual soil type was Meadowfield-Rhodhiss complex, 25 to 60 percent slopes, very stony (14.1% of total). However, collectively the Meadowfield soils only comprised 14.3% of all soils). The individual Pacolet soil types were very common and collectively comprise 36% of all soil types present. Woolwine, Rion, and Fairview soils were also collectively common, comprising 10.4%, 9.7%, and 8.8% of all soils present respectively.

Table 3.2. Percent contribution of the environmental variables

Environmental Variable	Percent Contribution
SSURGO map unit key	23.5%
Minimum Annual Temperature	17.8%
Average Annual Precipitation	15.7%
Landcover	12.9%
Landcover Majority	12.0%
Landcover Hexastylis Grouping	5.4%
Geomorphons	4.9%
Elevation	4.6%
Canopy Cover	3.2%

Can you explain what this is? What does the variable describe

So what is the SSURGO? Please explain

The minimum annual average temperature range in the analysis extent is 39 – 51 degrees Fahrenheit. The majority of the *Hexastylis naniflora* element occurrences (89%) are found at the 47 and 48 degrees. The average annual precipitation range in the analysis extent is 42 – 81 inches per year. The majority of the *Hexastylis naniflora* element occurrences (82%) are found in the 47 – 49 inches per year range.

Piedmont forested landcover habitats dominate the land area of the element occurrences.

Southern Piedmont Dry Oak-Pine Forest – Hardwood Modifier (53%), Southern Piedmont Mesic Forest (9%), Southern Piedmont Dry Oak-Pine Forest (5.2%), Southern Piedmont Small Floodplain and Riparian Forest (4.4%), and collectively comprise 71% of the element occurrences area. Evergreen Plantation or Managed Pine (9%), Harvested Forest (7.2%), Developed, Open Space (5%), Pasture/Hay (2.1%) collectively comprise 22% of the total element occurrence area. The remaining 6 percent of element occurrence area is comprised of a mix of 14 other natural and disturbed landcover classes, but each at small percentages.

The landcover majority classification scheme reduces the total number of landcover classes present in the analysis extent from 23 to 11. Southern Piedmont Dry Oak-Pine Forest – Hardwood Modifier is still the dominant landcover class (58%). However disturbed categories are increased in area (sum total of 35%). Evergreen plantation or managed pine (12%) and Pasture/Hay (12%) are the only other categories that have at least 10% or greater area. The increase in disturbed landcover area representation in the landcover majority layer suggests that many *Hexastylis naniflora* population areas are situated in areas impacted by disturbed landcover. This is likely due to urban encroachment and increasing fragmentation of habitats.

The landcover *Hexastylis naniflora* grouping reveals the amount of disturbance present in *Hexastylis naniflora* population areas. Landcover classes grouped as disturbed comprises 27% of the total area. Mixed forest (deciduous and evergreen) comprises 58%, pasture/hay 12%, and hardwood forest 2%. Open water, evergreen and barren landcover groupings are all at less than 1% each.

Geomorphons revealed that the majority of *Hexastylis naniflora* element occurrence areas are situated in concave landforms. Geomorphon categories hollow (13%), valley (46%), and

or that this is where all the surveys have been located of development required surveys. How can you rule out survey bias?

depression (10%) collectively comprise 69% of all *Hexastylis naniflora* population areas. Flat landforms comprise 15.5% of the area and convex landforms the remaining 15.5%.

Within the analysis extent, the range of elevation present is 335 – 5,265 feet. For *Hexastylis naniflora*, the prime elevation range is from 666 – 908 feet (53% of total element occurrence area). A lesser elevation range is present from 935 – 1,184 (37% of total element occurrence area).

Canopy cover for the *Hexastylis naniflora* populations are dominated by Tree Cover 70-80% (20.2%) and Tree Cover 80-90% (63.9%). The rest of the canopy cover categories are 2% or less.

We performed a Kruskal-Wallis 1-way non-parametric Analysis of Variance (ANOVA) to investigate the relationship between Maxent scores and current resilience of populations (Table 3.3). There are significant differences in the average Maxent scores between the four resilience categories ($p = 0.04$) and the mean Maxent score increases as population resilience increases from low to very high. The model gives us some predictive ability regarding habitat suitability where higher Maxent scores, on average, result in higher population resilience.

Table 3.3 Results of the Kruskal-Wallis 1-way non-parametric ANOVA investigating relationships between Maxent scores and current resilience groups for dwarf-flowered heartleaf.

Groups	Count	Mean Rank
low	13	30.7
moderate	25	30.7
high	5	42.8
very high	28	45.7

— So what does this mean? Are we simply saying that larger pop's are more resilient? Please dumb it down a little.

Source of Variation	SS	df	MS	F	P-value
Between Groups	4375.7	4	1093.92	2.65	0.0404

Within Groups 28036.3 68 412.30

Total 32412.0 72

Reproduction and Presence of Pollinators

The pollination of *Hexastylis* has not been well studied but the genus is thought to be pollinated by insects including flies, wasps, and thrips (Otte 1977). Additionally, Lengyel et al. (2010) described how, within the family Aristolochiaceae, more than 50% of the plant lineage is myrmecochorous (seed dispersal via ants). This supports Gaddy's work (1986), which found three species within the *Hexastylis Heterophylla* subgroup (*H. heterophylla*, *H. naniflora*, and *H. minor*), which employ myrmecochory as a method for seed dispersal.

Because the flower for this species is oftentimes partially or completely covered with soil and leaf litter, possibly inhibiting pollinator activity (Gonzalez 1972), there is still uncertainty in the pollination mechanism for dwarf-flowered heartleaf. Otte (1977) suggests that a variety of possible pollinators reside in this leaf litter, however, the calyx opening is considered to be far too small for efficient pollinating (Gaddy 1981). There are, however, invertebrates within this proposed size limit that could theoretically act as pollinators. It is possible that the species employs self-pollination, with or without a vector, or that cross-pollination occurs by a number of invertebrates. Jones et al. (2014) investigated pollination of dwarf-flowered heartleaf under a manipulative experimental design, and found that while insects may play a significant role in pollination, even without them, flowers managed to produce a partial seed set. However, two points need to be considered here. First, although flowers managed to produce seeds in the absence of insect pollinators, the efficiency of pollination decreased by almost 50%. Also, even if successful pollination occurs in the absence of insect vectors, the dispersal of plants amongst populations would be limited, and could result in decreased resilience due to genetic concerns such as limited gene flow and issues associated with potential inbreeding depression.

Abundance

The influence of stochastic variation in demographic (reproductive and mortality) rates is much higher for small populations than large ones. Stochastic variation in demographic rates causes small populations to fluctuate randomly in size. In general, the smaller the population, the greater the probability that fluctuations will lead to extinction. There are also genetic concerns with small populations, including reduced availability of compatible mates, genetic drift, and inbreeding depression. Small populations of dwarf-flowered heartleaf have low resilience, leaving them particularly vulnerable to stochastic events.

As of 2016, the combined databases of the NCNHP and SCDNR contain 239 Element Occurrence Records (EORs) for *H. naniflora* (NCNHP 2016, SCDNR 2016). These EORs depict roughly 113 locations which are sufficiently geographically distinct to be regarded as proxies for populations of the species (See *Delineating Populations*). Thus, the total number of populations has increased more than four-fold (from 24 to 113) since the species was listed in 1989.

At this time, the largest known populations have been monitored by NCNHP and NCDOT. The estimates for entire populations are based on a consistent monitoring methodology developed by NCDOT, USFWS, and NCNHP with monitoring plots representing roughly 10% of a population. Populations were delineated to get a more accurate boundary and size of the area occupied. All rosettes are counted annually in each monitoring plot to estimate an extrapolated population size, based on the number and density in the plots. As a result of these efforts, better estimates of population sizes for the largest known populations are available, compared to when the last five-year review was completed in 2010 (Robinson and Padgett 2016).

The 113 EORs have been estimated to contain anywhere from a single rosette to over 100,000 rosettes. Appendix 1 was created by NCNHP (2016) to replicate the same format and population data as Table B2 of the most recent USFWS five-year review of *H. naniflora* (USFWS 2010), for comparison of changes since 2010, and summarizes the largest occurrences of *H. naniflora*, with the size of the population based on the number of rosettes it was last estimated to contain. The number of populations estimated to contain over 1,000 rosettes is 26. This is approximately 23%

of the total known populations and many of these populations contain well over 1,000 individuals.

There are, however, 13 populations (12% of all known) that are simply known to be extant, with no available estimate of population size (NCNHP 2016, SCDNR 2016). If the most recent population estimates for each EOR are compiled across years of observation, the 113 populations could conservatively be estimated to contain a collective total of more than 300,000 rosettes (NCNHP 2016, SCDNR 2016).

Population Trends

Although abundance is critical in assessing the resilience of dwarf-flowered heartleaf, trends in population growth can also be informative. Long-term growth trends are typically defined as the degree of change in population size over 200 years, whereas short-term growth is typically measured as that degree of change over a 10 year period. We lack a robust data set to assess trends at either of these time scales. However, from 2012-2016, NCNHP conducted systematic annual surveys of thirteen of the largest populations across the range.

Based on the results of the five-year monitoring efforts completed in 2016, nine out of thirteen populations remain stable during the five years of data collection (Robinson and Padgett 2016). The largest known population, Broad River: Henson's Creek, Brice, & Sandy Mush Outcrop in Rutherford County, NC, is estimated to have over 100,000 rosettes (Robinson and Padgett 2016). This large population consists of many scattered subpopulations on private property; two of the subpopulations are protected as a Registered Heritage Area, although Registry is a non-binding agreement with landowners that can be cancelled at any time (NCNHP 2018).

Two of the thirteen populations increased in numbers from 2012-2016: Cliffside Steam Station and Broad River: Floyds Creek, Long Branch. The Cliffside Steam Station is protected with a voluntary agreement with Duke Energy and was estimated to contain over 39,000 rosettes in 2016. The Broad River: Floyds Creek, Long Branch population is not at all protected, but was last estimated to consist of over 12,000 individuals in 2016 (Robinson and Padgett 2016).

593

594 Based on the results of recent surveys and a review of all known populations of *Hexastylis*
595 *naniflora*, the overall trend over approximately 30 years is estimated to be declining 10-30%.
596 This is estimated by a combination of documented declines of some populations, while many
597 others appear to be remaining relatively stable, and some have increased.

598

599 **Chapter 4: CURRENT CONDITIONS**

600

601 Below we assess current resilience, representation, and redundancy as they relate to population
602 and habitat factors known to be important for species viability. Based off of recent reports
603 (Robinson and Padgett 2016; Robinson 2016), the species consists of 119 populations distributed
604 across 12 counties in North Carolina and South Carolina. Populations are composed of both
605 multiple EOs and stand-alone EO records. Recent genetic research discussed in Chapter 2,
606 suggests that dwarf-flowered heartleaf, as originally described, is found in the southern portion
607 of its presumed range based on current EO locations, and the northern portion could be a
608 currently undescribed species (Figure 4.1; Estep pers. Comm. 2018). The genetic analysis to
609 support this is complete, but a review of the morphology is ongoing and a new species has not
610 yet been described (Estep pers. Comm. 2018). For the purpose of this SSA, we assume all EO
611 detections are *H. naniflora*, and represent the best currently available scientific data.

612

Inconsistent with p. 27 (113)
Which says 119 poplns.

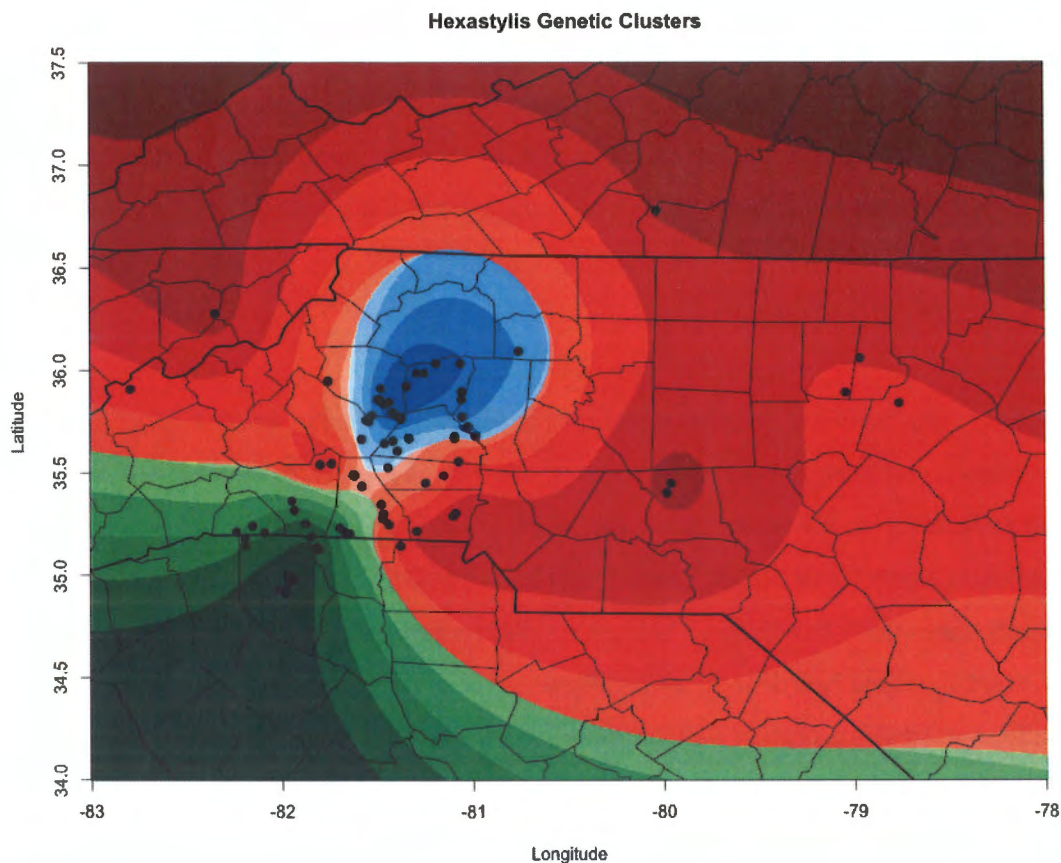


Figure 4.1. Recent genetic analyses detailing clustering of the genus *Hexastylis*. Black dots represent GIS locations of individual plants included in the genetic analysis. Green areas represent “true” *H. naniflora*; Blue represents a possible new species; Red represents other species in the genus (*H. minor*, *H. heterophylla*, etc.).

Current Population Resilience

Categorizing Resilience

For the purposes of this SSA, we use population size as the main driver of population resilience. The unit of measurement for population size in this species is a “clump” (rosette). As discussed previously, populations in North Carolina were delineated by NCNHP, whereas the Service defined populations in South Carolina. These delineations were based off of NatureServe criteria such as EO separation distance and intervening landscape matrix. EO data included a wide range

of years since the species was last observed at a given location (1964-2017), so although recent reports suggest the species consists of 113 populations, some of that data is fairly outdated. For the purposes of this SSA, we only used EOs that were observed since 2005. We did this for several reasons. First, we did not want to go back too far and assume a population was still present. Second, we wanted to be consistent in what we considered “current” for both categorizing resilience and use in the habitat model (discussed later). Also, experts concurred that records as old as 12 years are still likely to persist. Finally, there was a natural break in the data at the year 2005, coinciding with the year the last five-year review was initiated, where the number of EOs dropped off significantly in the years 2004 and earlier. It is important to note that many of the populations that we excluded from our analysis may still persist on the landscape. In fact, many EOs for this species have persisted for decades, despite not having intervening surveys to confirm their persistence.

Based on the criteria (excluding EOs prior to 2005), there are currently 78 populations distributed across the range of dwarf-flowered heartleaf, although this may be an underestimate as discussed above.

To determine overall resilience for populations, we used EO viability ranks and expert opinion to bin population size classes into corresponding resilience categories. EO viability ranks for the species include excellent, good, fair, poor, extant, historical, and failed to find. The primary factor in determining these ranks is EO size (as quantified by number of clumps). Condition of habitat (vegetation community and structure) and landscape context (extent of suitable habitat and physical factors) are also incorporated secondarily. Appendix 2 shows the NCNHP EO rank specifications for dwarf-flowered heartleaf. The EO rank specifications suggest good-excellent viability for populations consisting of at least 500 individuals, given there is sufficient high quality habitat; fair viability for populations consisting of 100-500 individuals, depending on habitat conditions; poor viability for populations consisting of less than 100 individuals. Recent reports (Robinson 2016; Robinson and Padgett 2016) focus monitoring studies on populations with greater than 1,000 individuals, populations that are assumed to be very viable. Because we do not have habitat level information for every population we assessed, we synthesized all of the above population size information and created four resilience categories as follows:

- Very high—populations with >1,000 individuals; very high probability of persistence for 20-30 years at or above the current population size.
- High—populations with 500-1,000 individuals; moderate-high probability of persistence for 20-30 years at or above the current population size.
- Moderate—populations with 100-500 individuals; low probability of persistence for 20-30 years at or above the current population size.
- Low—populations with <100 individuals; low probability of persistence for 20-30 years at or above the current population size, and moderate-high probability of extirpation.

Occupancy and Abundance

There are 78 populations of dwarf-flowered heartleaf that have been observed since 2005 (Table 4.1), and resilience of these populations is as follows: 28 (very high); 5 (high); 26 (moderate); 19 (low). Table 4.2 shows the contribution of each resilience category as follows: 36% (very high); 7% (high); 34% (moderate); 23% (low). When looking at cumulative percentages of resilience, it is interesting to note that 77% of all of the populations are classified as moderate to very high resilience (Table 4.2).

Table 4.1. Current populations of dwarf-flowered heartleaf and associated resilience across the species range. Abundance and last observation date based on Natural Heritage Program data (2018).

Site Name	State	County	Last Observed	Total plants	Resilience
Glade Creek, Alex County	NC	Alexander	2017	>1000	very high
Catawba River: Hoyle Crk-Micol Crk	NC	Burke	2013	>1000	very high
Island Creek Heath Bluff	NC	Burke	2016	>1000	very high
Gunpowder Creek: South of Hudson	NC	Caldwell	2012	>1000	very high
Peaked Top Rare Plant Site/Foothills Landfill	NC	Caldwell	2014	>1000	very high
Jacob Fork West Corridor	NC	Catawba	2012	>1000	very high
Murrays Mill/Upper Balls Creek NA	NC	Catawba	2013	>1000	very high
NCDOT TIP: R-2824	NC	Catawba	2015	>1000	very high
South Fork Catawba R: Clark Crk, Miller Br, Cata Mem Hos	NC	Catawba	2013	>1000	very high
Cowpens NBF - Site 1	SC	Cherokee	2016	>1000	very high

Site Name	State	County	Last Observed	Total plants	Resilience
Cliffside Steam Station	NC	Cleveland/Rutherford	2016	>1000	very high
Broad River/Sandy Run NA	NC	Cleveland	2012	>1000	very high
Broad River: Brushy Creek	NC	Cleveland	2016	>1000	very high
Buffalo Creek: Kings Mountain Res	NC	Cleveland	2016	>1000	very high
Buffalo Creek: Tributaries N and S of SR 2047	NC	Cleveland	2012	>1000	very high
Rhyne Conservation Preserve	NC	Lincoln	2016	>1000	very high
Mill Creek Forest and Seep	NC	Polk	2016	>1000	very high
New Hope Springhead Swamp	NC	Polk	2016	>1000	very high
Big Horse Creek Rare Plant Site	NC	Rutherford	2015	>1000	very high
Broad River: Floyds Creek	NC	Rutherford	2016	>1000	very high
Davenport Road/Mountain View Rare Plant Site	NC	Rutherford	2016	>1000	very high
Facebook Site	NC	Rutherford	2016	>1000	very high
Floyds Creek Tributary Rare Plant Site	NC	Rutherford	2012	>1000	very high
New Bethel Rare Plant Site	NC	Rutherford	2015	>1000	very high
Richardson Creek trib above Toms Lake	NC	Rutherford	2016	>1000	very high
DNR Peters Creek Heritage Preserve	SC	Spartanburg	2016	>1000	very high
Taylor Blalock Res	SC	Spartanburg	2016	>1000	very high
Leepers Creek Heartleaf Site	NC	Lincoln	2006	>1000	very high
Little Gunpowder Creek Rare Plant Site 1	NC	Caldwell	2015	500-1000	high
Little Gunpowder Creek Rare Plant Site 2	NC	Caldwell	2015	500-1000	high
Northern Catawba County	NC	Catawba	2017	500-1000	high
Rock Barn Solar Farm	NC	Catawba	2010-2011	500-1000	high
Buffalo Creek Rare Plant Site	NC	Cleveland	2012	500-1000	high
Third Creek Rare Plant Site	NC	Alexander	2010	100-500	moderate
Hickory Area	NC	Burke/Catawba/Caldwell	2016	100-500	moderate
Burke County - Drowning Creek UT	NC	Burke	2017	100-500	moderate
Simms Hill/Little River Uplands	NC	Burke	2015	100-500	moderate
Smith Cliff/Henry Fork River	NC	Burke	2015	100-500	moderate
NCDOT non-TIP Div 12 road const at SR 1115 South Fork Catawba River Jacobs Fork and Camp Creek	NC	Catawba	2016	100-500	moderate
NCDOT TIP R-2824	NC	Catawba	2015	100-500	moderate
South Fork Catawba River, Henry Fork	NC	Catawba	2007	100-500	moderate
Broad River/Sandy Run NA	NC	Cleveland	2012	100-500	moderate
Brushy Creek Headwaters	NC	Cleveland	2014	100-500	moderate
First Broad River: Crooked Run Creek	NC	Cleveland	2010	100-500	moderate
No Business Creek, Boyd Tract	NC	Cleveland	2007	100-500	moderate

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Site Name	State	County	Last Observed	Total plants	Resilience
West Shelby Mesic Slope	NC	Cleveland	2016	100-500	moderate
UT of Kings Mountain Res	NC	Gaston	2012	100-500	moderate
Buffalo Shoals Creek	NC	Iredell	2014	100-500	moderate
Cat Square Heartleaf Forest	NC	Lincoln	2012	100-500	moderate
Collinsville (Hughes) Creek Slopes	NC	Polk	2016	100-500	moderate
Fox Knoll Farm	NC	Polk	2016	100-500	moderate
Forest City: Adj to Isothermal CC	NC	Rutherford	2010	100-500	moderate
Jonas Road Rare Plant Site	NC	Rutherford	2014	100-500	moderate
Knob Creek NA	NC	Cleveland	2005	100-500	moderate
Buffalo Creek	NC	Cleveland	2005	100-500	moderate
Kross Keys NA	NC	Polk	2005	100-500	moderate
Catawba River: North Fork Mountain Creek	NC	Catawba	2005	100-500	moderate
Catawba River: Lake James	NC	Burke	2006	100-500	moderate
Hogpen Branch Transplant Site	NC	Rutherford	2005	100-500	moderate
NCDOT TIP R-3603A	NC	Alexander	2017	<100	low
South Mountains Pleasant Grove Uplands	NC	Burke	2016	<100	low
Gunpowder Creek	NC	Caldwell	2012	<100	low
Killian Crossroads	NC	Catawba	2010	<100	low
Pott Creek	NC	Catawba	2012	<100	low
Beaverdam Crk at First Broad River	NC	Cleveland	2011	<100	low
Buffalo Creek: Potts Creek	NC	Cleveland	2012	<100	low
Buffalo Creek: Ravine	NC	Cleveland	2007	<100	low
Hickory Creek - UT (Shelby High School)	NC	Cleveland	2016	<100	low
Boulder Creek Subdivision - Jordan Road	SC	Greenville	2016	<100	low
Gateway Elementary School	SC	Greenville	2017	<100	low
Fanjoy Road Site	NC	Iredell	2015	<100	low
Levan Family Farm	NC	Iredell	2013	<100	low
Lincoln County, SR-1314	NC	Lincoln	2014	<100	low
Northeast Lincoln: UT Walker Branch	NC	Lincoln	2009	<100	low
Sandy Spring Church Springhead Swamp	NC	Polk	2005	<100	low
First Broad River: Hickory Creek	NC	Cleveland	2006	<100	low
Smith Cliff/Henry Fork River	NC	Burke	2005	<100	low
First Broad River: Beaverdam Creek Tribs	NC	Cleveland	2006	<100	low

681

682 **Table 4.2.** Population resilience categories by county for dwarf-flowered heartleaf.

County	Very High	High	Moderate	Low	Totals
Alexander	1		1	1	3
Burke/Catawba/Caldwell			1		1
Burke	2		4	2	8
Caldwell	2	2		1	5
Catawba	4	2	4	2	12

Cherokee	1				1
Cleveland/Rutherford	1				1
Cleveland	4	1	7	6	18
Gaston			1		1
Greenville				2	2
Iredell			1	2	3
Lincoln	2		1	2	5
Polk	2		3	1	6
Rutherford	7		3		10
Spartanburg	2				2
Totals	28	5	26	19	78
% of total	36	7	34	23	100
Cumulative %	40	43	77	100	--

Population Trends

Although we lack an adequate past time series of abundance data for all populations to estimate growth rates or population trends, NCNHP conducted surveys of thirteen of the largest populations across the range of the species from 2012-2016. Table 4.3 shows the results of all of these surveys. Two populations show an increasing trend, nine show a stable trend, and two show a decreasing trend.

Table 4.3. Summary of population trends over 5 years of monitoring data for 13 of the largest populations of dwarf-flowered heartleaf across its range (from: Robinson and Padgett 2016).

Trend	Survey	Site	2016 estimated number of plants (Rosettes)	2016 area occupied (Acres)
Increasing	NCNHP	Cliffside Steam Station (EO 276)	39,535	52
	NCNHP	Broad River: Floyds Creek, Long Branch (EO 177)	12,687	5.67
Stable	NCNHP	Island Creek Bluff/Love Lady Site (EO 029)	50,481	61.76
	NCNHP	Rhyne Preserve (EO 302)	19,873	22.43
	NCNHP	Mills Creek Forest and Seep (EO 023)	1,733	1.39
	NCNHP	New Hope Springhead Swamp (EO 125)	12,235	5.03

	NCNHP	Broad River: Henson's Creek, Brice, & Sandy Mush Outcrop (EO099)	106,940	83.39
	NCNHP	Broad River: Cleghorn Creek, US 221 (EO 176)	6,750	7.24
	NCNHP	Cowpens National Battlefield (SC EO 016, 017, 018)	2,823	6.05
	NCNHP	Peters Creek Preserve (SC EO 011)	3,306	8.98
	NCNHP	Blalock Reservoir (SC EO 007, 031)	3,505	7.59
Decreasing	NCNHP	Second Broad River (Forest City Industrial Complex) (EO 154)	2,576	4.74
	NCNHP	South Fork Catawba River: Jacob Fork, Camp Creek (EO 158)	123	0.09

Current Species Representation

Representation describes the ability of a species to adapt to changing environmental conditions. We lack genetic and ecological diversity data to characterize representation for dwarf-flowered heartleaf. In the absence of species-specific genetic and ecological diversity information, we typically evaluate representation based on the extent and variability of habitat characteristics across the geographical range. However, the dwarf-flowered heartleaf has a very limited range, and after consulting with experts, we decided delineating representative units was not appropriate for this species.

Current Species Redundancy

For the dwarf-flowered heartleaf to maintain viability, the species also needs to exhibit some degree of redundancy. Species-level redundancy reflects the ability of a species to withstand catastrophic events, and is best achieved by having multiple, widely distributed populations relative to the spatial occurrence of catastrophic events. Redundancy for dwarf-flowered heartleaf is the total number and resilience of population segments and their distribution across the species range.

An important question when investigating redundancy for dwarf-flowered heartleaf is, “what exactly is a catastrophe?” We consider a catastrophe to be any population level disturbance that

has the potential to negatively influence population resiliency outside of normal environmental and demographic stochasticity. Disturbances often act quickly, like hurricanes, and often with devastating effects, however they can also occur over long periods of time. A disturbance that occurs as a relatively discrete event in time is referred to as a “pulse” disturbance, while more gradual or cumulative pressures on a system are referred to as “press” disturbance. Both types of disturbances are part of the natural variability of dwarf-flowered heartleaf ecological systems, and must be considered when assessing redundancy. While there is certainly a variety of potential pulse disturbances for the species (timber harvest, hydrological alterations, road and right-of-way construction), the primary potential catastrophic disturbances are press disturbances from long term climate change, which have great potential to affect ecosystem processes and communities by altering the underlying abiotic conditions (DeWan et al. 2010).

As stated previously, there are 78 populations of dwarf-flowered heartleaf that have been observed since 2005 (Table 4.1), and resilience of these populations is as follows: 28 (very high); 5 (high); 26 (moderate); 19 (low). The populations are spread across the range, although a majority occur in North Carolina. Although, there appears to be adequate redundancy within the range of dwarf-flowered heartleaf to withstand the impacts of localized press catastrophic disturbances, the species range is very small, making it potentially vulnerable to long-term catastrophic events, such as climate change.

CHAPTER 5: INFLUENCES ON VIABILITY

Hexastylis naniflora populations occur in rapidly growing urban areas with expanding suburbs of Charlotte, NC, to the east; Hickory, NC, to the north; and Greenville and Spartanburg, SC, to the south. At the time of listing, it was determined that the species was most threatened by habitat loss due to the conversion of land to residential, commercial, and industrial use in these areas. In addition to threats associated with residential, commercial, and industrial development, other documented threats include habitat loss from land conversion to agricultural use, timber harvest, hydrological alterations from the damming of ponds, impacts from grazing cattle, ORV damage, trampling from foot traffic, invasive species, highway or road improvements, and erosion or

siltation (NCNHP 2016, Robinson and Padgett 2016). Climate change may exacerbate these risk factors through changes in temperature and precipitation.

Threats were assessed for populations monitored by NCNHP during 2012-2016 (Robinson and Padgett 2016), and EOs were reviewed for other documented threats to populations. Indirect or direct threats that were observed, inferred, or suspected to have an impact on populations were recorded and assigned a ranking based on their severity, scope, and immediacy from field observations. The rank for each threat factor determines the overall value for each threat observed at each population. No significant changes in threats within populations were noted from 2012-2016. Threats observed during these years included development, incompatible forestry practices, agriculture, trampling, invasive exotic species, sedimentation, erosion, and road construction.

Below, we summarize primary threats to the viability of dwarf-flowered heartleaf. Primary influences will be carried forward in our future projections in the next section.

Human Population Change

Increasing human populations drive development. With increases in population, there will be increasing conversion of open space to more impervious cover, with a subsequent increase in roads and other associated infrastructure. Increases in roads and impervious cover have the potential to lead to habitat loss and/or fragmentation, a primary risk factor for dwarf-flowered heartleaf. Tables 5.1-5.2 and Figures 5.1-5.2 show the estimated human population increases for North Carolina and South Carolina counties within the range of the species. The most populous counties include Greenville and Spartanburg in South Carolina, and Catawba, Gaston and Iredell counties in North Carolina.

Table 5.1-Human population projections for North Carolina counties within the range of dwarf-flowered heartleaf. *Source: North Carolina OSBM, Standard Population Estimates.*

County	2018	2023	2028	2033	2037
Alexander	38,609	39,244	39,686	39,992	40,169
Burke	90,865	93,124	95,382	97,644	99,452

Caldwell	83,919	86,723	88,689	91,126	92,870
Catawba	157,424	159,799	162,175	164,549	166,447
Cleveland	98,862	99,685	100,004	100,128	100,170
Gaston	221,112	227,667	237,344	245,276	252,388
Iredell	179,740	195,623	211,501	227,383	240,088
Lincoln	84,494	91,034	96,865	103,069	107,858
Polk	21,273	21,823	22,288	22,681	22,955
Rutherford	67,880	68,154	68,283	68,341	68,368

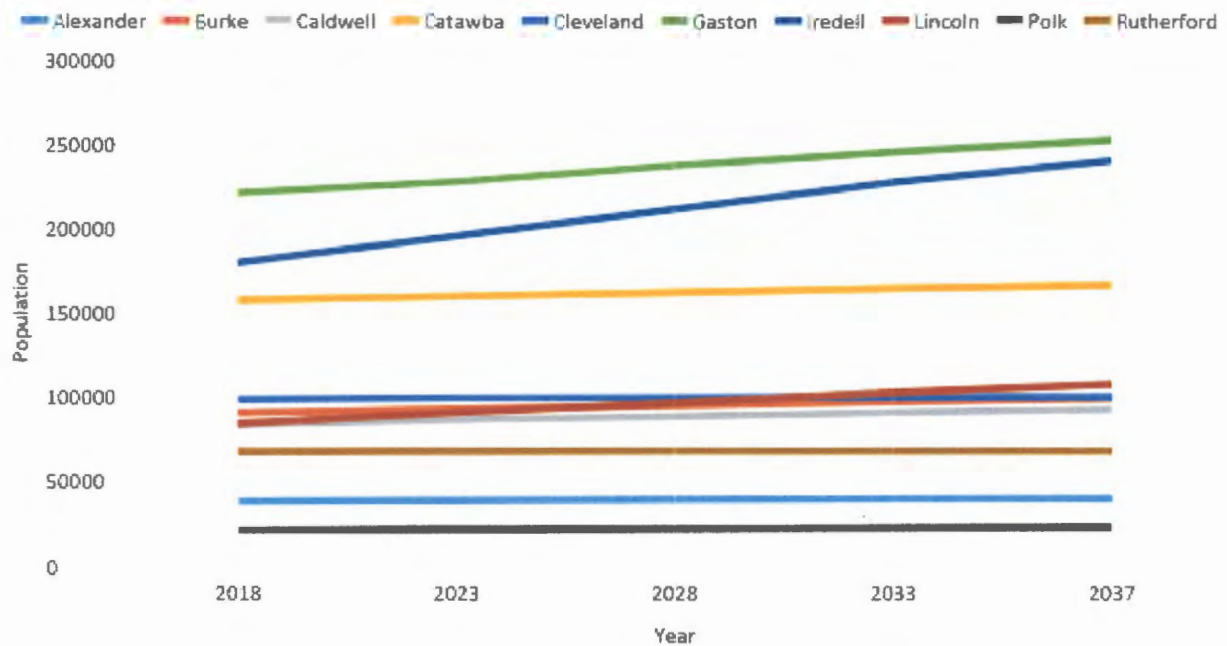


Figure 5.1- Human population projections for North Carolina counties within the range of dwarf-flowered heartleaf. *Source: North Carolina OSBM, Standard Population Estimates.*

Table 5.2- Human population projections for South Carolina counties within the range of dwarf-flowered heartleaf. *Source: U.S. Census Bureau, 2000 Census and 2007 Population Estimates. Population projections calculated by South Carolina Budget and Control Board, Office of Research and Statistics.*

County	2020	2025	2030	2035
Cherokee	61,760	64,760	67,350	70,170

Greenville	492,890	517,740	542,290	567,010
Spartanburg	310,220	323,550	336,810	350,110

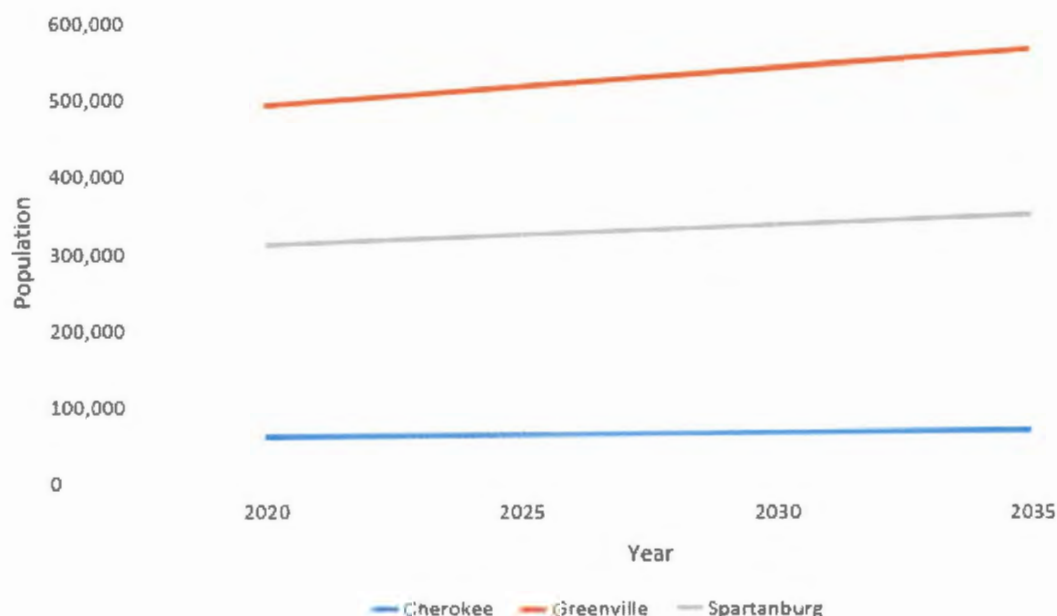


Figure 5.2. Human population projections for South Carolina counties within the range of dwarf-flowered heartleaf. *Source: U.S. Census Bureau, 2000 Census and 2007 Population Estimates. Population projections calculated by South Carolina Budget and Control Board, Office of Research and Statistics.*

Development

A large number of the known populations occur near expanding urban areas and are threatened by the residential, commercial, and industrial development associated with this growth. Populations occurring in more rural areas are threatened by habitat alteration or loss from land conversion to pasture or other agricultural uses, cattle grazing, intensive timber harvesting, residential construction, and construction of small ponds.

A 2010 review of existing NHP EOR data revealed that all or portions of 26 populations (24% of the total) had been directly or indirectly impacted through development projects or other causes such as trash disposal, expansion of residential lawns, cattle, or invasive exotics (NCNHP 2010;

back to 113 → I thought we were at 78

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 113 populations (corresponding to 37% of all known populations). Of these 42 populations, all or portions of 22 (50%) had been adversely impacted by activities requiring ESA Section 7 consultation with the USFWS. The fact that nearly 20% of all known populations had been subject to formal Section 7 consultation illustrates the threats faced by the species.

In the same 2010 review, 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. 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).

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. 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.

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). 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).

Invasive Species and Woody Encroachment

Several of the known populations of dwarf-flowered heartleaf occur on steep ravine slopes which also support stands of mixed hardwoods with an understory of mountain laurel (*Kalmia latifolia*) or *Rhododendron spp.* These stands are often very dense and reduce the amount of light reaching the dwarf-flowered heartleaf plants growing below. Under these conditions the plants often show reduced vigor and reduced flower and fruit production. Careful, selective logging or natural tree fall and limited understory removal would open up these populations to more light. Additional light, if not accompanied by increased siltation from the intensive soil disturbances associated with forest clear-cutting, probably would benefit these populations (Gaddy 1981).

Invasive exotic plant species are rampantly spreading throughout riparian corridors and ravines across the range of this species (USFWS 2011). 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.

Climate Change

There is a growing concern that climate change may lead to increased frequency of severe storms and droughts (McLaughlin *et al.* 2002, p. 6074; Golladay *et al.* 2004, p. 504; Cook *et al.* 2004, p. 1015). Because typical habitats for this species include moist soils adjacent to creeks, streamheads, or along lakes and rivers, and plants have been observed to grow larger and have more frequent flowering in floodplains along rivers, lakes, and streams (Newberry 1993), specific effects of climate change to the dwarf-flowered heartleaf are likely related to changes in soil moisture associated with potential increases in drought.

Warming in the Southeast is expected to be greatest in the summer (NCCV 2016) which is predicted to increase drought frequency, while annual mean precipitation is expected to increase slightly, leading to increased flooding events (IPCC 2013, p.7; NCCV 2016). Changes in climate may affect ecosystem processes and communities by altering the abiotic conditions experienced by biotic assemblages resulting in potential effects on community composition and individual species interactions (DeWan *et al.* 2010, p.7).

Despite the recognition of potential climate effects on ecosystem processes, there is uncertainty about what the exact climate future for the Southeastern US will be and how the ecosystems and species in this region will respond. Although climate change was not a factor leading to the original listing of the species, it should be recognized that the greatest threat from climate change may come from synergistic effects. That is, factors associated with a changing climate may act as risk multipliers by increasing the risk and severity of more imminent threats. As a result, impacts from rapid urbanization in the region might be exacerbated under even a mild to moderate climate future.

Regardless of a pessimistic, optimistic, or status quo climate future, the following systematic changes are expected to be realized to varying degrees in the Southeastern US (IPCC 2013):

- More frequent drought
- More extreme heat (resulting in increases in air and water temperatures, Figure 5-3)
- Increased heavy precipitation events (e.g., flooding)
- More intense storms (e.g., frequency of major hurricanes increases)
- Rising sea level and accompanying storm surge

In recent years, the Southeast has experienced moderate to severe droughts that many observers have implicated in population declines and poor transplant survivorship (NCNHP, 2010). 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 dwarf-flowered heartleaf is currently unknown.

so how do they respond to fire? Fire can be good + too. Eliminating competition + fertilizing the soil.

Appendices 4a and 4b gives summary reports on historical and future predicted climate parameters from the USGS National Climate Change Viewer for both North Carolina and South Carolina. As discussed above, the trend for these States is consistent with the general trend in the Southeast: more frequent drought, more extreme heat, and increased precipitation events. If these predictions hold true, dwarf-flowered heartleaf habitat would likely be impacted through increased evaporative rates and decreased soil moisture (Appendices 4a and 4b), increased potential for catastrophic wildfire events, as well as potential disruption of stream bank morphology through increased flooding events. Our habitat model indicates a preferred temperature and precipitation range, indicating that the species would be sensitive to a changing climate.

Chapter 6: FUTURE CONDITION

Future Considerations

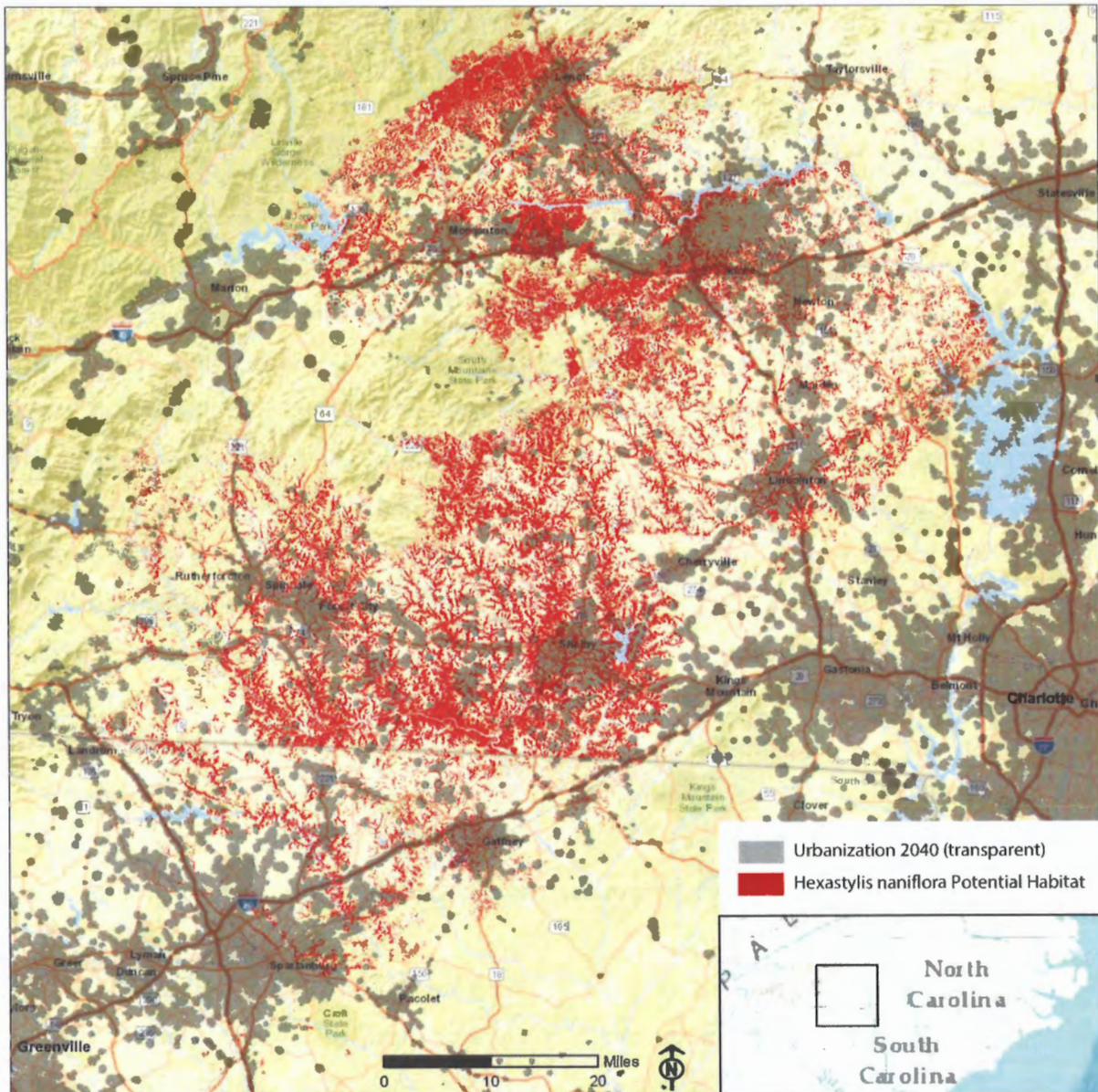
Our analysis of the past, current, and future influences on what the dwarf-flowered heartleaf needs for long term viability revealed that there are several influences that pose risks to future viability of the species. These risks are primarily related to habitat changes from development and long term climate change. We use projections of urban development to assess potential habitat loss and fragmentation. We also considered how climate change may exacerbate the impacts of development in a qualitative fashion using a narrative approach.

Because the actual impacts of urbanization are unknown, we use three scenarios, projected out to the year 2040, to capture the uncertainty related to the potential impacts to each population's resiliency: Status Quo, Targeted Conservation, and High Development. Results of future projections within each scenario are focused on current populations and potential habitat identified by the Maxent model as described below. Based on the life span of the species, expert input, development as the key risk factor brought forward, uncertainty about future conditions, and lack of knowledge about where additional populations may persist on the landscape, we chose to project populations out to the year 2040 under each scenario, but no further.

In constructing our scenarios, we considered two main influences by which species viability projections could be affected: location of additional populations (positive influence) and habitat loss and fragmentation due to urban development (negative influence). Habitat quantity can be negatively impacted by development or land use change (particularly on private lands) or positively impacted by land acquisition, restoration, and/or introductions into unoccupied sites that already have suitable habitat.

We use the Slope, Land cover, Exclusion, Urbanization, Transportation, and Hillshade (SLEUTH) models to determine areas predicted to be urbanized by 2040 (Figure 6.1). SLEUTH is a cellular automata model that applies transition rules to the states of a gridded series of cells, and in this case the transition is that from undeveloped to developed land cover, otherwise known as urbanization, and has been successfully applied worldwide over the last 15 years to simulate land use change (Clarke 1995).

Figure 6.1. Results of the SLEUTH model with *Hexastylis naniflora* potential habitat predicted by the MAXENT model overlaid.



The SLEUTH model predictions are broken down by probabilities of urbanization, ranging from 0-100%. We chose 80% probability as our cutoff, as this cutoff has been used by USGS and other SSAs, and this threshold represents a highly likely outlook for urbanization of the landscape. To forecast viability using urban development projections, we assessed the following:

- % increase in projected development (SLEUTH probability of urbanization >80%) within current populations (from Current Conditions—68 populations)

- % increase in projected development (SLEUTH probability of urbanization >80%) within areas delineated as potential habitat by the Maxent habitat model

There is no data available on the exact relationships between urbanization and the impacts to dwarf-flowered heartleaf. We do know that several current populations are located in areas with surrounding urban landscapes. We also know that urban development has led to extirpation of populations in the past through loss of habitat. Because of this uncertainty, we attempted to capture unknowns in two ways. First, our scenarios reflect a range of potential impacts from urban development. Also, we used two thresholds for % increase in urban development to capture potential deleterious effects: 25% and 50%. Our assumptions were that very small increases in development are unlikely to negatively impact populations; development increase of at least 25% of the area of current populations was likely to have some negative impacts; development increase of at least 50% was likely to have significant impacts to populations. We also assume that populations currently on protected lands are likely to see smaller impacts from urbanization compared to those that are not protected, but protection status (perpetuity vs non-perpetuity) matters. For example, Registered Heritage Areas are non-binding agreements with a land owner, and if the land changes ownership, or the owner decides not to continue with the agreement, then the Registry is no longer valid. Appendix 4 shows the protection status of each delineated population which helped to inform our assessment of resilience under each scenario.

We also assessed potential positive effects by integrating the potential location or rediscovery of additional populations throughout the range into two of our scenarios: Targeted Conservation and Status Quo. We believe this is appropriate for several reasons. First, location of new EOs is common; many of the populations we consider for Current Conditions include detections that have occurred within the last few years. Second, we did not include many older detections (i.e. only included detections since 2005), although many of those detections are likely to persist. Dwarf-flowered heartleaf is a long-lived perennial, and several EOs have been revisited after more than 10 years and the species was present. For example, one such EO was first observed in 1957 and next observed in 2001. It seems as long as suitable habitat is still present it is reasonable to assume that the species is still there. Finally, there is plenty of predicted suitable

1016 habitat present within older EOs based on the Maxent model predictions that were not included
1017 as current populations. *why not?*

1018

1019 The first step in identifying additional areas where dwarf-flowered heartleaf is likely to be found
1020 in the future, was to identify EOs from populations that were last observed prior to 2005 (i.e. our
1021 cut-off for current populations). Although our focus is on older EOs, where dwarf-flowered
1022 heartleaf is likely to persist into the future, we also included current EOs (2005-current) in our
1023 analysis because we were interested in how the older EOs compared to those known to be
1024 persisting on the landscape since 2005. Also, by including older EOs that are within current
1025 delineated populations, we can investigate whether current populations might be predicted to
1026 contain more plants than the most recent abundance estimate. For example, many of our current
1027 populations consist of multiple EOs, and we only considered EOs that were detected from 2005-
1028 current. If these older EOs within current populations that were not included in our Current
1029 Condition assessment are found to be likely to persist, then it is possible we underestimated the
1030 resilience of that population.

1031

1032 Once these older EOs were identified, we created a 1,000 meter buffer around the population and
1033 calculated a number of useful metrics including resilience category based on the last known
1034 abundance estimate, Maxent habitat model metrics, and the results of the SLEUTH model to
1035 further refine a list of potential sites where the species would likely be found to persist within our
1036 20-25 year projection window. Resilience categories were assessed using last known abundance
1037 in the same way as populations assessed in the Current Conditions section (i.e. low = less than
1038 100 individuals; moderate = 100-500 individuals; high = 500-1000 individuals; very high =
1039 greater than 1,000 individuals). We assessed two habitat metrics for these older EOs: average
1040 Maxent score and % Maxent classified as 0.8-1.0 score. Average Maxent score was calculated
1041 by taking the mean Maxent score of all potential habitat within the 1,000 foot buffer. The %
1042 Maxent classified as 0.8-1.0 represents the percentage of all potential habitat within the 1,000
1043 foot buffer that falls within the highest habitat class. Together, these two habitat metrics give
1044 general estimates of habitat quantity and quality. Finally, we calculated the total percentage of
1045 the 1,000 foot buffer around each EO that is projected to be urbanized in the year 2040, which
1046 helps capture the primary risk factor of development when assessing the areas where dwarf-

and what does the maxent score actually tell me? that is not explained

most suitable? I don't know what "highest" means here

only the buffer - not the EO itself?

flowered heartleaf is likely to persist. Table 6.1 (North Carolina) and 6.2 (South Carolina) show all of the EOs we considered and the corresponding metrics associated with resilience categories, urban development, and habitat scores.

Table 6.1. North Carolina raw data for metrics assessed to investigate potential sites where dwarf-flowered heartleaf was historically found and is likely to persist. Resilience categories are based on last known abundance estimates as follows: 1 = low; 2 = moderate; 3 = high; 4 = very high. MAXENT Average Mean refers to the mean Maxent score of all potential habitat. % Maxent classified as 0.8-1.0 represents the percentage of all potential habitat that falls within the highest habitat class. % Urban Development refers to the percentage of the 1,000 foot buffer around the EO that is projected to be urbanized in the year 2040.

EO not part of a current population

EO included as part of a current population

EO is a part of a current population but last detection was prior to 2005

Eliminated/not scored

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	2	34	1	3
2				
3	2	22	0	10
4	2	22	0	7
5	2	21	0	0
6				
8	1	27	0	6
9	3	44	4	0
10	4	33	2	0
11				
12	4	54	10	0
13	1	31	1	30
14	2	61	16	7
15				
16	4	18	0	47
17	1	50	13	0
18	1	36	8	2
19				
20	2	22	1	88
21	2	34	4	54
23	4	15	0	8
25	1	47	15	30
27				

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
28	2	43	12	29
29	4	43	8	30
30	4	27	2	74
31	4	30	3	86
32	2	34	2	47
33	2	33	3	0
34	1	49	13	63
35	1	42	10	23
36	1	19	0	12
37	4	41	6	17
38	2	14	0	46
39	1	19	0	11
40	2	37	2	32
44	4	20	0	59
45	1	27	5	13
46	3	42	6	6
47	1	28	1	96
48	1	14	0	12
49	4	61	14	5
50				
51	4	52	11	18
52	2	46	4	0
53	1	35	4	24
54	1	35	1	10
55	4	30	0	0
56	2	40	2	6
57	2	21	0	80
58	1	42	5	0
59	2	11	0	49
60	1	25	0	2
61	3	41	0	0
62	2	34	0	0
63	1	27	0	6
64	2	39	9	11
69	2	46	11	19
70	2	38	1	0
71	2	30	2	0
72	2	52	14	0
73	4	60	17	1

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
74	3	65	14	4
75	4	47	6	9
76	4	42	4	10
77	3	31	1	27
79	2	39	1	0
80	1	43	4	15
83	2	17	0	11
84	2	13	0	1
85	2	42	4	5
87				
89	2	13	2	0
90	2	28	2	0
91	1	49	5	0
92	2	15	0	30
106	4	39	4	38
107	1	14	0	40
113	4	46	4	7
114				
115	2	37	3	26
118	3	42	0	9
121	2	41	5	0
122	1	12	0	39
124	1	12	0	9
125	4	15	0	41
130	2	17	0	24
149	4	64	17	3
151	2	16	0	27
154	4	30	1	22
157	2	20	0	0
158	3	36	7	5
159	4	62	24	60
160	3	62	24	32
161	4	64	28	30
162	1	32	2	58
163	2	15	0	56
164	3	18	0	52
165	1	13	0	56
166	1	14	0	40
167	4	30	0	20

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
168	4	19	0	34
169	1	30	0	12
170	2	17	0	40
172	1	39	3	7
173	2	30	1	48
174	1	42	4	16
175				
180	2	21	1	0
181	4	29	2	0
182	4	45	4	0
183	2	15	0	5
184	4	19	0	19
187	2	20	1	35
188	2	24	0	53
189	1	25	0	14
190				
191	2	34	2	0
192	2	35	3	0
193	2	36	7	6
194	4	51	14	18
195	1	21	0	96
196	1	23	4	67
197	4	35	8	38
198	2	32	6	25
199	2	29	5	43
200	1	26	2	87
201	1	39	4	63
202	4	35	4	85
203	1	43	4	49
204				
205	2	43	1	49
206	1	37	3	66
207	2	33	2	85
208	1	32	1	67
209	2	33	2	94
210				
212	1	37	3	85
213	1	36	4	72
219	1	32	1	4

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
222	2	23	3	7
223				
224	1	22	3	17
225	2	24	2	12
227	4	55	2	5
229	2	28	0	21
230	1	54	15	13
231	1	41	7	0
233	4	53	12	14
235	2	50	8	6
236	2	62	14	5
237	2	67	16	5
238	4	51	15	0
239	2	63	14	5
240	1	57	18	0
241	2	62	16	3
242	1	53	9	0
246	1	62	13	4
249	4	47	5	0
250	4	45	4	0
251	4	43	4	0
254	2	54	18	6
255				
256	2	54	15	13
258	3	19	0	51
259	4	25	0	0
262	4	29	2	50
263				
264				
265				
266				
267	2	29	1	0
268	1	33	2	0
269	2	49	17	0
270	1	46	18	1
271	1	26	7	0
272	1	33	0	71
273	2	28	2	0
274	2	50	8	0

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
275	2	12	0	0
276	4	42	5	21
277				
278				
279	1	32	4	89
280	2	64	30	30
281	1	64	31	36
282	1	64	31	51
283	1	65	34	59
284	1	64	35	45
286				
287	2	15	0	35
291	2	21	1	84
292	2	14	0	83
293	1	8	0	16
294	2	36	4	61
296	2	3	0	5
297				
298	2	16	0	1
299	1	12	0	0
300	1	9	0	18
303	2	31	0	0
304	2	31	0	0
305	1	30	2	0
306	1	4	0	53
308	2	15	0	3
309	1	5	0	0
310	4	58	26	35
311	2	15	0	0
312	4	17	0	57
313				
314				
315	1	36	4	61
317	1	15	0	53
318	2	34	4	52
319	4	43	4	10
320	4	41	6	98
321				

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
Min	1	3	0	0
Max	4	67	35	98

Table 6.2. South Carolina raw data for metrics assessed to investigate potential sites where dwarf-flowered heartleaf was historically found and is likely to persist. Resilience categories are based on last known abundance estimates as follows: 1 = low; 2 = moderate; 3 = high; 4 = very high. MAXENT Average Mean refers to the mean Maxent score of all potential habitat. % Maxent classified as 0.8-1.0 represents the percentage of all potential habitat that falls within the highest habitat class. % Urban Development refers to the percentage of the 1,000 foot buffer around the EO that is projected to be urbanized in the year 2040.

EO not part of a current population

EO included as part of a current population

EO is a part of a current population but last detection was prior to 2005

Eliminated/not scored

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	2	21	0	0
2	2	1	0	4
3				
4	1	13	0	10
5	2	0	0	64
6	1	0	0	36
7	4	27	0	35
8	2	0	0	14
9				
10				
11	4	14	0	52
12				
13	1	7	0	100
14	4	14	0	43
15	1	0	0	4
16	4	22	0	38
17	4	22	0	33
18	3	19	0	52
19	1	12	0	65
20	2	5	0	100
21	3	5	0	90
22	1	0	0	0
23				

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
24	1	4	0	3
25	1	14	0	48
26	4	12	0	65
27	4	18	1	40
28	4	19	1	49
29				
30	2	7	0	88
31	4	0	0	0
32	2	7	0	93
33	2	2	0	20
34	1	31	3	1
35	1	23	1	53
36	2	6	0	0
37	1	24	2	0
38	4	5	0	37
39	1	6	0	1
40	2	6	0	20
41	1	11	0	87
42	2	3	0	6
43	1	23	0	43
44				
45				
46	1	10	0	96
47				
48				
49	3	8	0	70
50	2	5	0	54
51	1	0	0	35
52	3	0	0	0
53	2	10	0	66
54	2	9	0	91
55	1	4	0	99
56	2	14	0	96
57	3	15	0	38
59	2	4	0	17
60	4	17	1	12

Min	1	0	0	0
Max	4	31	3	100

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
---------	---------------------	----------------------	--------------------------------	---------------------

Next, we implemented a set of ranking rules using the data from Tables 6.1 and 6.2 to further assess which EOs had a higher likelihood of persistence on the landscape. We used SMART methodology to quantify and implement our ranking rules. Because the metrics of interest vary in data type (i.e. categorical vs continuous) and range of values (i.e. not all continuous variables have the same maximum and minimum), our first step was to normalize all of the data on a scale of 0-100. Normalization techniques allow for aggregation of criteria with numerical and comparable data. We decided to analyze North and South Carolina data separately because the Maxent model predicts habitat differently across state lines due to differences in soil classification. We weighted each variable according to our opinion of the level of contribution each variable had to the probability of persistence of that particular EO. This resulted in abundance having the highest weight (100%), with habitat (as calculated by average Maxent score) and urbanization given relatively similar weighting (80%). The results of the normalization procedure and weighting can be found in Tables 6.3 and 6.4.

Table 6.3. Normalized scores for SMART analysis of North Carolina EOs and weighting scores. Resilience category represents the normalized scoring based on the last known abundance (0=low; 33=moderate; 67=high; 100=very high); MAXENT Mean is the normalized score of the average Maxent rank of all potential habitat; MAXENT percent 0.8-1 represents the normalized score of the percentage of potential habitat that falls within the highest rank category; 80% or greater SLEUTH Percent of Total is the total amount of current urbanization plus predicted urbanization at year 2040 (>80% probability) from the SLEUTH model.

EO not part of a current population

EO included as part of a current population

EO is a part of a current population but last detection was prior to 2005

Eliminated/not scored

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	33	49	3	97
2				
3	33	30	0	90
4	33	29	0	93
5	33	28	1	100
6				

Can this be defined here?

So this isn't projected rather resilience current? Is there a reason they are different than the 1-4 previous categories from tables 6.1 + 6.2?

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
8	0	37	0	94
9	67	65	11	100
10	100	46	6	100
11				
12	100	80	28	100
13	0	43	2	69
14	33	90	44	93
15				
16	100	23	0	52
17	0	73	37	100
18	0	52	22	98
19				
20	33	30	3	11
21	33	48	12	45
23	100	19	0	92
25	0	68	42	69
27				
28	33	62	33	71
29	100	63	22	69
30	100	38	5	24
31	100	43	8	12
32	33	48	5	52
33	33	47	8	100
34	0	73	37	35
35	0	60	29	77
36	0	25	0	88
37	100	60	17	82
38	33	17	0	53
39	0	24	0	89
40	33	54	7	67
44	100	26	1	40
45	0	37	14	86
46	67	60	18	94
47	0	39	2	2
48	0	17	0	88
49	100	91	39	95
50				
51	100	77	31	82
52	33	68	11	100

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
53	0	50	11	76
54	0	49	1	90
55	100	43	0	100
56	33	58	7	94
57	33	28	0	19
58	0	60	15	100
59	33	12	0	50
60	0	34	1	98
61	67	59	1	100
62	33	49	0	100
63	0	38	0	94
64	33	56	24	88
69	33	67	31	80
70	33	55	3	100
71	33	42	5	100
72	33	77	41	100
73	100	89	48	99
74	67	97	41	95
75	100	69	16	91
76	100	61	11	89
77	67	43	2	72
79	33	56	4	100
80	0	62	11	85
83	33	22	0	89
84	33	15	0	99
85	33	61	10	95
87				
89	33	15	5	100
90	33	38	5	100
91	0	71	13	100
92	33	18	0	70
106	100	56	10	61
107	0	16	0	59
113	100	68	11	93
114				
115	33	53	8	74
118	67	61	1	91
121	33	59	13	100
122	0	14	0	60

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
124	0	13	0	91
125	100	19	0	58
130	33	22	0	76
149	100	95	49	97
151	33	20	0	72
154	100	41	2	78
157	33	26	0	100
158	67	51	20	95
159	100	92	69	39
160	67	92	69	68
161	100	95	79	69
162	0	45	7	41
163	33	18	0	43
164	67	24	0	47
165	0	16	0	43
166	0	16	0	59
167	100	41	0	79
168	100	25	0	65
169	0	42	0	88
170	33	22	0	60
172	0	56	8	93
173	33	42	3	52
174	0	62	12	84
175				
180	33	28	2	100
181	100	41	6	100
182	100	66	12	100
183	33	18	1	95
184	100	24	0	81
187	33	27	2	64
188	33	33	0	46
189	0	33	1	86
190				
191	33	48	7	100
192	33	49	10	100
193	33	51	19	94
194	100	75	40	81
195	0	28	0	3
196	0	30	10	32

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
197	100	50	24	61
198	33	45	18	74
199	33	41	14	56
200	0	35	6	11
201	0	56	11	36
202	100	49	11	13
203	0	62	11	50
204				
205	33	62	4	50
206	0	52	8	33
207	33	47	4	14
208	0	45	4	32
209	33	46	5	4
210				
212	0	53	9	14
213	0	52	11	27
219	0	45	2	96
222	33	31	9	92
223				
224	0	29	8	83
225	33	32	6	88
227	100	81	7	95
229	33	39	0	79
230	0	80	44	87
231	0	59	20	100
233	100	79	34	86
235	33	74	22	94
236	33	93	41	95
237	33	100	46	95
238	100	74	41	100
239	33	94	40	94
240	0	85	51	100
241	33	93	47	97
242	0	78	27	100
246	0	93	38	95
249	100	68	13	100
250	100	65	12	100
251	100	62	11	100
254	33	80	51	93

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
255				
256	33	80	44	87
258	67	25	0	48
259	100	34	0	100
262	100	41	6	49
263				
264				
265				
266				
267	33	41	3	100
268	0	46	7	100
269	33	72	49	100
270	0	67	52	99
271	0	35	19	100
272	0	47	0	28
273	33	39	7	100
274	33	73	23	100
275	33	14	0	100
276	100	61	14	79
277				
278				
279	0	46	11	9
280	33	95	85	70
281	0	95	88	64
282	0	96	88	48
283	0	97	95	40
284	0	95	100	54
286				
287	33	18	0	64
291	33	28	4	14
292	33	16	0	16
293	0	7	0	84
294	33	52	11	38
296	33	0	0	95
297				
298	33	20	0	99
299	0	13	0	100
300	0	9	0	82
303	33	44	1	100

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
304	33	43	0	100
305	0	42	5	100
306	0	1	0	46
308	33	18	0	97
309	0	3	0	100
310	100	86	75	64
311	33	19	0	100
312	100	22	0	42
313				
314				
315	0	51	10	38
317	0	19	0	46
318	33	48	12	47
319	100	63	12	89
320	100	60	17	0
321				

Weights			
100	60	20	80

1092

1093 **Table 6.4.** Normalized scores for SMART analysis of South Carolina EOs and weighting scores.
1094 Resilience category represents the normalized scoring based on the last known abundance
1095 (0=low; 33=moderate; 67=high; 100=very high); MAXENT Mean is the normalized score of the
1096 average Maxent rank of all potential habitat; MAXENT percent 0.8-1 represents the normalized
1097 score of the percentage of potential habitat that falls within the highest rank category; 80% or
1098 greater SLEUTH Percent of Total is the total amount of current urbanization plus predicted
1099 urbanization at year 2040 (>80% probability) from the SLEUTH model.

1100

EO not part of a current population
EO included as part of a current population
EO is a part of a current population but last detection was prior to 2005
Eliminated/not scored

1101

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	33	67	14	100
2	33	2	0	96
3				
4	0	42	3	90
5	33	0	0	36

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EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
6	0	0	0	64
7	100	87	2	65
8	33	0	0	86
9				
10				
11	100	43	0	48
12				
13	0	23	0	0
14	100	43	0	57
15	0	0	0	96
16	100	72	1	62
17	100	70	1	67
18	67	62	0	48
19	0	37	0	35
20	33	16	0	0
21	67	15	0	10
22	0	1	0	100
23				
24	0	13	0	97
25	0	44	0	52
26	100	40	0	35
27	100	56	18	60
28	100	60	28	51
29				
30	33	22	0	12
31	100	0	0	100
32	33	23	0	7
33	33	5	0	80
34	0	100	100	99
35	0	75	34	47
36	33	18	0	100
37	0	78	66	100
38	100	16	0	63
39	0	19	0	99
40	33	18	0	80
41	0	36	0	13
42	33	10	0	94
43	0	72	0	57
44				

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
45				
46	0	32	0	4
47				
48				
49	67	27	0	30
50	33	16	0	46
51	0	1	0	65
52	67	0	0	100
53	33	33	0	34
54	33	29	0	9
55	0	13	0	1
56	33	43	0	4
57	67	47	8	62
59	33	13	0	83
60	100	53	21	88

Weights			
100	60	20	80

1102

1103 To determine a final rank for likelihood of persistence, we calculated a weighted sum for each
 1104 EO. We then converted the weighted sum to a final rank value that ranged from 0-100. Finally,
 1105 we determined the top 10% or 90th percentile, and top 25% or 75th percentile ranking for EOs in
 1106 each state. Table 6.5 summarizes the final ranks and top 10% and 25% percentile ranks for
 1107 North and South Carolina. We will include the top 10% in the status quo scenario, and the top
 1108 25% in the conservation scenario.

1109

1110 **Table 6.5.** Final Rank Scores for EOs in North and South Carolina. Dark green represents the
 1111 top 10% of scores, and light green includes the top 25% of scores.

EO not part of a current population
EO included as part of a current population
EO is a part of a current population but last detection was prior to 2005
Eliminated/not scored

1112

South Carolina		North Carolina	
EO_Code	Final Score	EO_Code	Final Score
60	79	149	94
7	79	73	93
17	75	49	92

I don't know what this table is supposed to be telling me.

You lost me with stats. Less detail, more explanation of purpose for normalizing and using percentiles.

16	74
27	71
28	70
31	69
14	66
11	63
38	62
34	61
1	60
26	59
52	56
57	56
18	55
37	54
36	48
42	44
2	43
40	42
59	41
49	41
8	39
33	39
4	37
39	35
35	34
43	34
24	33
21	32
22	31
53	31
50	31
15	30
25	26
56	24
5	24
54	22
30	22
32	20
51	20
6	20
19	19

12	90
238	90
161	88
227	87
249	86
233	86
182	85
250	85
251	84
194	84
51	84
310	84
75	84
113	84
319	81
76	81
74	81
10	80
181	79
55	79
37	79
276	78
259	77
159	77
29	76
160	73
167	72
9	72
154	72
23	71
106	71
197	71
61	70
46	70
184	69
237	69
158	68
118	68
241	68
239	67
236	66

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20	17
41	12
46	8
13	5
55	3
3	0
9	0
10	0
12	0
23	0
29	0
44	0
45	0
47	0
48	0

14	66
72	64
168	64
254	64
269	64
262	64
280	63
274	62
256	62
125	61
235	60
52	60
16	60
121	58
77	58
85	57
79	57
44	57
70	57
312	56
192	56
56	56
69	55
33	55
30	55
191	55
193	55
64	55
62	55
202	55
240	54
1	54
303	54
246	54
71	54
320	54
304	54
267	53
273	53
90	53
31	53

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28	51
242	51
17	51
5	50
180	50
270	50
157	50
222	49
230	49
115	48
281	48
91	48
4	48
298	48
311	48
225	48
198	47
89	47
3	47
84	47
308	47
275	47
183	46
40	46
284	46
258	46
231	46
229	46
58	46
164	46
83	45
282	44
18	44
205	43
172	42
296	42
283	42
268	42
80	41
130	41
174	41

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305	41
199	41
271	40
25	40
32	40
219	40
35	40
151	40
54	39
318	39
187	39
173	39
92	39
21	39
60	38
63	38
8	38
294	37
169	37
287	37
170	36
45	36
53	36
188	34
189	34
299	34
38	33
224	33
39	33
36	33
13	32
309	31
124	31
59	31
48	31
34	30
203	30
163	30
207	28
293	27
300	27

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57	25
209	25
201	25
315	24
291	24
162	23
20	23
206	23
107	22
166	22
122	22
292	21
213	21
208	20
272	20
317	19
196	18
212	17
165	17
306	14
279	14
200	12
47	10
195	7
2	0
6	0
11	0
15	0
19	0
27	0
50	0
87	0
114	0
175	0
190	0
204	0
210	0
223	0
255	0
263	0
264	0

265	0
266	0
277	0
278	0
286	0
297	0
313	0
314	0
321	0

Below we describe how we integrated potential positive and negative influences across the scenarios. We can assume there is some tipping point at which an area becomes so urbanized it is unsuitable for dwarf-flowered heartleaf, but we don't know exactly what that tipping point is. Similarly, we can assume additional populations are likely to be found or rediscovered across the range, but there is no clear way to predict the exact number or location of these populations. Although there is great uncertainty associated with how the species will be influenced by these factors, the three scenarios are intended to capture the range of this uncertainty. Note, changes in climate have potential to exacerbate the effects of urbanization, but these effects are not likely to occur within our projection window (e.g. 2040).

Status Quo Scenario

Under the status quo scenario, we assume a few populations will be identified as persisting throughout the range, and that there will be a range of impacts from urbanization that are related to the % increase in urban development and whether a population is protected or not. We assessed population resilience under the following assumptions:

- Two additional populations are identified as persisting based on Maxent model metrics, last known abundance category, and total predicted urbanization from SLEUTH modelling. Six additional EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist based on the same metrics.
- Potential impacts of urban development based on SLEUTH Model projections focused on current delineated populations:
 - Protected areas

Are we sure about this? That's a big assumption and makes a big difference. Just because we have in the past, doesn't mean we will continue to find more.

- 1137 ▪ Protected in perpetuity—no negative impacts from urbanization
- 1138 ▪ Voluntary protection/non-perpetuity—population drops 1 resilience rank if
- 1139 % increase in urbanization exceeds >50% threshold
- 1140 ○ Non-protected—population drops 1 resilience rank if % increase in urbanization
- 1141 exceeds >25% threshold; population drops 2 resilience ranks if % increase in
- 1142 urbanization exceeds >50% threshold
- 1143

Why
just 1
resilience
rank?

1144 *High Development Scenario*

1145 Under the high development scenario, we assume no additional populations will be identified as

1146 persisting throughout the range, and that impacts from urbanization ~~that~~ are relatively high, and

1147 are also affected by whether a population is protected or not. We assessed population resilience

1148 under the following assumptions:

- 1149 • No additional populations are identified as persisting
- 1150 • Potential impacts of urban development based on SLEUTH Model projections focused on
- 1151 current delineated populations:
- 1152 ○ Protected areas
- 1153 ▪ Protected in perpetuity— population drops 1 resilience rank if % increase
- 1154 in urbanization exceeds >50% threshold
- 1155 ▪ Voluntary protection/non-perpetuity— population drops 1 resilience rank
- 1156 if % increase in urbanization exceeds >25% threshold; population drops 2
- 1157 resilience ranks if % increase in urbanization exceeds >50% threshold
- 1158 ○ Non-protected—population drops 1 resilience rank if % increase in urbanization
- 1159 exceeds >25% threshold; population drops 2 resilience ranks if % increase in
- 1160 urbanization exceeds >50% threshold; extirpation of populations if % increase in
- 1161 urbanization exceeds >90% threshold.
- 1162

Why this high? Do we really
believe anything would persist
at higher than 80-75% development

1163 *Targeted Conservation Scenario*

1164 Under the targeted conservation scenario, we assume it is likely several additional populations

1165 (i.e. more than status quo scenario) will be identified as persisting throughout the range. The

range of impacts from urbanization are the same as the Status Quo scenario. We assessed population resilience under the following assumptions:

- Only 6 - can't figure out where this came from*
- Six populations are identified as persisting based on Maxent model metrics, last known abundance category, and total predicted urbanization from SLEUTH modelling. Six additional EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist based on the same metrics.
 - Potential impacts of urban development based on SLEUTH Model projections focused on current delineated populations:
 - Protected areas
 - Protected in perpetuity—no impacts from urbanization
 - Voluntary protection/non-perpetuity—population drops 1 resilience rank if % increase in urbanization exceeds >50% threshold
 - Non-protected—population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold

Future Resilience

Our focus on future resilience of dwarf-flowered heartleaf is on the potential impacts from urbanization. Table 6.6 shows a summary of currently delineated populations and the predicted urban development to occur within each of the populations. The table only includes those populations that already have some current amount of urban development, or are predicted to have some amount of development occur by the year 2040. Populations not included in this table are not predicted to be urbanized at all, so for the purposes of future analysis, will be assumed to retain the same resilience category as current. For those populations included in the table, we focus on those populations that are anticipated to increase in urbanization beyond a threshold value, depending on the scenario, but thresholds include >25% and >50% increases. Also taken into account is whether or not a population is on protected lands, and if so, whether the population is protected in perpetuity or not. Below is a summary of projected future resilience under each of the three scenarios.

what about 99% identified as on the last page?

1196
1197
1198
1199
1200
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Table 6.6. Results of the SLEUTH model. Populations consist of both stand-alone EOs and aggregates of multiple EOs following the definition of delineating demographic populations from Chapter 4. Included are only those populations that already have some current amount of urban development, or are predicted to have some amount of development occur by the year 2040. Red cells indicate populations that are predicted to increase >50% in urbanization. Orange cells indicate populations that are predicted to increase >25% in urbanization.

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Population Number	Total Area (sq m)	Already classed Urban	80% chance	90% chance	95% chance	97.5% chance	100% chance	>80%
206	17346.37096	0.40%	0.00%	0.00%	0.00%	6.24%	93.41%	99.65%
306	7804.656249	0.00%	15.11%	49.91%	7.83%	0.00%	22.40%	96.24%
208	55360.86786	17.31%	0.00%	0.00%	0.00%	0.00%	82.69%	92.19%
279	1951.661571	0.00%	0.00%	0.00%	0.00%	0.00%	80.85%	81.85%
214	15043.2984	0.00%	0.00%	1.44%	10.97%	0.00%	55.72%	88.13%
248	25486.15611	28.80%	0.00%	3.22%	0.02%	0.02%	53.03%	56.30%
316	43177.79587	20.06%	0.00%	16.68%	7.08%	0.00%	20.67%	44.43%
247	49898.17159	5.87%	0.00%	6.37%	0.00%	0.00%	23.35%	29.73%
291	11666.76374	35.39%	12.28%	13.53%	2.43%	0.00%	0.23%	28.47%
287	7901.775408	0.00%	0.00%	11.50%	0.00%	0.00%	14.25%	25.75%
312	6535.273235	0.00%	25.28%	0.00%	0.00%	0.00%	0.00%	25.28%
32	31220.60253	60.74%	0.00%	20.39%	0.00%	0.00%	0.00%	20.39%
177	26954.54153	25.34%	12.19%	0.92%	0.10%	5.31%	0.13%	18.66%
292	15611.18205	0.00%	0.00%	0.00%	0.00%	0.00%	18.40%	18.40%
261	21644.22924	0.00%	0.00%	13.21%	3.35%	0.00%	0.00%	16.56%
295	23486.00987	18.20%	0.00%	3.41%	11.99%	0.25%	0.00%	15.65%
125	20742.3249	0.00%	1.02%	5.65%	0.00%	6.67%	0.00%	13.34%
59	8172.007769	0.00%	13.09%	0.00%	0.00%	0.00%	0.00%	13.09%
302	120342.0641	1.46%	2.55%	2.55%	0.77%	2.33%	3.98%	12.19%
178	376781.2214	28.59%	2.79%	2.40%	0.68%	0.59%	2.64%	9.11%
93	43754.11642	0.19%	0.00%	0.00%	0.00%	0.00%	7.82%	7.82%
77	6044.427562	0.00%	1.51%	6.14%	0.00%	0.00%	0.00%	7.64%
179	15145.19453	85.06%	1.14%	0.00%	5.12%	0.00%	0.49%	6.75%
44	15081.76951	61.17%	0.27%	0.00%	0.00%	0.00%	4.68%	4.95%
252	39595.93143	63.47%	0.00%	3.80%	0.00%	0.00%	0.00%	3.80%
100	423621.7376	9.01%	1.32%	1.10%	0.72%	0.14%	0.00%	3.27%
276	123688.7819	0.61%	0.36%	1.87%	0.01%	0.00%	0.00%	2.24%
216	66424.06073	0.00%	0.91%	0.00%	0.00%	0.00%	0.00%	0.91%
154	33924.92259	0.00%	0.00%	0.37%	0.00%	0.00%	0.00%	0.37%
29	249998.8742	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%	0.05%
1	30711.68144	0.41%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2	36339.91976	11.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3	24498.03483	24.77%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
31	42929.76479	100.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
96	95947.32128	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
130	1168.240433	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
176	39787.48373	0.89%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
195	7805.599588	99.94%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
317	584.7346337	99.70%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
318	5396.859208	99.74%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1221	320	125.5182447	98.79%	0.00%	0.00%	0.00%	0.00%	0.00%

Status Quo Scenario

In the Status Quo scenario, there are predicted to be 75 populations of dwarf-flowered heartleaf on the landscape (Table 6.7). The predicted resilience of the extant populations are as follows:

in 2040?

very high (27); high (6); moderate (23); low (17); and 2 additional populations identified as persisting, with an unknown resilience. Six EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist, but resilience is unchanged because each of the populations are already predicted to be of very high resilience. When comparing future population resilience to current condition a few populations drop in their resilience category. One current population of very high resilience is predicted to drop to high resilience; two moderate populations are predicted to drop to low resilience; and five populations (one currently moderate and four currently low) are predicted to be extirpated due to urban development. Of the seven additional populations predicted to persist under this scenario, four are in South Carolina, and three in North Carolina. We did not assess resilience for these additional populations, but it is worth mentioning that the last time these populations were detected, resilience was very high (2), high (1), and moderate (4).

Table 6.7. Predicted resilience categories for *Hexastylis naniflora* populations under the Status Quo scenario, and comparison to current condition.

Site Name	Current Resilience	Status Quo
DNR Peters Creek Heritage Preserve	very high	very high
Cowpens NBF	very high	very high
Mill Creek Forest and Seep	very high	very high
Island Creek Heath Bluff	very high	very high
NCDOT TIP: R-2824	very high	very high
Murrays Mill/Upper Balls Creek NA	very high	very high
Big Horse Creek Rare Plant Site	very high	very high
Broad River/Sandy Run NA	very high	very high
New Hope Springhead Swamp	very high	very high
Facebook Site	very high	very high
Davenport Road/Mountain View Rare Plant Site	very high	very high
Broad River: Floyds Creek	very high	very high
Catawba River: Hoyle Crk-Micol Crk	very high	very high
South Fork Catawba R: Clark Crk, Miller Br, Cata Mem Hos	very high	very high
Buffalo Creek: Tributaries N and S of SR 2047	very high	high
Buffalo Creek: Kings Mountain Res	very high	very high
Broad River: Brushy Creek	very high	very high
Peaked Top Rare Plant Site/Foothills Landfill	very high	very high
Jacob Fork West Corridor	very high	very high
Floyds Creek Tributray Rare Plant Site	very high	very high

Site Name	Current Resilience	Status Quo
New Bethel Rare Plant Site	very high	very high
Leepers Creek Heartleaf Site	very high	very high
Cliffside Steam Station	very high	very high
Rhyne Conservation Preserve	very high	very high
Glade Creek, Alex County	very high	very high
Richardson Creek trib above Toms Lake	very high	very high
Gunpowder Creek: South of Hudson	very high	very high
Taylor Blaylock Res	very high	very high
Little Gunpowder Creek Rare Plant Site 1	high	high
Little Gunpowder Creek Rare Plant Site 2	high	high
Buffalo Creek Rare Plant Site	high	high
Northern Catawba County	high	high
Rock Barn Solar Farm	high	high
NCDOT TIP R-2824	moderate	moderate
Third Creek Rare Plant Site	moderate	moderate
Knob Creek NA	moderate	moderate
Buffalo Creek: Northeast of SR 1903	moderate	moderate
West Shelby Mesic Slope	moderate	low
Cat Square Heartleaf Forest	moderate	low
Kross Keys NA	moderate	moderate
First Broad River: Crooked Run Creek	moderate	moderate
NCDOT non-TIP Div 12 road const at SR 1115 South Fork Catawba River Jacobs Fork and Camp Creek	moderate	moderate
Catawba River: North Fork Mountain Creek	moderate	moderate
Catawba River: Lake James	moderate	moderate
Hogpen Branch Transplant Site	moderate	moderate
Jonas Road Rare Plant Site	moderate	extirpated
South Fork Catawba River, Henry Fork	moderate	moderate
No Business Creek, Boyd Tract	moderate	moderate
Broad River/Sandy Run NA	moderate	moderate
Buffalo Shoals Creek	moderate	moderate
Fox Knoll Farm	moderate	moderate
Forest City: Adj to Isothermal CC	moderate	moderate
Hickory Area	moderate	moderate
UT of Kings Mountain Res	moderate	moderate
Brushy Creek Headwaters	moderate	moderate
Smith Cliff/Henry Fork River	moderate	moderate
Simms Hill/Little River Uplands	moderate	moderate
Collinsville (Hughes) Creek Slopes	moderate	moderate

Site Name	Current Resilience	Status Quo
Burke County - Drowning Creek UT	moderate	moderate
Sandy Spring Church Springhead Swamp	low	low
First Broad River: Hickory Creek	low	low
Buffalo Creek: Ravine	low	extirpated
Buffalo Creek: Potts Creek	low	extirpated
Smith Cliff/Henry Fork River	low	low
Pott Creek	low	low
Northeast Lincolnton: UT Walker Branch	low	extirpated
Gunpowder Creek	low	low
Killian Crossroads	low	low
Beaverdam Crk at First Broad River	low	low
Lincoln County, SR-1314	low	low
Levan Family Farm	low	low
Fanjoy Road Site	low	extirpated
First Broad River: Beaverdam Creek Tribs	low	low
South Mountains Pleasant Grove Uplands	low	low
NCDOT TIP R-3603A	low	low
Hickory Creek - UT (Shelby High School)	low	low
Boulder Creek Subdivision	low	low
Gateway Elementary School	low	low
First Broad River (North Carolina)	n/a	present
Cherokee Creek/Bonner and Robin School Roads	n/a	present

High Development Scenario

In the High Development scenario, there are predicted to be 72 populations of dwarf-flowered heartleaf on the landscape (Table 6.8). The predicted resilience of the extant populations are as follows: very high (27); high (4); moderate (25); and low (16). No new future populations are predicted to be discovered. When comparing future population resilience to current condition a few populations drop in their resilience category. One current population of very high resilience is predicted to drop to moderate resilience; one high resilience population is predicted to drop to moderate; two moderate populations are predicted to drop to low resilience; and six populations (one currently moderate and five currently low) are predicted to be extirpated due to urban development.

Table 6.8. Predicted resilience categories for *Hexastylis naniflora* populations under the High Development scenario, and comparison to current condition.

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Site Name	Current Resilience	High Development
DNR Peters Creek Heritage Preserve	very high	very high
Cowpens NBF	very high	very high
Mill Creek Forest and Seep	very high	very high
Island Creek Heath Bluff	very high	very high
NCDOT TIP: R-2824	very high	very high
Murrays Mill/Upper Balls Creek NA	very high	very high
Big Horse Creek Rare Plant Site	very high	very high
Broad River/Sandy Run NA	very high	very high
New Hope Springhead Swamp	very high	very high
Facebook Site	very high	very high
Davenport Road/Mountain View Rare Plant Site	very high	very high
Broad River: Floyds Creek	very high	very high
Catawba River: Hoyle Crk-Micol Crk	very high	very high
South Fork Catawba R: Clark Crk, Miller Br, Cata Mem Hos	very high	very high
Buffalo Creek: Tributaries N and S of SR 2047	very high	moderate
Buffalo Creek: Kings Mountain Res	very high	very high
Broad River: Brushy Creek	very high	very high
Peaked Top Rare Plant Site/Foothills Landfill	very high	very high
Jacob Fork West Corridor	very high	very high
Floyds Creek Tributary Rare Plant Site	very high	very high
New Bethel Rare Plant Site	very high	very high
Leepers Creek Heartleaf Site	very high	very high
Cliffside Steam Station	very high	very high
Rhyne Conservation Preserve	very high	very high
Glade Creek, Alex County	very high	very high
Richardson Creek trib above Toms Lake	very high	very high
Gunpowder Creek: South of Hudson	very high	very high
Taylor Blaylock Res	very high	very high
Little Gunpowder Creek Rare Plant Site 1	high	high
Little Gunpowder Creek Rare Plant Site 2	high	high
Buffalo Creek Rare Plant Site	high	high
Northern Catawba County	high	moderate
Rock Barn Solar Farm	high	high
NCDOT TIP R-2824	moderate	moderate
Third Creek Rare Plant Site	moderate	moderate
Knob Creek NA	moderate	moderate
Buffalo Creek: Northeast of SR 1903	moderate	moderate
West Shelby Mesic Slope	moderate	low
Cat Square Heartleaf Forest	moderate	low

Site Name	Current Resilience	High Development
Kross Keys NA	moderate	moderate
First Broad River: Crooked Run Creek	moderate	moderate
NCDOT non-TIP Div 12 road const at SR 1115 South Fork Catawba River Jacobs Fork and Camp Creek	moderate	moderate
Catawba River: North Fork Mountain Creek	moderate	moderate
Catawba River: Lake James	moderate	moderate
Hogpen Branch Transplant Site	moderate	moderate
Jonas Road Rare Plant Site	moderate	extirpated
South Fork Catawba River, Henry Fork	moderate	moderate
No Business Creek, Boyd Tract	moderate	moderate
Broad River/Sandy Run NA	moderate	moderate
Buffalo Shoals Creek	moderate	moderate
Fox Knoll Farm	moderate	moderate
Forest City: Adj to Isothermal CC	moderate	moderate
Hickory Area	moderate	moderate
UT of Kings Mountain Res	moderate	moderate
Brushy Creek Headwaters	moderate	moderate
Smith Cliff/Henry Fork River	moderate	moderate
Simms Hill/Little River Uplands	moderate	moderate
Collinsville (Hughes) Creek Slopes	moderate	moderate
Burke County - Drowning Creek UT	moderate	moderate
Sandy Spring Church Springhead Swamp	low	low
First Broad River: Hickory Creek	low	low
Buffalo Creek: Ravine	low	extirpated
Buffalo Creek: Potts Creek	low	extirpated
Smith Cliff/Henry Fork River	low	low
Pott Creek	low	low
Northeast Lincolnton: UT Walker Branch	low	extirpated
Gunpowder Creek	low	extirpated
Killian Crossroads	low	low
Beaverdam Crk at First Broad River	low	low
Lincoln County, SR-1314	low	low
Levan Family Farm	low	low
Fanjoy Road Site	low	extirpated
First Broad River: Beaverdam Creek Tribs	low	low
South Mountains Pleasant Grove Uplands	low	low
NCDOT TIP R-3603A	low	low
Hickory Creek - UT (Shelby High School)	low	low
Boulder Creek Subdivision	low	low

Site Name	Current Resilience	High Development
Gateway Elementary School	low	low

Targeted Conservation Scenario

In the Targeted Conservation scenario, there are predicted to be 79 populations of dwarf-flowered heartleaf on the landscape (Table 6.9). The predicted resilience of the extant populations are as follows: very high (27); high (6); moderate (23); low (17); and 6 additional populations discovered to persist, with an unknown resilience. Six EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist, but resilience is unchanged because each of the populations are already predicted to be of very high resilience. When comparing future population resilience to current condition a few populations drop in their resilience category. One current population of very high resilience is predicted to drop to high resilience; two moderate populations are predicted to drop to low resilience; and five populations (one currently moderate and four currently low) are predicted to be extirpated due to urban development. Of the sixteen additional populations predicted to persist under this scenario, ten are in South Carolina, and six in North Carolina. We did not assess resilience for these additional populations, but it is worth mentioning that the last time these populations were detected, resilience was very high (2), high (1), moderate (11), and low (2).

Table 6.9. Predicted resilience categories for *Hexastylis naniflora* populations under the Targeted Conservation scenario, and comparison to current condition.

Site Name	Current Resilience	Targeted Conservation
DNR Peters Creek Heritage Preserve	very high	very high
Cowpens NBF	very high	very high
Mill Creek Forest and Seep	very high	very high
Island Creek Heath Bluff	very high	very high
NCDOT TIP: R-2824	very high	very high
Murrays Mill/Upper Balls Creek NA	very high	very high
Big Horse Creek Rare Plant Site	very high	very high
Broad River/Sandy Run NA	very high	very high
New Hope Springhead Swamp	very high	very high
Facebook Site	very high	very high
Davenport Road/Mountain View Rare Plant Site	very high	very high

Site Name	Current Resilience	Targeted Conservation
Broad River: Floyds Creek	very high	very high
Catawba River: Hoyle Crk-Micol Crk	very high	very high
South Fork Catawba R: Clark Crk, Miller Br, Cata Mem Hos	very high	very high
Buffalo Creek: Tributaries N and S of SR 2047	very high	high
Buffalo Creek: Kings Mountain Res	very high	very high
Broad River: Brushy Creek	very high	very high
Peaked Top Rare Plant Site/Foothills Landfill	very high	very high
Jacob Fork West Corridor	very high	very high
Floyds Creek Tributary Rare Plant Site	very high	very high
New Bethel Rare Plant Site	very high	very high
Leepers Creek Heartleaf Site	very high	very high
Cliffside Steam Station	very high	very high
Rhyne Conservation Preserve	very high	very high
Glade Creek, Alex County	very high	very high
Richardson Creek trib above Toms Lake	very high	very high
Gunpowder Creek: South of Hudson	very high	very high
Taylor Blaylock Res	very high	very high
Little Gunpowder Creek Rare Plant Site 1	high	high
Little Gunpowder Creek Rare Plant Site 2	high	high
Buffalo Creek Rare Plant Site	high	high
Northern Catawba County	high	high
Rock Barn Solar Farm	high	high
NCDOT TIP R-2824	moderate	moderate
Third Creek Rare Plant Site	moderate	moderate
Knob Creek NA	moderate	moderate
Buffalo Creek: Northeast of SR 1903	moderate	moderate
West Shelby Mesic Slope	moderate	low
Cat Square Heartleaf Forest	moderate	low
Kross Keys NA	moderate	moderate
First Broad River: Crooked Run Creek	moderate	moderate
NCDOT non-TIP Div 12 road const at SR 1115 South Fork Catawba River Jacobs Fork and Camp Creek	moderate	moderate
Catawba River: North Fork Mountain Creek	moderate	moderate
Catawba River: Lake James	moderate	moderate
Hogpen Branch Transplant Site	moderate	moderate
Jonas Road Rare Plant Site	moderate	extirpated
South Fork Catawba River, Henry Fork	moderate	moderate
No Business Creek, Boyd Tract	moderate	moderate
Broad River/Sandy Run NA	moderate	moderate

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Site Name	Current Resilience	Targeted Conservation
Buffalo Shoals Creek	moderate	moderate
Fox Knoll Farm	moderate	moderate
Forest City: Adj to Isothermal CC	moderate	moderate
Hickory Area	moderate	moderate
UT of Kings Mountain Res	moderate	moderate
Brushy Creek Headwaters	moderate	moderate
Smith Cliff/Henry Fork River	moderate	moderate
Simms Hill/Little River Uplands	moderate	moderate
Collinsville (Hughes) Creek Slopes	moderate	moderate
Burke County - Drowning Creek UT	moderate	moderate
Sandy Spring Church Springhead Swamp	low	low
First Broad River: Hickory Creek	low	low
Buffalo Creek: Ravine	low	extirpated
Buffalo Creek: Potts Creek	low	extirpated
Smith Cliff/Henry Fork River	low	low
Pott Creek	low	low
Northeast Lincolnton: UT Walker Branch	low	extirpated
Gunpowder Creek	low	low
Killian Crossroads	low	low
Beaverdam Crk at First Broad River	low	low
Lincoln County, SR-1314	low	low
Levan Family Farm	low	low
Fanjoy Road Site	low	extirpated
First Broad River: Beaverdam Creek Tribs	low	low
South Mountains Pleasant Grove Uplands	low	low
NCDOT TIP R-3603A	low	low
Hickory Creek - UT (Shelby High School)	low	low
Boulder Creek Subdivision	low	low
Gateway Elementary School	low	low
First Broad River (North Carolina)	n/a	present
First Broad Hop-Hornbeam NA	n/a	present
Big Island Carolina Hemlock Bluff	n/a	present
Cherokee Creek/Bonner and Robin School Roads	n/a	present
Arrowood Branch	n/a	present
Cherokee Creek/SC 11	n/a	present

1281

1282 *Viability Summary*

Urban development is predicted to have negative impacts on several of the current populations under all of our scenarios. However, this loss of resilience and extirpation of a few populations is offset by the fact that several additional populations were found to persist in the Status Quo and Targeted Conservation scenarios. In the High Development Scenario, there is a predicted loss of 6 populations, with loss of resilience in several additional populations. Regardless of the scenario, the majority of the populations expected to persist on the landscape in 2040 are of at least moderate resilience.

Given the relatively high number of populations across each scenario, redundancy remains similar to current conditions. That is to say, there appears to be adequate redundancy within the range of dwarf-flowered heartleaf to withstand the impacts of localized press catastrophic disturbances, however the species range is relatively small, making it potentially vulnerable to long-term catastrophic events, such as climate change.

Given that dwarf-flowered heartleaf has a very limited range, and after consulting with experts, we decided delineating representative units was not appropriate for this species. It is worth noting that in two of our scenarios (Status Quo and Targeted Conservation), additional populations are found to persist in South Carolina, an area where we have relatively few current populations. As discussed below, we believe there are opportunities to find additional populations based on the amount of predicted unoccupied potential habitat. Although we did not delineate representative units, we believe our scenarios do not predict declines in species representation.

Table 6.10. Viability summary for *Hexastylis naniflora* under 3 future scenarios (projected to year 2040) and compared to Current Condition.

	CURRENT	STATUS QUO	HIGH DEVELOPMENT	TARGETED CONSERVATION
VERY HIGH	28	27	27	27
HIGH	5	6	4	6
MODERATE	26	23	25	23
LOW	19	17	16	17

EXTIRPATED	n/a	5	6	5
PERSISTING	n/a	2	0	6
TOTAL	78	75	72	79

Opportunities for Additional Conservation

Although our scenarios focus on areas where dwarf-flowered heartleaf have been found in the past, the Maxent model identifies a number of areas as high quality potential habitat for the species that falls outside the immediately known occurrence areas. A few of these areas are detailed below (Figure 6.2).

1. West of the city of Lenoir, south of Highway 90/Adako Rd., north of Highway 64 within Caldwell County. This area identifies a large block of potential habitat. This area falls just outside the administrative boundary of the Pisgah National Forest. The bluffs and tributaries along the Johns River are identified as the best habitat, but there is also ample habitat identified along the forested areas of Celia, Husband, Abingdon and Greasy Creeks. The only known occurrence within this area is associated with Abingdon Creek and is under a conservation easement.

2. Henry Fork River bluffs and tributaries east of Highway 18 within Burke County. A historic element occurrence is present by the Burke County line, but the entire area is identified as good quality potential habitat for the species where forested habitats remain.

3. South West corner of Catawba County west of Highway 321. Several disjointed patches of high quality potential habitat are identified in this region associated with the river and creek slopes. Rock Creek, Jacob Fork River, Pott Creek, and their associated tributaries all contain blocks of potential habitat. A number of element occurrences are identified within this area, but additional habitat is identified both upstream and downstream of the known occurrences.

4. Clark, Pinch Gut, Maiden, and Allen Creeks, north of the town of Maiden. The slopes along these creeks all contain quality potential habitat. Known element occurrences are in the general area, but none are situated within the creeks listed.

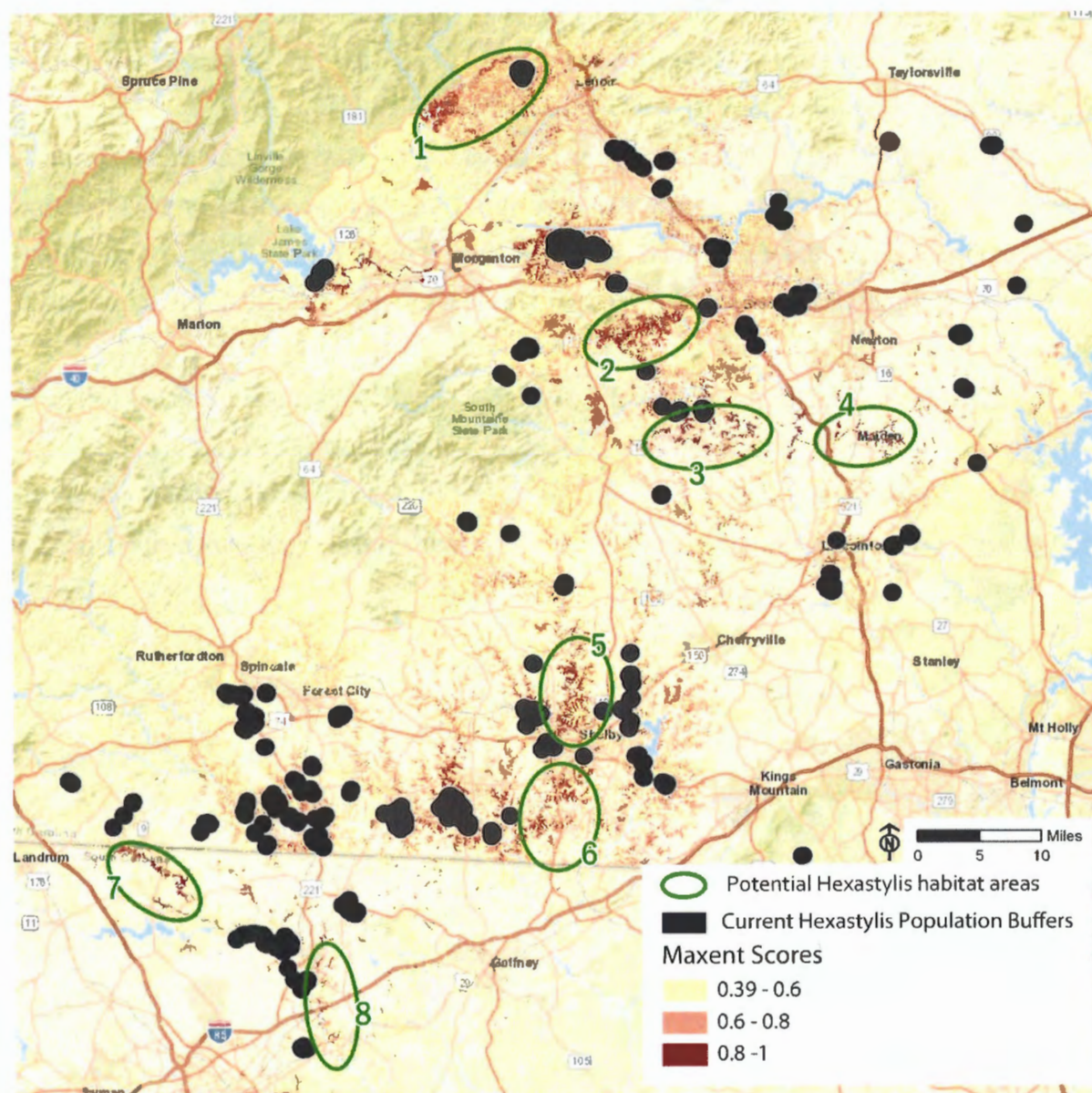
5. First Broad River North of Highway 74, Rutherford County. Two older element occurrences are located within this area, however, the forested bluffs along the First Broad River and associated tributaries are identified as good quality potential habitat in many additional upstream and downstream areas in this system.

6. Hickory Creek, Sulphur Springs Branch (Little Hickory), Shoal Creek, and tributaries draining into First Broad River South of the Town of Shelby, north of the South Carolina border. The town of Shelby has likely disconnected this site from area 5 listed above. Here, slopes along the creeks and tributaries draining into the First Broad River are identified as potential habitat more so than the slopes along the First Broad River themselves. There is only a single element occurrence known upstream along Hickory Creek.

7. North Pacolet River and Obed Creek, north of where they join. The majority of potential habitat falls along the slopes of the North Pacolet River. Two older element occurrences (1991 last observation) are found in the tributaries draining into the North Pacolet River, and many occurrences are found further upstream. The habitat model suggests that additional undiscovered habitat areas are present.

8. Pacolet River and Island Creek, north of Peters Creek, downstream of the Pacolet River dam. This area displays limited amounts of good quality potential habitat. Recent element occurrences are present in the upper headwaters of Peters and Zekial Creeks (Zekial Creek drains into Peters Creek) and in areas north of the Pacolet River dam, but none are known along the areas identified in this immediate area.

Figure 6.2. Areas identified as high quality potential habitat by Maxent model for *Hexastylis naniflora* that fall outside the immediately known occurrence areas.



Literature Cited

- Amoroso, J.L. 2016. *Hexastylis naniflora* status meeting with USFWS, NCNHP, ASU, and NCDOT [meeting minutes]. North Carolina Department of Natural and Cultural Resources office, Asheville, NC, 11 May 2016.
- Baldwin, R.A. 2009. Use of maximum entropy modeling in wildlife research. *Entropy*. 11:854-866.
- Barringer, K. 1993. New combinations in North American *Asarum* (Aristolochiaceae). *Novon* 3:225-227.
- Blomquist, H.L. 1957. A Revision of *Hexastylis* in North America. *Brittonia* 8:255-281.
- Clarke, K.C., Riggan, P., and Brass, J.A., 1995. A cellular automaton model of wildfire propagation and extinction, *Photogram. Eng. Rem S.* 60, 1355-1367.
- Dobzhansky, T. 1937. *Genetics and the origin of species*. Columbia University Press, New York, NY.
- DeWan, A., N. Dubois, K. Theoharides, and J. Boshoven. 2010. Understanding the impacts of climate change on fish and wildlife in North Carolina.
- Flora of North America 1997. *Flora of North America north of Mexico*. Volume 3, Magnoliophyta: Magnoliidae and Hamamelidae. Oxford University Press, New York, NY. 590 pp. Contains Whittemore and Gaddy's treatment of *Asarum* and *Hexastylis*.
- Gaddy, L.L. 1980. Status Report on *Hexastylis naniflora* Blomquist. Prepared for and submitted to USFWS, Endangered Species Office, Region 4, Atlanta, Georgia. July 1980.
- Gaddy, L.L. 1981. The status of *Hexastylis naniflora* Blomquist in North Carolina. Unpublished report prepared under contract to the Plant Conservation Program, North Carolina Department of Agriculture, Raleigh.
- Gaddy, L. 1986. Twelve new ant-dispersed species from the southern Appalachians. *Bulletin of the Torrey Botanical Club* 113: 247-251.
- Gaddy, L.L. 1987. A review of the taxonomy and biogeography of *Hexastylis* (Aristolochiaceae). *Castanea* 52(3):186-196.
- Golder Associates, Inc. 2009. Year 5 Monitoring Report, *Hexastylis naniflora*, Foothills Conservation Area, Caldwell County, North Carolina. Submitted to: Republic Services of North Carolina, LLC; copies (per cover letter) distributed to US Army Corps of Engineers, Asheville Regulatory Office and USFWS Asheville ES Office. June 26, 2009.

- Golladay SW, Gagnon P, Kearns M, Battle JM, Hicks DW. Response of freshwater mussel assemblages (Bivalvia: Unionidae) to a record drought in the Gulf Coastal Plain of southwest Georgia. *J. N. Am. Benthol. Soc.* 2004;23:494–506.
- Gonzalez, V. C. 1972. The ecology of *Hexastylis arifolia*, an evergreen herb in the North Carolina deciduous forest. Ph.D. dissertation, Duke University. Durham, North Carolina, USA. HDR. 2005. Identification of *Hexastylis naniflora*. Notes on characteristics and field observations provided to the North Carolina Natural Heritage Program, Raleigh.
- IPCC, 2013: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
- Jones M.S., T. H. Jones, and J. J. English. 2014. The Pollination of *Hexastylis naniflora* in Cleveland County, North Carolina. *Castanea*: June 2014, Vol. 79, No. 2, pp. 74-77.
- Jordan, Jones and Goulding (JJ&G), Inc. 1998. Section 404 Application and Conceptual Mitigation Plan, Lake Blalock Expansion Project. USFWS Log number 4-6-97-358. ACOE Project # 80-97-1732 (S). Section 9: *Hexastylis naniflora* Biological Assessment. Received by the Asheville Field Office July 16, 1998.
- Jordan, Jones and Goulding (JJ&G), Inc. 2006. Lake Blalock Buffer Disturbance – Vicinity of Casey Creek Road. Memorandum to: Eddie Dearbury, Spartanburg Water Systems. Date: October 25, 2006.
- Karl, T. R., Melillo, J. M., & Peterson, T. C. (Eds.). (2009). *Global Climate Change Impacts in the United States*. Washington, DC: U.S. Global Change Research Program.
- Kelly, L. M. 1997. A Cladistic Analysis of *Asarum* (Aristolochiaceae) and Implications for the Evolution of Herkogamy. *American Journal of Botany* 84:1752-1765.
- Kelly, L. M. 1998. Phylogenetic Relationships in *Asarum* (Aristolochiaceae) Based on Morphology and ITS Sequences. *American Journal of Botany* 85:1454-1467.
- Kelly, L. M. 2001. Taxonomy of *Asarum* Section *Asarum* (Aristolochiaceae). *Systematic Botany* 26:17-53.
- Lengyel, S., A. D. Gove, A. M. Latimer, J. D. Majer, and R. R. Dunn. 2010. Convergent evolution of seed dispersal by ants, and phylogeny and biogeography in flowering plants: A global survey. *Perspectives in Plant Ecology, Evolution and Systematics* 12: 43-55.
- McLaughlin, J.F. et al. (2002). Climate change hastens population extinctions. *Proceedings of the National Academy of Sciences* 99(9): 6070–6074.
- Murrell, Z. et al. 2007. Ecological, Morphological, Micromorphological and Molecular Analyses of the Species in the *Hexastylis heterophylla* Complex. A report to the North Carolina

- 1474 Department of Transportation. NCDOT and CTE Joint Project 2002-2004,
1475 FHWA/NC/2004-01. May 2007.
- 1476
- 1477 Murrell, Z. 2015. Development of molecular and morphological tools to circumscribe and
1478 identify the Dwarf Flowered Heartleaf (*Hexastylis naniflora*). Report to the North
1479 Carolina Department of Transportation, NCDOT Project 2012-2111, July 2015.
- 1480
- 1481 National Climate Change Viewer. 2016. USGS. Accessed at
1482 https://www2.usgs.gov/climate_landuse/clu_rd/nccv.asp, January 2018.
- 1483
- 1484 NatureServe. 2002. Element Occurrence Data Standard, 6 February 2002. NatureServe,
1485 Arlington, Virginia. Accessed at
1486 http://www.natureserve.org/library/deliminting_plant_eos_Oct_2004.pdf, August 2016.
- 1487
- 1488 NCOSBM. North Carolina Budget and Management County and State Population Projections.
1489 Accessed at <https://www.osbm.nc.gov/demog/county-projections>, March 2018.
- 1490
- 1491 Newberry, G. 2006. South Carolina Populations of *Hexastylis naniflora*: 2006 updates. Received
1492 by the USFWS Asheville Field Office, September 7, 2006.
- 1493
- 1494 Newberry, G. 2009. University of South Carolina at Spartanburg. Evaluation of damage to
1495 *Hexastylis naniflora* plants on acreage bordering the hunt club. Letter to Jon Morgan,
1496 Lake Warden, Spartanburg Water Systems. Dated February 24, 2009.
- 1497
- 1498 North Carolina Natural Heritage Program (NCNHP). 2016. Element Occurrence Records for
1499 *Hexastylis naniflora* (dwarf-flowered heartleaf). As of: August 5, 2016.
- 1500
- 1501 North Carolina Natural Heritage Program (NCNHP). 2018. Natural Heritage Element
1502 Occurrences. Accessed at [https://www.ncnhp.org/activities/conservation/natural-heritage-](https://www.ncnhp.org/activities/conservation/natural-heritage-element-occurrences)
1503 [element-occurrences](https://www.ncnhp.org/activities/conservation/natural-heritage-element-occurrences), January 2018.
- 1504 Newberry, G. 1993. Progress Report on Monitoring Studies of *Hexastylis naniflora*. Unpublished
1505 report. Copy submitted to the USFWS Asheville Field Office, on September 7, 2006.
- 1506
- 1507 Niedenberger, B.A. 2010. Molecular phylogeny and comparative pollen morphology of the
1508 genus *Hexastylis* (Aristolochiaceae). M.S. thesis. Appalachian State University, Boone,
1509 NC.
- 1510
- 1511 Otte, D. 1977. The pollination biology of *Hexastylis arifolia* (Michx.) Small var. *arifolia* and *H.*
1512 *minor* (Ashe) Blomquist (Aristolochiaceae) in the area of Chapel Hill, North Carolina.
1513 M.S. Thesis, University of North Carolina Chapel Hill, Chapel Hill, North Carolina,
1514 USA.
- 1515
- 1516 Padgett, J. E. 2004. Biogeographical, ecological, morphological, and micromorphological
1517 analyses of the species in the *Hexastylis heterophylla* complex. M.S. thesis. Appalachian
1518 State University, Boone, NC.
- 1519

- 1520 Phillips, S. J. 2018. A Brief Tutorial on Maxent. Available from url:
1521 http://biodiversityinformatics.amnh.org/open_source/maxent/. Accessed on 2018-02/21.
1522
- 1523 Renninger, H. 2010. North Carolina Department of Transportation (NCDOT). E-mail
1524 communication to Carolyn Wells, USFWS Asheville Field Office. Date: May 28, 2010.
1525 Subject: Dwarf-flowered heartleaf research proposal.
1526
- 1527 Robinson L.G. 2016. Dwarf-flowered Heartleaf range-wide status report. Final report to U.S.
1528 Department of Interior—U.S. Fish and Wildlife Service by North Carolina Natural
1529 Heritage Program. August 2016.
1530
- 1531 Robinson, L.G. and J.E. Padgett. 2016. Dwarf-flowered Heartleaf (*Hexastylis naniflora*)
1532 comprehensive review and monitoring report. Final report to the U.S. Department of
1533 Interior—U.S. Fish and Wildlife Service by the North Carolina Natural Heritage
1534 Program. August 2016.
1535
- 1536 Schneider, S. 2006. Spartanburg Water System (SWS) & Sanitary Sewer District, Assistant
1537 General Manager. E-mail communication to Lora Zimmerman, USFWS (formerly with
1538 the Charleston Field Office), dated December 18, 2006. Subject: Meeting at SWS on
1539 December 21, 2006 [to discuss Lake Blalock Buffer Disturbance].
1540
- 1541 South Carolina Department of Natural Resources (SCDNR) Heritage Trust. 2016. Element
1542 Occurrence Records for *Hexastylis naniflora* (dwarf-flowered heartleaf). As of: February
1543 4, 2016.
1544
- 1545 USFWS. 2001. Biological Opinion for Spartanburg Water System, Lake Blalock, P/N 2000-IP-
1546 194-W, USFWS log number 4-6-01-F-115. May 10, 2001.
1547
- 1548 USFWS. 2010. Draft Five Year Review for *Hexastylis naniflora* (dwarf flowered heartleaf).
1549 September 30, 2010. Submitted to the USFWS Southeast Regional Office September 30,
1550 2010.
1551
- 1552 USFWS. 2015, August. Fact sheet for *Hexastylis naniflora*. Retrieved from
1553 https://www.fws.gov/raleigh/species/es_dwarf-flowered_heartleaf.html.
1554
- 1555 USFWS. 2016. USFWS species status assessment framework: an integrated analytical
1556 framework for conservation. Version 3.4.8, August 2016.
1557
- 1558 Wagner, J. 2013. Developing new morphological, geographic, and molecular tools to
1559 circumscribe *Hexastylis naniflora*. M.S. thesis. Appalachian State University, Boone,
1560 NC.
1561
- 1562 Walker, J. et al. 2009. What are the effects of prescribed fire on *Hexastylis naniflora*, a federally
1563 protected plant species? Unpublished final report prepared by U.S. Forest Service,
1564 Southern Research Station, Clemson University, Clemson, SC. Submitted to Timothy
1565 Stone, Superintendent, Cowpens National Battlefield. In partial fulfillment for Agreement

- 1566 04-IA-11330138-234, between the NPS and USFS Southern Research Station. Revised
1567 March 19, 2009.
1568
- 1569 Warren II, R. J., 2008. Mechanisms driving understory evergreen herb distributions across slope
1570 aspects: as derived from landscape position. *Plant Ecology* 198: 297-308.
1571
- 1572 Weakley, A. 2010. Flora of the Southern and Mid-Atlantic States. University of North Carolina
1573 Herbarium (NCU), North Carolina Botanical Garden, University of North Carolina at
1574 Chapel Hill. Working Draft as of March 8, 2010.
- 1575 Weakley, A. 2015. Flora of the Southern and Mid-Atlantic States. University of North Carolina
1576 Herbarium (NCU), North Carolina Botanical Garden, University of North Carolina at
1577 Chapel Hill. Working Draft as of 21 May 2015.
1578
- 1579 Whittemore, A. T., and L. L. Gaddy. 1997. Hexastylis. In Flora of North America Editorial
1580 Committee [Eds.], Flora of North America north of Mexico, vol. 3, 54–58. Oxford
1581 University Press, New York, New York, USA.
- 1582 Wolf, S., B. Hartl, C. Carroll, M.C. Neel, and D.N. Greenwald. 2015. Beyond PVA: why
1583 recovery under the Endangered Species Act is more than population viability. *BioScience*
1584 65:200-207.
1585

Scenarios	Urbanization			Non-Current Populations Predicted to Persist
	Protected Areas		Non-Protected Areas	
	Perpetuity	Voluntary/Non-Perpetuity		
Status Quo	No negative impacts from urbanization.	Population drops 1 resilience rank if % increase in urbanization exceeds >50% threshold .	Population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold ; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold .	EOs prior to 2005 in the top 10% based on weighted ranking.
High Development	Population drops 1 resilience rank if % increase in urbanization exceeds >50% threshold .	Population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold ; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold .	Population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold ; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold ; extirpation of populations if % increase in urbanization exceeds >90% threshold .	None
Conservation	No negative impacts from urbanization.	Population drops 1 resilience rank if % increase in urbanization exceeds >50% threshold .	Population drops 1 resilience rank if % increase in urbanization exceeds >25% threshold ; population drops 2 resilience ranks if % increase in urbanization exceeds >50% threshold .	EOs prior to 2005 in the top 25% based on weighted ranking.

Scenarios	Urbanization			Non-Current Populations Predicted to Persist
	Protected Areas		Non-Protected Areas	
	Perpetuity	Voluntary/Non-Perpetuity		
Status Quo	No change.	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	EOs prior to 2005 in the top 10% based on weighted ranking.
High Development	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2 If increase in urbanization is>90% THEN extirpation	None
Conservation	No change.	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	EOs prior to 2005 in the top 25% based on weighted ranking.

Information Memorandum for the Secretary/Director

Date: July 16, 2018
From: Gary Frazier, Assistant Director, Ecological Services
Telephone: 202-208-4646
Subject: Dwarf-flowered Heartleaf Proposed Delisting

I. Introduction

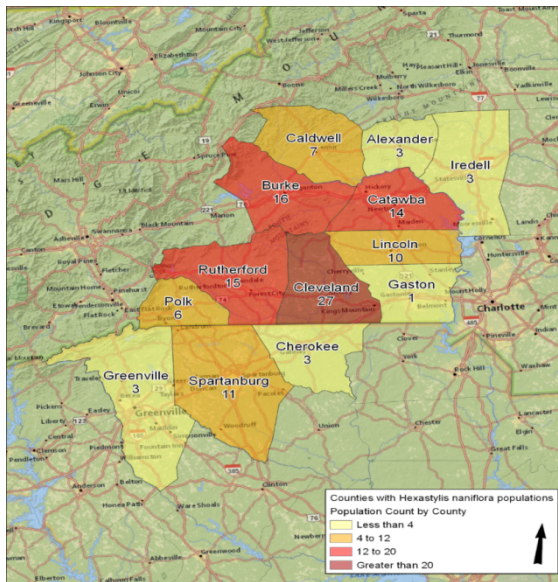
We are proposing to delist the dwarf-flowered heartleaf (*Hexastylis naniflora*). This ~~recommendation-proposal~~ is based on a thorough review of the best available scientific and commercial information, which indicates that this species does not meet the definition of an endangered species or threatened species.

II. Background



the species in 2018.

On April 14, 1989, we published a final rule in the Federal Register (FR 54 14964) listing listed the dwarf-flowered heartleaf as threatened due to residential and industrial development, conversion of habitat to pasture or small ponds, timber harvesting and cattle grazing (FR 54 14964). A recovery plan for the species was never completed. However, Over the last 29 years, the Service has worked closely with partners to recover this species. The Service initiated a Species Status Assessment (SSA) to aid in determining the appropriateness of reclassifying



Key Drivers of Species Status

CURRENT AND FUTURE CONDITIONS - The dwarf-flowered heartleaf is a low growing herbaceous plant in the birthwort family. When dwarf-flowered heartleaf was federally listed in 1989, the listing rule described 24 extant “populations” (and one extirpated population) distributed across eight counties in the upper Piedmont of North and South Carolina. Since 1989, the range has expanded to include five additional counties in North Carolina. In North Carolina, it is found in Alexander, Burke, Caldwell, Catawba, Cleveland, Gaston, Iredell, Lincoln, Polk, and Rutherford Counties. In South Carolina, it is in Cherokee, Greenville, and Spartanburg Counties. As of 2018, the distribution of this species consisted of 119 populations distributed across 13 counties in these two states.

At the time of listing, the species was most threatened by habitat loss due to the conversion of land to residential, commercial, and industrial use in these areas. In addition, other documented threats include habitat loss from land conversion to agricultural use, timber harvest, hydrological alterations from the damming of ponds, impacts from grazing cattle, ORV damage, trampling from foot traffic, invasive species, highway or road improvements, and erosion or siltation. In the SSA, we assessed these same factors as well as climate change to determine the viability of the dwarf-flowered heartleaf currently and in the future. Climate change through changes in temperature and precipitation may exacerbate these risk factors to the species.

Commented [KNN1]: Please define this

To determine current resiliency for populations, we used EO viability ranks and expert opinion to bin population size classes into corresponding resiliency categories. EO viability ranks for the species include excellent, good, fair, poor, extant, historical, and failed to find. The primary

Commented [KNN2]: Have we define this term in the IM?

factor in determining these ranks is EO size (as quantified by number of clumps). Condition of habitat (vegetation community and structure) and landscape context (extent of suitable habitat and physical factors) are incorporated secondarily. Recent reports (Robinson 2016, p. 7; Robinson and Padgett 2016, p. 4) focused monitoring studies on populations with greater than 1,000 individuals (assumed to be very viable). Because we do not have ~~habitat-level~~ information for every population we assessed, we synthesized available population size information and created four resiliency categories as follows:

- Very high—populations with >1,000 individuals; very high probability of persistence for 20-30 years at or above the current population size.
- High—populations with 500-1,000 individuals; moderate-high probability of persistence for 20-30 years at or above the current population size.
- Moderate—populations with 100-500 individuals; low probability of persistence for 20-30 years at or above the current population size.
- Low—populations with <100 individuals; low probability of persistence for 20-30 years at or above the current population size, and moderate-high probability of extirpation.

Of the 78 populations assessed, 28 had very high resiliency, five had high, 26 had moderate, while 19 had low resiliency.

We assessed the future condition of the dwarf-flowered heartleaf under three scenarios projected out to the year 2040. ~~We have identified 2040 as our foreseeable future based on the life span of the species, expert input, development as the key risk factor brought forward, uncertainty about future conditions, and lack of knowledge about where additional populations may persist on the landscape.~~ In the Status Quo scenario, there are predicted to be 75 populations of *Hexastylis naniflora* on the landscape in 2040. The predicted resiliency of the extant populations are as follows: very high (27); high (6); moderate (23); low (17); and two additional populations identified as persisting, with an unknown resiliency. Six EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist, but resiliency is unchanged because each of the populations are already predicted to be of very high resiliency. In the High Development scenario, there are predicted to be 72 populations of *Hexastylis naniflora* on the landscape in 2040. The predicted resiliency of the extant populations are as follows: very high (27); high (4); moderate (25); and low (16). No additional populations are identified as persisting. When comparing future population resiliency to current condition, a few populations drop in their resiliency category. One current population of very high resiliency is predicted to drop to moderate resiliency; one high resiliency population is predicted to drop to moderate; two moderate populations are predicted to drop to low resiliency; and six populations (one currently moderate and five currently low) are predicted to be extirpated due to urban development. In the Targeted Conservation scenario, there are predicted to be 79 populations of *Hexastylis naniflora* on the landscape in 2040. The predicted resiliency of the extant populations are as follows: very high (27); high (6); moderate (23); low (17); and six additional populations identified as persisting, with an unknown resiliency. Six EOs within currently delineated populations not included in our Current Conditions analysis are predicted to persist, but resiliency is unchanged because each of the populations are already predicted to be of very high resiliency. Thus, after considering the best available scientific and commercial

Commented [FB3]: Do we mean population estimates?

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information, we determine the dwarf-flowered heartleaf is not likely to become in danger of extinction in the foreseeable future.

Data Sources

The data set available for determining species abundance, distribution, and factors influencing the species viability predominantly relies on existing information from unpublished field survey results, research project reports, peer reviewed scientific publications, unpublished field observations by experienced biologists, personal communications, latest 5-year review, and the species status assessment report.

Section 4(d) Rule

~~Because we are proposing to delist this species, there will be no 4(d) rule for the dwarf-flowered heartleaf.~~

Recovery Criteria

~~There was no Recovery Plan completed for this species.~~

Conservation Efforts

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 *Hexastylis naniflora*.

The overwhelming majority of *Hexastylis 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 *Hexastylis 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. We actively working to follow-up on commitments previously pledged on behalf of *Hexastylis naniflora*. It is unlikely that any of these sites would have been afforded protection without this statutory protection.~~

Commented [FB5]: This section is too vague. Should include time frames, who did the surveys, etc.

Commented [FB6]: Include information on the number of acres or % of the range (or populations) conserved as a result of these. Are they conservation easements? Fee title purchases with long-term management assured?

Tens of thousands of threatened dwarf-flowered heartleaf plants are conserved by Duke Energy along the Broad River. Another population is conserved at Cowpens National Battlefield, in upstate South Carolina. A third is part of the Broad River Greenway, a local park in North Carolina's Cleveland County. These are three of many conservation efforts for the heartleaf, leading the USFWS to propose removing it from the federal threatened and endangered species list. Key to that conservation effort has been organizations acquiring and permanently protecting sites where the plant grows. Foothills Conservancy, Catawba Lands Conservancy, and The Nature Conservancy all protect sites. The North Carolina Department of Transportation is one of the greatest contributors to conservation, acquiring land and conserving multiple populations over the years, including land that became part of Cleveland County's Broad River Greenway.

Commented [FB7]: Collectively, how much of the range is in permanent protection? And, any of these were a result of S7 consultation, move that part of the information to the above .

Post-Delisting Monitoring

The purpose of post-delisting monitoring is to verify that the dwarf-flowered heartleaf (*Hexastylis naniflora*) remains secure from the risk of extinction after it has been removed from the protections of the Act. The Service prepared ~~this a~~ draft post-delisting monitoring (PDM) plan (~~Plan~~), in coordination with ~~different our~~ partners. This draft plan is designed to detect substantial declines in the dwarf-flowered heartleaf population with reasonable certainty and precision. It meets the minimum requirement set forth by the Act by effectively monitoring the status of dwarf-flowered heartleaf using annual sampling events.

The information below this line is for informational and outreach purposes only and has not been used as the basis for any potential Agency decision.

III. Positions of Interested Parties

The dwarf-flowered heartleaf occurs on public and private land, based on a long history of outreach and conservation projects, landowners would likely be neutral or favorable regarding a proposed delisting.

IV. Potential Issues/Conflicts

Potential issues and conflicts with this proposed delisting are not anticipated.

V. Communications and Outreach

Outreach Lead: Phil Kloer

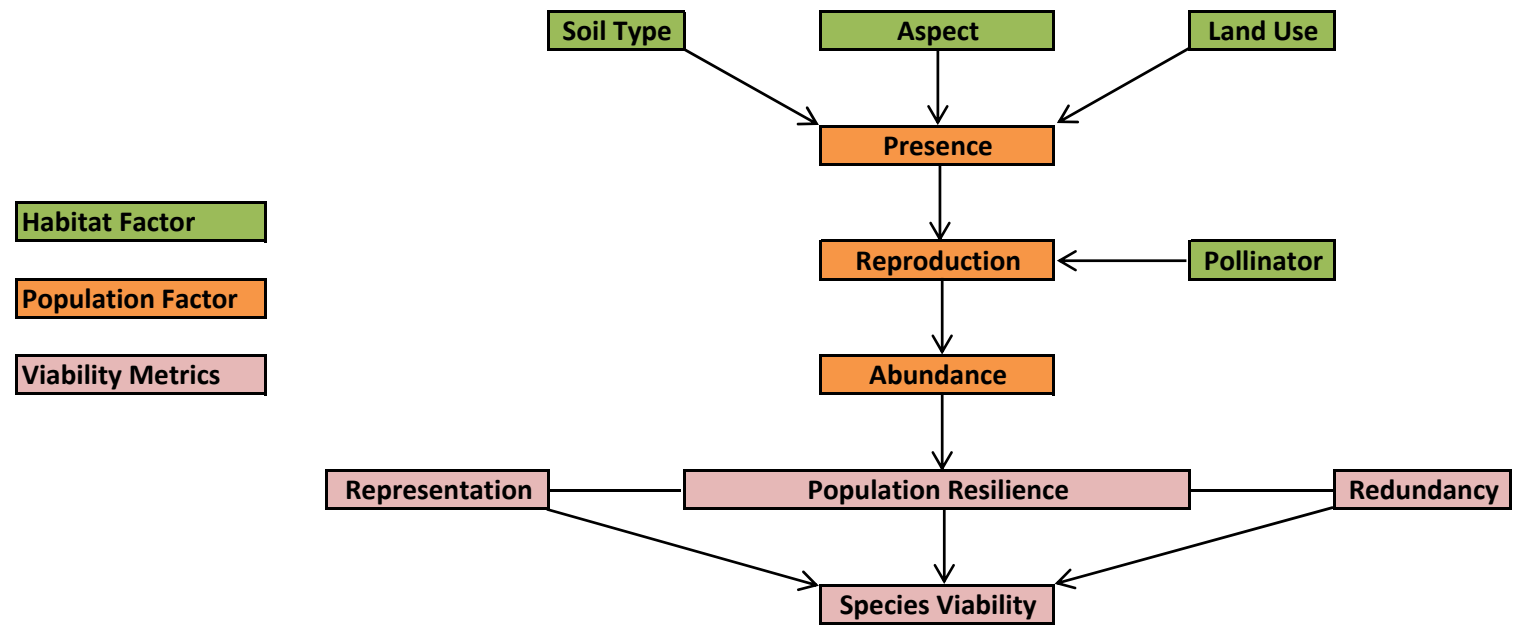
Affected States: North/South Carolina

Media POC: Phil Kloer 404-679-7299

Congressional: Kristen Peters (EA) will send advance notification emails to Congressionals via email two days before rule publication.

State Contacts: Raleigh Ecological Services Office Field Supervisor (Pete Benjamin) will ensure email notification sent to the following offices: North/South Carolina Governor's Office, Deputy Chief of Staff; NC Botanical Garden, Director of Conservation Programs; NC Forest Service, Regional Forester; NC Division of Parks and Recreation – State Parks, Director; NC Natural Heritage Program, Director; NC Plant Conservation Program, Administrator; NC Clean Water Management Trust Fund, Acquisition Program Manager.

Other Outreach: Region 4 Facebook and Twitter Accounts – Katherine Taylor.



Information Memorandum for the Secretary/Director

Date: October 10, 2018
From: Gary Frazier, Assistant Director, Ecological Services
Telephone: 202-208-4646
Subject: Dwarf-flowered Heartleaf Proposed Delisting

I. Introduction

We are proposing to delist the Dwarf-flowered heartleaf (*Hexastylis naniflora*). This recommendation is based on a thorough review of the best available scientific and commercial information, which indicates that this species does not meet the definition of an endangered species or threatened species.

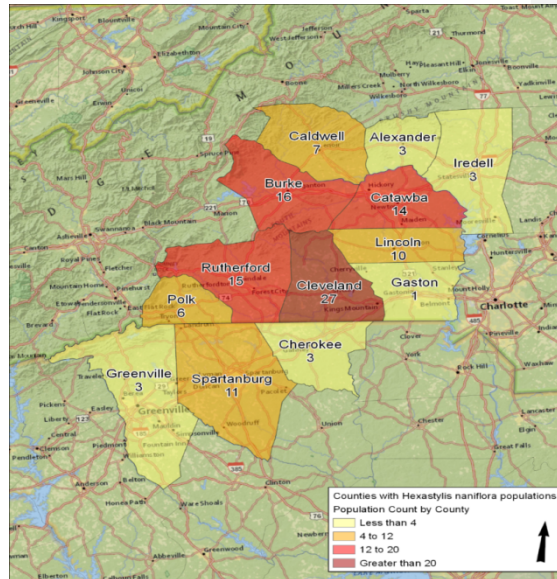
II. Background



On April 14, 1989, we published a final rule in the Federal Register (FR 54 14964) listing the Dwarf-flowered heartleaf as threatened due to residential and industrial development, conversion of habitat to pasture or small ponds, timber harvesting and cattle grazing. A Recovery Outline was developed in 1989; however, a Recovery Plan for the species was never completed. However, over the last 29 years, the Service has worked closely with partners to recover this species. In January of 2018, the Service initiated a Species Status Assessment (SSA) to aid in determining the

appropriateness of reclassifying the species in 2018.

The dwarf-flowered heartleaf is a rare, low growing herbaceous plant in the birthwort family. The habitat consists of mesic to dry bluffs, slopes, or ravines; and moist soils adjacent to creeks, streamheads, or along lakes and rivers. When dwarf-flowered heartleaf was federally listed in 1989, the listing rule described 24 extant “populations” (and one extirpated population) distributed across eight counties in the upper Piedmont of North and South Carolina. This included approximately 5,000 individuals. Since 1989, the range has expanded to include five additional counties in North Carolina. In North Carolina, it is found in Alexander, Burke, Caldwell, Catawba, Cleveland, Gaston, Iredell, Lincoln, Polk, and Rutherford Counties. In South Carolina, it is found in Cherokee, Greenville, and Spartanburg Counties. As of 2018, the distribution of this species ~~consisted~~ consists of 119 populations distributed across 13 counties ~~in these two states totaling more than 300,000 individuals.~~



Key Drivers of Species Status

CURRENT AND FUTURE CONDITIONS - When dwarf-flowered heartleaf was federally listed in 1989, the listing rule described 24 extant “populations” (and one extirpated population) distributed across eight counties in the upper Piedmont of North and South Carolina. Since 1989, the range has expanded to include five additional counties in North Carolina. In North Carolina, it is found in Alexander, Burke, Caldwell, Catawba, Cleveland, Gaston, Iredell, Lincoln, Polk, and Rutherford Counties. In South Carolina, it is in Cherokee, Greenville, and Spartanburg Counties. As of 2018, the distribution of this species consisted of 119 populations distributed across 13 counties in these two states. At the time of listing, the species was most threatened by habitat loss due to the conversion of land to residential, commercial, and industrial use in these areas. In addition to threats associated with residential, commercial, and industrial development, other documented threats include habitat loss from land conversion to agricultural use, timber harvest, hydrological alterations from the damming of ponds, impacts from grazing cattle, ORV damage, trampling from foot traffic, invasive species, highway or road improvements, and erosion or siltation. Climate change may exacerbate these risk factors through changes in temperature and precipitation.

Commented [RNR1]: This seems to be the same information described in the Intro and Background. Consider my revision.

For the purposes of the SSA, we took a conservative approach and defined current populations as those populations that had been observed since 2005. This year was chosen to be consistent with the habitat model used in our analysis, and this year coincides with a significant monitoring effort that occurred during initiation of the last 5-year review. Based on these criteria, we identified 78 populations, across the species range, that meet our definition of current. To defined current conditions, each population was assigned a resiliency rank that is based on abundance and Element Occurrence viability ranks as defined by the Heritage Programs.

To analyze future condition of the species, three scenarios were developed and assessed to 2040: Status Quo, High Development, and Targeted Conservation. These scenarios represent a range of possibilities that capture uncertainty about the future. Modeling tools were used to predict which populations would be affected by urban development. Assessment rules were then developed to predict how urban development would affect resiliency of each population for each scenario. Populations not defined as current were also assessed, and a determination of persistence was made based on results of a weighted ranking model. Below is a table comparing current and future conditions of the 78 populations.

	Current	Status Quo	High Development	Targeted Conservation
Very High	28	27	27	27
High	5	6	4	6
Moderate	26	23	25	23
Low	19	17	16	17
Extirpated	n/a	5	6	5
Persisting	n/a	2	0	6
Total	78	75	72	79

Urban development is predicted to reduce the resiliency of several current populations under all scenarios. Extirpations are also predicted under each scenario. However, loss of resilience and extirpations are offset by persisting populations in the Status Quo and Targeted Conservation scenarios. In all scenarios, the majority of the populations in 2040 are of at least moderate resilience.

Given the number of populations across each scenario, redundancy remains similar to current conditions. Although we did not delineate representative units, we do not believe our scenarios predict declines in species representation since the populations in each scenario occur in both habitats known for the species.

Data Sources

NatureServe. 2002. Element Occurrence Data Standard, 6 February 2002. NatureServe, Arlington, Virginia. Accessed at http://www.natureserve.org/library/deliminting_plant_eos_Oct_2004.pdf, August 2016.

Newberry, G. 2006. South Carolina Populations of *Hexastylis naniflora*: 2006 updates. Received by the USFWS Asheville Field Office, September 7, 2006.

North Carolina Natural Heritage Program (NCNHP). 2018. Natural Heritage Element Occurrences. Accessed at <https://www.ncnhp.org/activities/conservation/natural-heritage-element-occurrences>, January 2018.

Robinson L.G. 2016. Dwarf-flowered Heartleaf range-wide status report. Final report to U.S. Department of Interior—U.S. Fish and Wildlife Service by North Carolina Natural Heritage Program. August 2016.

Robinson, L.G. and J.E. Padgett. 2016. Dwarf-flowered Heartleaf (*Hexastylis naniflora*) comprehensive review and monitoring report. Final report to the U.S. Department of Interior—U.S. Fish and Wildlife Service by the North Carolina Natural Heritage Program. August 2016.

South Carolina Department of Natural Resources (SCDNR) Heritage Trust. 2016. Element Occurrence Records for *Hexastylis naniflora* (dwarf-flowered heartleaf). As of: February 4, 2016.

USFWS. 2010. Draft Five Year Review for *Hexastylis naniflora* (dwarf flowered heartleaf). September 30, 2010. Submitted to the USFWS Southeast Regional Office September 30, 2010.

Recovery Criteria

There was no Recovery Plan completed for this species.

Section 4(d) Rule

Because we are delisting this species, there will be no 4(d) rule for the ~~d~~dwarf-flowered heartleaf.

Conservation Efforts

Protection status for the 78 populations identified as current was determined as a part of the SSA. Twenty-four populations, at least in part, are protected in perpetuity, 18 populations, at least in part, are voluntarily protected or protected but not in perpetuity, 34 populations are not protected, and two populations have an unknown status. Several populations are afforded permanent protection through fee title ownership by conservation partners. These sites include NCDOT mitigation sites at Murrays Mill and the Broad River Greenway. Other sites in permanent protection include the Catawba Lands Conservancy's Rhyne Preserve, the Cleveland County Landfill, Cowpens National Battlefield, and Peters Creek South Carolina State Heritage

Preserve. NCNHP holds four voluntary Registry Agreements with private landowners for the purpose of protecting *Hexastylis naniflora*. These sites are the Parris Heartleaf Registered Heritage Area (RHA), the New Hope Springhead (Barefield) RHA, the Catawba County Wildlife Club RHA, and the Smith Cliff/Henry Fork RHA. Some populations are protected through conservation easements held by various partners. These include populations at the New Bethel Rare Plant Site, held by NCDOT. The Foothills Conservancy of NC holds a conservation easement at Peaked Top Rare Plant Site, and The Nature Conservancy holds a conservation easement at Jacob Fork West Corridor.

The information below this line is for informational and outreach purposes only and has not been used as the basis for any potential Agency decision.

III. Positions of Interested Parties

A total of 78 emails and six letters were sent to interested parties at the beginning of the SSA process. The three responses received pertained to site-specific locations of *Hexastylis naniflora*. No comments or opinions regarding the appropriateness of reclassifying the species were received. Our technical team included members of the NC Natural Heritage Program and faculty at Appalachian State University. Members of these organizations did not express a position for or against reclassification of the species. The draft SSA was sent to seven potential peer reviewers. To date, no comments have been received as a result of the peer review.

IV. Potential Issues/Conflicts

Potential issues and conflicts with this proposed delisting are not anticipated.

V. Communications and Outreach

Outreach Lead: Phil Kloer

Affected States: North/South Carolina

Media POC: Phil Kloer 404-679-7299

Congressional:

State Contacts:

Commented [RNR2]: I think Gary Peebles has a spreadsheet with outreach information and contacts. He is at the Project Leaders Meeting this week so I won't be able to get this for you until he returns.

From: [Joe Lemeris](#)
To: [Reid, Rebekah N](#); [Keith A. Bradley](#); [Punsalan, April L](#); [Straight, Carrie A](#)
Subject: RE: [EXTERNAL] FW: Hexastylis Naniflora Data
Date: Tuesday, August 3, 2021 10:11:51 AM
Attachments: [image001.png](#)
[image002.png](#)

Hey all,

As an update here, Keith and I chatted about this and decided to let him know we'd prefer he focus on another species for his course, given the sensitivity of the species and the fact that several entities have already modeled it. We suggested a few alternatives (Georgia aster, may white azalea) but his response was as follows:

'No problem at all.

I'm aware of that NCDOT report. I will just use the parameters from it instead.'

I guess he's not too concerned about conducting something new – and all he needs may be in the DOT report anyway.

Thanks for your input all!

Joe

[Joseph Lemeris, Jr.](#)

GIS/Data Manager, Natural Heritage Program | o: 803-734-1396 | m: 843-729-0679 | e: LemerisJ@dnr.sc.gov
South Carolina Dept. of Natural Resources | 1000 Assembly St, Columbia, SC 29201 | www.heritagetrust.dnr.sc.gov



From: Reid, Rebekah N <rebekah_reid@fws.gov>
Sent: Monday, August 2, 2021 1:55 PM
To: Joe Lemeris <LemerisJ@dnr.sc.gov>; Keith A. Bradley <BradleyK@dnr.sc.gov>; Punsalan, April L <april_punsalan@fws.gov>; Straight, Carrie A <carrie_straight@fws.gov>
Subject: Re: [EXTERNAL] FW: Hexastylis Naniflora Data

Thanks. I reached out to NCNHP and they have not had a similar request but did say they think NatureServe and DOT has already done models for the species.

I'm open to ideas but we usually recommend people work with non-listed species unless it's necessary to use a listed species.

Rebekah Reid

US Fish and Wildlife Service
Asheville Ecological Services Field Office

160 Zillicoa St.
Asheville, NC 28801
phone: 828-258-3939 x42238
cell: 828-782-0090

NOTE: This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act (FOIA) and may be disclosed to third parties.

From: Joe Lemeris <LemerisJ@dnr.sc.gov>
Sent: Monday, August 2, 2021 1:41 PM
To: Reid, Rebekah N <rebekah_reid@fws.gov>; Keith A. Bradley <BradleyK@dnr.sc.gov>; Punsalan, April L <april_punsalan@fws.gov>; Straight, Carrie A <carrie_straight@fws.gov>
Subject: RE: [EXTERNAL] FW: Hexastylis Naniflora Data

Thanks for the feedback Rebekah!

I followed up with Lukas to see if he could elaborate, and he provided the following:

I am working on a project for Coursera and since the Dwarf Flowered Heartleaf comes up all the time for the IPaC I wanted to use the data to make a habitat suitability model. And no the model is more for internal use but specifically for the project in my course. I will not be sharing it.

I wonder if we could make the data available to him under the stipulation that they share their suitability model back with us for review/comment? We've also recently developed a modelling workflow internally that we could use to compare results if possible (if you're up for it Keith!)

Joe

[Joseph Lemeris, Jr.](#)

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South Carolina Dept. of Natural Resources | 1000 Assembly St, Columbia, SC 29201 | www.heritagetrust.dnr.sc.gov



From: Reid, Rebekah N <rebekah_reid@fws.gov>
Sent: Monday, August 2, 2021 11:35 AM
To: Keith A. Bradley <BradleyK@dnr.sc.gov>; Punsalan, April L <april_punsalan@fws.gov>; Straight, Carrie A <carrie_straight@fws.gov>
Cc: Joe Lemeris <LemerisJ@dnr.sc.gov>
Subject: Re: [EXTERNAL] FW: Hexastylis Naniflora Data

Hi,

I have heard of this consulting firm but not this particular individual. They typically help development clients through environmental permitting and Section 7 (at least that's how I've interacted with them). I'm not aware of any modeling they are doing. I would be hesitant to provide all data records for a State unless we had more info on the modeling effort. What are they doing? Why?

I'll reach out to NCNHP to see if they've had a similar request.

Thanks,

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Subject: [EXTERNAL] FW: Hexastylis Naniflora Data

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Hi all,

Have you ever heard of this consultant or any modelling work they're doing with Hexastylis naniflora?

Thanks,

Keith

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Hey Keith –

See the below request from an env. consultant from S&ME. Do you have any heartburn about providing Hexastylis records to them?

Joe

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South Carolina Dept. of Natural Resources | 1000 Assembly St, Columbia, SC 29201 | www.heritagetrust.dnr.sc.gov



From: Lukas P Ballard <lballard@smeinc.com>
Sent: Monday, August 2, 2021 10:12 AM
To: Joe Lemeris <LemerisJ@dnr.sc.gov>
Subject: RE: Hexastylis Naniflora Data

That's right Joe,

It would be for state-wide occurrences.

I am wanting the observed locations in data format so I can derive the data and create potential models.

From: Joe Lemeris <LemerisJ@dnr.sc.gov>
Sent: Monday, August 2, 2021 9:29 AM
To: Lukas P Ballard <lballard@smeinc.com>
Subject: RE: Hexastylis Naniflora Data

This message originated outside of S&ME. Please report this as phishing if it implies it is from an S&ME employee.

Hi Lukas,

Thanks, hope you're doing well too!

Is this in reference to a particular project you're concerned about impacts to? Generally we usually only provide static copies of datasets for sensitive species if it's related to a specific impact area. If you're able to provide a description of what you'd like the data for, if you're looking for state-wide occurrences for the species or just specific areas, and why, we can try to assist you further.

Thanks!

Joe

[Joseph Lemeris, Jr.](#)

GIS/Data Manager, Natural Heritage Program | o: 803-734-1396 | m: 843-729-0679 | e: LemerisJ@dnr.sc.gov
South Carolina Dept. of Natural Resources | 1000 Assembly St, Columbia, SC 29201 | www.heritagetrust.dnr.sc.gov



From: Lukas P Ballard <lballard@smeinc.com>

Sent: Sunday, August 1, 2021 10:04 AM

To: Joe Lemeris <LemerisJ@dnr.sc.gov>

Subject: Hexastylis Naniflora Data

Good Morning Joe,

I hope you are doing well.

Is it possible for you to provide me with the shapefiles for known occurrences of Hexastylis Naiflora?

Please let me know what options would be available.

Thank you

Lukas Ballard
Staff Scientist



S&ME
48 Brookfield Oaks Drive, Suite F
Greenville, SC 29607 [map](#)
O: 864.297.9944
M: 864.923.0239
www.smeinc.com
[LinkedIn](#) | [Twitter](#) | [Facebook](#)

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EXTERNAL EMAIL: Do not click any links or open any attachments unless you trust the sender and know the content is safe.

Kelly Bibb/R4/FWS/DOI

05/02/2011 03:49 PM To

Kate Norman/ARL/R9/FWS/DOI, Kelly Hornaday/ARL/R9/FWS/DOI, Jennifer Strickland/R4/FWS/DOI, Brian Cole/R4/FWS/DOI, Carolyn Wells/R6/FWS/DOI
cc

bcc

Subject

Another 5-year review ready for uploading =o)

Thanks to Asheville for the hard work on this one =o) Yippee another one done for the Region =o)

Kelly and Kate, here is another one ready for uploading to the species profiles on our nat'l page =o) another one signed yea!!

Jenny, Here is another one ready for

<http://www.fws.gov/southeast/5yearReviews/5yearreviews/index.html>

You have a line on this table already for this plant; it is just waiting for the file to be hyperlinked to it =o)

Kelly Ann Bibb
Recovery Coordinator
Endangered Species Program
Southeast Region
Phone: 404-679-7132
Fax: 404-679-7081
kelly_bibb@fws.gov

From: [Straight, Carrie A](#)
To: [Valenta, Aaron](#)
Subject: RE: Congressional Inquiry (McHenry) - Dwarf-flowered heartleaf
Date: Thursday, June 18, 2020 1:30:00 PM

Thanks, This is the species that I asked Kristi about earlier today, so that I could take it out of my FR notice.

carrie

<°)))))< <°)))))< <°)))))< <°)))))< <°)))))<

Carrie A. Straight, PhD

Pronouns: she, her, hers

Recovery Coordinator
U.S. Fish and Wildlife Service
1875 Century Boulevard
Atlanta, Georgia 30345

NOTE: This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act (FOIA) and may be disclosed to third parties.

From: Valenta, Aaron <aaron_valenta@fws.gov>
Sent: Thursday, June 18, 2020 1:00 PM
To: Straight, Carrie A <carrie_straight@fws.gov>
Subject: Fw: Congressional Inquiry (McHenry) - Dwarf-flowered heartleaf

FYI

Thanks,

Aaron Valenta

Chief, Division of Restoration and Recovery
U.S. Fish and Wildlife Service
1875 Century Boulevard
Atlanta, Georgia 30345
404/679-4144

This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act and may be disclosed to third parties.

From: Young, Kristi <kristi_young@fws.gov>
Sent: Thursday, June 18, 2020 12:55 PM
To: Mizzi, Janet <janet_mizzi@fws.gov>; Valenta, Aaron <aaron_valenta@fws.gov>
Cc: Peeples, Gary <gary_peeples@fws.gov>
Subject: Re: Congressional Inquiry (McHenry) - Dwarf-flowered heartleaf

>:<>:<>:<>:<>:<>:<><>:<>:<>:<>:<>:<>:<>:<

>:<>:<>:<>:<>:<>:<><>:<>:<>:<>:<>:<>:<>:<>:<

From: Young, Kristi <kristi_young@fws.gov>
Sent: Thursday, June 18, 2020 12:29 PM

There is no current petition to delist the Dwarf Flowered Heart Leaf under the ESA. I'm copying in my colleague Kristen Peters, who covers Congressional Affairs for the Service's Southeast Regional office. Kristen should be able to tell you if there is an upcoming status review for the species and share any specific restrictions to protect the species.

Best,
Alyssa

Alyssa Hausman
Congressional and Legislative Affairs Specialist
U.S. Fish and Wildlife Service
Office: (703) 358-2275
Mobile: (703) 785-3402
alyssa_hausman@fws.gov

From: Jones, Lisa M <lisa_m_jones@fws.gov>
Sent: Thursday, June 18, 2020 10:56 AM
To: McCrary, David <David.McCrary@mail.house.gov>
Cc: Hausman, Alyssa B <alyssa_hausman@fws.gov>
Subject: Re: [EXTERNAL] Neill

Hi David,

Thank you for reaching out to our office. I'm looping in my colleague Alyssa who can help you with this inquiry.

Best,

Lisa

Lisa Hummon-Jones
Congressional and Legislative Affairs Specialist
U.S. Fish and Wildlife Service
703-358-2536 (o)
202-365-7255 (c)

From: McCrary, David <David.McCrary@mail.house.gov>
Sent: Wednesday, June 17, 2020 9:09 PM
To: Jones, Lisa M <lisa_m_jones@fws.gov>

Subject: [EXTERNAL] Neill

Lisa,

Mr. Neill has contacted us about his interest in learning what, if any, development restrictions are associated with the Dwarf Flowered Heart Leaf's current threatened status and if there are any petitions under review or other pending action that could potentially delist the plant or classify it in a more stable status.

Any information you can provide that will help us respond to the constituent will be appreciated.

Thanks,

David

David McCrary
Constituent Services Director
Congressman Patrick McHenry
Phone: 828-327-6100
Fax: (828) 327-8311



Dwarf-flowered Heartleaf (*Hexastylis naniflora*)

Species Status Assessment Overview



Photo credit: Jim Fowler

RD Briefing

October 10, 2018



Stakeholder Engagement

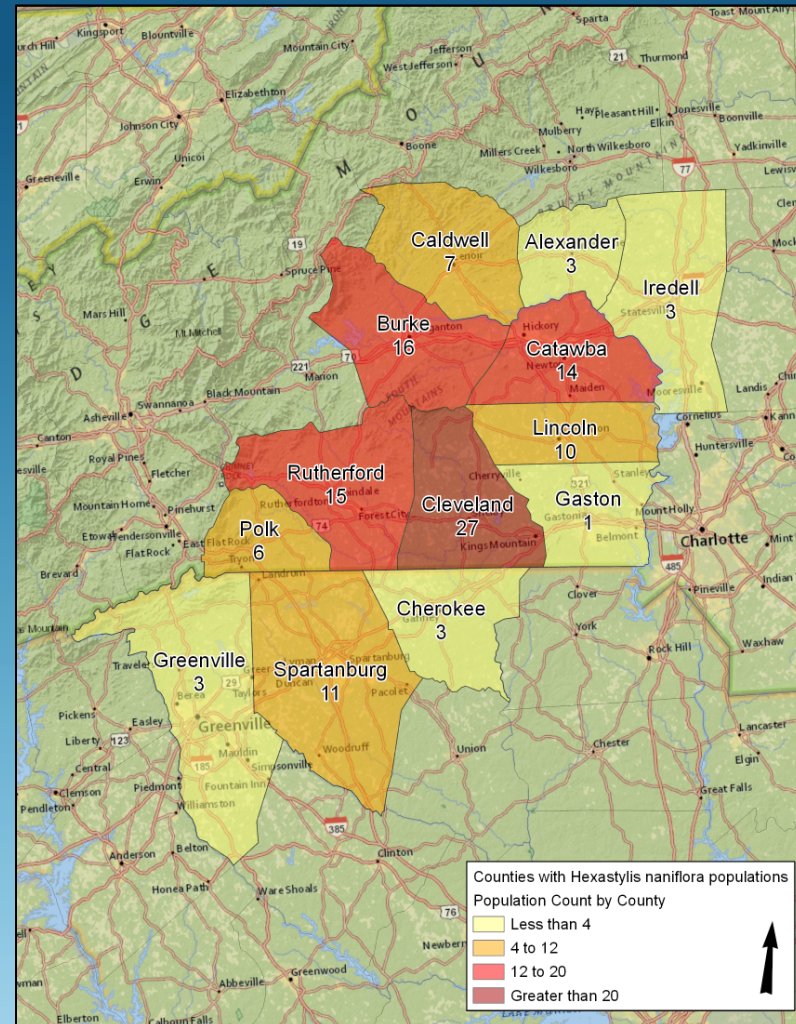
- “Dear Interested Party” letters
- Expert review and engagement
- NC vs. SC Involvement
- Peer Review





Listing & Recovery History

- Listed as threatened in 1989
 - 24 known populations in 8 counties
 - Approx. 5,000 individuals
 - Development was listed as the main threat
- Recovery Outline developed in 1989
- Recovery Plan never completed
- 5-Year Review (2011)
- Range-wide Status Report (2016)
- Species Status Assessment (2018)
 - 119 known populations in 13 counties
 - Approx. 300,000+ individuals





Species Description

- Low-growing herbaceous perennial.
- Leaves – small, evergreen, heart-shaped, dark green (variegated), and leathery.
- Flowers – small, jug-shaped, beige to dark brown, found near the base of plant.
- Blooms from mid-March to June, fruits from mid-May to July
- Pollinated by small insects, dispersed by ants



Photo credit:
A. Krings (NCSU)



Photo credit
(all others):
Jim Fowler



Species Habitat and Needs

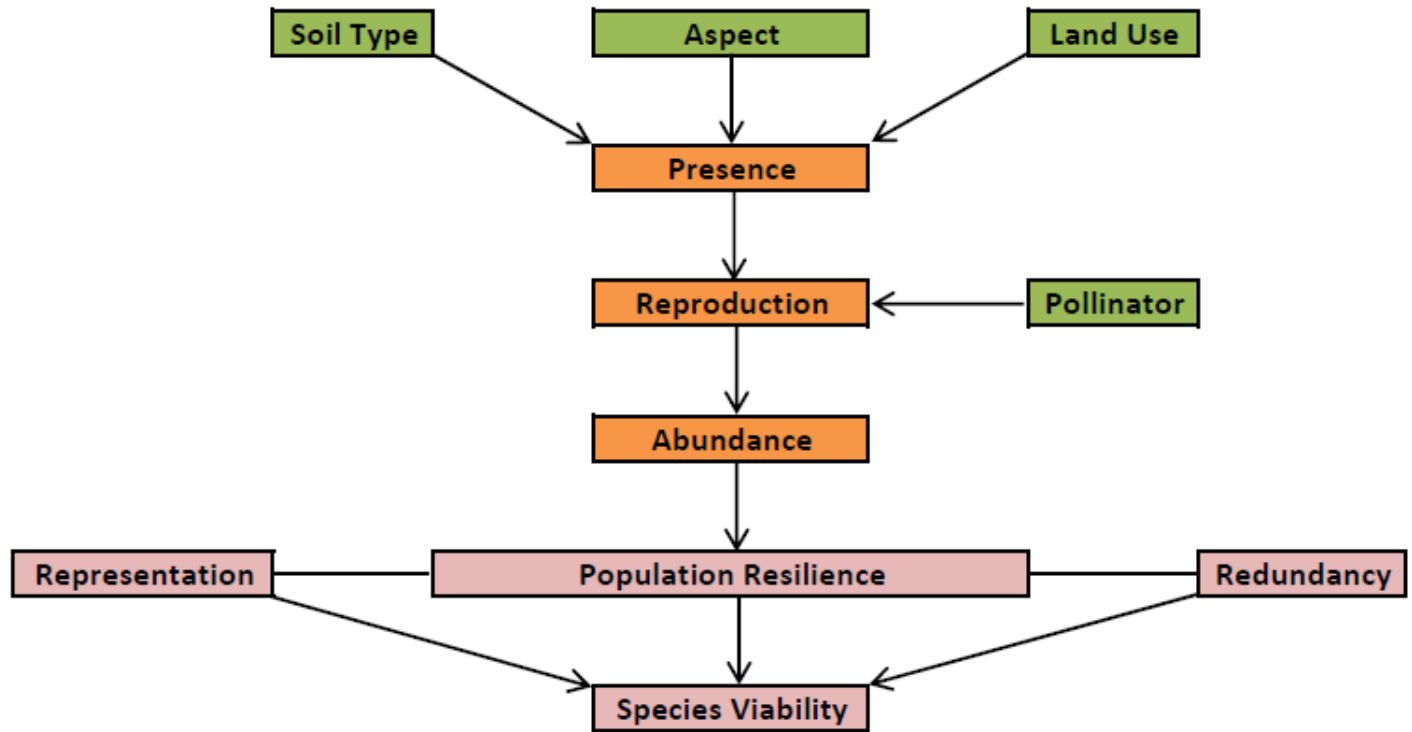


- Piedmont uplands
- Acidic sandy-loam soils
- Mesic to dry bluffs, slopes, or ravines in deciduous forest OR
- Moist soils adjacent to streams, and along lakes and rivers
- Affinity for:
 - mountain laurel (*Kalmia latifolia*)
 - north and northwest facing slopes
 - floodplains

Photo credit:
A. Krings (NCSU)



Overview of Species Needs and Viability





Current Conditions

Population Resilience

County	Very High	High	Moderate	Low	Totals
Alexander	1		1	1	3
Burke/Catawba/Caldwell			1		1
Burke	2		4	2	8
Caldwell	2	2		1	5
Catawba	4	2	4	2	12
Cherokee	1				1
Cleveland/Rutherford	1				1
Cleveland	4	1	7	6	18
Gaston			1		1
Greenville				2	2
Iredell			1	2	3
Lincoln	2		1	2	5
Polk	2		3	1	6
Rutherford	7		3		10
Spartanburg	2				2
Totals	28	5	26	19	78
% of total	36	7	34	23	100
Cumulative %	40	43	77	100	--

•Resilience

- Defined “current” populations .
- Assessed using abundance and EO viability ranks
- 4 categories

•Representation

- Lack of genetic and ecological diversity data
- No representative units defined
- Two habitat types

•Redundancy

- 78 pops defined as current (total 119 pops) distributed across 13 counties



Potential Factors Influencing Viability

- Development
- Incompatible forestry practices
- Erosion and sedimentation
- Invasive exotic species
- Trampling
- Agricultural use
- Road construction and improvement





Future Conditions

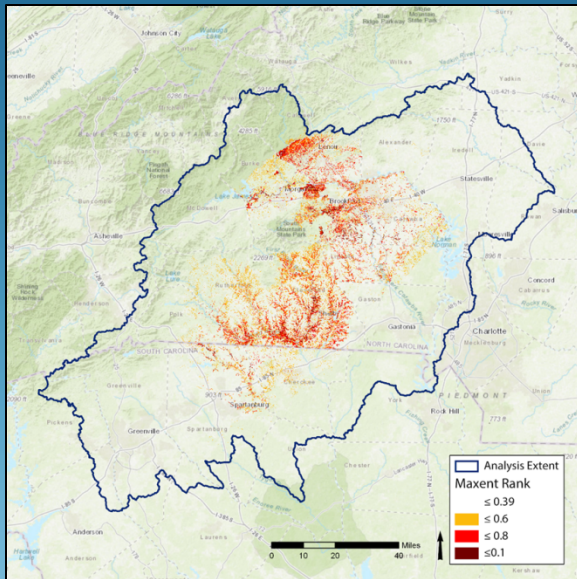
- Development of Future Scenarios
 - Primary threat = Development
 - Persistence of populations (pre-2005)
 - Assessment to 2040
- Three Scenarios
 - Status Quo
 - High Development
 - Targeted Conservation



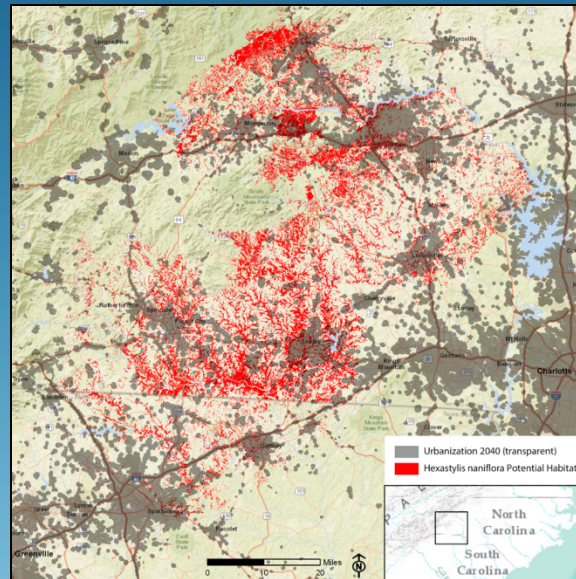


Future Conditions

Tools used to assess future scenarios



Maxent Habitat Model



SLEUTH Model

Table 6.5. Final Rank Scores for EOs in North and South Carolina. Dark green represents the top 10% of scores, and light green includes the top 25% of scores.
 EO not part of a current population
 EO included as part of a current population
 EO is a part of a current population but last detection was prior to 2005
 Eliminated/not scored

South Carolina		North Carolina	
EO Code	Final Score	EO Code	Final Score
60	79	149	94
7	79	73	93
17	75	49	92
16	74	12	90
27	71	238	90
28	70	161	88
31	69	227	87
14	66	249	86
11	63	233	86
38	62	182	85
34	61	250	85
1	60	251	84
26	59	194	84
52	56	51	84
57	56	310	84
18	55	75	84
37	54	113	84
36	48	319	81
42	44	76	81
2	43	74	81
40	42	10	80
59	41	181	79
48	40	156	78

Weighted Ranking Model

•Protection Status



Future Condition

Assessment Rules

Scenarios	Urbanization			Non-Current Populations Predicted to Persist
	Protected Areas		Non-Protected Areas	
	Perpetuity	Voluntary/Non-Perpetuity		
Status Quo	No change.	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	EOs prior to 2005 in the top 10% based on weighted ranking.
High Development	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2 If increase in urbanization is>90% THEN extirpation	None
Conservation	No change.	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	EOs prior to 2005 in the top 25% based on weighted ranking.



Status Quo Results

	Current	Status Quo
Very High	28	27
High	5	6
Moderate	26	23
Low	19	17
Extirpated	n/a	5
Persisting	n/a	2
Total	78	75

Scenarios	Urbanization			Non-Current Populations Predicted to Persist
	Protected Areas		Non-Protected Areas	
	Perpetuity	Voluntary/Non-Perpetuity		
Status Quo	No change.	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	EOs prior to 2005 in the top 10% based on weighted ranking.



High Development Results

	Current	High Development
Very High	28	27
High	5	4
Moderate	26	25
Low	19	16
Extirpated	n/a	6
Persisting	n/a	0
Total	78	72

Scenarios	Urbanization			Non-Current Populations Predicted to Persist
	Protected Areas		Non-Protected Areas	
	Perpetuity	Voluntary/Non-Perpetuity		
High Development	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2 If increase in urbanization is>90% THEN extirpation	None



Targeted Conservation Results

	Current	Targeted Conservation
Very High	28	27
High	5	6
Moderate	26	23
Low	19	17
Extirpated	n/a	5
Persisting	n/a	6
Total	78	79

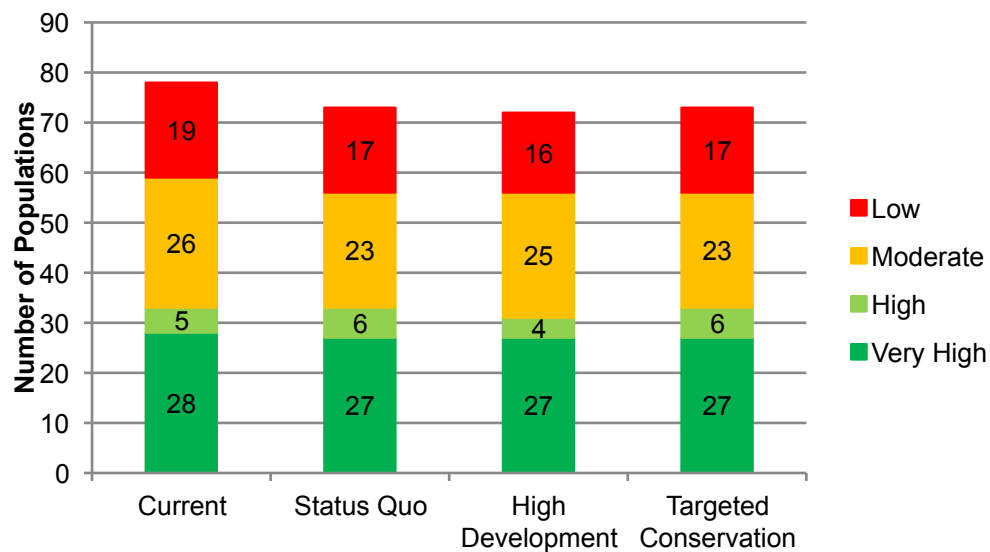
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Viability Summary

	Current	Status Quo	High Development	Targeted Conservation
Very High	28	27	27	27
High	5	6	4	6
Moderate	26	23	25	23
Low	19	17	16	17
Extirpated	n/a	5	6	5
Persisting	n/a	2	0	6
Total	78	75	72	79

Future Scenarios





Questions?



Photo credit: Jim Fowler

From: [Reid, Rebekah N](#)
To: [Keith A. Bradley](#); [Punsalan, April L](#); [Straight, Carrie A](#)
Cc: [Joe Lemeris](#)
Subject: Re: [EXTERNAL] FW: Hexastylis Naniflora Data
Date: Monday, August 2, 2021 11:35:03 AM
Attachments: [image001.png](#)
[image002.png](#)

Hi,

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[Joseph Lemeris, Jr.](#)

GIS/Data Manager, Natural Heritage Program | o: 803-734-1396 | m: 843-729-0679 | e: LemerisJ@dnr.sc.gov
South Carolina Dept. of Natural Resources | 1000 Assembly St, Columbia, SC 29201 | www.heritagetrust.dnr.sc.gov



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Subject: RE: Hexastylis Naniflora Data

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Hi Lukas,

Thanks, hope you're doing well too!

Is this in reference to a particular project you're concerned about impacts to? Generally we usually only provide static copies of datasets for sensitive species if it's related to a specific impact area. If you're able to provide a description of what you'd like the data for, if you're looking for state-wide occurrences for the species or just specific areas, and why, we can try to assist you further.

Thanks!

Joe

Joseph Lemeris, Jr.

GIS/Data Manager, Natural Heritage Program | o: 803-734-1396 | m: 843-729-0679 | e: LemerisJ@dnr.sc.gov

South Carolina Dept. of Natural Resources | 1000 Assembly St, Columbia, SC 29201 | www.heritagetrust.dnr.sc.gov



From: Lukas P Ballard <lballard@smeinc.com>

Sent: Sunday, August 1, 2021 10:04 AM

To: Joe Lemeris <LemerisJ@dnr.sc.gov>

Subject: Hexastylis Naniflora Data

Good Morning Joe,

I hope you are doing well.

Is it possible for you to provide me with the shapefiles for known occurrences of Hexastylis Naiflora?

Please let me know what options would be available.

Thank you

Lukas Ballard

Staff Scientist

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From: [Reid, Rebekah N](#)
To: [Joe Lemeris](#); [Keith A. Bradley](#); [Punsalan, April L](#); [Straight, Carrie A](#)
Subject: Re: [EXTERNAL] FW: Hexastylis Naniflora Data
Date: Monday, August 2, 2021 1:55:01 PM
Attachments: [image001.png](#)
[image002.png](#)

Thanks. I reached out to NCNHP and they have not had a similar request but did say they think NatureServe and DOT has already done models for the species.

I'm open to ideas but we usually recommend people work with non-listed species unless it's necessary to use a listed species.

Rebekah Reid

US Fish and Wildlife Service
Asheville Ecological Services Field Office
160 Zillicoa St.
Asheville, NC 28801
phone: 828-258-3939 x42238
cell: 828-782-0090

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From: Joe Lemeris <LemerisJ@dnr.sc.gov>
Sent: Monday, August 2, 2021 1:41 PM
To: Reid, Rebekah N <rebekah_reid@fws.gov>; Keith A. Bradley <BradleyK@dnr.sc.gov>; Punsalan, April L <april_punsalan@fws.gov>; Straight, Carrie A <carrie_straight@fws.gov>
Subject: RE: [EXTERNAL] FW: Hexastylis Naniflora Data

Thanks for the feedback Rebekah!

I followed up with Lukas to see if he could elaborate, and he provided the following:

I am working on a project for Coursera and since the Dwarf Flowered Heartleaf comes up all the time for the IPaC I wanted to use the data to make a habitat suitability model. And no the model is more for internal use but specifically for the project in my course. I will not be sharing it.

I wonder if we could make the data available to him under the stipulation that they share their suitability model back with us for review/comment? We've also recently developed a modelling workflow internally that we could use to compare results if possible (if you're up for it Keith!)

Joe

[Joseph Lemeris, Jr.](#)

GIS/Data Manager, Natural Heritage Program | o: 803-734-1396 | m: 843-729-0679 | e: LemerisJ@dnr.sc.gov

South Carolina Dept. of Natural Resources | 1000 Assembly St, Columbia, SC 29201 | www.heritagetrust.dnr.sc.gov



From: Reid, Rebekah N <rebekah_reid@fws.gov>

Sent: Monday, August 2, 2021 11:35 AM

To: Keith A. Bradley <BradleyK@dnr.sc.gov>; Punsalan, April L <april_punsalan@fws.gov>; Straight, Carrie A <carrie_straight@fws.gov>

Cc: Joe Lemeris <LemerisJ@dnr.sc.gov>

Subject: Re: [EXTERNAL] FW: Hexastylis Naniflora Data

Hi,

I have heard of this consulting firm but not this particular individual. They typically help development clients through environmental permitting and Section 7 (at least that's how I've interacted with them). I'm not aware of any modeling they are doing. I would be hesitant to provide all data records for a State unless we had more info on the modeling effort. What are they doing? Why?

I'll reach out to NCNHP to see if they've had a similar request.

Thanks,

Rebekah Reid

US Fish and Wildlife Service
Asheville Ecological Services Field Office
160 Zillico St.
Asheville, NC 28801
phone: 828-258-3939 x42238
cell: 828-782-0090

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From: Keith A. Bradley <BradleyK@dnr.sc.gov>

Sent: Monday, August 2, 2021 10:48 AM

To: Reid, Rebekah N <rebekah_reid@fws.gov>; Punsalan, April L <april_punsalan@fws.gov>; Straight, Carrie A <carrie_straight@fws.gov>

Cc: Joe Lemeris <LemerisJ@dnr.sc.gov>

Subject: [EXTERNAL] FW: Hexastylis Naniflora Data

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Hi all,

Have you ever heard of this consultant or any modelling work they're doing with Hexastylis naniflora?

Thanks,
Keith

From: Joe Lemeris <LemerisJ@dnr.sc.gov>
Sent: Monday, August 2, 2021 10:20 AM
To: Keith A. Bradley <BradleyK@dnr.sc.gov>
Subject: FW: Hexastylis Naniflora Data

Hey Keith –

See the below request from an env. consultant from S&ME. Do you have any heartburn about providing Hexastylis records to them?

Joe

[Joseph Lemeris, Jr.](#)

GIS/Data Manager, Natural Heritage Program | o: 803-734-1396 | m: 843-729-0679 | e: LemerisJ@dnr.sc.gov
South Carolina Dept. of Natural Resources | 1000 Assembly St, Columbia, SC 29201 | www.heritagetrust.dnr.sc.gov



From: Lukas P Ballard <lballard@smeinc.com>
Sent: Monday, August 2, 2021 10:12 AM
To: Joe Lemeris <LemerisJ@dnr.sc.gov>
Subject: RE: Hexastylis Naniflora Data

That's right Joe,

It would be for state-wide occurrences.

I am wanting the observed locations in data format so I can derive the data and create potential models.

From: Joe Lemeris <LemerisJ@dnr.sc.gov>
Sent: Monday, August 2, 2021 9:29 AM
To: Lukas P Ballard <lballard@smeinc.com>
Subject: RE: Hexastylis Naniflora Data

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Hi Lukas,

Thanks, hope you're doing well too!

Is this in reference to a particular project you're concerned about impacts to? Generally we usually only provide static copies of datasets for sensitive species if it's related to a specific impact area. If you're able to provide a description of what you'd like the data for, if you're looking for state-wide occurrences for the species or just specific areas, and why, we can try to assist you further.

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Joe

[Joseph Lemeris, Jr.](#)

GIS/Data Manager, Natural Heritage Program | o: 803-734-1396 | m: 843-729-0679 | e: LemerisJ@dnr.sc.gov
South Carolina Dept. of Natural Resources | 1000 Assembly St, Columbia, SC 29201 | www.heritagetrust.dnr.sc.gov



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Sent: Sunday, August 1, 2021 10:04 AM
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Subject: Hexastylis Naniflora Data

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Please let me know what options would be available.

Thank you

Lukas Ballard

Staff Scientist



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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

V. REFERENCES

Personal Communications

Austin, Kristen. The Nature Conservancy, South Carolina Chapter. Personal communications with Carolyn Wells, USFWS Asheville ES Field Office, 2006.

Bunch, Mary. South Carolina Department of Natural Resources. Personal communications with Carolyn Wells, USFWS Asheville ES Field Office, 2005 and 2006. Ms. Bunch also provided comments in response to request for peer review.

Buncick, Marella. U.S. Fish and Wildlife Service. USFWS liason to North Carolina Department of Transportation. Personal communications with Carolyn Wells, USFWS Asheville ES Field Office, 2005 and 2006.

Holling, Julie. Data Manager, South Carolina Department of Natural Resources, Heritage Trust. Personal communication with Carolyn Wells, USFWS Asheville ES Field Office, 2006.

Moldenhauer, Denise. (formerly with) USFWS Asheville ES Office. Ms. Moldenhauer provided comments in response to request for peer review.

Morgan, Jon. Spartanburg Water System (SWS) Blalock Reservoir Lake Warden. Personal communication with Carolyn Wells, USFWS Asheville ES Field Office, 2006.

Murrell, Zack. Appalachian State University. Personal communications with Carolyn Wells, USFWS Asheville ES Field Office, 2006.

Newberry, Gill. University of South Carolina at Spartanburg. Personal communications with Carolyn Wells, USFWS Asheville ES Field Office, 2006.

Padgett, James. North Carolina Natural Heritage Program. Personal communications with Carolyn Wells, USFWS Asheville ES Field Office, 2005 and 2006.

Ratzlaff, Allen. U.S. Fish and Wildlife Service. Asheville ES Field Office. Personal communications with Carolyn Wells, USFWS Asheville ES Field Office, 2005 and 2006.

Suiter, Dale. USFWS Raleigh ES Field Office. Mr. Suiter provided comments in response to a request for peer review.

West, Rebecca. Spartanburg Water System, Director of Technical Services. Personal communications with Carolyn Wells, USFWS Asheville ES Field Office, 2006 and 2007.

Literature Cited

- Barringer, K. 1993. New combinations in North American *Asarum* (Aristolochiaceae). *Novon* 3: 225-227
- Bimbi, M. 2010. USFWS Charleston Field Office. E-mail communication to Timothy Stone, National Park Service, Cowpens National Battlefield (cc: to Carolyn Wells, U.S. Fish and Wildlife Service, Asheville Field Office), dated March 5, 2010. Subject: Cowpens National Battlefield Fire Management Plan.
- Bunch, M. 2006. South Carolina Department of Natural Resources (SCNDR). E-mail communication to Carolyn Wells, USFWS Asheville Field Office, dated June 7, 2006. Subject: Dwarf-flowered heartleaf inventory at Peters Creek Heritage Preserve, conducted by Dr. Gillian Newberry from June 1-6, 2006.
- Flora of North America 1997. Flora of North America north of Mexico. Volume 3, Magnoliophyta: Magnoliidae and Hamamelidae. Oxford Univ. Press, New York, NY. 590 pp. Contains Whittemore and Gaddy's treatment of *Asarum* and *Hexastylis*.
- Gaddy, L.L. 1987. A review of the taxonomy and biogeography of *Hexastylis* (Aristolochiaceae). *Castanea* 52(3): 186-196.
- Golder Associates, Inc. 2009. Year 5 Monitoring Report, *Hexastylis naniflora*, Foothills Conservation Area, Caldwell County, North Carolina. Submitted to: Republic Services of North Carolina, LLC; copies (per cover letter) distributed to US Army Corps of Engineers, Asheville Regulatory Office and USFWS Asheville ES Office. June 26, 2009.
- Golder Associates, Inc. 2006. Year 2 Monitoring Report, *Hexastylis naniflora*, Foothills Conservation Area, Caldwell County, North Carolina. Submitted to: Republic Services of North Carolina, LLC; copies (per cover letter) distributed to US Army Corps of Engineers, Asheville Regulatory Office and USFWS Asheville ES Office. August 30, 2006.
- Golder Associates, Inc. 2005. Report on Baseline Monitoring of *Hexastylis naniflora*, Foothills Conservation Area, Caldwell County, North Carolina. Submitted to: Republic Services of North Carolina, LLC; copies (per cover letter) distributed to US Army Corps of Engineers, Asheville Regulatory Office and USFWS Asheville ES Office. July 2005.
- Jordan, Jones and Goulding (JJ&G), Inc. 2006. Lake Blalock Buffer Disturbance – Vicinity of Casey Creek Road. Memorandum to: Eddie Dearbury, Spartanburg Water Systems. Date: October 25, 2006.
- Jordan, Jones and Goulding (JJ&G), Inc. 1998. Section 404 Application and Conceptual Mitigation Plan, Lake Blalock Expansion Project. USFWS Log number 4-6-97-358. ACOE Project # 80-97-1732 (S). Section 9: *Hexastylis naniflora* Biological Assessment. Received by the Asheville Field Office July 16, 1998.

- Karl, T. et al. 2009. Global Climate Change Impacts in the United States. Cambridge University Press. 196 pp.
- Kelly, L.M. 1997. A cladistic analysis of *Asarum* (Aristolochiaceae) and implications for the evolution of herkogamy. *Am. J. Bot.* 84: 1752-1765.
- . 1998. Phylogenetic relationships in *Asarum* (Aristolochiaceae) based on morphology and ITS sequences. *Am. J. Bot.* 85: 1454-1467.
- , and F. González. 2003. Phylogenetic relationships in Aristolochiaceae. *Systematic Botany* 28: 236-249.
- Murrell, Z. et al. 2007. Ecological, Morphological, Micromorphological and Molecular Analyses of the Species in the *Hexastylis heterophylla* Complex. A Report to the North Carolina Department of Transportation. NCDOT and CTE Joint Project 2002-04, FHWA/NC/2004-01. May 2007.
- NatureServe. 2004. A Habitat-based Strategy for Delimiting Plant Element Occurrences: Guidance from the 2004 Working Group. A full copy of this guidance is available at: http://www.natureserve.org/library/delimiting_plant_eos_Oct_2004.pdf. Additional information on NatureServe and Natural Heritage methods is available at <http://www.natureserve.org/prodServices/heritagemethodology.jsp>.
- Newberry, G. 2009. University of South Carolina at Spartanburg. Evaluation of damage to *Hexastylis naniflora* plants on acreage bordering the hunt club. Letter to Jon Morgan, Lake Warden, Spartanburg Water Systems. Dated February 24, 2009.
- Newberry, G. 2006. South Carolina Populations of *Hexastylis naniflora*: 2006 updates. Received by the USFWS Asheville Field Office, September 7, 2006.
- Newberry, G. 1993. Progress Report on Monitoring Studies of *Hexastylis naniflora*. Unpublished report. Copy submitted to the USFWS Asheville Field Office, on September 7, 2006.
- North Carolina Natural Heritage Program (NC NHP). 2010. Element Occurrence Records for *Hexastylis naniflora* (dwarf-flowered heartleaf). As of: April 7, 2010.
- North Carolina Department of Transportation (NCDOT). 2005. Dwarf-flowered heartleaf (*Hexastylis naniflora*) inventory: Burke, Caldwell, Catawba, Cleveland, and Polk Counties, North Carolina. NCDOT TIP No. R-2824. Report prepared by HDR, Engineering, Inc. of the Carolinas and Habitat Assessment and Restoration Program (HARP), and submitted to NCDOT. May 2005.
- Padgett, J. 2004. Biogeographical, Ecological, Morphological, and Micromorphological Analyses of the Species in the *Hexastylis heterophylla* Complex. Masters Thesis, Appalachian State University. Submitted May 2004.

- Rayner, D. 2006. Wofford College. E-mail communication to Carolyn Wells, USFWS Asheville Field Office, dated August 31, 2006.
- Renninger, H. 2010. North Carolina Department of Transportation (NCDOT). E-mail communication to Carolyn Wells, USFWS Asheville Field Office. Date: May 28, 2010. Subject: Dwarf-flowered heartleaf research proposal.
- Schneider, S. 2006. Spartanburg Water System (SWS) & Sanitary Sewer District, Assistant General Manager. E-mail communication to Lora Zimmerman, USFWS (formerly with the Charleston Field Office), dated December 18, 2006. Subject: Meeting at SWS on December 21, 2006 [to discuss Lake Blalock Buffer Disturbance].
- South Carolina Department of Natural Resources (SCDNR) Heritage Trust. 2010. Element Occurrence Records for *Hexastylis naniflora* (dwarf-flowered heartleaf). As of: August 19, 2010.
- South Carolina Department of Natural Resources (SCDNR), 2006. Management Plan for Peters Creek Heritage Preserve. July 21, 2006.
- Stone, T. 2010. National Park Service, Cowpens National Battlefield. E-mail communication to Melissa Bimbi, USFWS Charleston Field Office (cc: to Carolyn Wells, USFWS Asheville Field Office), dated March 22, 2010. Subject: Cowpens National Battlefield Fire Management Plan.
- Tompkins, B. 2010. USFWS Asheville Field Office. E-mail communication to Carolyn Wells, USFWS Asheville Field Office, dated September 13, 2010. Subject: *Hexastylis naniflora* five-year review.
- USFWS, 2009. Biological Opinion for the Proposed Upgrade of Lovelady Road, TIP No. R-2824, in Burke County, North Carolina. USFWS log number 4-2-09-367. November 13, 2009.
- USFWS, 2003. Biological Opinion for the Foothills Municipal Solid Waste Landfill Facility Expansion, Caldwell County, North Carolina (Action ID 200231111). USFWS log number 4-2-02-254. May 30, 2003.
- USFWS, 2001. Biological Opinion for Spartanburg Water System, Lake Blalock, P/N 2000-IP-194-W, USFWS log number 4-6-01-F-115. May 10, 2001.
- USFWS, 1989. Federal Register, Vol. 54 (1494-14967); April 14, 1989. ETWP; Threatened Status for *Hexastylis naniflora*. Final Rule.
- Walker, et al. 2009. What are the effects of prescribed fire on *Hexastylis naniflora*, a federally protected plant species? Unpublished final Report prepared by US Forest Service, Southern Research Station, Clemson University. Submitted to Timothy Stone,

Superintendent, Cowpens National Battlefield. In partial fulfillment for Agreement 04-IA-11330138-234, between the NPS and USFS Southern Research Station. Revised March 19, 2009. 26 pp.

Weakley, A. 2010. Flora of the Southern and Mid-Atlantic States. University of North Carolina Herbarium (NCU), North Carolina Botanical Garden, University of North Carolina at Chapel Hill. Working Draft as of March 8, 2010.

Wells, C. 2009. USFWS Asheville Field Office. E-mail communication to Lora Zimmerman, USFWS (then with the Charleston Field Office), dated June 8, 2009. Subject: *Hexastylis naniflora* monitoring report for Cowpens National Battlefield.

Additional works consulted

Blomquist, H. L. 1957. A revision of *Hexastylis* of North America. Brittonia 8: 255-281.

Federal Highway Administration (FHA). 2004. Revised Biological Assessment (BA) for the Dwarf-flowered heartleaf for Proposed US 74 Bypass, Cleveland County, North Carolina, Federal-Aid No. NHF-74(14), State Project No. 8.1801001, TIP No.R-2707.

Fish and Wildlife Associates, Inc. 2009. Monitoring Report Year 3, Dwarf-flowered heartleaf (*Hexastylis naniflora*) on the Draughn High School Site, Burke County, North Carolina. Unpublished report prepared by Pam Boaze, June 2009.

Gaddy, L.L. 1981. The Status of *Hexastylis naniflora* Blomquist in North Carolina. Prepared for North Carolina Department of Agriculture, Plant Protection Program. October 1981.

Gaddy, L.L. 1980. Status Report on *Hexastylis naniflora* Blomquist. Prepared for and submitted to USFWS, Endangered Species Office, Region 4, Atlanta, Georgia. July 1980.

Newberry, G. 1996. North Carolina and South Carolina Populations of *Hexastylis naniflora*. Site reports (maps and site observations) prepared for and submitted to the USFWS Southeast Regional Office, Atlanta, Georgia. August 2006.

Padgett, J., et al. 2003. Phylogeographical, Ecological, Morphological, Micromorphological and Molecular Analyses of the Species in the *Hexastylis heterophylla* Complex. Report submitted to the North Carolina Department of Transportation (NCDOT). Report Number: FHWA/NC/2004-01. December 2003.

S&ME, Inc. 2008. Year 2 Annual Monitoring, Dwarf-flowered heartleaf transplants, Rutherford 74 Corporate Center, Forest City, North Carolina. S&ME Project No. 1357-05-190B. Report submitted to the USFWS Asheville Field Office on May 21, 2008.

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

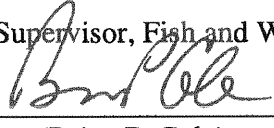
Current Classification: Threatened
Recommendation resulting from the 5-Year Review

☐ 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)	<u>Anticipated</u> 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)	<u>Anticipated</u> 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).

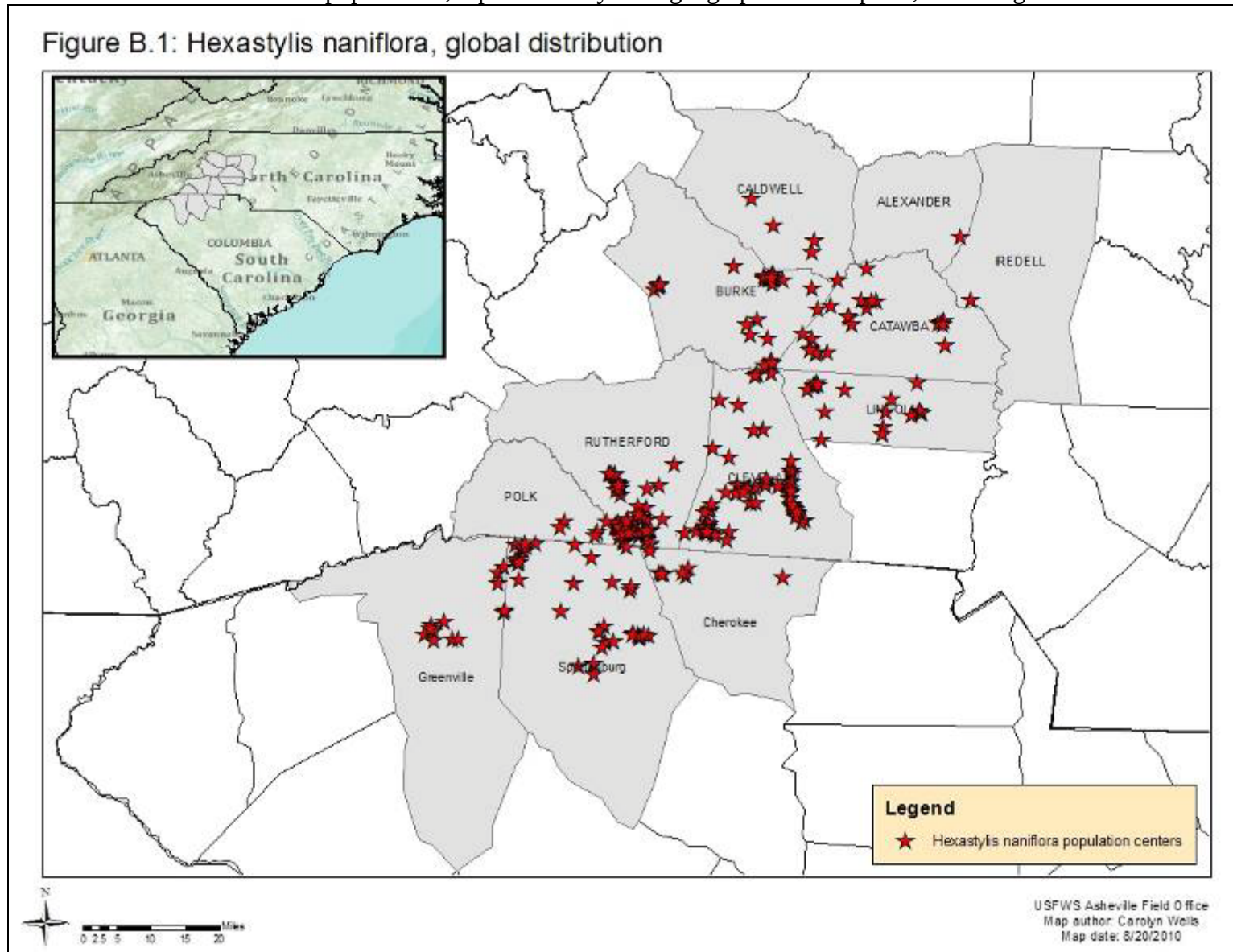
Table B.5. Remaining sites (not listed in preceding tables) with some potential to afford long-term protection to *Hexastylis naniflora*.

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).

Yes, we had dwarf-flowered heartleaf proposed delisting get pulled back from OFR this morning. We were so close!

>:<:<:<:<:<:<:<:<:<:<:<:<:<:<:<

From Trish Adams to the HCP CoP Team - I've received questions regarding the Federal Register clearance process during the transition to a new administration. I reached out to PERMA. They have been instructed to pull everything back from the FR and not to send in anything new at this time. It's unclear how long this delay will be or if there will be changes to the clearance process. As I learn more, I will keep you updated.

NOTE: This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act (FOIA) and may be disclosed to third parties.

From: [Straight, Carrie A](#)
To: [Reid, Rebekah N](#)
Subject: RE: DFHL Post Delisting Monitoring Plan
Date: Tuesday, June 22, 2021 9:24:00 AM

Thanks!

Carrie

<°)))))< <°)))))< <°)))))< <°)))))< <°)))))<

Carrie A. Straight, PhD
She, her, hers

Regional Recovery Coordinator
South Atlantic-Gulf and Mississippi Basin Regions
U.S. Fish and Wildlife Service
Ecological Services
1875 Century Boulevard
Atlanta, Georgia 30345
404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

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From: Reid, Rebekah N <rebekah_reid@fws.gov>
Sent: Tuesday, June 22, 2021 9:23 AM
To: Straight, Carrie A <carrie_straight@fws.gov>
Cc: Peeples, Gary <gary_peeples@fws.gov>
Subject: Re: DFHL Post Delisting Monitoring Plan

Hey Carrie,

It hasn't changed from when you and Byron asked for it last summer.

Rebekah Reid

US Fish and Wildlife Service
Asheville Ecological Services Field Office
160 Zillico St.
Asheville, NC 28801
phone: 828-258-3939 x42238
cell: 828-782-0090

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From: Straight, Carrie A <carrie_straight@fws.gov>

Sent: Tuesday, June 22, 2021 9:18 AM
To: Reid, Rebekah N <rebekah_reid@fws.gov>
Cc: Peeples, Gary <gary_peeples@fws.gov>
Subject: RE: DFHL Post Delisting Monitoring Plan

Thanks for the update. Do you have the most recent version of the PDM or was that put up with the original docket?

Carrie

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Carrie A. Straight, PhD
She, her, hers

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404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

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From: Reid, Rebekah N <rebekah_reid@fws.gov>
Sent: Tuesday, June 22, 2021 8:37 AM
To: Straight, Carrie A <carrie_straight@fws.gov>
Cc: Peeples, Gary <gary_peeples@fws.gov>
Subject: Re: DFHL Post Delisting Monitoring Plan

No, as planned none of those folks will be conducting the monitoring.

Rebekah Reid

US Fish and Wildlife Service
Asheville Ecological Services Field Office
160 Zillicoa St.
Asheville, NC 28801
phone: 828-258-3939 x42238
cell: 828-782-0090

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From: Straight, Carrie A <carrie_straight@fws.gov>
Sent: Tuesday, June 22, 2021 8:34 AM

To: Reid, Rebekah N <rebekah_reid@fws.gov>
Cc: Peeples, Gary <gary_peeples@fws.gov>
Subject: RE: DFHL Post Delisting Monitoring Plan

Thanks Rebekah,

A quick question, will Keith (or any of them) be involved in any of the monitoring? If so we'll need someone different.

Thanks,

Carrie

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Carrie A. Straight, PhD
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From: Reid, Rebekah N <rebekah_reid@fws.gov>
Sent: Tuesday, June 22, 2021 7:44 AM
To: Straight, Carrie A <carrie_straight@fws.gov>
Cc: Peeples, Gary <gary_peeples@fws.gov>
Subject: DFHL Post Delisting Monitoring Plan

Hi Carrie,

Below is a list of possible reviewers. These folks were not involved in the SSA or development of the PDM plan.

Dr. Doug Rayner

Wofford College

raynerda@wofford.edu

Dr. LL “Chick” Gaddy

Terra Incognita

llgaddy2@gmail.com

Keith Bradley

SC Heritage Trust Program

bradleyk@dnr.sc.gov

I'll update the plan if we get any comments.

Thanks,

Rebekah Reid

US Fish and Wildlife Service

Asheville Ecological Services Field Office

160 Zillicoa St.

Asheville, NC 28801

phone: 828-258-3939 x42238

cell: 828-782-0090

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Straight, Carrie A

From: Peeples, Gary
Sent: Monday, June 21, 2021 8:57 AM
To: Straight, Carrie A; Mizzi, Janet
Subject: Re: Dwarf-flower heartleaf PDM - peer review

Follow Up Flag: Follow up
Flag Status: Completed

Hey Carrie,

Rebekah Reid will be reaching out to you on this.

-G

Gary Peeples
Deputy Field Office Supervisor/Public Affairs Officer
Asheville Field Office
U.S. Fish & Wildlife Service, South Atlantic/Gulf Region
160 Zillicoa St.
Asheville, NC 28801
gary_peeples@fws.gov
cell 828/216-4970
fax 828/258-5330
he/him/his

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From: Straight, Carrie A <carrie_straight@fws.gov>
Sent: Monday, June 14, 2021 3:28 PM
To: Mizzi, Janet <janet_mizzi@fws.gov>; Peeples, Gary <gary_peeples@fws.gov>
Subject: Dwarf-flower heartleaf PDM - peer review

Hello,

I was notified by Kristi Young that the proposed rule for the dwarf-flowered heartleaf states that we will be initiating a peer review of the PDM concurrent with the proposed listing rule (see the sentence on the top right column of page 22004, under FOR FURTHER INFORMATION CONTACT).

Facilitating that review has fallen to me. Since we've stated it will happen, here goes... I need a list of at least 3 experts that are not responsible in any way for the post delisting monitoring plan implementation. They can be an expert that might be consulted, but wouldn't be responsible for the actual monitoring or reporting. Let me know if you have a biologist that will be responsible for both this and updating the PDM and incorporating any of the comments, etc. I have attached the PDM from the docket and the proposed rule. Unless there have been major changes of the PDM since the proposed rule, I will use that document to solicit the peer review.

Thanks,

Carrie

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Carrie A. Straight, PhD

She, her, hers

Recovery Coordinator
South Atlantic-Gulf and Mississippi Basin Regions
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From: [Straight, Carrie A](#)
To: [Reid, Rebekah N](#)
Subject: RE: the Post Delisting Monitoring (PDM) plan - dwarf flowered heartleaf
Date: Wednesday, July 22, 2020 10:57:00 AM

Thanks Rebekah,

I likely think this was in response to the same issue that came up so we are just double checking all of the species in the delisting workplan!

Carrie

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Carrie A. Straight, PhD

Pronouns: she, her, hers

Recovery Coordinator
U.S. Fish and Wildlife Service
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Atlanta, Georgia 30345
404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

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From: Reid, Rebekah N <rebekah_reid@fws.gov>
Sent: Wednesday, July 22, 2020 8:13 AM
To: Straight, Carrie A <carrie_straight@fws.gov>
Cc: Davis, Victoria <victoria_davis@fws.gov>
Subject: Re: the Post Delisting Monitoring (PDM) plan - dwarf flowered heartleaf

Hi Carrie,

Yes, there is a draft PDM for dwarf flowered heartleaf. I worked on it with Drew Becker the first half of 2019. See attached. Just FYI, Byron Hamilton asked for this document yesterday as well.

Thanks.

Rebekah Reid

US Fish and Wildlife Service
Asheville Ecological Services Field Office
160 Zillicoa St.
Asheville, NC 28801

phone: 828-258-3939 x42238
cell: 828-782-0090

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From: Straight, Carrie A <carrie_straight@fws.gov>
Sent: Tuesday, July 21, 2020 7:47 PM
To: Reid, Rebekah N <rebekah_reid@fws.gov>
Cc: Davis, Victoria <victoria_davis@fws.gov>
Subject: the Post Delisting Monitoring (PDM) plan - dwarf flowered heartleaf

Hi Rebekah,

I have a list of species are on the current list of delistings either with HQ or the DCC branch. Although DCC will be working on the delisting rules, the Post Delisting Monitoring (PDM) plan still falls to the Division of Restoration and Recovery. These plans need to be completed prior to the Final Rule and apparently a draft should be posted with the proposed delisting rule. Can you tell me if there is a PDM for dwarf flowered heartleaf and if so, what the status of that document is?

Thanks,

Carrie

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Carrie A. Straight, PhD
Pronouns: she, her, hers

Recovery Coordinator
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Straight, Carrie A

From: Straight, Carrie A
Sent: Monday, August 23, 2021 5:22 PM
To: Keith A. Bradley
Subject: RE: [EXTERNAL] RE: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021

Hello Keith,

I hope this email is finding you better than the last time we spoke and that your arm is healing. Just wanted to check in and see where we stood with the peer review of this document.

Thank you again for your time,

Carrie

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Carrie A. Straight, PhD
She, her, hers

Regional Recovery Coordinator
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404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

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From: Straight, Carrie A
Sent: Tuesday, August 10, 2021 9:45 AM
To: Keith A. Bradley <BradleyK@dnr.sc.gov>
Subject: RE: [EXTERNAL] RE: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021

Wow! A string of bad luck, please take care of yourself. If you have some time to review sometime soon, that would be great.

Thanks again,

Carrie

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Carrie A. Straight, PhD
She, her, hers

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404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

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From: Keith A. Bradley <BradleyK@dnr.sc.gov>
Sent: Tuesday, August 10, 2021 9:31 AM
To: Straight, Carrie A <carrie_straight@fws.gov>
Subject: RE: [EXTERNAL] RE: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021

Hi Carrie – I apologize for the delay but at the beginning of last week I broke my arm surveying mountain pitcher plants and had surgery yesterday. So I've gotten a bit behind but I do intend to get it to you this week maybe by tomorrow.

From: Straight, Carrie A <carrie_straight@fws.gov>
Sent: Tuesday, August 10, 2021 9:24 AM
To: Keith A. Bradley <BradleyK@dnr.sc.gov>
Subject: RE: [EXTERNAL] RE: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021

Keith,

I hope you are feeling better and wanted to check in to see if you had time to finalize your review. Just let me know.

Thank you again for serving as a peer reviewer for these documents.

Carrie

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Carrie A. Straight, PhD
She, her, hers

Regional Recovery Coordinator
South Atlantic-Gulf and Mississippi Basin Regions
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Atlanta, Georgia 30345
404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

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From: Keith A. Bradley <BradleyK@dnr.sc.gov>
Sent: Monday, August 2, 2021 9:08 AM
To: Straight, Carrie A <carrie_straight@fws.gov>
Subject: RE: [EXTERNAL] RE: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021

Sorry, I was out sick and got behind. I'll get you comments on this and Echinacea today.

From: Straight, Carrie A <carrie_straight@fws.gov>

Sent: Monday, July 26, 2021 4:07 PM

To: Keith A. Bradley <BradleyK@dnr.sc.gov>

Subject: RE: [EXTERNAL] RE: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021

I was wondering if you have had time or still needed time to participate in the peer review of this monitoring plan. If you do not have time to participate, please let me know and I can let the species lead know. I just wanted to follow up in case I missed a return email or if you still wanted to participate in the review.

Thank you for your time.

Carrie

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Carrie A. Straight, PhD

She, her, hers

Regional Recovery Coordinator
South Atlantic-Gulf and Mississippi Basin Regions
U.S. Fish and Wildlife Service
Ecological Services
1875 Century Boulevard
Atlanta, Georgia 30345
404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

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From: Keith A. Bradley <BradleyK@dnr.sc.gov>

Sent: Wednesday, June 30, 2021 4:15 PM

To: Straight, Carrie A <carrie_straight@fws.gov>

Subject: [EXTERNAL] RE: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021

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Hi Carrie,

I'd be happy to do the peer review.

Keith A. Bradley, Botanist
SC Dept. of Natural Resources
Heritage Trust Program
1000 Assembly St., Columbia, SC 29201
BradleyK@dnr.sc.gov

From: Straight, Carrie A <carrie_straight@fws.gov>

Sent: Friday, June 25, 2021 3:37 PM

To: Keith A. Bradley <BradleyK@dnr.sc.gov>

Subject: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021

Mr. Bradley,

The Fish and Wildlife Service is requesting your help by asking you to serve as a peer reviewer of our draft post delisting monitoring (PDM) plan for the dwarf-flowered heartleaf.

Post-delisting monitoring (PDM) refers to activities undertaken to verify that a species delisted due to recovery remains secure from risk of extinction after the protections of the Endangered Species Act (ESA) no longer apply. The primary goal of PDM is to monitor the species to ensure the status does not deteriorate, and if a substantial decline in the species (numbers of individuals or populations) or an increase in threats is detected, to take measures to halt the decline so that re-proposing it as a threatened or endangered species is not needed.

Section 4(g), added to the ESA in the 1988 reauthorization, requires the U.S. Fish and Wildlife Service to implement a system in cooperation with the states to monitor for not less than five years the status of all species that have recovered and been removed from the list of threatened and endangered plants and animals (50 CFR 17.11, 17.12, 224.101, and 227.4). This plan is being developed in accordance with the requirements of Section 4(g) of the ESA.

We ask for your comments on the draft PDM plan to focus specifically on the quality of the scientific information and analyses and whether the best available information was used. Please identify any oversights, omissions, and inconsistencies; provide advice on reasonableness of judgments made from the scientific evidence; help us ensure that scientific uncertainties are identified and characterized; provide advice on the overall strengths and limitations of the scientific data used in the document; and inform us of any scientific information that we did not use. We request that you direct your review to the scientific issues and assumptions relating to your expertise and provide references when needed.

Please note that we are not seeking your opinion of the legal status of this species, but rather that the best available data and analyses were considered in reassessing its status.

Additionally, as part of the peer review process, we must evaluate the potential for conflicts of interest with the subject species or the action. Please complete the attached Conflict of Interest form and return it with any notes, comments, or questions that you are willing to provide along with your peer review.

By agreeing to participate in the peer review process for this species, you are considered an unpaid, volunteer consultant to assist the Service by providing the best scientific information and clarity in this document. As part of our reporting process under the [Information Quality Act](#), we will also be listing your name and affiliation along with the comments in a document available to the public.

We hope that you view this peer review process as a worthwhile undertaking. Once you complete your review of the attached document, please submit comments and signed Conflict of Interest Form to the Atlanta Regional Office, to our Regional Recovery Coordinator, Carrie Straight. Your comments can be provided to Carrie by email carrie_straight@fws.gov or by letter (1875 Century Boulevard, 4th Floor, Atlanta, Georgia 30345) and should be received by **July 16, 2021**, to help us complete the document. Thank you in advance for your assistance. We appreciate your time

in helping complete this review. If you feel you cannot complete the review in the allotted time or would like to decline review, please let me know.

Thank you for your time,

Carrie

<°)))))< <°)))))< <°)))))< <°)))))< <°)))))<

Carrie A. Straight, PhD
She, her, hers

Regional Recovery Coordinator
South Atlantic-Gulf and Mississippi Basin Regions
U.S. Fish and Wildlife Service
Ecological Services
1875 Century Boulevard
Atlanta, Georgia 30345
404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

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EXTERNAL EMAIL: Do not click any links or open any attachments unless you trust the sender and know the content is safe.

Straight, Carrie A

From: L L Gaddy <llgaddy2@gmail.com>
Sent: Monday, August 2, 2021 3:08 PM
To: Straight, Carrie A
Subject: [EXTERNAL] Re: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021
Attachments: hexletter.08.02.21.docx; hexletter.06.24.21.docx

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Sorry I am so late. See two attached letters. Call me to discuss.

Chick 803 629-6128

On Fri, Jun 25, 2021 at 12:36 PM Straight, Carrie A <carrie_straight@fws.gov> wrote:

Dr. Gaddy,

The Fish and Wildlife Service is requesting your help by asking you to serve as a peer reviewer of our draft post delisting monitoring (PDM) plan for the dwarf-flowered heartleaf.

Post-delisting monitoring (PDM) refers to activities undertaken to verify that a species delisted due to recovery remains secure from risk of extinction after the protections of the Endangered Species Act (ESA) no longer apply. The primary goal of PDM is to monitor the species to ensure the status does not deteriorate, and if a substantial decline in the species (numbers of individuals or populations) or an increase in threats is detected, to take measures to halt the decline so that re-proposing it as a threatened or endangered species is not needed.

Section 4(g), added to the ESA in the 1988 reauthorization, requires the U.S. Fish and Wildlife Service to implement a system in cooperation with the states to monitor for not less than five years the status of all species that have recovered and been removed from the list of threatened and endangered plants and animals (50 CFR 17.11, 17.12, 224.101, and 227.4). This plan is being developed in accordance with the requirements of Section 4(g) of the ESA.

We ask for your comments on the draft PDM plan to focus specifically on the quality of the scientific information and analyses and whether the best available information was used. Please identify any oversights, omissions, and inconsistencies; provide advice on reasonableness of judgments made from the scientific evidence; help us ensure that

scientific uncertainties are identified and characterized; provide advice on the overall strengths and limitations of the scientific data used in the document; and inform us of any scientific information that we did not use. We request that you direct your review to the scientific issues and assumptions relating to your expertise and provide references when needed.

Please note that we are not seeking your opinion of the legal status of this species, but rather that the best available data and analyses were considered in reassessing its status.

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By agreeing to participate in the peer review process for this species, you are considered an unpaid, volunteer consultant to assist the Service by providing the best scientific information and clarity in this document. As part of our reporting process under the [Information Quality Act](#), we will also be listing your name and affiliation along with the comments in a document available to the public.

We hope that you view this peer review process as a worthwhile undertaking. Once you complete your review of the attached document, please submit comments and signed Conflict of Interest Form to the Atlanta Regional Office, to our Regional Recovery Coordinator, Carrie Straight. Your comments can be provided to Carrie by email carrie_straight@fws.gov or by letter (1875 Century Boulevard, 4th Floor, Atlanta, Georgia 30345) and should be received by **July 16, 2021**, to help us complete the document. Thank you in advance for your assistance. We appreciate your time in helping complete this review. If you feel you cannot complete the review in the allotted time or would like to decline review, please let me know.

Thank you for your time,

Carrie

<°)))))< <°)))))< <°)))))< <°)))))< <°)))))<

Carrie A. Straight, PhD

She, her, hers

Regional Recovery Coordinator

South Atlantic-Gulf and Mississippi Basin Regions

U.S. Fish and Wildlife Service

Ecological Services

1875 Century Boulevard

Atlanta, Georgia 30345

404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

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--

L. L. Gaddy, Ph. D., President
terra incognita

125 South Edisto Avenue
Columbia, South Carolina 29205

803 629-6128

www.tibooks.org

Yet all experience is an arch wherethro'
Gleams that untravell'd world...

"Ulysses," Tennyson

terra incognita
125 S. Edisto Avenue, Columbia, SC 29205
llgaddy2@gmail.com 803 629-6128

June 24, 2021

re: Endangered and threatened species: removal of the dwarf-flowered heartleaf from the federal list of endangered and threatened plants

Sirs/Mme:

It can be asserted that as much as 50% of the known global population of *Shortia galacifolia* (Oconee bells) may have been inundated by the creation of Lake Jocassee along the Blue Ridge front in North and South Carolina. Oconee bells, like Venus flytrap (*Dionaea muscipula*) and *Hexastylis naniflora* (dwarf-flowered heartleaf) are all North Carolina-South Carolina endemics—species found only in these two states and nowhere else. If the Fish and Wildlife Service has their way, none of these three vascular plant species will be protected by Federal law.

As was the case with *Shortia*, acres of *Hexastylis naniflora* were probably destroyed by the creation of Lake Bowen in Spartanburg, South Carolina and Lake James in North Carolina. *Hexastylis naniflora* is a narrow endemic species found only on a few soil types, soils that occur along streams, in bogs, and on low bluffs. Like many endemics, *Hexastylis naniflora* is often locally common, even abundant, but its range is limited to the Piedmont of North and South Carolina. The rarity of endemics is misunderstood. Unlike many other plant species, population range and size are severely limited. The precise habitat of the endemic is determined by micro-features (such as soil types), and their mega-population size is controlled by geography. Because of genetic similarity from plant to plant, narrow endemics are very susceptible to extinction by disease or large ecological disasters (creation of lakes that inundate large populations of the plant). Our famous two-state endemics are part of our Carolina natural heritage and should all be protected and not delisted. If the Federal government will not protect these plants, who will? Let's keep *Hexastylis naniflora* on the list and add *Shortia galacifolia* and *Dionaea muscipula*.

L. L. Gaddy, botanist, naturalist, and biogeographer
Ph. D., University of Georgia, 1985; President of terra incognita

Gaddy, L. L. 1987. A review of the taxonomy and biogeography of *Hexastylis*. *Castanea* 52:186-196.
Whittemore, A. T. and L. L. Gaddy. 1997. *Hexastylis*, pp. 54-58 In *Flora of North America*, Volume 3, Oxford University Press, New York, London. 590 p.

endangered species/natural areas/wetland inventory conservation easement and planning

terra incognita
125 S. Edisto Avenue, Columbia, SC 29205
llgaddy2@gmail.com 803 629-6128

August 02, 2021

re: review of delisting plan for *Hexastylis naniflora*

Dr.. Carrie A. Straight, Ph. D.
Regional Recovery Coordinator
Fish and Wildlife Service
Atlanta
carrie_straight@fws.gov

Dr. Straight:

I have quickly and cursorily reviewed the *Hexastylis naniflora* delisting plan. I have no major comments on the science and methods of the plan, I think they seem very reasonable. My comments are general and on the nature of the species and how it differs from other listed species. In addition to the following comments, I have attached a letter I wrote to the Fish and Wildlife Service in June of this year.

Hexastylis naniflora is known only from 13 counties in two states. It is what biogeographers call a narrow endemic. It seems to only occur on special types of sandy loam soils in the upper Piedmont of SC and NC, but these soil types occur in other counties where the plant does not occur. We, therefore, do not know why it only occurs in these counties (the reason is probably related to historic distribution and original speciation). Also, the plant does not seem to occur in every ravine or on every bluff or in every spring that has its preferred habitat. I remember many field days when I found ideal habitat for the species, but there were no plants there.

The above problems, including the problem of endemism, brings up other issues. Because of its range and the number of populations already found, a saturation level of its maximum species richness has probably been reached. A good question to ask, therefore, is how many of the populations are protected by law. One must assume that all the unprotected populations could legally be destroyed if it were not state- or federally-listed. What would its protected range look like—that would be a good map. Smooth coneflower, for example, occurs from PA to GA, only a few populations are known, but every year or so a good population is found in SC or VA (one was found on Fort Jackson in SC last year). A similar situation exists with small-whorled pogonia, known from ME to GA. The sets of where the two above plants may occur are much larger than set of potential *Hexastylis naniflora* (and there is no delisting plan for those two).

This big thing that separates endemics from plants with more expansive ranges is that, with endemics, the historic range is the only place where you will probably ever find the plant. It is therefore severely limited in possibilities. This must be understood and taken into consideration. I don't think it has heretofore (I also think the same thing about *Shortia galacifolia* and *Dionaea muscipula*, but that can be discussed later).

L. L. Gaddy, President
botanist, naturalist, and biogeographer
Ph. D., University of Georgia

endangered species/natural areas/wetland inventory conservation easement and planning

U.S. Fish and Wildlife Service
Participation in Peer Review of the
Post Delisting Monitoring Plan Dwarf Flowered Heartleaf

CONFLICT OF INTEREST DISCLOSURE

NAME: L. L. GADDY TELEPHONE: 803 629-6128
ADDRESS: 125 S. EDISTO AVE
COLUMBIA SC 29205
EMAIL ADDRESS: llgaddy2@gmail.com
CURRENT EMPLOYER: terra incognita, Env. Cons.,
President

Please complete, **sign** and **date** the form on the last page, and **return the form** to Carrie Straight at carrie_straight@fws.gov. **Please retain a copy for your records.**

CONFLICT OF INTEREST DISCLOSURE

INSTRUCTIONS

It is essential that a peer reviewer used by the U.S. Fish and Wildlife Service as part of its peer review of proposed listing and proposed critical habitat rules under the ESA report any conflict of interest. For this purpose, the term “conflict of interest” means any financial or other interest which conflicts with the service of the individual because it (1) could significantly impair the individual’s objectivity or (2) could create an unfair competitive advantage for any person or organization.¹ In those situations in which the Service determines that a conflict of interest is unavoidable we will publicly disclose the conflict of interest.

The term “conflict of interest” means something more than individual bias. There must be an *interest* that could be directly affected by your participation as a peer reviewer.

¹ This definition and the other information in these instructions are drawn from the National Academy of Sciences Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports (May 12, 2003).

The following questions are designed to elicit information from you concerning possible conflicts of interest that are relevant to the functions to be performed by your peer review.

1. EMPLOYMENT. (a) If the information received by the Service through the peer review process were to provide the basis for government regulatory action or inaction with respect to the species--

(i) If you are employed or self-employed, could your current employment or self-employment (or your spouse's current employment or self-employment) be directly affected?

(ii) To the best of your knowledge, could any financial interests of your (or your spouse's) employer or, if self-employed, your (or your spouse's) clients and/or business partners be directly affected?

(iii) If you are an officer, director or trustee of any corporation or other legal entity, could the financial interests of that corporation or legal entity be directly affected?

(iv) If you are a consultant (whether full-time or part-time), could there be a direct effect on any of your current consulting relationships?

(v) Regardless of the potential effect on the consulting relationship, do you have any current or continuing consulting relationships (including, for example, commercial and professional consulting and service arrangements, scientific and technical advisory board memberships, serving as an expert witness in litigation, or providing services in exchange for honorariums and travel expense reimbursements) that are directly related to the subject matter of the possible government regulatory action or inaction?

(b) If you are or have ever been a U.S. Government employee (either civilian or military), to the best of your knowledge, are there any federal conflict of interest restrictions that may be applicable to your service in connection with this peer review?

(c) If you are a U.S. Government employee, are you currently employed by the Service?

If the answer to all of the above questions under EMPLOYMENT is either "no" or "not applicable," check here ☒ (NO).

If the answer to any of the above questions under EMPLOYMENT is "yes," check here ☐ (YES), and briefly describe the circumstances on the last page of this form.

2. INVESTMENT INTERESTS. Taking into account stocks, bonds, and other financial instruments and investments including partnerships (but excluding broadly diversified mutual funds and any investment or financial interest valued at less than \$10,000), if the

information received by the Service through the peer review process were to provide the basis for government regulatory action or inaction with respect to the species --

(a) Do you or your spouse or minor children own directly or indirectly (e.g., through a trust or an individual account in a pension or profit-sharing plan) any stocks, bonds or other financial instruments or investments that could be affected, either directly or by a direct effect on the business enterprise or activities underlying the investments?

(b) Do you have any other significant financial investments or interests such as commercial business interests (e.g., sole proprietorships), investment interests (e.g., stock options), or personal investment relationships (e.g., involving parents or grandchildren) that could be affected, either directly or by a direct effect on the business enterprise or activities underlying the investments?

If the answer to all of the above questions under INVESTMENT INTERESTS is either "no" or "not applicable," check here ☒ (NO).

If the answer to any of the above questions under INVESTMENT INTERESTS is "yes," check here ☐ (YES), and briefly describe the circumstances on the last page of this form.

3. PROPERTY INTERESTS. Taking into account real estate and other tangible property interests, as well as intellectual property (patents, copyrights, etc.) interests, if the information received by the Service through the peer review process were to provide the basis for government regulatory action or inaction with respect to the species --

(a) Do you or your spouse or minor children own directly or indirectly any such property interests that could be directly affected?

(b) To the best of your knowledge, do any others with whom you have substantial common financial interests (e.g., employer, business partners, etc.) own directly or indirectly any such property interests that could be directly affected?

If the answer to all of the above questions under PROPERTY INTERESTS is either "no" or "not applicable," check here ☒ (NO).

If the answer to any of the above questions under PROPERTY INTERESTS is "yes," check here ☐ (YES), and briefly describe the circumstances on the last page of this form.

4. RESEARCH FUNDING AND OTHER INTERESTS. (a) Taking into account your research funding and other research support (e.g., equipment, facilities, industry partnerships, research assistants and other research personnel, etc.), if the information

received by the Service through the peer review process were to provide the basis for government regulatory action or inaction with respect to the species --

- (i) Could the research funding and support for you or your close research colleagues and collaborators be directly affected, or

(ii) If you have any research agreements for current or continuing research funding or support from any party whose financial interests could be directly affected, and such funding or support is directly related to the subject matter of the regulatory process, do such agreements significantly limit your ability to independently conduct and publish the results of your research?

(b) Is the central purpose of the proposed rule for which this disclosure form is being prepared a critical review and evaluation of your own work or that of your employer?

(c) Do you have any existing professional obligations (e.g., as an officer of a scientific or engineering society) that effectively require you to publicly defend a previously established position on an issue that is relevant to the proposed rule?

(d) To the best of your knowledge, will your participation in this peer review process enable you to obtain access to a competitor's or potential competitor's confidential proprietary information?

(e) Could your service as a peer reviewer create a specific financial or commercial competitive advantage for you or others with whom you have substantial common financial interests?

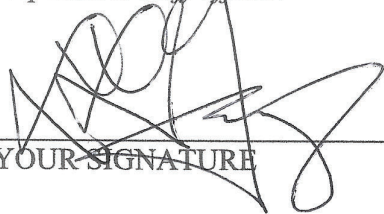
If the answer to all of the above questions under RESEARCH FUNDING OR OTHER INTERESTS is either "no" or "not applicable," check here ☒ (NO).

If the answer to any of the above questions under RESEARCH FUNDING OR OTHER INTERESTS is "yes," check here ☐ (YES), and briefly describe the circumstances below.

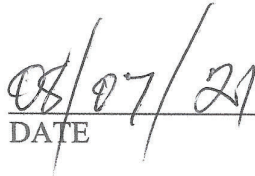
EXPLANATION OF "YES" RESPONSES:



During your period of service in connection with the activity for which this form is being completed, any changes in the information reported, or any new information, which needs to be reported, should be reported promptly by written or electronic communication to the responsible staff officer.



YOUR SIGNATURE



DATE

Reviewed by:

Regional Liaison
U.S. Fish and Wildlife Service

CARRIE
STRAIGHT

Digitally signed by CARRIE
STRAIGHT
Date: 2021.08.08 21:41:03 -04'00'

Date

From: [Straight, Carrie A](#)
To: [Valenta, Aaron](#)
Subject: RE: Dwarf-flowered heartleaf PDM plan
Date: Friday, June 11, 2021 11:43:00 AM

Yes I will.

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Carrie A. Straight, PhD
She, her, hers

Recovery Coordinator
South Atlantic-Gulf and Mississippi Basin Regions
U.S. Fish and Wildlife Service
Ecological Services
1875 Century Boulevard
Atlanta, Georgia 30345
404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

NOTE: This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act (FOIA) and may be disclosed to third parties.

From: Valenta, Aaron <aaron_valenta@fws.gov>
Sent: Friday, June 11, 2021 10:53 AM
To: Straight, Carrie A <carrie_straight@fws.gov>
Subject: Fw: Dwarf-flowered heartleaf PDM plan

Hi Carrie, Can you run with this?

Thanks,

Aaron Valenta

Regional Program Manager, Division of Restoration and Recovery
U.S. Fish and Wildlife Service
1875 Century Boulevard
Atlanta, Georgia 30345
404/679-4144

This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act and may be disclosed to third parties.

From: Young, Kristi <kristi_young@fws.gov>
Sent: Friday, June 11, 2021 10:38 AM
To: Straight, Carrie A <carrie_straight@fws.gov>; Valenta, Aaron <aaron_valenta@fws.gov>
Cc: Hamilton, Byron <byron_hamilton@fws.gov>; Szymanski, Jennifer <jennifer_szymanski@fws.gov>
Subject: Dwarf-flowered heartleaf PDM plan

Happy Aloha Friday all,

So the scramble with FL golden aster this week made me wonder about some of our other, older rules. I went into the proposed rule for dwarf-flowered heartleaf, and lo and behold, there is the same language about seeking peer review on the PDM plan. What would you like to do? Public comment period closes on June 25th; so far only 3 comments and they are pretty standard. We sought peer review on the SSA and received no comments, so I'm not sure an additional effort would be successful.

I am double-checking the proposed delisting rules going through the review process now to make sure this language is not in any more rules.

-Kristi

[illegible]

Kristi Young
Acting Manager, Division of Conservation and Classification
U.S. Fish and Wildlife Service
South Atlantic-Gulf and Mississippi Basin
Unified Regions
Kristi_Young@FWS.gov
(404) 679-7119

>:<>:<>:<>:<>:<>:<><>:<>:<>:<>:<>:<>:<>:<>:<

From: Straight, Carrie A <carrie_straight@fws.gov>
Sent: Friday, June 11, 2021 12:16 PM
To: Young, Kristi <kristi_young@fws.gov>; Valenta, Aaron <aaron_valenta@fws.gov>
Cc: Hamilton, Byron <byron_hamilton@fws.gov>; Szymanski, Jennifer <jennifer_szymanski@fws.gov>

>.<:<.<.<.<.<:<:<:<:<:<:<:<:<:
Kristi Young

[illegible]

From: [Straight, Carrie A](#)
To: [Reid, Rebekah N](#)
Cc: [Peeples, Gary](#)
Subject: RE: DFHL Post Delisting Monitoring Plan
Date: Friday, June 25, 2021 3:40:00 PM
Attachments: [Sent to reviewers.zip](#)

I sent out the document for peer review today. Please find attached the documents that I sent out for your file. I have requested a response by 7/16.

Carrie

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Carrie A. Straight, PhD
She, her, hers

Regional Recovery Coordinator
South Atlantic-Gulf and Mississippi Basin Regions
U.S. Fish and Wildlife Service
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1875 Century Boulevard
Atlanta, Georgia 30345
404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

NOTE: This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act (FOIA) and may be disclosed to third parties.

From: Reid, Rebekah N <rebekah_reid@fws.gov>
Sent: Tuesday, June 22, 2021 9:23 AM
To: Straight, Carrie A <carrie_straight@fws.gov>
Cc: Peeples, Gary <gary_peeples@fws.gov>
Subject: Re: DFHL Post Delisting Monitoring Plan

Hey Carrie,

It hasn't changed from when you and Byron asked for it last summer.

Rebekah Reid

US Fish and Wildlife Service
Asheville Ecological Services Field Office
160 Zillico St.
Asheville, NC 28801
phone: 828-258-3939 x42238
cell: 828-782-0090

NOTE: This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act (FOIA) and may be disclosed to third parties.

From: Straight, Carrie A <carrie_straight@fws.gov>
Sent: Tuesday, June 22, 2021 9:18 AM
To: Reid, Rebekah N <rebekah_reid@fws.gov>
Cc: Peeples, Gary <gary_peeples@fws.gov>
Subject: RE: DFHL Post Delisting Monitoring Plan

Thanks for the update. Do you have the most recent version of the PDM or was that put up with the original docket?

Carrie

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Carrie A. Straight, PhD
She, her, hers

Regional Recovery Coordinator
South Atlantic-Gulf and Mississippi Basin Regions
U.S. Fish and Wildlife Service
Ecological Services
1875 Century Boulevard
Atlanta, Georgia 30345
404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

NOTE: This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act (FOIA) and may be disclosed to third parties.

From: Reid, Rebekah N <rebekah_reid@fws.gov>
Sent: Tuesday, June 22, 2021 8:37 AM
To: Straight, Carrie A <carrie_straight@fws.gov>
Cc: Peeples, Gary <gary_peeples@fws.gov>
Subject: Re: DFHL Post Delisting Monitoring Plan

No, as planned none of those folks will be conducting the monitoring.

Rebekah Reid

US Fish and Wildlife Service
Asheville Ecological Services Field Office
160 Zillicoa St.
Asheville, NC 28801
phone: 828-258-3939 x42238
cell: 828-782-0090

NOTE: This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act (FOIA) and may be disclosed to third parties.

From: Straight, Carrie A <carrie_straight@fws.gov>
Sent: Tuesday, June 22, 2021 8:34 AM
To: Reid, Rebekah N <rebekah_reid@fws.gov>
Cc: Peeples, Gary <gary_peeples@fws.gov>
Subject: RE: DFHL Post Delisting Monitoring Plan

Thanks Rebekah,

A quick question, will Keith (or any of them) be involved in any of the monitoring? If so we'll need someone different.

Thanks,

Carrie

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Carrie A. Straight, PhD
She, her, hers

Regional Recovery Coordinator
South Atlantic-Gulf and Mississippi Basin Regions
U.S. Fish and Wildlife Service
Ecological Services
1875 Century Boulevard
Atlanta, Georgia 30345
404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

NOTE: This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act (FOIA) and may be disclosed to third parties.

From: Reid, Rebekah N <rebekah_reid@fws.gov>
Sent: Tuesday, June 22, 2021 7:44 AM
To: Straight, Carrie A <carrie_straight@fws.gov>
Cc: Peeples, Gary <gary_peeples@fws.gov>
Subject: DFHL Post Delisting Monitoring Plan

Hi Carrie,

Below is a list of possible reviewers. These folks were not involved in the SSA or development of the PDM plan.

Dr. Doug Rayner

Wofford College

raynerda@wofford.edu

Dr. LL “Chick” Gaddy

Terra Incognita

llgaddy2@gmail.com

Keith Bradley

SC Heritage Trust Program

bradleyk@dnr.sc.gov

I'll update the plan if we get any comments.

Thanks,

Rebekah Reid

US Fish and Wildlife Service

Asheville Ecological Services Field Office

160 Zillicoa St.

Asheville, NC 28801

phone: 828-258-3939 x42238

cell: 828-782-0090

NOTE: This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act (FOIA) and may be disclosed to third parties.

Attachment 20210625 154000_RE_DFHL Post Delisting Monitoring Plan.zip (2459727 Bytes) cannot be converted to PDF form

Project Plan – Dwarf-flowered Heartleaf Species Status Assessment and Listing Status Determination

Reason for Action: The Dwarf-flowered heartleaf (*Hexastylis naniflora*) is a threatened species that is distributed across 12 counties in North and South Carolina. When *Hexastylis naniflora* (dwarf-flowered heartleaf) was federally listed in 1989, there were 24 known extant populations across the species' range. As of 2016, there are an estimated 113 total populations (91 in NC and 22 in SC) of the species. The species continues to face threats to its habitat through development projects or other causes such as trash disposal, expansion of residential lawns, cattle, or invasive exotics, which may impact the population in the future. The U.S. Fish and Wildlife Service needs to better understand the viability of this species now and into the future in order to make management decisions based upon sound science. Specifically, the species needs a Recovery Plan, and an upcoming 5-year review under the Endangered Species Act will require the Service to determine the appropriate protection status of Dwarf-flowered heartleaf. In support of this decision, the Service will complete a Species Status Assessment (SSA) and will then make a determination of threatened (no status change), endangered (uplisting), or protection not warranted (delisting).

Project Goal: The goal of this project is to develop an SSA that characterizes the viability of the Dwarf-flowered heartleaf under varying future scenarios in a measurable fashion using the best available scientific information, and to produce a legally defensible status determination in a timely manner.

Document Review and Surname Briefings – Rather than the traditional surname process wherein each individual who surnames is expected to read the entirety of a draft Federal Register notice, we intend to use a detailed “surname briefing” to replace detailed review by multiple individuals. Through this process, we expect that a surname on a package means that the individual has been briefed and supports the decision. To keep the science and policy separate, we may also utilize outlines, results of the conceptual model or geospatial analyses, and other intermediate products and brief the Management Team at any key decision points. For this package, we intend to initiate formal decision analysis with the Field Office and Regional Office Management Team after the SSA Report is peer-reviewed, but before the Field Office/Project Manager is expected to prepare a draft Federal Register notice.

No other individuals are expected to review the drafts at the FO or RO levels. Any other individuals who choose to review the draft must do so in a timely manner (meaning their review cannot delay the process) and keep their comments limited to their expertise (refrain from second guessing already reviewed and revised biology or policy points).

Resources Needed:

- GIS: maps will be necessary for the analysis and Report.
- Expert Input: NCNHP; NCDOT; Appalachian State University; SCNHP

Roles and Responsibilities: The following table provides a list of individuals that will be responsible for developing the SSA as well as the responsibilities of others.

Table 1. Individuals involved in the development of the HENA SSA.

Roles	FWS Personnel	Others
Core Team	• Rebekah Reid –FO biologist • Michael Marshall - RO biologist, SSA specialist • Stephanie DeMay – TAMU-NRI SSA specialist • Drew Becker, Project Manager	Outreach: Phil Kloer Michael Stevens- Regional Solicitor
Recommendation Team	• Jack Arnold, R4 Deputy ARD-ES • Leo Miranda, R4 ARD-ES • Janet Mizzi, North Carolina FO Project Leader • Tom McCoy, South Carolina FO Project Leader	
Technical Team	• External experts/state biologists ○ Suzanne Mason (NC Natural Heritage Program) ○ Jame Amoroso (NC Natural Heritage Program) ○ Matt Estep (Appalachian State University)	Others as needed (South Carolina member and James Padgett, species expert)

Core Team

- Be the species experts: conduct research, analyze best available science, organize all information
- Provide first draft of SSA Report and any other analysis products (including interim products), consistent with project schedules
- Review other documents, as needed (outreach materials, briefing papers, and Economic Analysis)
- Keep official Administrative Record
- Keep FO management informed of progress and issues
- Be familiar with ES Program policy.
- Attend and actively participate in SSA Team meetings.
- Coordinate with other FWS programs within your geographic area of responsibility.
- Assist External Affairs with accurate and timely information sharing.
- Immediately bring any issues of concern to the attention of the Project Manager.
- Assist in drafting SSA reports and documentation.
- Keep in regular communication with your chain-of-command to ensure your management staff are aware of the status of the project and any issues or concerns that arise.
- Coordinate with State agencies.

Technical Team

- Support SSA as requested by Core Team
- Provide answers to key elicitation questions from the Core Team

- Provide reviews of the SSA throughout the drafting process
- Provide data and GIS support as needed

Recommendation Team

- Ensure timeliness of products and consistency with project schedules.
- Manage budgetary issues.
- Be aware of and communicate with others on Recommendation Team (and Project Manager) any potential political issues or sensitivities with local partners.
- Be familiar with ES Program Policy and species' biology, as needed.
- Approve decisions through surname briefing (assumes high-quality written document produced by Core Team).
- Assist in timely resolution of any issues that arise within the core team or with external interested parties.

Project Manager

- Coordinate all activities, and be the main point of contact for the core team.
- Draft Federal Register rules.
- Keep FWS Region 4 Regional Liaison informed of progress and issues.
- Work closely with External Affairs to assist in accurate and timely information sharing.
- Coordinate and communicate with the Regional Solicitor and HQ ES Staff.
- Review other documents, as needed (i.e., SSA, outreach materials, briefing papers, etc.).
- Provide accountability for meeting the schedule for SSA and rule package completion.
- Make decisions through surname briefings and decision analysis process (assumes high-quality written document produced by Core Team)
- Assist in resolution of any issues where the Lead Biologists need assistance.

External Affairs

- Attend Core Team meetings or conference calls, as requested.
- Be the point-of-contact for media or congressional inquiries
- Draft outreach materials (news releases, website copy, etc.).
- Review drafted SSA and other listing package products for external audiences, if necessary.
- Immediately bring any EA issues of concern to the attention of the Project Manager.

Schedule: This project will be initiated in FY2018 with the anticipation that the proposed rule will be published in the FY2018. See draft schedule for detailed internal deadlines.

Project Plan Revisions: We expect that we will meet deadlines for all products and any quality benchmarks associated with those products. However, this project plan can be revised at any time with the agreement of the ARDs and Field Supervisors.

Post-Project Debriefing: The Core Team and Technical Team commit to having a conversation after the completion of the project. This feedback on the process is necessary to ensure we are always utilizing the best available practices and working towards greater efficiencies in the Recovery Program.

Signed:

Field Supervisor

Date

DARD /
ARD-ES

Date

Project Manager

Date

Core Team Member

Date

Core Team Member

Date

Core Team Member

Date

Core Team Member

Date

Species Status Assessments

Mike Marshall
Texas A&M-IRNR
USFWS Region 4



Passed by Congress in the Nixon Administration

Species Status Assessments (SSA)—a new way of conducting business

USFWS
Species Status
Assessment
Framework

October

2015

Version 3.0

The US Fish and Wildlife Service is using an integrated and conservation-focused analytical approach, the Species Status Assessment Framework, to assess the species biological status for the purpose of informing decisions and activities under the Endangered Species Act.

SPECIES' NEEDS

+
 Current Availability
 or Condition of
 those Needs

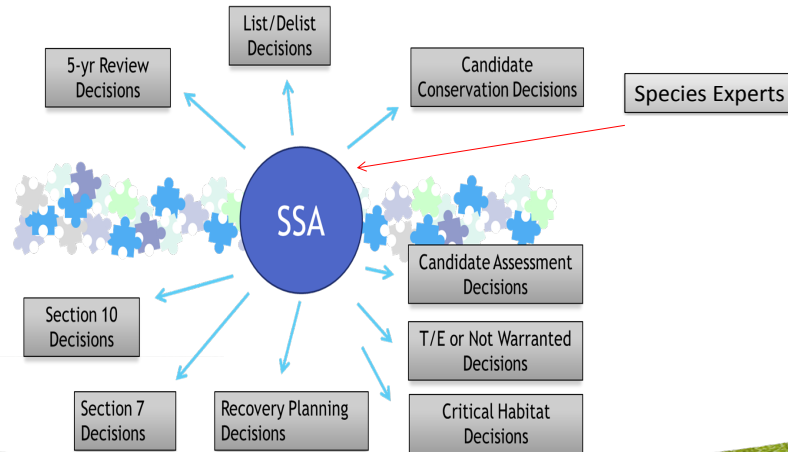
CURRENT SPECIES' CONDITION

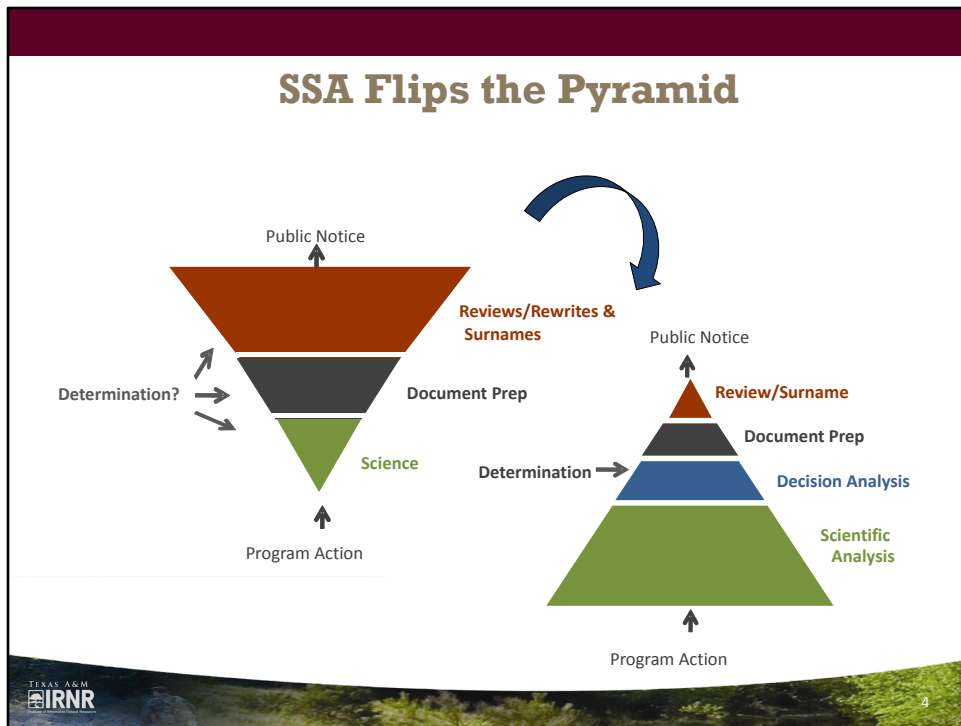
+
 Future Availability
 or Condition of
 those Needs

FUTURE SPECIES' CONDITION



THE BIG PICTURE: SSAs will inform all ESA decisions. They form the hub of information to be used across all ESA programs.





2 points: 1) one of the main goals is to flip the workload pyramid. So more time is spent on the science and less on reviews, rewrites, and surnames.
2) Also wanted to clarify and be explicit about where policy decisions are made in the process.

Should expect the SSA to be a major task; bulk of the work!

It's about assessing species viability



Resiliency

The ability of populations to withstand stochastic events.



Redundancy

The ability of species to withstand catastrophic events.

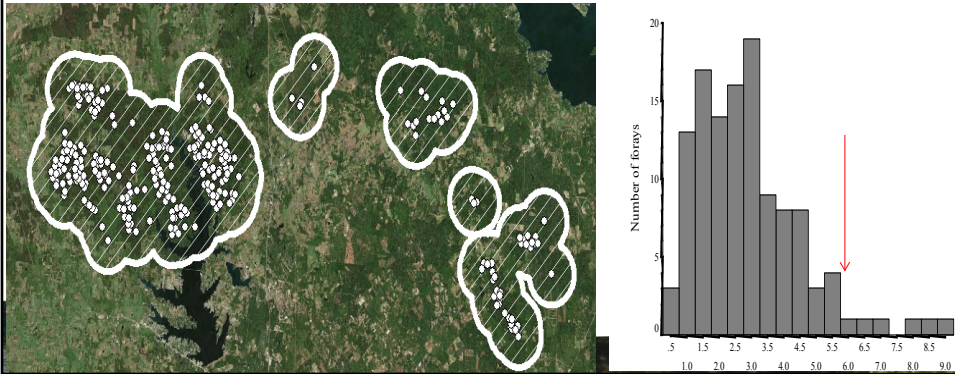


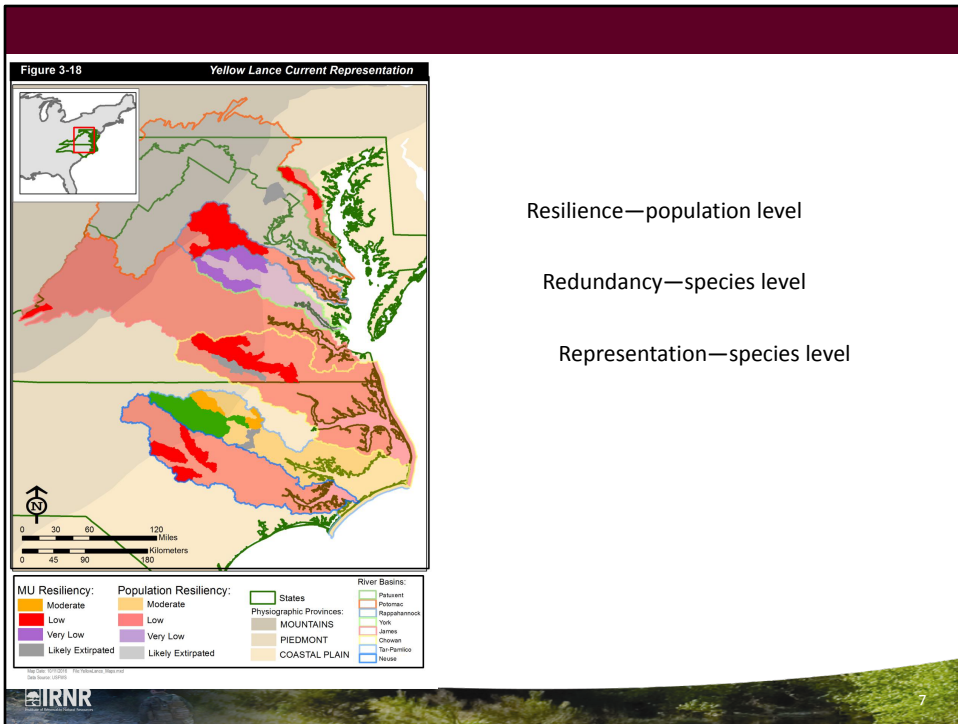
Representation

Ability of species to adapt to changing environmental conditions.

Delineating Populations

- Often one of the more difficult parts of the process
- Resilience is measured at this level





SSA and viability

Viability is the ability of a species to sustain populations in the wild beyond a biologically meaningful timeframe.

Viability is not a specific state, but rather can be thought of as a continuous measure of the likelihood that populations will be sustained over time.

SSA process intends to characterize a species' degree of viability over time (past, current, and future).



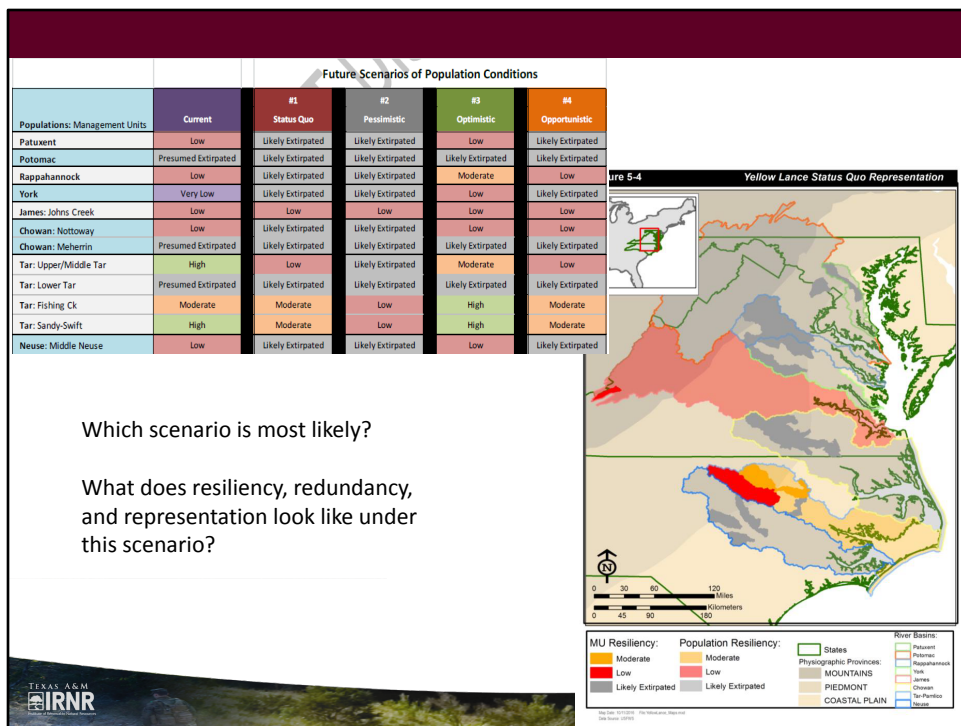
Viability is not a specific state, but rather it can be thought of as a continuum of degrees of ability to sustain populations over time. higher degree of viability means higher likelihood of being able to sustain populations over a longer period of time.

The decision then becomes: what degree of viability do we want for a species, or what is our risk tolerance?

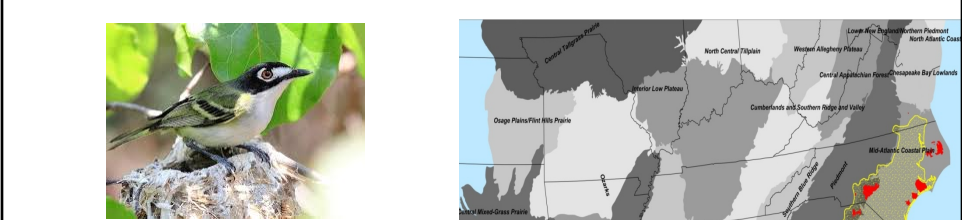
This is not a scientific question. It overlays ESA policy and societal norms over the scientific evaluation.

Not in the SSA.

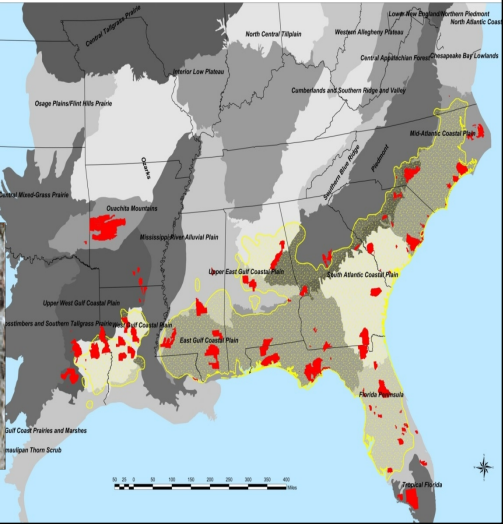
(Midwest crayfishes: **will have to check with Laura Ragan about particular species**)



- Black-capped vireo



- RCW--ongoing

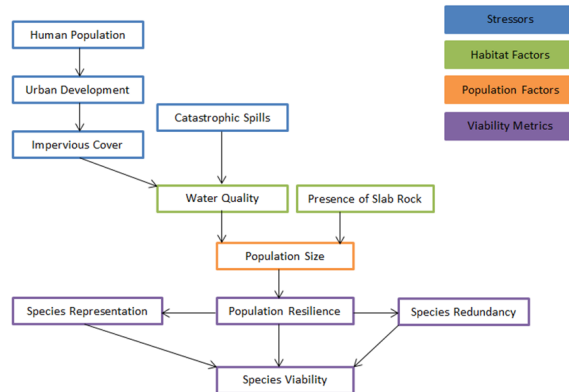


Dwarf-flowered heartleaf

- Lack of recovery plan and evidence of recovery
- SSA will provide the science to inform a recovery plan and potential reclassification
- Species Biology → Species needs → current condition → influences on viability → future condition
 - Background biology and ecology
 - Define factors to inform resilience
 - Delineate populations
 - Are there representative units?
 - What are the key risk factors to carry forward?
 - Scenarios and projection timeframe
 - Qualitative or quantitative assessment

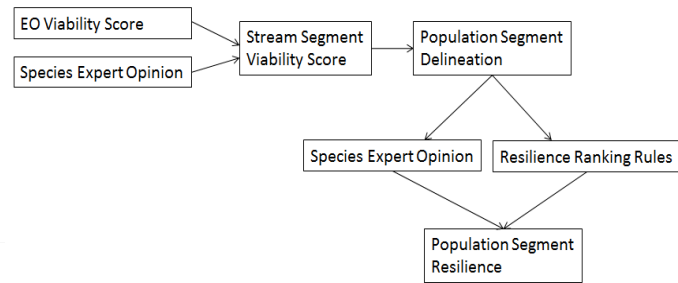
Defining Factors

- What factors drive resilience of populations?
- Habitat factors (soil type, canopy cover, water quality)
- Population factors (density, evidence of reproduction, dispersal)



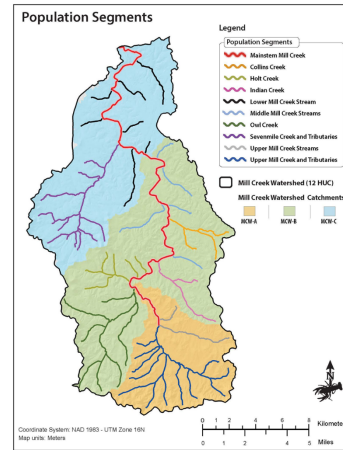
Defining Populations

- Genetics
- Dispersal
- EO Scoring



Representation

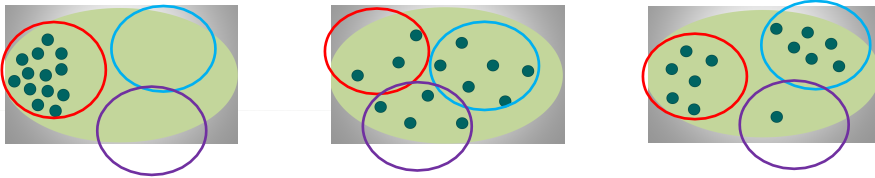
- *In the absence of species specific ecological and genetic data, we evaluate representation based on the extent and variability of habitat characteristics across the range of the species.*
- Typical representative units include genetic populations, ecoregions, watersheds, or none



Redundancy

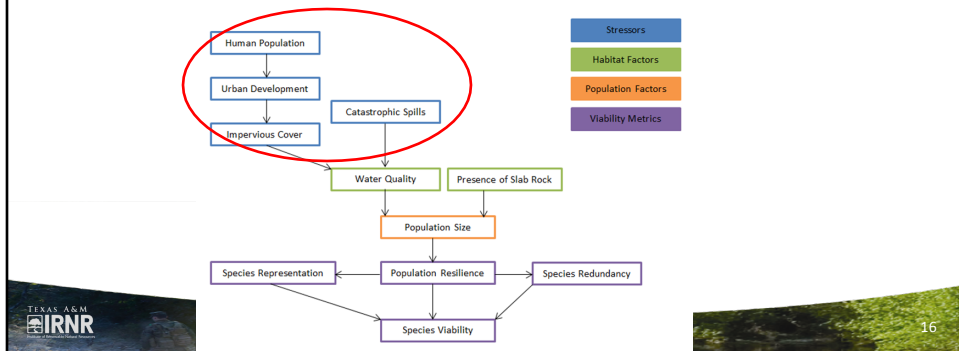
- Measured by the number of populations and their distribution
 - Across the range (tally)
 - Within representative units

Interplay between Redundancy and Representation



Influences on Viability

- Identify all potential stressors and risk factors (ROW development, climate change, water quality)
- Influences can be positive
- Identify key influences to project forward
- Influences help define scenarios



Scenarios

- Appropriate time frame
- Capture uncertainty
- Likelihood of scenarios
- How do scenarios influence the 3 R's

"The future is an unknown, but a somewhat predictable unknown. To look to the future we must first look back upon the past. That is where the seeds of the future were planted"—Albert Einstein

	Status Quo	Worst Case	Conservation
20-30 years	Likely	Unlikely	As likely as not

Confidence Terminology	Explanation
Very likely	Greater than 90% certain
Likely	70-90% certain
As likely as not	40-70% certain
Unlikely	10-40% certain
Very unlikely	Less than 10% certain

Analysis

- The complexity of the SSA and the associated analysis should match the complexity of the species and the associated data
- Statistical analysis; GIS models; qualitative projections from expert input
- At the end of the day, we look to compare current condition (3 R's) to future condition (3 R's) under several scenarios to assess viability and classify the species as threatened, endangered, or not warranted

Viability

Population Segment	Current	Status Quo	Conservation	Worst Case
Mainstem	High	High	High	Moderate
Sevenmile	High	High	High	Moderate
Indian Creek	High	High	High	High
Holt Creek	High	High	High	High
Owl Creek	Moderate	Low	Moderate	Low
Collins Creek	High	High	High	Moderate
Upper System	High	Moderate	High	Moderate
Lower Streams	Low	Low	Moderate	Low
Upper Streams	Moderate	Moderate	High	Moderate
Middle Streams	Low	Low	Low	Low

HENA SSA Team

- Core Team
 - Rebekah Reid
 - Mike Marshall
 - Drew Becker
 - Stephanie DeMay
- Technical Team
 - Jame Amoroso
 - Matt Estep
 - Others?

Roles and Responsibilities

- Core Team—synthesize science; write the SSA; coordinate with experts; conduct analysis; ensure timeliness
- Technical Team—provide data if needed; periodic reviews of document; expert input via elicitations

Example elicitations

- How would you suggest delineating for HENA?
- What factors are important for characterizing resilience for HENA?
 - Habitat factors
 - Population factors
- How would you suggest representation might look for this species (physiographic, latitudinal, urban/rural, elevational, habitat types)?
- In thinking about future scenarios and viability of this species, what are the most pertinent risk factors to consider?

Timeline

Task	Duration (Days)	Complete Date	Who
Initiation of Project- Rapid Assessment			
KICK-OFF MEETING	1	1/8/18	Technical Team, Core Team, and PAO
Send Dear Interested Party Letters	7	1/15/18	FO
Biology/Species Needs	14	1/29/18	Core Team
Present and Review Biology/Species Needs	7	2/5/18	Core Team, Technical Team
Current Conditions (Habitat and Populations)	14	2/19/18	Core Team
Present and Review Current Conditions Analysis	7	2/26/18	Core Team, Technical Team
Future Conditions Analysis	14	3/12/18	Core Team
Present and Review Future Conditions	7	3/19/18	Core Team, Technical Team
Write SSA Report	21	4/9/18	Core Team
Review of SSA Report	7	4/16/18	Core Team, Technical Team
Revisions to SSA Report	7	4/23/18	FO
Peer Review	28	5/21/18	Peer Reviewers
Incorporate Peer Review comments	7	5/28/18	FO
Draft SSA to Recommendation Team for Review	7	6/4/18	Recommendation Team
Prepare Briefing Materials for meeting	7	6/11/18	Core Team

Thank you so much for your conservation efforts and your willingness to participate!

Questions?

Appendix B3: NC Natural Heritage Program (NCNHP) Element Occurrence Rank Specifications for *Hexastylis naniflora*

"A" Rank Specifications (excellent viability)

An A-ranked population of *Hexastylis naniflora* should have 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" Rank Specifications (good viability)

A B-ranked population of *Hexastylis naniflora* should have 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 occurring in less than one acre of high quality forest or on land impacted by human disturbance such as logging, grazing, mowing, etc.

"C" Rank Specifications (fair viability)

A C-ranked population of *Hexastylis naniflora* should have 100-200 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 - 200- 500 clumps occurring in less than one acre of high quality forest or on land impacted by human disturbance such as logging, grazing, mowing, etc.

"D" Rank Specifications (poor viability)

A D-ranked population of *Hexastylis naniflora* should have fewer 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 occurring in less than one acre of high quality forest or on land impacted by human disturbance such as logging, grazing, mowing, etc.

"E" Rank Specifications (extant)

An E-ranked population of *Hexastylis naniflora* is an occurrence that has recently been verified as still existing, but sufficient information for the factors used to estimate viability has not yet been obtained.

"H" Rank Specification (historical)

An H-ranked population of *Hexastylis naniflora* lacks recent field information verifying the continued existence of the occurrence. In the absence of known disturbance and with the habitat still extant, H is generally recommended for occurrences that have not been reconfirmed for approximately 30 or more years.

"F" Rank Specification (failed to find)

An F-ranked population of *Hexastylis naniflora* has not been found despite a search by an experienced observer at a time and under conditions appropriate for the Element at a location where it was previously reported, but the occurrence still might be confirmed to exist at that location with additional field survey efforts. For occurrences with vague locational information, the search must include areas of appropriate habitat within the range of locational uncertainty.

"X" Rank Specification (failed to find)

An X-ranked population of *Hexastylis naniflora* is considered destroyed based on adequate surveys by one or more experienced observers at times and under conditions appropriate for the species at the occurrence location, or other persuasive evidence indicates that the species no longer exists there or that the habitat has been destroyed to such an extent that it can no longer support the species.

“U” Rank Specification (failed to find)

A U-ranked population of *Hexastylis naniflora* cannot be assigned a rank due to lack of sufficient information on the occurrence or the species identification has not been confirmed.

Rank Specifications Justification

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



Reid, Rebekah <rebekah_reid@fws.gov>

Hexastylis naniflora polygons in SC

1 message

Robinson, Laura <Laura.Robinson@ncdcr.gov>
To: "Reid, Rebekah" <rebekah_reid@fws.gov>

Thu, Sep 28, 2017 at 12:16 PM

Hi Rebekah,

Here's what we have in our files for SC populations. This data did not come from SCNHP. Since we signed a data sharing agreement with SC, you probably need to request from them the shapefiles with EO numbers and EO ID numbers.

Attached is information for Peters Creek Preserve, Cowpens National Battlefield, and Blalock Reservoir.

Peters Creek Preserve and Cowpens National Battlefield were remapped by James Padgett in 2012. The attached polygons are what James saved in our files. There may be more out there that he didn't have access to and was not mapped by him, but this is more accurate than what SC NHP has in their database.

There are two Blalock Reservoir polygons, Blalock_HexastylisBoundaries.shp is one from 2007 that was provided to James by the manager. The lake blalock in part_Padgett.shp is the polygon that James mapped in 2012 to add to the existing polygon, so use these in combination.

Sorry there aren't all extensions to the shapefiles. I think James might have been using an older version of ArcMap, but it seems to project ok in my ArcMap version 10.

Let me know if you need anything else.

Laura

LAURA ROBINSON

Botanist, N.C. Natural Heritage Program

121 W Jones St MSC 1651 Raleigh, NC 27699

919 707 8647 *office*



18 attachments

image001.jpg
39K



image003.jpg
26K

-  remapped peters creek 5-2-2012_Padgett.dbf
1K
-  remapped peters creek 5-2-2012_Padgett.shp
4K
-  remapped peters creek 5-2-2012_Padgett.shx
1K
-  remapped Cowpens 5-2-2012_Padgett.dbf
1K
-  remapped Cowpens 5-2-2012_Padgett.prj
1K
-  remapped Cowpens 5-2-2012_Padgett.shp
17K
-  remapped Cowpens 5-2-2012_Padgett.shx
1K
-  Blalock_HexastylisBoundaries.dbf
3K

-  **Blalock_HexastylisBoundaries.prj**
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-  **Blalock_HexastylisBoundaries.sbn**
1K
-  **Blalock_HexastylisBoundaries.sbx**
1K
-  **Blalock_HexastylisBoundaries.shp**
9K
-  **Blalock_HexastylisBoundaries.shx**
1K
-  **lake blalock in part_Padgett.dbf**
1K
-  **lake blalock in part_Padgett.shp**
2K
-  **lake blalock in part_Padgett.shx**
1K

From: [Phillips, Catherine](#)
To: [FW4 ALL ES](#)
Subject: Kudos to the Dwarf-flowered heartleaf team!
Date: Monday, May 3, 2021 8:00:14 AM

ES team,

We want to recognize the great work performed by the dwarf-flowered heartleaf core team.

On April 26, a rule proposing to remove the dwarf-flowered heartleaf (*Hexastylis naniflora*), a plant endemic to the upper Piedmont region of western North Carolina and upstate South Carolina, from the Federal List of Endangered and Threatened Plants (List) published in the Federal Register. Thanks to Rebekah Reid, Gary Peebles, Byron Hamilton, Drew Becker, our partners at Texas A&M, and others for their work to develop the Species Status Assessment and proposed delisting rule. Work began on the dwarf-flowered heartleaf SSA in 2018 and many efforts have been underway to recover this species. The move represents years of ESA-inspired collaborations between state, federal, and local stakeholders on behalf of the North Carolina and South Carolina plant. The proposed rule is currently undergoing public comment.

Congrats to the members of the SSA core team! Great job!

Catherine T. Phillips, Ph.D.
Assistant Regional Director, Ecological Services
South-Atlantic Gulf and Mississippi Basin Interior Regions
1875 Century Blvd
Atlanta, GA 30345
404-450-7563 (cell)



Dwarf-flowered Heartleaf (*Hexastylis naniflora*)

Proposed Delisting



Photo credit: Jim Fowler

HQ Briefing

August 29, 2019



Species Status Assessment

- SSA kicked off
- Interested Party Letters sent to stakeholders
- Species expert review
 - Species biology/needs/influences
 - Current condition
 - Future condition
 - Full report
- Peer review completed
- Final SSA completed



Species Introduction

- Listed as threatened in 1989
 - 24 known populations in 8 counties
 - Approx. 5,000 individuals
 - Development was listed as the main threat
- Recovery Outline developed in 1989
- Recovery Plan never completed
- 5-Year Review (2011)
- Range-wide Status Report (2016)
- Species Status Assessment (2018)
 - 119 known populations in 13 counties
 - Approx. 300,000+ individuals



Species Biology and Needs

- Low-growing herbaceous perennial.
- Leaves – small, evergreen, heart-shaped, dark green (variegated), and leathery.
- Flowers – small, jug-shaped, beige to dark brown, found near the base of plant.
- Blooms from mid-March to June, fruits from mid-May to July
- Pollinated by small insects, dispersed by ants



Photo credit:
A. Krings (NCSU)

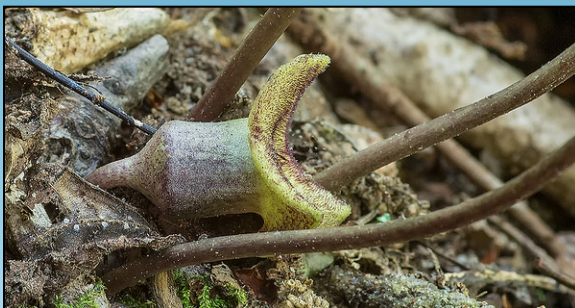


Photo credit
(all others):
Jim Fowler



Species Habitat and Needs



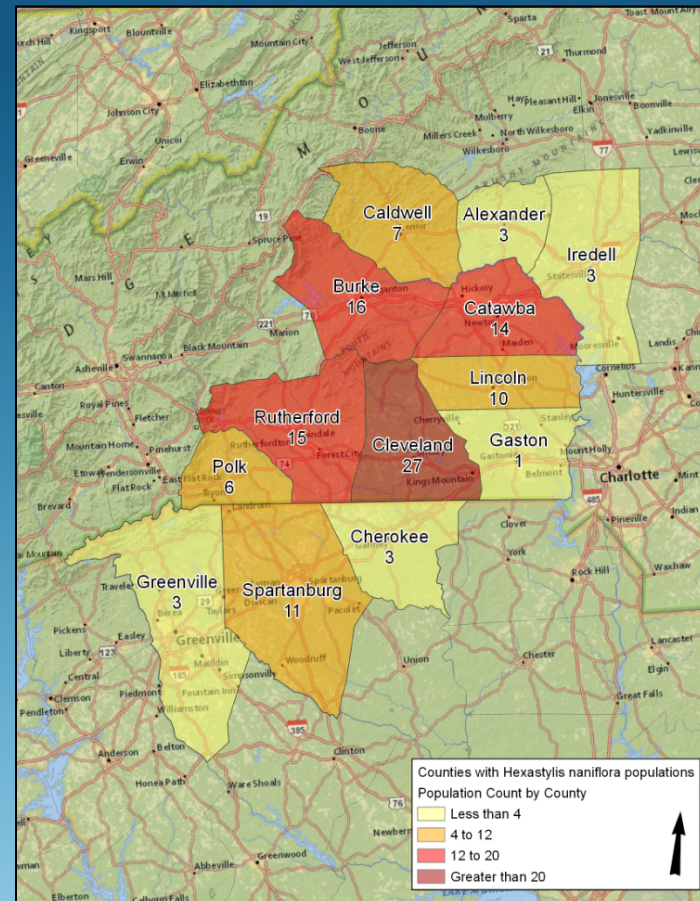
- Piedmont uplands
- Acidic sandy-loam soils
- Mesic to dry bluffs, slopes, or ravines in deciduous forest OR
- Moist soils adjacent to streams, and along lakes and rivers
- Affinity for:
 - mountain laurel (*Kalmia latifolia*)
 - north and northwest facing slopes
 - floodplains

Photo credit:
A. Krings (NCSU)



Species Biology and Needs

- Distribution
 - Endemic to the region of western NC and upstate SC
- Historical
 - 24 extant pops (one extirpated)
- Current
 - 2018, 119 pops across 13 counties in two states



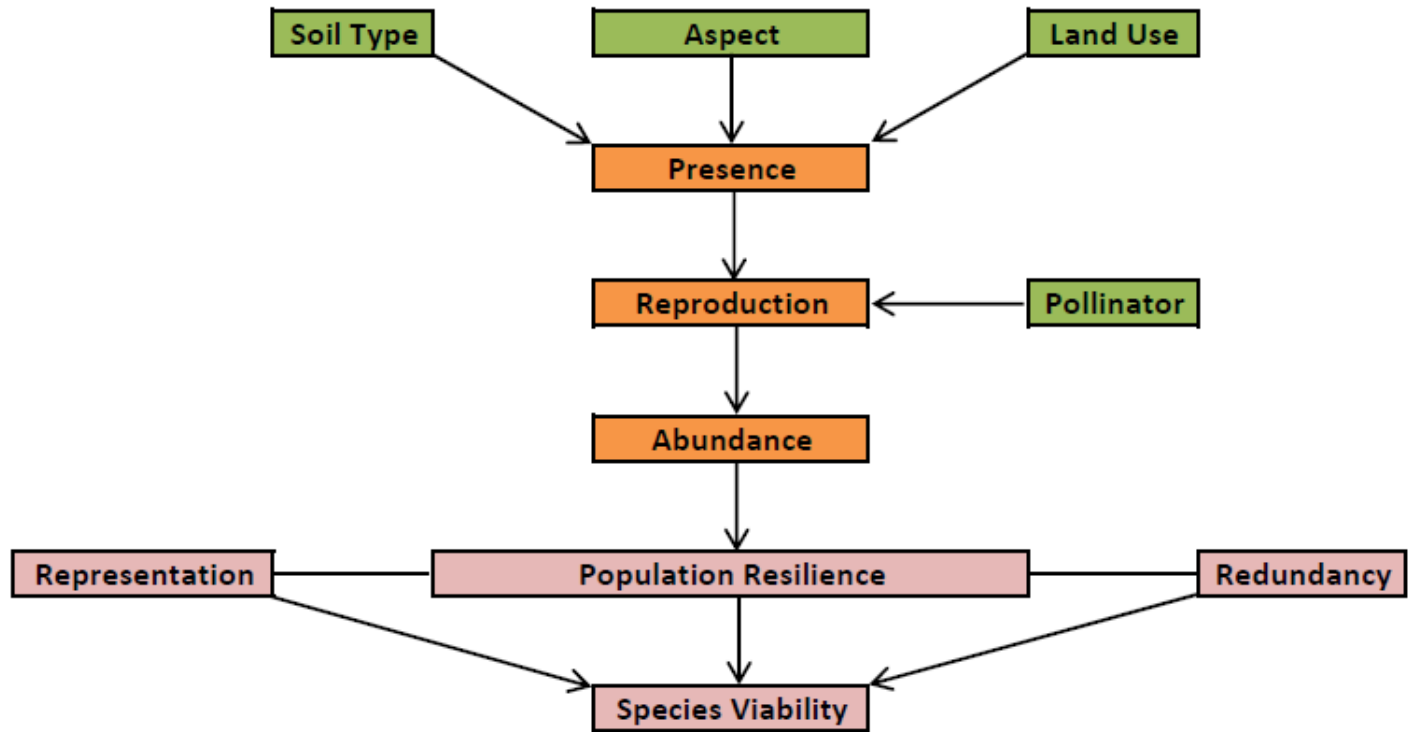


Data Sources

- Unpublished Field Surveys
- Research Project Reports
- Peer Reviewed Scientific Publications
- Unpublished Field Surveys
- Personal Communications
- Latest 5-Year Review
- Species Status Assessment Report



Overview of Species Needs and Viability





Current Conditions

Population Resilience

County	Very High	High	Moderate	Low	Totals
Alexander	1		1	1	3
Burke/Catawba/Caldwell			1		1
Burke	2		4	2	8
Caldwell	2	2		1	5
Catawba	4	2	4	2	12
Cherokee	1				1
Cleveland/Rutherford	1				1
Cleveland	4	1	7	6	18
Gaston			1		1
Greenville				2	2
Iredell			1	2	3
Lincoln	2		1	2	5
Polk	2		3	1	6
Rutherford	7		3		10
Spartanburg	2				2
Totals	28	5	26	19	78
% of total	36	7	34	23	100
Cumulative %	40	43	77	100	--

•Resilience

- Defined “current” populations .
- Assessed using abundance and EO viability ranks
- 4 categories

•Representation

- Lack of genetic and ecological diversity data
- No representative units defined
- Two habitat types

•Redundancy

- 78 pops defined as current (total 119 pops) distributed across 13 counties



Potential Factors Influencing Viability

- Development
- Incompatible forestry practices
- Erosion and sedimentation
- Invasive exotic species
- Trampling
- Agricultural use
- Road construction and improvement





Conservation Efforts

- The North Carolina Plant Conservation and Protection Act (NC State Code Article 19B, § 106-202.12)
- Section 7 Consultations
- Duke Energy
- Cowspens National Battlefield
- Broad River Greenway



Future Conditions

- Development of Future Scenarios
 - Primary threat = Development
 - Persistence of populations (pre-2005)
 - Assessment to 2040
- Three Scenarios
 - Status Quo
 - High Development
 - Targeted Conservation





Future Condition

Assessment Rules

Scenarios	Urbanization			Non-Current Populations Predicted to Persist
	Protected Areas		Non-Protected Areas	
	Perpetuity	Voluntary/Non-Perpetuity		
Status Quo	No change.	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	EOs prior to 2005 in the top 10% based on weighted ranking.
High Development	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2 If increase in urbanization is >90% THEN extirpation	None
Conservation	No change.	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	EOs prior to 2005 in the top 25% based on weighted ranking.



Status Quo Results

	Current	Status Quo
Very High	28	27
High	5	6
Moderate	26	23
Low	19	17
Extirpated	n/a	5
Persisting	n/a	2
Total	78	75

Scenarios	Urbanization			Non-Current Populations Predicted to Persist
	Protected Areas		Non-Protected Areas	
	Perpetuity	Voluntary/Non-Perpetuity		
Status Quo	No change.	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	EOs prior to 2005 in the top 10% based on weighted ranking.



High Development Results

	Current	High Development
Very High	28	27
High	5	4
Moderate	26	25
Low	19	16
Extirpated	n/a	6
Persisting	n/a	0
Total	78	72

Scenarios	Urbanization			Non-Current Populations Predicted to Persist
	Protected Areas		Non-Protected Areas	
	Perpetuity	Voluntary/Non-Perpetuity		
High Development	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2 If increase in urbanization is>90% THEN extirpation	None



Targeted Conservation Results

	Current	Targeted Conservation
Very High	28	27
High	5	6
Moderate	26	23
Low	19	17
Extirpated	n/a	5
Persisting	n/a	6
Total	78	79

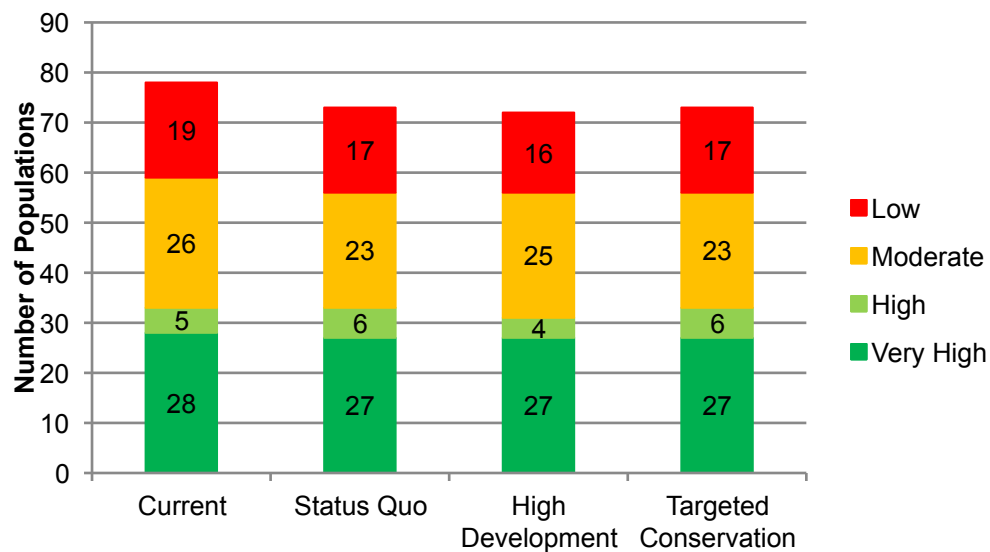
Scenarios	Urbanization			Non-Current Populations Predicted to Persist
	Protected Areas		Non-Protected Areas	
	Perpetuity	Voluntary/Non-Perpetuity		
Conservation	No change.	IF increase in urbanization is >50% THEN resilience rank is -1	IF increase in urbanization is >25% THEN resilience rank is -1 IF increase in urbanization is >50% THEN resilience rank is -2	EOs prior to 2005 in the top 25% based on weighted ranking.



Viability Summary

	Current	Status Quo	High Development	Targeted Conservation
Very High	28	27	27	27
High	5	6	4	6
Moderate	26	23	25	23
Low	19	17	16	17
Extirpated	n/a	5	6	5
Persisting	n/a	2	0	6
Total	78	75	72	79

Future Scenarios





Questions?



Photo credit: Jim Fowler



Dwarf-flowered Heartleaf (*Hexastylis naniflora*) Species Status Assessment Overview

Recommendation Meeting in Region 4

Rebekah Reid and Mike Marshall

June 8, 2018

Good morning. My name is Rebekah Reid and I am the species lead for HENA in the Asheville ES Field Office. Mike Marshall is joining us on the phone and we will be presenting the HENA Species Status Assessment.



Presentation Overview



Photo credit: Jim Fowler

- *Hexastylis naniflora* (HENA) Core and Expert Team
- Coordination & Communication
- Stakeholder Review & Engagement
- Listing & Recovery History
- Species Info, including Distribution, 3Rs & Current Condition
- Factors Affecting Viability
- Future Scenarios
- Q&A

Here is a brief overview of our presentation. I will introduce you to our team and talk through the introductory material. Mike will discuss current and future conditions in relation to the 3Rs and what that means for viability of the species. We have set aside time for questions at the end but please ask your questions as we go along.

To the left is a picture of HENA in bloom.



The HENA Team

CORE TEAM

- Mike Marshall-Atlanta Regional Office
- Rebekah Reid-Asheville Field Office
- Mark Endries-Asheville Field Office
- Stephanie DeMay-TAMU-NRI
- Byron Hamilton-Atlanta Regional Office
- Drew Becker-Atlanta Regional Office

EXPERT TEAM

- Suzanne Mason-NC Natural Heritage Program (NCNHP)
- Jame Amoroso-NCNHP
- Laura Robinson-NCNHP
- Matt Estep-Appalachian State University (ASU)

Core Team

Mike Marshall is with the Atlanta RO and is our lead writer.

I am a part of the Core Team.

Mark Endries is a GIS Analyst in our Asheville ES Field Office and completed all of the GIS modeling you see in the SSA.

Stephanie DeMay is with Texas A&M University's Natural Resources Institute and she provide additional review of the SSA.

Byron Hamilton and Drew Becker are our project managers and they provided support from the RO.

Expert Team

Suzanne Mason – Conservation Data Manager with NCNHP

Jame Amoroso – Conservation Information Specialist with the NCNHP

Laura Robinson – Botanist with the NHP and author or co-author of the NCNHP report referenced in the SSA

Dr. Matt Estep – Assistant Professor in the Department of Biology at ASU with a focus on Evolutionary Genetics and Genomics



Peer & Partner Review

- **7 potential peer reviewers contacted:**
 - Wesley Knapp (NCNHP)
 - Tim Bassette (NCDOT)
 - Dr. Gillian Newberry (University South Carolina—retired)
 - Dr. Doug Rayner (Wofford College)
 - Dr. LL “Chick” Gaddy (Terra Incognita)
 - Dr. Zack Murrell (ASU)
 - Herrick Brown (SC Heritage Trust Program)

_____ review returned to date

•No “deal-breaker” comments

We sent the SSA to seven potential peer reviewers on May 11.

Wesley Knapp – Western Regional Ecologist and Botanist with the NCNHP

Tim Bassette – Environmental Program Consultant with the NCDOT

Dr. Gillian Newberry - retired botanist from USC-Upstate

Dr. Doug Rayner – Professor of Biology at Wofford College with an emphasis on botany and ecology

Dr. Chick Gaddy – field-trained naturalist and consulting biologist

Dr. Zack Murrell – Professor and chair of the Biology Department at ASU focusing on plant systematics, speciation and hybridization, Southern Appalachian floristics and biogeography

Herrick Brown – Assistant Botanist at the SC Heritage Trust Program

All of the individuals chosen has worked closely with the species at some point during their careers. Peer review ended on June 4 and we have received no comments to date.

Other notes

Floristics – study of the plants in a specific area



Stakeholder Engagement

- “Dear Interested Party” letters
- Expert review and engagement
- NC vs. SC Involvement



We started the SSA process by sending Dear Interested Party letters to those that we thought would be interested or have information to share about the species. We sent 78 emails and 6 letters via snail mail. We received 3 responses – 1 call and 2 emails.

We first engaged our experts during a kick-off call and presentation. This was followed by elicitation questions and review of the SSA during each phase of the writing process.

NCNHP was incredibly involved in the process and provided input that helped shape the SSA. SCHTP declined to participate on the expert team citing that they had not worked with the species in many years and weren't sure what additional information they could contribute to the process. They did provide us with heritage data they had and they were asked to participate in the peer review process.

Other notes

Have timeline

Who responded – David Brown (Corps related projects), Jennifer Robertson (quarry site and ski lake), and Gill Newberry (differences between HENA and HEHE)

Have elicitation questions



Listing & Recovery History

Listing:

- Listed as threatened in 1989
 - 24 known populations in 8 counties – approx. 5,000 individuals
 - Development was listed as the main threat

Recovery:

- Recovery Outline developed in 1989
- Recovery Plan never completed
- 5-Year Review (2011)
 - 108 known populations in 12 counties
- Range-wide Status Report (2016)
 - 113 known populations in 13 counties, approx. 300,000 individuals
- Species Status Assessment (2018)
 - 119 known populations in 13 counties

HENA was listed in 1989. At the time of listing, there were 24 known populations in 8 counties. This included approx. 5,000 individuals. Residential and industrial development was cited as the main threat. Other threats cited in the listing rule include conversion of habitat to pasture or small ponds, timber harvesting, and cattle grazing. (Counties: SC – Chero, Green, Spart and NC – Clev, Cata, Burk, Ruth, Linc)

A recovery outline was developed in 1989. And, the outline indicated the draft plan would be completed by FY91. However, a Recovery Plan was never complete. The lack of Recovery Plan was what initially triggered this SSA; however, a significant amount of recovery has occurred. (There were attempts at Recovery Plans or Criteria by others – James Padgett, Gill Newberry, and NHP)

A 5-YR Review was finalized in 2011 (initiated in 2005). Known populations jumped to 108 and the range expanded to 12 counties. (Counties added: NC – Alex, Cald, Ired, Polk)

The 5-YR Review recommended working with partners to collect data capable of depicting status and trends in HENA at focal sites (over 1,000 individuals).

As a result, in 2012, the NCNHP initiated a status survey under a USFWS Flex Fund Grant to delineate and monitor some of the largest known populations previously identified by the USFWS to be important for recovery.

This effort produced a Range-wide Status Report, and a Comprehensive Review and Monitoring Report in 2016. The known populations increased to 113 populations and one additional county was added to the range. This included an estimate of approximately 300,000 individuals. (County added: NC – Gast)

The SSA was initiated in 2018 and 6 more populations have been added for a total of 119 populations in 13 counties.

Other notes

Fed government actions began when Section 12 of the ESA directed the secretary of the Smithsonian Institute to prepare a report of those plants considered to be TE or extinct. The report was presented to Congress in Jan of 1975. In July of 1975, the Service published a notice which formally accepted the report as a petition. By doing so, the FWS acknowledged the intention to review the status of those plant taxa named in the report. HENA was included. In June of 1976, the FWS published a proposed rule to determine that 1,700 vascular plants were endangered. HENA was included. The proposal was withdrawn in 1979 as a result of an amendment to the act. Another amendment in 1982 had all prior petitions treated as new. From 1983 to 1987, HENA was warranted but precluded by other listing actions. In 1988 there was a proposal to list HENA as threatened. Listed in 1989.



Taxonomy- *Hexastylis naniflora*

- Species described in 1957 (Blomquist)
- Recognized as a member of the Virginica Group
 - Virginica Group includes 3 sub-groups
 - Virginica
 - Shuttleworthii
 - Heterophylla
 - *Hexastylis heterophylla*
 - *Hexastylis minor*
 - *Hexastylis naniflora*
- A phylogeny estimate (Niedenberger 2010) using chloroplast genes supports that *Hexastylis* is a monophyletic clade therefore should be recognized as a genus.
- Based on a 2007 study (Murrell 2007), *Hexastylis naniflora* is a well-defined species.

HENA was described by Hugo Blomquist in 1957. The *Hexastylis* genus includes 10 species divided into 3 groups all endemic to the SE US. HENA is in the Virginica group which includes 8 species and 3 subgroups. HENA falls into the Heterophylla subgroup or complex which also includes HEHE and HEMI.

Niedenberger conducted a study in 2010 using chloroplast genes. The results of that study support that *Hexastylis* is a monophyletic clade and therefore should be recognized as a genus.

Murrell conducted a molecular genetics study in 2007 that resulted in a conclusion that HENA is a well-defined and discrete species.

Other notes

3 subgroups – Arifolia, Speciosa, (each have only 1 sp) and Virginica (8 ssp)
 8 species in the Virginica group. Virginica – 1 sp (*H. virginica*), Shuttleworthii – 2 ssp (*H. shuttleworthii* and *H. lewisii*), Heterophylla – 3 ssp. Other two species – *H. contracta* and *H. rhomiforis*

Gaddy's paper about taxonomy

Group based on morphology (leaf blade and variegation), biogeography, and phenological data. Plants in the heterophylla complex are the most closely related.

Phenology – the study of periodic plant life cycle events and how they are influenced by seasonal fluctuations or other habitat factors.

Species barriers are maintained by geographical and phenological isolation.

Hugo Blomquist – originally from Sweden, Professor Emeritus at Duke University in Botany

Mono clade – a group of organisms that consist of all the descendants of a common ancestor



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Species Description and Morphology

- Low-growing herbaceous plant in the Birthwort Family.
- Height rarely exceeds 15 cm.
- Leaves – heart-shaped, dark green (variegated), and leathery. Approx. 4-5 cm. Supported by long, thin petiole.
- Flowers – small, jug-shaped, beige to dark brown, found near the base of the plant. Calyx tube orifice typically 5mm, up to 7mm.
- It is recognized that there is considerable morphological overlap among species in the *Heterophylla* complex.



Photo credit:
A. Krings (NCSU)



Photo credit:
Jim Fowler

HENA is a low-growing, herbaceous plant in the Birthwort Family (Aristolochiaceae). Height of the plant rarely exceeds 15cm. The plant can have 1-40+ leaves. Leaves are heart-shaped, dark green with variegation, and leathery. They are 4-5 cm long and supported by a long, thin petiole.

Flowers are clustered at the base of the plant and often covered by leaf litter. They are small and jug shaped with no petals. 3 united sepals form a 3-lobed calyx tube. The calyx tube opening is typically 5mm or less but can be up to 7mm. Flowers have a wide range of coloring from beige to dark brown.

The species in the *Heterophylla* complex are the most closely related and it is recognized that there is considerable morphological overlap (ex. HEHE has a calyx tube 7-14mm).

Other notes

Aristolochiaceae – Birthwort Family – 7 genera and 590 species of mostly tropical woody vines

Common in birthworts – 3-lobed calyx tube with 3 united sepals and no petals, perennial herbs and vines, typically broad leaves with red, purple, or brown flowers, fruit is a dry capsule that releases seeds when ripe

Another example is Dutchman's pipe (*Aristolochia macrophylla*)

Collectively the sepals are called the calyx. The outermost whorl of parts that form a flower. Sepals typically function as protection for the flower in bud and support petals

when in bloom.
Underground rhizome.



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Life History

- Evergreen
- Blooms from mid-March to June
- Pollinated by small insects
- Fruits from mid-May to July
- Dispersed by ants
- Demographic study conducted from 1990-1991 (Newberry 1993)
 - 96.1% survival rate over the two field seasons
 - Mortality highest in small plants with <4 leaves
 - % of flowering plants averaged 70%
 - Correlation to floodplain




Photo credit:
Jim Fowler

HENA is evergreen and blooms from Mid-March to June. While blooming, the flower is pollinated by small insects. Fruits are produced from mid-May to July. Fruits are a dry capsule that releases seeds when ripe. One study has shown that ants are one method of dispersal.

We are aware of one demographic study that took place from 1990-1991 in Spartanburg County, SC. The study found that there was a survival rate of approx. 96% over the two field seasons with highest mortality occurring in plants with <4 leaves and plants located highest on the slope. Percentage of flowering plants average 70% with the highest frequency of flowering occurring in the floodplain. Additionally, plants located in the floodplain were generally larger than plants located on adjacent slopes.

Other notes

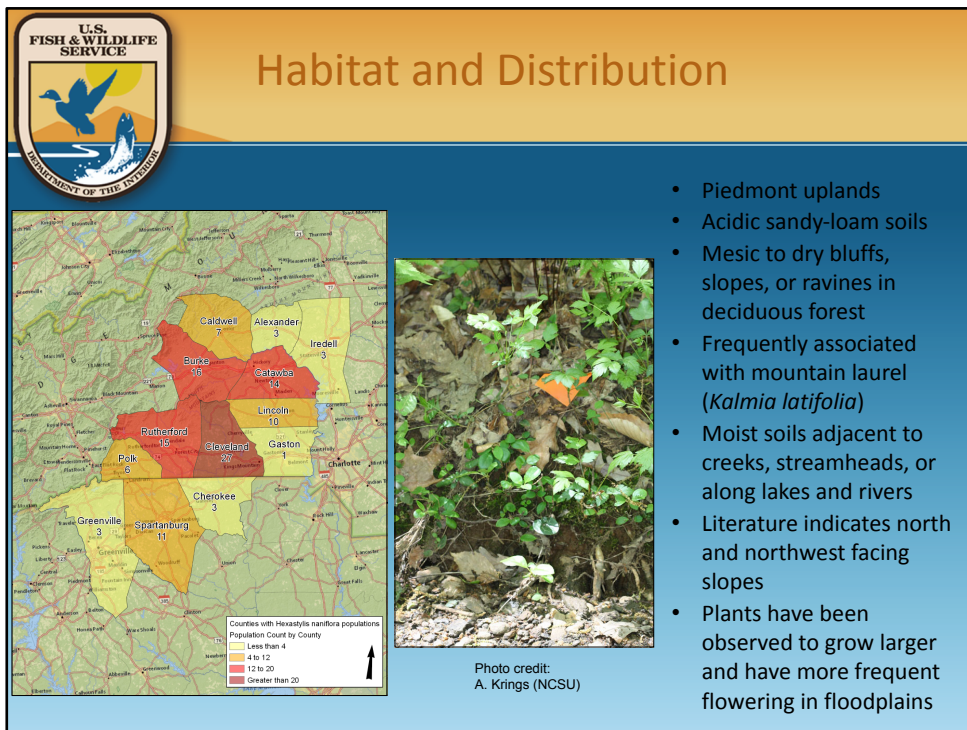
Not a ton of research done on pollination of dispersal

Ant pollination study Gaddy 1986

Flies, wasps, and thripes – Otte 1977

50% of ant lineage is ant dispersed – Lengyel 2010

Jones 2014 – insects play a significant role but even without them, flowers managed to produce a partial seed set.



Generally, two types of habitat noted within Piedmont uplands with acidic soils – mesic to dry bluffs, slopes, and ravines AND moist soils adjacent to creeks, streamheads, and rivers. Literature indicates an association with Mountain Laurel, and an affinity for north facing slopes and floodplains.

What we knew about habitat preferences in the beginning changed and expanded as a result of the Habitat Model that we did but this is a list of what we knew when we started. Mike will discuss the model later in the presentation.

Cleveland County seems to be the strong-hold with 27 populations followed by the other counties shown in red – Rutherford, Burke, and Catawba.

Other notes

Mesic – a habitat containing a moderate amount of moisture.



Genetics

- Several attempts made to determine boundaries between *HENA* and the other species in the *Heterophylla* complex.
- In 2007, ISSRs were unsuccessful at distinguishing *HENA* from close relatives. However, analyses did support the continued recognition of these taxa as well-defined, discrete species (Murrell 2007).
- Morphological overlap – no vegetative characters were previously known to consistently distinguish *HENA* from close relatives.
- NCDOT funded ASU to develop a microsatellite library of molecular markers which could be applied to populations with highly variable morphology.
- Preliminary findings (Murrell 2015) – hybridization??

There have been several attempts made to determine the boundaries between HENA and other species in the *Heterophylla* complex. In 2007, Inter Simple Sequence Repeats were unsuccessful at distinguishing HENA from close relatives; however, the analyses did support the continued recognition of these taxa as well-defined, discrete species.

Field observations demonstrate that there are some populations of HENA with morphological characteristics that do not fit within the range of published values for key traits. These values overlap with values for HEHE and HEMI. Additionally, there were no vegetative characters known to consistently distinguish HENA from other close relatives. Given difficulties with field identification, particularly when not in flower, NCDOT funded ASU to develop a microsatellite library of molecular markers which could be applied to populations with highly variable characteristics.

Preliminary findings of the study suggest that populations in the southern range of HENA exhibit a more uniform genetic pattern, with some possible hybridization with HEMI. Populations in the northern part of the range appear to have hybridized with both HEHE and HEMI, although there are still some individuals with “pure” HENA genotypes in the northern range. The study made a point to say that the findings were preliminary and although they provide anecdotal evidence of hybridization – variation could be caused by forces other than hybridization.

Other notes

ISSR – track of repetitive DNA in which certain DNA sequence pattern are repeated multiple times

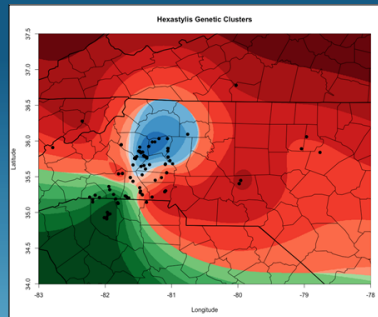
Other forces of hybridization – convergent morphological evolution, species in the process of speciation and the study shows incomplete speciation, or other environmental factors that cause morphology to be at the extreme end of the ranges.

In evolutionary biology, convergent evolution is the process whereby organisms not closely related (not monophyletic), independently evolve similar traits as a result of having to adapt to similar environments or ecological niches.



Genetics

- Dr. Matt Estep of ASU disagrees with the analyses that lead to a conclusion of hybridization and no longer thinks hybridization is happening.
- A second look at data suggests a southern group of *Hexastylis* that is *naniflora* (green) and a northern group of *Hexastylis* that is yet to be described (blue).
- The genetic analysis to support the graphic is complete, a study of morphology is ongoing, no new species has been described, and no peer-reviewed publication is available.
- For purposes of the SSA, we assumed that all EO detections are *HENA*, and represent the best currently available scientific data.



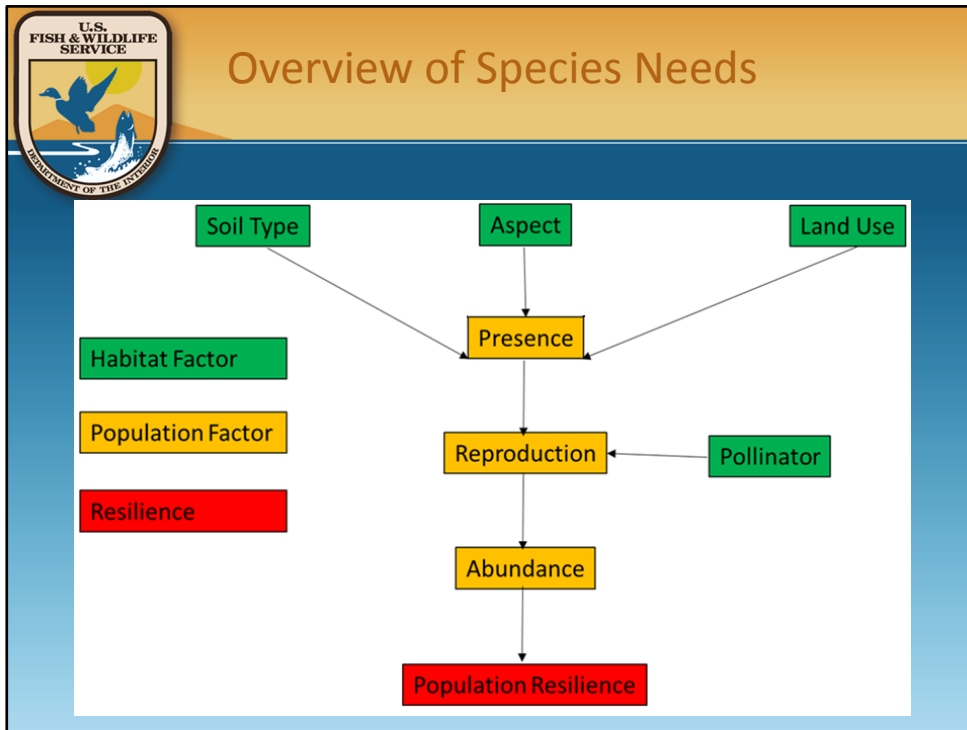
During the elicitation process, Dr. Matt Estep of ASU indicated that he disagreed with the analyses that lead to a conclusion of hybridization. He took a second look at the data and thinks there is a southern group of *Hexastylis* that is *naniflora* (green) and a northern group of *Hexastylis* that is something else – not described (shown in blue). Red is other species – HEHE or HEMI.

So, the genetic analysis to support the map is complete and a study of the morphology is ongoing. However, a new species has not been described and there is no peer-reviewed publication to support the new analysis of data. With all of that in mind, for the purposes of the SSA, we assumed that all Eos identified as *HENA* are *HENA* and we assumed that Element Occurrence data represents the best currently available scientific data.

Other notes

Disagreement had to do with the way the samples were labeled and possibly the mis-identification of the samples.

EO – an area of land or water in which a species or natural community is or was present, for a species it often corresponds with the local population or a portion of a population.



This is a conceptual diagram showing how we get to a resilient population and what the species needs to be resilient. Abundance is the driving factor when we talk about resilience for HENA. If we step that back, abundance requires presence of individuals and reproduction with reproduction requiring the small insect pollinator. Presence is tied back to habitat factors – acidic sandy loam soils, north-northwest facing slopes, and forested areas. This represents what we knew about the species when we started. As I mentioned earlier, we learn more about habitat during development of the Habitat Model.

Are there any questions about what we've discussed so far? With that, I'll turn it over to Mike.



Assessing Viability

- What is an appropriate unit of resilience?
- What key factors influence resilience?
- What are the primary risk factors?
- Are there representative units?
- What future scenarios makes sense?

Expert Input Was Critical!



Population Delineation

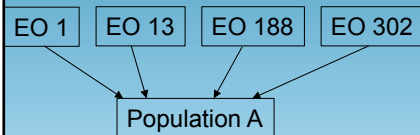
- What is a population?
- Lacking dispersal data and genetics
- Relied heavily on expert input
- Unit of resilience for the SSA



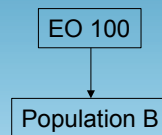
Delineating Populations

- Unit of measurement is the “clump” (rosette)
- Delineations made by NHP and based on EO separation distance and intervening landscape matrix
- Range of data (1964-2017); only included populations that had detections since 2005
 - 5-year review was initiated → increased survey effort

Population composed of multiple EOs



Stand-alone EO





Resilience

"The ability of populations to withstand stochastic events"





Population Resilience

- Resilience Based on Abundance
 - Categories from EO information
- Species Expert Input and Concurrence
- 4 categories: Very High, High, Moderate, Low



Resilience Categories

- Very high—populations with **>1,000 individuals**; very high probability of persistence for 20-30 years at or above the current population size.
- High—populations with **500-1,000 individuals**; moderate-high probability of persistence for 20-30 years at or above the current population size.
- Moderate—populations with **100-500 individuals**; low probability of persistence for 20-30 years at or above the current population size.
- Low—populations with **<100 individuals**; low probability of persistence for 20-30 years at or above the current population size, and moderate-high probability of extirpation.



Current Resilience

- 78 populations (detected since 2005)
 - 28 very high (36%)
 - 5 high (7%)
 - 26 moderate (34%)
 - 19 low (23%)

	Very High	High	Moderate	Low	Totals
Totals	28	5	26	19	78
% of total	36	7	34	23	100
Cumulative %	40	43	77	100	--



Associated Growth Trends

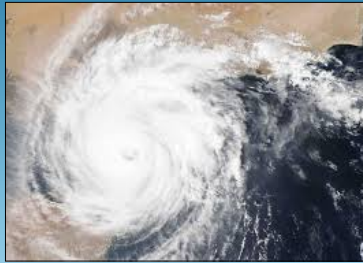
Rangewide monitoring report
At least 5 years of surveys

Trend	Survey	Site	2016 estimated number of plants (Rosettes)	2016 area occupied (Acres)
Increasing	NCNHP	Cliffside Steam Station (EO 276)	39,535	52
	NCNHP	Broad River: Floyds Creek, Long Branch (EO 177)	12,687	5.67
Stable	NCNHP	Island Creek Bluff/Love Lady Site (EO 029)	50,481	61.76
	NCNHP	Rhyne Preserve (EO 302)	19,873	22.43
	NCNHP	Mills Creek Forest and Seep (EO 023)	1,733	1.39
	NCNHP	New Hope Springhead Swamp (EO 125)	12,235	5.03
	NCNHP	Broad River: Henson's Creek, Brice, & Sandy Mush Outcrop (EO099)	106,940	83.39
	NCNHP	Broad River: Cleghorn Creek, US 221 (EO 176)	6,750	7.24
	NCNHP	Cowpens National Battlefield (SC EO 016, 017, 018)	2,823	6.05
	NCNHP	Peters Creek Preserve (SC EO 011)	3,306	8.98
	NCNHP	Blalock Reservoir (SC EO 007, 031)	3,505	7.59
Decreasing	NCNHP	Second Broad River (Forest City Industrial Complex) (EO 154)	2,576	4.74
	NCNHP	South Fork Catawba River: Jacob Fork, Camp Creek (EO 158)	123	0.09



Redundancy

“The ability of a species to withstand catastrophic events”





Current Redundancy

- What is a catastrophic event for the species?
 - Pulse vs Press
 - Press disturbances are primary focus for this species
- There are multiple highly resilient populations spread throughout the range
- Range is relatively small, so some risk to press disturbance such as climate change



Representation

“The ability of a species to adapt to changing environmental conditions”





Species Representation

- *In the absence of species specific ecological and genetic data, we evaluate representation based on the extent and variability of habitat characteristics across the range of the species.*
 - *Some variation in a habitat types (e.g. dry bluffs vs stream head habitat)*
- No Representative Units Assessed



Potential Factors Influencing Viability

- Land conversion to residential, commercial, agricultural and industrial use
- Timber harvesting
- Hydrological alterations from the damming of ponds
- Impacts from grazing cattle
- ORV damage and trampling from foot traffic
- Invasive species and woody encroachment
- Highway or road improvements
- Erosion or siltation
- Climate change—particularly changes in precipitation and temperature
- Positive Influences—management, restoration, land protection



Risk Factors

- Assessed primary factors
 - Negative factor--Urban Development
 - Positive factor--potential to find additional populations
- Use of scenarios to capture uncertainty in:
 - Species response to urban development
 - Likelihood of finding additional populations



Development

- Threat of development has either occurred or is reasonably foreseeable in approx. 37% of known population (NCNHP 2010)
- Of those populations, all or portions of 50% had been adversely impacted by activities requiring ESA Section 7 consultation with the USFWS
- Road and bridge improvement projects are the most recurrent source of habitat destruction
- 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 (NCNHP 2010)



Future Conditions

- Threats: Urban Development
- Positive: finding additional populations
- Analysis tools: Habitat Model, SLEUTH Model, and SMART Analysis
- Assessed viability to 2040 under 3 scenarios:
Status Quo; High Development; Conservation
 - Why 2040?
 - Different scenarios represent our uncertainty in both the response of the species to development and the likelihood of finding additional populations



Habitat Model

- Previous effort identified some key variables of interest
- Use of MAXENT to identify the suite of variables and their relative contribution to predicting habitat for the species
- Classes were created that further refine habitat into suitability classes



Habitat Model

- Extent—53 HUC 10 watersheds within the range of HENA
- Use of EO detections since 2005 (Current)





Habitat Model

Variables were excluded if they contributed <1% to the model

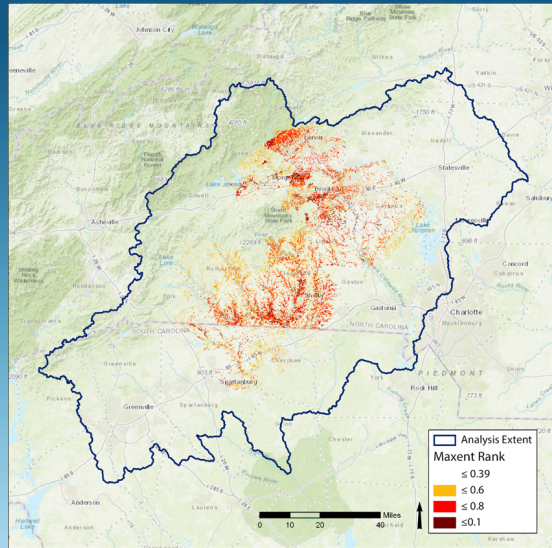
Table 3.2. Percent contribution of the environmental variables

Environmental Variable	Percent Contribution
SSURGO map unit key	23.5%
Minimum Annual Temperature	17.8%
Average Annual Precipitation	15.7%
<u>Landcover</u>	12.9%
<u>Landcover Majority</u>	12.0%
<u>Landcover Hexastylis Grouping</u>	5.4%
<u>Geomorphons</u>	4.9%
Elevation	4.6%
Canopy Cover	3.2%



Habitat Model

- 708 square miles of potential habitat
- Soil layer naming convention led to issues across state and watershed boundaries





Habitat Suitability

•A minimum cutoff value (to determine if an area is considered potential habitat for a species) of 0.39 was determined by using the average 10th percentile training presence (excludes outliers). This led to only 6% of the area being excluded.

Maxent Score	Acres	Square Miles	Percent of Total
0.39 and greater	302,834.13	473.18	6.02%
0.6 and greater	128,273.52	200.43	2.55%
0.8 and greater	22,115.97	34.56	0.44%

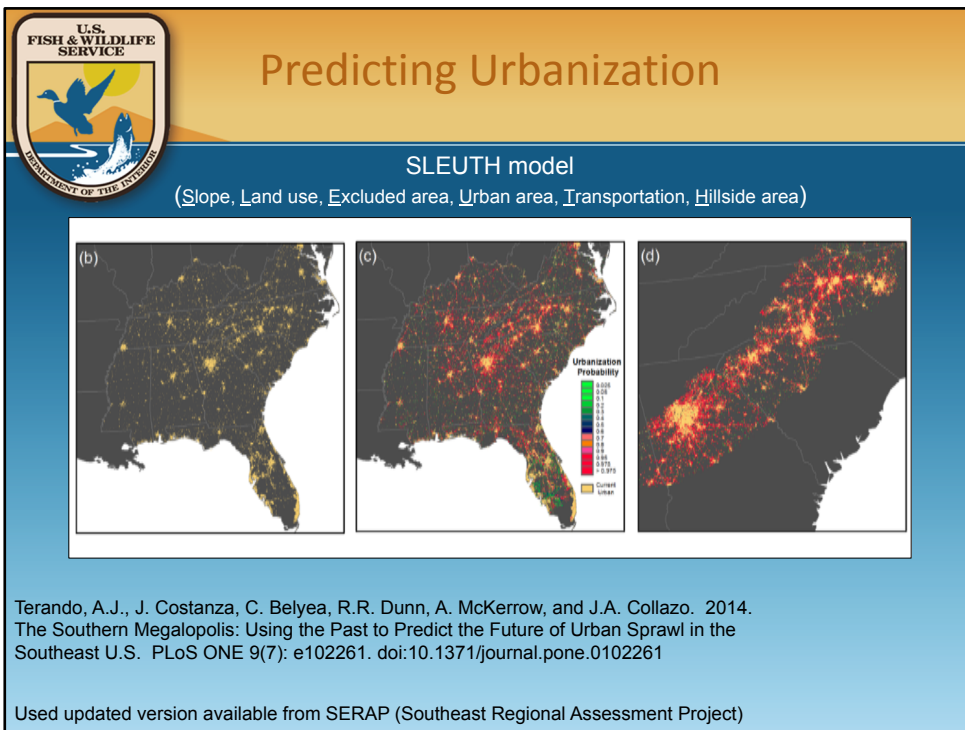


Habitat Suitability

- There are significant differences in the average Maxent scores between the four resilience categories ($p = 0.04$) and the mean Maxent score increases as population resilience increases from low to very high.
- The model gives us some predictive ability regarding habitat suitability where higher Maxent scores, on average, result in higher population resilience.

<i>Groups</i>	<i>Count</i>	<i>Mean Rank</i>
low	13	30.7
moderate	25	30.7
high	5	42.8
very high	28	45.7

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>
Between Groups	4375.7	4	1093.92	2.65	0.0404
Within Groups	28036.3	68	412.30		
Total	32412.0	72			



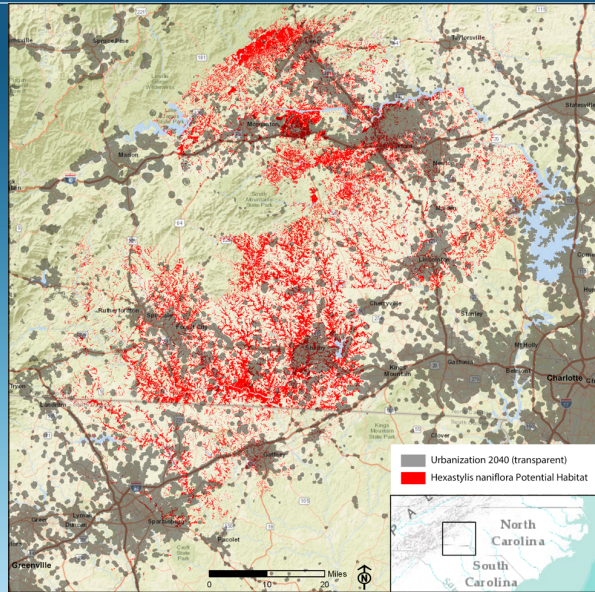
Data for urbanization scenarios for the Southeast US from Terando et al. 2014, p.3. - used updated version available from SERAP ([Southeast Regional Assessment Project](#))

Probability of growth in 10 year increments



SLEUTH Model Results

- 80% probability cutoff
- Focus on % increase in urbanization rather than total urbanization
- Scenarios will reflect different thresholds for species response to these increases
- SLEUTH + Habitat model + Protection Status helps to inform future viability and what areas are most likely to harbor additional populations





SMART Analysis

- SMART – Simple Multi Attribute Rating Technique
- Step 1 – Identify the question.
 - What EOs with observance dates older than 2005 are likely to still persist on the landscape in 2040?
- Step 2 – Identify the criteria.
 - Last known abundance estimate (resilience categories)
 - Habitat model metrics (average MAXENT score and % of habitat classified as highest suitability)
 - Results of the SLUETH model (% of site urbanized at 2040)
 - Each EO buffered by 1,000 meters to calculate habitat model metrics and result of the SLUETH model

SMART is the third tool we used to inform our future scenerios. SMART stands for Simple Multi Attribute Rating Technique. It is a step-wise decision making process for objectively ranking alternatives based on preference. It is appropriate when all alternatives have a common set of attributes and those attributes are or can be represented by a numerical range of values.

Step 1 is identifying your question. Our questions was – What Eos with observance dates older than 2005 are likely to still persist on the landscape in 2040?

Step 2 is identifying the criteria that will be the bases of the decision. We had several calls and discussions about what should be included and developed this list – last known abundance, habitat model metrics, and results of the SLUETH model.

To calculate values for each model criteria, each EO was buffered by 1,000 meters.



SMART Analysis: Raw Data

- Step 3 – List alternatives (EO_Code) and input raw data for each criteria.
- Step 4 – Identify minimum and maximum score in all criteria.

EO not part of a current population	EO included as part of a current population	EO is a part of a current population but last detection was prior to 2005	Eliminated/not scored	
EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	2	34	1	3
2				
3	2	22	0	10
4	2	22	0	7
5	2	21	0	0
6				
8	1	27	0	6
9	3	44	4	0
10	4	33	2	0
11				
12	4	54	10	0
13	1	31	1	30

EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
Min	1	3	0	0
Max	4	67	35	98

Step 3 is to list the alternatives, in this case each EO, and input the raw data for each criteria. So that every EO could be ranked against every other EO, we included all Eos – our current plus our non-current. The different colors in the table help us keep that straight. For purposes of this discussion, the focus should be on those colored in orange – 1, 5, 8, etc. These are EO that are not a part of a population that we considered current (observed since 2005).

For resilience category – Because SMART must use numerical ranges. Very High, High, Moderate, and Low became 4, 3, 2, and 1. The other data for other categories came straight from the model analysis.

Step 4 is to identify the minimum and maximum score in all criteria. This is used in the next step.

Other notes

Many of the best large populations have been surveyed since 2005 so if we excluded those, we felt like we could have skewed the analysis. We wanted to avoid a “best of the worst” situation – we wanted best of the best to be identified.



Normalizing and Weighting

- Step 5 – Determine if criteria should “aim” high or low.
- Step 6 – Normalize data for meaningful comparison.
- Step 7 – Weight each criteria.

EO not part of a current population				
EO included as part of a current population				
EO is a part of a current population but last detection was prior to 2005				
Eliminated/not scored				
EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	33	49	3	97
2				
3	33	30	0	90
4	33	29	0	93
5	33	28	1	100
6				

Weights			
100	60	20	80

Step 5 is to determine if the criteria should aim high or low. For example, high resilience is a positive for the species; therefore, we are desiring a high score – so we are aiming high. Low urban development is positive for the species; therefore, we are desiring a low score for urban development – so we are aiming low.

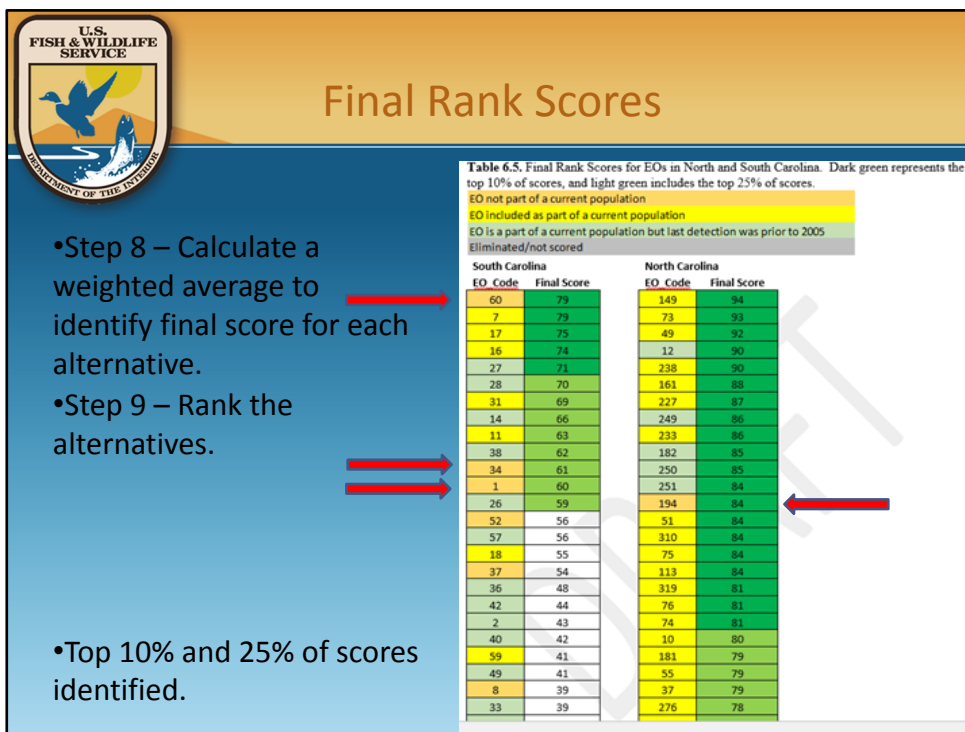
Aiming high or low determines the formula used to normalize the scores on a scale of 0-100 with 0 being low and 100 being high for all criteria. Normalizing the scores provides scores for all criteria on a scale of 0-100 while maintaining the integrity of the original raw scores. It's similar to calculating C to F. For example, the categories 4, 3, 2, and 1 of the resilience category become 100, 66, 33, and 0. Because a high resiliency is the most desired condition, 4 equates to 100. Average Maxent Score and % classified as 0.8-1.0 use the same calculation to normalize their scores based on their maximum and minimum raw scores. % urban development is the opposite. A low score, for example EO1 has a % of urban development of 3%, is most desirable so on a scale of 0-100 that would normalize to a high score – which is 97.

Step 7 is to weight each criteria based on perceived importance and each category is weighted 1-100. Our core team got together and hashed this out over several calls and this was included in expert team reviews. We landed on the weights on the screen. We felt that resilience category which is based on abundance was the most importance factor in answering our original question. Urban development was close behind since development was listed as a major threat. The average Maxent score tells us how well the habitat and landscape around each EO matches the desired

habitat and landscape for HENA as defined by the model. We weighted that as next most important. And, we gave a little boost to those EO that had model scores in the highest category of 0.8-1.

Other notes

% urban development is % of 1,000m buffer over 80% urbanization



Once you have your normalized scores and weights, you calculate a weighted average which is Step 8.

Step 9 is to rank the alternatives. In our case we ranked the scores high to low. Generally, a high score in the ranking means that the EO has high abundance, low urban development, and a matches the desired habitat and landscape as defined by the model.

Because of the differences in the model across state lines and the differences in the quality of data when comparing NC and SC, we ranked each state separately. And, SC and NC scores are not comparable – a 79 in NC is not the same as a 79 in SC.

So, the ranking is usually the last step of the SMART process; however, we took it one step further. We wanted to know which Eos were in the Top 10% and Top 25%. This is an excerpt of the ranking table. Dark green is top 10% and light green plus the dark green is the top 25%. The red arrows are pointing to the Eos that are not part of a current population (orange) that we feel based on the SMART analysis will persist on the landscape in 2040 under different scenarios. Mike will talk about how these were incorporate into the future scenarios. Any additional questions about the SMART analysis?

Other notes

An average resulting from the multiplication of each component by a factor reflecting

its importance.



Status Quo Scenario

- Additional populations—EOs prior to 2005 that fell into the top 10% based on SMART analysis
- Urbanization
 - Protected areas
 - Protected in perpetuity—no negative impacts from urbanization
 - Voluntary protection/non-perpetuity—population drops **1 resilience rank** if % increase in urbanization exceeds **>50% threshold**
 - Non-protected areas
 - population drops **1 resilience rank** if % increase in urbanization exceeds **>25% threshold**; population drops **2 resilience ranks** if % increase in urbanization exceeds **>50% threshold**



Status Quo Results

- 2 additional populations predicted to persist
- 5 predicted extirpations

	Current	Status Quo
Very High	28	27
High	5	6
Moderate	26	23
Low	19	17
Extirpated	n/a	5
Persisting	n/a	2
Total	78	75



High Development Scenario

- No additional populations
- Urbanization
 - Protected areas
 - Protected in perpetuity—population drops **1 resilience rank** if % increase in urbanization exceeds **>50% threshold**
 - Voluntary protection/non-perpetuity—population drops **1 resilience rank** if % increase in urbanization exceeds **>25%** threshold; population drops **2 resilience ranks** if % increase in urbanization exceeds **>50%** threshold
 - Non-protected areas
 - population drops **1 resilience rank** if % increase in urbanization exceeds **>25%** threshold; population drops **2 resilience ranks** if % increase in urbanization exceeds **>50%** threshold; **extirpation** of populations if % increase in urbanization exceeds **>90%** threshold.



High Development Results

- No additional populations predicted to persist
- 6 predicted extirpations
- Small loss in resilience across all categories

	Current	High Development
Very High	28	27
High	5	4
Moderate	26	25
Low	19	16
Extirpated	n/a	6
Persisting	n/a	0
Total	78	72



Conservation Scenario

- Additional populations—EOs prior to 2005 that fell into the top 25% based on SMART analysis
- Urbanization
 - Protected areas
 - Protected in perpetuity—no negative impacts from urbanization
 - Voluntary protection/non-perpetuity—population drops **1 resilience rank** if % increase in urbanization exceeds **>50%** threshold
 - Non-protected areas
 - population drops **1 resilience rank** if % increase in urbanization exceeds **>25%** threshold; population drops **2 resilience ranks** if % increase in urbanization exceeds **>50%** threshold



Targeted Conservation Results

- 6 additional populations predicted to persist
- 5 predicted extirpations

	Current	Targeted Conservation
Very High	28	27
High	5	6
Moderate	26	23
Low	19	17
Extirpated	n/a	5
Persisting	n/a	6
Total	78	79



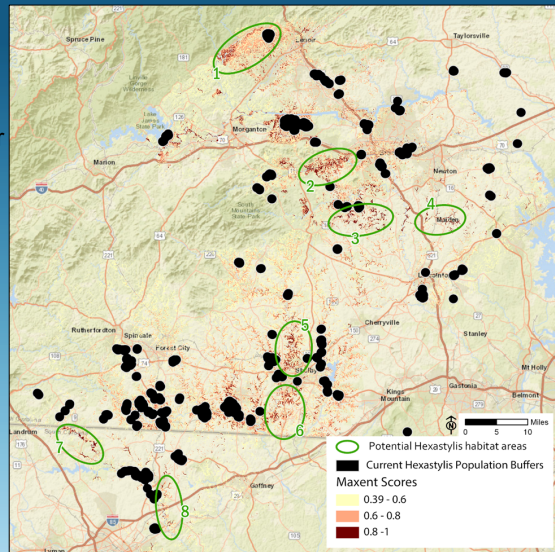
Viability Summary

	Current	Status Quo	High Development	Targeted Conservation
Very High	28	27	27	27
High	5	6	4	6
Moderate	26	23	25	23
Low	19	17	16	17
Extirpated	n/a	5	6	5
Persisting	n/a	2	0	6
Total	78	75	72	79



Future Conservation Opportunities

Areas identified as high quality potential habitat by Maxent model for *Hexastylis naniflora* that fall outside the immediately known occurrence areas.



Recommendations for Headquarters Briefings

June 2018

Purpose: The purpose of the Headquarters (HQ) briefings are to prepare HQ staff for the monthly package briefings with DOI policy officials on significant ESA decisions (please refer to the AD-ES memo of May 21, 2018 titled “Briefing Up on ESA Classification Packages” DTS-067942). The DOI briefings are designed to decide which packages can be moved forward immediately versus which packages will require a more in-depth briefing led by the lead Region. If, following the monthly briefing, an action is determined to require a follow-up briefing with DOI, we will contact you as soon as possible to arrange.

Participation: For HQ, the appropriate HQ Division and Branch Chief should be invited, with a courtesy invite to the AD-ES who chooses to participate based on the controversy and complexity of the action. Regions have flexibility to decide who from the Region participates, but we recommend that the SAT project manager (if applicable) and the field office species expert be available, plus any regional or FO leadership you see fit.

Timing: Packages should be briefed to HQ (and shortly thereafter covered in the monthly DOI briefing) once the Regional Director(s) has provided direction on a recommended course of action (generally 90-120 days from being submitted to HQ and before the Federal Register documentation has been drafted). At a minimum, the HQ briefings should occur 20 days before the DOI package briefing, so that any changes to briefing materials can be made before we share the briefing materials with the DOI policy participants (which is required 7 calendar days before the briefing). The DOI briefings are scheduled to occur on the first Tuesday of each month; however, they are often rescheduled, requiring some changes to the DOI briefing agenda.

Powerpoint – We recommend that the powerpoint cover the following information. This approach is not intended to be prescriptive – if your information lends itself to being covered in a different order or manner, do what makes sense. For example, rather than having one slide that covers data sources, you could cover the relevant data sources when presenting information on the species or the threats on separate slides.

Title Slide: include the name of the action and photo of the species (or if no photo: what kind of creature is it? Do not assume that folks know Tinian monarch is a bird or yellow lance is a mussel 😊) Discuss current Federal status (e.g., when listed, candidate, petitioned). [Done](#).

Map: where is the species found? Share what we know about its range. Be prepared for questions about whether the species could be found in more places where surveys have not been conducted. [Species could definitely be found in more places. You can see a trend over the years that additional populations are found – listing = 24, 2011 = 108, 2016 = 113, 2018 = 119. Additionally, our habitat model identified eight areas with high quality potential habitat that falls outside of the known occurrence areas. \(Extra slide from RD briefing and info in SSA\).](#)

Approach: how did we do the analysis? Was an SSA done or is it based on a recent 5-year review or other type of status assessment? Did we look at future projections? Address state participation on the core team, if applicable. [Done](#).

Data Sources: include a slide that lays out the data upon which the recommendation is made. Include data sources for information on both the species itself and the threats, including the time span range for

such data. How recent is it? Who was the source? How strong/weak is it (i.e., presence/absence vs statistically significant trend)? Provide full disclosure on any uncertainties and information gaps. The briefing process is a good opportunity to make sure we've fully internally vetted issues that we are likely to hear from the public. [Done.](#)

Species Needs and Status: how does the species make a living? What are the relevant limiting habitat features and essential life history functions? Give a little bit of background biology but stick to the 30,000 foot level. If we have survey or trend data, include figures/tables that illustrate what is happening to the species. [Done.](#)

Threats: what is happening on the landscape that is affecting the status? Review operative/primary stressors (skip the laundry list though). Differentiate between historical stressors and current/future stressors, if needed. Include figures/tables that illustrate what is happening with the threats, if helpful. [Done.](#) [Main stressors are climate change, exotic/invasive species, and development.](#)

Conservation efforts: what good things are happening to ameliorate the stressors? Has captive propagation and reintroduction been tried? Are there CCAAs/CCAs? Any Partners Program involvement? For de/downlistings, was a recovery plan done? If so, what are the criteria for de/downlisting and have we met them? [Done.](#) [No recovery plan.](#)

Recommended direction: T, E, not warranted? What is the key driver of the decision? Cover 4(d) or 10(j) rules, if applicable. If T, discuss how you looked at the foreseeable future. Discuss differences between foreseeable future and SSA/model time steps (e.g., models out 100 years and foreseeable future of 30 years). Any other novel policy issues? [Done.](#) [Added notes slide.](#) [Models and FF are the same.](#)

Critical habitat: describe the approach to designating CH, including draft maps showing relevant areas. These are for discussion purposes and do not have to be the final Federal Register quality maps. [N/A.](#)

Partnerships/Stakeholders: who cares about this decision? What is the position of the States and Tribes? What Federal agencies and others have we coordinated with? Will anyone be mad about the decision and why? What activities will be restricted by a listing? How would the action impact private landowners? [Federal – US Army Corps of Engineers, NPS \(Cowpens\), Federal Highways Administration.](#) [State – NC Natural Heritage Program, SC Heritage Trust Program, NCDOT.](#) [Other – ASU? Service has been transparent about the SSA and possible outcomes of the analysis – Recovery Plan or reclassification. To date, no concerns have been express over possible reclassification.](#)

Note – Because we often brief from paper slides, “test” print the slides to ensure they are clear and legible. Please ensure there are clear page numbers on all slides. Check for font color and style relative to the background; we recommend a simple, professional dark font on a light or white background. Maximize the size of maps on the slides to improve detail on printed pages. Please ensure all maps and figures have necessary keys. [Byron didn't do this.](#)

Additional talking points, if applicable:

- Outreach plans [Done.](#) [Added notes slide.](#)
- Be prepared to demonstrate that the recommendation is based on the best available science. How recent is the observational data? Who collected/assessed the data? If there aren't recent observational data, why not and why can our inferences about status and trends be relied upon? [Done.](#) [NCNHP and NCDOT provided baseline data – mostly from 2012-2016.](#)

- Are there unsurveyed portions of the range (e.g., Mexico, Canada, Tribal lands, remote areas, private lands)? What are our thoughts about the status in those unsurveyed areas? [Yes, additional populations could be found in unsurveyed areas.](#)
- If your analysis relies largely on a (complicated/sophisticated) projection model, be prepared to discuss the empirical, observable data that backs up the model. Unpack the “black box”. [Habitat \(Maxent\) Model and SLUETH model.](#)
- What kinds of conservation efforts might be needed to recover the species? E.g., habitat restoration, captive propagation, translocation, etc. [N/A](#)
- Who will be affected by the regulation? Who will need new permits or consultations? [N/A](#)
- What will be the impact of the regulation on the species? [N/A](#)
- For downlisting actions and threatened determinations be prepared to discuss an associated 4(d) rule, including both prohibitions and exemptions. [N/A](#)
- For delisting actions be prepared to discuss post delisting monitoring. [Done. Added notes slide.](#)



Dwarf-flowered Heartleaf (*Hexastylis naniflora*) Species Status Assessment Overview

Recommendation Meeting in Region 4

Rebekah Reid and Mike Marshall

June 12, 2018



Presentation Overview



Photo credit: Jim Fowler

- *Hexastylis naniflora* (HENA) Core and Expert Team
- Coordination & Communication
- Stakeholder Review & Engagement
- Listing & Recovery History
- Species Info, including Distribution, 3Rs & Current Condition
- Factors Affecting Viability
- Future Scenarios
- Q&A



The HENA Team

CORE TEAM

- Mike Marshall-Atlanta Regional Office
- Rebekah Reid-Asheville Field Office
- Mark Endries-Asheville Field Office
- Stephanie DeMay-TAMU-NRI
- Byron Hamilton-Atlanta Regional Office
- Drew Becker-Atlanta Regional Office

EXPERT TEAM

- Suzanne Mason-NC Natural Heritage Program (NCNHP)
- Jame Amoroso-NCNHP
- Laura Robinson-NCNHP
- Matt Estep-Appalachian State University (ASU)



Peer & Partner Review

- **7 potential peer reviewers contacted:**

- Wesley Knapp (NCNHP)
- Tim Bassette (NCDOT)
- Dr. Gillian Newberry (University South Carolina—retired)
- Dr. Doug Rayner (Wofford College)
- Dr. LL “Chick” Gaddy (Terra Incognita)
- Dr. Zack Murrell (ASU)
- Herrick Brown (SC Heritage Trust Program)

0 review returned to date



Stakeholder Engagement

- “Dear Interested Party” letters
- Expert review and engagement
- NC vs. SC Involvement





Listing & Recovery History

Listing:

- Listed as threatened in 1989
 - 24 known populations in 8 counties – approx. 5,000 individuals
 - Development was listed as the main threat

Recovery:

- Recovery Outline developed in 1989
- Recovery Plan never completed
- 5-Year Review (2011)
 - 108 known populations in 12 counties
- Range-wide Status Report (2016)
 - 113 known populations in 13 counties, approx. 300,000 individuals
- Species Status Assessment (2018)
 - 119 known populations in 13 counties



Taxonomy- *Hexastylis naniflora*

- Species described in 1957 (Blomquist)
- Recognized as a member of the Virginica Group
 - Virginica Group includes 3 sub-groups
 - Virginica
 - Shuttleworthii
 - Heterophylla
 - Hexastylis heterophylla*
 - Hexastylis minor*
 - Hexastylis naniflora*
- A phylogeny estimate (Niedenberger 2010) using chloroplast genes supports that *Hexastylis* is a monophyletic clade therefore should be recognized as a genus.
- Based on a 2007 study (Murrell 2007), *Hexastylis naniflora* is a well-defined species.



Species Description and Morphology

- Low-growing herbaceous plant in the Birthwort Family.
- Height rarely exceeds 15 cm.
- Leaves – heart-shaped, dark green (variegated), and leathery. Approx. 4-5 cm. Supported by long, thin petiole.
- Flowers – small, jug-shaped, beige to dark brown, found near the base of the plant. Calyx tube orifice typically 5mm, up to 7mm.
- It is recognized that there is considerable morphological overlap among species in the *Heterophylla* complex.



Photo credit:
A. Krings (NCSU)



Photo credit:
Jim Fowler



Life History

- Evergreen
- Blooms from mid-March to June
- Pollinated by small insects
- Fruits from mid-May to July
- Dispersed by ants
- Demographic study conducted from 1990-1991 (Newberry 1993)
 - 96.1% survival rate over the two field seasons
 - Mortality highest in small plants with <4 leaves
 - % of flowering plants averaged 70%
 - Correlation to floodplain



Photo credit:
Jim Fowler





Habitat and Distribution

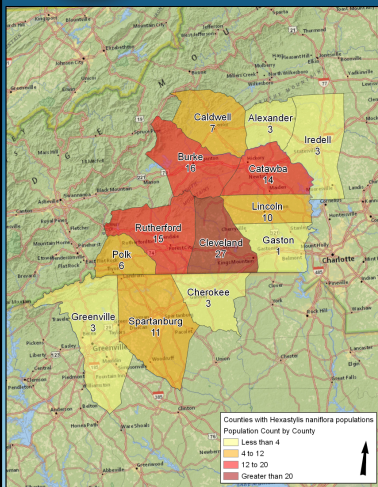


Photo credit:
A. Krings (NCSU)

- Piedmont uplands
- Acidic sandy-loam soils
- Mesic to dry bluffs, slopes, or ravines in deciduous forest
- Frequently associated with mountain laurel (*Kalmia latifolia*)
- Moist soils adjacent to creeks, streamheads, or along lakes and rivers
- Literature indicates north and northwest facing slopes
- Plants have been observed to grow larger and have more frequent flowering in floodplains



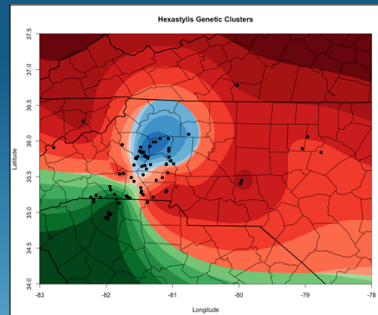
Genetics

- Several attempts made to determine boundaries between *HENA* and the other species in the *Heterophylla* complex.
- In 2007, ISSRs were unsuccessful at distinguishing *HENA* from close relatives. However, analyses did support the continued recognition of these taxa as well-defined, discrete species (Murrell 2007).
- Morphological overlap – no vegetative characters were previously known to consistently distinguish *HENA* from close relatives.
- NCDOT funded ASU to develop a microsatellite library of molecular markers which could be applied to populations with highly variable morphology.
- Preliminary findings (Murrell 2015) – hybridization??



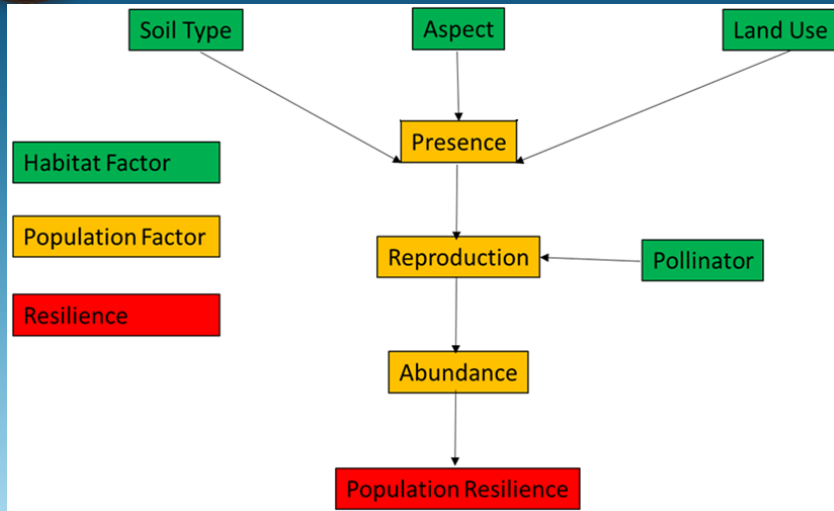
Genetics

- Dr. Matt Estep of ASU disagrees with the analyses that lead to a conclusion of hybridization and no longer thinks hybridization is happening.
- A second look at data suggests a southern group of *Hexastylis* that is *naniflora* (green) and a northern group of *Hexastylis* that is yet to be described (blue).
- The genetic analysis to support the graphic is complete, a study of morphology is ongoing, no new species has been described, and no peer-reviewed publication is available.
- For purposes of the SSA, we assumed that all EO detections are *HENA*, and represent the best currently available scientific data.





Overview of Species Needs





Assessing Viability

- What is an appropriate unit of resilience?
- What key factors influence resilience?
- What are the primary risk factors?
- Are there representative units?
- What future scenarios makes sense?

Expert Input Was Critical!



Population Delineation

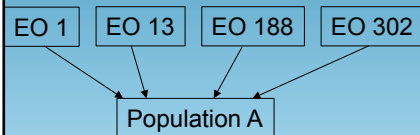
- What is a population?
- Lacking dispersal data and genetics
- Relied heavily on expert input
- Unit of resilience for the SSA



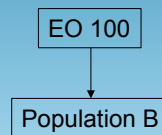
Delineating Populations

- Unit of measurement is the “clump” (rosette)
- Delineations made by NHP and based on EO separation distance and intervening landscape matrix
- Range of data (1964-2017); only included populations that had detections since 2005
 - 5-year review was initiated → increased survey effort

Population composed of multiple EOs



Stand-alone EO





Resilience

"The ability of populations to withstand stochastic events"





Population Resilience

- Resilience Based on Abundance
 - Categories from EO information
- Species Expert Input and Concurrence
- 4 categories: Very High, High, Moderate, Low



Resilience Categories

- Very high—populations with **>1,000 individuals**; very high probability of persistence for 20-30 years at or above the current population size.
- High—populations with **500-1,000 individuals**; moderate-high probability of persistence for 20-30 years at or above the current population size.
- Moderate—populations with **100-500 individuals**; low probability of persistence for 20-30 years at or above the current population size.
- Low—populations with **<100 individuals**; low probability of persistence for 20-30 years at or above the current population size, and moderate-high probability of extirpation.



Current Resilience

- 78 populations (detected since 2005)
 - 28 very high (36%)
 - 5 high (7%)
 - 26 moderate (34%)
 - 19 low (23%)

	Very High	High	Moderate	Low	Totals
Totals	28	5	26	19	78
% of total	36	7	34	23	100
Cumulative %	40	43	77	100	--



Associated Growth Trends

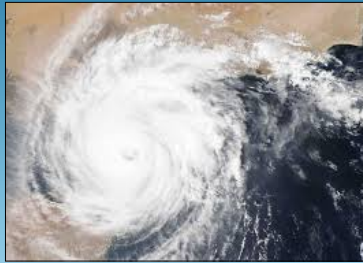
Range-wide monitoring report
At least 5 years of surveys

Trend	Survey	Site	2016 estimated number of plants (Rosettes)	2016 area occupied (Acres)
Increasing	NCNHP	Cliffside Steam Station (EO 276)	39,535	52
	NCNHP	Broad River: Floyds Creek, Long Branch (EO 177)	12,687	5.67
Stable	NCNHP	Island Creek Bluff/Love Lady Site (EO 029)	50,481	61.76
	NCNHP	Rhyne Preserve (EO 302)	19,873	22.43
	NCNHP	Mills Creek Forest and Seep (EO 023)	1,733	1.39
	NCNHP	New Hope Springhead Swamp (EO 125)	12,235	5.03
	NCNHP	Broad River: Henson's Creek, Brice, & Sandy Mush Outcrop (EO099)	106,940	83.39
	NCNHP	Broad River: Cleghorn Creek, US 221 (EO 176)	6,750	7.24
	NCNHP	Cowpens National Battlefield (SC EO 016, 017, 018)	2,823	6.05
	NCNHP	Peters Creek Preserve (SC EO 011)	3,306	8.98
	NCNHP	Blalock Reservoir (SC EO 007, 031)	3,505	7.59
Decreasing	NCNHP	Second Broad River (Forest City Industrial Complex) (EO 154)	2,576	4.74
	NCNHP	South Fork Catawba River: Jacob Fork, Camp Creek (EO 158)	123	0.09



Redundancy

“The ability of a species to withstand catastrophic events”





Current Redundancy

- What is a catastrophic event for the species?
 - Pulse vs Press
 - Press disturbances are primary focus for this species
- There are multiple highly resilient populations spread throughout the range
- Range is relatively small, so some risk to press disturbance such as climate change



Representation

“The ability of a species to adapt to changing environmental conditions”





Species Representation

- *In the absence of species specific ecological and genetic data, we evaluate representation based on the extent and variability of habitat characteristics across the range of the species.*
 - *Some variation in a habitat types (e.g. dry bluffs vs stream head habitat)*
- No Representative Units Assessed



Potential Factors Influencing Viability

- Land conversion to residential, commercial, agricultural and industrial use
- Timber harvesting
- Hydrological alterations from the damming of ponds
- Impacts from grazing cattle
- ORV damage and trampling from foot traffic
- Invasive species and woody encroachment
- Highway or road improvements
- Erosion or siltation
- Climate change—particularly changes in precipitation and temperature
- Positive Influences—management, restoration, land protection



Risk Factors

- Assessed primary factors
 - Negative factor--Urban Development
 - Positive factor--potential to find additional populations
- Use of scenarios to capture uncertainty in:
 - Species response to urban development
 - Likelihood of finding additional populations



Development

- Threat of development has either occurred or is reasonably foreseeable in approx. 37% of known population (NCNHP 2010)
- Of those populations, all or portions of 50% had been adversely impacted by activities requiring ESA Section 7 consultation with the USFWS
- Road and bridge improvement projects are the most recurrent source of habitat destruction
- 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 (NCNHP 2010)



Future Conditions

- Threats: Urban Development
- Positive: finding additional populations
- Analysis tools: Habitat Model, SLEUTH Model, and SMART Analysis
- Assessed viability to 2040 under 3 scenarios:
Status Quo; High Development; Conservation
 - Why 2040?
 - Different scenarios represent our uncertainty in both the response of the species to development and the likelihood of finding additional populations



Habitat Model

- Previous effort identified some key variables of interest
- Use of MAXENT to identify the suite of variables and their relative contribution to predicting habitat for the species
- Classes were created that further refine habitat into suitability classes



Habitat Model

- Extent—53 HUC 10 watersheds within the range of HENA
- Use of EO detections since 2005 (Current)





Habitat Model

Variables were excluded if they contributed <1% to the model

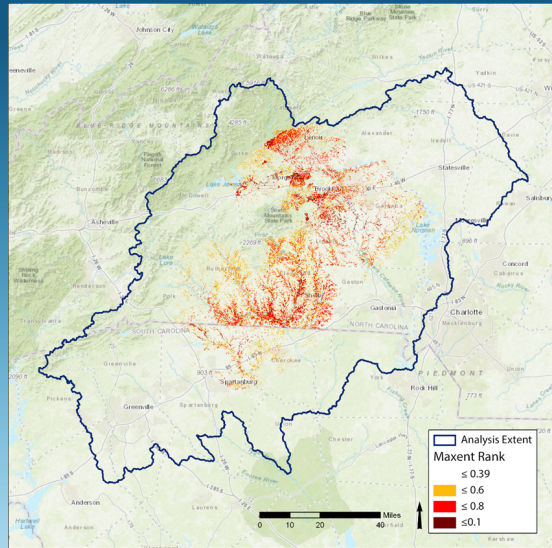
Table 3.2. Percent contribution of the environmental variables

Environmental Variable	Percent Contribution
SSURGO map unit key	23.5%
Minimum Annual Temperature	17.8%
Average Annual Precipitation	15.7%
<u>Landcover</u>	12.9%
<u>Landcover Majority</u>	12.0%
<u>Landcover Hexastylis Grouping</u>	5.4%
<u>Geomorphons</u>	4.9%
Elevation	4.6%
Canopy Cover	3.2%



Habitat Model

- 708 square miles of potential habitat
- Soil layer naming convention led to issues across state and watershed boundaries





Habitat Suitability

•A minimum cutoff value (to determine if an area is considered potential habitat for a species) of 0.39 was determined by using the average 10th percentile training presence (excludes outliers). This led to only 6% of the area being excluded.

Maxent Score	Acres	Square Miles	Percent of Total
0.39 and greater	302,834.13	473.18	6.02%
0.6 and greater	128,273.52	200.43	2.55%
0.8 and greater	22,115.97	34.56	0.44%

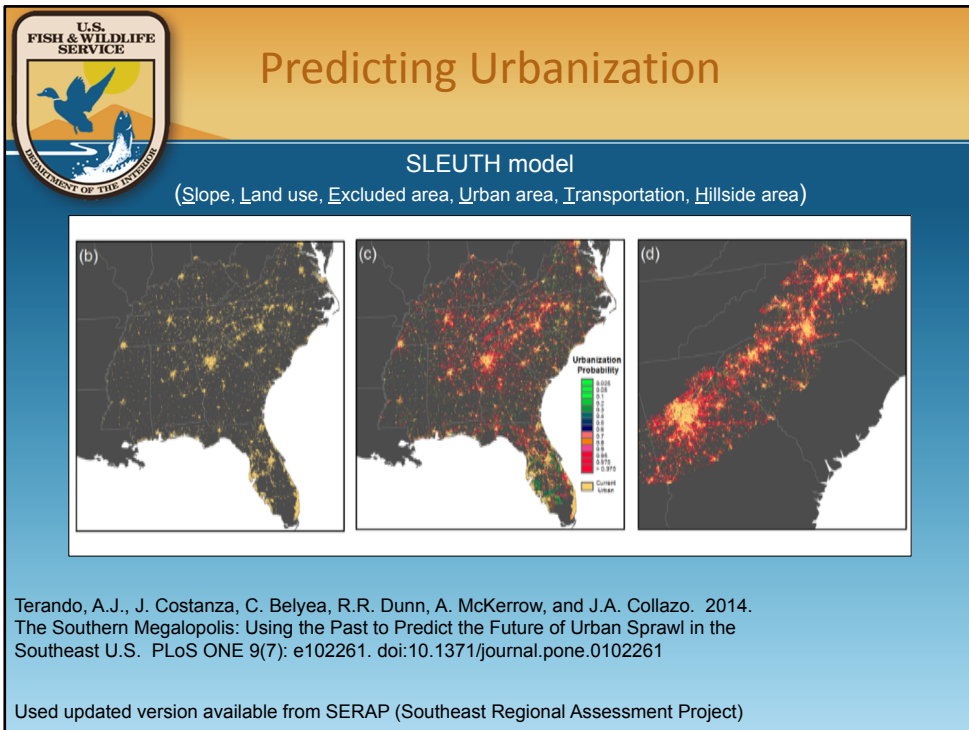


Habitat Suitability

- There are significant differences in the average Maxent scores between the four resilience categories ($p = 0.04$) and the mean Maxent score increases as population resilience increases from low to very high.
- The model gives us some predictive ability regarding habitat suitability where higher Maxent scores, on average, result in higher population resilience.

<i>Groups</i>	<i>Count</i>	<i>Mean Rank</i>
low	13	30.7
moderate	25	30.7
high	5	42.8
very high	28	45.7

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>
Between Groups	4375.7	4	1093.92	2.65	0.0404
Within Groups	28036.3	68	412.30		
Total	32412.0	72			



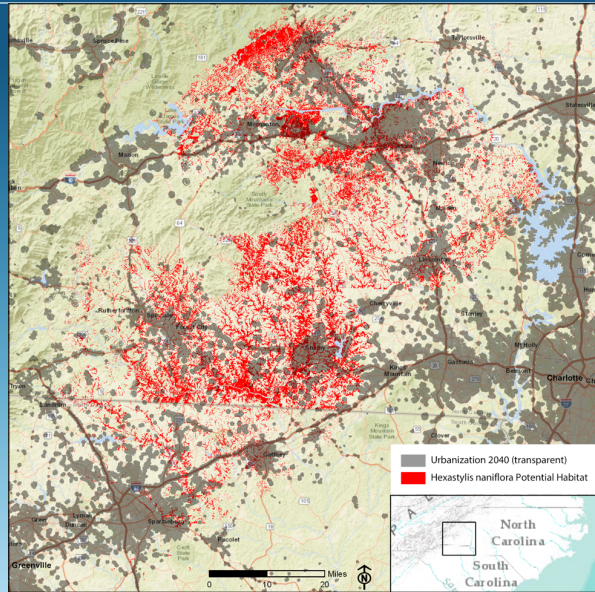
Data for urbanization scenarios for the Southeast US from Terando et al. 2014, p.3. - used updated version available from SERAP ([Southeast Regional Assessment Project](#))

Probability of growth in 10 year increments



SLEUTH Model Results

- 80% probability cutoff
- Focus on % increase in urbanization rather than total urbanization
- Scenarios will reflect different thresholds for species response to these increases
- SLEUTH + Habitat model + Protection Status helps to inform future viability and what areas are most likely to harbor additional populations





SMART Analysis

- SMART – Simple Multi Attribute Rating Technique
- Step 1 – Identify the question.
 - What EOs with observance dates older than 2005 are likely to still persist on the landscape in 2040?
- Step 2 – Identify the criteria.
 - Last known abundance estimate (resilience categories)
 - Habitat model metrics (average MAXENT score and % of habitat classified as highest suitability)
 - Results of the SLUETH model (% of site urbanized at 2040)
 - Each EO buffered by 1,000 meters to calculate habitat model metrics and result of the SLUETH model



SMART Analysis: Raw Data

- Step 3 – List alternatives and input raw data for each criteria.
- Step 4 – Identify minimum and maximum score in all criteria.

EO not part of a current population				
EO included as part of a current population				
EO is a part of a current population but last detection was prior to 2005				
Eliminated/not scored				
EO Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	2	34	1	3
2				
3	2	22	0	10
4	2	22	0	7
5	2	21	0	0
6				
8	1	27	0	6
9	3	44	4	0
10	4	33	2	0
11				
12	4	54	10	0
13	1	31	1	30

EO Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
Min	1	3	0	0
Max	4	67	35	98



Normalizing and Weighting

- Step 5 – Determine if criteria should “aim” high or low.
- Step 6 – Normalize data for meaningful comparison.
- Step 7 – Weight each criteria.

EO not part of a current population				
EO included as part of a current population				
EO is a part of a current population but last detection was prior to 2005				
Eliminated/not scored				
EO_Code	Resilience Category	Average Maxent Score	% Maxent classified as 0.8-1.0	% Urban Development
1	33	49	3	97
2				
3	33	30	0	90
4	33	29	0	93
5	33	28	1	100
6				

Weights			
100	60	20	80



Final Rank Scores

•Step 8 – Calculate a weighted average to identify final score for each alternative.

•Step 9 – Rank the alternatives.

•Top 10% and 25% of scores identified.

Table 6.5. Final Rank Scores for EOs in North and South Carolina. Dark green represents the top 10% of scores, and light green includes the top 25% of scores.

EO not part of a current population
EO included as part of a current population
EO is a part of a current population but last detection was prior to 2005
Eliminated/not scored

South Carolina		North Carolina	
EO Code	Final Score	EO Code	Final Score
60	79	149	94
7	79	73	93
17	75	49	92
16	74	12	90
27	73	238	90
28	70	161	88
31	69	227	87
14	66	249	86
11	63	233	86
38	62	182	85
34	61	250	85
1	60	251	84
26	59	194	84
52	56	51	84
57	56	310	84
18	55	75	84
37	54	113	84
36	48	319	81
42	44	76	81
2	43	74	81
40	42	10	80
59	41	181	79
49	41	55	79
8	39	37	79
33	39	276	78



Status Quo Scenario

- Additional populations—EOs prior to 2005 that fell into the top 10% based on SMART analysis
- Urbanization
 - Protected areas
 - Protected in perpetuity—no negative impacts from urbanization
 - Voluntary protection/non-perpetuity—population drops **1 resilience rank** if % increase in urbanization exceeds **>50% threshold**
 - Non-protected areas
 - population drops **1 resilience rank** if % increase in urbanization exceeds **>25% threshold**; population drops **2 resilience ranks** if % increase in urbanization exceeds **>50% threshold**



Status Quo Results

- 2 additional populations predicted to persist
- 5 predicted extirpations

	Current	Status Quo
Very High	28	27
High	5	6
Moderate	26	23
Low	19	17
Extirpated	n/a	5
Persisting	n/a	2
Total	78	75



High Development Scenario

- No additional populations
- Urbanization
 - Protected areas
 - Protected in perpetuity—population drops **1 resilience rank** if % increase in urbanization exceeds **>50% threshold**
 - Voluntary protection/non-perpetuity—population drops **1 resilience rank** if % increase in urbanization exceeds **>25%** threshold; population drops **2 resilience ranks** if % increase in urbanization exceeds **>50%** threshold
 - Non-protected areas
 - population drops **1 resilience rank** if % increase in urbanization exceeds **>25%** threshold; population drops **2 resilience ranks** if % increase in urbanization exceeds **>50%** threshold; **extirpation** of populations if % increase in urbanization exceeds **>90%** threshold.



High Development Results

- No additional populations predicted to persist
- 6 predicted extirpations
- Small loss in resilience across all categories

	Current	High Development
Very High	28	27
High	5	4
Moderate	26	25
Low	19	16
Extirpated	n/a	6
Persisting	n/a	0
Total	78	72



Conservation Scenario

- Additional populations—EOs prior to 2005 that fell into the top 25% based on SMART analysis
- Urbanization
 - Protected areas
 - Protected in perpetuity—no negative impacts from urbanization
 - Voluntary protection/non-perpetuity—population drops **1 resilience rank** if % increase in urbanization exceeds **>50%** threshold
 - Non-protected areas
 - population drops **1 resilience rank** if % increase in urbanization exceeds **>25%** threshold; population drops **2 resilience ranks** if % increase in urbanization exceeds **>50%** threshold



Targeted Conservation Results

- 6 additional populations predicted to persist
- 5 predicted extirpations

	Current	Targeted Conservation
Very High	28	27
High	5	6
Moderate	26	23
Low	19	17
Extirpated	n/a	5
Persisting	n/a	6
Total	78	79



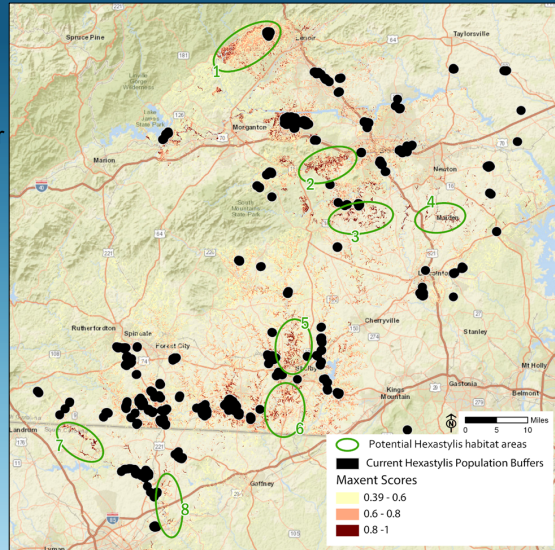
Viability Summary

	Current	Status Quo	High Development	Targeted Conservation
Very High	28	27	27	27
High	5	6	4	6
Moderate	26	23	25	23
Low	19	17	16	17
Extirpated	n/a	5	6	5
Persisting	n/a	2	0	6
Total	78	75	72	79



Future Conservation Opportunities

Areas identified as high quality potential habitat by Maxent model for *Hexastylis naniflora* that fall outside the immediately known occurrence areas.



From: [Federal Register Subscriptions](#)
To: [Straight, Carrie A](#)
Subject: [EXTERNAL] [FR] Documents from Fish and Wildlife Service
Date: Saturday, April 24, 2021 4:12:09 AM

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Documents from Fish and Wildlife Service

MATCHING DOCUMENTS

Fish and Wildlife Service

Rules

Endangered and Threatened Species:

Listing the Yangtze Sturgeon as an Endangered Species

FR Document: [2021-08466](#)

[PDF](#) Pages 21950-21961 (12 pages)

Citation: 86 FR 21950

[Permalink](#)

Abstract: We, the U.S. Fish and Wildlife Service (Service), determine endangered species status under the Endangered Species Act of 1973 (Act), as amended, for the Yangtze sturgeon (*Acipenser dabryanus*). Loss of individuals due to overharvesting on the Yangtze River is the main factor that contributed to the historical decline of the species. Despite conservation efforts, this species is still currently in decline, due primarily to the effects of dams and bycatch. This rule adds the Yangtze sturgeon to...

Proposed Rules

Endangered and Threatened Species:

Reclassifying the Virgin Islands Tree Boa from Endangered to Threatened; Reclassification of *Eugenia woodburyana* as Threatened

FR Document: [2021-08580](#)

[PDF](#) Pages 22005-22006 (2 pages)

Citation: 86 FR 22005

[Permalink](#)

Abstract: We, the U.S. Fish and Wildlife Service (Service), are reopening the public comment periods on two proposed rules to allow all interested parties

additional time to comment, and to conduct a public hearing. The two relevant proposed rules are our September 30, 2020, proposed rule to reclassify the endangered Virgin Islands tree boa (*Chilabothrus granti*) as a threatened species with a rule issued under section 4(d) of the Endangered Species Act of 1973 (Act), as amended; and our October 21,...

Removal of the Dwarf-flowered Heartleaf from the Federal List of Endangered and Threatened Plants

FR Document: [2021-08459](#)

[PDF](#) Pages 21994-22005 (12 pages)

Citation: 86 FR 21994

[Permalink](#)

Abstract: We, the U.S. Fish and Wildlife Service (Service), propose to remove the dwarf-flowered heartleaf (*Hexastylis naniflora*), a plant endemic to the upper Piedmont region of western North Carolina and upstate South Carolina, from the Federal List of Endangered and Threatened Plants (List). This determination is based on a thorough review of the best available scientific and commercial data, which indicate that the threats to the species have been eliminated or reduced to the point that the species...

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From: [Keith A. Bradley](#)
To: [Straight, Carrie A](#)
Subject: [EXTERNAL] RE: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021
Date: Wednesday, June 30, 2021 4:16:03 PM

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Hi Carrie,

I'd be happy to do the peer review.

Keith A. Bradley, Botanist
SC Dept. of Natural Resources
Heritage Trust Program
1000 Assembly St., Columbia, SC 29201
BradleyK@dnr.sc.gov
mobile: 803-587-0755
office: 803-734-4032

From: Straight, Carrie A <carrie_straight@fws.gov>
Sent: Friday, June 25, 2021 3:37 PM
To: Keith A. Bradley <BradleyK@dnr.sc.gov>
Subject: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021

Mr. Bradley,

The Fish and Wildlife Service is requesting your help by asking you to serve as a peer reviewer of our draft post delisting monitoring (PDM) plan for the dwarf-flowered heartleaf.

Post-delisting monitoring (PDM) refers to activities undertaken to verify that a species delisted due to recovery remains secure from risk of extinction after the protections of the Endangered Species Act (ESA) no longer apply. The primary goal of PDM is to monitor the species to ensure the status does not deteriorate, and if a substantial decline in the species (numbers of individuals or populations) or an increase in threats is detected, to take measures to halt the decline so that re-proposing it as a threatened or endangered species is not needed.

Section 4(g), added to the ESA in the 1988 reauthorization, requires the U.S. Fish and Wildlife Service to implement a system in cooperation with the states to monitor for not less than five years the status of all species that have recovered and been removed from the list of threatened and endangered plants and animals (50 CFR 17.11, 17.12, 224.101, and 227.4). This plan is being developed in accordance with the requirements of Section 4(g) of the ESA.

We ask for your comments on the draft PDM plan to focus specifically on the quality of the scientific information and analyses and whether the best available information was used. Please identify any oversights, omissions, and inconsistencies; provide advice on reasonableness of judgments made from the scientific evidence; help us ensure that scientific uncertainties are identified and characterized; provide advice on the overall strengths and limitations of the scientific data used in the document; and inform us of any scientific information that we did not use. We request that you direct your review to the scientific issues and assumptions relating to your expertise and provide references when needed.

Please note that we are not seeking your opinion of the legal status of this species, but rather that the best available data and analyses were considered in reassessing its status.

Additionally, as part of the peer review process, we must evaluate the potential for conflicts of interest with the subject species or the action. Please complete the attached Conflict of Interest form and return it with any notes, comments, or questions that you are willing to provide along with your peer review.

By agreeing to participate in the peer review process for this species, you are considered an unpaid, volunteer consultant to assist the Service by providing the best scientific information and clarity in this document. As part of our reporting process under the [Information Quality Act](#), we will also be listing your name and affiliation along with the comments in a document available to the public.

We hope that you view this peer review process as a worthwhile undertaking. Once you complete your review of the attached document, please submit comments and signed Conflict of Interest Form to the Atlanta Regional Office, to our Regional Recovery Coordinator, Carrie Straight. Your comments can be provided to Carrie by email carrie_straight@fws.gov or by letter (1875 Century Boulevard, 4th Floor, Atlanta, Georgia 30345) and should be received by **July 16, 2021**, to help us complete the document. Thank you in advance for your assistance. We appreciate your time in helping complete this review. If you feel you cannot complete the review in the allotted time or would like to decline review, please let me know.

Thank you for your time,

Carrie

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Carrie A. Straight, PhD
She, her, hers

Regional Recovery Coordinator
South Atlantic-Gulf and Mississippi Basin Regions
U.S. Fish and Wildlife Service
Ecological Services
1875 Century Boulevard
Atlanta, Georgia 30345
404.679.7226 (office) or via Teams (carrie_straight@fws.gov)

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From: [Straight, Carrie A](#)
To: [Keith A. Bradley](#)
Subject: RE: [EXTERNAL] RE: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021
Date: Thursday, July 1, 2021 8:01:00 AM

Thank you for your time in this effort.

Carrie

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Carrie A. Straight, PhD
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Regional Recovery Coordinator
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From: Keith A. Bradley <BradleyK@dnr.sc.gov>
Sent: Wednesday, June 30, 2021 4:15 PM
To: Straight, Carrie A <carrie_straight@fws.gov>
Subject: [EXTERNAL] RE: Peer Review Request: draft Post Delisting Monitoring Plan Dwarf-Flowered Heartleaf; response requested by COB 7/16/2021

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To: Keith A. Bradley <BradleyK@dnr.sc.gov>

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We ask for your comments on the draft PDM plan to focus specifically on the quality of the scientific information and analyses and whether the best available information was used. Please identify any oversights, omissions, and inconsistencies; provide advice on reasonableness of judgments made from the scientific evidence; help us ensure that scientific uncertainties are identified and characterized; provide advice on the overall strengths and limitations of the scientific data used in the document; and inform us of any scientific information that we did not use. We request that you direct your review to the scientific issues and assumptions relating to your expertise and provide references when needed.

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